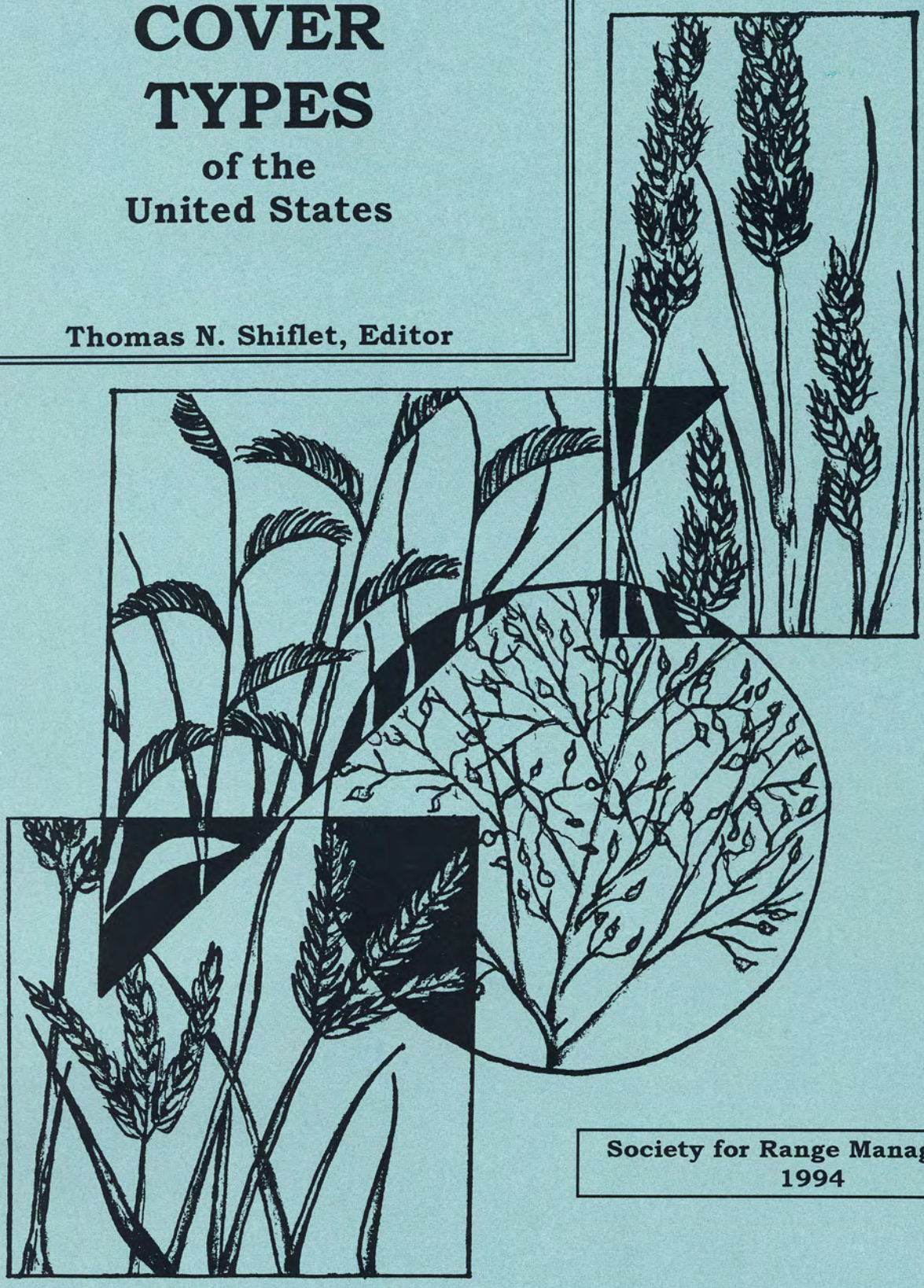
RANGELAND COVER TYPES

of the United States

Thomas N. Shiflet, Editor



Society for Range Management
1994

Rangeland Cover Types of the United States

Thomas N. Shiflet, Editor

Society for Range Management
1839 York Street
Denver, Colorado 80206

1994

COVER SKETCH: The Society for Range Management extends its appreciation to Bridgett S. Crane for her original sketch specifically designed for the cover of *Rangeland Cover Types of the United States.*

Copyright © 1994, by the Society for Range Management

All rights reserved. No part of this book may be reproduced in any form without written permission from the publisher, except by a reviewer who wishes to quote brief passages in connection with a review for the public press.

First Edition

ISBN 1-884930-01-8

Library of Congress Catalog Card No. 94-065345

Printed in the United States of America

CONTENTS

Acknowledgements iii
Preface ix
Introduction xi
Definition of Rangeland Cover Type xi
Criteria for Recognition of Types xi
Cover Type Nomenclature xi
Plant Names xi
Numbering System xii
Relation to Other Classifications xii
Arrangement of Cover Type Descriptions xii
Regional Coordinators x

Pacific Northwest Cover Types 1
Introduction 1
Bluebunch Wheatgrass (101) 1
Idaho Fescue (102) 2
Green Fescue (103) 4
Antelope Bitterbrush-Bluebunch Wheatgrass (104) 4
Antelope Bitterbrush-Idaho Fescue (105) 5
Bluegrass Scabland (106) 6
Western Juniper-Big Sagebrush-Bluebunch Wheatgrass (107) 6
Alpine Idaho Fescue (108) 7
Ponderosa Pine Shrublands and Grasslands 7
Ponderosa Pine - Shrubland (109) 8
Ponderosa Pine - Grassland (110) 8

Pacific Southwest Cover Types 10
Introduction 10
Blue Oak Woodland (201) 11
Coast Live Oak Woodland (202) 12
Riparian Woodland (203) 13
North Coastal Shrub (204) 14
Coastal Sage Shrub (205) 15
Chamise Chaparral (206) 16
Scrub Oak Mixed Chaparral (207) 17
Ceanothus Mixed Chaparral (208) 18
Montane Shrubland (209) 18
Bitterbrush (210) 19
Creosote Bush Scrub (211) 20
Blackbush (212) 21
Alpine Grassland (213) 22
Coastal Prairie (214) 23
Valley Grassland (215) 24
Montane Meadows (216) 25

Wetlands (217) 25

Northern Rocky Mountains Cover Types 27
Introduction 27
Bluebunch Wheatgrass - Blue Grama (301) 27
Bluebunch Wheatgrass - Sandberg Bluegrass (302) 27
Bluebunch Wheatgrass - Western Wheatgrass (303) 28
Idaho Fescue - Bluebunch Wheatgrass (304) 28
Idaho Fescue - Richardson Needlegrass (305) 29
Idaho Fescue - Slender Wheatgrass (306) 29
Idaho Fescue - Threadleaf Sedge (307) 30
Idaho Fescue - Tufted Hairgrass (308) 30
Idaho Fescue - Western Wheatgrass (309) 30
Needle-and-thread - Blue Grama (310) 31
Rough Fescue - Bluebunch Wheatgrass (311) 31
Rough Fescue - Idaho Fescue (312) 32
Tufted Hairgrass - Sedge (313) 32
Big Sagebrush - Bluebunch Wheatgrass (314) 32
Big Sagebrush - Idaho Fescue (315) 33
Big Sagebrush - Rough Fescue (316) 34
Bitterbrush - Bluebunch Wheatgrass (317) 34
Bitterbrush - Idaho Fescue (318) 35
Bitterbrush - Rough Fescue (319) 35
Black Sagebrush - Bluebunch Wheatgrass (320) 36
Black Sagebrush - Idaho Fescue (321) 37
Curlleaf Mountain-Mahogany - Bluebunch Wheatgrass (322) 37
Shrubby Cinquefoil - Rough Fescue (323) 38
Threetip Sagebrush - Idaho Fescue (324) 38

Great Basin Cover Types 40
Introduction 40
Sagebrush Types 40
Basin Big Sagebrush (401) 40
Mountain Big Sagebrush (402) 41
Wyoming Big Sagebrush (403) 42
Threetip Sagebrush (404) 43
Black Sagebrush (405) 44
Low Sagebrush (406) 45
Stiff Sagebrush (407) 46
Other Sagebrush Types (408) 47
Tall Forb (409) 48
Alpine Rangeland (410) 49
Aspen Woodland (411) 50
Juniper - Pinyon Woodland (412) 51
Gambel Oak (413) 51
Salt Desert Shrub (414) 53
Mountain - Mahogany Types 54

Curlleaf Mountain Mahogany (415) 54
True Mountain - Mahogany (416) 55
Littleleaf Mountain - Mahogany (417) 56
Mountain Brush Types 57
Bigtooth Maple (418) 57
Bittercherry (419) 58
Snowbush (420) 58
Chokecherry - Serviceberry - Rose (421) 59
Riparian (422) 59

Southwestern Cover Types 61
Introduction 61
Saltbush - Greasewood (501) 61
Grama - Galleta (502) 62
Arizona Chapparal (503) 62
Juniper - Pinyon Pine Woodland (504) 64
Grama - Tobosa Shrub (505) 65
Creosotebush - Bursage (506) 66
Palo Verde - Cactus (507) 66
Creosotebush - Tarbush (508) 67
Oak - Juniper Woodland and Mahogany - Oak (509) 68

Northern Great Plains Cover Types 69
Introduction 69
Bluestem Prairie (601) 69
Bluestem - Prairie Sandreed (602) 71
Prairie Sandreed - Needlegrass (603) 72
Bluestem - Grama Prairie (604) 73
Sandsage Prairie (605) 74
Wheatgrass - Bluestem - Needlegrass (606) 75
Wheatgrass - Needlegrass (607) 76
Wheatgrass - Grama - Needlegrass (608) 77
Wheatgrass - Grama (609) 78
Wheatgrass (610) 78
Blue Grama - Buffalograss (611) 79
Sagebrush - Grass (612) 80
Fescue Grassland (613) 81
Crested Wheatgrass (614) 82
Wheatgrass - Saltgrass - Grama (615) 83

Southern Great Plains Cover Types 85
Introduction 85
Grasslands 85
Alkali Sacaton - Tobosagrass (701) 85
Black Grama - Alkali Sacaton (702) .....
Black Grama - Sideoats Grama (703) 86
Blue Grama - Western Wheatgrass (704) 87

Blue Grama - Galleta (705) 87
Blue Grama - Sideoats Grama (706) 88
Blue Grama - Sideoats Grama - Black Grama (707) 88
Bluestem - Dropseed (708) 89
Bluestem - Grama (709) 89
Bluestem Prairie (710) 90
Bluestem - Sacahuista Prairie (711) 91
Galleta - Alkali Sacaton (712) 92
Grama - Muhly - Threeawn (713) 92
Grama - Bluestem (714) 93
Grama - Buffalograss (715) 93
Grama - Feathergrass (716) 94
Little Bluestem - Indiangrass - Texas Wintergrass (717) 95
Mesquite - Grama (718) 96
Mesquite - Liveoak - Seacoast Bluestem (719) 97
Sand Bluestem - Little Bluestem Dunes (720) 98
Sand Bluestem - Little Bluestem Plains (721) 98
Sand Sagebrush - Mixed Prairie (722) 99
Sea Oats (723) 100
Sideoats Grama - New Mexico Feathergrass - Winterfat (724) 100
Vine Mesquite - Alkali Sacaton (725) 101
Cordgrass (726) 101
Shrublands
Mesquite - Buffalograss (727) 102
Mesquite - Granjeno - Acacia (728) 104
Mesquite (729) 104
Sand Shinnery Oak (730) 106
Woodlands
Cross Timbers - Oklahoma (731) 106
Cross Timbers - Texas (Little Bluestem - Post Oak) (732) 107
Juniper - Oak (733) 108
Mesquite - Oak (734) 110
Sideoats Grama - Sumac - Juniper (735) 110

Southeastern Cover Types 111
Introduction 111
Savanna (801) 111
Missouri Prairie (802) 112
Missouri Glades (803) 112
Tall Fescue (804) 112
Riparian (805) 113
Gulf Coast Salt Marsh (806) 114
Gulf Coast Fresh Marsh (807) 114
Sand Pine Scrub (808) 115
Mixed Hardwood and Pine (809) 115
Longleaf Pine - Turkey Oak Hills (810) 116
South Florida Flatwoods (811) 117

North Florida Flatwoods (812) 117
Cutthroat Seeps (813) 118
Cabbage Palms Flatwoods (814)118
Upland Hardwood Hammocks (815) 119
Cabbage Palm Hammocks (816)120
Oak Hammocks (817) 120
Florida Salt Marsh (818)121
Freshwater Marsh and Ponds (819) 121
Everglades Flatwoods (820)122
Pitcher Plant Bogs (821) 122
Slough (822) 123

Alaska Cover Types 124
Introduction 124
Alder (901) 125
Alpine Herb (902) 126
Beach Wildrye - Mixed Forb (903) 127
Black Spruce - Lichen (904) 128
Bluejoint Reedgrass (905) 128
Broadleaf Forest (906) 129
Dryas (907) 130
Fescue (908) 131
Freshwater Marsh (909) 131
Hairgrass (910) 133
Lichen Tundra (911) 133
Low Scrub Shrub Birch - Ericaceous (912) 134
Low Scrub Swamp (913) 135
Mesic Sedge - Grass - Herb Meadow Tundra (914) 135
Mixed Herb - Herbaceous (915) 136
Sedge - Shrub Tundra (916) 136
Tall Shrub Swamp (917) 137
Tussock Tundra (918) 138
Wet Meadow Tundra (919) 138
White Spruce - Paper Birch (920) 139
Willow (921) 140

Literature Cited 142

Acknowledgements

The Society for Range Management (SRM) wishes to acknowledge the financial assistance of the Agricultural Research Service, Cooperative State Research Service, Extension Service and Forest Service, all of the U.S. Department of Agriculture, and the Bureau of Land Management of the U.S. Department of Interior. The Forest Service served as lead agency and Edward Schlatterer, Forest Service, served as liaison to the SRM. The encouragement and support of all the above made this project possible.

We also acknowledge the leadership of Barbara Allen-Diaz who chaired the Task Force that developed the criteria for cover type descriptions and the general framework for the process, the editorial and managerial ability of Thomas Shiflet who assembled the pieces, the diligent efforts of the regional coordinators (who are individually recognized following the preface) and the extensive knowledge and experience of the many SRM members who created the cover type descriptions.

Preface
Rangeland Cover Type Descriptions

The identification and description of rangeland cover types has long been an interest of the Society for Range Management. Prior to this effort, no major attempt was made to describe and catalog existing rangeland vegetation. Practically all rangeland classification systems presently in use are based on climax or potential vegetation and are used primarily to develop management strategies on individual operating units or allotments. The use of the nine Grazing Regions of the West and the 18 major grazing types developed by an interagency committee in 1936 has been abandoned as inadequate for meaningful inventory purposes. Federal legislation over the past two decades has intensified the need for standard cover type descriptions for the inventory of existing rangeland vegetation.

It is intended that this publication serve as a "companion" publication to the "Forest Cover Types of the United States and Canada (1980)", published by the Society of American Foresters (SAF). It is recognized that some overlap with the SAF forest types will occur since many existing vegetation types can be characterized as both forestland or rangeland. Also, a number of forest types produce understory vegetation that produce forage for grazing animals. The format of the rangeland cover type descriptions follow that of the forest cover types to a large degree.

The United States (exclusive of Hawaii) was initially divided into ten general geographic regions to facilitate the task and divide development responsibility. The Northeast Region was eventually dropped. These regions and geographic coverage are as follows:

Pacific Northwest - Washington and Oregon
Pacific Southwest - California (except the desert portion).
Northern Rocky Mountains - Rocky Mountain areas of Montana, and Idaho.
Great Basin - Intermountain areas of Nevada, Utah, Idaho, Oregon, and California.
Southwest - Trans-Pecos portion of Texas, New Mexico (except the Great Plains portion), Arizona, and the desert portion of California.
Northern Great Plains - Plains areas of Montana, Wyoming, Colorado; the states of North Dakota, South Dakota, Nebraska, Kansas; and, the prairie portion of Minnesota.
Southern Great Plains - Plains portions of New Mexico, Texas, and Oklahoma.
Southeast - East Texas, Louisiana, Mississippi, Alabama, Georgia, Florida, Arkansas, and Missouri.
Alaska - All of Alaska.
Northeast - All other states. This region was dropped when it was determined that only insignificant rangeland cover types occurred.

It is emphasized that these regions are very general and were delineated primarily for the purpose of dividing the project's labor. It is not intended that their boundaries become institutionalized in inventory activities.

The project got underway in 1987 when regional coordinators were recruited. These coordinators developed tentative lists of cover types and, in turn, recruited authors to develop selected cover type descriptions. The coordinator provided regional guidance to authors and coordinated with adjoining regions. All descriptions were reviewed within the region and most by neighboring regions. All descriptions were given national examination.

The release of rangeland cover type descriptions is especially timely with the current emphasis on ecosystem management and much of the focus at the landscape level. SRM endorses these cover types and plans to review and revise them as demanded by expanding scientific knowledge and to include Hawaii.

Regional Coordinators
Rangeland Cover Type Descriptions

The success of the project was due to the fine effort put forth by the regional coordinators. Their names and official affiliations are:

Pacific Northwest:
Charles G. Johnson
U.S.D.A. Forest Service
Baker City, Oregon

Pacific Southwest:
Barbara H. Allen-Diaz
University of California
Berkeley, California

Northern Rocky Mountains:
Carl L. Wambolt
and
John E. Taylor
Montana State University
Bozeman, Montana

Great Basin:
Al H. Winward
U.S.D.A. Forest Service
Ogden, Utah

Southwest:
Carlton H. Herbel
U.S.D.A. Agricultural Research Service
Las Cruces, New Mexico

Northern Great Plains:
Warren C. Whitman
and
William T. Barker
North Dakota State University
Fargo, North Dakota

Southern Great Plains:
Ronald E. Sosebee
Texas Tech University
Lubbock, Texas

Southeast:
David W. Sanders
U.S.D.A. Soil Conservation Service
Jackson, Mississippi

Alaska:
J. David Swanson
U.S.D.A. Soil Conservation Service
Anchorage, Alaska
and
Dorothy J. Helm
University of Alaska
Palmer, Alaska

Northeast:
Gerald Henke
U.S.D.A. Forest Service
Albuquerque, New Mexico

Project Manager:
Thomas N. Shiflet
Certified Range Management Consultant
Springfield, Missouri

Rangeland Cover Types of the United States

Thomas N. Shiflet, Editor

Rangeland vegetation may be aggregated into groupings or associations based on the plants that are present. These aggregations may approximate that of the original (climax) vegetation or display a multitude of variations due to past management and use. Some are relatively stable. Others are temporary occupants of disturbed areas and will gradually advance, through succession, to more stable situations and eventually to climax plant communities, if conditions are favorable. Included are pure stands of native or introduced species that have been reseeded on depleted rangelands and are being extensively managed.

Described here are the rangeland cover types of the United States (exclusive of Hawaii). The classification is based on existing vegetation. They describe what one finds on the ground and must deal with. The descriptions do recognize the ecological influences that contributed to their present structure and will continue to affect their development.

The type descriptions will be useful for making broad-scale inventories of rangelands and, in aggregating the inventory information, and to those who need to relate rangeland vegetation from one area to another. They should be of utility to range managers, other land managers, ecologists, wildlife scientists, teachers, and students.

Definition of Rangeland Cover Type

The "Glossary of Terms Used in Range Management (1989)", published by the Society for Range Management (SRM), includes two definitions that are applicable to this effort:

1. Cover Type - the existing vegetation of an area.
2. Vegetation Type - A kind of existing plant community with distinguishable characteristics described in terms of the present vegetation that dominates the aspect or physiognomy of an area.

The cover type descriptions in this publication embodies both definitions, with some restriction. The major restriction is that they are limited to rangeland vegetation, with the exception that some forest types may be included as discussed in the Preface. In addition, the descriptions are focused on the dominant plant species present and not the total plant community.

Criteria for Recognition of Types

Several criteria were established for distinguishing rangeland cover types. They are:

1. Each cover type will consist of present (existing) vegetation.
2. The type occupies a fairly large area in aggregate, but not necessarily in continuous stands. Many types occur sporadically and merge into others over short distances.
3. Recognition of a cover type must be based entirely on biological considerations.
4. Cover types must be mutually exclusive.

Cover Type Nomenclature

Rules for naming cover types call for each to be related to the dominant plant species with no more than three species per type (trinomial). Common plant names are used to identify the cover type, with scientific plant names used in the text of the description. However, authors were given considerable latitude in using "generic" names for types that are generally known and readily recognized. For example: Bluegrass scabland in the Pacific Northwest, Chamise Chaparral in the Pacific Southwest, Cross Timber in Oklahoma and Texas, Gulf Coast Salt Marsh in the Southeast, and others.

Plant Names

As stated above, common plant names are used to identify cover types, with scientific names used in the body of the type descriptions. Authors used regional flora for the selection of names. All were encouraged to utilize the latest botanical nomenclature for scientific names. The *National List of Scientific Plant Names* developed by the Smithsonian Institution (USDA - Soil Conservation Service, 1982) was used to resolve conflicts in scientific names. Where more than one valid scientific name was applied to the same common

name, the author's choice of nomenclature was left unchanged. Due to the vast geographical expanse covered and the huge number of individual plant species involved, no list of plant names was developed.

Numbering System

A numbering system was devised by designating blocks of 100's to each general region. These blocks were assigned from north to south for the conterminous 48 states, starting with the Pacific Northwest Region as 100, Pacific Southwest - 200, Northern Rocky Mountains - 300, Great Basin - 400, Southwest - 500, Northern Great Plains - 600, Southern Great Plains - 700, and Southeast - 800. The 900 block was assigned to Alaska.

Within each region, the cover types are numbered consecutively, e.g. for the Pacific Northwest - 101, 102, 103, etc.; for the Pacific Southwest - numbers run 201, 202, 203, etc. This system was applied throughout the nine regions.

Revisions of this work in the future may require that some cover types be deleted and new ones added. In this case, numbers of obsolete types will be deleted and new ones will be assigned new numbers within the block for that region (assuming that no region will ever have more than 99 types). This system will assure that any new type will be identified with its general geographic location.

Relation to Other Classification

Only minimal similarities exist between the rangeland cover types described here and other published classification systems. Kuchler (1964) compiled a map with accompanying manual outlining the *Potential Natural Vegetation of the Conterminous United States*. He briefly describes 116 potential natural plant communities (phytocenoces) based on "the vegetation that would exist today if man were removed from the scene and if resulting plant succession were telescoped into a single moment". Many of these plant communities would be classified as rangeland. Some of the cover types included here may bear some resemblance to those of Kuchler, but most do not since they are, for the most part, the result of human influence since the mid-1800's. If plant succession were allowed to take place unimpeded, in time the vegetation of these types should approximate those communities described by Kuchler.

Some relationship may be recognizable between the types included here and some of the ecoregions described by Bailey (1978). However, his treatment is much broader and is a regionalization which divides the land surface into regions defined by various factors and does not detail existing plant communities. Most other large scale classification systems that include rangelands emphasize potential (or climax) vegetation, rather than what is present at this time.

Numerous authors have published general descriptions of existing vegetation for specific locales. Some recent ones include Tueller (1989) for Nevada and Barker and Whitman (1989) for the Northern Great Plains. These works are expanded and refined in this publication. For the most part, the cover type descriptions present here represent an original attempt to document the existing rangeland vegetation.

Arrangement of Cover Type Descriptions

The type descriptions are presented by the general geographic regions described earlier.

It is, again, emphasized that these regions are very general and not intended to set firm boundaries.

Rangeland Cover Types of the Pacific Northwest

INTRODUCTION SRM 100

The Pacific Northwest Region constitutes the area north of the Great Basin of Nevada, west of the Rocky Mountains in Idaho, and south of the Okanogan Highlands and Cascade Mountains separating Canada and the United States. Topographically the rangelands pertaining to this region are located east of the Cascadian crest and west of the Rockies on the central and eastern portions of Washington and Oregon. Major physiographic provinces included in this region are: the Okanogan Highlands and Columbia Basin in the state of Washington: and the Basin and Range, High Lava Plains, and Blue Mountains of central and eastern Oregon.

In general these physiographic provinces occur in areas of low precipitation. The Cascade Mountains form a formidable north-south trending barrier which entraps the easterly moving maritime storms before passage of moisture eastward into the intermountain area where the primary rangelands are located. Storm tracks which pass to the north, providing British Columbia with ample moisture, usually pass on into the northern Rockies and Great Plains with little effective moisture for the Pacific Northwest. Wintertime precipitation in the most important to the region where snows provide the basis for crucial early and mid summer moisture requires by the plants. Summertime high intensity storms in late summer, and early autumn rains, provide the balance of the limited moisture the inland Pacific Northwest Region receives.

Annual precipitation ranges from lows of 7 to 8 inches (17.5-20cm) in the driest portions of the Basin and Columbia Basin provinces, to highs of up to 65 inches (163cm) in the subalpine of the Wallowa Mountains in northeastern Oregon. Most of the grasslands and shrublands of the region receive less than 20 inches (50cm) of precipitation a year. Temperatures are extreme with hot, dry summer months averaging 60°-70° F (15°-20° C) in the Basin and Range province while cold, dry winter months prevail from the continental climate. Average January temperatures may be as low as 15°-20° F. (-10° to -7° C) in the High Lava Plains.

The native flora is therefore well adapted to the warm, dry summer drought period and can not tolerate the cold, dry winter extremes as well. Sagebrush (*Artemisia*), juniper (*Juniperus*), and bitterbrush (*Purshia*) shrublands are well adapted for these extreme environmental conditions. Grasslands adapted to these warm, dry growing conditions are dominated by Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Agropyron spicatum*). Ponderosa pine (*Pinus ponderosa*) provides a savanna over grassland and shrubland communities at the drier limits of forest growth. Then at the upper limits of forests in the Region, green fescue (*Festuca viridula*) forms lush grasslands above 6000 ft.(2000m) in elevation where precipitation amounts often exceed 35 inches (88 cm) annually. A diverse vegetation occupies the grasslands and shrublands of the Pacific Northwest reflecting the ability of plants to persist in environments with climatic extremes and the principal modifying agents - fire, grazing, and browsing.

Charles G. Johnson Jr.
US Forest Service
Baker City, Oregon

BLUEBUNCH WHEATGRASS SRM 101

Definition, Composition, and Structure: The vegetation is characterized by the dominance of Bluebunch wheatgrass (*Agropyron spicatum*), a variable component of perennial forbs and virtually no shrubs. Bluebunch wheatgrass is the most abundant grass, with Sandberg bluegrass (*Poa secunda*) as a lesser but almost constant associate. No other perennial grass occurs commonly throughout the type, but several species are common or even dominant in certain areas. These include sand dropseed (*Sporobolus cryptandrus*) and red three-threeawn (*Aristida longiseta*) on highly xeric sites in the Snake and Columbia river drainages; and needle-and-thread (*Stipa comata*), and prairie junegrass (*Koeleria pyramidata*) in the Montana and British Columbia sections. Common and an introduced species, cheatgrass (*Bromus tectorum*). The perennial forb layer contains a large number of species, few of which are common throughout. Many genera are represented by different species in the various geographical regions included in this cover type. The most common forbs are yarrow (*Achillea millefolium var. lanulosa*), milk vetch (*Astragalus inflexus* and spp.), balsamroot (*Balsamorhiza* annuals include fescues (*Festuca megalura* and *F. octoflora*) *sagittata* and *B. careyana*), fleabane (*Erigeron pumilis* and spp.), biscuitroot (*Lomatium macrocarpum* and spp.), lupine (*Lupinus sericeus* and spp.), phlox (*Phlox longifolia, P. hoodii* and spp.) and salsify (*Tragopogon dubius* and *T. pratensis*), an introduced species. Annual forbs common in this type include spring whitlowwort (*Draba verna*), Indian wheat (*Plantago patagonica*) and

shining chickweed (*Stellaria nitens*). The only shrub occurring with appreciable frequency is rubber rabbitbrush (*Chrysothamnus nauseosus*), and it is a negligible part of the total plant cover. The structure of this type is one of relatively open stands of bluebunch wheatgrass, interspersed with the much smaller clumps of Sandberg bluegrass and a variable amount of forbs. Grasses (mainly the wheatgrass) compose 80 to 90% of the total production, with forbs contributing almost all of the remainder. The forb component is lowest on the most xeric sites and highest on the most productive. Average annual production ranges from 400 to 1200 pounds (445-1335 kg/ha) per year, depending on site quality. Average ground cover is approximately 20% cryptogams, 40% litter, 30% rock or gravel and 10% bare ground.

Geographic Distribution: This type occurs throughout the Pacific Northwest, in northeastern Oregon, eastern Washington, west-central Idaho, western Montana and southern interior British Columbia.

Ecological Relationships: This community occupies the drier portion of the Pacific Northwest bunchgrass region, with a range in mean precipitation from 8 to 20 inches (20 - 50cm). A high proportion (45-60%) falls during the winter months, and the late summer period is normally very dry. The climate favors fall germination of many species, and rapid growth during April through June. Most species become dormant by the end of this period. The principal contacts of this type are with the fescue grassland which occupies a moister section of the bunchgrass region, and with several kinds of sagebrush steppe. The latter types share many herbaceous species with the grassland community. The factors which prevent sagebrush species from occupying the grasslands are not well understood, but appear to be highly effective.

Seral Relationships: This type is suitable for spring, fall and winter use, but is highly sensitive to heavy grazing. The reaction to overuse is a rapid reduction in bluebunch wheatgrass and the more palatable forbs, and replacement mainly by introduced species. Many of the latter are annuals, including cheatgrass, rattlesnake brome (*Bromus brizaeformis*), Japanese brome (*B. japonicus*), and a more recent invader, medusahead (*Taniatherum asperum*). Exotic forb invaders include several species of knapweed (*Centaurea* spp.), salsify, cranesbill (*Erodium cicutarium*) and prickly lettuce (*Lectuca serriola*). Competition from these invaders, especially winter annuals such as cheatgrass makes recovery of depleted stands very difficult. Currently, large areas of the bluebunch wheatgrass type are dominated by these invaders and show little sign of responding to improved grazing management. Reseeding to desirable forage species is an alternative in areas of gentle topography, but less feasible in areas of stony soils or rough topography in which much of this grassland occurs. Fire is less important than grazing as a disturbing element in this type. Bluebunch wheatgrass and most of the other common species are fairly tolerant of fire. Damage can occur, however, from fires under very hot, dry conditions. Areas dominated by cheatgrass are highly flammable and present a continuing fire hazard.

Variants and Associated Species: This is a variable type, with noticeable regional differences. The portions in Oregon, Washington and Idaho are relatively uniform, although the canyon grasslands of the Snake and Salmon River drainages show distinctive community features. Stands in which sand dropseed and/or red three-threeawn are common or dominant occupy limited areas in the canyon region. Some of these stands, on xeric sites, may be climax, but lack of undisturbed sites makes this difficult to verify. On other sites these two species are seral, increasing under grazing regimes which are harmful to bluebunch wheatgrass. The most marked variants are in the Montana section, which borders on the Great Plains. Here the common grasses include not only needle-and-thread and prairie junegrass, but also western wheatgrass (*Agropyron smithii*) and bluegrama (*Bouteloua gracilis*). For further information see Daubenmire, 1970; Johnson and Simon, 1987; Mclean and Marchand, 1968; Mueggler and Stewart, 1980; Tisdale, 1947; and Tisdale, 1986.

Edwin W. Tisdale
University of Idaho
Moscow, ID

IDAHO FESCUE
SRM 102

Definition, Composition, and Structure: This type is characterized by the constant presence and usually the dominance of Idaho fescue (*Festuca idahoensis*), associated with a well developed component of perennial forbs. Idaho fescue is the principal grass, but bluebunch wheatgrass (*Agropyron spicatum*) is common and often co-dominant. Other perennial grasses common throughout include Sandberg bluegrass (*Poa secunda*) and prairie junegrass (*Koeleria pyramidata*). Additional perennial graminoids, including slender wheatgrass (*Agropyron caninum*), sedges (*Carex petasata* and *C. stenophylla*), intermediate oatgrass (*Danthonia intermedia*), western needlegrass (*Stipa occidentalis*) and Richardson needlegrass (*Stipa richardsonii*) are common in parts of the Montana section. Sedges (*Carex hoodii* and spp.), intermediate oatgrass and western needlegrass, mountain brome (*Bromus carinatus*) and Wheelers bluegrass (*Poa nervosa*) are also common in a high elevation community in Idaho and Oregon which is considered a variant of the Idaho fescue cover type. The perennial forb component shows considerable diversity within the type. Common throughout are yarrow (*Achillea millefolium var. lanulosa*), balsamroot (*Balsamorhiza sagittata*), bessaya (*Bessaya rubra* and *B. wyomingensis*),

prairie smoke aven (*Geum triflorum*), lupine (*Lupinus sericeus* and *L. laxiflorus*), cinquefoil (*Potentilla gracilis* and spp.), phlox (*Phlox longifolia* and *P. hoodii*) and salsify (*Tragopogon dubius*), an introduced species. Forbs common in the main portion of the type but lacking or uncommon in Montana include wild hyacinth (*Brodiaea douglasii*), Indian paintbrush (*Castilleja hispida* and spp.), western hawkweed (*Hieracium albertinum*), and fringecup (*Lithophragma parviflora* and *L. bulbifera*). Species common only in Montana include rosy pussytoes (*Antennaria microphylla*), capitate sandwort (*Arenaria congesta*), and pale agoseris (*Agoseris glauca*). Common annuals include rattlesnake brome (*Bromus brizaeformis*), Japanese brome (*B. japonicus*) and cheatgrass (*B. tectorum*), and forbs such as spring whitlow wort (*Draba verna*), and shining chickweed (*Stellaria nitens*). Shrubs are rare in the type as a whole but common snowberry (*Symphoricarpos albus*) and rose (*Rosa nutkana* and *R. woodsii*) are common in a few communities.

Foliage cover averages about 60% greater in this type than in the bluebunch wheatgrass cover type, and the more mesic stands present a sod-like appearance, sometimes referred to as meadow steppe. Most of the bluebunch wheatgrass plants in this type are rhizomatous, producing loose clumps. A major structural feature is the high proportion of perennial forbs, many of them growing as tall as the principal grasses. The proportion of grasses to forbs varies greatly within the type. On the basis of weight, forbs contribute from 35 to 65% of total production, which ranges from 600 to 2500 pounds per acre (666-2775 kg/ha). Shrub production is negligible in most of the type. Ground cover consists mainly of litter and cryptogams, with generally no more than 5% bare ground.

Geographic Distribution: This type extends throughout most of the Pacific northwest bunchgrass region, namely eastern Oregon and Washington, west-central Idaho and western Montana. In British Columbia, however, it is restricted to the southern portion of the bunchgrass region, and is replaced farther north by the rough fescue (*Festuca scabrella*) type.

Ecological Relationships: This type occupies the more mesic portions of the bunchgrass region. Annual precipitation ranges from 14 to 22 inches (35-55cm) or more, and elevation from 1200 to 7500 feet (400-2500m). Most of the type occurs above 2500 feet (830m), however, and it is generally confined to north slopes at lower elevations. Soils vary widely in depth, texture and stoniness and their total moisture capacity is critical in this region where winter precipitation amounts to 45 to 65 percent of the annual total. The wide range in effective moisture within the type is reflected in variation in ratio of forbs to grasses, and in total production. A distinctive feature of the type is the frequency of fall regrowth of the perennial grasses and some forbs. This type contacts a variety of communities, including conifer forests, mesic sagebrush communities, and, at its drier margin, the bluebunch wheatgrass cover type. The borders with forest and sagebrush are usually well defined, but transition to the bluebunch wheatgrass type is often gradual. The presence of an appreciable amount (over 10% by weight) of Idaho fescue is a reasonable demarcation index; but sizable areas thus defined will be higher in proportion of grasses, and lower in forbs than the bulk of the type.

Seral relationships: The type is well suited for late spring, summer and fall grazing use. Reaction of this type to heavy grazing consists initially in a marked reduction in amount of the two principal grasses, Idaho fescue and bluebunch wheatgrass. Some native forbs including yarrow, chickweed, balsamroot and lupine and hood's phlox may initially increase, but eventually invader species including Kentucky bluegrass (*Poa pratensis*) and the annuals become dominant.

Cheatgrass is a major invader in the drier parts of the type, but in more mesic areas rattlesnake and Japanese brome are the major invading annuals. Fire is generally a much less important factor than grazing, but becomes an increasing hazard on depleted stands dominated by annuals. Most of the native species including bluebunch wheatgrass are fire tolerant. Idaho fescue is somewhat more susceptible, especially to fire during the summer period, but mortality is usually low and recovery occurs in a few years at most. A much more destructive factor has been cultivation, which has destroyed most portions of the type which occur on arable soils and reasonably gentle topography.

Variants and Associated Species: The wide range of environments encompassed by this type results in much variability in species composition, proportion of grasses to forbs, and total production. One of the most striking variants is the Idaho fescue/common snowberry association of southeastern Washington and adjacent Idaho and Oregon in which shrubs (snowberry and rose) are common.

References include Daubenmire, 1970; Johnson and Simon, 1987; Mclean and March and, 1968; Mueggler and Stewart, 1980; Tisdale, 1947; and Tisdale, 1986.

Edwin W. Tisdale
University of Idaho
Moscow, ID

GREEN FESCUE
SRM 103

Definition, Composition, and Structure: Green fescue (*Festuca viridula*) plant communities are found in subalpine fir and whitebark pine zones occurring in parks, on open slopes and ridgetops, and as part of a savanna beneath open-growing trees. These grasslands occur above 6,000 feet (2000m) elevation on relatively dry sites within a high precipitation zone (over 35 inches (88cm) ppt/yr) that have been created by excessive wind transfer of winter snows, exposing these slopes to desiccation. Soils are deep with fine textures capable of high water-holding capacity to help compensate for wind desiccation and promote fescues on open slopes where exposure is high. Green fescue sites are often droughty in late summer when intense storms provide highly erosive winds with torrential rains capable of causing severe sheet and gully erosion.

Late seral stands are characterized by green fescue in dense mats with few breaks in a continuous sod. Western needlegrass (*Stipa occidentalis*), penstemons, lupines (*Lupinus* spp.), sedges (*Carex* spp.), and yarrow (*Achillea lanulosa*) are frequently associated.

Geographic Distribution: Green fescue communities occur in southern British Columbia and Alberta, the northern Rockies of western Montana and Idaho, along the Cascadian crest in Oregon and Washington, in the Sierras from Mount Lassen to Yosemite, and in the Wallowa and Northern Blue Mountains of northeastern Oregon.

Ecological Relationships: Late seral green fescue grasslands exhibit a nearly forb-free continuous sod mat. Effects of overgrazing result in exposure of bare ground which is then removed by accelerated surface wind and water erosion. Deteriorated green fescue communities are characterized by hummocks and deflation depressions containing an erosion pavement. Increasing with sod mat breakdown are lupines, asters, yarrow, buckwheats, and penstemons. Pioneering on depressions between hummocks are phlox, pussytoes, spraguea, knotweeds, and coneflower. Alpine fleeceflower (*Polygonum phytoeaccaefolium*) and Nuttall's linanthastrum (*Linantha-strum nuttallii*) are prominent invading species in northeastern Oregon. Plant communities occurring adjacent to green fescue grasslands may be dominated by whitebark pine, subalpine fir, Engelmann spruce, or lodgepole pine forested vegetation. Mountain big sagebrush communities are also commonly adjacent to green fescue dominated sites where soils are deep and/or underlying rock is fissured permitting shrub root penetration to greater depths.

The role of fire in establishing or perpetuating green fescues communities is not well understood. Fire has apparently played a role in the fescue balds found in the northern Cascades.

Reference include Daubenmire and Daubenmire, 1968; Franklin and Dyrness, 1973; Johnson and Simon, 1987; Reid, 1942; and Weaver, 1979.

Charles G. Johnson, Jr.
US Forest Service
Baker City, OR

ANTELOPE BITTERBRUSH-BLUEBUNCH WHEATGRASS
SRM 104

Definition, Composition, and Structure: Antelope bitterbrush (*Purshia tridentata*) and bluebunch wheatgrass (*Agropyron spicatum*) comprise the dominant species of this association. The antelope bitterbrush is of the columnar form, moderate to tall in stature, and ranging in height from 2.5 to 6 (1-2 m) feet. It grows in somewhat open stands averaging 5 to 20% cover. Other shrub associates are uncommon, but where present may include gray rabbitbrush (*Chrysothamnus nauseosus*), green rabbitbrush (*Chrysothamnus viscidiflorus*), and the big sagebrush subspecies, "foothill" (*Artemisia tridentata* ssp. *'xericensis'*) and basin (*A. tridentata* ssp. *tridentata*). Grass associates are Sandberg's bluegrass (*Poa sandbergii*) and prairie Junegrass (*Koeleria pyramidata*) with cheatgrass (*Bromus tectorum*) generally present. The most conspicuous and wide-spread forb in the association is arrowleaf balsamroot (*Balsamorhiza sagittata*); other perennial forbs consist of western yarrow (*Achillea millefolium*), lupine (*Lupinus* sp.), milkvetch (*Astragalus* sp.), and nine-leaf lomatium (*Lomatium triternatum*).

Geographic Distribution: While bitterbrush occurs over 340 mllion acres (136 million ha) in the 11 western states, this association is found locally from southern Washington through eastern Oregon, western and southern Idaho, and into portions of Utah, Nevada, Montana, and Colorado. Stands have been described on rather extensive areas in the foothills of the Bitterroot Valley, Montana, as a xerophytic inclusion along the eastern base of the Cascade mountains, in the transition area with Palouse grasslands in Idaho, along the southern flank of the Wallowa Mountains in Oregon, and also in Oregon in the southern Blue and Ochoco Mountains. It generally occurs in scattered, discrete localities, primarily from 10 to several hundred acres in size.

Ecological Relationships: The association is found primarily on rolling hills to steep slopes on south, east and west-facing aspects. Elevations of occurrence range from 1800' (600m) in Oregon to 5500' (1830m) in Montana. Soils may be basaltic, sedimentary, or granitic in origin, but are uniformly shallow (less than 10 to 20 inches) and overlie weathered or fractured bedrock. Stony to rocky loams predominate, tending toward either clay or sandy textures. Climate is semiarid with precipitation ranging from 10 to 15 inches annually. Winters are typically cool and moist, with

precipitation falling in the form of snow; summers are hot and dry.

The association occurs as a specialized xeric community, occupying rocky rims often at mid to upper slopes positions, although it has been observed on ridge brows and lower slopes. The association occupies sites where conditions are too dry and hot to include Idaho fescue (*Festuca idahoensis*), and so provides a transition between the lower elevation sagebrush/grassland communities and higher elevation communities characterized by a fescue component. Because bitterbrush has a strong taproot system, fractured bedrock provides a suitable situation for it to take advantage of deeply stored water without being severely limited by the more shallow soils. The nitrogen-fixing capabilities of bitterbrush give it an advantage in less fertile sites. The association is highly productive, providing both herbaceous and woody forage for wild ungulates as well as domestic livestock. It is considered highly valuable as big game winter range. If used heavily and repeatedly, both the shrub and grasses will decline in vigor, and cheatgrass will quickly increase.

For further reference see Alderfer, 1977; Daubenmire, 1970; Guinta et al, 1978; Hall, 1973; Hironaka et al, 1983; Johnson and Simon, 1987; Mueggler and Stewart, 1980; Nord, 1965; and Tew, 1983.

Jean Findley
Bureau of Land Management
Vale, OR

ANTELOPE BITTERBRUSH-IDAHO FESCUE SRM 105

Definition, Composition, and Structure: Antelope bitterbrush (*Purshia tridentata*), and Idaho fescue (*Festuca idahoensis)* comprise the dominant species of this association, with bluebunch wheatgrass (*Agropyron spicatum*) often included as a major component. Although considered a shrub steppe physiognomically, with the moderately-sized columnar bitterbrush generally reaching 2.5 to 4.5 feet (.9-1.5m) in height, acopious herbaceous component in certain geographical regions lends the association the description of "meadow steppe". Other shrubs are uncommon in the association, with rubber rabbitbrush (*Chrysothamnus nauseosus*) and mountain big sagebrush (*Artemisia tridentata* spp. *vaseyana*) occurring infrequently. Grass species include Sandberg's bluegrass (*Poa sandbergii*), prairie Junegrass (*Koeleria pyramidata*), needlegrass (*Stipa* sp.), and bottlebrush squirreltail (*Sitanion hystrix*). The forb component includes arrowleaf balsamroot (*Balsamorhiza sagittata*), western yarrow (*Achillea millifolium*), and at least one species of buckwheat, either sulfur buckwheat (*Eriogonum umbellatum*) or Wyeth's buckwheat (*E. heracleoides*). Where forbs occur with greater abundance, low pussytoes (*Antennaria rosea*), fleabane (*Eriogeron* sp.), wooly-pod milkvetch (*Astagalus purshii*), Hood's phlox (*Phlox hoodii*), lupine (*Lupinus* sp.), and rockcress (*Arabis* sp.) are found in the association.

Geographic Distribution: This association is found in local settings from 10 to several hundred acres (4 to several hundred ha), and is extensive in occurrence, particularly along the eastern slopes of the Cascade Mountains in both Oregon and Washington, in the Blue, Ochoco and Wallowa Mountains of Oregon, and in portions of Idaho, Utah, and Colorado. It reaches its eastern range in Montana in scant stands south of 47° latitude west of the continental divide. It extends to the Canadian border in Washington and can be found in Northern California.

Ecological Relationships: The association is represented in all slopes, including both rolling and very steep, and all aspects within its range. Elevations of occurrence range from 1200' in Washington to over 5800' (400-1930m) in Oregon. Soils may be granitic, basaltic, or sedimentary in origin, and the association has been reported on deep loess in southern Washington. Soil depths also vary considerably, with depths of 10 to 30 (25-75cm) or more inches in surface layers. Rock/fragment content also varies from very little to as much as 35% rock fragments by volume. Surface textures vary from sandy clay loams to sandy clays. Climate is semi-arid, with cool, moist winters and hot, dry summers.

The association represents a topographic climax in the big sagebrush/bunchgrass zone where it occurs on the drier, south-facing slopes, and as an edaphic climax alternating with ponderosa pine (*Pinus ponderosa*)/bitterbrush communities in the eastern Cascade foothills. It is representative of conditions where moisture is retained longer into the summer drought season and where soils are of a texture that also retain moisture longer into the summer, subsequently creating a more favorable environment for establishment of Idaho fescue.

The bitterbrush in this association is nonsprouting following wildfires. Because the association is highly productive both in volume and in dietary value of species for wild ungulates and domestic livestock, fire may reduce its value by eliminating the bitterbrush. Bitterbrush is an important source of both summer and winter browse for deer and elk, and heavy and repeated use of the association may result in declines of both bitterbrush and bunchgrasses.

References include Alderfer, 1977; Daubenmire, 1970; Dealy, 1971; Franklin and Dryness, 1973; Guinta et al, 1978; Hall, 1973; Hironaka et al, 1983; Johnson and Simon, 1987; Mueggler and Stewart, 1980; Nord, 1965; and Tew, 1983.

Jean Findley
Bureau of Land Management
Vale, OR

BLUEGRASS SCABLAND SRM 106

Definition, Composition, and Structure: The dominant feature of bluegrass scablands is a thin, rocky soil of less than 10 inches (25cm) in depth overlying a non-fractured basalt on gentle to flat slopes. The vegetation is characterized by co-dominance of Sandberg's bluegrass (*Poa sandbergii*) and one spike oatgrass (*Danthonia unispicata*). The grasses are typically oriented in a mosaic pattern with mosses, surface rock, and erosion pavement. Principal scabland forbs associated are bighead clover (*Trifolium marcocephalum*), bisquitroots (*Lomatium leptocarpum, L. cous*), stonecrops (*Sedum lanceolatum, S. stenopetulum*), serrated balsamroots (*Balsamorhiza incana, B. serrata*), and onions (*Allium tolmiei, A. fibrillum*).

Geographic Distribution: Scablands dominated by the scabland bunchgrasses are found principally on the intermountain plateau and ridges derived from Columbia River basaltic flows east of the Cascade Mountains and west of the Rocky Mountains in the Pacific Northwest. Elevations range from 4,000 to 6,000 feet (1330-2000m) on gentle slopes (less than 10%). Similar vegetation has been described on central Oregon pumice-derived substrates. A grouping of bluegrass dominated associations occurs on the east side of the Cascades in Washington where onespike oatgrass is replaced by dwarf squirreltail (*Sitanion hystrix var. hordeoides*).

Ecological Relationships: The association occurs on harsh sites where the thin soil mantle is saturated in the spring from melting snow and rainfall perched on the impervious basalt. Summer drought induced by high temperatures desiccates the scabland vegetation and severely limits those plants capable of surviving in the limited environment. As animals degrade the community, the protective plant rock-moss matrix is broken by loosening surface rock, exposing more bare ground and causing a decline in principal grasses due to frost heaving or soil moisture loss. The deterioration of the later seral vegetation permits aggressive increases by one or more of the following species which characterize earlier successional stages: balsamroots, pussytoes, lomatiums, stonecrops, and onions. Very early seral stages may be dominated by annual knotweeds (*Polygonum douglasii*), gumweeds (*Grindelia* spp.), and tarweeds (*Madia* spp.). Annual bromes are minor components due to the volatility of disturbed sites from soil saturation and frost heaving.

Peripheral to bluegrass scabland communities are grassland and shrubland communities characterized by either deeper soils (i.e., Idaho fescue/prairie junegrass) or fractured underlying basalt enabling plants to tap deeper moisture (i.e., stiff sagebrush/Sandberg's bluegrass, bluebunch wheatgrass-Sandberg's bluegrass).

For reference see Daubenmire, 1970; Hall, 1973; Johnson, 1982; Johnson and Simon, 1987; Tart et al, 1987; Volland, 1976; and Winward and Youtie, 1978.

Charles G. Johnson, Jr.
US Forest Service
Baker City, OR

WESTERN JUNIPER/BIG SAGEBRUSH/BLUEBUNCH WHEATGRASS SRM 107

Definition, Composition, and Structure: Western juniper (*Juniperus occidentalis*), big sagebrush (*Artemisia tridentata*) and bluebunch wheatgrass (*Agropyron spicatum*) comprise the dominant species of this association. Western juniper is a tree of medium stature, with maximum height of 35 ft. (12m) and 70 inches (175cm) d.b.h. In the north central portion of its range where western juniperis the single tree species overstory, common shrub associates are gray rabbitbrush (*Chrysothamnus nauseosus*), green rabbitbrush (*C. viscidiflorus*), antelope bitterbrush (*Purshia tridentata*), stiff sagebrush (*A. rigida*), low sagebrush (*A. arbuscula*), wax currant (*Ribes cereum*), and gray horsebrush (*Tetradymia canescens*). Common grass associates are Idaho fescue (*Festuca idahoensis*), cheatgrass (*Bromus tectorum*), prairie junegrass (*Koeleria pyramidata*), Sandberg bluegrass (*Poa sandbergii*), bottlebrush squirreltail (*Sitanion hystrix*), and Thurber needlegrass (*Stipa thurberiana*). Forb species include western yarrow (*Achillea millefolium*), milkvetch (*Astragalus* sp.), arrowleaf balsamroot (*Balsamorhiza sagittata*), lineleaf fleabane (*Erigeron linearis*), wooly eriophyllum (*Eriophyllum lanatum*), lupine (*Lupinus* sp.), strict buckwheat (*Eriogonum strictum*), sulphur buckwheat (*E. umbellatum*), broom buckwheat (*E. vimineum*), and Douglas phlox (*Phlox douglasii*).

Geographic Distribution: Western juniper is found from southern California (34° degrees N. latitude) to southeastern Washington (46° degrees, 37 minutes N. latitude) and from central Oregon (122.5° degrees W. longitude) into eastern Idaho (117° degrees W. longitude) and northwest Nevada. The largest contiguous area is found in central Oregon, extending in a band from the southern to northern Oregon borders and northeasterly to the Idaho border. In other parts of its range, it occurs as scattered, discrete stands varying in size from a few miles to about 100 miles (160km) in extent. Two subspecies of (*J. occidentalis*) have been recognized - occidentalis from Lassen county, California, northward, and autralis in the southern portion of the range.

Ecological Relationships: The association is found on all exposures and topography in the north central portion of its range. It occurs at elevations from 600 ft (200m) along the Columbia River to more than 10,000 ft (3330m) in the Sierra Nevada Mountains. Elevation range in central Oregon is from 2200 ft to about 5000 ft (700m to 1665m).

Western juniper grows in association with ponderosa pine (*Pinus ponderosa*) and mixed conifer dominated by Douglas-fir (*Pseudotsuga menziesii*) at the lower elevations of those forest types. In central Oregon, occasional ponderosa pine trees are found in the dense stands of western juniper. There appears to be two distinct age groups of western juniper in central Oregon - old growth stands with numerous trees in excess of 150 yr. of age and stands that have developed within the last 100 yr. Maximum age of trees is in excess of 400 yr.

Climate of the major portion of western juniper occupancy in central Oregon is semiarid, characterized by dry, hot summers and cold winters. Most (70% +) of the 9 to 14 in (23-35cm). MAP occurs as late fall and spring rain and as snow. Average temperatures in January and July are 31° F (0° C) and 65° F (18° C), respectively. Soils are typically Mollisols although Argixerolls, Haploxerolls and Haplaquolls are common great soil groups. In areas dominated by soils developed from Mazama ash and pumice, soils are young (<6700 yr) and are poorly developed with little horizon differentiation.

Western juniper is uniquely adapted to survive and compete in this semi-arid region. It has a taproot and a spreading lateral root system at a depth of 8 to 12 inches (20-30cm). Western juniper appears to be in a period of expansion. Locally, this is thought to be a result of fire exclusion and overgrazing that has reduced plant competition. However, there is evidence from paleo ecology studies that the range of western juniper expands and contracts in response to long term climatic cycles involving several thousand years. There is also evidence in the central Oregon area that establishment occurs in the area beneath shrubs as big sagebrush. References include Adams, 1975; Dealy et al, 1977; Driscoll, 1964; Eddleman, 1987; Hall, 1973; Hall, 1977; Johnson and Simon, 1987; Little, 1971; Mehringer, 1987; Quinsey, 1984; Vasek, 1966; and Volland, 1982.

Arthur R. Tiedemann
US Forest Service
La Grande, OR

ALPINE IDAHO FESCUE SRM 108

Idaho fescue (*Festuca idahoensis*) communities range from elevations below 1000 feet (330m) in canyonlands of the Pacific Northwest to alpine summits approaching 10,000 feet (3330m). The alpine Idaho fescue cover type encompasses those plant associations occurring above 6000 feet (2000m) in the Blue, Ochoco, and Wallowa Mountains of central and eastern Oregon. Often associated with the fescue are various sedges, rhizomatous bluebunch wheatgrass, and various forbs capable of persisting on cold, dry habitats. These communities occur on windswept openings, knobs and ridgetops where the summer growing season is short and drought is prevalent in the late summer.

Past overgrazing by domestic sheep has resulted in retrogression to early seral vegetation as a result of trampling, uprooting of plants, and utilization prior to flowering and seedset of the grasses and sedges. Sedges tend to increase when the more preferred fescue is overutilized. As degeneration of the climax community increases, the perennial sedgegrass composition is reduced with dominance by forbs characteristically resulting (i.e., lupines, asters, penstemons, buckwheats). Some alpine Idaho fescue rangelands have been degraded to communities dominated by tarweed (*Madia* spp.), needlegrasses (*Stipa* spp.), or phlox species.

Alpine Idaho fescue communities provide valuable forage at high elevations for bighorn sheep, mountain goat, and domestic sheep. The plant-soil relationship is extremely sensitive to trampling and over utilization. Domestic cattle are usually injurious to these communities.

For Further information see Hall, 1973 and Johnson and Clausnitzer, 1991.

Charles G. Johnson, Jr.
US Forest Service
Baker City, OR

PONDEROSA PINE SHRUBLANDS AND GRASSLANDS

Ponderosa pine is widely distributed as a seral tree species in the coniferous forests of the Pacific Northwest. At the lower limits of tree growth it can tolerate hot, dry growing conditions and withstand summer drought to form a climax forest. These forests are open growing with low canopy coverages; often forming a savannah with shrub-dominated communities or grass-dominated communities. The composition and structure of climax ponderosa pine communities has been influenced by the periodicity of naturally occurring wildfire. Fire reduces litter accumulation, promotes the regeneration of pine, and stimulates shrubs and grasses to renewed vigor and vitality.

Two cover types are discussed for the Pacific Northwest Region based on composition of understory vegetation associated with climax ponderosa pine. These two cover types are important to the grazing and browsing ungulate, as well as other wildlife species which use these communities for food, cover, and habitation.

Charles G. Johnson, Jr.
US Forest Service
Baker City, OR

PONDEROSA PINE SHRUBLAND SRM 109

Definition, Composition, and Structure: The ponderosa pine shrublands of the Pacific Northwest vary from tall statured shrub composition on mesic sites to low statured shrub composition on hot, dry sites. Plant associations have been classified with a continuous shrub layer beneath the scattered pines (i.e., ponderosa pine/mallow ninebark, ponderosa pine/common snowberry) as well as a more typical mosaic of shrub patches with sedge or grass dominated patches (i.e., ponderosa pine/antelope bitterbrush/Idaho fescue).

Geographic Distribution: In northern Washington state the most mesic ponderosa pine climax stands occur with common snowberry (*Symphoricarpos albus*). Bitterbrush (*Purshia tridentata*) is associated with the pine as a common forest fringe community on drier exposures. In central Oregon the most common shrubs associated with ponderosa pine are bitterbrush-dominated. Usually occurring with the bitterbrush are bunchgrasses - Idaho fescue (*Festuca idahoensis*), bluebunch wheatgrass (*Agropyron spicatum*), bottlebrush squirreltail (*Sitanion hystrix*), or western needlegrass (*Stipa occidentalis*). Long stolon sedge (*Carex pensylvanica*) occurs on the pumice of west central Oregon while elk sedge (*Carex geyeri*), Ross' sedge (*Carex rossii*), and pinegrass (*Calamagrostis rubescens*) are commonly found beneath bitterbrush in east central Oregon. The Blue and Wallowa Mountains contain ponderosa pine shrublands of a more mesic nature where common snowberry, mountain snowberry (*Symphoricarpos oreophilus*), mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) are often associated.

Fringes of climax pine shrubland communities that tend to be sporadically distributed are: ponderosa pine/mallow ninebark adjacent to forests where Douglas-fir is climax in eastern Washington; and ponderosa pine/netleaf hackberry clumps in central and southeastern Oregon.

Two xeric tree species occur with some ponderosa pine climax communities. Near the Columbia River Gorge in Oregon and Washington, Oregon white oak (*Quercus garryana*) forms a forest with the pine. Bitterbrush, balsamroot, common snowberry, elk sedge, and manzanita are principal associates with these pine-oak forests. The other tree species often associated with climax ponderosa pine throughout its range is western juniper (*Juniperus occidentalis*).

Ecological Relationships: Fire periodicity influences the composition and abundance of associated shrub species. At the drier extremes mountain big sagebrush, bitterbrush, and mountain mahogany (*Cerocarpus ledifolius*) all readily succumb to fire. At the moist end of climax pine shrubland types fire tends to provide stimulus and renovation to communities with mallow ninebark (*Physocarpus malvaceus*), common snowberry, and mountain snowberry.

Grazing and browsing pressure can alter these shrublands by decreasing competition from rhizomatous sedges and grasses; by hedging of the shrubs and weakening the vigor of the plant; by encouraging rhizomatous bluegrasses (*Poa* spp.) and annual bromes (*Bromus* spp.) to occupy overgrazed sites.

Removal of the trees, which results in the reduction of shade beneficial to moisture retention, often leads to deterioration and/or loss of the shrubs at the dry end of climax pine shrublands. At the moist end of this ponderosa pine shrubland covertype, tree removal can introduce currants and gooseberries (*Ribes* spp.), hawthornes (*Crataegus* spp.), and stimulate native roses (*Rosa* spp.), cherries (*Prunus* spp.), and serviceberries (*Amelanchier* spp.).

References include Clausnitzer and Zamora, 1987; Daubenmire and Daubenmire, 1968; Franklin and Dyrness, 1973; Hopkins, 1979a; Hopkins 1979b; Tart and Tart, 1986; Johnson and Simon, 1987; Johnson and Clausnitzer, 1991; Topik et al, 1988; Williams and Lillybridge, 1983; Williams et al, 1990; Williams and Smith, 1991; Wright and Baily, 1982; and Volland, 1976.

Charles G. Johnson, Jr.
US Forest Service
Baker City, OR

PONDEROSA PINE-GRASSLAND SRM 110

Definition, Composition, and Structure: The ponderosa pine grassland cover type contains communities dominated by rhizomatous grasses or sedges at the moist end of the type and by bunchgrasses at the dry end of the cover type. Examples of plant associations included in the rhizomatous grass-sedge group are: ponderosa pine/elk sedge and ponderosa pine/pine-grass. Bunchgrass dominated plant associations are prevalent with ponderosa pine at the drier end of the cover type where environmental conditions often preclude the ability of trees to establish or persist. Western juniper is the exception. Examples of plant associations found in the bunchgrass group are: ponderosa pine/Idaho fescue, ponderosa pine/bluebunch wheatgrass, and ponderosa pine/needlegrass.

Geographic Distribution: Bunchgrasses dominate beneath open-growing ponderosa pine at the edge of the Okanogan Highlands and the Columbia Basin in Washington State and at the edge of the Blue and Ochoco Mountains where Great Basin climatic conditions influence the vegetation. The bunchgrasses occur at lower elevations on well drained soils as contrasted with the rhizomatous grass and sedge types found at higher elevations, or on compensating aspects with soils more conducive to moisture retention. The rhizomatous grass and sedge communities beneath ponderosa pine

are often adjacent to the more mesic shrubland cover type or coniferous forests dominated by Douglas-fir or grand fir communities. Typically the bunchgrass dominated communities occurring with ponderosa pine are adjacent to juniper/bunchgrass, or sagebrush/bunchgrass communities.

Ecological Relationships: Fire has been a frequent modifying event in the ponderosa pine grassland cover type. Fire periodicity ranges from 10-30 years. Elk sedge and pinegrass are resistant to fire with palatability of both species temporarily improved by burning. Idaho fescue and bluebunch wheatgrass communities are generally enhanced by burning. Fire can damage some of the more mesic Idaho fescue communities where plant density is high resulting in a retrogression to earlier seral stages with more forb composition. Bluebunch wheatgrass is more resistant to fire than Idaho fescue and responds favorably to burning.

Grazing animals utilize pinegrass and elk sedge to a more limited extent than more preferred bluebunch wheatgrass and Idaho fescue plants. When bunchgrass communities are overgrazed the site is degraded with earlier seral vegetation resulting. On fescue sites the principal increasers are lupines (*Lupinus* spp.), yarrow (*Achillea millefolium*), and the bluegrasses (*Poa sandbergii, Poa nervosa*). Examples of invading species are annual bromes (*Bromus tectorum, Bromus mollis*) and rhizomatous bluegrasses (*Poa pratensis, Poa compressa*). Sylvicultural options are limited in the ponderosa pine grassland cover type. Many of the communities are incapable of sustaining timbergrowth rates and are unsuited for commercial forest land status. The open growth structure of the pine communities provides a desirable pattern between adjacent closed canopy coniferous forest land and the open rangelands of the cold desert steppe.

References include Clausnitzer, 1987; Daubenmire and Daubenmire, 1968; Franklin and Dyrness, 1973; Hopkins, 1979a; Hopkins 1979b; Tart and Tart, 1986; Johnson and Simon, 1987; Johnson and Clausnitzer, 1991; Topik et al, 1988; Williams and Lillybridge, 1983; Williams et al, 1990; Williams and Smith, 1991; Wright and Baily, 1982; and Volland, 1976.

Charles G. Johnson, Jr.
US Forest Service
Baker City, OR

Rangeland Cover Types of the PACIFIC SOUTHWEST REGION

INTRODUCTION SRM 200

California has a rich diversity of vegetation types. Some communities are rare and endemic to the state; others are well known. These diverse vegetation types are a function of biological and physical factors including slope, elevation, aspect and climatic factors such as precipitation and temperature. The majority of the Region is influenced by a Mediterranean climate characterized by long dry summers, and mild winters. However, higher elevations, areas east of the Sierra Nevada and the southern deserts are more affected by continental weather patterns.

Rangeland cover types for California have been divided into four major community types. Conifer and hardwood woodlands occupy approximately 15.5 million acres (6.3 million ha), shrublands (including desert shrublands) occupy approximately 40 million acres (16 million ha), and grasslands cover about 9.6 million acres (4 million ha) of the 100 million acres (40.5 million ha) of the state.

Rangeland cover types in the Conifer Woodlands are described in Section 100 and 400, as they also occur in the Pacific Northwest and Intermountain West, respectively. In California, the Western Juniper/Big Sagebrush/Bluebunch Wheatgrass type (SRM 107) occurs from sea level to above 10,000 feet (3,000 m), primarily on the Modoc Plateau and eastern slopes of the Sierra Nevada. The type is characterized by western, Utah or California juniper comprising greater than 80% of the conifer basal area. Associated species may include Jeffrey, ponderosa or whitebark pine. Ponderosa Pine Shrubland (SRM 109) and Ponderosa Pine - Grassland (SRM 110) occur primarily on the east side of the Sierra Nevada and Klamath Mountains. This type is characterized by widely spaced ponderosa pine, and/or Jeffrey pine, and an understory dominated by a mixture of perennial grasses and shrubs such as sagebrush and rabbitbrush. The Juniper-Pinyon Woodland (SRM 413) occurs in California at elevation ranges from 6,000 to 9,000 feet (2,000-3,000m) in the Sierra Nevada, primarily on the east side, 4,000 to 8,000 feet (1,120 - 2,440 m) in the Mojave Desert, and 3,500 to 5,500 feet (1,070-1,680 m) in the San Jacinto and Santa Rosa Mountains. Pinyon-juniper cover types range from 10% cover of pure pinyon (singleleaf or Perry) to stands of pinyon mixed with juniper, where juniper never exceeds 80% cover. Common associates may include California scrub or canyon live oaks.

The Hardwood Woodlands in California occur from sea level to 8,000 feet (2440 m), and occupies almost 10 million acres (4 million ha). It is a diverse woodland characterized by an overstory dominated by (*Quercus*) species, and an understory dominated by annual grasses, and less commonly shrubs such as buckbrush, toyon, poison oak, and coffeeberry. The Riparian Woodland cover type also commonly contains ash, cottonwood, and willow in addition to valley, interior live or other oak species. The hardwood rangeland in California is an ecosystem that is undergoing a lot of change caused by human development, fuel wood harvesting, and livestock grazing.

Shrublands of California, occupying some 40% of the state, are also diverse occupying elevations from sea level to 10,000 feet (3000 m). These rangeland cover types include communities characterized by sclerophylous shrubs adapted to fire and a Mediterranean climate, commonly known as chaparral. Shrub cover types also include Sagebrush types (401, 403, 405, 406, 408) and Saltbush (501) closely associated with Great Basin sagebrush communities and Southwest regional cover types, respectively.

Grasslands in the Pacific Southwest Region include six major rangeland cover types. Great Basin grassland, some of which occurs in California, is described in section 300. The five grassland types described here occupy elevations from sea level to alpine mountain tops. Four of the five types are dominated by perennial grass and grasslike species, while the Valley Grassland cover type is dominated by introduced Mediterranean annual grass species. Composition and productivity are diverse within and among the grassland cover types.

The 23 rangeland cover types described for the Pacific Southwest Region should be useful to anyone who must relate rangeland description and management practices in one area with those in another. Although each cover type is an aggregation of local species variability and productivity related to local soils and microclimate, general patterns of production and use potentials are evident. Thus, the cover type descriptions are especially useful for planners, teachers, land managers, and resource specialists because each cover type contains unique characteristics which allow for prediction of general productivity and trends.

Barbara Allen-Diaz
University of California
Berkeley, CA 94721

BLUE OAK WOODLAND
SRM 201

Definition and Composition: Occurring primarily in single species stands, blue oak (*Quercus douglasii*) forms extensive woodlands, savannas and occasional forests that make up a major part of California's foothill woodland vegetation. The most frequent associate of blue oak over much of its range is foothill pine (*Pinussabiniana*), but other tree species may be locally abundant such as valley oak (*Q. lobata*), interior live oak (*Q. wislizenii*), coast live oak (*Q. agrifolia*), and black oak (*Q. kelloggii*) (Griffin 1977). Shrubs are relatively unimportant in this type but the herbaceous component is almost always well developed. Typically, herb cover exceeds 80 percent and is composed of a rich mixture of forb and grass species, most of which are annual (Barbour 1987). In southern San Luis Obispo County, for example, 250 species were found in the understory of blue oak woodlands (unpublished data). Although 85 percent of these species were native, non-native species dominated the herb cover. Twelve blue oak communities within the Blue Oak Woodland have been described by Allen et al. (1989).

Geographic Distribution: Blue Oak Woodland surrounds California's Central Valley as a discontinuous belt of irregular width. Although this type is best developed between elevations of 300 (90 m) and 1300 ft (400 m) on the eastern slopes of the Coast Ranges, and between 300 (90 m) and 2300 ft (700 m) on the western slopes of the Sierra Nevada (White 1966, Griffin 1977), the extremes of its elevational limits extend from 165 ft (50 m) in the Sacramento Valley to 5900 ft (1800 m) on Mt. Pinos in Kern County. The northern and southern limits of Blue Oak Woodland are Montgomery Creek in Shasta County and the Liebre Mountains of Los Angeles County, respectively. The most extensive, continuous area of this type covers the Sierra Nevada foothills; elsewhere, its distribution tends to be more fragmented (Griffin 1977).

Ecological Relationships: Blue Oak Woodland grows on a wide variety of soils but compared to other foothill oak types it is most prevalent on drier sites. Blue oak is able to withstand periods of severe moisture stress and is aided in its droughttolerance by a deciduous habit and the ability to reach moisture deep in the soil (Lewis and Burghy 1964, Griffin 1973, Baker et al. 1981).

In the southern central Coast Range blue oaks form savannas of large-diameter trees with broad crowns. Tree heights of 28 ft (8 m) are common. Tree densities in these savannas are variable but range from 70-130/acre. As slope angle increases up to 40 percent on north-facing aspects, stands become increasingly dense and change to forests. Tree densities of 240-260 trees/acre are the norm. Tree diameters are correspondingly smaller than in the more open savannas, typically 4-6 inches (10-15 cm) dbh, and tree heights shorter, 16 to 24 ft (5-8 m).

The composition of the understory annuals in these blue oak woodlands and forests is highly variable but is strongly influenced by oak tree cover, solar insolation and slope angle (Borchert et al. 1991). In other areas of the region, changes in composition also are correlated with elevation.

Over most of its range blue oak is declining in numbers because regeneration is not replacing natural mortality or removal (Muick and Bartolome 1987, Bolsinger 1988). Numerous agents have been cited for the absence of regeneration including: livestock grazing and trampling, browsing by deer populations, abnormally high rodent populations, competition with non-native annuals, and fire (e.g., White 1966, Griffin 1971, Longhurst et al. 1976, Vankat and Major 1978, Gordon et al. 1989). However, no single factor appears to be responsible for the decline. Instead, varying combinations of these factors appear to operate locally or regionally (Bartolome et al. 1987).

Blue oak canopies exert a strong influence on the composition and productivity of the understory herbs. Compared to adjacent openings forage under oaks is higher in nitrogen, phosphorus, and sulfur (Holland 1973, Holland and Morton 1980, Kay and Leonard 1980). However, total forage production between the canopy and the open varies regionally. In northern California forage production is higher in the open than under the canopy while in the southern part of the range the opposite is true (Johnson et al. 1959, Murphy and Crampton 1964, Holland and Morton 1980, McClaran and Bartolome 1989).

Variants and Associated Species: Because its distribution spans nearly the entire length of the state, Blue Oak Woodland exhibits considerable latitudinal and elevational variation in composition. Several phases of Blue Oak Woodland occur within its range: in the Coast Ranges it mixes with coast live oak; in lower elevation riparian areas or on steep slopes at upper elevations interior live oak is a frequent associate; and at increasing elevations it co-occurs with canyon live oak (*Q. chrysolepis*), black oak and conifers such as Douglas-fir (*Pseudotsuga menziesii*) or ponderosa pine (*Pinus ponderosa*) (Barbour 1987). Locally blue oak forms a mosaic with other vegetation types. For example, in the southern foothills of the Sierra Nevada, Blue Oak Woodland is replaced elevationally by mixed evergreen woodland on north-facing slopes but on other aspects it abuts Chamise Chaparral (Baker et al. 1981). In the southern Coast Range, in contrast, Blue Oak Woodland changes abruptly to grassland on south-facing slopes and to Chamise Chaparral, Mixed Chaparral or Coast Live Oak Woodland at elevations above 1800 ft (550 m) (unpublished data).

Mark Borchert
Forest Service
Goleta, CA 93117

COAST LIVE OAK WOODLAND SRM 202

Definition and Composition: Coast live oak (*Quercus agrifolia*) is an important component of coastal mountain range woodlands and savannas. The vegetation type characterized by coast live oak has been termed southern oak woodland (Griffin 1977), or in some places as variants of mixed evergreen woodland or foothill woodland (e.g., Smith 1976). A number of woody tree and shrub species may also be associated, trees include valley oak (*Quercus lobata*), blue oak (*Q. douglasii*), Engelmann oak (*Q. engelmannii*), California buckeye (*Aesculus californica*), madrone (*Arbutus menziesii*), California walnut (*Juglans californica*), and California bay (*Umbellularia californica*). Shrubs include: toyon (*Heteromeles californica*), California coffeeberry (*Rhamnus californica*), and purple sage (*Salvia leucophylla*). The Coast Live Oak Woodland extends onto a number of different soil types, slopes, and exposures. The best recent review of this type was by Griffin (1977), with detailed type descriptions found in Allen et al. (1989).

Geographic Distribution: Coast Live Oak Woodland is found from southern Mendocino County to the Mexican border within the Coast Ranges (Griffin 1977). This type of woodland is generally more abundant in the inland parts of the outer Coast Ranges. It can also be found in portions of the outer Coast Ranges, but is usually more limited in development (Sharsmith 1945, Finch and McCleery 1980).

In the northern part of its range stands are discontinuous and generally restricted in size and may represent minor components or phases of woodland dominated by other oak species like blue oak or valley oak. From the San Francisco area south, Coast Live Oak Woodland becomes more prominent and extensive. In the southern end of its range, many associated tree species reach their distributional limits, with California walnut in Ventura and Los Angeles counties, and Engelmann oak in Riverside and San Diego counties, becoming locally important.

Ecological Relationships: In contrast to some woodland oaks, coast live oaks are able to regenerate in some areas even with grazing (Griffin 1971). This ability varies by region and may be associated with recovery of areas lost to disturbance or clearing in the last century (e.g., Wells 1962). Where grazing is heavy, regeneration may not be possible and large oaks can be found surrounded by introduced annuals (Finch and McCleery 1980).

Coast live oak is among the most fire resistant of the oak species in California (Plumb 1980). The thick bark and high moisture content protect trees from the cooler temperatures of grassland fires. Seedlings, smaller trees, or trees found in/or adjacent to chaparral or dense woodland may experience complete canopy dieback but resprouting will recover much of the canopy within a year depending upon the intensity of the fire (unpublished data, Sauer 1977, Snow 1980, Plumb 1980). Differences in sensitivity to burning may influence vegetation patterns in part of the Coast Live Oak Woodland range. In southern California, Snow (1980) found that Engelmann oak was more resistant to burning and recovered at a faster rate. He suggested that the greater dominance of Engelmann oak and the restriction of the coast live oak to rock outcrops in some areas may have resulted from fire.

Coast Live Oak Woodland is found on a diversity of soil types (e.g., Wells 1962), but the open phase is more common in valley bottoms and adjacent slopes where soils are generally deeper (e.g., Cole 1980). Compared to other oak types at lower elevations, distribution of coast live oaks are generally in more mesic locations and access to moisture may be more important than initial soil conditions. Coast live oak seedlings are not as drought tolerant as blue oak seedlings (Griffin 1971) and mature trees are found in areas where the root system reaches moisture throughout the dry period of the year (Griffin 1973).

Once established, live oak canopies considerably influence the composition and productivity of the associated vegetation (Parker and Muller 1982). Fertility is generally high beneath coast live oaks, and nitrogen levels and rates of nitrogen mineralization are among the highest for any California oak species, evergreen or deciduous (Billow 1987, Parker and Billow 1987). The evergreen canopy may restrict development of the herbaceous understory. However, when present, considerable compositional changes can be observed in the understory between the northern and southern sides of the canopy (Parker and Muller 1982).

Dynamics of the Coast Live Oak Woodland vegetation are tied to fire, grazing, moisture, soil type and development, and vegetation impact. Increases in fire and grazing seem to restrict regeneration, while coast live oak is able to invade chaparral, coastal shrub (Patric and Hanes 1964, McBride 1974) or grassland when these factors are relaxed.

Variants and Associated Species: One described variant of the Coast Live Oak woodland or southern California oak woodland is the Engelmann oak phase. From southern Riverside County into San Diego County, coast live oak can be found mixed with Engelmann oak. Engelmann oak often dominates valley areas and adjacent drier slopes and uplands while coast live oak is less dominant and found on more mesic slopes (Zuill 1967, Lathrop and Zuill 1984).The Coast Live Oak Woodland is adjacent to and grades into a number of other vegetation types. The savanna phase of the Coast Live Oak Woodland (grass woodland, grass phase, etc.) occupies more mesic locations but is often mixed in with blue oak and valley oak in the northern two-thirds of the range, as it is with Engelmann oak in the southern end. In the xeric parts of its distribution, Coast Live Oak Woodland thins to grassland in some areas or mixes into chaparral in other parts. In mesic areas, Coast Live Oak Woodland grades into various phases of mixed evergreen forest, oak-madrone, oak-madrone-tanbark oak (*Lithocarpus densiflora*), closed cone pine (*Pinus radiata*), and oak-bay forests.

V. Thomas Parker
San Francisco State University
San Francisco, CA 94132

RIPARIAN WOODLAND
SRM 203

Definition and Composition: Riparian Woodlands occur along rivers, streams, and creeks. Species composition and vegetation structure vary throughout California, but species in the following genera comprise the principal associates: willow (*Salix* spp.), cottonwood (*Populus* spp.), sycamore (*Platanus* spp.), alder (*Alnus* spp.), maple (*Acer* spp.), ash (*Fraxinus* spp.), and oak (*Quercus* spp.). The willows are the most common genera in the Riparian Woodland. Older Riparian Woodlands on higher stream terraces are usually characterized by two tree layers. The upper layer is dominated by species of cottonwood, walnut, oak, and/or sycamore while the lower level supports species of maple and elderberry (*Sambucus* spp.). Vines produced by poison oak (*Toxicodendron diversilobum*) and California wild grape (*Vitis californica*) are common in the Riparian Woodland of central California. Local understory thickets of various species of wild currant (*Ribes* spp.), blackberry (*Rubus* spp.) and poison oak are common in the shrub layer. Several exotic species readily invade Riparian Woodlands. They develop as local dominants in either the tree layer, tree of heaven (*Ailanthus altissima*); or in the herb layer, periwinkle (*Vinca major*), forest forget-me-not (*Myosotis sylvatica*), and hoary nettle (*Urtica holosericea*).

Geographic Distribution: The type occurs throughout California. The Riparian Woodland is often the only tree dominated cover type in areas with average annual rainfall less than 20 inches (51cm). In areas of higher rainfall, riparian species dominate the margins of streams and are often mixed with more typical upland species (e.g., alder and redwood (*Sequoia* spp.) along the Eel River) so that the margins of the Riparian Woodland are less well defined. Major areas of valley oak (*Quercus lobata*) dominated Riparian Woodland occurred along the Sacramento River and its tributaries prior to settlement of the Sacramento Valley. Sizeable stands remain in some county and state parks in Tehama, Butte and Sutter counties. Sycamore dominated Riparian Woodlands were more common in coastal regions of southern California. Although reduced by agriculture, urbanization and flood control projects, major stands remain along portions of the Salinas, Kern and Santa Inez rivers.

Differences in the geographic distribution of species accounts for the variation in species encountered in Riparian Woodlands across the state. Species distribution of alder, a typical example, is related to gradients of coastal fog and temperature. Red alder (*Alnus rubra*) is limited to streamside locations within the coastal fog belt from northern San Luis Obispo County north. White alder (*Alnus rhombifolia*) occurs primarily inland and to the south of the fog belt but not in the hot interior Central Valley nor the desert areas. It is also common along streams from the foothills of the Sierra Nevada to elevations of 5000 feet (1665m). Thinleaf alder (*Alnus tenuifolia*) occurs as a common riparian tree or shrub at elevation from 5000 to 8000 feet (1665-2660m) to the Sierra Nevada (Munz and Keck 1973).

Ecological Relationships: The distribution of the type is limited to environments along water courses. Riparian species are adapted to seasonal inundation by water. They also have a high demand for water as well as transient seed viability which restricts them to areas adjacent to streams.

Toposequences are evident within Riparian Woodlands adjacent to streams. The Riparian Woodland toposequence reflects the segregation of species along a gradient of depth to water table and durations of seasonal inundation. Conrad et al. (1980) described the toposequence occurring along the Sacramento River as follows: lowest elevations - valley willow (*Salix hindsianna*), white alder, and Fremont cottonwood (*Populus fremontii*); middle elevations - Fremont cottonwood, boxelder (*Acer negundo*), white alder, and arroyo willow (*Salix lasiolepis*); highest elevations - valley oak, California sycamore (*Platanus racemosa*), Oregon ash (*Fraxinus latifolia*), and California black walnut (*Juglans hindsii*).

Successional studies (McBride and Strahan 1984a, 1984b; Strahan 1984) suggest that the riparian zone can be viewed as a complex climax community controlled by fluvial geomorphic processes. In areas where the aggregation of silts, sands, and gravels occurs colonization by species of willows and cottonwoods can be observed. The presence of plants contribute to the process of aggregation of stream carried silt, sand, and gravel causing a building up of these materials at higher elevations above the stream bed. Species less tolerant of prolonged seasonal inundation (e.g., species of oak, ash, and walnut) are able to survive on these more elevated areas. These species are more shade tolerant than the species of willows and cottonwoods (which colonize the areas of initial stream deposition) and eventually dominate the higher elevations adjacent to streams. In time, stream meandering tends to undermine these areas of higher ground, destroy the vegetation, and redistribute the substrate to new locations where the process of colonization is initiated once more. Viewed as a mosaic of establishment, replacement, and destruction the riparian zone never exhibits a stable "climax" at any one location. The mosaic itself should be considered as a climax (McBride and Strahan 1982).

Variants and Associated Species: The Riparian Woodland is found adjacent to nearly all other cover types in California. In higher rainfall areas, it often supports species from adjacent vegetation types. Riparian woodlands support conifer species such as coast redwood (*Sequoia sempervirens*), and western red cedar (*Thuja plicata*) in the North Coastal areas, and incense cedar (*Calocedrus decurrens*), Pacific yew (*Taxus brevifolia*), and lodgepole pine

(*Pinus contorta*) in the Sierra Nevada.

Joe R. McBride
University of California
Berkeley, CA 94720

NORTH COASTAL SHRUB
SRM 204

Definition and Composition: This is a dense shrubland dominated by flexuous shrubs 15 to 20 feet (5-7m) tall with soft, but evergreen, foliage. Principal overstory species include the woody perennials; coyote bush (*Baccharis pilularis* ssp. *consanguinea*), blueblossom ceanothus (*Ceanothus thrysiflorus*), California coffeeberry (*Rhamnus californica*), California wax myrtle (*Myrica californica*), bush lupine (*Lupinus arboreus*), and salal (*Gaultheria shallon*). Also included are the large perennial herbs; cowparsnip (*Heracleum lanatum*), blue wildrye (*Elymus glaucus*), and giant horsetail (*Equisetum telmateia*) (Bakker 1984, Heady et al. 1988, Franklin and Dyrness 1973, Kuchler 1988, Munz and Keck 1963, Ornduff 1974).

The overstory canopy is rather open. Beneath it is a closed subcanopy, 0.3-0.5 m tall, with a rich mixture of plant growth forms, including: (1) evergreen subshrubs; bush monkeyflower (*Mimulus (Diplacus) aurantiacus*), coastal buckwheat (*Eriogonum latifolium*), goldenweed (*Haplo-pappus ericoides*), golden yarrow (*Eriophyllum staechadifolium*), Suksdorfs sagebrush (*Artemisia suksdorfii*), yerba santa (*Eriodictylon californicum*), (2) woody, and often thorny climbers; California blackberry (*Rubus vitifolius*), Nootka rose (*Rosa nutkana*), poison oak (*Toxicodendron diversilobum*), salmonberry (*Rubus spectabilis*), thimbleberry (*Rubus parviflorus*), trailing blackberry (*Rubus ursinus*), (3) perennial grasses and allies; red fescue (*Festuca rubra*), slough sedge (*Carex obnupta*), sweet vernalgrass (*Anthoxanthum odoratum*), sweet velvetgrass (*Holcus lanatus*), (4) perennial forbs; Canada goldenrod (*Solidago canadensis*), paintbrush (*Castilleja latifolia*), pearly everlasting (*Anaphalis margaritacea*), western yarrow (*Achillea millefolium*), and (5) ferns; brackenfern (*Pteridium aquilinum var. lanuginosum*), sword fern (*Polystichum munitum*). Herb cover alone may be 40 percent, and species richness is high relative to other shrublands (Heady et al. 1988). The introduced weedy shrubs gorse (*Ulex europaeus*) and Scotch broom (*Cytisus scoparius*) are sometimes major components of North Coastal Shrub.

Geographic Distribution: North Coastal Shrub occurs discontinuously from Santa Cruz, California (37 N) to the Olympic Peninsula of Washington (48 N). It occupies slopes below 1200 feet (400m) elevation and along draws, cliff edges, canyons, and portions of terraces immediately adjacent to the ocean (Franklin and Dyrness 1973, Munz and Keck 1963). This shrubland is ecotonal between Coastal Prairie Grassland and several coastal forests. A complex mosaic of grassland, shrubland, and forest characterizes the entire coastal strip (Bakker 1984). Kuchler (1988) mapped North Coastal Shrub in California as part of a "coastal prairie scrub mosaic," rather than as a separate type. Some elements of North Coastal Shrub (e.g., coyote bush, poison oak) extend south of the vegetation type's limit, intergrading with Coastal Sage Shrub.

Ecological Relationships: North Coastal Shrub experiences fog, wind, salt spray, and continuously cool temperatures. Annual precipitation ranges from 20-80 inches (50 to 200cm) (Munz and Keck 1963). No regional study of the vegetation nor of any of its characteristic species has yet been published, consequently there is no comprehensive understanding of habitat requirements. Patterns of association with geologic substrate, soils, fire frequency, grazing, disturbance, or land use history have not been studied and they are not intuitively apparent. Howell (1970) concluded that this shrubland "...is perhaps the least definite in its boundaries..." of any Marin County plant community.

One local study at Pt. Reyes National Seashore reported 20 stands of North Coastal Shrub grew on a diversity of slopes (26-80%), aspects (90-350), elevations (50-340 m), and soil textures (clay loam to sandy loam) (Grams et al.1977). The shrubland may, in places, be seral to forest. Along the Oregon coast, scattered individuals of Sitka spruce (*Picea sitchensis*) and lodgepole pine (*Pinus contorta*) overtop the shrubland, implying that a future climax may be conifer forest. On the Berkeley Hills east of San Francisco, McBride and Heady (1968) and McBride (1974) concluded that coyote bush dominated shrubland was being invaded by broadleaf elements of mixed evergreen forest. Many of the component species of North Coastal Shrub are characteristic understory plants in conifer and broadleaf coastal forests.

The shrubland's seral relationship with Coastal Prairie Grassland is incompletely understood (Hektner and Foin 1977). A study at Pt. Reyes noted modest correlations between increasing cover by North Coastal Shrub species with increasing grazing intensity by cattle (Elliott and Wehausen 1974). Another study, only 12 miles (20km) to the north at Bodega Head, failed to show any successional trends between shrubland and grassland over the course of several decades even though grazing intensity had changed during that period (Davidson and Barbour 1977). Many grassland dominants are also characteristic understory species of North Coastal Shrub, and islands of grassland frequently interrupt the shrubland across sharp ecotones. If there is a successional relationship, it must occur on a very local scale (Hobbs and Mooney 1986).

Variants and Associated Species: Lupine dominated scrub occurs on some grassland terraces. Woody lupines include bush lupine (*Lupinus arboreus*), Chamisso's lupine (*Lupinus chamissonis*), and many colored lupine (*Lupinus variicolor*). Associated woody and herbaceous species are otherwise no different from typical North Coastal Shrub. The demogra-

phy, growth patterns, and habitat preferences of bush lupine have been investigated by Davidson and Barbour (1977) and Pitelka (1974). Patches of bush lupine appear to be limited to a life span of only half a dozen years by episodic outbreaks of several insect herbivores. These specialized herbivores are capable of detoxifying the large amount of cyanogenic glycoside which accumulates in lupine foliage and seeds.

Along parts of the Oregon coast south of Port Orford (43 N), the shrubland overstory may include species normally characteristic of more protected, riparian habitats: deerbrush (*Ceanothus intergerrimus*), Menzie's gooseberry (*Ribes menziesii*), hairy manzanita (*Arctostaphylos columbiana*), silktassel bush (*Garrya elliptica*), Sitka alder (*Alnus sinuata*), and western azalea (*Rhododendron occidentale*) (Franklin and Dyrness 1973).

Michael G. Barbour
University of California
Davis, CA 95616

COASTAL SAGE SHRUB
SRM 205

Definition and Composition: This is a moderately dense shrubland dominated by facultatively drought-deciduous subshrubs less than 4.5 feet (1.5m) tall. Principal species are black sage (*Salvia mellifera*), purple sage (*Salvia leucophylla*), white sage (*Salvia apiana*), California sagebrush (*Artemisia californica*), California buckwheat (*Eriogonum fasciculatum*), California encelia (*Encelia californica*), and lemonadeberry (*Rhus integrifolia*). Westman (1981b) has identified more than 30 other commonly associated species in a variety of growth forms, including perennial bunch grasses, perennial forbs, stemless rosette plants, succulents, and additional evergreen and drought-deciduous shrubs.

Although total plant cover may reach 100 percent, the plant canopy is thin. Overlapping canopies are modest, 2/3 of the relative cover is deciduous, and the leaf area index is not much more than 1.0 (Mooney 1988, Westman 1981a). Synonyms for this type include "soft chaparral" and "southern coastal scrub." The soft foliar texture contrasts with evergreen (hard) chaparral foliage. The distribution of this vegetation type in California falls to the south of the North Coastal shrubland which extends north into Oregon.

Geographic Distribution: This shrubland occupies a relatively narrow coastal strip below 2760 feet (900m) elevation, extending from Monterey Bay (37 N) to El Rosario in Baja California (30 N). It typically occurs on dry, ocean facing slopes below chaparral. North of Pt. Dume (34 N), the vegetation is discontinuous and within 12 miles (20km) of the ocean, south of there it is continuous and can extend more than 60 miles (100 km) inland onto desert facing slopes, as in Riverside and San Bernardino counties (Bakker 1984, Munz and Keck 1973).

Many hectares of Coastal Sage Shrub have been converted to agricultural or urban use in the past two centuries. Its current distribution in California may be only 1/7-1/10 of its pristine extent (Kuchler 1988), and a significant portion of what remains is subject to high levels of oxidant and particulate air pollution (Westman 1981a, 1981b). Preservation of Coastal Sage Shrub may deserve special conservation action (Hanes 1976).

Ecological Relationships: Coastal Sage Shrub occurs within a range of 6-20 inches (15-50cm) annual precipitation, and it appears to occupy sites that experience longer, more severe summer drought periods than chaparral. It commonly grows on sandstone, shale, granite-diorite, and volcanic substrates, but component species may extend aswell onto unconsolidated sand, limestone, and serpentine (Westman 1981b). Soil texture ranges from coarse (Munz and Keck 1973, Ornduff 1974) to highly argillic (Cole 1980, Wells 1962). Soils are relatively low in nutrients, but concentrations of N, P, and Mg are 2-4 times that of nearby chaparral soils (Westman 1981b).

Coastal Sage Shrub exists in a fire climate, and its principal woody species are capable of stump sprouting following fire. Nevertheless, the role of fire and its natural frequency in this type are not well understood. There is no evidence for senescence in long unburned stands (Westman 1981a). More than half the herb species characteristic of Coastal Sage Shrub are also found in chaparral stands for the first few years following a fire. In Coastal Sage Shrub, however, these herbs retain relatively high cover values for 10-20 years following a fire (Westman 1979). In some sites (*perhaps ecotonal*), Coastal Sage Shrub is seral to chaparral, becoming overtopped by chaparral and senescent in its shade within 22-26 years (Gray 1983, McPherson and Muller 1967). However, in other areas, boundaries between the two shrublands have been stable for decades and through more than one fire cycle (Cole 1980, Mooney 1988). Such stable boundaries may be due to discontinuities in slope aspect, soil texture, or geological substrate; sometimes their origin is unknown.

Boundaries between Coastal Sage Shrub and Valley Grassland are also abrupt and complex. Allelopathy has been suggested as one possible causal factor for the ecotones, but grazing by small mammals which nest beneath the shrubs may be equally as important (Bartholomew 1970, Halligan 1974). The high terpene content (up to 3.5 percent leaf dry weight in purple sage) may play a role in either allelopathy or herbivore defense (Mooney 1988).Coastal Sage Shrub is shallowly rooted, relative to chaparral, and most of its biomass is above ground (Hellmers et al. 1955). Above ground biomass is about 1,500 g per square meter, and annual net productivity is 250 g per square meter. Both values are only half those of nearby chaparral (Gray and Schlesinger 1981). Vegetative growth begins in early winter and extends for 6 months into early summer. Leaf fall occurs in May - June, but twig growth and flowering may continue to October,

depending on the species (Gray 1982, Gray and Schlesinger 1981).

Variants and Associated Species: Coastal succulent scrub extends from San Diego (30 N) to El Rosario and also on the Channel Islands. Sage, sagebrush, lemonadeberry, and buckwheat continue into this area, but their dominance is reduced and cover is shared with Adolphia californica, laurel sumac (*Malosma (Rhus) laurina*), Munz's sage (*Salvia munzii*), Parry's buckeye (*Aesculus parryi*), Shaw's century plant (*Agave shawii*), velvet cactus (*Bergerocactus emoryi*), and Viguiera laciniata (Mooney 1988, Mulroy et al. 1979, Westman 1983b). Annual precipitation is below 250 mm, and relative cover by evergreens is half its usual value in Coastal Sage Shrub. Drought-deciduous species still account for more than half the relative cover, but succulents contribute 25 percent relative cover (Mooney 1988). This variant has also been called "maritime desert scrub" by Thorne (1976), and its transitional nature between Coastal Sage Shrub and Sonoran Desert vegetation has been well treated by Shreve (1936). In his monographic treatment of Coastal Sage Shrub, Westman (1983a, 1983b) recognized six regional variants ("floristic associations"). From north to south these were the Diablan, Venturan, Riversidian, Diegan, Martirian, and Viscainan. The latter three approximate the coastal succulent scrub described above, illustrating that it is not floristically homogeneous.

Associated vegetation types include Valley Grassland, chaparral, and coastal dune scrub (Barbour and Major 1977). Ecotones are often abrupt, and a patchwork mosaic of vegetation can result. Coastal dune scrub shares a number of characteristics species with Coastal Sage Shrub: bladderpod (*Isomeris arborea*), California sagebrush, coyote bush (*Baccharis pilularis* ssp. *consanguinea*), deerweed (*Lotus scoparius*), goldenbush (*Haplopappus venetus*), and lemonadeberry (Barbour and Johnson 1988, Barbour et al. 1981, Holton and Johnson 1979). Dune scrub differs in its dominance by evergreens (including such unique species as bush lupines), in the unconsolidated sand substrate, and in its unique complement of associated perennial herbs.

Chaparral differs almost completely in its dominants, principally ceanothus species (*Ceanothus* sp.), chamise (*Adenostoma fasciculatum*), and scrub oak (*Quercus dumosa*), but herbaceous associates are extensively shared with Coastal Sage Shrub, as noted earlier. Chaparral physiognomy is also unique, created by shrubs 2-3 times as tall as those in Coastal Sage Shrub which have rigid, dense, interlocking canopies and small, sclerophyllous, evergreen foliage.

At its northern limit, between Monterey and San Francisco, Coastal Sage Shrub gradually, species-by-species, gives way to North Coastal Shrub (Heady et al. 1988). Several elements of Coastal Sage Shrub continue north as important components of North Coastal Shrub: bush monkey flower (*Diplacus (Mimulus) aurantiacus*), coyote bush, ryegrass (*Elymus condensatus*), and poison oak (*Toxi-codendron diversilobum*). North Coastal Shrub differs in its dominance by larger, denser shrubs with soft but evergreen foliage, and a unique collection of herbaceous species which have northern affinities.

Michael G. Barbour
University of California
Davis, CA 95616

CHAMISE CHAPARRAL
SRM 206

Definition and Composition: Chamise chaparral is the dominate type of chaparral throughout California. The Spaniards applied the term "chamisal" to pure stands of chamise (*Adenostoma fasciculatum*). Associated species are California buckwheat (*Eriogonum fasciculatum*), black sage (*Salvia mellifera*), scrub oak (*Quercus dumosa*), manzanita (*Arctostaphylos* spp.), ceanothus (*Ceanothus* spp.), mountain mahogany (*Cercocarpus betuloides*), laurel sumac (*Malosma (Rhus) laurina*), sugarbush (*Rhus ovata*), silktassel (*Garrya* spp.), coyote bush (*Baccharis pilularis*), chaparral ryegrass (*Elymus* spp.), and chaparral yucca (*Yucca whipplei*). These species seldom represent more than 10 percent of the cover in Chamise Chaparral stands. The overall appearance of Chamise Chaparral is dense and uniform or, if a mixed stand, the vegetation can be uneven with occasional associated species (Critchfield 1971).

Geographic Distribution: Chamise Chaparral is associated with hot, xeric south and west-facing slopes and ridges, forming extensive stands at elevations between 450 ft (150m) and 3000 ft (1000m) (Brandegee 1891, Wieslander and Gleason 1954). The type occurs in the North Coast Ranges from Trinity, Shasta, and Mendocino counties south to San Francisco Bay (Cooke 1962); in the Central Coast Ranges from San Mateo, Alameda, and Contra Costa counties south to Kern, San Luis Obispo, and Santa Barbara counties (Cooper 1922); in the Sierra Nevada foothills mainly in El Dorado, Sacramento, Tuolumne, Mariposa, and Tulare counties; and it is the predominant chaparral type throughout the mountains of Ventura, Los Angeles, Orange, San Bernardino, Riverside, and San Diego counties, including the channel islands and northern Baja California (Epling and Lewis 1942).

Ecological Relationships: This type is not site-specific in that its occurrence and distribution is more a product of slope exposure, elevation, and fire history than edaphic factors (Hanes 1971). Soils are typically sandy to rocky, well-drained, and without well-developed soil horizons. Available soil nutrients are scarce and the Ph is neutral to somewhat alkaline.

Chamise Chaparral is considered a climax type of even-aged shrubs. Regrowth after fire is slow compared to other chaparral types because of poor site conditions (Horton

1960). During the regrowth phase the stand is more open and lower in stature than mature stands. Ephemeral annuals and short-lived perennials of the genera *Allophyllum, Avena, Bromus, Cryptantha, Lotus, Penstemon, Phacelia,* and *Zygadenus* occupy intershrub spaces during the first wet season after a fire, forming a lush herbaceous phase that persists for a few years while seedlings and rootcrown sprouts of shrubs are emerging. Shrub cover in Chamise Chaparral may reach 50 percent in 10 year old stands, 90 percent in 25 year old stands, and 80 percent in 50 year old stands (Hanes 1988). Stands older than 100 years may become decadent with limited new annual growth.

Variants and Associated Species: Drought-deciduous sage scrub species often occupy previously burned low elevation Chamise Chaparral sites (Hanes 1971). Common early successional scrub species are California sagebrush (*Artemisia californica*), California buckwheat, chaparral mallow (*Malacothamnus fasciculatus*), and black sage. Mixed Ceanothus Chaparral is a successional form of chaparral at intermediate elevations in southern California and a climax form in northern California and southwest Oregon where it replaces Chamise Chaparral. Scrub Oak Chaparral dominates north-facing slopes below 900 m and all slope aspects above 900 m. Woodland chaparral is associated with various oak tree species at low to intermediate elevation. Manzanita chaparral usually occupies slopes above 3000 ft (1,000m) and may mingle with Scrub Oak Chaparral on some sites (Cooper 1922). Montane chaparral forms a low, dense understory in mixed coniferous forest at elevations above 4500 ft (1,500m). Red shanks chaparral is found in four southern California mountains. Desert chaparral occupies desert slopes at elevations between 3000 ft (1,000m) and 4000 ft (1,350m) in southern California. Serpentine chaparral is found on serpentine rock outcrops from San Luis Obispo County northward through the Coast Ranges and foothills of the northern Sierra Nevada.

Ted L. Hanes
California State University
Fullerton, CA 92534

SCRUB OAK MIXED CHAPARRAL
SRM 207

Definition and Composition: Mature Scrub Oak Mixed Chaparral is dominated by scrub oak (*Quercus dumosa*) and less frequently, interior live oak (*Quercus wislizenii var. frutescents*) with a wide variety of associated shrubs usually comprising less than 30 percent cover. Common associates are mountain mahogany (*Cercocarpus betuloides*), toyon (*Heteromeles arbutifolia*), hollyleaf cherry (*Prunus ilicifolia*), silktassel (*Garrya fremontii, G. flavescens, G. veatchii*), California coffeeberry (*Rhamnus californica*), redberry (*Rhamnus ilicifolia*), foothill ash (*Fraxinus dipetala*), and elderberry (*Sambucus mexicana*). Several woody vines are generally associated with Scrub Oak Mixed Chaparral and are uncommon in other chaparral plant communities. These include honeysuckle (*Lonicera subspicata*), wild cucumber (*Marah macrocarpus*), chaparral virgin's bower (*Clematis lasiantha*), and poison oak (*Rhus (Toxicodendron) diversilobum*). Seral communities (10-60 years old) are characterized by a relatively high cover of ceanothus species including chaparral whitehorn (*Ceanothus leucodermis*), hairy ceanothus (*C. oliganthus*), woollyleaf ceanothus (*C. tomentosus*), hoaryleaf ceanothus (*C. crassifolius*), cupleaf ceanothus (*C.greggii*), buckbrush (*C.cuneatus*) and blue-blossom ceanothus (*C. thyrsiflorus*) (Hanes 1977).

Geographic Distribution: Scrub Oak Mixed Chaparral occurs extensively throughout California and northern Baja California. The type is found on all aspects of the upper elevations of the chaparral zone 2700 to 5100 ft (900 to 1,700m) where it grades into mixed evergreen forest. At lower elevation coastal sites (less than 900 meters) the type is restricted to north aspects (Hanes 1977).

Ecological Relationships: This type is generally found on shallow to moderately deep soils with a mesic temperature regime. Distribution is stable with disturbance by fire expected every 30-100 years. The primary effect of fire is to bring about significant changes in associated species composition. Scrub oak is a strong sprouting shrub which generally maintains its density on a site following fire (Keeley and Zedler 1978, Hanes and Jones 1967). Cover increases gradually relative to associated species until scrub oak is between 70 and 100 percent of the shrub cover. Ceanothus species are often the primary associates, sometimes codominant with scrub oak from 10-40 years following fire. As ceanothus declines, longer lived associates such as toyon or hollyleaf cherry can increase in cover filling in the openings left by the ceanothus (Hanes and Jones 1967). For example a scrub oak-toyon association occursin mature stands (40-90+years) in which toyon can reach between 15 and 30 percent cover and ceanothus is absent. The species of ceanothus which are associated with scrub oak varies by elevation, geographical location and climate; however, their successional patterns following fire are similar.

Common plant associations of Scrub Oak Mixed Chaparral include scrub oak-mt. mahogany, scrub oak-chaparral whitehorn, scrub oak-hoaryleaf ceanothus and scrub oak-toyon (White 1988, unpublished data). Scrub oak-mt. mahogany is most common on inland sites greater than 3000 ft (1,000m). Mt. mahogany is a strong sprouter and rapidly regains its relative cover following fire. It is often codominant with scrub oak on these sites. Cup-leaf ceanothus, buckbrush and chaparral whitehorn are the most common associates in seral communities. This is a valuable range site due to the high palatability of associated shrubs and good forage production in early seral communities. Scrub oak-chaparral whitehorn is a seral community usually found at mid-elevations of the Mixed Chaparral range. Mature stands of this

association are usually nearly pure scrub oak or at higher elevations and more northerly latitudes interior live oak (*Quercus wislizenii*) replace scrub oak. Scrub oak-toyon is characteristic of mature north aspect sites at low elevations. Foothill ash and elderberry are often associated on moist sites. Hairy ceanothus and woollyleaf ceanothus are associated in seral communities. Scrub oak-hoaryleaf ceanothus occurs on moderately dry low elevation sites. Mature stands are nearly pure scrub oak with variable cover of black sage (*Salvia mellifera*) in openings left by declining ceanothus.

Tom White
Forest Service
Escondido, CA 92025

CEANOTHUS MIXED CHAPARRAL
SRM 208

Definition and Composition: Ceanothus Mixed Chaparral is a type made up of a variety of seral plant communities dominated by ceanothus species (50-80 percent cover) (Hanes 1977). Dominant species include hoaryleaf ceanothus (*Ceanothus crassifolius*), buckbrush (*C. cuneatus*), cupleaf ceanothus (*C. greggii*), hairy ceanothus (*C. oliganthus*) and woollyleaf ceanothus (*C. tomentosus*). Pure stands of chaparral whitehorn (*C. leucodermis*), deerbrush (*C. integerrimus*), buckbrush or Palmer ceanothus (*C. palmeri*) are indicators of potential oak woodland or conifer forest sites. The presence of associated species such as scrub oak (*Quercus dumosa*), chamise (*Adenostoma fasciculatum*), bigberry manzanita (*Arctostaphylos glauca*) or Eastwood manzanita (*A. glandulosa*) in low cover values, indicates a Ceanothus Mixed Chaparral site versus a potential oak woodland or conifer site. Sites where chamise is codominant with ceanothus species are described under the Chamise Chaparral type.

Geographic Distribution: Ceanothus Mixed Chaparral occurs from Baja California through California and into southwestern Oregon (Hanes 1977). This is the least abundant of the mixed chaparral types although it can be locally extensive on favorable sites.

Ecological Relationships: This type often occurs on moderately deep to deep alluvial/colluvial soils or more mesic sites than surrounding Chamise or Scrub Oak Mixed Chaparral stands on shallow soils. As stands mature after fire, individual ceanothus plants decline and eventually die out leaving openings in the stand. These openings are often occupied by sub-shrubs such as California buckwheat (*Eriogonum fasciculatum*), black sage (*Salvia mellifera*), and at low elevations California sage (*Artemisia californica*) (Hanes 1977).

Although there is a high percentage of mortality in ceanothus as stands mature, some individuals persist for relatively long periods of time compared to plant communities with higher covers of sprouting shrub species. Moderate to long interval high intensity wildfires are likely to maintain this type (Keeley and Zedler 1978). Frequent fires can reduce the cover of ceanothus and other obligate seeding shrub species and develop stands dominated by the associated sub-shrubs and annual herbaceous vegetation (Zedler, Gautier and McMaster 1983).

Tom White
Forest Service
Escondido, CA 92025

MONTANE SHRUBLAND
SRM 209

Definition and Composition: Montane shrubland varies markedly throughout California. Montane shrubland is characterized by evergreen species; however, deciduous or partially deciduous species may also be present. Species composition changes with elevational and geographical range, soil type and aspect. One or more of the following species usually characterize montane shrubland communities: whitethorn ceanothus (*Ceanothus cordulatus*), snowbrush ceanothus (*C. velutinus*), greenleaf manzanita (*Arctostaphylos patula*), pinemat manzanita (*A. nevadensis*), Hoary manzanita (*A. canescens*), bitter cherry (*Prunus emarginata*), huckleberry oak (*Quercus vaccinifolia*), Sierra chinquapin (*Castanopsis sempervirens*), juneberry (*Amelanchier pallida*), fremont silktassel (*Garrya fremontii*), Greene goldenweed (*Haplopappus greenei*), mountain mahagony (*Cercocarpus betuloides*), toyon (*Heteromeles arbutifolia*), sumac (*Rhus* sp.), and California buckthorn (*Rhamnus californica*). As one or more of these species become dominant under various environmental regimes, further subclassification of the montane shrubland is possible (Krebs 1972, McNaughton 1968). Understory vegetation in the mature chaparral is largely absent. Conifer and oak trees may occur in sparse stands or as scattered individuals within the shrubland type.

Geographic Distribution: Montane shrubland is associated with mountainous terrain from mid to high elevation at 2745 to 9000 ft (915 to 3,050m). It occurs in southern California above 6400 ft (2130m) in the Transverse Range of Los Angeles, and in San Bernardino, Riverside and San Diego counties. In the northern portion of the state, montane chaparral is found between 2750 and 8250 ft (915 and 2,750m), from Siskiyou to Kern counties in the Cascade and Sierra Nevada mountains; and as a minor type in other mountainous areas (Barbour and Major 1977).

Montane shrubland can be found on shallow to deep soils, on all exposures, and from gentle to relatively steep slopes. It may dominate on more xeric sites, but occurs locally throughout the coniferous forest zone. Generally, climate is like that associated with the coniferous forest zone-cold winter temperatures with substantial precipitation; summers are typically hot and dry (Barbour and Major 1977).

Ecological Relationships: Montane shrubland in California occurs in gradations between two characteristic successional sequences. The first sequence is associated with poorer, typically shallow soils, often overlying fractured bedrock. Here, shrub species may dominate to form an edaphic climax community.

In the second sequence, shrubs are a secondary sere following disturbance on deeper forest soils. After disturbance, such as fire, logging,or erosion, shrubs often proliferate and may exclude conifers and other vegetation for many years. However, shrubs may facilitate the germination of red fir (*Abies magnifica*) seedlings (Barbour 1984) and other shade tolerant conifers by providing a protective cover, moderating microclimate, and improving soil conditions. Montane shrubs may be an essential link in forest succession by building up soil nutrient levels, especially nitrogen, to the point where trees can survive (Zavitovski and Newton 1968).

Montane shrubs are fire adapted. Mature plants often sprout vigorously from root crowns, while some species germinate readily from seed after fire (Gratkowski 1961). However, if fires are too frequent, seed-dependent species may be eliminated (Biswell 1969). Deer and livestock foraging on sprouting shrubs may also have a significant effect on rates of development, structure, and ultimate species composition (Biswell and Gilman 1961, Davis 1967). The forage yields of most sprouting shrubs are reduced for the first few years following fire, but rapidly regain their original status.

Following fire, herbaceous plants may dominate for up to five years. Usually within 7 to 9 years, the shrub overstory is fully developed (Sweeney 1956, Sampson 1944). Shrubs may persist for 50 years or longer before conifer development to significantly reduce the shrub growth through shading (Lyon 1969, Sweeney 1968). Where montane shrubland occurs as an edaphic climax, growth rates may be slow and growth form is usually small and stunted, although individuals may be quite old. Development of montane shrubland at high elevations is often slowed by cold temperature, snow and short growing season (Barbour and Major 1977).

Montane shrubland provides habitat for a wide variety of animals including rodents, deer, livestock, rabbits, and birds. Deer and other herbivores often make extensive use of montane shrubland as summer foraging areas, escape cover and fawning habitat. Other animals use montane for fall and winter forage, and shade during hot weather.

Variants and Associated Species: Montane shrubland adjoins a variety of other types, including montane riparian, mixed chaparral, and perennial grassland cover types. It becomes established in disturbed coniferous habitats such as ponderosa pine (*Pinus ponderosa*), mixed conifer, Jeffrey pine (*P. jeffreyi*), red fir, and lodgepole pine (*P. contorta*). At high elevation in the southern Sierra, it may occur with a sparse juniper (*Juniperus* spp.) overstory. At the lower extent of its elevation range, montane shrubland may intergrade with mixed chaparral, a very similar cover type. As a successional stage following disturbance, its distribution coincides with the ponderosa pine and mixed coniferous forest cover types (Barbour and Major 1977).

Montane shrubland has been broadly described as chaparral (Munz and Keck 1973). Other descriptions have been based on dominant species and cover types name for individual species or in mixed associations (Parker and Matyas 1981).

Roland J. Riser and Michael Fry
Pacific Gas &
Electric Company
San Ramon, CA

BITTERBRUSH
SRM 210

Definition and Composition: Bitterbrush is rarely found in pure stands. Two species occur; antelope bitterbrush (*Purshia tridentata*) which is slightly larger and grows in more mesic sites than desert bitterbrush (*P. glandulosa*). Antelope bitterbrush often occurs asa codominant with big sagebrush (*Artemisia tridentata*) or rubber rabbitbrush (*Chrysothamnus nauseosus*). It is also found with gray horsebrush (*Tetradymia canescens*) Douglas rabbitbrush (*Chrysothamnus viscidiflorus*), Mormon tea (*Ephedra fasciculata*), curleaf mountain mahogany (*Cercocarpus ledifolius*), and desert peach (*Prunus andersonii*). Overstory species include ponderosa pine (*Pinus ponderosa*), Jeffrey pine (*P. jeffreyii*), lodgepole pine (*P. contorta*), or western juniper (*Juniperus occidentalis*). Understory herbaceous plants vary greatly in composition and density; examples include Idaho fescue (*Festuca idahoensis*), bottlebrush squirreltail (*Sitanion hystrix*), needlegrass (*Stipa* spp.), bluebunch wheatgrass (*Agropyron spicatum*), *Eriogonum* spp,. and *Phlox* spp. The total understory makes up less than 10% cover.

Desert bitterbrush is found mixed with big sagebrush, fourwing saltbush (*Atriplex canescens*), creosotebush (*Larrea tridentata*), rubber rabbitbrush, Mormon tea, spiny hopsage (*Grayia spinosa*), and on the north end of its range, antelope bitterbrush. Overstory associates commonly include Utah juniper (*Juniperus utahensis*), singleleaf pinyon (*Pinus monophylla*), Joshua tree (*Yucca brevifolia*) and at higher elevations, Jeffrey pine. Some of the common understory species include Thurber needlegrass (*Stipa thurberiana*), Eriogonum spp., common snakeweed (*Gutierrezia* spp.) and big galleta (*Hilaria rigida*). These usually total less than 5% cover.

Geographic Distribution: Bitterbrush is found on flats and slopes with deep, well-drained, rapidly permeable soils having a slightly acid reaction. Elevation varies with latitude, exposure, soil and precipitation. Antelope bitterbrush ranges from about 3100 to 10,000 ft (1,050 to 3,350m) east of the Cascade and Sierra Nevada crest from the north

border of the state, south to Inyo County, and west of the crest in Shasta and Siskiyou counties, and the Transverse ranges. Desert bitterbrush is found from 2970 to 10,560 ft (900 to 3,200m) elevation, from Inyo and Mono counties on the north where it mixes with antelope bitterbrush, south along the mountains bordering the west side of the Colorado desert, south to the Mexican border. Precipitation in bitterbrush types varies from about 12 to 36 inches (30 to 90cm) and is mostly snow in the winter. Desert bitterbrush sites receive about 10 inches (25cm) or less; summers are hot and the winters somewhat milder.

Ecological Relationships: Bitterbrush reproduces sexually by seeds, vegetatively by stem layering, and by sprouting after fire or mechanical damage. According to Nord (1965), sprouting by antelope bitterbrush is rare in California. However, prescription burning of antelope bitterbush stands in Plumas county in the spring induced substantial sprouting. Some stands of desert bitterbrush have been repeatedly renewed by fire, as its sprouts more readily than antelope bitterbrush. Many stands of antelope bitterbrush are even-aged because they resulted from disturbance by fire or destructive grazing, which reduced competition when seed was available (Leopold 1950, Longhurst et,al. 1952, Neal 1981). Following disturbance, bitterbrush may reestablish itself on a site and exist as a nearly pure stand or as a component of a mixed shrub type (Martin 1983). Shrubs moderately browsed since they were young tend to become globular and tightly hedged, which protects them from overuse. Unbrowsed or lightly browsed plants tend to remain open-crowned and are susceptible to damaging overbrowsing and early death.

Seeds of antelope bitterbrush areoften infested with insects, rendering them infertile (Furguson et al. 1963). Late spring freezes frequently kill seed, and rodents consume a large portion of the seed crop. Seedlings emerging from rodent caches, often including hundreds of seeds, frequently die from intraspecific competition. Rodents and other animals, including insects, may damage or consume the seedlings in the cotyledon stage. Many seedlings succumb to a lack of moisture the first summer (Hubbard 1956, Sanderson 1962). Desert bitterbrush usually reproduces by sprouting, thereby avoiding many of these hazards.

Several bitterbrush stands over 125 years old have been found on deep, well-drained soils (Nord 1965). However, stands often become decadent at 30 years of age and die at 40 to 50 years. Stands tend to result from a single event, either a catastrophic disturbance or a rare year when many seedlings survive.

Bitterbrush is highly digestible and contains desirable levels of moisture, calcium, phosphorus, and fat (Hickman 1975). It tolerates considerable browsing, and leaves and twigs are favored by mule deer, pronghorn antelope, cattle, sheep, and horses. Many species of birds, rodents, and insects use seeds. Some of the more characteristic wildlife species that are found in Bitterbrush include the western fence lizard, gray flycatcher, Brewer's blackbird, green-tailed towhee, jackrabbits, least chipmunk, Belding's ground squirrel, kangaroo rats, and badger.

Variants and Associated Species: Bitterbrush habitats of both species are commonly included in other type descriptions in existing classification systems. For example, Bitterbrush is included in Cheatham and Haller's (1975) Sagebrush Scrub type. Barbour and Major (1977) list Pinyon-Juniper Woodlands, Sagebrush Steppe, Mountain Brush, Juniper Savanna, and Juniper-Shrub Savanna types that include both antelope and desert bitterbrush communities. Depending on soil condition and stand history, bitterbrush may give way to any of its other shrub associates. Particularly in basins and lowlands that have restricted drainage or alkali sols, bitterbrush gives way to low sagebrush (*Artemisia arbuscula*), silver sagebrush (*A. cana*) or one of the more moisture tolerant species. At higher elevation both species mix with ponderosa and jeffrey pine. At lower elevation, antelope bitterbrush mixes with sagebrush and pinyon-juniper communities. Desert bitterbrush occurs with pinyon-juniper, juniper, and joshua tree communities, and adjoins desert scrub communities.

Donald L. Neal
USDA Forest Service
Fresno, CA

CREOSOTE BUSH SCRUB
SRM 211

Definition and Composition: Creosote bush (*Larrea tridentata*) is the dominant species occurring in this cover type. Co-dominant species such as burro weed (*Franseria dumosa*), galleta grass (*Hilaria rigida*), jumping cholla (*Opuntia bigelovii*), cheese bush (*Hymenoclea salsola*) and brittle bush (*Encelia farinosa, E. frutescens*) occur regionally. Creosote bush and burro weed are most prominent. Other species occurring in this type are Ephedra sp., blackbush (*Coleogyne ramosissima*), hedgehog cactus (*Echinocactus* sp.), yucca (*Yucca* sp.), Joshua tree (*Yucca brevifolia*), ocotillo (*Fouquieria splendens*), indigo bush (*Dalea*), boxthorn (*Lycium*), globemallow (*Sphaeralcea ambigua*), cactus (*Echinocereus engelmanii, E. mojavensis*), golden cholla (*Opuntia echinocarpa*), beaver tail cactus (*O. basilaris*), mesquite (*Prosopis juliflora*), screwbean mesquite (*P.pubescens*) and various perennial and annual grasses and forbs. Baccharis (*Baccharis brachyphylla, B. sergiloides*), desert ironwood (*Olneya tesota*), arrowweed (*Pluchea sericea*) and desert willow (*Chilopsis linearis*) occurs along water courses (Munz and Keck 1973).

Geographic Distribution: Creosote Bush Scrub is the most widespread plant community in the southern deserts of California. It is found below sea level in Death Valley up to elevations of 3,500 ft (1,067m) elsewhere. It occurs locally in some interior cismontane valleys in Tulare and western

Riverside counties (Ornduff 1974). Summer temperatures are high, and winter temperatures are typically above freezing. Average annual rainfall ranges from 2-8 in (5-20cm).

Regionally, in the western Mojave, creosote bush is a strong dominant on stable alluvial fans where erosion is minimal. Also occurring in these areas are long-lived perennials including burro weed, ephedra, turpentine broom (*Thamnosa montana*), needlegrass (*Stipa speciosa*), cholla and short-lived perennials including cheese bush, *Dyssodia* sp., and goldenhead (*Acamptopappus* sp.). In the northern Mojave, creosote bush also occurs with saltbush (*Atriplex hymenelytra*) or (*A. polycarpa*) just above the zone of available ground water.

In the southern Mojave and into the Colorado desert, creosotebush is co-dominant with burro weed. Galleta grass is also abundant in sandy flats below 4500 ft (1,500m) (Munz and Keck 1973). At higher elevations creosote bush is present with Joshua tree. Creosote bush is also co-dominant with large stands of jumping cholla (*Opuntia bigelovii*) and burro weed (Vasek and Barbour 1977). In these areas, cholla and burro weed tend to be dominant on disturbed sites with creosote bush occupying undisturbed sites. Galleta grass has also been observed to do well in disturbed areas.

Ecological Relationships: Creosote Bush Scrub occurs on well-drained sandy flats, bajadas and upland slopes (Vasek and Barbour 1977). On washes, outcrops, and steep slopes creosote bush is present but not dominant. It is excluded from dense soils and actively disturbed sites.

The vegetation type is adapted to long periods of drought. Low temperatures and low salt concentration are thought to limit creosote bush in Death Valley. Germination is difficult in nature due to specific requirements of temperature, moisture and scarification (Barbour 1968).

Creosote bush is a climax species dominating late successional stages, often occurring as the sole dominant or co-dominant with burro weed. It is seldom present in newly disturbed sites. Recovery for disturbed creosote communities is extremely slow (Vasek and Lund 1980). Shorter-lived species such as goldenhead, globemallow, cheese bush, brittle bush, and *Stephanomeria pauciflora* increase in population size when the longer-lived species such as creosote bush, burro weed and ephedra are reduced in number by disturbance (Vasek et al. 1975). These pioneer and short-lived species have a greater forage value. During years of above-average moisture conditions, herbaceous perennials will grow providing further forage.

The palatability of creosote bush is very low for grazing animals. It may be nibbled slightly by some animals during periods of low forage, but is not used at all by others. The browse value is classified as poor to worthless for grazing animals (Sampson and Jespersen 1963, Stubbendieck et al. 1986).

Variants and Associated Species: Water courses within the CreosoteBush Scrub community support a woodland community that is adapted to take advantage of the occasional abundant supply of water during rainy peridos. The desert trees and shrubs occurring along these water courses include palo verde (*Cercidium floridum*), catclaw (*Acacia greggii*), desert willow, smoke tree (*Dalea spinosa*) and desert lavender (*Hyptis emoryi*) (Ornduff 1974). California fan palm (*Washingtonia filiferia*) often occurs with willows (*Salix* sp.) on alkaline spots within the water courses.

In the southern Mojave, creosote bush occurs with Joshua tree in a transition zone between the Creosote Bush Scrub and Joshua tree woodland communities (Miller and Stebbins 1964). At higher elevations and lower average summer and winter temperatures, Joshua tree becomes dominant with juniper (*Juniperus* sp.) and forms the Joshua tree woodland community where creosote bush is no longer present.

Barbara Holzman
University of California
Berkeley, CA 94720

BLACKBUSH
SRM 212

Definition and Composition: Blackbush (*Coleogyne ramosissima*) occurs mainly in disjunct stands where it may comprise 95 percent of the vegetation. Plants from the creosote bush (*Larrea tridentata*) and pinyon (*Pinus* spp.) juniper (*Juniperus* spp.) types are common associates, and include spiny hopsage (*Grayia spinosa*), mormon-tea (*Ephedra* spp.), rabbitbrush (*Chrysothamnus* spp.), desert thorn (*Lycium andersonii*), desert bitterbrush (*Purshia glandulosa*), antelope bitterbrush (*Purshia tridentata*), big sagebrush (*Artemisia tridentata*), California buckwheat (*Eriogonum fasciculatum*), and goldenbush (*Haplopappus cooperii*). Red brome (*Bromus rubens*) and filaree (*Erodium cicutarium*) may be in the understory, as well as desert needlegrass (*Stipa speciosa*) and black grama (*Bouteloua uripoa*) where the shrub cover is reduced.

Geographic Distribution: Blackbush extends from southwestern Colorado across southern Utah and Nevada to southeastern California, with extensive stands in the southern end of the Great Basin Desert and higher elevations of the Mojave Desert. It occurs on dry sites below 5400 ft (1,800m) in the lower and upper Sonoran life zones between the creosote bush and pinyon-juniper woodland types (Sampson and Jesperson 1963, Shreve and Wiggins 1964, McLeary 1968, Bowns 1973, Bates 1984).

Ecological Relationships: Climatic and edaphic factors are both important in the distribution and zonation of blackbush. The type tends to occupy dry sites, often slopes with coarse sandy, gravelly, stony, or otherwise coarse soils which are non-alkaline and low in salt content (McLeary 1968, Foster 1968). The distinct zonation between blackbush and other vegetation types tends also to suggest a soil moisture limitation.

Blackbush dominates the sites on which it occurs, but is generally quite sensitive to disturbances such as fire, chaining, and cabling, as the plant is a weak and variable sprouter. In most cases, blackbush has reoccupied dry disturbed sites more rapidly than the more mesic sites.

The species is a fair winter forage species for mule deer, bighorn sheep, and domestic livestock. Only goats will browse the shrub extensively, as the dead, spinescent branches discourage other animals.

Variants and Associated Species: A most common associate of blackbush is spiny hopsage. Occasional associates are big sagebrush, antelope and desert bitterbrush, desert almond (*Prunus fasciculata*), California buckwheat, goldenbush,and Nevada ephedra (*Ephedra nevadensis*). Scattered concentrations of desert thorn and mormon tea may occur within stands. Where shrub cover is reduced, perennial grasses such as desert needlegrass and black grama may be prominent. Filaree, red brome, fescues (*Festuca* spp.), cheatgrass (*Bromus tectorum*), cryptantha (*Cryptantha* spp.), Mormon tea, buckwheat (*Eriogonum* spp.), mentzelia (*Mentzelis* spp.), Parry's monkeyflower (*Mimulus parryi*), phacelia (*Phacelia* spp.), Pursh's plantain (*Plantago purshii*), (*Poa* spp.), Wallace's eriophyllum (*Eriophyllum wallacei*), *Androstephium breviolium, Calochortus flexuosus, Navarretia propinqua,* and *Stephanomeria parryi* occur as understory plants. A small amount of Sandberg's bluegrass (*Poa sandbergii*) can be found in some stands. Utah juniper (*Juniperus osteosperma*) and Joshua tree (*Yucca brevifolia*) may exist as overstory species, but their percent cover is generally very low (Bowns and West 1976, Bates 1984).

Robert E. Martin
University of California
Berkeley, CA 94720

ALPINE GRASSLAND
SRM 213

Definition and Composition: The vegetation above timberline can be classified physiognomically as meadows, both wet and dry, and willow scrub. Ratliff's (1982, 1985c) and Benedict's (1983) classifications are more detailed. Wet meadows are often dominated by the circumboreal beaked sedge (*Carex rostrata*) (Hermann 1970) where water stands several dm deep all summer, or by the grazing-resistant Nebraska sedge (*Carex nebraskensis*) (Hermann 1970, Ratliff 1983) where standing water does not persist. Tufted hairgrass (*Deschampsia caespitosa*) can be very prominent on some acid soils, that are wet in spring from snowmelt.On mesic sites that are wet in early summer from melting snow, the low growing shorthair reedgrass (*Calamagrostis breweri*) can form associations with *Oryzopsis kingii,* the often minute *Vaccinium nivictum,* or Anderson aster (*Aster alpigenus*) (Benedict 1983). Ratliff (1982) mentions that dry matter production averages 121 g/m2 on these sites which contain acute acid soils (pH 5.0).

On the dry side, Sierran alpine communities are "dominated" by shorthair sedge (*Carex exserta*) (Ratliff 1985a, 1985b). Soils are raw gruss, and they dry out quickly as the short alpine summer progresses. Shorthair sedge is often associated with such early summer, evanescent species as steershead bleedingheart (*Dicentra uniflora*) and least lewisia (*Lewisia (Oreobroma) pygmaea*) found immediately after snowmelt. Mat muhly (*Muhlenbergia richardsonis*) stands do occur at alpine elevations in the Sierra Nevada. The species is mildly halophytic. Water drains to it but not away from it, and since it occurs in the valley sagebrush belt and upwards it seems out of place in the alpine. Its low stature and matted growth fit however.

Other kinds of meadow vegetation are discussed and classified by Ratliff (1982, 1985c).

Geographic Distribution: Alpine communities occur above timberline and below permanent snow lines in the Sierra Nevada, Klamath and Cascade mountain ranges in California. In the southern Sierra Nevada, alpine communities generally occur above 10,500 ft (3,500m), while in the northern Sierra, alpine communities may occur at 9000 ft (3000m) and above. Actual timberline varies with geographic location and climatic influences. The vertical span of the alpine belt, as the difference between timberline and snow line, variesfrom 3900-4200 ft (1300-1400m) in the southern Sierra Nevada to 3938 ft (1200m) in the north to 2700 ft (900m) on Mt. Shasta, and to only 2100 ft (700m) in the more coastal Klamath mountains.

Ecological Relationships: Meadows above timberline are the grazed resource in the alpine Sierra Nevada (Ratliff 1982, 1985a; Benedict and Major 1982, Benedict 1983, Major and Taylor 1977). While grazing pressure by domestic sheep, John Muir's "hoofed locusts," was extremely heavy until well after the turn of the century, pack stock and the recently reintroduced mountain sheep (*Ovis canadensis*) are now the only large grazing ungulates.

Many sites above timberline have little soil but are rather talus or scree slopes, blockfields, cliffs, rocky moraines, or "f jell fields." They produce little vegetation biomass. Billings (1988) has recently reviewed alpine vegetation in a North American context.

Variants and Associated Species: On some wet sites in the alpine Sierra Nevada occur extensive willow communities. These have been neglected by range managers as well as other plant ecologists. They do form a very valuable forage resource however. The two prostrate willows, *Salix anglorum* and snow willow (*S. nivalis*) of Munz & Keck (1973) are circumpolar-alpine willows. Mountain willow (*Salix eastwoodiae*) is often considered subalpine, but the alpine Sierra Nevada has, besides the two prostrate willows mentioned, (*S. orestera*) as the Holarctic (*S. glauca*), barren ground willow (*S. brachycarpa*) on limestone or mildly alkaline soils, and (*S. planifolia*) on more nearly saturated soils

than the other medium-tall shrubs. Much additional work needs to be done on willow taxonomy. Species of willow differ markedly in palatability, but we seem to have no Sierra Nevada data on this point.

Shorthair sedge is very similar and closely related to the alpine (*C. elynoides*) occurring from Colorado to Nevada and to the taller, predominately Great Plains threadleaf sedge (*C. filifolia*) which also occurs from Manitoba to the Yukon, southward to Texas, Arizona and California (Hermann 1970).

Jack Major
University of California
Davis, CA 95616

COASTAL PRAIRIE
SRM 214

Definition and Compositionj: Herbaceous perennial plants dominate California's coastal prairie. California oatgrass (*Danthonia californica*), the most characteristic species, commonly associated with Idaho fescue (*Festuca idahoensis*) and red fescue (*F. rubra*) (Heady et al. 1977). Other common native grasses include Pacific hairgrass (*Deschampsia holciformis*), Pacific reedgrass (*Calamagrostis nutkaensis*), and species from the genera (*Hordeum, Poa, Bromus, Elymus, Agrostis, Melica, Stipa,* and *Agropyron*). Many broadleaved perennials occur, including locally abundant Douglas iris (*Iris douglasiana*), California buttercup (*Ranunculus californicus*), western blueeyegrass (*Sisyrinchium bellum*), and brackenfern (*Pteridium aquilinum*). Perennial grasses from Europe which dominate locally include sweet vernalgrass (*Anthoxanthum odoratum*), common velvetgrass (*Holcus lanatus*), and Kentucky bluegrass (*Poa pratensis*). Annuals are common in openings among the perennials and on disturbed sites; some, like hedgehog dogtail (*Cynosurus echinatus*), Ialian ryegrass (*Lolium multiflorum*), silver hairgrass (*Aira caryophyllea*), brome fescue (*Festuca dertonensis*), and broadleaf filaree (*Erodiumbotrys*) are introduced from the old world.

The annual growth cycle reflects thecoastal Mediterranean climate, with cool, wet winters and cool, foggy, but essentially rainless summers (Jackson 1985). Peak biomass occurs in spring, averaging about 2700 lb/ac (3000 kg/ha) (Bartolome et al. 1980), but can exceed 9000lb/ac (10,000kg/ha) (Cooper and Heady 1964). On a site with mixed perennials and annuals, perennials dominated community biomass in fall and winter, but by early spring introduced annual grasses made up most above ground biomass (Batzli and Pitelka 1970). Plant growth begins in fall with the first rains, and ends with the summer drought, but summer fog and cool temperatures may considerably extend the growing season. This mitigation of summer drought may explain both the persistence of native perennials and the origin of exotic species (Jackson 1985). In contrast to the seasonally drier Valley Grassland, nearly all coastal introduced species originated in Europe and North Africa, not Eurasia and eastern Mediterranean (Baker 1989).

Geographic Distribution: The Coastal Prairie is found along the immediate coast of California from Monterey to Oregon (Heady et al. 1977), often on coastal terraces.

Ecological Relationships: The present Coastal Prairie shows the effects of livestock grazing, cultivation, changes in fire regime, and tree planting; activities which have greatly altered the extent and composition of native vegetation since about 1850.

Livestock damaged the native species and contributed to invasion of nonnative annual and perennial plants (Heady et al. 1977). The extent of this change is not well documented, although Burtt-Davy (1902) interviewed early settlers who had observed the decline of species such as California oatgrass. Grazing rarely eliminates perennials and recovery from heavy grazing can be rapid. Cooper (1960) observed return of California oatgrass twoyears after a stocking rate reduction and imposition of a rotational grazing system. Elliott and Wehausen (1974) also suggested that successional models for range condition adequately explained vegetation change from annual to native perennial dominated grasslands. Early in a study of vegetations change following livestock removal Hecktner and Foin (1977) noted that native perennial species were recovering. However, a few years later they found that the exotic perennial sweet vernalgrass, not native perennials, had become dominant (Foin and Hecktner 1986) and they doubted that native plants would ever dominate again.

The coastal prairie was the scene for a celebrated success in biological control. By the late 1940's the toxic shrub, Klamath weed (*Hypericum perforatum*) had invaded and dominated a million acres of northern California grassland. With introduction of the Klamath weed battle, the shrub quickly became rare and was largely replaced with native grasses (Huffaker and Kennett 1959).

The Coastal Prairie and North Coastal Shrub boundary is strongly affected by grazing and fire (McBride and Heady 1968). Fire suppression allows for shrub expansion, as does grazing removal. In many areas of the Coastal Prairie, cultivation was widespread, and destroyed the native vegetation (Heady et al. 1977). In the past 100 years, many coastal grasslands have been invaded or planted to Monterey pine (*Pinus radiata*).

Variants and Associated Species: The coastal prairie varies considerably in composition of the dominants. Local variation in dominance was described for ungrazed coastal prairie by Peart and Foin (1985). They recognized four patch types; one dominated by annuals and the exotic perennial (*Rytidosperma pilosa*), two dominated by the introduced perennials common velvetgrass and sweet vernalgrass, and one by the native Pacific hairgrass.Many northern grasses find their southern limit in the Coastal Prairie, including

spike trisetum (*Trisetum spicatum*), Geyer oniongrass (*Melica geyeri*), Pacific hairgrass, and Pacific reedgrass (Heady et al. 1977). Additionally, two species found at higher elevations, sheep fescue (*Festuca ovina*) and alpine timothy (*Phleum alpinum*) are found near the coast. Serpentine soils are usually dominated by purple needlegrass (*Stipa pulchra*) and contain numerous endemics, some exceptionally rare and localized such as Tiburon Mariposa (*Calochortus tiburonensis*). In southern California, the purple needlegrass dominated Valley Grassland type reaches the coast (Barry 1972).

James W. Bartolome
University of California
Berkeley, CA 94720

VALLEY GRASSLAND
SRM 215

Definition and Composition: Herbaceous annual plants characterize the Valley Grassland of California. Species from the grass genera (*Avena, Bromus, Festuca,* and *Hordeum*) mix with other annuals from common genera like *Erodium, Trifolium, Madia, Amsinckia,* and *Brassica* (Heady 1977). Although native plants are usually present, species of Eurasian origin provide most plant productivity in the Valley Grassland.

Plant growth is strongly seasonal and well adapted to California's Mediterranean climate with fall germination from seeds produced the previous spring, slow winter growth, followed by rapid spring growth, maturity, and death (George et al. 1985). Only a few species of annuals grow through the yearly summer drought (Pendleton et al. 1983). The peak standing crop in spring varies considerably from year to year and among sites but can exceed 3600lb/ac (4000 kg/ha) (Bartolome et al. 1980).

Geographic Distribution: Valley Grassland surrounds California's Great Central Valley, occupying the foothills below about 1500 ft (500m) elevation. Other extensive Valley Grassland regions are the valley of the central and south Coast Ranges (Heady 1977). The type is exclusively Californian.

Ecological Relationships: The Valley Grassland was once dominated by perennial grasses (Bartolome et al. 1986). For descriptions of potential or natural vegetation refer to the Pacific bunchgrass or California prairie communities in Heady (1977). Introduction of domestic livestock and aggressive Mediterranean annual grasses in the late 18th and early 19th centuries resulted in the replacement of the perennial bunchgrasses by annual grasses and forbs (Burcham 1957).

The annual grasslands are a stable new vegetation type. In some areas, especially near the coast, remnant native perennial bunchgrasses persist and have increased with protection from heavy livestock use (Heady et al. 1977). However, alterations in livestock grazing generally do not result in successional changes towards the original vegetation (Bartolome and Gemmill 1981). Instead, species composition of introduced annuals changes (Heady 1956, 1961). Patterns of grazing-induced succession are relatively minor compared to fluctuations in composition and productivity in response to annual rainfall and temperature patterns (Bentley and Talbot 1951, Pitt and Heady 1978, George et al. 1988).

Variants and Associated Species: Many Valley Grassland species are important in other types. For example, the border between Valley Grassland and adjacent oak savanna is rarely well defined and oftenr eflects recent oak clearing. Changes in oak canopy influencesboth productivity and composition of the understory annual plants (McClaran and Bartolome 1989). Valley Grassland species are also important as early seral plants in burned chaparral (Bartolome 1987). Conversely, Valley Grassland has been invaded by coastal shrub or chaparral species following changes in fire and grazing regime (Heady 1977).

Species composition in the Valley Grassland varies with average annual rainfall and distance from the coast. Perennial grasses are commonly present in more mesic coastal regions. Soft chess (*Bromus mollis*) and broadleaf filaree (*Erodium botrys*) commonly dominate in the Sacramento Valley, and red brome (*Bromus rubens*) and redstem filaree (*Erodium cicutarium*) dominate the more arid southern regions (Bartolome et al. 1980).

Serpentine and vernal pool sites support a unique, often native-dominated flora. Serpentine soils vary considerably in structure and composition, but are derived from ultramafic rocks characteristically high in magnesium and often with high levels of trace minerals (Kruckeberg 1984).

Vernal pools harbor several endemic species, including the unique grasses from the Orcuttiae tribe, (*Tuctoria* and *Neostapfia*) (Jain and Moyle 1984). These sites accumulate standing water during the winter and spring, but dry rapidly in early summer. The native annual species are adapted to an aquatic existence early in their life cycle and to drought during reproduction.

James Bartolome
University of California
Berkeley, CA 94720

Joel Brown
Soil Conservation Service
Davis, CA 95616

MONTANE MEADOWS
SRM 216

Definition and Composition: Montane meadows are habitats occupied by grass (*Poaceae family*) and grasslike species primarily of the genera *Carex, Juncus,* and *Luzula.* Meadow composition is diverse and Ratliff (1985c) suggests that over 1500 meadow types, based on species, topography, and hydrology, may be identifiable. The primary environmental characteristic of meadow vegetation is an associated high water table, during all or part of the year (Benedict 1982, Ratliff 1985c, Allen-Diaz 1991).

Meadows may generally be classified as wet/mesic meadows or dry meadows. The wet/mesic type is characterized by a continuous vegetation canopy and standing water all or part of the year (Allen 1987). These meadows grade from sites with standing water, dominated by (*Sphagnum*) or (*Juncus*) species, to more well-drained sites dominated by sedges, grasses, and forbs. Dry meadow types generally contain no standing water and are comprised of dryland sedges, grasses and forbs. Short hair sedge meadows, dominated by *Carex exserta*), are examples of high elevation dry meadows. Willows (*Salix* sp.) may be a component of meadow vegetation along stream courses within the meadow.

Meadow production is variable, but generally decreases with increasing elevation in excellent condition meadows (Ratliff 1985c). Ratliff (1985c) reported herbage production for seven meadow series ranging from 290 lb/ac (325 kg/ha) for short-hair sedge meadows to 2830 lb/ac (3145 kg/ha) for Nebraska sedge (*Carex nebrascensis*) meadows. Allen (1989b) reported that meadow production for stringer meadows along water courses in the central Sierra averaged 2460 lb/ac (2733 kg/ha) over a 10-year period, though dry sites within the stringer system averaged 1430 lb/ac (1590 kg/ha), mesic sites averaged 2745 lb/ac (2495 kg/ha), and wet sites produced an average of 3800 lb/ac (4210 kg/ha). Higher elevation meadows produced an averaged of 3000 lb/ac (3300 kg/ha) (Allen-Diaz 1991).

Geographical Distribution: Meadows are found scattered throughout all six major mountain ranges in California and occupy over 500,000ac (200,000 ha). They occur between 3600-5400 ft (1200 and 1800m) elevation throughout the coniferous forests of California.

Meadows vary in size from several hundred hectares occupying relatively flat drainage basins to narrow stringers following water courses. Montane Meadows may also be less than a hectare in size associated with springs and seeps.

Ecological Relationships: Meadows in the Sierra Nevada are relatively stable biological systems that respond to disturbance (e.g., grazing, road building, timber harvesting) primarily through changes in water regimes. The oldest meadows in California are 10,000 to 12,000 bp, and evidence from Wood (1975) suggests that meadows have gone through forest-herbaceous dominated vegetation cycles over time. The common thread for meadows is a shallow water table and high water table during some portion of the year.

Meadow soils are characterized by 4 general layers, though not all meadows have this four layer sequence (Ratliff 1985c). In the general meadow soil model, the surface layer is composed of organically rich materials, which overlay a stratified sand layer with no profile development. The third layer is generally a Paleosol or old soil high in reduced ferrous iron, while the fourth layer is coarse pre-Holocene alluvium. Tephra deposits are often used as benchmarks for dating meadow succession.

Variants and Associated Species: Montane meadows may be associated with willow communities along streamcourses. They are also associated with fen communities where accumulations of peat, underground water supply and water chemistry combine to support fen species including; glutin tofieldia (*Tofieldia glutinosa*), fewflowered spikerush (*Eleocharis pauciflora*), and Anderson aster (*Aster alpigenus*). Most often, montane meadows are surrounded by or interspersed with different forest communities, including mixed conifer, red fir (*Abies magnifica*), Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), and lodgepole pine (*Pinus contorta*), depending on elevation. Although meadows are relatively stable ecosystems over geologic time, changes in the drainage system may radically alter meadow species' capabilities to persist (Benedict 1982). Change in meadow hydrology, which results in a lowering of the water table, often leads to forest occupation of meadow sites (Wood 1975). Return of montane meadow communities is possible only with the return of hydrologic conditions which support meadow species.

Barbara H. Allen-Diaz
University of California
Berkeley, CA 94720

WETLANDS
SRM 217

Definition and Composition: California wetlands are diverse and are products of many variables, including geographic location, water duration, depth, and salinity, and plant species composition (Barry 1989). Wetlands can be divided into two major types: fresh emergent wetland and saline emergent wetland (Kramer 1988, Springer 1988). Fresh emergent wetlands are characterized by frequent flooding, upright, perennial hydrophytes and roots that are adapted to anaerobic conditions (Cowardin et al. 1979, Kramer1988). On moist sites of the fresh emergent wetlands species such as big leaf sedge (*Carex amplifolia*), balticrush (*Juncus balticus*), redroot nutgrass (*Cyperus erythrorhizos*) dominate, while on more alkali sites, saltgrass (*Distichlis spicata*) dominates. On wetter sites, tule bulrush (*Scirpus validus*), river bulrush (*Scirpus fluviatilis*), and arrowhead (*Sagitarria* spp.) are potential dominants (Kramer 1988).

Saline emergent wetlands are characterized by salt or brackish water and are dominated by distinctive vascular plants such as cordgrass (*Spartina* spp.), pickleweed (*Salicornia* spp.), saltgrass (*Distichlis spicata* var. *stricta*), marsh dodder (*Cuscuta* spp.) and others (Springer 1988). The mostly perennial graminoids and forbs often occur in patches or along elevational gradients within the marsh, although component plants sometimes occur in zones (Springer 1988).

Geographic Distribution: Fresh emergent wetlands occur throughout the state on virtually all exposures and slopes, provided a basin or depression is saturated or periodically flooded (Kramer 1988). Vegetation often occurs in concentric circles, following basin contours and changes in duration and depth of water. Soils are predominantly clay and silt, although organic material may predominate on specific sites (Cowardin et al. 1979). Saline emergent wetlands occur along the margins of estuaries, bays, and lagoons protected from wave action (Springer 1988). Duration and depth of submergence varies with location, from short and infrequent to weeks or months of exposure. Soil salinity varies depending on fresh water run-off and evapotranspiration (Springer 1988). Climatic conditions for both fresh emergent and saline emergent wetlands are highly variable, ranging from mild coastal conditions in the south, to desert heat to cold freezing winters of the Modoc Plateau.

Ecological Relationships: Fresh emergent wetlands are relatively stable successionally, but may be transitory in a geological timeframe (Benedict 1982). Succession occurs with siltation of basins, reduction in periods of flooding and eventual replacement of species by those adapted to drier conditions. Overall, the acreage of fresh emergent wetlands in California has decreased tremendously because of drainage and conversion to other uses, primarily agriculture (Jones & Stokes 1987). Fresh emergent wetlands are among the most productive habitats providing food, cover, and nesting opportunities for more than 160 species of birds, and numerous mammals, reptiles, and amphibians (Kramer 1988).

Saline emergent wetlands becomes established as low marsh on intertidal flats which gradually changes to higher marsh, dominated by cordgrass, pickleweed or alkali heath (*Frankeria grandefolia*) to name a few species (Springer 1988). Although sites nearer the sea may fluctuate widely, higher marsh is believed to be more stable, persisting for periods of 700 years (Springer 1988). Sedimentation rates, coastal submergence, diking, ditching, dredging, hydraulic mining and other activities influence composition and duration saline emergent wetland vegetation.

Variants and Associated Species: Fresh emergent wetland is also known as riverine, lacustrine, and palustrine emergent wetlands (Cowardin et al. 1979). Cheatham and Haller (1975) identify tule marsh, cattail-sedge (*Typha-Carex*), fresh water marsh, and alkali marsh communities as variants of the general fresh emergent wetland described here. The fresh emergent wetland may occur in association with meadow habitat, although the boundary between the types is identified by the habitats dominated by hyrophytic plants and habitats dominated by mesophytic or xerophytic plants (Kramer 1988). Saline emergent wetlands include coastal marsh, saltwater marsh, pickleweed-cordgrass, cattail-sedge, saltgrass and other similar type names (Cheatham and Haller 1975, Paysen et al. 1980, and Munz and Keck 1973). Saline emergent wetlands occur above intertidal mud flats and may grade into brackish and/or freshwater marshes (Springer 1988) farther inland. Barry (1989) lists 39 wetland types in California based on dominant species and environmental conditions.

Barbara H. Allen-Diaz
University of California
Berkeley, CA

Rangeland Cover Types

INTRODUCTION
SRM 300

The cover types in this section are the non-forested grasslands and shrublands of Fenneman's (1931) Northern Rocky Mountains physiographic province. This region includes mountains and valleys of western Montana, central and northern Idaho, and the Okanogan highlands of northeastern Washington. Much of the region is dominated by forest types, which are described elsewhere (Society of American Foresters 1980).

The grass and shrub-dominated cover types in this region are most extensive in southwestern Montana, in the wide intermountain valleys and extensive foothills common to the eastern extension of the province. The remainder of the area is characterized by essentially continuous mountain and gorge topography, so the grass and shrub cover types are limited in abundance and size.

Cover type names used have generally followed the usage of Mueggler and Stewart (1980). Cited references use several other classification systems. We offer no translations among authors. We have made our own assumptions of equivalence among plant community description and nomenclature.

Carl L. Wambolt and
John E. Taylor
Montana State University
Bozeman, MT

BLUEBUNCH WHEATGRASS-BLUE GRAMA
SRM 301

Definition, Composition, and Structure: In this cover type bluebunch wheatgrass (*Agropyron spicatum*) and needle-and-thread (*Stipa comata*) are strong co-dominants. Blue grama (*Bouteloua gracilis*) always is present, and sometimes assumes its own dominance, especially with disturbance (Mueggler and Stewart 1980, Payne 1973, Ross and Hunter 1976). Other typical graminoids are prairie junegrass (*Koeleria pyramidata*), sandberg bluegrass (*Poa secunda*) and sedges (*Carex* spp.). Characteristic forbs include Hood's phlox (*Phlox hoodii*), and scarlet globemallow (*Sphaeralcea coccinea*). Fringed sagewort (*Artemisia frigida*) and prickly pear (*Opuntia polyacantha*) are ubiquitous, and become more so with excessive grazing pressure (Payne 1973, Ross and Hunter 1976).

Geographic Distribution: This type is found primarily east of the continental divide in Montana, often on steeper slopes. It typically is found adjacent to and at slightly higher elevation than the Needle-and-thread - Blue Grama Type (Mueggler and Stewart 1980).

Ecological Relationships: This is vegetation of inherently droughty sites. Soils often are shallow and poor in water holding capacity. Both annual production and species composition are strongly influenced by amount of seasonal precipitation. This is especially noticeable in the relative proportions of the three predominant grasses; bluebunch wheatgrass, needle-and-thread, and blue grama (Mueggler and Stewart 1980, Ross and Hunter 1976).

Variants and Associated Species: On the less droughty end of the environmental gradient supporting this type a few more forbs appear, such as hairy goldenaster (*Chrysopsis villosa*), and dotted gayfeather (*Liatris punctata*). Plains reedgrass (*Calamagrostis montanensis*) may become abundant locally. With range deterioration bluebunch wheatgrass decreases in the composition and is replaced by needle-and-thread (Ross and Hunter 1976).

John E. Taylor
Montana State University
Bozeman, MT

BLUEBUNCH/WHEATGRASS-SANDBERG BLUEGRASS
SRM 302

Definition, Composition and Structure: Bluebunch wheatgrass (*Agropyron spicatum*) is the strong and characteristic dominant in this type, with Sandberg bluegrass (*Poa secunda*) and prairie junegrass (*Koeleria pyramidata*) commonly associated. Neither blue grama (*Bouteloua gracilis*) nor rhizomatous wheatgrasses are important. A needle-and-thread (*Stipa comata*) phase sometimes is seen, where this species shares dominance with bluebunch wheatgrass. Forb composition varies widely, both in species and in relative contribution to total cover. There are no diagnostic forbs species, but arrowleaf balsamroot (*Balsamorhiza sagittata*) is sometimes abundant, especially west of the continental divide.

Geographic Distribution: This type is found intermittently throughout western Montana and northern Idaho. It occupies moderately arid slopes at all exposures: elevations run from 3000 to 6000 ft (1000-2000m).

Ecological Relationships: Soils vary in origin, but usually are loamy to loamy sands, and may be shallow and rocky. Thus, they are rather susceptible to the effects of inappropriate grazing practices.

Variants and Associated Species: Bluebunch wheatgrass decreases rapidly with excessive grazing. Sandberg bluegrass and arrowleaf balsamroot may either increase or decrease, depending on the grazing animals involved (ie. cattle and horses vs. sheep). Fringed sagewort (*Artemisia frigida*) and broom snakeweed (*Gutierrezia sarothrae*) often assume dominant proportions. The aspect may become a shrub steppe through increases in big sagebrush (*Artemisia tridentata*) and rabbitbrushes (*Chrysothamnus* spp.). With continuing abuse, these sites may be reduced to cheatgrass brome (*Bromus tectorum*) and spotted knapweed (*Centaurea maculosa*).

John E. Taylor
Montana State University
Bozeman, MT

BLUEBUNCH WHEATGRASS-WESTERN WHEATGRASS SRM 303

Definition, Composition and Structure: This type is characterized by a very strong dominance of bluebunch wheatgrass (*Agropyron spicatum*), associated with the rhizomatous species, western wheatgrass (*A. smithii*) and/or thickspike wheatgrass (*A. dasystachyum*). Other important grasses are prairie junegrass (*Koeleria pyramidata*), needle-and-thread (*Stipa comata*), and small caespitose bluegrasses (*Poa secunda* and *P. cusickii*). Forbs, while not typically abundant, are relatively diverse. Hood's phlox (*Phlox hoodii*), scarlet globemallow (*Sphaeralcea coccinea*), hairy goldenaster (*Chrysopsis villosa*), and salsify (*Tragopogon dubius*) are common. The suffrutescents, fringed sagewort (*Artemisia frigida*) and broom snakeweed (*Gutierrezia sarothrae*) usually are present. On steeper slopes a green needlegrass (*Stipa viridula*) phase sometimes occurs (Mueggler and Stewart 1980, Payne 1973, Ross and Hunter 1976).

Geographic Distribution: This type is found both east and west of the continental divide, but is more common east. It occupies sites on all exposures, usually on relatively gentle slopes between 4000 and 5700 ft (1300-1900m) elevation (Mueggler and Stewart 1980).

Ecological Relationships: Annual precipitation is 12-18 inches (30-45cm), making sites moderately arid at these latitudes. The type often is interspersed with a shrub steppe type dominated by big sagebrush (*Artemisia tridentata* spp.) when the bluebunch wheatgrass - western wheatgrass cover type comprises the understory (Morris et al, 1976, Payne 1973).

Variants and Associated Species: With excessive grazing pressure bluebunch wheatgrass is replaced by needle-and-thread and rhizomatous wheatgrasses. This retrogressional type is relatively resistant to additional grazing pressure, so may be persistent for a long while. Other heavy grazing indicators include hairy goldenaster, Hood's phlox, fringed sagewort, plains pricklypear (*Opuntia polyacantha*) and broom snakeweed. Sometimes woody species such as big sagebrush and rabbitbrush (*Chrysothamnus* spp.) assume dominance by grazing-induced retrogression (Daubenmire 1970, Mueggler and Stewart 1980).

John E. Taylor
Montana State University
Bozeman, MT

IDAHO FESCUE-BLUEBUNCH WHEATGRASS SRM 304

Definition, Composition and Structure: Idaho fescue (*Festuca idahoensis*) is the diagnostic species in this type. Bluebunch wheatgrass (*Agropyron spicatum*) always is present and is clearly the co-dominant. Other wheatgrasses (*Agropyron*) species are much less significant. Associated graminoids include prairie junegrass (*Koeleria pyramidata*), Sandberg bluegrass (*Poa secunda*), and needlegrasses (*Stipa* spp.). Forb composition varies greatly, but usually is substantial in both species and abundance. Woody species are rare or absent except following disturbance (Daubenmire 1970, Mueggler and Stewart 1980, Sharp and Sanders 1978).

Geographic Distribution: This is one of the most wide-spread and important grassland types in the region. It occurs on a variety of sites throughout the Northern Rocky Mountains valleys and foothills (Daubenmire 1970, Daubenmire and Daubenmire 1968, Franklin and Dyrness 1973, Kuchler 1964, Morris et al. 1976, Mueggler and Stewart 1980, Sharp and Sanders 1978).

Ecological Relationships: This type is prevalent on intermediate slopes and elevations, mostly in the 15-19 inch (38-48cm) precipitation zone. Soils are various, but usually fairly deep and well-developed. This is very important habitat for both wildlife and domestic animals (Mueggler and Stewart 1980, Munn et al. 1978, Payne 1973).

Variants and Associated Species: A western needlegrass (*Stipa occidentalis*) phase occurs at higher elevations up to 7500 ft (2500m). With overuse, Idaho fescue may replace bluebunch wheatgrass temporarily, but then is itself replaced by such species as red three-awn (*Artistida*

longiseta), bluegrasses (*Poa* spp.), fringed sagewort (*Artemisia frigida*) and numerous forbs (Mueggler and Stewart 1980, Ross and Hunter 1976).

John E. Taylor
Montana State University
Bozeman, MT

IDAHO FESCUE-RICHARDSON NEEDLEGRASS SRM 305

Definition, Composition, and Structure: The proportion of Richardson needlegrass (*Stipa richardsonii*) (around 1/3 of the cover) and its constant co-dominance with Idaho fescue (*Festuca idahoensis*) define this relatively uncommon type. Other common, often abundant species are timber danthonia (*Danthonia intermedia*), western needlegrass (*Stipa occidentalis*) and sticky geranium (*Geranium viscosissimum*). A greatmany forbs are found in this vegetation. Shrubs are uncommon except for rose (*Rosa* spp.), which sometimes is conspicuous (Mueggler and Stewart 1980).

Geographic Distribution: This type is uncommon but widely distributed at medium to high elevations throughout the region on both sides of the continental divide. It occurs on gentle slopes and moderately deep soils (Mueggler and Stewart 1980, Sharp and Sanders 1978).

Ecological Relationships: This is a moderately mesic and productive vegetation type. Its primary use is for summer range for livestock and wildlife, particularly elk.

Variants and Associated Species: The grazing responses of many species in this type are not well understood, especially the taller needlegrass species. Otherwise, grazing reactions are similar to those of other mesic foothill and mountain grasslands (Mueggler and Stewart 1980, Payne 1973).

John E. Taylor
Montana State University
Bozeman, MT

IDAHO FESCUE-SLENDER WHEATGRASS SRM 306

Definition, Composition and Structure: Idaho fescue (*Festuca idahoensis*) is usually the dominant grass in this type with slender wheatgrass (*Agropyron trachycaulum*) consistently present. Other wheatgrasses are scarce or absent. Other significant graminoids are Columbia needlegrass (*Stipa columbiana*), and timber oatgrass (*Danthonia intermedia*), and sedges (*Carex* spp.) Forbs are diverse and abundant, more so than in any other major grassland type in the region. Typical species include avena (*Geum triflorum*), slender cinquefoil (*Potentilla gracilis*), pale agoseris (*Agoseris glauca*), and harebell (*Campanula rotundifolia*) (Mueggler and Stewart 1980).

Geographic Distribution: This cover type is found at moderate to high elevations of 6500 to 8500 ft, (2170-2830m) mostly east of the continental divide in Montana. It occupies gentle slopes and well developed soils from a wide variety of parent materials (Mueggler and Stewart 1980, Munn et al. 1978, Payne 1973).

Ecological Relationships: This is a moderately mesic type; precipitation falls within the 18 to 30 inch (45-75cm) zone. Growing seasons are short due to the high elevations. This is an extremely productive vegetation type, and is very important as summer range for many wild and domestic animals. It also constitutes a critical watershed (Mueggler and Stewart 1980, Payne 1973, Ross and Hunter 1976).

Variants and Associated Species: The generally favorable growing conditions and reliability of moisture in these zones produce a great variety of species and associations. An important example on more mesic sites is a sticky geranium (*Geranium viscosissinum*) phase, which is characterized by the presence of either mountain brome (*Bromus carinatus*) or nodding brome (*Bromus anomalous*) and rush-leaf bluegrass (*Poa juncifolia*) (Mueggler and Stewart 1980).

With heavy grazing, the dominant grasses tend to be replaced by less palatable and productive species such as timber oatgrass (*Danthonia intermedia*) common thistle (*Cirsium vulgare*), and a number of forbs. Several sedges (*Carex species*) also act as grazing increasers, and mountain big sagebrush (*Artemisia tridentata vaseyana*) may become abundant with continued abusive grazing (Mueggler and Stewart 1980, Payne 1973).

John E. Taylor
Montana State University
Bozeman, MT

IDAHO FESCUE-THREADLEAF SEDGE SRM 307

Definition, Composition and Structure: The absence of a dominant wheatgrass (*Agropyron* spp.) and the constant association and abundance of threadleaf sedge (*Carex filifolia*), prairie smoke (*Geum triflorum*) and gentian (*Gentiana affinis*) with Idaho fescue (*Festuca idahoensis*) separate this type from others. Slender wheatgrass (*Agropyron trachycaulum*) and several sedges (*Carex* spp.) also are common. The forb flora is rich and abundant. Characteristic species are pale agoseris (*Agoseris glauca*), and cinquefoils (*Potentilla* spp.). Shrubs are virtually non-existent (Mueggler and Stewart 1980, Payne 1973, Ross and Hunter 1976).

Geographic Distribution: This is an infrequent type of southwestern Montana. It is found on gentle slopes in or near mountain saddles at high elevations of 7800 to 9200 ft (2600-3100m) (Mueggler and Stewart 1980, Munn et al. 1978).

Ecological Relationships: The overriding ecological factors in this cover type are those related to high elevation and short growing seasons. Its limited distribution suggests a topo-edaphic requirement which is not widely available (Mueggler and Stewart 1980).

Variants and Associated Species: Changes in plant composition induced by careless grazing practices are similar to those described for other high elevation situations.

John E. Taylor
Montana State University
Bozeman, MT

IDAHO FESCUE-TUFTED HAIRGRASS SRM 308

Definition, Composition and Structure: This is a high elevation grassland type, with tufted hairgrass (*Deschampsia caespitosa*) and Idaho fescue (*Festuca idahoensis*) the most typical and productive graminoids. Associated species include slender wheatgrass (*Agropyron trachycaulum*), alpine timothy (*Pheum alpinum*), spike woodrush (*Luzula spicata*), and sedges (*Carex scirpoidea* for example). A high percentage of forbs is typical; common species are American bistort (*Polygonum bistortoides*), cinquefoil (*Potentilla diversifolia*) and clovers (*Trifolium* spp.). At highest elevations Idaho fescue often is replaced by sheep fescue (*F. ovina*).

Geographic Distribution: East and west of the continental divide on gentle to moderate slopes at high elevations 8000 to 10000 ft (2700-3300m). (Mueggler and Stewart 1980, Payne 1973, Sharp and Sanders 1978).

Ecological Relationships: This is a subalpine meadow type, which is important wildlife habitat. Its short growing season and restricted topo-edaphic requirements make its use limited in time and space (Mueggler and Stewart 1980, Munn et al. 1978).

Variants and Associated Species: The principal species adjustment to excessive grazing impact is the replacement of the more productive graminoids with lower quality species such as timber (*Danthonia intermedia*) and various forbs.

John E. Taylor
Montana State University
Bozeman, MT

IDAHO FESCUE-WESTERN WHEATGRASS SRM 309

Definition, Composition, and Structure: Idaho fescue (*Festuca idahoensis*) is the dominant graminoid, associated with rhizomatous wheatgrasses (*Agropyron smithii* and *A. dasystachyum*). Rough fescue (*Festuca scabrella*) is rare or absent, as is bluebunch wheatgrass (*Agropyron spicatum*). Bluegrasses (*Poa secunda* and/or *Poa cusickii*) may contribute substantial cover, especially as deterioration takes place. Forbs and shrubs are typically inconspicuous (Mueggler and Stewart 1980, Payne 1973).

Geographic Distribution: This type is found from Canada to Wyoming along the east slopes of the Rocky Mountains as they meet the plains. Most are on gentle slopes at elevations from 4000 to 6000 ft (1300-2000m) (Mueggler and Stewart 1980, Munn et al. 1978, Ross and Hunter 1976).

Ecological Relationships: This is a type of moderately dry sites; annual precipitation ranges from 15 to 19 inches (38-48cm). Soils are well developed on sedimentary materials. The rhizomatous growth of the co-dominants leaves little bare soil (Mueggler and Stewart 1980, Munn et al. 1978).

Variants and Associated Species: This cover type is remarkably uniform throughout its range. In deteriorated range condition Idaho fescue is replaced by the rhizomatous wheatgrasses, which in turn yield to such species as bluegrass, western yarrow (*Achillea millefolium*) and fringed sagewort (*Artemisia frigida*) (Mueggler and Stewart 1980, Ross and Hunter 1976).

John E. Taylor
Montana State University
Bozeman, MT

NEEDLE-AND-THREAD-BLUE GRAMA SRM 310

Definition, Composition, and Structure: This community type is characterized by a dominance of needle-and-thread (*Stipa comata*) and blue grama (*Bouteloua gracilis*). Other graminoids present are thickspike wheatgrass (*Agropyron dasystachyum*), prairie junegrass (*Koeleria pyramidata*), and threadleaf sedge (*Carex filifolia*). Common associates include fringed sagewort (*Artemisia frigida*), Hood's phlox (*Phlox hoodii*), and scarlet globemallow (*Sphaeralcea coccinea.*) There typically is a strong grassland aspect, with few forbs or shrubs. The type shares many characteristics of Northern Great Plains grasslands (Kuchler 1964, Mueggler and Stewart 1980, Payne 1973, Ross and Hunter 1976).

Geographic Distribution: This is the driest of the grasslands associated with the Northern Rocky Mountain region. It is found primarily on drier aspects of intermountain valleys and broad alluvial benches east of the continental divide and south of the 47th parallel (Mueggler and Stewart 1980, Payne 1973).

Ecological Relationships: The sites supporting this vegetation typically receive 10 to 14 inches (25-35cm) of annual precipitation and experience relatively high growing season temperatures. Soils tend to be silty or sandy, and often are shallow. Thus, these sites are inherently droughty, which makes the plant community especially vulnerable to poor grazing practices (Munn et al. 1978). This type may represent an extension of the Great Plains grassland as a result of induced drought caused by excessive livestock grazing. It may even be the legacy of pre-Columbian influences in some cases, since natural adjustments to changed grazing circumstances may be extremely slow (Mueggler and Stewart 1980, Payne 1973).

Variants and Associated Species: A Western wheatgrass (*Agropyron smithii*) phase occurs on some more mesic sites within this cover type. It is richer floristically, especially with forbs. Such species as hairy goldenaster (*Chrysopsis villosa*), scarlet gaura (*Gaura coccinea*), and dotted gayfeather (*Liatris punctata*) are conspicuous (Mueggler and Stewart 1980, Ross and Hunter 1976).

With excessive grazing pressure the vegetation composition changes, with blue grama, prickly pear (*Opuntia polyacantha*) and broom snakeweed (*Gutierrezia sarothrae*) becoming more abundant (Ross and Hunter 1976).

John E. Taylor
Montana State University
Bozeman, MT

ROUGH FESCUE-BLUEBUNCH WHEATGRASS SRM 311

Definition, Composition and Structure: This cover type is very strongly and conspicuously dominated by rough fescue (*Festuca scabrella*). Bluebunch wheatgrass (*Agropyron spicatum*) and Idaho fescue (*Festuca idahoensis*) usually are abundant, although the latter may be absent or inconsequential on some drier sites, especially near the eastern limit of the type. The general aspect is clearly grassland, although the composition is fairly rich floristically, containing numerous forbs, but none are definitive. Some typical herbaceous associates are arrowleaf balsamroot (*Balsamorhiza sagittata*), kittentail (*Besseya wyomingensis*) and Indian paintbrush (*Castilleja* spp.). Silky lupine (*Lupinus sericeus*) sometimes becomes an important associate; shrubs are scarce (Mueggler and Stewart 1980, Payne 1973, Ross and Hunter 1976).

Geographic Distribution: Since this cover type is defined by rough fescue, its extent is determined by the distribution of that species. It is found east and west of the continental divide, most abundantly to the west, and north of 46 degrees latitude (Mueggler and Stewart 1980).

Ecological Relationships: This type occupies both level and steep slopes, mostly on deep, well-developed soils. Elevations vary from 3000 to 6000 ft (1000-2000m). Annual precipitation is 15 to over 20 inches (38-50cm) (Mueggler and Stewart 1980, Munn et al. 1978).

Variants and Associated Species: A needle-and-thread (*Stipa comata*) phase is common east of the continental divide. This vegetation has strong affinities with Great Plains flora, and typically includes blue grama (*Bouteloua gracilis*) plains muhly (*Muhlenbergia cuspidata*) and fringed sagewort (*Artemisia frigida*) (Mueggler and Stewart 1980).

Grazing-induced deterioration is indicated by a rapid decrease in rough fescue, then in bluebunch wheatgrass and Idaho fescue. Finally, sites are occupied by cheatgrass (*Bromus tectorum*), spotted knapweed (*Centaurea maculosa*) and common dandelion (*Taraxacum officinale*). Substantial areas of this cover type have deteriorated to this weedy vegetation due to poor livestock management practices. Once this has occurred, restoration of desirable vegetation is extremely difficult (Mueggler and Stewart 1980, Payne 1973, Ross and Hunter 1976).

John E. Taylor
Montana State University
Bozeman, MT

ROUGH FESCUE-IDAHO FESCUE SRM 312

Definition, Composition and Structure: Rough fescue (*Festuca scabrella*) and Idaho fescue (*F.idahoensis*) make up the bulk of the vegetational aspect in this cover type, although their relative proportions differ among individual situations. Bluebunch wheatgrass (*Agropyron spicatum*) is notably inconspicuous or absent. Timber danthonia (*Danthonia intermedia*), western needlegrass (*Stipa occidentalis*) and sedges (*Carex* spp.) may be abundant locally. Species diversity is high, with many forbs present, such as Prairie smoke (*Geum triflorum*), northern bedstraw (*Galium boreale*), harebell (*Campanula rotundifolia*) and silky lupine (*Lupinus sericeus*) (Mueggler and Stewart 1980).

Geographic Distribution: East and west of the continental divide, primarily north of the 46th parallel. Mostly on gentle mountain slopes up to 7000 ft (2300m) elevation. (Mueggler and Stewart 1980).

Ecological Relationships: This type is found on relatively mesic upland sites (precipitation 20 to 30 inches (50-75cm) annually). Soils tend to be deep and well developed. This is an extremely productive and important vegetation type for livestock and wildlife (Mueggler and Stewart 1980, Munn et al. 1978, Payne 1973).

Variants and Associated Species: Sticky geranium (*Geranium viscosissimum*) and Richardson needlegrass (*Stipa richardsonii*) may assume sufficient dominance to constitute phases within the general cover type. Grazing induced deterioration is similar to that described for the Rough fescue bluebunch wheatgrass cover type (Payne 1976).

John E. Taylor
Montana State University
Bozeman, MT

TUFTED HAIRGRASS-SEDGE SRM 313

Definition, Composition and Structure: The diagnostic species of this cover type is tufted hairgrass (*Deschampsia caespitosa*), which always is associated with one or more sedges (*Carex species*). Timber danthonia (*Danthonia intermedia*) alpine timothy (*Phleum alpinum*), and species of bentgrasses (*Agrostis* spp.) and rushes (*Juncus* spp.) also are typical. Wheatgrasses (*Agropyron* spp.) and fescues (*Festuca* spp.) are conspicuously absent. Numerous forbs also are encountered but shrubs are uncommon (Mueggler and Stewart 1980, Payne 1973, Ross and Hunter 1976, Sharp and Sanders 1978).

Geographic Distribution: This type is found both east and west of the continental divide on poorly drained sites at moderate to high elevations (Mueggler and Stewart 1980, Ross and Hunter 1976).

Ecological Relationships: The dominant ecological influence on these sites is the high water table during some or all of the short growing season. Thus, it is the wettest of grasslands in the region, and is potentially the most productive. Soils are deep and fertile, and growing season moisture is essentially assured. There is some variation in these factors, which is reflected in plant species and production differences among locations (Mueggler and Stewart 1980, Munn et al. 1978).

Variants and Associated Species: Vegetation changes induced by grazing are not well understood in this type, but in general the grasses such as tufted hairgrass and alpine timothy are replaced by timber danthonia, rushes, and various forbs. Under long-term abuse these sites may be occupied by Kentucky bluegrass (*Poa pratensis*) and dandelion (*Taraxacum officinale*) (Mueggler and Stewart 1980, Payne 1973).

John E. Taylor
Montana State University
Bozeman, MT

BIG SAGEBRUSH-BLUEBUNCH WHEATGRASS SRM 314

Definition, Composition, and Structure: The physiognomy of this type is dominated by the species that provide much of the Northern Cold Desert its aspect. This type is one of the most common in the western United States, being dominated by big sagebrush (*Artemisia tridentata*) and bluebunch wheatgrass (*Agropyron spicatum*). The associated species do vary over the great extent of this general type and can be used to further characterize the type in the Northern Rocky Mountains. Big sagebrush, being the dominant shrub averages about 15% canopy cover (Mueggler and Stewart 1980). Within the Northern Rocky Mountain area, three subspecies of big sagebrush may be found within the general type, including: Wyoming big sagebrush (*A.t.* spp. *wyomingensis*), mountain big sagebrush (*A.t.* ssp. *vaseyana*) and basin big sagebrush (*A.t.* ssp. *tridentata*) (Morris et al 1976). The latter is found occupying the deeper soils in swales or drainage ways and is not as common as the other two subspecies.

Geographic Distribution: Communities of this type are widespread through the Northern Rocky Mountain region. The portion of the type with Wyoming big sagebrush is found primarily in the southwestern portion of Montana, although the distribution of the type with mountain big

sagebrush is throughout the region at elevations from 4000 to 6000 ft (1300-2000m) (Payne 1973). The type occurs on various exposures and slopes up to 54%. Generally, considerable rocks and bare soil are present on the surface in this type (Morris et al 1976).

Ecological Relationships: Although falling within the region of the highland climatic type within the Northern Rocky Mountains, the climate prevailing in the region of this type is similar to that of the temperature steppe, found elsewhere in the interior western United States. This semi-arid type is usually found in the precipitation zone receiving 12 to 16 inches (30-40cm) annually. The majority of the precipitation comes between April and June, although there is an overall winter distribution of moisture. Temperatures can range between -40° F to nearly 100° F (-40° C to 38° C). The type is located on shallow to moderately deep soils from a variety of parent materials. Usually, rocks and bare soil cover a good deal of the soil surface in this type (Munn et al 1978). Game species use this type commonly as year around or seasonal habitat. Mule deer, pronghorn antelope, elk and sagegrouse find their requirements in this type. Because it is relatively free of snow compared to many other community types in the Northern Rockies and also because it furnishes a good forage base in the wintertime due to the dominant shrubs and associated grasses, its value as a winter range for big game animals is often great.

Variants and Associated Species: The variation within the big sagebrush complex was outlined above and is a primary consideration in this type. A good deal of vegetative manipulation has occurred, both planned and unplanned. As a result, a lot of this type has either an abnormally high or low amount of shrub cover compared to what might be expected under pristine conditions. Generally, with poor grazing practices and no other vegetative manipulation, shrubs have often increased coverage. However, with vegetative manipulation through various brush control techniques, the shrub cover has been significantly reduced from what would be expected naturally. Associated shrubs in this type include rabbitbrush taxa (*Chrysothamnus* spp.) fringed sagewort (*Artemisia frigida*), broom snakeweed (*Gutierrezia sarothrae*) and gray horsebrush (*Tetradymia canescens*). Other conspicuous grasses found with bluebunch wheatgrass include prairie junegrass (*Koeleria pyramidata*), Sandberg bluegrass (*Poa secunda*), needle-and-thread (*Stipa comata*) and blue grama (*Bouteloua gracilis*). A great variety of forbs are found within this type and vary considerably over the distribution of the type. Perhaps arrowleaf balsamroot (*Balsamorhiza sagittata*) is the most commonly recognized forb (Mueggler and Stewart 1980).

Carl L. Wambolt
Montana State University
Bozeman, MT

BIG SAGEBRUSH-IDAHO FESCUE SRM 315

Definition, Composition, and Structure: The physiognomy of this type is from sagebrush and bunchgrasses, thus, appearing like much of the Northern Cold Desert. Mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) is the most common shrub dominant. Occasionally, Wyoming big sagebrush (*A.t.* ssp. *wyomingensis*) is encountered. The type is also characterized by the dominant understory species Idaho fescue (*Festuca idahoensis*). The type is similar to the big sagebrush - rough fescue (*Festuca scabrella*) type, but is void of rough fescue. Bluebunch wheatgrass (*Agropyron spicatum*) and prairie junegrass (*Koeleria pyramidata*) are highly associated with Idaho fescue. Forbs are quite abundant, especially in the more mesic portions. Prairie smoke (*Geum triflorum*) is especially common. In the drier portions, other shrubs such as rubber rabbitbrush (*Chrysothamnus nauseosus*), green rabbitbrush (*C. viscidiflorus*), and fringed sagewort (*Artemisia frigida*) are common (Payne 1973, Morris et al 1976, Ross and Hunter 1976, Mueggler and Stewart 1980).

Geographic Distribution: This type appears to be restricted to south of 46° 30' latitude. It is located on mountainous slopes that may reach a 40 percent grade and in the elevational range between 6000 to 8000 feet (2000-2700m) (Payne 1973, Ross and Hunter 1976, Mueggler and Stewart 1980). The area of this type, occupied extensively by sticky geranium (*Geranium viscosissimum*), is usually located within the portions receiving the highest amounts of precipitation on northern and eastern exposures at elevations above 7000 feet (2300m) (Mueggler and Stewart 1980).

Ecological Relationships: The prevailing climatic type is of the complex highlands nature. This vegetation may be found throughout regions receiving between 16 and 30 inches (40-75cm) of moisture annually (Ross and Hunter 1976), but if located in the higher portions of that precipitation zone, it will be on sites that impose limitations to moisture effectiveness. Most precipitation is received through the winter-spring period with the high months being April-June. Temperatures experienced may vary from -40° F to 90° +F (-40° C to 37° C). Soils may be quite well developed in this type, with depths up to 33 inches (82cm). The solums may be slightly acid to neutral in reaction. Normally, there is a good covering of vegetation and litter on the soil surface (Munn et al 1978). The sticky geranium phase occupies deeper soil (Mueggler and Stewart 1980). The most common game species utilizing this area would be elk, mule deer, sagegrouse and blue grouse.

Variants and Associated Species: Grasses, forbs and shrubs are all quite well represented in biomass in this type. Many of the forbs are considered rather poor forage for cattle, although their value changes for other classes of animals. Possible exceptions to this statement would include

coneflower (*Helianthella uniflora*), sticky geranium and tall cinquefoil (*Potentilla arguta*). When cattle overuse occurs, big sagebrush and green rabbitbrush will increase, as will more unpalatable forbs like prairie smoke, ballhead sandwort (*Arenaria congesta*) and western yarrow (*Achillea millefolium*). A variety of grasses may also increase at first under poor grazing management and eventually decrease, including slender wheatgrass (*Agropyron trachycalum*), mountain brome (*Bromus carinatus*) and, in some areas, Columbia needlegrass (*Stipa columbiana*) (Mueggler and Stewart 1980).

Carl L. Wambolt
Montana State University
Bozeman, MT

BIG SAGEBRUSH-ROUGH FESCUE SRM 316

Definition, Composition, and Structure: The physiognomy of this type is that of the shrub-steppe common in the Northern Cold Desert. Big sagebrush (*Artemisia tridentata*) is more widely spaced in this type than in most of the other types, where it is important. Rough fescue (*Festuca scabrella*) is a large bunchgrass that is very conspicuous in the aspect. Shrubs other than big sagebrush are usually scarce. Bluebunch wheatgrass (*Agropyron spicatum*) and Idaho fescue (*Festuca idahoensis*) are the most commonly associated grasses of importance and there are a variety of abundant forbs (Morris et al 1976, Mueggler and Stewart 1980).

Geographic Distribution: The type is found on both sides of the continental divide, but is usually restricted to north of 46° latitude. It is most common on south exposures with less than a 30% slope (Payne 1973). It is found in northwestern Montana, northern Idaho, and northeastern Washington.

Ecological Relationships: The type lies within the region of the highlands climatic type. Precipitation amounts are very high for a sagebrush steppe. They may receive between 15 and 20 inches(38-50cm) commonly, with some rare exceptions receiving as little as 12 inches (30cm) (Ross and Hunter 1976). Winter precipitation is important in the type, but the months of peak precipitation are April-June. Temperatures range from -40° F (-40° C) in the winter to 95° F (35° C) in the summer. Soils are usually deeper and better developed than in other big sagebrush types and are well drained. Loam soils are most common (Munn et al 1978).

Variants and Associated Species: Mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*) is the only big sagebrush taxon of importance in this type. Wyoming big sagebrush (*A.t.* ssp. *wyomingensis*) may be found, but is relatively unimportant. Traditionally, rough fescue and bluebunch wheatgrass have decreased with livestock grazing, while Idaho fescue, Cusick bluegrass (*Poa cusickii*) and prairie junegrass (*Koeleria pyramidata*) may increase initially, but will often eventually decrease as well if heavy grazing persists. Principal herbaceous species that will likely increase with poor grazing management include field chickweed (*Cerastium arvense*), western yarrow (*Achillea millefolium*), ballhead sandwort (*Arenaria congesta*), rose pussytoes (*Antennaria rosea*) and Hood phlox (*Phlox hoodii*) (Mueggler and Stewart 1980).

Carl L. Wambolt
Montana State University
Bozeman, MT

BITTERBRUSH-BLUEBUNCH WHEATGRASS SRM 317

Definition, Composition, and Structure: This shrub community is dominated by bitterbrush (*Purshia tridentata*) that typically grows in somewhat open stands. This shrub is of medium height and is associated with other shrubs of a similar stature, such as rubber rabbitbrush (*Chrysothamnus nauseosus*) and green rabbitbrush (*C. viscidiflorus*). Bluebunch wheatgrass (*Agropyron spicatum*) is the predominant understory grass with prairie junegrass (*Koeleria pyramidata*), Sandberg bluegrass (*Poa secunda*) and needle-and-thread (*Stipa comata*) also present commonly. Species such as Idaho fescue (*Festuca idahoensis*) and rough fescue (*Festuca scabrella*) are absent as the type is too dry for them. Cheatgrass (*Bromus tectorum*) is a conspicuous annual within the type and arrowleaf balsamroot (*Balsamorhiza sagittata*) is a dominant forb. Other common forbs include hairy goldenaster (*Chrysopsis villosa*), silky lupine (*Lupinus sericeus*), stoneseed (*Lithospermum ruderale*), salsify (*Tragopogon dubius*) and western yarrow (*Achillea millefolium*) (Mueggler and Stewart).

Geographic Distribution: This type is known only west of the continental divide. It occupies rather extensive foothill areas in the Bitterroot Valley, but elsewhere is found only in small patches, usually less than 20 acres (8ha). It occupies slopes of 40% to 75% that have a predominately southern exposure. It is found at elevations ranging from 3500 to 5500 ft (1200-1800m) (Payne 1973, Ross and Hunter 1976, Mueggler and Stewart 1980).

Ecological Relationships: Although this type is found within the general region of the highlands climate type, it is more typical of the temperate semi-arid steppe climate. The type is quite dry, generally receiving in the range of 10 to 15 inches (25-38cm) of annual precipitation with rather high evapo-transportation (Ross and Hunter 1976). Most precipitation comes in winter and spring, with the peak

received during the spring. Temperature extremes may reach as low as -20° F (-29° C) to as high as 100° F (38° C). The soils are usually dry, compounded by shallow nature. The soil surface has considerable rock and so does the profile. The parent material is predominately granite. The area is sometimes important year round for mule deer and is often heavily used by mule deer and elk during winter periods.

Variants and Associated Species: Bluebunch wheatgrass will probably decrease most dramatically under heavy cattle use, while arrowleaf balsamroot will be the most likely to decrease under heavy spring and early summer sheep use. Green rabbitbrush and fringed sagewort (*Artemisia frigida*) usually increase with overgrazing and cheatgrass will likely invade. Bitterbrush is quite palatable to all classes of livestock and game animals, particularly in fall and winter, and thus it may also be severely impacted by heavy browsing pressures (Mueggler and Stewart 1980).

Carl L. Wambolt
Montana State University
Bozeman, MT

BITTERBRUSH-IDAHO FESCUE SRM 318

Definition, Composition, and Structure: This type has similar physiognomy to the bitterbrush (*Purshia tridentata*) rough fescue (*Festuca scabrella*) cover type. However, the bitterbrush plant may often be somewhat smaller in stature than those that occur commonly in the zone with rough fescue. Compositionally, the chief difference between the two types is that this type has a greater presence of Idaho fescue (*Festuca idahoensis*). Bluebunch wheatgrass is often the dominant grass in this type. This is particularly the case on drier exposures. Other grasses that may be found commonly include prairie junegrass (*Koeleria pyramidata*) and Sandberg bluegrass (*Poa secunda*). Forbs that are most abundant include ballhead sandwort (*Arenaria congesta*), Hood phlox (*Phlox hoodii*), sulfur eriogonum (*Eriogonum umbellatum*) and silky lupine (*Lupinus sericeus*) (Ross and Hunter 1976, Mueggler and Stewart 1980).

Geographic Distribution: This type is uncommon, but when found, is south of 47° latitude and west of the continental divide. The type favors steep south exposures, but only those with moisture adequate to support Idaho fescue. This uncommon type has generally been located at about 5000 ft (1700m) elevation (Payne 1973, Ross and Hunter 1976, Mueggler and Stewart 1980).

Ecological Relationships: This type is found within the drier portions of the highlands climatic type. Annual precipitation ranges between 14 to 18 inches (35-40cm) (Ross and Hunter 1976). Most of the precipitation comes in the winter-spring period with the peak during the spring months. Temperatures range from approximately -30° F (-36° C) in the winter to the 90° F (32° C) range in the summer. The soils are typical of bitterbrush communities in other types where rocks tend to be common on the surface and in the profile. Soils are generally shallow and of a coarse texture, usually from a granitic origin (Munn et al 1978). Big game use, particularly mule deer and elk, may be quite heavy in this type. This is particularly true if the area is used as a winter range for these species.

Variants and Associated Species: Heavy growing season use will cause the dominant grasses, including Idaho fescue, bluebunch wheatgrass and green needlegrass (*Stipa viridula*), to decline. Sandberg bluegrass and prairie junegrass may benefit from that decline initially, but will generally decrease themselves with continued heavy use. The bitterbrush itself will decrease if livestock use is overly heavy or continues into the late summer/fall period. Bitterbrush may also likely decrease if the area is used as winter range by big game species. Relatively unpalatable species that may thrive, would include hairy goldenaster (*Chrysopsis villosa*), fringed sagewort (*Artemisia frigida*), Hood phlox and cheatgrass (*Bromus tectorum*) (Mueggler and Stewart 1980).

Carl L. Wambolt
Montana State University
Bozeman, MT

BITTERBRUSH-ROUGH FESCUE SRM 319

Definition, Composition, and Structure: The physiognomy of this type is generally determined by a tall growth form of bitterbrush (*Purshia tridentata*) plant, often widely spaced with the large bunchgrass rough fescue (*Festuca scabrella*), the dominant understory species, in the shrub interspaces. Often bluebunch wheatgrass (*Agropyron spicatum*) and Idaho fescue (*Festuca idahoensis*) may be the most prevalent species, depending on past use and site moisture relationships. Sandberg bluegrass (*Poa secunda*) and prairie junegrass (*Koeleria pyramidata*) are also usually present. Annual grasses may be conspicuous in some stands, particularly cheatgrass (*Bromus tectorum*) and six weeks grass (*Vulpia octoflora*). The very conspicuous arrowleaf balsamroot (*Balsamorhiza sagittata*) is probably the most common forb, with western yarrow (*Achillea millefolium*) and salsify (*Tragopogon dubius*) found frequently (Mueggler and Stewart 1980).

Geographic Distribution: The type is found north of 47° latitude and is distributed principally west of the continental divide (Payne 1973). This type does seem to display a topographic preference for steep slopes, of more than 35 percent, on south and east facing exposures. The typical elevation range is from 3000 to 5000 ft (1000-1700m)

(Mueggler and Stewart 1980).

Ecological Relationships: Although lying within the highland climatic type, the type is usually found on sites drier than typical over that broad climatic zone. Usually, annual precipitation where this type occurs will be in the 12 to 20 inch (30-50cm) zone (Ross and Hunter 1976). The majority of the precipitation comes in the winter and spring period, with the peak during the period April-June. Temperatures rarely go below -30° F (-36° C) and may range above 90° F (32° C) during the summer months. Soils are usually coarse textured, often of granitic origin, with the profile somewhat less well developed than in neighboring cover types. The type is often located in a situation that it offers good winter range for mule deer and elk in the vicinity.

Variants and Associated Species: With cattle grazing, usually rough fescue and bluebunch wheatgrass are the first to decrease. Idaho fescue, prairie junegrass and Sandberg bluegrass usually increase initially after the dominant grasses start to diminish. However, these subdominant grasses will also decrease with continued heavy use. If sheep are utilized, the forb components may not thrive with grazing either, and species such as arrowleaf balsamroot will tend to decrease. Bitterbrush is palatable to livestock, as well as game species, and will often decrease as well, particularly if livestock grazing is heavy in the late summer-fall period. Cheatgrass is the principal invading species on sites severely abused (Mueggler and Stewart 1980).

Carl L. Wambolt
Montana State University
Bozeman, MT

BLACK SAGEBRUSH-BLUEBUNCH WHEATGRASS SRM 320

Definition, Composition, and Structure: Although occurring within the Northern Rocky Mountain Province, this type is one of the driest in the region (Mueggler and Stewart 1980). The physiognomy of the type is that of the Northern Cold Desert and in the Northern Rockies it is best differentiated from the Basin and Range and Columbia Plateau distributions by associated species. This type is dominated by black sagebrush (*Artemisia nova*) and bluebunch wheatgrass (*Agropyron spicatum*) (Payne 1973, Morris et al 1976, Mueggler and Stewart 1980). Other very common understory species include prairie junegrass (*Koeleria pyramidata*) and Sandberg bluegrass (*Poa secunda*). Forbs are usually not very abundant but, big sagebrush (*Artemisia tridentata*) may be common in portions of the type with generally deeper soils.

Geographic Distribution: Foothill areas east of the continental divide are the primary locations for communities of this type. It is restricted to areas south of 47° latitude and usually occurs on south or west exposures. Slopes may be quite steep, up to 37%, and the type will be found at elevations between 4500 and 7700 ft (1500-2600m) (Payne 1973, Ross and Hunter 1976, Mueggler and Stewart 1980).

Ecological Relationships: The type lies within the complex highlands climatic regime although it is restricted to the most arid portions of that region. Total annual precipitation received is generally less than 12 inches (30cm) (Mueggler and Stewart 1980). The type is within a winter-spring precipitation regime with its greatest precipitation generally falling April-June. Temperatures characterize distinct seasonal changes and extreme temperatures may vary from -40° F (-40° C) in the winter to nearly 100° F (38° C)in the summer. Soils are usually dry and rocky, with large amounts of bare soil and surface rocks of a limestone nature. In some locations there is a marked shift in associated species where soils are sandier (Payne 1973, Mueggler and Stewart 1980). The most noteworthy game species that occupy this habitat would include the pronghorn antelope, mule deer and sagegrouse.

Variants and Associated Species: Much of the change noticed in this type is a result of past grazing practices. Generally, these changes result in a decrease in the abundance of the understory species, most notably bluebunch wheatgrass. Associated species that may also decrease with past misuse by cattle include Indian ricegrass (*Oryzopsis hymenoides*), winterfat (*Ceratoides lanata*), needle-and-thread (*Stipa comata*) and prairie junegrass. With enough overuse or more sheep grazing, often the black sagebrush will decrease as well. The needle-and-thread phase tends to prevail in the areas of sandier soils. Associated species at those locations include Indian ricegrass, broom snakeweed (*Gutierrezia sarothrae*) and fringed sagewort (*Artemisia frigida*). (Mueggler and Stewart 1980).

Carl L. Wambolt
Montana State University
Bozeman, MT

BLACK SAGEBRUSH-IDAHO FESCUE SRM 321

Definition, Composition, and Structure: In physiognomy, the structure of this type is similar to many of the Northern Cold Desert phases. Black sagebrush (*Artemisia nova*) and Idaho fescue (*Festuca idahoensis*) are the dominant species (Morris et al 1976, Mueggler and Stewart 1980). The presence of Idaho fescue indicates a more mesic environment than most of the Northern Cold Desert types contain. Due largely to the greater precipitation amounts received in this type over the black sagebrush-bluebunch wheatgrass (*Agropyron spicatum*) type, forbs are much more abundant (Mueggler and Stewart 1980). Prairie junegrass (*Koeleria pyramidata*) is a consistent associated species. A dominance by bluebunch wheatgrass is quite common, particularly in the drier extremes of this type.

Geographic Distribution: The type is found relatively infrequently east of the continental divide. It is generally located on dry mountain slopes at elevations ranging from 6200 to 9100 ft (2100-3000m). Although this type is often found in the same general area as the black sagebrush-bluebunch wheatgrass type, it is usually located at higher elevations where more mesic conditions prevail. (Morris et al 1976, Ross and Hunter 1976, Mueggler and Stewart 1980).

Ecological Relationships: Within the Northern Rocky Mountains, this type is found within the complex highlands type climate. Annual precipitation amounts do not vary greatly within this type and generally range between 14 to 16 inches (35-40cm) precipitation (Ross and Hunter 1976, Mueggler and Stewart 1980). Although a general winter distribution of moisture prevails in the region, the months of heaviest precipitation are April-June. Temperatures may vary from a low of -40° F (-40° C) in the winter to 100° F (38° C) in the summer. Soils are usually underlined with limestone deposits and are quite shallow. Important game species frequenting this type include pronghorn antelope, mule deer and sagegrouse.

Variants and Associated Species: Most variation within the type has been a result of past grazing practices, generally leading to a lesser importance on the part of the principal grasses, Idaho fescue and bluebunch wheatgrass. Species that tend to increase as a result of poor grazing practices are fringed sagewort (*Artemisia frigida,*) Sandberg bluegrass (*Poa secunda*) and Hood phlox (*Phlox hoodii*). Black sagebrush itself may decrease under continued heavy use, particularly if sheep or large wild ungulate populations are present. Associated grasses include bluebunch wheatgrass, prairie junegrass and Sandberg bluegrass. Important associated forbs include rose pussytoes (*Antennaria rosea*), Hood phlox, fernleaf fleabane, (*Erigeron compositus*) and longleaf phlox (*Phlox longifolia*).

Occasionally, big sagebrush (*Artemisia tridentata*) becomes important within pockets of deeper soil (Mueggler and Stewart 1980).

Carl L. Wambolt
Montana State University
Bozeman, MT

CURLLEAF MOUNTAIN MAHOGANY-BLUEBUNCH WHEATGRASS SRM 322

Definition, Composition, and Structure: In physiognomy, this type resembles the cover types dominated by bitterbrush (*Purshia tridentata*). The dominant shrub, curlleaf mountain-mahogany (*Cercocarpus ledifolius*) has a growth form much like bitterbrush and the interspersed bunchgrasses are generally of the same composition as in the habitat types dominated by bitterbrush. The amount of bluebunch wheatgrass (*Agropyron spicatum*) present as understory in this type is usually dependent upon soil development. In areas that are very rocky, bluebunch wheatgrass is not abundant. Species of sagebrush (*Artemisia*), rabbitbrush (*Chrysothamnus*) and juniper (*Juniperus*) are often present. Conspicuous halfshrubs, like fringed sagewort (*Artemisia frigida*) and broom snakeweed (*Gutierrezia sarothrae*), are common. Herbaceous vegetation consists primarily of bluebunch wheatgrass, but also includes needle-and-thread (*Stipa comata*), Indian ricegrass (*Oryzopsis hymenoides*) and prairie junegrass (*Koeleria pyramidata*) as common associates (Payne 1973, Ross and Hunter 1976, Mueggler and Stewart 1980).

Geographic Distribution: This type is located on both sides of the continental divide, usually at elevations between 4500 to 6800 ft (1500-2300m). The limestone outcrops that feature this cover type are often found on very steep slopes up to 100 percent (Payne 1973, Ross and Hunter 1976, Mueggler and Stewart 1980).

Ecological Relationships: Although the type falls within the highlands climatic type, it is not very representative of the majority of that climate. Instead, it is an area of greater aridity due to the relatively low 12 to 18 inch (30-45cm) precipitation that falls annually (Ross and Hunter 1976), and the moisture limitations imposed by the sites where the type is located. Most of the precipitation comes in the winter-spring period, with the peak received generally between April and June. Temperatures typically vary from a low of -40° F (-40° C) in the winter to the 90° F (32° C) range in the summer. Soils are usually poorly developed and shallow. Rocks are common at the surface and in the profile and the parent material is limestone (Mueggler and Stewart 1980). Like the other shrub types in the region, this area is used very commonly as winter range for species like mule deer and elk.

Variants and Associated Species: The type dominant,

curlleaf mountain mahogany, is highly used by big game in the winter in most of its distribution. It may decrease severely with heavy use. This is particularly true if livestock stocking during the summer is excessive. Heavy summer use also decreases bluebunch wheatgrass and Indian ricegrass. With continued heavy use, needle-and-thread and prairie junegrass will also decrease although they may be benefitted by heavy grazing in its first phases (Mueggler and Stewart 1980).

Carl L. Wambolt
Montana State University
Bozeman, MT

SHRUBBY CINQUEFOIL-ROUGH FESCUE SRM 323

Definition, Composition, and Structure: This type appears similar to the Palouse bunchgrass but contains more of a shrub aspect through the conspicuousness of the dominant shrubby cinquefoil (*Potentilla fruticosa*) interspersed with the large bunchgrass rough fescue (*Festuca scabrella*). Vegetation and litter cover often exceed 98 percent in the portion of this type where timber danthonia (*Danthonia intermedia*) is importantly interspersed with the other dominants. The growth of rough fescue is often enough that the relatively small shrub shrubby cinquefoil may not be easily visible, even though it may attain canopy covers up to 30 percent on some sites. Important associated grasses include Idaho fescue (*Festuca idahoensis*) and prairie junegrass (*Koeleria pyramidata*). Forbs are usually present in great diversity with the most prevalent often being northern bedstraw (*Galium boreale*), blanketflower (*Gaillardia aristata*), western yarrow (*Achillea millefolium*), Missouri goldenrod (*Solidago missouriensis*) and roundleaf harebell (*Campanula rotundifolia*). On the driest sites within the type, bluebunch wheatgrass (*Agropyron spicatum*), fringed sagewort (*Artemisia frigida*), broom snakeweed (*Gutierrezia sarothrae*), hairy goldenaster (*Chrysopsis villosa*) and woolly groundsel (*Senecio canus*) are often conspicuous (Ross and Hunter 1976, Mueggler and Stewart 1980).

Geographic Distribution: The type is found only north of 46° latitude and is seldom encountered west of the continental divide. Gently sloping or rolling topography is typical of the type between elevations of 4500 and 6000 ft (1500-2000m) (Payne 1973).

Ecological Relationships: In the Northern Rocky Mountains, this type is found sporadically within the broad highlands climatic type, although the climate is typical of semi-arid. This is a mesic foothill type that generally receives between 20 and 30 inches (50-75cm) of moisture (Ross and Hunter 1976), with the majority coming during the April-June period. Temperatures range widely from lows in the -50° F (-50° C) range to nearly 100° F (38° C) in the summer. The soils are moderately deep in the range of 10 to 18 inches rooting depths and are usually composed of either limestone or sandstone parent materials. Considerable rocks may be exposed at the surface with typically very little bare soil to be found (Munn et al 1978). Due to the lack of woody vegetation, particularly species utilized as cover and forage by wildlife species, game numbers are not as high in this type as many nearby types. Mule deer and occasionally sharptail grouse utilize the type.

Variants and Associated Species: The portion of this type containing significant quantities of timber danthonia are the most productive. With heavy cattle grazing usually shrubby cinquefoil, being unpalatable to livestock, will increase. Other prominent increasers include fringed sagewort, Parry danthonia (*Danthonia parryi*), timber oatgrass and several forbs. The palatable grasses, rough fescue, slender wheatgrass (*Agropyron trachycaulum*) and bluebunch wheatgrass, generally decrease with heavy use. Idaho fescue, prairie junegrass, and spikeoat (*Helictotrichon hookeri*) tend to increase until use becomes so severe that even they will decrease (Mueggler and Stewart 1980).

Carl L. Wambolt
Montana State University
Bozeman, MT

THREETIP SAGEBRUSH-IDAHO FESCUE SRM 324

Definition, Composition, and Structure: The physiognomy provided by the dominants threetip sagebrush (*Artemisia tripartita*) and Idaho fescue (*Fescue idahoensis*) is primarily that of the Northern Cold Desert. The vegetative composition is similar to the drier portions of the big sagebrush (*Artemisia tridentata*) - Idaho fescue type. Exceptions to that include the prevalent overstory of threetip sagebrush and the association of plains reedgrass (*Calamagrostis montanensis*) with Idaho fescue in the understory. The sprouting shrubs, green rabbitbrush (*Chrysothamnus viscidiflorus*) and gray horsebrush (*Tetradymia canescens*), are usually present as is fringed sagewort (*Artemisia frigida*). Big sagebrush may be present, although not abundant. The principal grasses are, other than Idaho fescue, prairie junegrass (*Koeleria pyramidata*) and plains reedgrass. Hood phlox (*Phlox hoodii*), rose pussytoes (*Antennaria rosea*) and silky lupine (*Lupinus sericeus*) are the principal forbs (Morris et al 1976, Mueggler and Stewart 1980).

Geographic Distribution: This type is very localized, generally found only in the extreme southern portions of the Northern Rocky Mountains. In Montana, it is found in the extreme southwestern portion and in Idaho, within the mountains near the high lava plains. This type is usually located on gentle alluvial slopes with moderately deep soils.

The majority of the type lies between 6000 to 8000 ft (2000-2700m) elevation (Payne 1973).

Ecological Relationships: The type lies within the highly variable highlands climatic type. The majority of the precipitation is received during the winter-spring seasons, with the peak received April-June. Frigid winter temperatures may be received in this type to -50° F (-50° C), with summer temperatures seldom reaching beyond the 90 F (32° C) range. Surface rock may be fairly prevalent, up to 25% on some sites, while bare soil is relatively low, at less than 11%. Soils are generally moderately deep (Munn et al 1978). Important game animals utilizing the type commonly would include mule deer, pronghorn antelope, elk, sage-grouse and blue grouse.

Variants and Associated Species: The proportion of grasses in this type is considerably higher than in the big sagebrush-Idaho fescue cover type, although both types have a similar structure. Shrubs that may increase, often with heavy cattle grazing, include threetip sagebrush, green rabbitbrush and gray horsebrush. The low shrubs, broom snakeweed (*Gutierrezia sarothrae*) and fringed sagewort (*Artemisia frigida*), also act as increasers. The dominant grasses, especially Idaho fescue, tend to decrease with heavy use. Other grasses, including pinegrass (*Calamagrostis rubescens*), thickspike wheatgrass (*Agropyron dasystachyum*) and prairie junegrass, may increase until use becomes more severe. With heavy use, forbs tend to be predominant in the aspect (Mueggler and Stewart 1980). With the advent of fire in this type, the reaction is somewhat different than in the other sagebrush cover types within the Northern Rockies, as threetip sagebrush sprouts readily and can quickly reoccupy a burned area.

Carl L. Wambolt
Montana State University
Bozeman, MT

Rangeland Cover Types of the GREAT BASIN REGION

INTRODUCTION SRM 400

The term "Great Basin" was first applied by John C. Fremont following his 1843-1844 expedition along the edges of this region. Physiographically the Great Basin lies west of the Colorado Plateau and is bordered on the west by the Sierra Nevada mountains, on the east by the Wasatch Mountains in Utah, on the north by the lava flows of the Snake River Plains, and on the south by the arbitrary designation of 35' 30" latitude (Fenneman 1931).

Topographically, this region consists of numerous parallel north-south trending isolated mountain ranges separated by nearly level intermountain basins (Cronquist and others, 1972). Elevations range from the 4000-6000 foot (1300-2000m) valley floors to the 12,000 foot (4000m) mountain peaks.

In general, the Great Basin is an area of low rainfall - a desert in the rain shadow of the Sierra Nevada and the Cascade Ranges. Moisture that falls within the region flows into streams that empty onto low, flat playa lakes, where the water gradually evaporates, leaving salt and mineral deposits to be blown in a mixture with dust and sand by the hot and persistent winds. This interior drainage characterizes the Great Basin (Cronquist et al 1972).

Precipitation in this region ranges between 6 to 11 inches (15-28cm) annually in the lowlands, but may reach up to 25 to 30 inches (63-75cm) in the higher mountainous areas. A majority of this moisture comes as winter snow, although summer thunderstorms are common and often violent, as is evidenced by the deeply cut canyons that dissect the alluvial terraces at the mountain/valley interfaces.

The natural flora consists of plant species that are well adapted to the cold winters as well as the warm, dry summer seasons. The foothills and lowlands are largely dominated by genera of the *Asteraceae* and *Cuppressaceae* families such as *Artemisia* and *Juniperus*, or in more saline areas, genera of the *Chenopodiaceae* family such as Atriplex. Mountainous areas often are dominated by shrubby genera from the *Rosaceae* family, such as *Amelanchier, Prunus, Cercocarpus, Purshia* and *Rosa*, and their associated understory flora or, on more protected aspects, forest genera including *Pinus, Psuedotsuga, Abies* and *Picea*. Extensive patches of quaking aspen (*Populus tremuloides*) fill the appropriate environmental niches within and between the coniferous forests and mountain brush types.

A.H. Winward
Forest Service
Ogden, UT

SAGEBRUSH TYPES

The genus *Artemisia* (*sagebrush*) is known on most continents of the world. In the United States it occupies at least 96 million acres (38.5 million ha) and a major portion of this acreage is found in the Great Basin Region. At least 16 taxa are represented in this Region, and because some dominate such extensive acreages and have their own unique environments and prescriptions for management, they have been treated as separate cover types in this report. Others, though distinct in their taxonomy and ecology, have rather limited acreages and, consequently, have been treated under a common heading "Other Sagebrush Types".

A.H. Winward
Forest Service
Ogden, UT

BASIN BIGBRUSH SRM 401

Definition, Composition, and Structure: This type is characterized by an overstory consisting mainly of basin big sagebrush and an understory dominated by perennial grasses along with a lesser cover of perennial forbs. Basin big sagebrush (*Artemisia tridentata* subsp. *tridentata*) is the principal shrub, usually accompanied by smaller amounts of rubber and green rabbitbrush (*Chrysothamnus nauseosus* and *C. viscidiflorus*). Antelope bitterbrush (*Purshia tridentata*) and gray horsebrush (*Tetradymia canescens*) also occur, but less frequently. The major grasses are bluebunch wheatgrass (*Agropyron spicatum*), Sandberg bluegrass (*Poa secunda*) and, in moister areas, Idaho fescue (*Festuca idahoensis*). Other perennial grasses which occur commonly include bottlebrush squirreltail (*Sitanion hystrix*), needle-and-thread (*Stipa comata*), rhizomatic wheatgrasses (*Agropyron dasystachyum*) and related species. Cheatgrass (*Bromus tectorum*), an introduced annual, occurs in small amounts on most sites. The forb cover contains a number of species which occur frequently but in small amounts. The most common of these include yarrow (*Achillea mille-*

folium var. lanulosa), pale agoseris (*Agoseris glauca*), pussytoes (*Antennaria dimorpha*) and spp., tapertip onion (*Allium acuminatum*), milkvetch (*Astragalus* spp.), arrowleaf balsamroot (*Balsamorhiza sagittata*), hawksbeard (*Crepis acuminata* and spp.), fleabane (*Erigeron pumilis* and spp.), biscuit root (*Lomatium macrocarpum* and *L. triternatum*), Lupine (*Lupinus* spp). and longleaf phlox (*Phlox longifolia*).

The shrub layer is relatively tall (40 inches or more), fairly open and comprises about 20 percent of annual production by weight. Perennial grasses usually constitute slightly over half by weight, and forbs the remainder (20% approximately). Over half of the ground surface is usually bare, 25-30% is occupied by litter, and the cryptogam cover is sparse (10%). Average annual production ranges from 700 to 1900 pounds per acre (775-2100kg/ha), depending on site quality.

Geographic Distribution: This type has a wide range extending from New Mexico and Arizona north to Wyoming, Montana, southern Idaho, eastern Washington and southern British Columbia, and west through Utah, Nevada and northeastern California. However, the agricultural potential of the deep soils associated with the type was recognized early in the course of European settlement, and large areas have been taken over for crop production, both dry land and irrigated. As a result, the area currently occupied is greatly diminished, and is probably less than that of the other two big sagebrush cover types.

Ecological Relationships: This cover type occurs in areas of low annual precipitation, mostly in the 8 to 14 inch (20-35cm) range, but on deep, permeable soils, in areas generally below 7000 ft (2300m) elevation. Since only 40 percent of annual precipitation occurs during the growing season, soil water storage from winter precipitation is the key to the existence of this type. Soil moisture is usually available for 2 to 4 weeks longer than in the Wyoming big sagebrush community.

The basin big sagebrush type frequently borders on the other two big sagebrush communities. In drier areas it often adjoins the Wyoming big sagebrush type which occurs on shallower and often stonier soils. At higher elevations, in moister, cooler, habitats, it often borders the mountain big sagebrush type, with the latter occurring on stonier soils and often rougher topography. Spring, fall and often winter grazing for domestic livestock and wildlife is provided by the basin big sagebrush type. The sagebrush itself is one of the less palatable of its genus.

Seral Relationships: This type occurs in areas readily accessible to livestock and a high percentage is currently in a depleted condition due to grazing and fire. Heavy grazing causes a massive reduction of the grass component and of many perennial forbs. The sagebrush cover becomes denser and more vigorous, and the understory dominated by annuals, with cheatgrass usually the principal species. The sagebrush is highly susceptible to fire, and on areas where fire has destroyed the shrub cover, annuals may become the dominant cover. Secondary shrubs such as rabbitbrush and horsebrush, which are more fire-tolerant, may increase where fires are not too frequent. Competition from cheatgrass and other annuals including medusahead (*Taeniatherum asperum*), and/or from the vigorous sagebrush cover of badly depleted areas, makes reestablishment of native grass species a difficult process. On the other hand, the productive soils of this type provide favorable sites for natural recovery when the sagebrush is controlled and a sizeable nucleus of native grasses remains, or for artificial seeding of perennial grasses on severely depleted stands.

Variants and Associated Species: The type varies considerably over its range, mainly in response to climatic differences. At the moister, cooler edge of the type, with elevation of 5000-7000 feet (1700-2300m), Idaho fescue replaces bluebunch wheatgrass as the principal grass. In very dry areas, Sandberg bluegrass may constitute the dominant understory species. On areas with deep sandy or highly calcareous soils, needle-and-thread dominates the understory. Antelope bitterbrush is a common associate on sandy soils.

References include Beetle and Johnson, 1982; Daubenmire, 1970; Hironaka et al, 1983; McLean and Marchand, 1968; Passey et al, 1982; and Winward, 1980.

Edwin W. Tisdale
University of Idaho
Moscow, ID

MOUNTAIN BIG SAGEBRUSH
SRM 402

Definition, Composition, and Structure: This type is marked by the dominance of mountain big sagebrush (*Artemisia tridentata* subsp. *vaseyana*) and by a well-developed understory of perennial grasses and forbs. Mountain big sagebrush is the most abundant shrub, with antelope bitterbrush (*Purshia tridentata*), green rabbitbrush (*Chrysothamnus viscidiflorus*) and gray horsebrush (*Tetradymia canescens*) frequently present but in much smaller amounts. Mountain snowberry (*Symphoricarpos oreophilus*) is common in moister areas. The understory consists of perennial grasses, along with a large number of perennial forbs. The principal grasses are Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Agropyron spicatum*). Other graminoids which occur in significant amounts include Sandberg bluegrass (*Poa secunda*), mountain brome (*Bromus carinatus* and related spp.), slender wheatgrass (*Agropyron caninum*), junegrass (*Koeleria pyramidata*), onion grass (*Melica* spp.), western

needlegrass (*Stipa occidentalis*) and sedges (*Carex geyeri* and spp.). Common forbs include yarrow (*Achillea millefolium var. lanulosa*), milkvetches (*Astragalus miser* and spp.), arrowleaf balsamroot (*Balsamorhiza sagittata*), tapertip hawksbeard (*Crepis acuminata*), Wyeth and sulphur buckwheat (*Eriogonum heracleoides* and *E. umbellatum*), Aven (*Geum triflorum*), biscuitroot (*Lomatium triternatum* and spp.), Lupine (*Lupinus* spp.), longleaf phlox (*Phlox longifolia*) and groundsel (*Senecio integerrimus*).

The shrub stand is of medium height 35-40 inches (88-100cm), and fairly dense, averaging 25-30% foliage cover and contributing about the same proportion to the annual production. Grasses make up 40-50% of the annual crop and forbs 25% or more. The ground cover contains a high amount of litter, but relatively low cryptogam cover. Average annual production ranges from 1000 to 2500 pounds per acre (1100-2750kg/ha), depending on site quality.

Geographic Distribution: This type occupies large areas in the foothills and mountains of western Montana and Wyoming, northwestern Colorado, northern Utah and Nevada, southern and central Idaho, eastern Oregon, central Washington and southern interior British Columbia, Canada.

Ecological Relationships: This is the most mesic of the big sagebrush cover types, occurring in areas of relatively high elevation 3500-9000 ft (1200-3000m) with mean annual precipitation in the 14-18 inch (35-45cm) range. The period of major growth begins in late March and lasts through June. Soils range from moderate to deep, often with a high content of rock or gravel, and are well drained. This type usually constitutes the upper elevation sagebrush zone, occurring just below taller shrub or forest communities. Its lower boundary often borders on the Wyoming big sagebrush type, or in areas of variable soil depth it may form a mosaic with the low sagebrush (*Artemisia arbuscula*) cover type.

Seral Relationships: The type produces high yields of forage for livestock and big game, and is adapted to summer and fall use. It reacts to heavy grazing by a marked decrease in palatable grasses and forbs, while the sagebrush, relatively low in palatability, becomes more dense and vigorous. Depleted stands typically consist of dense shrub covers and an understory dominated by the less palatable forbs, and a mixture of native and introduced annuals. Cheatgrass (*Bromus tectorum*) is one of the increasers, but does not dominate depleted stands to the extent that it does in drier sagebrush types. Mountain big sagebrush is easily killed by fire, but reestablishes readily from seed and tends to form dense stands after fire. Green rabbitbrush and gray horsebrush, which sprout after fire also, tend to increase in abundance with repeated burning. Due to the rugged topography occupied by much of this type, grazing use should be based on erosional hazards as well as herbage removal.

Variants and Associated Species: This type covers a wide range of ecological conditions, and exhibits much variation. Differences include associations in which mountain snowberry is a major component of the shrub cover, and one subtype in which sedges are dominant in the understory. Another major variant occurs due to domination by the closely related subalpine big sagebrush, (*Artemisia tridentata* subsp. *spiciformis*), which occurs at high elevations in southeastern Idaho, southwestern Wyoming, northern Utah and western Colorado. This community is otherwise similar in composition and structure to the more mesic stands of mountain big sagebrush, and hence, is included in this cover type. Another source of variation within the mountain big sagebrush type is due to the presence of two varieties, var. *vaseyana* and var. *pauciflora* (Goodrich et al., 1985). It appears that var. *vaseyana* is restricted to the most mesic portions of the mountain big sagebrush cover type, and that var. *pauciflora*, a smallheaded, few flowered form may occupy the bulk of the type, but this relationship requires further study. References include Beetle and Johnson, 1982; Goodrich et al, 1985; Hironaka et al, 1983; Marchand et al, 1966; and Mueggler and Stewart, 1980.

Edwin W. Tisdale
University of Idaho
Moscow, ID

WYOMING BIG SAGEBRUSH
SRM 403

Definition, Composition, and Structure: This type is characterized by Wyoming big sagebrush (*Artemisia tridentata* subsp. *wyomingensis*) associated with an understory consisting of perennial grasses with a sparse component of forbs.

Wyoming big sagebrush, a low growing form of the species (Beetle and Young 1965), forms the bulk of the shrub overstory, accompanied by much smaller amounts of green rabbitbrush (*Chrysothamnus viscidiflorus*). The principal understory species are the perennial bunchgrasses, bluebunch wheatgrass (*Agropyron spicatum*) and Sandberg bluegrass (*Poa secunda*). Other perennial grasses which occur commonly and may dominate in certain sites include bottlebrush squirreltail (*Sitanion hystrix*), thurber needlegrass (*Stipa thurberiana*), needle-and-thread (*Stipa comata*), Indian ricegrass (*Oryzopsis hymenoides*) and rhizomatic wheatgrasses (*Agropyron riparium* and *A. dasystachyum*). The sparse and variable forb cover is characterized by milk vetches (*Astragalus* spp.), pussytoes (*Antennaria dimorpha* and spp.), aster (*Aster scopulorum*), phlox (*Phlox longifolia* and *P. hoodii*), and fleabanes (*Erigeron pumilis* and spp.). Arrowleaf balsamroot

(*Balsamorhiza sagittata*), hawksbeard (*Crepis acuminata*), and lupine (*Lupinus* spp.) are fairly common in the more mesic portions of this type, while prickly pear cactus (*Opuntia polyacantha*) and globe mallow (*Sphaeralcea* spp.) occur frequently in the drier portions.

The shrub layer is low in stature, 16-22 inch (40 to-55cm), fairly open, averaging 13-18% in foliage cover and constituting 25-35% by weight of total annual production. Perennial grasses usually constitute 50-60% by weight, while forbs make up the remainder. There is a high percentage of bare ground, a small amount of litter and an extensive ground cover of cryptogams, including the moss (*Tortula*). Total production in average years ranges from 400 to 700 lbs/acre (440-775 kg/ha), depending on site quality.

Geographic Distribution: This is the largest of the big sagebrush cover types, with a wide distribution including southeastern Oregon, southern Idaho, western Wyoming and Montana, northwestern Colorado, Utah and Nevada, northern Arizona and New Mexico, extreme northeastern California and small areas in central Washington.

Ecological Relationships: This is the most xeric of the big sagebrush cover types, occurring in areas of 7-12 inches (18-30cm) of precipitation, only about 40% of which occurs during the growing season. The soils are moderate to fairly shallow in depth often over hardpan or parent rock; low in organic matter and often stony. Much of the area occupied by this type is similar climatically to that supporting basin big sagebrush (*Artemisia tridentata* subsp. *tridentata*) which occurs on deeper, more fertile soils.

Growth occurs mainly during a relatively short period from mid-March to late May, and soil moisture is usually limiting for herbaceous species after that date. Wyoming big sagebrush has a root system well adapted to utilize this spring moisture and also to maintain limited photosynthesis and seasonal development until the fall months. On its xeric edge, this type meets black sagebrush (*Artemisia nova*) orshadscale (*Atriplex*) types. At its moister, cooler boundary, the contact is often with the mountain big sagebrush (*Artemisia tridentata* subsp. *vaseyana*) type.

Seral Relationships: Much of this cover type is currently in depleted condition due to various combinations of grazing and fire. The most palatable species, such as the perennial grasses and some forbs are easily injured by grazing, and decline drastically under heavy use. Wyoming big sagebrush is rarely browsed enough to deplete its stands. As a result, heavy grazing, without fire, results in stands with increased shrub cover and a sparse herbaceous layer composed mainly of Sandberg bluegrass and annuals. Once established, this condition is likely to persist for a long time regardless of management practices, due to the longevity of the sagebrush and the difficulty of establishment of the more desirable grasses and forbs. If fire occurs, this will destroy the sagebrush cover, and the resulting vegetation generally will be dominated by annuals, especially cheatgrass (*Bromus tectorum*). This type of annual cover is highly inflammable, and is likely to be perpetuated by wildfires unless rehabilitated by reseeding to perennial species. Large areas of this fire-induced annual type now occur in areas formerly occupied by the Wyoming big sagebrush cover type.

Variants and Associated Species: The most common association within the Wyoming big sagebrush cover type has bluebunch wheatgrass and Sandberg bluegrass as the principal associated species. Variants include communities whose herb layer is dominated by needle-and-thread or Indian ricegrass on sandy or calcareous soils; thurber needlegrass in very dry areas with moderately deep, silty soils and Sandberg bluegrass only on very dry sites. Bottlebrush squirreltail has a greater potential for natural reseeding than most of the native grasses, and is often abundant on areas which have made some recovery from a depleted condition. References include Beetle and Young, 1965; Beetle and Johnson, 1982; Hironaka et al, 1983; Hodkinson, 1982; Morris, 1976; Passey et al, 1982; and Winward, 1980.

Edwin W. Tisdale
University of Idaho
Moscow, ID

THREETIP SAGEBRUSH
SRM 404

Definition, Composition, and Structure: This type is characterized by a shrub layer of threetip sagebrush (*Artemisia tripartita*) and a well developed herbaceous component of perennial grasses and forbs. Threetip sagebrush dominates the shrub layer; green rabbit brush (*Chrysothamnus viscidiflorus*) and grey horsebrush (*Terradymia canescens*) occur on most sites but in much smaller amounts. The perennial grass component is dominated by Idaho fescue (*Festuca idahoensis*) and bluebunch wheatgrass (*Agropyron spicatum*). Common but less abundant species include Sandberg bluegrass (*Poa secunda*), prairie Junegrass (*Koeleria pyramidata*), needle-and-thread (*Stipa comata*), rhizomatous wheatgrasses (*Agropyron dasystachyum* and spp.), and Nevada bluegrass (*Poa nevadensis*). The perennial forb cover, although slightly less than a third of the grass component by weight, contains a wide variety of species. The most common of these include pussytoes (*Antennaria microphylla* and spp.), milkvetch (*Astragalus*), Indian paintbrush (*Castilleja angustifolia* and spp.), tapertip hawksbeard (*Crepis acuminata*), fleabane (*Erigeron pumilis* and spp.), eriogonum (*Eriogonum ovalifolium* and spp.), biscuitroot (*Lomatium triternatum* and spp.), lupine (*Lupinus caudatus* and spp.), longleaf and hoods phlox (*Phlox longifolia* and *P. hoodii*) and death

camas (*Zigadenus paniculatus* and *Z. venenosus*).

Threetip sagebrush is low in stature, usually 18-24 inches (45-60cm), and often does not exceed the height of the taller bunchgrasses. Percent composition by weight ranges from 18 to 30 with an average of about 22 percent for the shrub layer, 60 for grasses and 18 for forbs. Ground cover is high in litter and bare ground, but low in surface rock or gravel and cryptogams. Average annual production ranges from 450 to 1100 lbs. per acre (500-1225kg/ha).

Geographic Distribution: This type is confined to the northern portion of the sagebrush region, including Wyoming; southwestern Montana; southern Idaho; the northern tips of Utah and Nevada; eastern Oregon and Washington; and southern British Columbia. Within its range, occurrence tends to be sporadic and discontinuous, with few large stands.

Ecological Relationships: This cover type occurs in areas of relatively high elevation 4000-9000 ft (1300-3000m) except near its northern limits, with average annual precipitation of 12 to 16 inches (30-40cm). Its restriction to the northern part of the sagebrush region, shows an affinity for cool, moderately moist sites. The factors which separate its habitat from that of the mountain and basin big sagebrush types are not well understood, but edaphic factors appear to play a considerable role. Hauxwell (1977) in a soils study of 5 sagebrush types in east central Idaho found that the threetip community was intermediate between the dwarf sagebrush types (low and black sagebrush) and mountain big sagebrush in depth to lime layer, soil texture, and rooting depth. The threetip type ranked next to the mountain big sagebrush in depth of "A" horizon and soil moisture regime. Similar data are not available for other areas, but in general it appears that threetip occurs in many areas which are similar climatically to those occupied by mountain or basin big sagebrush, but on shallower and/or more gravelly soils.

Seral Relationships: Threetip sagebrush differs from most sagebrush taxa in its ability to sprout from shallow lateral roots. As a result, the shrub stand tends to regenerate readily after fire or herbicide treatment, although the extent of this response varies considerably. Under heavy grazing the shrub cover tends to thicken, and desirable perennial grasses and forbs are replaced by annuals and less palatable forbs. Although cheatgrass is common on depleted stands of this type, it is not as predominant as in more xeric sagebrush communities. The presence of Kentucky bluegrass (*Poa pratensis*) as an increaser also indicates the relatively mesic nature of this type. Mixed stands of threetip with basin or mountain big sagebrush are fairly common. These probably reflect the influence of fire, which enables the fire tolerant threetip to occur in habitats where one or the other of the two big sagebrushes is climax.

Variants and Associated Species: The main threetip sagebrush type is fairly uniform over most of its range, with Idaho fescue as the dominant grass. A more xeric phase, dominated by bluebunch wheatgrass, occurs sparingly. The ability of threetip sagebrush to sprout after fire or herbicidal treatment differs considerably in different populations. The principal variation of the type occurs in Wyoming, in areas east of the continental divide. Here the threetip sagebrush is the subspecies *rupicola*, a dwarf spreading shrub rarely exceeding 6 inches (15cm) in height, which is confined to thin rocky soils at elevations of 7,000 to 9,000 ft (2300-3000m). The associated herbaceous vegetation is very sparse. References include Beetle, 1960; Daubenmire, 1970; Maxwell, 1977; Hironaka et al, 1983; Mueggler and Stewart, 1980; Passey et al, 1982; and Winward, 1980.

Edwin W. Tisdale
University of Idaho
Moscow, ID

BLACK SAGEBRUSH
SRM 405

Definition, Composition, and Structure: Black sagebrush (*Artemisia nova*) is the characteristic shrub, accompanied by an herbaceous layer of perennial grasses and forbs. Black sagebrush is clearly the dominant shrub, with green rabbitbrush (*Chrysothamnus viscidiflorus*) as an almost constant but much less abundant associate. Winterfat (*Ceratoides lanata*) and slenderbush eriogonum (*Eriogonum microthecum*) are of less frequent occurrence. Bluebunch wheatgrass (*Agropyron spicatum*) is the most abundant grass, but Sandberg bluegrass (*Poa secunda*) and bottlebrush squirreltail (*Sitanion hystrix*) occur commonly throughout the type. Species of more restricted habitat, which are important on certain sites include Indian ricegrass (*Oryzopsis hymenoides*), needle-and-thread (*Stipa comata*) and, less commonly, Thurber needlegrass (*Stipa thurberiana*) and Idaho fescue (*Festuca idahoensis*). Associated forbs include a large number of species, none of great abundance, and relatively few with a high degree of occurrence. Those most likely to occur include milkvetch (*Astragalus purshii* and spp.), Indian paintbrush (*Castilleja* spp.), fleabane (*Erigeron pumilis* and spp.), stemless goldenweed (*Haplopappus acaulis*), lomatium (*Lomatium* spp.) and phlox (*Phlox hoodii* and *P. longifolia*). Plains prickly pear (*Opuntia polyacantha*) is common on many drier sites, as is hawksbeard (*Crepis acuminata* and spp.) on more mesic areas.

The shrubs are low in stature 12 to 20 inches (30-50cm), with moderate cover. Percent composition by weight averages about 35 for shrubs, 45-50 for grasses and 15-20 for forbs. The ground cover is low in litter and about 70 percent gravel or bare ground. Average annual production ranges from 350 to 500 pounds per acre (390-550kg/ha).

Geographic Distribution: This type occurs mainly in

western Wyoming and Colorado, Utah, Nevada and southern Idaho, with outliers in southwestern Montana, southeastern Oregon, eastern California, northern Arizona and New Mexico.

Ecological Relationships: This type occurs at middle elevations, in an annual precipitation zone of 8 to 16 inches (20-40cm), most of it within 8 to 12 inches (20-30cm). Climatically this overlaps the range of the big sagebrush cover types. The key to the occurrence of black sagebrush is edaphic; droughty soils which are coarse textured, usually calcareous and either shallow over a silica hardpan, or if deeper, with extreme gravelly subsoil. Compared to those occupied by low sagebrush, these black sage soils are less developed, unlikely to be saturated with moisture in spring, and generally drier. As a result, the growing season is very short. On its mesic side, the black sagebrush type often abuts the Wyoming big sagebrush or basin big sagebrush types which occur on deeper, usually finer soils. On its xeric side, the black sagebrush merges into shadscale (*Atriplex confertifolia*) types.

The morphological similarity of black and low sagebrush has led to considerable confusion between the two. The abundance of black sage in eastern Oregon (and southwestern Idaho) was greatly overestimated in earlier surveys (Winward 1980). The two species have also been lumped together in some studies i.e., in Montana (Mueggler and Stewart 1980).

The type is suited for livestock grazing in late spring, fall and often winter. Wildlife, especially pronghorn antelope, may utilize it year-long.

Seral Relationships: Heavy grazing reduces the herbaceous component, especially the larger bunchgrasses. Sandberg bluegrass is less affected, and may come to dominate the herb layer. Black sage itself is used moderately by sheep, but less by cattle or deer, and its stands usually remain relatively unaffected by grazing. Most annuals do not thrive in the black sage community, and cheatgrass (*Bromus tectorum*) does not become dominant as it does in many sagebrush cover types. Wildfire is relatively scarce in this type due to the sparseness of fuel. Depleted sites may be subject to erosion due to the large proportion of bare ground surface. Natural recovery in this type is slow and the potential for artificial revegetation is low.

Variants and Associated Species: Although this type occurs over a considerable range of annual precipitation, the strong influence of the droughty soils makes for a high degree of uniformity. A mesic subtype in which Idaho fescue dominates the grass cover is a noticeable variant, reported only from small, high elevation areas in southeastern Idaho, but possibly occurring elsewhere under favorable moisture and temperature conditions.

Edwin W. Tisdale
University of Idaho
Moscow, ID

LOW SAGEBRUSH
SRM 406

Definition, Composition, and Structure: The type is characterized by a shrub layer of low sagebrush (*Artemisia arbuscula*) and a herbaceous layer of perennial bunchgrasses and forbs. Low sagebrush is the most abundant shrub; green rabbitbrush (*Chrysothamnus viscidiflorus*) occurs frequently but in much smaller amounts; slenderbush eriogonum (*Eriogonum microthecum*) and antelope bitterbrush (*Purshia tridentata*) occur only on particular sites. The principal grasses are bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*) and Sandberg bluegrass (*Poa secunda*). Less common species include bottlebrush squirreltail (*Sitanion hystrix*), Thurber needlegrass (*Stipa thurberiana*), needle-and-thread (*Stipa comata*) and prairie junegrass (*Koeleria pyramidata*). Cheatgrass (*Bromus tectorum*) an introduced annual, occurs on many sites still considered in near-climax condition. Numerous species of perennial forbs occur, but only a few with a sufficient frequency to be characteristic of the type. Wild onion (*Allium textile* and spp.), pussytoes (*Antennaria dimorpha* and spp.), milk vetch (*Astragalus purshii* and spp.), balsamroot (*Balsamorhiza hookeri* and *B. sagittata*), herbaceous eriogonums (*Eriogonum ovalifolium* and spp.), fleabane (*Erigeron bloomeri* and spp.), biscuitroot (*Lomatium triternatum* and spp.), goldenweed (*Haplopappus acaulis* and *H. carthamoides*) and phlox (*Phlox hoodii* and *P. longifolia*) belong in this class.

The shrub stand is low in stature, 12-20 inches (30-50cm), with a canopy cover of 15-25%. Approximately 35% of the composition by weight is contributed by shrubs, 45% by grasses and 20% by forbs. The ground cover consists of about 30% litter, few cryptogams, 10% or more of surface gravel and over 50% bare ground. Average annual production ranges from 300 to 650 pounds per acre (330-750kg/ha), depending largely on the precipitation zone occupied.

Geographic Distribution: The range of this type includes extreme western Wyoming and southwestern Montana, southern Idaho, eastern Oregon, northern Nevada and Utah, northwestern Colorado and northeastern California.

Ecological Relationships: The type occurs over a wide range climatically, with average annual precipitation from 8 to 16 inches (20-40cm), but is generally confined to areas of moderate to high elevations 3000-9000 ft (1000-3000m). This climatic range overlaps that of the big sagebrush types, and low sage occurs as an edaphic climax throughout this range. The associated soils are usually characterized by shallow depth 12-20 inches (30-50cm) to an impermeable clay "B" horizon or bedrock substrate. Such profiles have a low total moisture holding capacity, but may be saturated for a short period during spring, and soon become dry as the

season progresses. This edaphic situation results in a wide range of seasonal moisture conditions and a short growing season. Because occurrence of the type is edaphically determined, it often occurs in mosaics with one of the big sagebrush types, with the two communities sharply separated. The type is valuable for late spring and summer grazing, but can suffer from trampling of the wet surface soil if grazed too early.

Seral Relationships: This community is highly susceptible to grazing and trampling of herbivores; low sagebrush itself is also easily killed by fire, although the relatively sparse cover makes it less likely to burn than are the big sagebrush communities. Although low sage is one of the more palatable species of sagebrush, the type still responds to heavy grazing by loss of most of the palatable understory. The common result is a shrub dominated community with a sparse understory of unpalatable perennials and a few annual species. Cheatgrass is common under such conditions, but does not usually become as abundant as it does in the big sagebrush types. Another introduced annual grass, medusahead (*Taeniatherum asperum*) sometimes becomes abundant on areas where the sagebrush cover has been reduced by fire.

Variants and Associated Species: Considerable variation is produced by differences in climatic and soil factors. Climatic differences are reflected largely in the herbaceous understory, which can range from one dominated by bluebunch wheatgrass and Sandberg bluegrass to a more mesic component consisting mainly of Idaho fescue with numerous perennial forbs. The soil component varies also, for although the bulk of the type occurs on shallow soils with impermeable substrates, it also occurs on deep, very coarse-textured profiles, especially along the eastern border of its range (Sabinske and Knight, 1978). The reasons for occupation of such sites by low sagebrush is not well understood. These coarse soils become very dry in summer, but are not likely to be saturated with moisture in the spring as do the shallow soils with impermeable substrates.

Sagebrush taxonomic variation within the type occurs in two ways. First is the inclusion of two subspecies of low sage, namely *Artemisia arbuscula* ssp. *arbuscula*, and *A. arbuscula* ssp. *thermopola*. The former occurs over most of the type. The latter is a distinctive form limited to small areas in extreme western Wyoming, northwestern Utah and southeastern Idaho. It occurs in relatively high elevations, on thin, poorly drained soils, usually within forest openings. The other variant is one dominated by early sagebrush (*Artemisia longiloba*), a species closely related to low sage, but distinguished by its earlier seasonal development. The herbaceous cover is dominated by Idaho fescue and includes many of the forb species which are associated with low sagebrush. The early sagebrush type occurs in eastern Oregon, southern Idaho, western Wyoming, northern Colorado, Utah and Nevada. The actual area occupied is relatively small and confined to patches of fine textured soils which usually have a strongly developed clay "B" horizon within 13-14 inches (32-35cm) of surface. The soils of such sites are similar to those occupied by low sagebrush and the ecological characteristics which separate the two species in the field are not understood.

References include Beetle and Johnson, 1982; Hironaka et al, 1983; Mueggler and Stewart, 1980; Passey et al, 1982; Winward, 1980; Young et al, 1977; and Zamora and Tueller, 1977.

Edwin W. Tisdale
University of Idaho
Moscow, ID

STIFF SAGEBRUSH
SRM 407

Definition, Composition, and Structure: This type has a shrub layer of stiff sagebrush (*Artemisia rigida*), and a relatively sparse herbaceous cover of perennial bunchgrass and forbs. Stiff sagebrush forms almost all of the shrub component; slenderbush eriogonum (*Eriogonum microthecum*) is the only associated shrub, and it is found on a minority of sites. The perennial grass cover consists mainly of Sandberg bluegrass (*Poa secunda*), with much smaller amounts of bottlebrush squirreltail (*Sitanion hystrix*). The sparse forb cover includes several species of biscuitroot (*Lomatium macrocarpum, L. nudicaule* and spp.), wild onion (*Allium accuminatum* and spp.), cut-leaf balsamroot (*Balsamorhiza hookeri*), and bighead clover (*Trifolium macrocephalum*). This group comprises the most common species; others occurring less frequently include wild hyacinth (*Brodiaea douglasii*), pussytoes (*Antennaria* spp.), eriogonum (*Eriogonum* spp.), bitterroot (*Lewisia rediviva*), phlox (*Phloxhoodii* and spp.), microseris (*Microseris nutans* and spp.) and prairiestar (*Lithophragma parviflora* and spp.).

Stiff sagebrush is a dwarf species, 12-16 inches tall, which forms a moderate foliage cover, averaging 20 percent, associated with a sparse herbaceous layer dominated by the low-growing Sandberg bluegrass. The percent composition by weight is 35-45 percent shrub, an equal amount for grasses, and 15-20 percent forbs. The annual production of 100 to 200 lbs. per acre (110-220kg/ha) is the lowest of any sagebrush cover type. The ground cover generally is about 65 percent bare ground, 20 percent cryptogams and 10 to 15 percent litter. Stiff sagebrush differs from other mentioned sagebrush species in that it is deciduous.

Geographic Distribution: This type has a highly restricted distribution in the northwestern segment of the sagebrush region. It is found only in eastern and central Oregon and Washington, and in extreme western Idaho.

Ecological Relationships: The stiff sagebrush type occurs in areas of low to moderate elevation 700 to 4,000 ft (230-1300m) on level to moderately sloping terrain, and in a

wide range of annual precipitation, from 8 to 16 inches (20-40cm). The key to its presence is edaphic, for it is restricted to shallow soils over basalt. These soils are usually less than 10 inches (25cm) deep, and if deeper, have more than 50 percent of stone or gravel in the profile. The result in either case is a soil with low moisture capacity which becomes saturated in early spring and then dries out rapidly in the growing season. The nature of this harsh habitat is reflected in the low stature of the dominant shrub and grass species, and the shortness of the growing season. The taller bunchgrasses characteristic of most sagebrush types are lacking or occur sparsely in pockets of deeper soil. Because of its edaphic limitations, this type is commonly found in close juxtaposition with cover types of very different composition. Over much of its range the contact is with communities of the Pacific Northwest bunchgrass, while in southern Oregon and southern Idaho the contact is with other sagebrush types, especially mountain big sagebrush. In all cases, the stiff sagebrush stands are separated from the surrounding vegetation by the distinctive, shallow soil type. The other principal contact of the stiff sagebrush type is with vegetation dominated by low-growing, shrubby species of eriogonum (*Eriogonum niveum, E. sphaerocephalum*, and spp.). These eriogonums, with an herbaceous cover dominated by Sandberg bluegrass, occur on soils too rocky or shallow for even stiff sagebrush to survive. Such vegetation is fairly common in the same geographical area as stiff sagebrush, but the total area occupied is relatively small.

Seral Relationships: This type is easily damaged by grazing animals, especially in early spring when the forage is most attractive to them. Since the soil is usually saturated with moisture at this time, and is lacking in protective ground cover, trampling damage is often more important than actual forage utilization. Much of the type is currently in a depleted condition, marked by dominance of the sagebrush, and an herbaceous layer consisting mainly of cheatgrass (*Bromus tectorum*) and other annuals.

Variants and Associated Species: The restricted geographical distribution and edaphic limitations of this type make for a high degree of uniformity over most stands of this cover type. The considerable range in elevation and annual precipitation, however, does result in a relatively mesic, high elevation variant. This community (Tisdale 1986), which occurs at elevations of 3,600 to 4,000 ft (1200-1300m), differs from that described for most of the type. The soil profile is generally deeper, ranging from 12 to 18 inches (30-45cm). The vegetation is characterized by a rather sparse cover of stiff sagebrush (10-14%) and by a larger amount of perennial forbs than are found in the main type, although species composition remains similar. References include Beetle and Johnson, 1982; Hironaka et al, 1983; Mueggler and Stewart, 1980; Passey et al, 1982; Sabinske and Knight, 1982; Winward, 1980; Young et al, 1977; and Zamora and Tueller, 1977.

Edwin W. Tisdale
University of Idaho
Moscow, ID

OTHER SAGEBRUSH TYPES SRM 408

Definition, Composition, and Structure: Several other sagebrush taxa are found scattered within the Great Basin Region. These include silver sagebrush (*Artemisia cana*), fringed sagebrush (*Artemisia frigida*), bud sage (*Artemisia spinescens*), spiked sagebrush (*Artemisia spiciformis*), bigelow sagebrush (*Artemisia bigelovii*) and pygmy sagebrush (*Artemisia pygmaea*).

Artemisia cana

Artemisia cana occurs as two separate subspecies within the Great Basin. *Artemisia cana* subspecies *viscidula* (mountain silver sagebrush) is present throughout, but in limited acreage. It occurs in more poorly drained settings than other *Artemisia* taxa. It is found around margins of meadows or adjacent to some streams. Sites supporting it are highly productive with annual average production often exceeding 1,500 pounds per acre (1650kg/ha). *Artemisia cana* subspecies *bolanderi* (*Bolander silver sagebrush*) is very restricted in the Great Basin. Winward (1982) recorded several small populations in the Snake River Plains near Bliss, Idaho. It also is found near the Oregon and Nevada borders in southwestern Idaho. Bolander silver sagebrush occurs in catchment basins where water ponds during the spring thaw. Sites supporting it have relatively low production potential.

Both *A. cana* subspecies are resprouters and management should consider this somewhat unusual regenerating capability. Habitat types of *A. cana* include:

A. cana subspecies *visciduda/Festuca idahoensis.*
A. cana subspecies *visciduda/Deschampsia caespitosa.*
A. cana subspecies *bolanderi/Muhlenbergii richardsonis.*
A. cana subspecies *bolanderi/Poa nevadensis.*

Artemisia frigida (fringed sagebrush)

Artemisia frigida is suffrutescent and is common but scattered in the Great Basin and surrounding Regions. It is found on wind swept ridges and in open sites where soil appears to puddle in the spring season. It occurs from salt desert to alpine settings. No habitat types of *A. frigida* have been described in the Great Basin. This species needs further study.

Artemisia spinescens (budsage)

Artemisia spinescens is a low-growing, suffrutescent shrub that occurs in most western states. It is found in silty, clayey, or gravelly substrates, often at the interface between sagebrush grasslands and salt desert shrub types. This low shrub is a principle spring browse plant for both domestic and native animals. Communities and habitat types have not been described for this sagebrush taxon.

Artemisia spiciformis (spiked sagebrush)

Artemisia spiciformis occurs in upper elevations in the eastern portion of the great Basin. It has been described at various taxonomic levels, recently as a subspecies of *A. tridentata* (Goodrich and others 1985) and most recently as a distinct species (Welch and others 1987). It is distinguished from other big sagebrush taxa by its large, relatively few seed heads, and the common presence of seven or more seeds per head. Average annual production often exceeds 1,500 pounds per acre (1650kg/ha). It occurs in sites similar but slightly more productive than *A. tridentata* subspecies vaseyana var. vaseyana. Due to its interchanging taxonomic status it is difficult to know which habitat types actually belong to this taxon. Major graminoides that occur with it include: *Agropyron caninum, Bromus carinatus*, and *Carex geyeri*. This taxon is believed to have originated from a crossing of *A. tridentata* subspecies *viscidula* with *A.*-var. *vaseyana*. As such, it carries a modest resprouting characteristic it gained from subspecies viscidula.

Artemisia bigelovii (Bigelow sagebrush)

Artemisia bigelovii is restricted to the very southern portions of the Great Basin. It occurs on or near rimrock areas in pinyon-juniper and mixed desert shrub communities (Welch and others 1987). Little is known of the ecology of this taxon. It resembles *A. arbuscula* except for presence of occasional ray flowers and the more sharply pointed leaf lobes.

Artemisia pygmaea (pygmy sagebrush)

Artemisia pygmaea is a very dwarf sagebrush often reaching only .5 dm tall. It occurs on peculiar edaphic situations primarily on Green River Shale (Welch and others 1987). Little is known of its specific ecology. It is a common component of sites that support rare plant species. References include Daubenmire, 1970; Hironaka et al, 1983; Tisdale, 1986; and Winward, 1980.

A.H. Winward
Forest Service
Ogden, UT

TALL FORB
SRM 409

Definition, Composition, and Structure: The type is characterized by a large array of luxuriant, rather tall 16 to 48 inches (0.4 to 1.2 m) mesic forbs. In the climax condition many species are present without any species dominating (Ellison, 1954). Stands vary in number of species present and in those that are visually prominent. Certain grass and sedge species are found throughout the range of the type, but within the type, they are mostly inconspicuous and seldom comprise more than 10% of the composition. Shrubs are mostly absent. Most present day stands are in an early seral stage because of grazing disturbance or invasion of woody species, and are now dominated by a few species of seral forbs and grasses.

Major grass species found within the type include mountain bromegrass (*Bromus carinatus*), slender wheatgrass (*Agropyron trachycaulum*), oniongrass (*Melica spectabilis*), alpine timothy (*Phleum alpinum*), bluegrass (*Poa fendleriana, P. reflexa*), needlegrass (*Stipa columbiana, S. lettermanii*), and spike trisetum (*Trisetum spicatum*). Important sedges include *Carex festivella* and *C. raynoldsii*. Prominent forb species found within the type include Columbia monkshood (*Aconitum columbianum*), nettleleaf (*Agastache urticifolia*), Colorado columbine (*Aquilegia caerulea*), asters (*Aster engelmannii, A. foliaceus*), larkspur (*Delphinium barbeyi, D. occidentale*), Oregon fleabane (*Erigeron speciosus*), geranium (*Geranium richardsonii, G. viscosissimum*), stickseed (*Hackelia floribunda*), oneflower helianthella(*Helianthella uniflora*), cow parsnip (*Heracleum lanatum*), ligusticum (*Ligusticum filicinum, L. porteri*), lupine (*Lupinus alpestris, L. argenteus, L. sericeus*), bluebells (*Mertensia arizonica leonardi, M. ciliata*), western sweetroot (*Osmorhiza occidentalis*), lousewort (*Pedicularis bracteosus, P. groenlandica*), cinquefoil (*Potentilla glandulosa, P. gracilis*), western coneflower (*Rudbeckia occidentalis*), groundsel (*Senecio crassulus, S. cymbalarioides*), goldenrod (*Solidaga* spp.), meadowrue (*Thalictrum fendleri*), valerian (*Valeriana edulis, V. occidentalis*), showy goldeneye (*Viguiera multiflora*), and violet (*Viola* sp.) (Ellison, 1954; Langenheim, 1962; Ream, 1964; Gregory, n.d.; and VanHorn Ecret, 1986).

Geographic Distribution: Tall forb communities occur at elevations between 6300-9900 ft (2100 to 3300m), near springs, along streams, in small openings in forest, and in larger open parklands within Douglas-fir (*Pseudotsuga menziesii*) and spruce-fir (*Picea engelmannii-Abies lasiocarpa*) forest zones.

The type extends from the southern Wasatch range in Utah northward into Montana. It is especially prominent on the central Wasatch plateau (Ellison, 1954), on west (Horton, 1971) and east slopes of the Teton Range along

the Idaho-Wyoming border, and in the Wind River Range, Wyoming (Gregory, 1982). The type extends eastward into the Big Horn Mountains (Despain, 1973) and westward into the Centennial Mountains which are on the Idaho-Montana border (VanHorn Ecret, 1986). More southerly, the type is found in the Jarbridge Mountains along the Idaho-Nevada border (Lewis, 1975); the Ruby Mountains of Nevada (Loope, 1970; Lewis, 1971); the Uinta Mountains in Utah, and as far east as Gunnison, Colorado (Langenheim, 1962). The same and similar tall forb species occur in a seral role in the Madison (Patten, 1963) and Gallatin (Gregory, n.d.) ranges in southwestern Montana. They are also found, to a limited extent, on the non-granitic soils surrounding the central Idaho Batholith (Bill J. Little, retired USFS, 1988, personal communication; USDA-FS-R4, 1981), and possibly in the Olympic Mountains, Washington (Kuramoto and Bliss, 1970).

Ecological Relationships: The type is found on all aspects and slope gradients where soils are deep (>0.5m) and soil moisture is adequate for nearly season-long plant growth. Intensive grazing by domestic livestock causes a shift from mesic to xeric plant types. This change is accelerated where soil erosion is active. Mesic forbs and grasses are replaced by more xeric species like sticky geranium (*G. viscosissimum*), western yarrow (*Achillea millefolium*), and dandelion (*Taraxacum officinale*). During the process, there is often a pronounced increase in ephemeral species with tarweed (*Madia glomerata*) becoming prominent on many sites. On other sites, continued overgrazing or repeated site disturbance allows wyethia (*Wyethia amplexicaulis*), California falsehellebore (*Veratrum californicum*), aspen peavine (*Lathyrus lanzwertii*), or coneflower (*Rudbeckia* spp.) to become dominant.

On the Wasatch plateau, prolonged heavy grazing by cattle results in forb dominated communities, while heavy sheep use results in grass dominated communities (Ellison, 1954). Similar vegetational responses to overgrazing would be expected where ever the type occurs. With substantial soil loss, a return to the original conditions would be very slow.

Variants and Associated Species: Tall forb vegetation often extends as an understory layer into mountain big sagebrush (*Artemisia tridentata* spp.) *vaseyana* stands,) aspen (*Populus tremuloides*), and open Douglas-fir and spruce-fir forest when adjacent or near to tall forbs communities. In the Centennial Mountains, Nelson (1964) found a similar composition between tall forb types and mountain big sagebrush types, except the latter had a sagebrush overstory. However, on rocky sites, understory species in big sagebrush communities are the same as those found at lower elevations. Tall forbs are prominent as an herbaceous layer under tall shrubs (Rocky Mountain maple, *Acer glabrum; serviceberry, Amelanchier alnifolia*; chokecherry, *Prunus virginiana*) and under low density, uniformly-aged Douglas-fir (Horton, 1971).

R.B. Murray
Agricultural Research Service
Dubois, ID
and
H.F. Mayland
Agricultural Research Service
Kimberly, ID

ALPINE RANGELAND
SRM 410

Definition, Composition, and Structure: Alpine has been defined as the zone on mountains above treeline and below permanent snowline (Oosting 1956; Box, Van Dyne, and West 1966).

Several plant communities ranging from those occurring on cliffs and dry exposed ridges to those in wet and boggy meadows are found in alpine areas (Lewis 1970; Rottman and Hartman 1987). The plant communities are often fragmented into a patchwork or myriad of small units (Briggs and MacMahon 1983; Box, Van Dyne, West 1966). Alpine floras with a few hundred species are meager compared to tropical floras where over 100,000 species are common (Billings 1969). Lewis (1970) listed about 335 taxa for the Uinta Mountains. Wind, cold temperatures, and ultra violet radiation all contribute to the harsh environment that limits the kinds and number of alpine plants. Wind is a primary factor limiting tree growth.

Alpine communities are generally dominated by low perennial sedges, grasses, and herbaceous dicots. Kobresia like sedge (*Carex elynoides*), Bellards kobresia (*Kobresia bellardii*), tufted hairgrass (*Deschampsia caespitosa*), timber oatgrass (*Danthonia intermedia*), and spike trisetum (*Trisetum spicatum*) are among the common graminoides of dry to mesic places. Water sedge (*Carex aquatilis*) is common in wetlands. Moss campion (*Silene acaulis*) and Rocky Mountain nailwort (*Paronychia sessiliflora*) are common cushion or mat plants. Alpine avens (*Geum rossii*) is a widespread, aggressive, colonizing forb. Shrubs including dwarf willows such as *Salix cascadensis* and white dryad (*Dryas octopetala*) are limited to a few species of stature equal to that of associated herbaceous plants. Low willows such as plainleaf willow (*Salix planifolia*), glaucous willow (*S. glauca*), and barrenground willow (*S. brachycarpa*) form dense willow fields about 1-4 ft (.3-1.3m) tall in places and especially at the lower limits of alpine and at treeline with krummholtz trees.

Distribution: (General North America) Alpine is found on mountains high enough to have a treeline. In the Canadian mountains, it is found as low as 6,000 ft (2000m), but its lower limit steadily increases some 360 feet (120m) per degree latitude to 30 north latitude and then declines gradually to the equator. In the central Rocky Mountains, it

is well developed between 11,000 and 14,000 ft (3600-4600m) (Oosting 1956). The total area covered by alpine is small compared to some other rangeland types (Box, Van Dyne, and West 1966).

Distribution: (Intermountain Region)Holmgren (1972) treated alpine of the Intermountain Region under the Basin Range, Wasatch, and Uinta Series. In both the Basin Range and Wasatch Series, alpine is represented as isolated islands on the higher mountain ranges. In the Basin Range Series are included high points of the: Wassuk, White, Humboldt, East Humboldt, Toiyabe, Toquima, Ruby, Grant, Schell Creek, Snake, Deep Creek, and Stansbury Ranges. In the Wasatch Series are included Mount Timpanogos, Mount Nebo, and the head of Cottonwood Canyon in the Wasatch Range, and Delano Peak and Mount Belknap of the Tusher Range, and the high peaks of the LaSal Mountains. In contrast the alpine zone of the Uinta Mountains is continuous for 60 miles (96km). With about 300 square miles (780 sq. ha) of alpine, the area above timberline in the Uinta Mountains exceeds that of the rest of the Intermountain Region combined (Holmgren 1972).

Ecological Relationships: Primary succession of alpine vegetation has been difficult to study primarily because of the slowness of the processes imposed by the harsh environment. The seres from bare rock and open water have been proposed as a convergence toward a meadow or sedge-grass climax. Lichens and mosses colonize bare rock followed by mat or cushion plants and soil buildup which leads to the climax community. Wetland sedges followed by willows and other plants fill in open water with organic matter. This leads to soil build up and formation of the climax community. This climax concept in the alpine zone has been questioned. At best this succession is one of geological time, and it is difficult to study and substantiate (Box, Van Dyne, and West 1966). Lewis (1970) considered a sedge-grass community dominated by *Kobresia myosuroides* or *Carex elynoides* to be the nearest approach to alpine climax in the Uinta Mountains.

Retrogression is caused by abiotic and biotic factors such as ground ice heaving and churning and by grazing and other animal activities (Box, Van Dyne, West 1966). Plants active in secondary succession on disturbed sites are the same native plants active in primary succession. Invading, introduced weeds common to secondary succession at lower elevations are excluded by the harsh environment. Alpine secondary succession has been described as a recovery in vigor and density of native plants already on the site (Lewis 1970).

Variants and Associated Species: In general Great Basin Ranges and especially those included by Holmgren (1972) in the Basin Range Series are warmer and drier than the Rocky and Sierra Mountains. They also occur as isolated islands rather than continuous chains. Some are high enough to have alpine or alpine-like areas, but these are sufficiently different from typical alpine that Billings (1978) referred to them "as what might be called alpine desert". Compared to Rocky Mountain alpine, these alpine desert areas have: fewer arctic species, more endemics, floral composition more varied from peak to peak, greater species-substrate correlation, and inherently lower ground cover (Billings 1978). Alpine turf is usually limited to a few moist or wet places.

Sherel Goodrich
Forest Service
Vernal, UT

ASPEN WOODLAND
SRM 411

Definition, Composition, and Structure: This western range type, characterized by a tree overstory dominated by trembling aspen (*Populus tremuloides*), may have a simple undergrowth structure consisting primarily of graminoids, or a complex structure consisting of both tall and low shrubs, and a wide variety of both forbs and graminoids in the herbaceous layer. Among the hundreds of plant species encountered in western aspen woodlands, few can be considered characteristic of the type. Only mountain snowberry (*Symphoricarpos oreophilus*) and Fendler meadowrue (*Thalictrum fendleri*) are reported to occur in at least 50% of the aspen stands sampled throughout the interior West (Mueggler 1985a). Other commonly encountered shrubs include Saskatoon serviceberry (*Amelanchier alnifolia*), creeping barberry (*Berberis repens*), and rose (*Rosa* spp.). Frequently encountered forbs include sticky geranium (*Geranium viscosissimum*), spreading sweetroot (*Osmorhiza chilensis*), western valerian (*Valeriana occidentalis*), tuber starwort (*Stellaria jamesiana*), and western yarrow (*Achillea millefolium*). Frequent grasses are mountain brome (*Bromus carinatus*), blue wildrye (*Elymus glaucus*), western needlegrass (*Stipa occidentalis*), and Kentucky bluegrass (*Poa pratensis*). Conifers, most often subalpine fir (*Abies lasiocarpa*), may be present as understory in the process of replacing aspen as the dominant tree.

Geographic Distribution: Aspen woodlands are found on a wide variety of upland sites throughout the mountains of the West. They occur either as scattered groves or as broad expanses of forest. Colorado and Utah contain the most aspen-dominated woodlands, with (3.5 and 1.7 million acres (1.41 and 0.67 million ha) respectively (Green and Van Hooser 1983). The amount of aspen woodlands in the surrounding states is not nearly so great, but even Nevada, the driest state in the nation, contains over 36,000 ac (90,000 ha) of this type scattered among relatively small groves on favorable sites. Aspen grows at elevations ranging from less than 3280 ft (1,000m) in northern Montana to over 9844 ft (3,000m) in southern Colorado and Arizona. The upper elevational limits appear to be determined primarily by length

of growing season, and the lower limits by evapotranspiration. It usually is confined to sites with a minimum annual precipitation of 16 to 20 inches (40 to 50 cm), cold winters, deep snow and reasonably long growing season (Jones and DeByle 1985).

Ecological Relationships: Trembling aspen functions as both a successional species on climax coniferous forest sites and as a climax-dominant tree in stable aspen woodlands (Mueggler 1985b). It has been observed as a seral constituent in a wide variety of climax conifer types, ranging from the relatively moist subalpine fir zone to the relatively dry ponderosa pine (*Pinus ponderosa*) zone (Mueggler 1988). Because of its ability to reproduce vigorously by root suckering, aspen may dominate a forest community for many decades following fire or clearcutting, but will gradually decline as the more shade tolerant conifers become reestablished. This successional process can occur in a single aspen generation (less than 100 years) or take several aspen generations, depending on the abundance of conifer reproduction. The abiotic environmental conditions determining aspen's role as a climax tree species are not well understood. It appears to form relatively stable communities at mid to low elevations and on southerly exposures, but is usually successional to conifers at the higher elevations and on northerly exposures. The most valid general indicator of seral aspen is the presence of conifers either in the overstory or as reproduction.

Variants and Associated Species: The broad environmental amplitude of trembling aspen, and its ability to function as a major seral as well as climax tree, contribute to a wide diversity of overstory and undergrowth conditions in western aspen woodlands. In addition, manyof these woodlands have undergone considerable alteration from the intense grazing pressure received in the late 1800's and early 1900's. For example, 56 aspen-dominated community types, occurring within 8 tree cover types, were identified just in the Intermountain Region (Mueggler 1988). The most rudimentary yet useful classification of type variants takes into account the occurrence of conifers in the tree layer, the occurrence of a tall shrub and/or low shrub layer, whether the herbaceous layer consists primarily of forbs or of graminoids, and whether the forbs are primarily tall and lush or low and relatively unproductive.

Walter F. Mueggler
Forest Service (retired)
Logan, UT

JUNIPER-PINYON WOODLAND
SRM 412

Vegetation dominated by either juniper alone or with various cembroid pines extends over at least 42.5 million acres (17 x 10^6 ha), centered in the Intermountain Region (West 1988). About nine species of junipers and four pinyons are involved. Junipers are more widespread geographically and elevationally, going into both drier and colder habitats than the pinyons. In the central parts of this biome and in the midst of the woodland belt, usually one juniper and one pinyon form the tree guild, hence the name for these woodlands. Tree heights and canopy cover varies enormously, usually increasing with elevation (West 1988). Understory dominants are even more diverse than the trees (West et al. 1975), varying with seasonality and effectiveness of precipitation and temperatures and strongly similar to adjacent grasslands or shrub steppes. Cool season bunchgrasses prevail in the northern and western Great Basin whereas there are more warm season sod grasses and fewer shrubs in the woodlands of the Colorado Plateau and Rio Grande basin where `monsoonal' rainfall patterns prevail.

Juniper-pinyon woodlands have changed enormously because of human uses extending back to prehistoric times (West 1988). However, the more pervasive influences have been livestock and fire control introduced by European colonists (West 1984a). Savanna-like conditions have reverted to thickening tree stands as understory was lost. Accelerating erosion has led to site degradation because of increasing proportions of bare ground when trees dominate (West & Van Pelt 1988). Because the trees can live for centuries this trend can only be reversed by destruction of the trees, thus explaining the widespread use of chaining and herbicides in recent decades. Because seed banks of native understory species were usually depleted, artificial seeding typically accompanied such operations (West 1984b).

Although radical type conversions have now largely ceased because of economic and environmental reasons, the type continues to become more tree-dominated and will eventually burn in fire storms. If not reseeded to more desirable species immediately, such hot burns will likely become dominated by annuals and then reburned more frequently. The loss of nutrients via volatilization and erosion will rachet site potential further downward.

Neil E. West
Utah State University
Logan, UT

GAMBEL OAK
SRM 413

Definition, Composition, and Structure: Gambel oak (*Quercus gambellii*) is the major dominant. Other trees that occur prominently in various portions of the Gambel Oak type include white fir (*Abies concolor*), big toothed maple (*Acer grandidentatum*), Utah and Rocky Mountain junipers

(*Juniperus osteosperma* and *J. scopulorum*), pinyon pines (*Pinus edulis*) and more rarely (*P. monophylla*), ponderosa pine (*Pinus ponderosa*), and quakingaspen (*Populus tremuloides*) (Wells 1960, Holmgren 1972, Harper et al. 1985, Albee et al. 1988). Gambel oak understories are normally richer in shrub species than in forbs and graminoids (Harper et al. 1985). Shrubs commonly associated with Gambel oak include Saskatoon and Utah serviceberries (*Amelanchier alnifolia* and *A. utahensis*), sagebrushes (*Artemisia* spp.) usually mountain big sagebrush (*A. tridentata* ssp. *vaseyana*), Oregon grape (*Berberis repens*), ceanothus or buckbrush (*Ceanothus* spp.), mountain-mahoganies (*Cercocarpus intricatus, C. ledifolius*, and *C. montanus*), Stansbury cliffrose (*Cowania stansburiana*), mountain lover (*Pachistima myrsinites*), chokecherry (*Prunus virginiana*), antelope bitterbrush (*Purshia tridentata*), wild rose (*Rosa* spp.), blue elderberry (*Sambucus caerulea*), and mountain snowberry (*Symphoricarpos oreophilus*) (Dixon 1935, Wells 1960, Holmgren 1972, Harper et al. 1985, Albee et al. 1988). Graminoids and forbs are not as common but a large array of native and introduced species occur in various parts of the Gambel oak type (Harper et al. 1985, Albee et al. 1988). The most notable and widespread of these include yarrow (*Achillea millefolium*), aster (*Aster* spp.), fleabane (*Erigeron* spp.), buckwheat (*Eriogonum* spp.), lupine (*Lupinus* spp.), knotweed (*Polygonum* spp.), goldenrod (*Solidago* spp.), dandelion (*Taraxacum* spp.), wheatgrass (*Agropyron* spp.), fescue (*Festuca* spp.), bluegrass (*Poa* spp.), and needlegrass (*Stipa* spp.) (Holmgren 1972, Harper et al. 1985, Albee et al. 1988).

Geographic Distribution: Gambel oak occurs from northern Utah and extreme south central Wyoming south through the mountains of Utah, Colorado, New Mexico, and Arizona and in a few outlier populations in northern Mexico. On an east-west axis, it occurs from isolated pockets in southern Nevada to isolated pockets in west Texas, and larger stands in southeastern Colorado, and northeastern New Mexico (Little 1971, Harper et al. 1985). It occurs at elevations ranging from approximately 3000-9300 ft (1,000-3,100m) with a wider elevational range limit in the southern portions of its distributional range than in the north (Neilson and Wullstein 1983). The species' distributional patterns seem to be limited by absence of summer rain and by late spring frost in the northwestern portion of the range (Neilson and Wullstein 1980, 1983, 1985). Southern and eastern range limits are probably maintained by competition from other species. The optimal elevational ranges for two areas of common occurrence are ca. 2,500 + 300 m for southwestern Colorado and ca. 2,000 + 300 m for northern Utah (Harper et al. 1985).

Gambel oak is a major component on more than 9.25 million acres (3.7 million ha) in the western United States with most of that area in the states of Arizona, Utah, and Colorado (49, 29, and 21 percent, respectively, of the area dominated by Gambel oak) (Harper et al. 1985).

Ecological Relationships: On some sites, Gambel oak is apparently a climax species, but in many other areas it is subclimax or seral (Brown 1958, Holmgren 1972, Floyd 1982, Harper et al. 1985). In various parts of its range, Gambel oak may be suppressed and replaced in natural succession by canyon maple (*Acer grandidentatum*), white fir (*Abies concolor*), pinyon and ponderosa pines (*Pinus edulis* and *P. ponderosa*), and Rocky Mountain juniper (*Juniperus scopulorum*). Although fire, herbicides, and mechanical treatments are used to reduce the dominance of Gambel oakfor management purposes, the species sprouts prolifically after most treatments. In fact, Gambel oak is a fire climax species and generally reclaims its prefire dominance in a decade or two (Brown 1958, Harper et al. 1985). Gambel oak's clonal growth habit and underground lignotuber, rhizome, and root system(Tiedemann et al. 1987) are well suited for stand recovery after disturbance.

Gambel oak communities are best developed on sloping upland sites, but the species also occurs regularly along slope bases adjacent to streams and on river plains (Brotherson et al. 1983, Harper et al. 1985). In these lowland sites, the species is frequently associated with such species as sandbar willow (*Salix exigua*), hawthorne (*Crataegus douglasii*), boxelder (*Acer negundo*), and ninebark (*Physocarpus malvaceus*). There also, Gambel oak reaches it largest size, up to 20 + m in height. While many of the growth differences observed among Gambel oak clones are related to environmental conditions, genotypic differences are undoubtedly also important (Pendleton et al. 1985).

Gambel oak grows mostly on soils derived from limestone, limey sandstones, and shales or granitic parent materials. Soil textures are generally loam to silt loam; soil pH ranges from 5.9 to 8.0 with most readings being near neutral (pH - 7); and soil moisture holding capacity and organic content are usually high (Harper et al. 1985).

Variants and Associated Species: Gambel oak is an ecological equivalent to ponderosa pine (*Pinus ponderosa*) in many areas (Dixon 1935). Gambel oak communities grade into ponderosa pine, canyon maple (*Acer grandidentatum*), white fir (*Abies concolor*), Rocky Mountain juniper (*Juniperus scopulorum*), pinyon pine (*Pinus edulis*), mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*), mountain-mahogany (*Cercocarpus* spp.), antelope bitterbrush (*Purshia tridentata*), Stansbury cliffrose (*Cowania stansburiana*), and quaking aspen (*Populus tremuloides*) communities (Holmgren 1972, Harper et al. 1985).

Gambel oak has affinities with other white oak species. There are extant hybrids of Gambel oak with shrub live oak (*Quercus turbinella*) not only where they are currently parapatric but also hundreds of miles to the north in Utah's Wasatch and Oquirrh Mountains (Cottam et al. 1959). Gambel oak hybridizes naturally with several other oak

species including *Q. arizonica, Q. grisea, Q. harvardii, Q. mohriana, Q. muehlenbergii*, and *Q. undulata* (Harper et al. 1985). It has been artificially hybridized with several other oak species as well (Cottam et al. 1982).

Kimball T. Harper
Brigham Young University
and
E. Durant McArthur
Forest Service
Provo, UT

SALT DESERT SHRUB
SRM 414

Definition, Composition, and Structure: The salt desert shrub vegetation may be defined as those low elevation landscapes in the temperate deserts of the Great Basin and surrounding areas in the western United States dominated by one or more species of low growing chenopod shrubs. Vegetation cover is low, usually less than 10 per cent. Shadscale (*Atriplex confertifloia*), black greaseweed (*Sarcobatus vermiculatus*) and winterfat (*Ceratoides lanata*) are possibly the most extensive in their dominance throughout the Salt Desert Shrub vegetation. Other important woody species include four-wing saltbush (*Atriplex canescens*), Bailey's greasewood (*Sarcobatus baileyii*), bud sagebrush (*Artemisia spinescens*), salt rabbitbrush (*Chrysothamnus* spp.), blacksagebrush (*Artemisia nova*), Nuttall's saltbush (*Atriplex nuttallii*). Of these latter species, four-wing saltbush is usually not found as a dominant species over large areas. Rabbitbrush species are intermediate in this regard but are usually considered to be low seral plant communities. See Tueller (1975) and West (1983) for a consideration of plant associations and habitat types in the salt desert shrub vegetation.

Important grasses in the salt desert shrub vegetation include both cool season and warm season species: Indian ricegrass (*Oryzopsis hymenoides*), Saltgrass (*Distichlis spicatum*), Galleta (*Hilaria jamesii*), Squirreltail (*Sitanion hystrix*), alkali sacaton (*Sporobolus airoides*), bluejoint (*Elymus triticoides*), and great basin wildrye (*Elymus cinereus*). Forbs are generally not conspicuous. One that should be listed is globe mallow (*Sphaeralcea ambiqua*). Halogeton (*Halogeton glomeratus*), Russian Thistle (*Salsola kali australis*), and barbwire Russian Thistle (*S. iberia*) are invader species.

Geographic Distribution: The salt desert shrub vegetation is found on alluvial terraces, bajadas, playas and playa edges (lake plains), salt flats, saline canyons and valleys. Elevations vary from approximately 3,600 to 6,000 ft (1200-2000m) but the vegetation is commonly found below 5,500 ft (1800m); many of the species have a much wider ecological amplitude. The pleistocene lakes in the Great Basin (Snyder et al. 1964) ascribe the low elevation areas where evaporation rates are high and the terrain is relatively flat. As the climate became more arid, most of these lakes completely evaporated leaving salts and fine sediments in the lake beds which are now known as playas. There is a high correlation between the boundaries of the lakes and the distribution of the salt desert shrub vegetation. Kuchler (1970) list 43 million acres (17 million ha) as being salt desert shrub. Branson et al. (1967) indicate that there are 38 million acres, but states that many of the species occur on about 143 million acres. Salt desert shrub plant communities are found mostly in Nevada, Utah, California, Oregon, Wyoming, Idaho and Arizona where they are often used as winter and spring range for livestock.

Ecological Relationships: The Great Basin dry lake beds or playas tend to be surrounded by halophytes. Moving from higher to lower elevations towards these playas, i.e., from the sagebrush/grass to the salt desert shrub vegetation, the precipitation decreases, temperatures generally increase except in winter when playa bottoms may be cooler than the uplands, the salinity increases, and the soil particle size decreases. These are areas of high summer temperatures, cold blowing snow in the winter and high evaporation rates. Clay soils result in higher soil moisture stress. Salinity also increases with depth in the soil, and, in many cases, may actually impede root growth. However, if the water table reaches the soil surface salinity decreases with depth.

These landscapes are commonly covered with low growing chenopod shrubs exhibiting uniform physiognomy, usually less than 10 percent ground cover, considerable bare ground between the shrubs and much desert pavement due to wind and water erosion. Billings (1949) reported that the average annual precipitation in the east is 7.9 inches (20cm) and in the west 4.5 inches (11cm) thought to be attributable to the rain shadow cast by the Sierra Nevada. The annual range in temperature is very high. Fautin (1946) found it could be as much as 145 for some shadscale sites. There is a frost free growing season of 120 days from May 20 to September 20. The wind usually blows every day. Precipitation comes in the winter with a slight bimodal distribution caused by a spring peak. June and July are the driest months.

Fautin (1949) showed that salt desert plants have certain morphological adaptations designed to conserve water. These are reduction in leaf surface, heavy cutinization, extreme pubescence and shedding of leaves. They adapt physiologically by increasing osmotic pressure values of the cell sap enabling them to obtain moisture from salt laden soils. Salt desert species adaptations for germination, growth and survival include tolerance to low soil solution osmotic potential and to specific ions in the soil solution, tolerance to flooding and low soil aeration, tolerance to drought, genetic potential for adaptation to specific soil conditions and chenopods may produce polymorphic seeds adapted to germination and growth under salt desert

conditions (Roundy and Young 1985).

Saline Great Basin soils tend to be dominated by sodium sulfate and chloride ions which form the relatively soluble salts, sodium chloride and sodium sulfate. Salt desert species may accumulate ions and synthesize solutes to maintain low osmotic potentials and facilitate continued water absorption (Roundy 1984). Caldwell (1974) described how halophytes deal with the accumulation of ions by osmotic adjustment.

Variants and Associated Species: Spiny hopsage (*Grayia spinosa*) and blackbrush (*Colegogyne ramossissima*) are transitional to the sagebrush and Mojave desert, respectively. On sand dunes one must list spotted dalea (*Dalea polyadenia*) smooth horsebrush (*Tetradymia glabrata*) and sand horsebrush (*Tetradymia comosa*). The little or low rabbitbrush species (*Chrysothamnus viscidiflorus* spp. *axillaris* and *puberulus* and *C. greenei*) have been important invader species on many salt desert shrub plant communities originally dominated by Ceratoides lanata or Artemisia nova (Blaisdell and Holmgren 1984). Kochia (*Kochia americana*) generally occurs on finer textured soils than shadscale although it is distributed much less extensively and is shallow rooting.

On the edges of the playas true halophytes are found including such species as pickleweed (*Allenrolfea occidentalis*) Glassort (*Salicornia* sp.), and Seepweed (*Suaeda* sp.). Branson (1956) referred to this as the salt marsh zone. With very high salt content the soils on some playas support only algae and fungi.

Paul T. Tueller
University of Nevada
Reno, NV

MOUNTAIN-MAHOGANY TYPES

Species of the genus *Cercocarpus*, commonly called mountain-mahogany, are shrubs or small trees that commonly occupy the drier sites of the interior mountainous regions of Western North America. All species provide important browse and cover for many wildlife species, especially big game. Three major species occur in the Intermountain and Great Basin area (Holmgren 1987, Welsh et al. 1987): curlleaf mountain-mahogany (*C. ledifolius*) and true mountain-mahogany (*C. montanus*), which are widely distributed and utilized species; and littleleaf mountain-mahogany (*C. intricatus*) which has a more restricted habitat. Where any two occur together, hybrids often result and great amounts of variation in growth form and leaf size occur within any one of the species on most sites. Relatively little autecological information is available in the literature on curlleaf mountain-mahogany, even less information on true mountain-mahogany, and almost none is obtainable for littleleaf mountain-mahogany.

James N. Davis
Utah Division of Wildlife Resources
Provo, UT

CURLLEAF MOUNTAIN-MAHOGANY SRM 415

Definition, Composition, and Structure: Curlleaf mountain mahogany can best be described as an evergreen montane xerophyte that is found normally as a small tree, but it sometimes occurs as a large shrub with average heights from only about 6 ft (2m) in the extreme north-eastern parts of its range to 27 ft (9m) or more in the central portions of its distribution. Curlleaf mountain-mahogany growth form varies from tree-like (1-2 stems per tree) to shrub-like (several stems per plant) in Utah. Varying growth forms can be observed throughout the areas where it occurs. Holmgren (1987) recognizes two varieties of curlleaf mountain-mahogany: var. *ledifolius* with narrow leaves .06-.16 inches (1.5-4mm) wide and var. *intermountanus* with broad leaves .2-.4 inches (5-10mm) wide. But it is not unusual to find leaf widths to .6 inches (14mm) or greater. There is no distinction made between the two varieties of curlleaf mountain- mahogany because they are ecologically similar in habitat preferences.

Curlleaf mountain-mahogany is a highly palatable, preferred winter browse for big-game species. It is also heavily used in summer within areas that do not have suitable summer ranges. Being evergreen, its nutritive value (about 12 percent protein) and digestibility ratings (around 50 percent) in the winter are high when compared with most associated winter browse species.

Curlleaf mountain-mahogany most frequently occurs in pure stands, but it can be found intermixed in ponderosa pine, pinyon pine, juniper, scrub oak, aspen, and spruce-fir communities. The stands characteristically consist ofisolated patches but infrequently are found singly or in continuous extensive stands.

Geographic Distribution: This type occurs widely but sporadically throughout all Western United States except for New Mexico (Martin 1950). The distribution for the two somewhat indistinct taxonomic varieties can be summarized in the following manner. The narrow-leafed variety (*var. ledifolius*) is widely dispersed throughout the more northern and eastern portions of the species' distribution. It occurs from eastern Oregon, across Idaho into southwestern Montana and down north-central Wyoming and through northern Utah. The wide-leaved variety (*var. intermountanus*) is commonly more central and southern in the species' range. It is found from southern Oregon to California, through Nevada, northern Arizona, Utah, and into western Colorado. Both varieties overlap from Oregon

and California, eastward into western Colorado.

Ecological Relationships: Curlleaf mountain-mahogany is found at relatively high elevations throughout its range. Within any area of occurrence, it is at higher elevations on southern than on northern exposures. It approaches or exceeds elevations of 9000 ft (3,000m) in the southern parts of its range and as low as 3000 ft (1,000m) in some areas of the northern portions of its range, but most commonly it grows between 4500-9000 ft (1,500m to 3,000m).

Stands of the species characteristically have sparse understories with considerable bare soil. Sometimes in central Nevada, it can be found at intermediate elevations where ponderosa and/or aspen forests occur at more easterly or westerly locations. Curlleaf mountain-mahogany is considered to be a local climax dominant species within a transition zone of variable altitudinal width between lower desert steppes, plains, or plateaus and higher elevation coniferous forests. It has been described by many as a dominant constituent of the vegetation of the Rocky Mountains and Great Basin within the mountain brush zone. However, almost all of the occupied sites have been disturbed by fire and/or grazing. Most curlleaf mountain-mahogany investigative research has dealt with two major management problems: (1) how to increase available forage production on old, evenaged, out of reach, curlleaf mountain-mahogany communities, and (2) how to increase reproduction in these same curlleaf mountain-mahogany communities. Excessive use of young plants by browsing animals has delayed successional trends and replacement of older plants, especially since seedlings develop slowly even without heavy use.

Utah stands appear to be older on average than comparable stands in Oregon. Such comparisons between Oregon and Utah are possible because Dealy (1975) developed two regression lines to describe diameter growth against time, one line for dry sites and one for moist sites. A line midway between his two regression lines would estimate a 8.12 inches (20.3cm) diameter stem to be 130 years old. Using the diameter-age regression equation developed for Utah populations (Davis 1976, Brotherson et al. 1980), the age of the same 8.12 inches (20.3cm) stem would be 131 years. Such remarkable similarity between regression equations suggests that the curlleaf mountain-mahogany diameter growth rate is similar in Oregon and Utah.

Relic specimens (older individuals) seem to occur often on the most rocky portions of sites. That pattern may indicate that such areas rarely burned. Other researchers have noted this phenomenon as well. Another explanation for this observed pattern is that such sites would not support much plant cover to compete with curlleaf mountain-mahogany seedlings that might become established there. The stands most often occur on south to southwest facing exposures. Where conifer species (*ponderosa* and *Douglas-fir*) grow intermixed with curlleaf mountain-mahogany on deeper soils, the conifer species will dominate, but on shallow-rocky soils, curlleaf is competitively superior, and rocky outcrops within these conifer types are often dominated by curlleaf.

Youngberg and Hu (1972) reported that in Oregon curlleaf mountain-mahogany produced root nodules and fixed nitrogen. They also determined that foliage nitrogen was highest in leaves from nodulated plants. Lepper and Fleschner (1977) showed that soils supporting limber pine and curlleaf mountain-mahogany associations had higher percentages of total nitrogen than soils beneath similar limber pine stands without curlleaf. The capacity of curlleaf mountain-mahogany to fix nitrogen helps explain how the species can successfully occupy the infertile sites that it is so regularly associated with.

Variants and Associated Species: Where the two varieties of curlleaf mountain-mahogany coexist with the other two species of mahogany in the Intermountain area, true mountain-mahogany and littleleaf mountain-mahogany, hybrids often occur. Great amounts of variation in growth form and leaf size occur within each of these species on sites where they occur together. The most common shrub associates of curlleaf are with serviceberry (*Amelanchier* spp.), snowberry (*Symphoricarpus* spp.), big sagebrush (*Artemisia tridentata*), black sagebrush (*Artemisia nova*), bitterbrush (*Purshia tridentata*), rabbitbrush (*Chrysothamnus* spp.), and Oregon grape (*Mahonia repens*). Grasses most often affiliated with curlleaf include bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), bluegrass (*Poa* spp.), cheatgrass (*Bromus tectorum*), Indian ricegrass (*Oryzopsis hyme noides*), needlegrass (*Stipa* spp.), and sedge (*Carex* spp.).

James N. Davis
Utah Division of Wildlife Resources
Provo, UT

TRUE MOUNTAIN-MAHOGANY SRM 416

Definition, Composition, and Structure: True mountain-mahogany is unlike curlleaf mountain-mahogany in that it is deciduous and more shrub-like. It commonly reaches 3 to 6 ft (1 to 2m) in height but can be found approaching 12 ft (4m) or more. As a winter forage, it is often valued higher than curlleaf mountain-mahogany because it occupies lower elevations and is more available as winter browse because of its shorter stature. Even though half the plant's protein occurs in its deciduous leaves, it is still a preferred and valuable forage. True mountain-mahogany is rated as good to excellent as browse for both livestock and wildlife, especially deer. It has also been found to make up over 80 percent of the diet of Rocky Mountain bighorn sheep on one low elevation summer

range in Colorado.

Geographic Distribution: True mountain-mahogany's principal range appears to be centered on Utah, Colorado, and Wyoming. It grows throughout the foothills and mountains of Utah and Colorado. The species also reaches into areas of South Dakota, Nebraska, Oklahoma, New Mexico, Arizona, and Nevada.

Ecological Relationships: It traditionally grows along ridges, bluffs, mountain slopes, and foothills at intermediate elevations between 3000 and 9000 ft (1,000 and 3,000m). True mountain-mahogany roots bear both nitrogen-fixating nodules and mycorrhizae that enhance phosphorus uptake (Hoeppel and Wollum 1971). These associations undoubtedly aid in the species' survival on the barren sites that it habitually occupies. The species' habitat has been characterized as harsh and rocky with shallow and undeveloped soils, especially when populations occur on warmer southern and westerly exposures. As with curlleaf mountain-mahogany, this species occupies all exposures but it appears to occupy increasingly southern exposures as elevation increases.

Variants and Associated Species: Plants intermediate between true mountain-mahogany and curlleaf mountain-mahogany occur frequently in zones of overlap. Such hybrids range from being much like the parents to a rich array of intermediate forms.

The species is frequently associated with grassland, sagebrush, mountain brush, pinyon-juniper, and sometimes even aspen or mixed conifer communities. Some of the species' more important associates in the mountain brush zone where it is probably most common are: serviceberry, snowberry, bitterbrush, sagebrush (*Artemisia* spp.), and oakbrush (*Quercus gambelii*).

James N. Davis
Utah Division of Wildlife Resources
Provo, UT

LITTLELEAF MOUNTAIN-MAHOGANY SRM 417

Definition, Composition, and Structure: This is a very narrow- leafed, intricately branched, evergreen shrub 1.5 to 9 feet (0.5 to 3 m) in height) whose ecology is not well understood. The species is commonly confined to steep rocky canyon faces in the Great Basin or in pinyon-juniper and desert shrub of the Colorado Plateau.

Geographic Distribution: Littleleaf mountain-mahogany can be found throughout most of Utah, sporadically in Nevada, in eastern and southern California, and in northern-most Arizona and extreme western Colorado.

Ecological Relationships: This taxon can be characterized as growing in shallow soils or in cracks and crevices of rock outcrops where few other plants are found. It appears to thrive on rimrock, cliffs, and rocky dry slopes within desert shrub, pinyon-juniper, and mountain brush communities from 2700 feet (900 m) in Arizona to almost 9,000 feet (3,000 m) in elevation in California's White mountains. It is commonly found in two habitats. One habitat is on steep, rocky surfaces, while the other is on poorly developed soils in pinyon-juniper woodlands or desert shrub communities. The first type has been described by Brayton and Mooney (1966) in eastern California. There, it is apparently restricted to steep limestone sites with little soil development. The "type collection" for Utah (Martin 1950) was collected on a similar site in American Fork Canyon where it occurs almost exclusively on steep limestone canyon slopes in association with curlleaf mountain-mahogany and conifer species. Just a short distance to the north of American Fork Canyon where the exposed rock is granite, littleleaf is absent and only curlleaf mountain-mahogany is present. Brayton and Mooney (1966) found that littleleaf occurred from low to high elevations of 5400 to 9000 feet (1,800 to 3,000 m), while curlleaf mountain-mahogany was restricted to the higher elevations 8100-9600 ft (2,700 to 3,200m) where it seemed indifferent to substrate. They reported that rock cover on littleleaf mountain-mahogany sites exceeded 90 percent and that such soils as were present had a pH of 8 to 8.5.

Fairchild and Brotherson (1980) gave some basic ecological information for the littleleaf mountain-mahogany type in pinyon-juniper and desert shrub habitats. They found it to be one of six species important in the pinyon-juniper understory of northeastern Arizona. There, littleleaf mountain-mahogany appeared as a pioneering species establishing islands of vegetation in crevices in exposures of slick-rock. Growing under such harsh conditions, one might assume that like the other two mountain-mahoganies it would also have the ability to fix nitrogen. Fairchild and Brotherson (1980) found littleleaf mountain-mahogany to be restricted to slick-rock areas where associated soils averaged only 7 inches (17cm) in depth and were of sandy texture (over 80 percent sand). Soil pH was neutral to slightly alkaline. Available studies generally support the basic conclusion that littleleaf mountain-mahogany occurs on sandstone on the Colorado Plateau, but in the Great Basin, it primarily occurs on limestone.

Variants and Associated Species: This species appears to maintain its morphological distinctiveness better than the other two species. It forms only occasional hybrids with the more sympatric southern, broad-leaved variety of curlleaf mountain-mahogany. It commonly occurs in southern Utah with rock spirea (*Petrophytum caespitosum*), ponderosa pine (*Pinus ponderosa*), Fendler's bluegrass (*Poa fendleriana*), and golden aster (*Heterothica vilosa*).

James N. Davis
Utah Division of Wildlife Resources
Provo, UT

MOUNTAIN BRUSH TYPES

Several tree/shrub dominated types occur within the Great Basin Region. These have been grouped under the heading "Mountain Brush Types". Some of these types occur in relatively large acreages and are rather distinct types, while others have mixed composition of several tree/shrub species. The more distinct types include Mahoganies and Gambel Oak. Those which may or may not have mixed compositions of several tree/shrub species include: Bigtooth Maple, Bittercherry, Snowbrush, and a combination Chokecherry Serviceberry-Rose Snowberry type.

A.H. Winward
Forest Service
Ogden, UT

BIGTOOTH MAPLE
SRM 418

Definition, Composition, and Structure: The *Acer grandidentatum* (*bigtooth maple*) type may occur in relatively pure stands or may be found interspersed with oak, sagebrush, Douglas-fir and white fir communities (Welch and others 1987). As such, a variety of tree, shrub, forb, and grass species may be found in its understories. No type classifications have been developed for this species. Stands which appear to be oldest and best developed usually are in canyon bottoms and on portions of side slopes with deep, well developed modal soils. It grows as a single or multi-stemmed tree ranging from 12 to 30 ft (4-10m) in height (Welch and others 1987). In settings where it is at the edge of its ecological range it normally occurs more shrub-like.

Geographic Distribution: The bigtooth maple type occurs mainly in southeast Idaho, southwest Wyoming, Utah, and eastern Nevada. Scattered occurrences may be found in states adjacent to these (Hitchcock and Cronquist 1973). In the Great Basin it ranges from approximately 4,000 ft (1300m) to over 8,000 ft (2700m) in elevation.

Ecological Relationships: It is believed that bigtooth maple has a moderate allelopathic influence on sites it occupies as it becomes dominant. This influence, along with competition for light, moisture, and nutrients, can result in near exclusion of understory associates when maple canopies become excessively dense.

In the geographic center of the range of this species, bigtooth maple has been gradually expanding its range into adjacent sagebrush, grassland and other cover types. Although no data are available to document this expansion, photographic records clearly indicate that a considerable amount of expansion of maple has occurred during the past 40 years, especially in southeastern Idaho and northern Utah. Most likely, an absence of natural wild fires is at least partially responsible for this expansion. Historical fire frequencies of 20-40 years would allow sagebrush and other surrounding cover types to remain, but would essentially keep the slower developing maple from establishing on sites highly suited to the other cover type dominants. Only on the more favorable settings could maple persist, mainly through resprouting, throughout the 20-40 year fire cycles. It is difficult to reestablish natural fire, or use prescribed fire in invaded settings where maple has gained dominance and crowded out the under-fuel component.

Under more natural conditions the bigtooth maple type is believed to have occurred with more open tree densities and in a mosaic with other rangeland cover types. Under these conditions the associated understory species provided the needed ground cover to help maintain watershed values beneath this deciduous species.

Presence of maple stands add considerably to the biodiversity of a geographic area and provide valuable habitat to many bird and mammal species. Its value as a foraging area for livestock is limited due to the relatively low amount of understory species associated with it, especially under moderate to dense tree canopies. The type does provide an aesthetically appealing variety of color to wildland settings, especially after fall frosts bring out the brilliant orange and red hues that complement other fall foliage.

Variants and Associated Species: In canyon bottoms associated in or near riparian settings, bigtooth maple normally grows as a codominant with box elder (*Acer negundo*). The wetter the site is, the greater will be the abundance of box elder.

Bigtooth maple serves as an important successional species in several coniferous forest habitat types. However, unlike its close relative-vine maple (*Acer glabrum*), it is not able to maintain itself under a closed forest canopy. As such, it has not been used in the naming of any coniferous forest habitat types.

A.H. Winward
Forest Service
Ogden, UT

BITTERCHERRY
SRM 419

Definition, Composition, and Structure: Prunus emarginata is a several stemmed plant often more shrublike than tree like. It occurs as two varieties, with *P. emarginata* var. emarginata represented in the Great Basin (Hitchcock and others 1973). It occurs from British Columbia, Canada; south to Mexico, with a scattered presence in most western states. In the Great Basin it often is found in relatively pure stands as isolated patches within the lower coniferous forest - upper sagebrush grassland types or in association with other mountain brush species such as snowbrush (*Ceanothus velutinus*) or serviceberry (*Amelanchier alnifolia*). Bittercherry occurs from approximately 3,000 ft (1000m) elevation in the northern portion of the Great Basin to approaching 9,000 ft (3000m) elevation in the southern portion of the Basin. Although it occurs on flats and along streams, it is seldom abundant in these situations, usually preferring well-drained, moderately fertile but stony sites, on open slopes and ridge tops (USDA Forest Service 1937).

Ecological Relationships: The name bittercherry is appropriate for this species as the small fruits, or cherries, are intensely bitter even when fully ripe (USDA Forest Service 1937). Although the foliage is relatively palatable to livestock and wild ungulates, total use is often restricted due to (1) most foliage is produced above reach of ungulates and (2) the dense thickets, which the species form either alone or in combination with other shrubs, are so dense as to be inaccessible. Birds, squirrels, and bears are only light users of the cherries probably because of finding them too bitter (USDA Forest Service 1937). Unlike its close ally chokecherry (*P. virginiana*), which is known to be poisonous under some conditions, bittercherry is believed to be non-poisonous, at least under good range conditions.

Variants and Associated Species: It is difficult to assign cover type status to this species where it occurs in combination with other mountain brush species such as *Amelanchier alnifolia* and *Ceanothus velutinus*. Considerably more information on the ecological aspects of sites supporting this species is needed.

A.H. Winward
Forest Service
Ogden, UT

SNOWBRUSH
SRM 420

Definition, Composition, and Structure: Snowbrush (*Ceanothus velutinus*), also known as buckbrush, tobacco brush, sticky laurel, or shiny leaf ceanothus, is found scattered throughout the Great Basin Region between 5000 and 9000 ft (1700-3000m) elevation (Welch and others 1987). On less favorable sites it may form a low, spreading bush, while under more favorable conditions it may attain heights up to 12 feet (4m) (USDA,1937). In surrounding Regions snowbrush forms dense inaccessible brush fields, often several thousand acres in size. Its more common occurrence in the Great Basin, however, is in relatively small, dense stands, or as an associate of other cover types.

Geographic Distribution: Snowbrush is common in mountainous areas from Canada south to California and Colorado (USDA, 1937). Within the Great Basin it can be found associated with upper mountain sagebrush- grasslands, pinyon- juniper, quaking aspen, and coniferous forest sites. In more open rangeland settings, it is found either in near pure patches, often associated with locations where snow drifts, or as a mixed component of several other mountain brush types. Also, within the Region it is found as a seral understory dominant of several coniferous forest types.

Ecological Relationships: Where snowbrush occurs in dense stands in non-forested settings, it appears to be a relatively stable type. The shrub is well adapted to recover after burning, since the germination of the long-lived seeds is stimulated by heat and resprouts profusely after fire. It provides an excellent soil cover because of its compact growth, and is valuable in protection of watersheds (USDA, 1937). However, this dense growth often inhibits establishment of very many associated undercover forbs and grasses.

Snowbrush is known to have nitrogen fixing root-nodules and as such may play a vital role in productivity of some sites. Although it is not a preferred foraging species for domestic and wild ungulates, it serves as valuable habitat for several native bird and mammal species. Its dark, shiny evergreen leaves and seasonal white flower clusters make it an attractive addition to many rangeland and forest land settings.

Variants and Associated Species: Snowbrush occurs as two varieties separated by the presence or absence of fine pubescence on the undersurface of the leaves. The Great Basin variety is *C. velutinus* var. *velutinus*. On sites where this variety occurs in combination with other mountain brush species it is difficult to assign cover type status (see other types described under the heading Mountain Brush).

A.H. Winward
Forest Service
Ogden, UT

CHOKECHERRY-SERVICEBERRY-ROSE SRM 421

Definition, Composition, and Structure: Within the Great Basin there occurs a mountain brush type dominated by one or more of the following species: chokecherry (*Prunus virginiana*), serviceberry (*Amelanchier alnifolia*), wild rose (*Rosa* spp.) and snowberry (*Symphoricarpos* spp.). These species may occur as relatively pure types, but most often are found growing together as mixed types representing most any combination of these species. Because they are so widespread and conspicuous in the Great Basin, they are covered here even though they cannot be described as distinct cover types.

Geographic Distribution: This combination type is found in ecological settings slightly more moist than pure sagebrush types and slightly drier than quaking aspen types. They occur in appropriate ecological settings throughout the Great Basin.

Ecological Relationships: At lower elevations of the range of this type it often occurs on protected northerly exposures or in depressions where snow accumulates within the more widely scattered sagebrush types. At upper elevations it occurs on southerly aspects or rocky ridges within quaking aspen and coniferous forest types. A wide variety of shrubs, grasses and forbs are associated with it. It serves as an important foraging type for livestock and provides protection and feed for many wildlife species. The majority of the type is outside the range of what is usually considered winter game range. However, drier variations of the type where *Rosa* and *Symphoricarpos* become most prominent often lie at the upper edge of important wintering areas.

Likely, no other type offers the variety of associated shrubs within one geographical setting. In addition to those already listed, other shrub species include: several varieties of both rubber rabbitbrush (*Chrysothamnus nauseosus*), and green rabbitbrush (*C. viscidiflorius*), bitterbrush (*Purshia tridentata*), horsebrush (*Tetradymia canescens*), Oregon grape (*Berberis repens*), and wild currants (*Ribes* spp.). These numerous shrub species, along with a rich herbaceous layer, provide extremely diverse habitats for many wildlife species. When this type occurs with a healthy, balanced understory, it also is a valuable watershed type.

Variants and Associated Species: At the drier end of its range, the type merges in with sagebrush, oak, and other mountain brush types. At the more moist end of its range, it merges into quaking aspen and coniferous forest types.

Much is left to be learned concerning the ecology of this type. Because of its value as a habitat for numerous wildlife, mammals, and birds, as foraging areas for livestock, the great biodiversity it provides, and its watershed values, it is deserving of more study.

A.H. Winward
Forest Service
Ogden, UT

RIPARIAN SRM 422

Definition, Composition, and Structure: The term riparian relates to the Latin word riparius, which means living or located on the bank of a natural water course (as a stream or river) or sometimes of a lake or a tidewater. In more recent times the term has been broadened by some to include all areas where free or unbound water is present, at least seasonally, in the upper soil profile. Presence of this "extra" moisture results in establishment of moisture loving or moisture tolerant plant species, and provides important habitats for people, animals, birds and fish. Although riparian areas constitute only a fraction of the total land area, they are more productive in terms of both plant and animal species diversity and biomass per unit than the remainder of the land base.

Because riparian areas can be found scattered throughout most geographic settings, numerous plant species can be found in them. Dominant graminoides often include members of the grasslike group such as *Carex, Juncus, Eleocharis,* and *Scirpus*. Representative grass genera include: *Calamagrostis, Glyceria, Poa, Phalaris, Distichlis* and many others. Common shrub genera include: *Salix, Ribes, Lonicera, Cornus, Sarcobatus* and others. Typical tree genera include: *Picea, Abies, Populus, Alnus, Betula* and *Acer*. Forb species are normally present, but only a few genera, such as *Caltha, Mertensia, Pedicularis, Camassia, Smilacina* and a few others become community dominants in riparian areas under natural settings. Several other genera such as *Urtica, Taraxacum* or *Cirsium* may become dominant in disturbed settings. Streams with gradients less than .5 percent are generally dominated by herbaceous species. Shrubs and trees are most often absent. Streams with gradients between .5 and 1.5 percent usually have patchy willows or trees present. Where gradients range between 1.5 and 3.0 percent, large willows and trees become very prominent. Example species include *Salix geyeriana, S. boothii, S. lasiandra* and *Populus angustifolia*. On gradients greater than 3.0 percent, species of *Alnus, Betula* or *Picea* become most dominant.

The above mentioned species and genera, either singly or in various combinations serve as indicators of important community types in riparian settings in the Great Basin (Youngblood and others, 1985; Padgett and others, 1989; and Padgett and Manning, in Press).

In general, almost all of the dominant natural species that occur in riparian settings are extremely strong, deep rooted species. As such, their major role is in buffering the forces of moving water.

Geographic Distribution: Riparian areas occur scattered throughout all elevations and in almost all geographic settings. Although common in their occurrence, they normally make up only 1 to 4 percent of the acreage of any one geographic area. In steep terrain they are mainly confined to the bottoms of canyons or drainages, while on more gentle terrain they may encompass entire valley bottoms.

Riparian areas can be negatively impacted by a variety of land management activities such as timber harvest, recreational use, road construction, mining activities, and grazing. When damage occurs, the size of riparian areas is usually reduced. Any activity that compacts the soil, removes the appropriate deep rooted species, or in any way alters the natural gradient of a water channel has potential to cause downcutting of channels, loss of water tables, and a subsequent reduction, or complete loss, of riparian areas.

Ecological Relationships: In all riparian settings natural processes have evolved to develop a balance between the soil, water, and vegetation resources. In the higher gradient areas (greater than 3 to 4 percent) rocks, boulders, and/or large trees most often serve to buffer effects of moving water. In moderate gradient systems (between .5 and 3.0 percent) a combination of large shrubs or trees along with a group of robust deep rooted understory species buffer the effects of moving water. On more shallow gradients (less than .5 percent), deep rooted herbaceous species are able to buffer the hydrologic forces of water. Some of the most important herbaceous species which serve this important purpose in the Great Basin include: (*Carex nebrascensis, C. rostrata, C. aquatilis, Juncus balticus* and *Calamagrostis canadensis*).

Several plant species serve as important colonizers on disturbed settings. These species are normally stoloniferous and have an ability to rapidly elongate their stems as temperatures begin to warm each spring. Their major purpose is to colonize edges of water bodies, filter out sediments which, in turn, provides a medium for establishment of the stronger, robust, stabilizing species. Important colonizers include such species as *Catabrosia aquatica* and *Agrostis scabra* at higher elevational settings, and *Alopecurus aequalis, A. geniculatus, Ranunculus aquatilis, Veronica americana* and *Nasturtium officinale* at mid to lower elevations.

Variants and Associated Species: Occasionally it is difficult to determine whether or not a specific area fits the definition of riparian based solely on the dominant plant species that are present. Species such as *Populus tremuloides, Rosa woodsii*, or *Poa pratensis* may be found growing within or outside riparian settings.In these situations it is necessary to look at all plant species present on the area, as well as the soil characteristics, to determine if they fit the definition of riparian. Also, since some areas receive extra moisture for such a short period of the year, such as intermittent streams or "dry washes", it is difficult to determine their status. Normally, if the soils do not show presence of persistent water in the upper profiles and if the vegetation is not unlike the surrounding upland vegetation, the area would not be considered riparian. Occasionally soils on an area may show evidences of previously formed mottles or gleying near the surface, but through gulling, have now lost their normal water tables. These areas should not be considered as riparian until their water tables have been restored.

A.H. Winward
Forest Service
Ogden, UT

Rangeland Cover Types of the SOUTHWESTERN REGION

INTRODUCTION SRM 500

This is a diverse region of plateaus, plains, basins, and many isolated mountain ranges. The land resources in western Texas, southern and western New Mexico, Chihuahua, Arizona, southeastern California, northern Sonora, and Baja California are: Southern Desertic Basins, Plains, and Mountains; Southeastern Arizona Basin and Range; Arizona, Chihuahua, New Mexico, and Sonora Mountains and Plateaus; Central Arizona Basin and Range; San Juan River Valley Plateaus; Colorado River Plateau; and Sonoran Basin and Range (Herbel 1979). A few of the animal species common to this area are: pronghorn antelope (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), coyote (*Canis latrans*), blacktailed jackrabbit (*Lepus californicus*), antelope jackrabbit (*L. alleni*), desert cottontail (*Sylvilagus audubonii*), badger (*Taxidea taxus*), spotted skunk (*Spilogala gracilis*), wood rat (*Neotoma albigula*), bannertailed kangaroo rat (*Dipodomys spectabilis*), Merriam's kangaroo rat (*D. merriami*), Ord's kangaroo rat (*D. ordii*), hispid cotton rat (*Sigmodon hispidus*), deer mouse (*Peromyscus maniculatus*), Bailey's pocket mouse (*Perognathus baileya*), grasshopper mouse (*Onychomys* spp.), redtailed hawk (*Buteo jamaicensis*), and rattlesnake (*Crotalus* spp.) (Shelford 1963, as cited in Herbel 1979).

Only a few southwestern drainages presently contain any extensive linear riparian development (Brown et al. 1977, as cited in Herbel 1984). This habitat was originally populated with cottonwoods (e.g., Fremont poplar (*Populus fremontii*) and willows (e.g., Goodding willow (*Salix gooddingii*). Some of the species successfully revegetated in riparian sites in the Southwest are blue paloverde (*Cercidium floridum*), Goodding willow, cottonwoods (*Populus* spp.), honey mesquite (*Prosopis glandulosa*), fourwing saltbush (*Atriplex canescens*), and big saltbush (*A. lentiformis*) (Anderson et al. 1979, as cited in Herbel 1984).

Carlton H. Herbel (retired)
USDA, Agricultural Research Service
Jornada Experimental Range
Las Cruces, NM

SALTBUSH-GREASEWOOD SRM 501

Definition, Composition, and Structure: The salt desert shrub type occurs with the largest expanses of shadscale (*Atriplex confertifolia*) occurring in the dry southeastern California and Nevada and extends to greasewood (*Sarcobatus vermiculatus*) in the moist drainages throughout. The type is characterized by low species diversity with shrubby species of shadscale, greasewood, winterfat (*Ceratoides lanata*), gray molly (*Kochia americana*), spiny hopsage (*Grayia spinosa*), and Castle Valley clover (*Atriplex cuneata*) often growing in nearly pure stands or in association with each other. Fourwing saltbush (*Atriplex canescens*) is widespread and generally found in association with other shrubby plants. Grasses, if present, include galleta (*Hilaria jamesii*), alkali sacaton (*Sporobolus airoides*), Indian ricegrass (*Oryzopsis hymenoides*), bottlebrush squirrel tail (*Sitanion hystrix*) and to a lesser extent, blue grama (*Bouteloua gracilis*). Several of the grasses may be found together or singly as the subdominant with the woody plants. Forbs in the area include globemallow (*Sphaeralcea grossulariaefolia*), Russian thistle (*Salsola kali*), and halogeton (*Halogeton glomeratus*). In the more moist, saline areas pickleweed (*Allenrolfea occidentalis*) and seepweed (*Suaeda* spp.) may occur with greasewood.

Geographic Distribution: The type occurs as a fingerlike mosaic primarily in and along drainages, on alluvial fans and plains and often in the playas from northern New Mexico (Donart et al. 1978) northward to Idaho, Oregon and Wyoming. It is located throughout Nevada and Utah and is sparsely located in southern California and western Colorado (Blaisdell and Holmgren 1984, Brown 1982). The elevation generally ranges from 3600-7800 ft (1,200m to 2,600m). The average annual precipitation ranges from 3 to 10 inches (8 to 26 cm) with a stronger summer influence in the eastern part gradually shifting to a winter dominated pattern in the west.

Ecological Relationships: In the northern regions this type is generally located below the sagebrush steppe or the juniper-pinyon woodlands while in the southern regions it is generally found in association with the grama-galleta steppe, the galleta-three-awn shrub steppe, creosotebush or the California steppe (Kuchler 1964). The saltbush-greasewood type is generally located in areas of high salinity and/or alkalinity or on areas of marine shale outcropping (West 1982). Drainages often have a high water table or are subject to frequent overflow flooding. While this type may vary from pure monoculture stands of

shrubs or grasses and is generally an area of low species diversity, deterioration of the site generally results in losses of perennial grass and substantial increases of annual plants. Cheatgrass (*Bromus tectorum*) and Russian thistle are common invaders throughout the type. Halogeton is common in the northern region and recently has become noticeable in northern Arizona and New Mexico. Years of high precipitation may favor many of the annual Chenopods, including Atriplex species and seepweed. Woody plants which may invade the area are rabbitbush (*Chrysothamnus* spp.) and snakeweed (*Gutierrezia sarothrae*), often at the expense of winterfat or bud sagebrush (Blaisdell and Holmgren 1984, Francis 1986). Many areas of the saltbush-greasewood type have been altered and desirable species reduced in amount. The harsh environment and poor soils result in slow natural recovery and difficulties in artificial revegetation.

Variants and Associated Species: Classification of this type is less than complete. Many small communities, variable in composition and forming a mosaic throughout the type are prevalent. Mat saltbush (*Atriplex corrugata*) is found on alluvial fans, Gardner saltbush (*A. gardneri*) is generally located on shale outcrops and saltsage (*A. tridentata*) on eroded slopes. These species may be found in nearly pure stands or may be associated with galleta and alkali sacaton. Inland saltgrass (*Distichilis stricta*) may be found in pure stands at slightly higher elevations and in better drainages than that found for greasewood. Species like black sagebrush (*Artemisia nova*) and blackbrush (*Coleogyne ramosissima*), while often associated with other vegetation types, are often found within the mosaic of the saltbush-greasewood type.

Gary B. Donart
New Mexico State University
Las Cruces, NM

GRAMA-GALLETA
SRM 502

Definition, Composition, and Structure: Generally, the type is dominated by blue grama (*Bouteloua gracilis*) with galleta (*Hilaria jamesii*) as an important secondary species (Donart et al. 1978). Other herbaceous species include species of dropseed (*Sporobolus* spp.), threeawns (*Aristida* spp.), ring muhly (*Muhlenbergia torreyi*), broom snakeweed (*Gutierrezia sarothrae*) half shrub). Alkali sacaton (*Sporobolus airoides*) is an important grass on some sites. Succulents include cacti (*Opuntia* spp.), yucca (*Yucca* spp.) and walking stick cholla (*Opuntia imbricata*).

Blue grama and galleta occur on a wide variety of soils. In Arizona galleta grows on soils derived from uplifted sedimentary formations as well as on shallow volcanic soils overlying basalt (West 1972). In New Mexico galleta grows on soils formed from limestone, sandstone, basalt, volcanic cinders, and alluvial materials.

Geographic Distribution: The grama-galleta steppe is located in central and northwestern New Mexico and northern Arizona. Topographically, the type occurs in valleys and lowlands below woodlands although in many locations it is associated with sagebrush-grass vegetation.

Ecological Relationships: Information on successional patterns within the grama-galleta steppe is limited. Yearlong cattle grazing reduced basal cover of perennial grass (alkali sacaton, galleta, and blue grama) on the San Luis Watershed in northwestern New Mexico, while summer rest increased basal cover of these grass species (Hickey and Garcia 1964). Big sagebrush probably encroaches upon these grasslands following disturbance, but detailed descriptions of these changes have not been published. Francis and Aldon (1983) have described *Artemisia tridentata/Hilaria Jamesii-Bouteloua gracilis* habitat type, but successional status was not given. On some sites, greasewood (*Sarcobatus vermiculatus*) may also increase under heavy grazing pressure.

Variants and Associated Species: Several grass species, including sand bluestem (*Andropogon gerardii* var. *paucipilus*), sideoats grama (*Bouteloua curtipendula*), hairy grama (*B. hirsuta*) and Indian ricegrass (*Oryzopsis hymenoides*), occur in this type (Kuchler 1965). Associated shrubs include fourwing saltbush (*Atriplex canescens*), horsebrush (*Tetradymia* spp.) and yuccas (*Yucca* spp.). Big sagebrush (*Artemisia tridentata*) often occurs on areas subjected to heavy grazing.

Rex D. Pieper
New Mexico State University
Las Cruces, NM

THE ARIZONA CHAPARRAL
(Arizona Interior Chaparral)
SRM 503

The Arizona chaparral (located in the Arizona and New Mexico Plateaus and Mountains Resource Area) is the chaparral of Nichol (1952), Pond and Bohning (1971), Cable (1975), and Knipe et al. (1979); also the interior chaparral of Lowe (1964), Lowe and Brown (1973) and Brown and Lowe (1980) and the transition type between the oak-juniper woodland and the mountain mahogany-oak scrub referred to by Kuchler (1964). In addition, it has been referred to as a disjunctive type of the California scrub formation by Lowe and Brown (1973) and others.

However, because the dominant species in the Arizona chaparral (turbinella oak, *Quercus turbinella*) and climatic conditions are considerably different from that of the California chaparral (dominated by chamise, *Adenostoma fasciculata*) and the Rocky Mountain scrub oak type

(dominated by the deciduous Gambel oak, *Quercus gambelii*), these three types are quite distinct. Also, because of these differences, plus the fact that the term interior chaparral is not exclusive and that all of the type is located in Arizona, the term Arizona chaparral is most definitive.

Definition, Composition, and Structure: The Arizona chaparral generally consists of leathery- leaved, mostly evergreen, predominantly oak shrubs. (The name chaparral is derived from the Spanish term *chaparro* meaning dwarf evergreen oaks). Plants usually grow in dense to occasionally open stands of straggly shrubs. The shrubs are fairly uniform in size, usually ranging in height from 3 to 7 feet (1 to 2m), and more in favorable sites such as along streams and on north slopes (Lowe 1964, Lowe and Brown 1973). Precipitation varies widely, ranging from 13 to 35 inches (32 to 86cm) or more, 50 to 60% of which falls during the winter (Nichol 1952, Lowe 1964, Pond and Schmutz 1984). Average daily minimum temperatures vary from 20° to 32° F (-7° to 0° C) in the winter months to average daily maximum temperatures of 87° to 98° F (31° to 37° C) in the summer months (Pond and Schmutz 1984).

The type contains over 100 species of shrubs with a scattered to dense understory of grasses, halfshrubs, and forbs. The dominant and most characteristic shrub, often in almost pure stands making up 70 to 90% of the vegetation is turbinella or shrub live oak (Nichol 1952, Lowe 1964, Lowe and Brown 1973). The second most abundant species also frequently in dense stands is pointleaf manzanita (*Arctostaphylos pungens*). Other characteristic species of lesser abundance include Pringle manzanita (*A. pringlei*), sugar sumac (*Rhus ovata*), skunkbush (*R. trilobata*), birchleaf mountainmahogany (*Cercocarpus montanus var. glabra*), hairy mountainmahogany (*C. montanus var. breviflorus*), jojoba (*Simmondsia chinensis*), desert ceanothus (*Ceanothus greggi*), cliffrose (*Cowania mexicana*), catclaw mimosa (*Mimosa biuncifera*), silktassel (*Garrya* spp.), redberry buckthorn (*Rhamnus crocea* var. *ilicifolia*), California buckthorn (*B. californica* var. *ursina*), apacheplume (*Fallugia paradoxa*), California bricklebush (*Brickellia californica*), red barberry (*Berberis haematocarpa*), yerba-santa (*Eriodictyon angustifolium*), turpentinebush (*Haplopappus laricifolius*) and broom snakeweed (*Gutierrezia sarothrae*).

Common grasses include sideoats grama (*Bouteloua curtipendula*), black grama (*B. eriopoda*), blue grama (*B. gracilis*), red threeawn (*Aristida longiseta*), cane beardgrass (*Bothriochola barbinodis*), plains lovegrass (*Eragrostis intermedia*), wolftail (*Lycurus phleoides*), bush muhly (*Muhlenbergia porteri*), fluffgrass (*Erioneuron pulchellum*), red brome (*Bromus rubens*), tobosa (*Hilaria mutica*), and curlymesquite (*H. belangeri*) (Nichol 1952, Lowe 1964, Pond and Bohning 1971). Forbs are usually scattered, their niche mostly occupied by the halfshrub, broom snakeweed.

Geographic Distribution: The Arizona chaparral occurs in the central part of the state mostly at 4,000 to 6,000 ft (1,200 to 1,800m) elevation (Nichol 1952, Lowe 1964, Lowe and Brown 1973). It extends from the Hualpai and Aquarius Mountains on the west, southeast along the foothills below the Mogollon Rim through the Bradshaw, Mazatzal, Sierra Ancha, Apache, Pinal, and Santa Teresa Mountains, plus small patches on the Galiura, Catalina, and Rincon Mountains (Nichol 1952, Lowe and Brown 1973, Brown and Lowe 1980). Scattered stands may occur as low as 3,500 ft (1,100m) and as high as 7,000 ft (2,100m) (Lowe 1964, Lowe and Brown 1973). Topography varies from rolling to steep, often rocky, hills, mesas, and valleys. Soils range from very shallow to deep and moderately coarse to medium textured. The Arizona chaparral merges with pinyon-juniper and ponderosa pine forests at its upper elevation and with the desert shrub and desert grassland below.

Estimates of the area of the Arizona chaparral generally range from 4 to 6 million acres (1.6 to 2.4 million ha) but some estimates go up as high as 8 million acres (3.2 million ha) (Nichol 1952, Pond and Bohning 1971, and Pond and Schmutz 1984).

Ecological Relationships: The ecological relationships of the Arizona chaparral are controversial. It is generally found on south-facing moderate to steep slopes on shallow, often rocky, soils on hills, ridges, and low mountain sides but extends down on moderately deep to deep soils on mesas and valleys. Present stands are often very dense, almost impenetrable to livestock and game. However, historical data indicate that early stands of chaparral were a more or less open shrub-savanna type with dense stands of fire resistant grasses in the interspaces. Also, that the area of chaparral has remained fairly stable except for some encroachment into timbered areas where shrubs were able to recover from fire and logging faster than the timber species. Stability of the type is mainly due to limited site adaptation of the two dominant species and by their inability to spread significantly by seeds. Both species recover from fire and rapidly increase in density (about 75% in 4 years) - oak by sprouts from massive underground root crowns (*lignitubers*) and manzanita from fire-enhanced seed germination and layering of stems (Tiedemann and Schmutz 1966, Pond and Bohning 1971, and Harlan 1977).

There are some differences in species composition of the chaparral, mainly due to ecological influences but rarely as distinct type differences. In general, the more drought tolerant species, such as turbinella oak, pointleaf manzanita, desert ceanothus, turpentinebush, wait-a-minute bush, and skunkbush are more abundant at lower elevations while species such as the sumacs, mountain-mahoganies, Pringles manzanita, apacheplume, and silktassel are more abundant at higher elevations and along streams.

Variants and Associated Species: At the lower fringe of the chaparral there is some intrusion of desert grassland species into the lower edges of the chaparral as extensions or islands, especially on shallow south-facing slopes. These

species include black grama, bush muhly, plains lovegrass, broom snakeweed, beargrass (*Nolina microcarpa*), sotol (*Dasylirion wheeleri*), turpentinebush, catclaw (*Acacia greggi*), and jojoba. Also at lower elevations, chaparral species intrude into the desert shrub and desert grassland types along streams and in deeper soil areas.

At high elevations there are intrusion of forest species into the chaparral. These include alligator juniper (*Juniperus deppeana*), Utah juniper (*J. osteosperma*), pinyon pine (*Pinus edulis*), ponderosa pine (*P. ponderosa*), Gambel oak, sedges (*Carex* sp.), and cliffrose. Likewise, at higher elevations the chaparral species intrude into the pinyon-juniper and ponderosa pine types as an understory or as extensions on shallow south-facing slopes.

Riparian communities, in addition to the chaparral species, include such species as Fremont cottonwood (*Populus fremontii*), Emory oak (*Quercus emoryi*), Arizona oak (*Q. arizonica*), sycamore (*Platanus wrightii*), black walnut (*Juglans major*), and velvet mesquite (*Prosopis juliflora*).

Ervin M. Schmutz (retired)
University of Arizona
Tucson, AZ

JUNIPER-PINYON PINE WOODLANDS SRM 504

Definition, Composition, and Structure: Rocky Mountain pinyon (*Pinus edulis*), singleseed juniper (*Juniperus monosperma*) and alligator juniper (*J. deppeana*) are the dominant tree species within the type. Mexican pinyon (*Pinus cembroides*) occurs widely in Mexico while Rocky Mountain juniper (*Juniperus scopulorum*) and Utah juniper (*Juniperus osteosperma*) are more abundant further north (Lanner 1981, Little 1950). Understory vegetation is extremely varied depending on geographical location and local environmental conditions (Springfield 1976). In northern Arizona and New Mexico, this woodland is often associated with big sagebrush (*Artemisia tridentata*). Other shrubby associates include Gambel oak (*Quercus gambellii*), wavy leaf oak (*Quercus undulata*), other oaks, mountain mahogany (*Cercocarpus* spp.), and bitterbrush (*Purshia tridentata*). Grasses and forbs are extremely varied with cool season species (C_3) dominating in northern areas and warm season species (C_4) in southern areas (Pieper 1977).

Geographic Distribution: Juniper-pinyon woodlands occur on foothills and lower mountain slopes below 7500 ft (2500m) and occasionally in valley bottoms on nearly level terrain. In Arizona and New Mexico, the type occupies about 54,000 sq. miles (134,000 km) or just over 20% of the area (West et al. 1975). In southwestern New Mexico and southeastern Arizona, the type forms a transition with oak woodlands in northern Mexico.

Ecological Relationships: Rocky Mountain pinyon is considered the climax dominant species in many of these stands with varying amounts of juniper (singleseed or alligator). However, many stands have been disturbed by wood cutting, mechanical control treatments, fire, grazing, etc. Consequently, these stands are currently in a seral stage. Secondary successional patterns appear to be similar within the type, but some variation occurs depending on soil conditions. In central New Mexico, the grass-forb and shrub-grass stage is often missing or poorly represented on lithic hapustoll soils with rock outcrops while these stages are well represented on soils without the rock outcrops (Schott and Pieper 1986, 1987). Consequently, wavy leaf oak is much more likely to increase in abundance following mechanical treatment on deep soils than on shallow, rocky soils.

Juniper-pinyon woodlands form a two-phase mosaic of vegetational patterns with the trees and their associated plants and the interspace vegetation. Three or four zones can be recognized around each pinyon or juniper tree (Armentrout and Pieper 1988, Arnold 1964). Two or three zones are beneath the tree canopy and the other in the open space. Some species, such as pinyon ricegrass (*Piptochaetium fimbriatum*) and bottlebrush squirreltail (*Sitanion hystrix*), and mutton bluegrass (*Poa fendleriana*) apparently are more abundant under juniper canopy than in the open spaces (Clary and Morrison 1973, Schott and Pieper 1985).

Variants and Associated Species: These woodlands often grade into ponderosa pine (*Pinus ponderosa*) forests at higher elevation and with oak woodlands in southeastern Arizona and northern Mexico. Associated tree species include grey oak (*Quercus grisea*), Emory oak (*Q. emoryi*), and Arizona oak (*Quercus arizonica*). Shrubs include beargrass (*Nolina texana*), apache plume (*Fallugia paradoxa*), and skunkbush (*Rhus trilobata*). Herbaceous associates include bull muhly (*Muhlenbergia emersleyi*), mountain muhly (*M. montana*), and sideoats grama (*Bouteloua curtipendula*).

Rex D. Pieper
New Mexico State University
Las Cruces, NM

GRAMA-TOBOSA SHRUB
SRM 505

Definition, Composition, and Structure: Black grama (*Bouteloua eriopoda*) and tobosa (*Hilaria mutica*) are the diagnostic dominants in this type, although blue grama (*B. gracilis*) is often a dominant at higher elevations. Many plants are associated with the dominants and only the most common are mentioned below. Summer-active perennial grasses include grama grasses (*B. filiformis, B. breviseta, B. chondrosioides, B. curtipendula, B. hirsuta*), threeawns (*Aristida longiseta, A. hamulosa, A. divaricata, A. wrightii*), and dropseeds (*Sporobolus flexuosus, S. cryptandrus, S. contractus, S. airoides*). In addition, Arizona cottontop (*Digitaria californica*), curly mesquite (*Hilaria belangeri*), slim tridens (*Tridens muticus*), plains bristlegrass (*Setaria macrostachya*), fluffgrass (*Erioneuron pulchellum*) and, in low-lying areas, vine mesquite (*Panicum obtusum*) are frequently found.

Perennial forbs are mostly summer active and include globemallows (*Sphaeralcea* spp.), rushpeas (*Hoffmanseggia* spp.), allionias (*Allionia* spp.), and zinnias (*Zinnia* spp.). Annual forbs are abundant and are divided into a winter-spring group including tansymustards (*Descurainia* spp.), spectaclepod (*Dithyrea wislizenii*), and pepperweeds (*Lepidium* spp.), and a summer-active group including the conspicuous desert baileya (*Baileya multiradiata*) and purple rollleaf (*Nama hispida*). A large number of summer--active annual grasses occur, including sixweeks grama (*B. barbata*) needle grama (*B. aristidoides*), sixweeks threeawn (*A. adscensionis*), and annual panic grasses (*Panicum* spp.).

Stem and leaf succulents are well represented and very characteristic of the type, particularly where soils are shallow and rocky. These include the sotols (*Dasylirion* spp.), beargrasses (*Nolina* spp.), the agaves (*Agave* spp.), and cacti (*Opuntia* spp., *Echinocerus* spp.). Yuccas (*Yucca* spp.) are common on well-developed, sandy soils and Palmilla or soaptree yucca (*Y. elata*) is a particularly conspicuous plant over much of the type. Shrub components are conspicuous and often share or assume dominance. Mesquite (*Prosopis* spp.), creosotebush (*Larrea tridentata*), tarbush (*Flourensia cernua*), snakeweeds (*Gutierrezia* spp.), whitethorns and catclaws (*Acacia* spp.), allthorn (*Koeberlinia spinosa*), saltbushes (*Atriplex* spp.), Mormon or Mexican tea (*Ephedra* spp.), and littleleaf sumac (*Rhus microphylla*), are often prime determinants of community physiognomy (Kuchler 1966, Brown 1982, Henrickson and Johnston 1986).

Geographic Distribution: The discontinuous type occurs primarily on the floors and adjacent bajada slopes of intermountain basins in northwest through central to southeast Arizona, southern New Mexico and the Trans-Pecos of Texas. It is also well represented in the northern states of Chihuahua and Coahuila in Mexico. Lower elevational range is usually between 3300-4200 ft (1,100 and 1,400m) and upper elevations are usually between 4500-5100 ft (1,500 and 1,700m) although it occasionally extends to 5,700 feet (1,900 m). Precipitation ranges from about 9-18 inches (22 to 45cm) with summer precipitation being a major component (Kuchler 1964, Brown 1982).

Ecological and Seral Relationships: At upper elevations in Arizona and New Mexico the type adjoins pinyon-juniper woodlands or a type transitional between pinyon-juniper and mountain mahogany-oak. In the Trans-Pecos, upper elevation boundaries are with oak-juniper woodlands. Lower elevation boundaries are with the creosotebush-bursage type (Arizona), creostoebush-tarbush (New Mexico), or Trans-Pecos shrub savanna (*Flourensia-Larrea*) in Texas (Kuchler 1964). In many areas throughout the geographical range of the type grasses have been replaced as dominants by shrubs. On sandy soils vast areas have changed from black grama grasslands to a mesquite coppice dune type. Gravelly soils are often now dominated by creosotebush and on clay and silt soils tarbush has increased. Much of the change has occurred within the historical period and it is likely that heavy grazing by domestic livestock at the turn of the century was a prime contributor to change. Both inter- and intra-season droughts are common and dictate a high degree of flexibility in grazing management. The encroachment of shrubs has severely reduced forage production in many areas and this can be alleviated only by shrub eradication programs.

Variants and Associated Species: In those areas retaining grasses as dominants, three variants may be recognized — pure black grama grasslands, blue grama - black grama grasslands and tobosa grasslands where burrograss (*Scleropogon brevifolius*) and alkali sacaton are often associated. Shrub-dominated areas are often nearly mono-dominant stands of either mesquite, creosotebush, or tarbush. The suffrutescent broom snakeweed waxes and wanes in abundance and often assumes a temporary dominant role. Weed species are common and the aggressive Russian thistle (*Salsola kali*) can be very abundant in favorable years. Drainageways may support desert willow (*Chilopsis linearis*) but few trees are found except at higher elevations.

Robert P. Gibbens
USDA, Agricultural Research Service
Jornada Experimental Range
Las Cruces, NM

CREOSOTEBUSH-BURSAGE SRM 506

Definition, Composition, and Structure: Creosotebush (*Larrea tridentata*) and white bursage (*Ambrosia dumosa*) comprise this association. However, the extensive stands of creosotebush and/or bursage are interrupted by linear stands of taller shrubs and trees along water courses. These include velvet mesquite (*Prosopis velutina*), foothill paloverde (*Cercidium microphyllum*), blue paloverde (*C. floridum*), smoketree (*Dalea spinosa*), ironwood (*Olneya tesota*), and catclaw acacia (*Acacia greggii*).

Perennial grasses such as black grama (*Bouteloua eriopoda*) and big galleta (*Hilaria rigida*) occur only where exceptional features of soil or topography make the site less arid. Consequently, herbaceous vegetation consists mainly of cool-season annual forbs and grasses. If soil moisture is available from late fall through February or March, annuals germinate in the fall, winter in rosette form, then resume rapid growth as the temperature rises in the spring. Major species include gold poppy (*Eschscholtzia* spp.), filaree (*Erodium cicutarium*), plantain (*Plantago* spp.) and various legumes, borages, and mustards. Schizmus (*Schismus barbatus*) is the most abundant cool-season annual grass. Livestock grazing is opportunistic. When cool-season annuals are abundant ranges may be grazed by stocker cattle from early to late spring.

Geographic Distribution: The association occurs in southeastern California, southwestern Arizona and extends southward into the states of Baja California and Sonora in northern Mexico. Within the Western Range and Irrigated Region (USDA 1981), it includes most of the Sonoran Basin and Range Major Natural Resource Area (MLRA 30), and the less arid western edge of the Central Arizona Basin and Range Major Natural Resource Area (MLRA 40).

Ecological Relationships: The association is found on gently sloping plains and bajadas at elevations of 600-2400 ft (200-800m). Annual precipitation ranges from 5 to 12 inches (12 to 30 cm) of which 60% or more comes during the cool season and summer rains June-September provide most of the remainder. Winters are mild and summers hot.

All vegetation is adapted to survive on short periods of favorable moisture separated by longer periods of drought. Shrubs characteristically have small leathery leaves that are shed progressively as soil moisture is depleted. Ocotillo (*Fouquieria splendens*), which may grow and shed several sets of leaves in a single summer, is an extreme example. Shrubs and trees have widely-spreading networks of roots close to the soil surface that absorb moisture rapidly after a rain, as well as roots that draw moisture from deeper layers during dry periods. The waxy cuticle of succulents, (*Opuntia* spp.) and other cacti, retards water loss and water stored in their fleshy stems keeps them alive during dry periods. Chlorophyll in the green stems of the cacti, and in such trees as paloverde, carry on photosynthesis in the absence of leaves. Annuals are not equipped to endure drought but escape it by completing their life cycles during the brief periods when moisture is available.

Variants and Associated Species: Within the association are islands of paloverde-cactus (*Cercidium- Opuntia*) that occupy less arid sites; along water courses, on bajadas of the included mountain ranges, and at higher elevations at the edge of the association on the north and east. Foothill paloverde is the dominant tree. Associated trees include blue paloverde and ironwood. Common cacti include buckhorn cholla (*Opuntia acanthocarpa*), staghorn cholla (*O. versicolor*), cane cholla (*O. spinosior*), teddy bear cholla (*O. biglovii*) and chain fruit cholla (*O. fulgida*). Triangle-leaf bursage (*A. deltiodea*) is a common shrub.

S. Clark Martin
Emeritus, USDA Forest Service
and University of Arizona
Tucson, AZ.

PALO VERDE - CACTUS SRM 507

Definition, Composition, and Structure: Three palo verde species and numerous cactus species make up this type. Dominant species are blue palo verde (*Cercidium floridum*), foothills palo verde (*C. microphyllum*), Mexican palo verde (*Parkinsonia aculeate*), saguaro (*Cereus giganteus*), prickly pear, and cholla cacti (*Opuntia* spp.). The type is composed of small scattered trees with an understory of cacti, shrubs and annuals. Species composition is extremely variable. Local dominants may be ironwood (*Olneya tesota*), western honey mesquite (*Prosopis glandulosa* var. *torreyana*), velvet mesquite (*P. velutina*), screwbean mesquite (*P. pubescens*), desert willow (*Chilopsis linearis*), staghorn cholla (*O. versicolor*), jumping cholla (*O. fulgida*), teddy bear cholla (*O. bigelovii*), Engelmann prickly pear (*O. phaeacantha* var. *discata*), Christmas cactus (*O. leptocaulis*), organpipe cactus (*Cereus thurberi*), hedgehog cactus (*Echinocereus triglochidiatus*), and pencil cactus (*O. arbuscula*). Other important shrubs include desert saltbrush (*Atriplex polycarpa*), fourwing saltbush (*A. canescens*), bursage (*Ambrosia deltoides*), mariola (*Parthenium incanum*), whitethorn acacia (*Acacia constricta*), range ratany (*Krameria parvifolia*), ocotillo (*Fouquieria splendens*), creosotebush (*Larrea tridentata*), and wolfberry (*Lycium andersonii, L. berlandieri,* and *L. fremontii*) (Benson 1981, Lamb 1975).

Geographic Distribution: The cover type occurs in southern Arizona, southeastern California, Baja California Norte, and central and northern Sonora. It occurs from slightly above sea level to about 4000 ft (1,200m).

Ecological Relationships: The type occurs primarily on gently sloping bajadas transected by arroyos where blue

palo verde dominates and ridges where foothills palo verde dominates. In the more mesic parts of the type, jumping cholla has a 30- to 50-year life-cycle and may be infested by insects and pathogens (Martin et al. 1974). Cacti can be infected with viruses (Milbrath et al. 1973). Palo verdes and cacti are damaged and often killed by mechanical and herbicidal treatments (Garcia and Hickey 1964, Martin and Tschirley 1969, Martin et al. 1974). Natural reseeding or stand renewal of palo verde and cacti usually requires more than 10 years. Disturbed areas, such as road and utility rights-of-way are frequently revegetated by annual species, such as schismus (*Schismus barbatus*), London rocket (*Sisymbrium irio*), sixweeks threeawn (*Aristida adscensionis*), and fiddleneck (*Erodium cicutarium*), or saltbushes and brittlebush (*Encelia farinosa*) may establish then or later.

Variants and Associated Species: The most widespread is the foothills and blue palo verde, saguaro, prickly pear and cholla cacti variant which occurs in southern Arizona, northern Sonora, and southwestern Arizona (Lamb 1975), where the associates are velvet mesquite, desert willow, catclaw acacia (*Acacia greggii*), whitethorn acacia, ocotillo, and mariola. The Mexican palo verde, prickly pear and cholla cacti variant is found in northern Sonora, southeastern California, Baja California Norte, and southern Arizona, where the associates are velvet, western honey, and screwbean mesquites; desert willow, and catclaw acacia. The blue palo verde, cholla cactus variant is found mostly in valleys, arroyos, and low sites which receive run-on water from ridges in western Arizona, southeastern California and Baja California Norte, where the associates are western honey and screwbean mesquites, desert willow, ironwood, catclaw acacia, brittlebush, and creosotebush. There is considerable intermingling of this type with the creosotebush - bursage association. During the cool, rainy season numerous annual species are present; and in years when precipitation is timely and in sufficient amounts, these species provide the colorful "desert wildflower show".

Howard L. Morton (retired)
Agricultural Research Service/USDA
Tucson, AZ

CREOSOTEBUSH-TARBUSH
SRM 508

Definition, Composition, and Structure: This shrub savanna occurs in nearly pure stands of creosotebush (*Larrea tridentata*) on the piedmont slopes of desert mountains and tarbush (*Flourensia cernua*) on the plains below the desert mountains in western Texas, southern New Mexico, southeastern Arizona, and northern Chihuahua. These plains may be occasionally flooded from the adjacent slopes. A mixture of the two species is common in the extensive areas between the nearly pure stands in the eastern and central part of the area, where the type occurs. In western Arizona and northwestern Mexico, the type grades to a pure stand of creosotebush with some subdominants. The latter area is the warmest and most arid of this type.

Geographic Distribution: The type occurs sporadically in the Southern Desertic Basins, Plains, and Mountains of western Texas, southern New Mexico, and northern Chihuahua; the Southeastern Arizona Basin and Range of Arizona and Sonora; the Central Arizona Basin and Range of Arizona and Sonora; and the Sonoran Basin and Range of southwestern Arizona, southeastern California, Sonora, and Baja California (Soil Conservation Service 1981). The elevation ranges from 0 to 4500 ft (0 to 1,500m). The average annual precipitation is 5 to 12 inches (12.5 to 30cm), with a strong summer influence in the eastern part and strong winter influence in the western part of the area.

Ecological Relationships: In western Texas, southern New Mexico, southeastern Arizona, and northern Chihuahua, this type is a persistent subclimax of the grama-tobosa shrubsteppe. Tarbush is a mesophyte and creosotebush is a xerophyte. Generally, honey mesquite (*Prosopis glandulosa*) or tarbush invades an area dominated by black grama (*Bouteloua eriopoda*) or tobosa (*Hilaria mutica*). When this occurs, there is some deterioration of the site-soil erosion and the formation of drainages. Then creosotebush invades and, in a few years, dominates the site. As creosotebush begins to dominate a site, there is little forage for domestic livestock. The soils on most of the slopes, often dominated by creosotebush, are well-drained and calcareous. These sites may be revegetated with lehmann lovegrass (*Eragrostis lehmanniana*), boer lovegrass (*E. chloromelas*), black grama, yellow bluestem (*Bothriochloa ischaemum*), and fourwing saltbush (*Atriplex canescens*). Heavier soils dominate the basins. These areas may be seeded with sacaton (*Sporobolus wrightii*), alkali sacaton (*S. airoides*), yellow bluestem, and fourwing saltbush (Herbel et al., 1973).

In the lower elevations west of the area described in the preceding paragraph, creosotebush is the major dominant. Only in occasional years accompanied by above-average moisture conditions will ephemerals grow and support livestock grazing.

Variants and Associated Species: Tarbush is well adapted to the Southern Desertic Basins and Plains, and the Southeastern Arizona Basins and Range whereas creosotebush is dominant throughout. Giant dropseed (*Sporobolus gigantea*) and mesa dropseed (*S. flexuosus*), along with scattered shrubs such as sand sagebrush (*Artemisia filifolia*), longleaf ephedra (*Ephedra trifurca*), and yuccas (*Yucca* spp.), grow on the sandier soil of the Southern Desertic Basins, Plains, and Mountains. Catclaws (*Acacia* spp.), fluffgrass (*Erioneuron pulchellum*), and bush muhly (*Muhlenbergia porteri*) often accompany creo-

sotebush on gravelly, calcareous foot slopes. Alkali sacaton, tobosa, burrograss (*Scleropogon brevifolius*), and honey mesquite grow in basins dominated by tarbush.

In the southeastern Arizona Basin and Range dominated by creosotebush and tarbush, other plants are mescat acacia (*Acacia constricta*), soaptree yucca (*Yucca elata*), fourwing saltbush, honey mesquite, velvet mesquite (*Prosopis velutina*), ocotillo (*Fouquieria splendens*), rothrock grama (*Bouteloua rothrocki*), black grama, curly mesquite (*Hilaria belangeri*), red threeawn (*Aristida longiseta*), and bush muhly. In the Central Arizona Basin and Range where creosotebush dominates, the giant saguaro cactus (*Carnegiea gigantea*) is a prominent species. Bursage (*Franseria acanthicarpa*), cholla cactus (*Opuntia fulgida*), burroweed (*Aplopappus fruticosus*), Arizona cottontop (*Trichachne califonica*), and filaree (*Erodium cicutarium*) are some of the major associated species. Creosotebush dominates the Sonoran Basin and Range. Other noteworthy components are: white bursage (*Franseria dumosa*), white brittlebush (*Encelia farinosa*), joshua tree (*Yucca brevifolia*), dalea (*Dalea* spp.), big galleta (*Hilaria rigida*), desert thorn (*Lycium brevipes*), tesota (*Olneya tesota*), cacti (*Opuntia* spp.), and velvet mesquite (Kuchler 1964). During years with adequate moisture, ephemerals that grow are: annual forbs (such as careless weeds [*Amaranthus* spp.], cryptantha [*Cryptantha* spp.], cinchweed [*Pectis papposa*], peppergrass [*Lepidium lasiocarpum*], spurges [*Chamaesyce* spp.], sand verbena [*Abronia villosa*], and buckwheats [*Eriogonum* spp.]) and grasses (such as threeawns [*Aristida* spp.], gramas, [*Bouteloua* spp.], sixweeks fescue [*Festuca octoflora*], bromegrass [*Bromus arizonicus*], and bluegrasses [*Poa* spp.]) (Felger 1980; Shreve and Wiggins 1964).

Carlton H. Herbel
USDA, Agricultural Research Service
Las Cruces, NM

TRANSITION BETWEEN OAK-JUNIPER WOODLAND AND MAHOGANY-OAK ASSOCIATION SRM 509

Definition, Composition, and Structure: This is a transition zone between the oak-juniper woodland and the mahogany-oak association. The oak-juniper woodland is located to the southeast of this transition zone in the southeastern corner of Arizona and northern Chihuahua. Dominant shrubs and trees of the oak-juniper woodland that contribute to the transition zone include alligator juniper (*Juniperus deppeana*), one-seed juniper (*J. monosperma*), Emory oak (*Quercus emoryi*), and Mexican blue oak (*Q. oblongifolia*). Minor associates are pointleaf manzanita (*Arctostaphylos pungens*), sideoats grama (*Bouteloua curtipendula*), blue grama (*B. gracilis*), hairy grama (*B. hirsute*), buckbrush (*Ceonothus spp.*), cliff rose (*Cowania mexicana*), Wheeler sotol (*Dasylirion wheeleri*), silktassel (*Garrya spp.*), small seed nolina (*Nolina microcarpa*), sacahuista (*N. erumpens*), Mexican pinyon (*Pinus cembroides*), Chihuahuan pine (*P. leiophylla var. chihuahua*), Arizona white oak (*Q. arizonica*), silverleaf oak (*Q. hypoleucoides*), shrub live oak (*Q. turbinella*), wavyleaf oak (*Q. invaginate*), skunkbush sumac (*Rhus trilobata*), littleleaf sumac (*R. microphylla*), and hoary yucca (*Yucca schottii*).

The mahogany-oak association is located in the Wasatch Mountains of north central Utah, northwestern Colorado, and a small range in south central Wyoming. Dominant shrubs and trees of the mahogany-oak association that contribute to the transition zone include mountain mahogany (*Cercocarpos ledifolius*), and Gambel oak (*Q. gambelii*). Minor associates are big tooth maple (*Acer grandidentatum*), serviceberry (*Amelanchier utahensis*), manzanita (*A. spp.*), ceonothus (*C. spp.*), cliffrose, Apache plume (*Fullugia paradoxa*), Myrtle box-leaf (*Pachystima myrsinites*), ninebark (*Physocarpos spp.*), bitterbrush (*Purshia tridentata*), sand shinnery oak (*Q. havardii*), shrub live oak, wavyleaf oak, skunkbush sumac, and snowberry (*Symphoricarpos spp.*).

Geographic Distribution: This type occurs on plateaus and mountains in a long, narrow belt extending northwest to southeast in central Arizona. The belt is about 50 miles (80km) wide and about 250 miles (400km). This type merges with the creosotebush-bursage association and the grama-tobosa shrubsteppe on the south and the juniper-pinyon pine woodlands on the north. Above this type in elevation are the Arizona pine forest and the pine-douglas fir forest. Elevations range from 3,000 to 6,000 ft (1,000 to 2,000m).

Ecological Relationships: This type is commonly found on coarse granitic intrusive and limestone derived soils. These soils tend to be poorly developed. Organic matter content is ordinarily low (0.5 to 2.0%). Infiltration rates are usually high into the coarse soils except after severe wildfires. Shrub cover varies but averages about 60 to 70% in mature stands. This type has been grazed heavily, especially between 1880 and 1920. The area had a flourishing mohair goat industry until 1940. Important range grasses are now largely confined to rocky, protected sites.

M. Karl Wood
New Mexico State University
Las Cruces, NM

Rangeland Cover Types of the NORTHERN GREAT PLAINS REGION

INTRODUCTION SRM 600

This section of the Range Cover Types report provides information on fifteen currently existing range types in the Northern Great Plains, extending north-south from approximately central Saskatchewan to southern Kansas and east-west from the plains border to the foothills of the Rocky Mountains. Not included in this description of types are those cover types of major importance in the western region, but which extend into portions of the plains area. It is assumed that the primary description of these types is given in other sections of the report, with the indication that these types extend in minor distribution to the plains area.

Also omitted from this report are the description of forest and woodland types commonly occurring in the plains, and which may be subject to range grazing use. Most of these types are described in "Forest Cover Types of the United States and Canada", (Soc. of Am. Foresters, 1980). The map provided with this report shows the distribution and extent of these woody types. More recent general descriptions of these types in the plains area are given in papers by Goetz (1988) and Barker and Whitman (1989).

One woodland vegetation type not described in detail in the Forest Cover Types report is the so-called "Green ash-hardwood draw". From the range use point of view this small type is relatively unimportant, but its important to wildlife in portions of the northern plains can scarcely be overestimated. The major occurrence of the type is in western North Dakota, where it was first described in detail by Nelson (1961), but it extends into South Dakota, Nebraska, and eastern Montana. Additional descriptions of the type are provided by Girard (1985), Johnston (1987), Goetz (1988), and Barker and Whitman (1989).

All cover types associated with salt-affected (solonetzic) soils have not been described separately from the cover types in which they occur. Only the vegetation on upland saline-alkaline soil types has been described in detail. Frequently occurrences of both dryland and wetland alkaline situations are referred to as sites, and in the aggregate thousands of acres of such sites are found in the northern plains of the United States and Canada. The composition of the vegetation on these sites is described in some detail in the Range Site Designations and Descriptions prepared for each of the northern Great Plains states by the Soil Conservation Service, U.S. Dept. of Agriculture. Frequently, in the present report species composition of the cover type on such sites are mentioned in relation to their occurrence in the overall type described.

Warren C. Whitman and
William T. Barker
North Dakota State University
Fargo, ND

BLUESTEM PRAIRIE SRM 601

Definition, Composition, and Structure: This tall grass prairie, now largely eliminated by cultivation east of the plains border, is dominated by big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), Indiangrass (*Sorghastrum nutans*) and little bluestem (*Schizachyrium scoparium*). Needlegrass (*Stipa spartea*), side-oats grama (*Bouteloua curtipendula*), Junegrass (*Koeleria pyramidata*), Canada wildrye (*Elymus canadensis*), prairie sandreed (*Calamovilfa longifolia*), western wheatgrass (*Agropyron smithii*), and prairie cordgrass (*Spartina pectinata*) are important secondary species in the border region. Kentucky bluegrass (*Poa pratensis*) has become a common and sometimes important associated grass throughout the plains range of the type.

A host of perennial forbs, some half-shrubs, and a few shrubs are numerous and common through the range of the type and add color, interest, and variety to the diet of grazing animals. Normally they do not make up more than 10 percent or less of the vegetation volume.

Geographic Distribution: The bluestem prairie as it exists today extends in highly fragmented condition along the eastern border of the plains from southern Manitoba (Canada) to central Oklahoma. Important remnants are found in eastern North and South Dakota, western Minnesota, eastern Nebraska, and eastern and central Kansas to central Oklahoma. Along its eastern edge through Kansas and Oklahoma it meets and mingles with the broadleaf Oak-Hickory forest (Kuchler, 1974). Well-known grazing areas where the type is still the major forage-producing vegetation are in the Flint Hills of eastern Kansas and the loess hills and plains of southeastern Nebraska and northeastern Kansas (Barker, 1969; Weaver, 1960).

Small pieces of the type extend far out into the northern plains under favorable microclimatic conditions, with examples found in western North and South Dakota and eastern Montana and Wyoming.

Ecological Relationships: The Bluestem Prairie of the eastern Great Plains border is found over an annual average precipitation range of about 18 inches (45cm) in the north to some 36 inches (90cm) in the south. The higher temperatures southward result in about equal precipitation effectiveness over the north-south range of the type. The dominant grasses are primarily warm-season species. Topography is from nearly level lowlands, gently rolling to nearly level plains, to moderately rolling uplands and even steep hills. Soil textures are variable from fairly coarse sands to silts, clays, and in some cases heavy clays. Some extensive stands of the type have been developed on thin soil over shattered rock (Flint Hills). Where small fragments of the type extend far west into the plains, the type is most often found in depressions receiving run in, the lower portions of steep north and east-facing slopes, and the bottom of sharply sloping draws. The occurrence of the type in these situations is nearly always related to an increased supply of soil moisture and reduced evaporation.

Within typical stands, big bluestem, Indian grass, and switchgrass are major dominants on moderately moist to wet lowlands, while little bluestem, porcupine grass, prairie dropseed (*Sporobolus heterolepis*), and side-oats grama are more common over the uplands (Weaver, 1960). Where the type becomes drier little bluestem becomes increasingly important, with the mixed grass prairie ultimately replacing the type across the uplands in the north and the shortgrasses bluegrama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*) increasing in the south and west.

In wet, poorly drained lowlands prairie cordgrass once formed extensive, nearly pure stands with the typical bluestem prairie beginning on the slightly higher, better drained situations. The cordgrass type is still found where water stands for some time in the spring (Redmann, 1972).

While a large part of the Bluestem Prairie considered here is developed on glacially derived sediments of one type or another, the prairie is primarily climate dependent rather than edaphic dependent. Of the grassland vegetation types of the northern Great Plains, the Bluestem Prairie has the most favorable precipitation-temperature-evaporation relations.

Variants and Associated Species: The principal tall grass dominants are well-distributed over the entire range of the type. However, toward the southern border of the type in Kansas and Oklahoma porcupine grass becomes less common. Toward the northern edge porcupine grass, while common, is in part replaced by green needlegrass (*Stipa viridula*), and to some extent on drier sites by needle-and-thread (*Stipa comata*) (Ralston, 1969). Western wheatgrass also becomes more abundant to the north, while slender wheatgrass (*Agropyron caninum* subsp. *majus*) and northern reedgrass (*Calamagrostis stricta*) increase in lower, wetter areas.

Areas of high soil salinity are not uncommon, especially toward the northern range of the type, and here typical communities of saltgrass (*Distichlis spicata* var. *stricta*) foxtail (*Hordeum jubatum*), and other salt tolerant species occupy fairly extensive areas (Redmann, 1972).

The Bluestem Prairie does have a short component of grasses and sedges, which becomes apparent especially under grazing. Included here are several rosette panic grasses, (*Dichanthelium oligosanthes* var. *scribnerianum*), and D. *wilcoxianum* especially, penn sedge (*Carex pensylvanica*), and needleleaf sedge (*Carex eleocharis*). On overgrazed pastures the taller species are much reduced and blue grama, hairy grama (*Bouteloua hirsuta*), and to the south, buffalo grass, become abundant. Kentucky bluegrass, while not truly a short grass, under heavy grazing of the type spreads out and may form a short dense sod (Weaver & Tomanek, 1951).

The many forb species associated with the Bluestem Prairie are mainly perennials of appreciable stature. Important among these are a number of sunflowers (*Helianthus rigidus, H. maximiliani, H. tuberosus, H. grosseserratus*) and goldenrods (*Solidago missouriensis, S. canadensis, S. rigida* and *Euthamia graminifolia*). The blazing stars are colorful and conspicuous at maturity (*Liatris aspera, L. punctata, L. pycnostachya*). Among the common legumes in the type are the scurf-peas (*Psoralea argophylla* and *P. tenuiflora*). The breadroot or Indian turnip (*Psoralea esculenta*) is widespread but seldom as abundant, as is the ground plum (*Astragalus crassicarpus*).

The prairie clovers (*Dalea purpurea* and *D. candida*) are common. The halfshrub, leadplant, (*Amorpha canescens*), is frequently conspicuous in the type, especially on the somewhat drier sites. Asters, such as *Aster ericoides, A. oblongifolius*, and *A. sericeus* are frequent. The ironweed (*Vernonia fasiculata*) is often abundant.

The little orchid, lady's tresses (*Spiranthes cernua*), occurs in the type, as do the inconspicuous strawberry (*Fragaria virginiana*), and the violets (*Viola pedatifida* and *V. pratincola*). The pussy-toes (*Antennaria* spp.), while not inconspicuous, is low-growing and widespread.

Among the shrubs commonly found in the type are the prairie wild rose (*Rosa arkansana*), meadow sweet (*Spiraea alba*), willows (*Salix exgiua* subsp. *interior, S. bebbiana*, and others), and especially in the north, where it is common and abundant, western snowberry (*Symphoricarpos occidentalis*). Eastern red cedar (*Juniperus virginiana*), a conifer, may be abundant from northern Nebraska, south.

William T. Barker and
Warren C. Whitman
North Dakota State University
Fargo, ND

BLUESTEM - PRAIRIE SANDREED SRM 602

Definition and Composition: This tall grass prairie type occupies the great central sandhill of Nebraska and extends for a short distance into southern South Dakota. The area of the type overall is something over 20,000 sq. miles (52,000 sq. ha. This area supports a grassland cover that has shown surprisingly little degeneration since domestic livestock grazing began in the region (Branson, 1985). Principal species on the sandy uplands are sand bluestem (*Andropogon gerardii* var. *paucipilus*), little bluestem (*Schizachyrium scoparium*), prairie sandreed (*Calamovilfa longifolia*), switchgrass (*Panicum virgatum*), needle--and-thread (*Stipa comata*), sand lovegrass (*Eragrostis trichodes*), side-oats grama (*Bouteloua curtipendula*), and Junegrass (*Koeleria pyramidata*). Blue grama (*Bouteloua gracilis*), hairy grama (*B. hirsuta*) and short sedges, along with rosette panic grasses (*Dichanthelium oligosanthes* var. *scribnerianum* and *D. wilcoxianum*) often form an understory. On lower areas better supplied with moisture, big bluestem (*Andropogon gerardii*), prairie cordgrass (*Spartina pectinata*), switchgrass, Indiangrass (*Sorghastrum nutans*), prairie dropseed (*Sporobolus heterolepis*), and little bluestem become the major species (Frolik and Shepherd, 1940).

Forbs are common and generally abundant. A number of shrubs are relatively common associates. Many wetland areas of permanent and temporary ponds and small lakes dot the sandhills area supporting typical wetland and aquatic vegetation, as well as abundant wildlife populations.

Geographic Distribution: By definition the type is considered to be characteristic of the Nebraska sandhills region. However, there are a number of sandhill areas scattered throughout the Northern Great Plains. For the most part the vegetation on these sandhill areas is somewhat different from the Nebraska sandhills type, though there are substantial similarities. The sandhill vegetation area in southern South Dakota is actually part of the Nebraska sandhills Prairie. The sandhill vegetation of southeastern, east central, and northern North Dakota is quite similar to the eastern part of the Nebraska type, though it does have an arboreal component that is not commonly found in the Nebraska type. Progressing northward and westward the bluestem component becomes less important on the sandhills areas, until in the great sandhills of Saskatchewan it is almost entirely lacking (Watts, 1960). It is logical to place these areas in a different vegetation type.

Ecological Relationships: The area on which the type is developed consists largely of rolling to steep, irregular sand dunes with narrow elongated, nearly level to gently sloping valleys between the dunes (Bose, 1977). The general elevation of the region is from 2,000 to 4,000 ft. (700-1300m), increasing from east to west. Throughout the hills scattered many small depressions with permanent or intermittent water bodies. Local relief may be from only a few feet to over 200 ft. (70m).

The deep sandy soils of the uplands are on wind deposited sand, and well-drained, while the soils in the valleys and depressions are somewhat loamy and less well-drained. Average annual precipitation over the region ranges from about 16 to 23 inches (40 to 58cm), increasing eastward. The major precipitation period is from mid-spring to mid-autumn. The freeze-free period ranges from about 140 to 150 days (USDA, 1981).

The vegetation of the type bears an obvious relation to the Bluestem Prairie with which it is in contact on the east. In part the Nebraska sandhills type represents a western displacement of the bluestem prairie, primarily due to the edaphic situation of the widespread occurrence of the deep sands favoring tall grass vegetation (Goetz, 1987). While the sands of the uplands are generally dry on the surface, in favorable years the sand is almost continuously moist downward from a few inches below the surface (Weaver and Albertson, 1956). The strong development of the sand-loving components of the vegetation differentiate it from the Bluestem Prairie.

Variants and Associated Species: Forbs on the uplands prairie development commonly include such species as hairy prairie clover (*Dalea villosa*), bush morning-glory (*Ipomoea leptophylla*), stiff sunflower (*Helianthus rigidus*), sand milkweed (*Asclepias arenaria*) annual eriogonum (*Eriogonum annuum*) spreading wild buckwheat (*Eriogonum effusum*), prairie coneflower (*Ratibida columnifera*), spiderwort (*Tradescantia occidentalis*), little prickly pear (*Opuntia fragilis*), and, westward, soapweed (*Yucca glauca*). Especially prominent in the shrub component of the type are leadplant (*Amorpha canescens*), sandcherry (*Prunus pumila* var. *besseyi*), New Jersey tea (*Ceanothus herbaceous*), prairie wild rose (*Rosa arkansana*), and in some cases western snowberry (*Symphoricarpos occidentalis*).

In the lowland valleys, which are often cut for hay, where big bluestem, prairie cordgrass, switchgrass, and Indian grass are major species, Kentucky bluegrass (*Poa pratensis*) has become an important species. Redtop (*Agrostis stolonifera*) and smooth bromegrass (*Bromus inermis*) also are often frequent.

Where the grass cover of the hills has been broken, blowouts and blowout communities are developed. Blowout grass (*Redfieldia flexuosa*) and lemon scurf-pea (*Psoralealanceolata*) are common pioneer species in this situation. Indian ricegrass (*Oryzopsis hymenoides*), sand lovegrass (*Eragrostis-trichodes*), needle-and-thread (*Stipa comata*), and prairie sandreed (*Calamovilfa longifolia*) may provide a relatively sparse cover with blowout grass early in the revegetation process (Weaver and Albertson, 1956). A sandhill muhly (*Muhlenbergia pungens*) community may later dominate the stabilizing areas, to be followed

eventually by the bunchgrass community of the uplands. Sandhill muhly is thus an important and widespread species of the upland communities.

The wet lowlands of the area support typical wetland communities of grasses, sedges, rushes and reeds, depending on the nature of the wetland involved. Frequently shrubby communities are developed in the low, wet areas with sandbar willow (*Salix exuiga* subsp. *interior*) commonly present. Saline soils may support an inland saltgrass community with nearly pure stands of (*Distichlis spicata* var. *stricta*) (Frolik and Shepherd, 1940).

Warren C. Whitman and
William T. Barker
North Dakota State University
Fargo, ND

PRAIRIE SANDREED - NEEDLEGRASS SRM 603

Definition and Composition: This type is distinguished to separate it from the Bluestem-Sandreed type which characterizes the Nebraska Sandhills area. Northward from the Nebraska area the bluestems become less important on dryland sandy areas while prairie sandreed (*Calamovilfa longifolia*) and needle-and-thread (*Stipa comata*) become the primary dominants in the sandy land vegetation association. The bluestems are present to some extent in most cases, especially sand bluestem (*Andropogon gerardii* var. *paucipilus*), and little bluestem (*Schizachyrium scoparium*). Big bluestem (*Andropogon gerardii*), if present at all, is relatively unimportant in this type.

In addition to sandreed, needle-and-thread, and sand bluestem, other commonly associated grasses include porcupine grass (*Stipa spartea*), sand dropseed (*Sporobolus cryptandrus*), Junegrass (*Koeleria pyramidata*), Canada wild rye (*Elymus canadensis*) Indian ricegrass (*Oryzopsis hymenoides*), and to some extent western wheatgrass (*Agropyron smithii*) and thickspike wheatgrass (*Agropyron dasystachyum*).

Often-times an appreciable understory of blue grama (*Bouteloua gracilis*), threadleaf sedge (*Carex filifolia*), penn sedge (*C. pensylvanica*), and other sedges is present. Kentucky bluegrass (*Poa pratensis*) is not uncommon.

Forbs are common in the type, especially such species as lemon scurf-pea (*Psoralea lanceolata*), prairie goldenrod (*Solidago missouriensis*), prairie clovers (*Dalea purpurea* and *D. villosa*), fringed sage (*Artemisia frigida*), white sage (*A. ludoviciana*), white aster (*Aster ericoides*), western ragweed (*Ambrosia psilostachya*), golden aster (*Chrysopsis villosa*), and skeletonweed (*Lygodesmia juncea*). Leadplant (*Amorpha canescens*) is frequent in the more southerly developments of the type.

Woody plants are common northward on sheltered slopes and in lower areas. Principal among these are prairie wild rose (*Rosa arkansana*), woods rose (*R. woodsii*), silverberry (*Elaeagnus commutata*), creeping juniper (*Juniperus horizontalis*), dwarf juniper (*J. communis*), and western snowberry (*Symphoricarpos occidentalis*). Willows (*Salix* spp.) and chokeberry (*Prunus virginiana*) may be frequent in some cases, and northward such tree species as bur oak (*Quercus macrocarpa*) and quakingaspen (*Populus tremuloides*) are commonly present.

Geographic Distribution: Sandhill areas, developed on windblown fine sands, and undifferentiated sandy areas with usually coarser sands are relatively common in the northern plains. For the most part these areas are small as compared to the Nebraska sandhills, but taken in the aggregate they would total many thousands of acres. It is the areas such as these which support the Sandreed-Needlegrass type. The largest development of the type in the northern plains is represented by the Great Sandhills in southwest Saskatchewan, below the South Saskatchewan River. Examples of the type are common elsewhere in Saskatchewan (Coupland, 1950), in central and western North Dakota, eastern Montana, southeastern Wyoming and northeastern Colorado (Barchenger, 1983).

Ecological Relationships: The type is usually developed on rolling to hilly and choppy dune topography or on nearly level to rolling or strongly rolling uplands. Altitude over most of the range of the type varies from 1,000 to 3,000 ft (330 to 1000m). For the most part precipitation ranges from 13 to 17 inches (32 to 42cm) with major distribution in spring and early summer. Since the type ranges over such an extensive territorial area, the frost-free period is variable from north to south; most of the range would fall between 115-140 days.

Blowout communities developed in areas of active sand erosion or deposition are fairly common throughout the type. Blowout grass (*Redfieldia flexuosa*) is present to some extent in the more southerly developments, but to the north prairie sandreed (*Calamovilfa longifolia*), Indian ricegrass (*Oryzopsis hymenoides*), and sand dropseed (*Sporobolus cryptandrus*), together with lemon scurf-pea (*Psoralea lanceolata*) are the pioneer species in most cases. The stabilizing communities exhibit increasing amounts of needle-and-thread in association with prairie sandreed. Also, northward, there is a marked increase in the importance of woody species such as the shrubby junipers, larger shrubs, and even trees, in the stabilization of sandy areas.

Variants and Associated Species: The boundaries of this type, in the areas of its occurrence are usually quite distinct. Often boundaries are marked by an abrupt change in soil texture from sands to more medium textured soil classes. Thus prairie sandreed may abruptly disappear from the cover, while needle-and-thread and other species may continue as components of adjoining cover types.

Under intensive grazing use of the type blue grama, hairy

grama, and the upland sedges increase, so that a fairly dense cover of the shorter species may develop. Soapweed (*Yucca glauca*) increases. Should the cover become broken numerous annual species commonly invade. In the western and southern developments of the type sand sagebrush (*Artemisia filifolia*) often becomes abundant (Weaver and Albertson, 1956). Usually prairie sandreed and needle-and-thread remain sufficiently abundant so that the type is readily recognizable. As distinctive as anything about the type, however, is its generally great range in stand size, which may vary from a few acres to thousands of acres.

Warren C. Whitman and
William T. Barker
North Dakota State University
Fargo, ND

BLUESTEM - GRAMA PRAIRIE SRM 604

Definition, Composition, and Structure: This mixed grass prairie shows its major development in west-central Kansas, where the characterizing grass dominants are little bluestem (*Schizachyrium scoparium*), big bluestem (*A. gerardi*), side-oats grama (*Bouteloua curtipendula*), blue grama (*B. gracilis*), and hairy grama (*B. hirsuta*). Important associated species include western wheatgrass (*Agropyron smithii*), Indian grass (*Sorghastrum nutans*), Junegrass (*Koeleria pyramidata*), switchgrass (*Panicum virgatum*), and the three-awns (*Aristida purpurea* var. *robusta* and *A. oligantha*). Buffalo grass (*Buchloe dactyloides*) becomes a prominent part of the understory on dry sites. The combination of medium tall to tall grass components with the characteristic short grasses of the plains gives this type a distinct two-layered appearance (Kuchler, 1974).

Perennial forbs are abundant in the type and widely distributed, commonly forming a fairly conspicuous part of the upper layer. Shrubs and other woody growth normally do not make up an appreciable part of the cover.

Geographic Distribution: The Bluestem-Grama cover type occurs in south central Nebraska, on both sides of the Republican River. This portion of the type has been referred to as the Kansas Mixed Prairie (Kaul, 1975; Bose, 1977). From thence it extends southward through the west-central portion of Kansas, and the approximate western half of Oklahoma into extreme northern Texas along the Red River, east of the panhandle (Kuchler, 1964). Small pieces of the type extend into eastern Colorado.

The Nebraska portion of the type, while recognized as mixed grass prairie, has been heavily overgrazed and largely converted to a short grass prairie with blue grama and buffalo grass as the dominant species (Bose, 1977). Throughout the western portion of its Kansas occurrence the type is also intermingled with the Blue grama-Buffalo grass type. The Bluestem-Grama type normally occupies the breaks, valleys, ravines, and lower slopes in the region while the shortgrass type dominates the drier upland sites (Weaver and Albertson, 1956; Kuchler, 1974). Overall about one-third of the original area of the type remains in native range (USDA, 1981).

Ecological Relationships: The average annual precipitation range over the type is from about 22 to 28 inches (55 to 70cm), increasing from west to east, with the major precipitation period from midspring to early fall. Temperatures increase southward and eastward with the average frost-free period ranging from 150 to 180 days. Soils are generally medium to moderately fine textured with good drainage. The general aspect of the area is that of a rolling upland plain dissected by hilly and steep breaks along streams and rivers. Altitude over most of the type ranges from about 3,000 ft. (1000m) west to about 1,000 ft. (330m) east and south. In the extreme west, altitude may exceed 3,000 ft. (1000m). Normally local relief does not much exceed 100 ft. (33m) (USDA, 1981).

To the north and east the type is in contact with the bluestem prairie through a fairly wide transition zone. To the south and east the type contacts woody vegetation combinations, especially the oaks of the Cross Timbers. At the extreme southern end of the type mesquite and shortgrasses become dominant. On the western edge the type is in nearly continuous contact with the shortgrass plains (*Blue grama - Buffalo grass*).

Variants and Associated Species: The principal variations in the type are the result of differences in slope, exposure, and soil materials, primarily as these factors affect amount, distribution, and seasonal duration of available soil moisture. Throughout the type the same taller grasses and forbs are relatively shorter than in the Bluestem prairie to the east. Big bluestem, Indiangrass, and switchgrass, decrease in the cover as the drier sites are approached. Little bluestem and side-oats grama increase toward the upper stretches of rocky hillsides, steep slopes and shallow ravines, forming a distinct aspect of the type as a whole. As a characteristic type the little bluestem dominated community extends in fragmented manner out of this overall range type on rough, broken slopes and hilltops far to the north. On the dry uplands the short grasses rapidly become dominant, commonly making up about 80 percent of the cover (Weaver and Albertson, 1956).

Common forbs associated with the type include many of those from the prairie to the east such as western ironweed (*Vernonia baldwini*), wild licorice (*Glycyrrhiza lepidota*), prairie dogbane (*Apocynum cannabinum*), Maxmilian sunflower (*Helianthus maxmilianii*) and leadplant (*Amorpha canescens*). More characteristic of the type as a whole are such forbs species as prairie coneflower (*Ratibida columnifera*), scarlet gaura (*Gaura coccinea*), western wallflower (*Erysimum asperum*), red false globemallow (*Sphaeralcea*

coccinea), puccoon (*Lithospernum incisum*), goldenrod species (*Solidago missouriensis; S. mollis; S. rigida*), purple coneflower (*Echinacea augustifolia*), western ragweed (*Ambrosia psilostachya*), blazing star (*Liatris punctata*), white aster (*Aster ericoides*), and few-flowered psoralea (*Psoralea tenuifolia*). Broom snakeweed (*Gutierreza sarothrae*), curly-top gumweed (*Grindelia squarrosa*), and plains pricklypear (*Opuntia polyacantha*), are often abundant where grazing has been heavy.

While woody plants are not normally abundant in the vegetation, there has been some spread of eastern redcedar (*Juniperus virginiana*) into the type (Albertson, 1940; Great Plains Flora Assoc., 1977).

William T. Barker and
Warren C. Whitman
North Dakota State University
Fargo, ND

SANDSAGE PRAIRIE
SRM 605

Definition and Composition: The characterizing species in this type is the sandsage (*Artemisia filifolia*). Associated with it as dominating grass species are sand bluestem (*Andropogon gerardii* var. *paucipilus*), little bluestem (*Schizachyrium scoparium*), and prairie sandreed (*Calamovilfa longifolia*). Often switchgrass (*Panicum virgatum*), sand dropseed (*Sporobolus cryptandrus*), Indian ricegrass (*Oryzopsis hymenoides*), lovegrass (*Eragrostis trichodes*), needle-and-thread (*Stipa comata*), and side-oats grama (*Bouteloua curtipendula*) will make up a substantial part of the cover. Blue grama (*Bouteloua gracilis*) and hairy grama (*B. hirsuta*) are usually present in the understory. Buffalo grass (*Buchloe dactyloides*) also may be found. Forbs are common (Kuchler, 1974; Bose, 1977). The overall appearance of the type is that of a fairly dense, medium-tall grassland with an overtopping shrubby component.

Geographic Distribution: This type is found on the sandy soils of southwestern Nebraska and north eastern Colorado mainly south of the South Platte River; on the sands in east central Colorado east of Colorado Springs; and along the upper Arkansas and Cimmarron Rivers in southwestern Kansas. The type becomes prominent in Oklahoma (Weaver and Albertson, 1956). In the northern plains the type occurs primarily as an inclusion in the Blue grama-Buffalo grass type. Much of its occurrence is obviously associated with sand depositions blown up out of the broad river valleys in past geologic time. Total area of the type north of the Colorado-Kansas line is probably not greater than 10 percent of the Blue grama-Buffalograss type in which it is included.

The general topography of the area is that of rolling to hilly sand dunes that have been stabilized by vegetation. For the most part the hills are relatively low with local relief mainly less than 100 ft (33m). Between the hills are often relatively gently sloping broad flats. Elevations of the areas of occurrence of the type vary from about 2,500 ft. (830m) east to over 4,500 ft. (1500m) in west (USDA, 1981).

Ecological Relationships: Over most of the area where the type occurs annual precipitation averages 12 to 20 inches (30-50cm), increasing from northwest to southeast. The major period of rainfall is from late spring to mid to late fall. The soils, developed mainly on wind deposited sands, are deep, mainly loamy fine sands to fine sands. The frost-free period ranges from about 140 days north to as much 180 as days south and east.

While sandsage is relatively widespread in the western plains and in the southwest, it seems not to develop into a distinctive type with an association of taller grasses except on the sandy soils of the southern portion of the Great Plains. A small example of the type has been identified north of the Black Hills in South Dakota. The sandsage plant itself is relatively unpalatable (Stubbendieck, Hatch, and Hirsch, 1989) and is little used by livestock. When heavily utilized over time, the short grass element of the cover tends to increase while the tall and midgrasses decrease. The sandsage itself seems to increase to some extent. Chemical control of sandsage has been fairly effective.

Variants and Associated Species: Eastward in Kansas the type merges into the Sand Prairie and the Bluestem-Grama prairie (Kuchler, 1974), while to the northeast it borders the Wheatgrass-Bluestem- Needlegrass type, where the upland soils are heavier textured (Bose, 1977). To the north, west and south the type is in contact with the Blue grama-Buffalo grass type. Throughout its range the type is mainly restricted to specific sandy soil areas, largely stabilized sand dune areas (Johnston, 1987).

Among the forbs associated with the type plains prickly pear (*Opuntia polyacantha*) and soapweed (*Yucca glauca*) are commonly conspicuous. Other forbs common in the type include sand sunflower (*Helianthus petiolaris*), blazing star (*Liatris punctata*), golden aster (*Chrysopsis villosa*) slimflower scurf-pea (*Psoralea tenuiflora*), western sagewort (*Artemisia caudata*), spiderwort (*Tradescantia occidentalis*), western ragweed (*Ambrosia psilostachya*), and annual buckwheat (*Eriogonum annuum*).

William T. Barker and
Warren C. Whitman
North Dakota State University
Fargo, ND

WHEATGRASS - BLUESTEM - NEEDLEGRASS SRM 606

Definition, Composition, and Structure: The Wheatgrass-Bluestem-Needlegrass type is essentially a transition type between the Bluestem Prairie to the east and the more arid grasslands to the west. It is fundamentally a perennial mixed grass prairie with the taller grasses important, though not always dominant in the cover. The type is not uniform north to south by any means. Considering the full extent of the type the principal grass dominants are western wheatgrass (*Agropyron smithii*), thickspike wheatgrass (*Agropyron dasystachyum*) slender wheatgrass (*Agropyron caninum* subsp. *majus*), big bluestem (*Andropogon gerardi*), little bluestem (*Schizachyrium scoparium*), porcupine grass (*Stipa spartea*), needlegrass (*Stipa curtiseta*), needle-and-thread(*Stipa comata*), green needlegrass (*Stipa viridula*), sideoats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), Junegrass (*Koeleria pyramidata*), prairie sandreed (*Calamovilfa longifolia*), and Kentucky bluegrass (*Poa pratensis*). Important sedges are needleleaf sedge (*Carex eleocharis*), penn sedge (*C. pensylvanica*), threadleaf sedge (*C. filifolia*), and sunsedge (*C. heliophila*). Forbs are numerous and moderately abundant in the type with many of the same species found throughout the entire range of the type.

Shrubs are fairly frequent in the type, while tree growth is largely confined to favorable moisture situations.

Geographic Distribution: This type extends from southeastern Saskatchewan through south western Manitoba, thence angling across northwestern and central North Dakota through east central South Dakota and Nebraska approximately to the Kansas border (Kuchler, 1964, Kaul, 1975). The transitional belt is wider in the north, approximately 200 miles, than it is in the central and southern parts, where it is generally less than 100 miles. Elevation through most of the range is between 1000 to 2500 ft (330 to 830m).

Ecological Relationships: Range of average annual precipitation from west to east in the northern portion of the type is about 15 to 18 inches (38-45cm), while the same range in the southern part of the type is about 19 to 25 inches (48-63cm). Again precipitation effectiveness would be about the same north to south.

Throughout its extent most of the type occurs on soils derived from glacial materials. The terrain varies from nearly level to moderately rolling, and to hilly and steeply hilly areas occasionally marked by deposits of glacial boulders and a generally hummocky appearance, especially in the northern part. Soil textures vary through sands, silts, and clays. On favorable terrain much of the area is cultivated. Considered in total only about a quarter of the area of the type remains in native grass (Garrison et al. 1977).

Low wet areas are frequent, and ponds and small permanent or semi-permanent sloughs and lakes are a characteristic feature of the glaciated terrain. Saline and non-saline wetlands are common.

The tall grasses from the Bluestem Prairie (big bluestem, Indian grass, switchgrass, prairie dropseed, and prairie cordgrass) are largely confined to the lower, more moist areas. Little bluestem has a wider range in the type and usually becomes an important component of the cover on the uplands. The bluestems do not have much significance in the Canadian portion of the type. On the north in Canada the type mingles with the Fescue grasslands, and outliers of the aspen woodland are dotted throughout, with remnants of both types extending into northern North Dakota.

On the uplands and drier sites wheatgrasses, needlegrasses, blue grama, and the upland sedges largely dominate the cover.

Variants and Associated Species: Kentucky bluegrass has become an important component of the type, especially in the central portion. This species has not been considered part of the original vegetation, and its increase has corresponded with the increased grazing use of the type. Another species which has increased greatly in the cover is the shrub, western snowberry (*Symphoricarpos occidentalis*). In some cases, especially in the central region, this species would rank as a sub-dominant.

Among the important forbs of the type would be included white aster (*Aster ericoides*), silverleaf scurf-pea (*Psoralea agrophylla*), lemon scurf-pea (*P. lanceolata*, numerous milkvetches (*Astragalus* spp., purple locoweed (*Oxytropis lambertii*), purple coneflower (*Echinacea angustifolia*), narrow-leaved blazing star (*Liatris punctata*), scarlet gaura (*Gaura coccinea*), red false mallow (*Sphaeralcea coccinea*), fringed sage (*Artemisia frigida*), white sage (*A. ludoviciana*), soft goldenrod (*Solidago mollis*), prairie goldenrod (*S. missouriensis*), other goldenrods, curly-top gumweed (*Grindelia squarrosa*), golden aster (*Chrysopsis villosa*), stiff sunflower (*Helianthus rigidus*) and Hood's phlox (*Phlox hoodii*).

In addition to western snowberry, other shrubs of importance are willows (*Salix* spp.), roses (*Rosa* spp.), buffaloberry (*Shepherdia argentea*), silverberry (*Elaeagnus commutata*), chokeberry (*Prunus virginiana*), wild plum (*P. americana*), northern hawthorn (*Crataegus rotundifolia*), and in some cases dwarf sagebrush (*Artemisia cana*).

Warren C. Whitman and
William T. Barker
North Dakota State University
Fargo, ND

WHEATGRASS - NEEDLEGRASS SRM 607

Definition, Composition, and Structure: The wheatgrass-needlegrass type is fundamentally a perennial mixed grass prairie in which the mid-grass component (wheatgrasses and needlegrasses) maintain dominance over the shortgrass component (primarily blue grama and sedges) throughout most of the range of the type. However, the shortgrass component is now notably more important in the type than it was formerly. In general, however, except when closely grazed, the aspect of the type is that of the mixed grass prairie.

The major midgrasses (mainly cool-season grasses) are western wheatgrass (*Agropyron smithii*), thickspike wheatgrass (*A. dasystachyum*), needle-and-thread (*Stipa comata*), porcupine grass (*S. spartea*), green needlegrass (*S. viridula*), Junegrass (*Koeleria pyramidata*), and plains reedgrass (*Calamagrostis montanensis*). On the eastern edge of the type Kentucky bluegrass frequently occurs. In some cases Muhlenbergia spp. are of some importance, especially plains muhly (*M. cuspidata*). Other taller grasses of some importance include prairie sandreed (*Calamovilfa longifolia*) and red three-awn (*Aristida purpurea var. robusta*.)

The principal shortgrass throughout the type is blue grama (*Bouteloua gracilis*). Two other shortgrasses, Sandberg's bluegrass (*Poa sandbergii*) and buffalograss (*Buchloe dactyloides*), are occasionally abundant, with Sandberg's bluegrass rather widely distributed, while buffalograss may become important, especially on heavy soils, solonetzic soils, or bottomlands of small drainages. Needleleaf sedge (*Carex eleocharis*), threadleaf sedge (*C. filifolia*) and sun sedge (*C. heliophila*) are the equivalents of short grasses in the type.

Major forbs of the type are generally similar to those of the adjoining types and are usually moderately abundant. Shrub species are common but usually not of major importance. However, dwarf sagebrush (*Artemisia cana*) and big sagebrush (*A. tridentata*) are present in portions of the type.

Geographic Distribution: This type extends from mid-Saskatchewan across the western two-thirds of North Dakota, most of northwestern South Dakota, a short distance into eastern Montana and Wyoming, and thence south into northeastern Colorado (Barker and Whitman, 1989). It is one of the major range types in the north central part of the plains, but the short grass component becomes increasingly important west and south. Over two-thirds of the land area of the type is in native grass (Garrison, et al. 1977).

Ecological Relationships: Range of average annual precipitation from west to east over the type is about 11 to 16 inches (28-40cm). North to south there is not much change in total annual precipitation, so because of increasing temperature southward the type becomes increasingly arid toward its southern extremity. The frost free period ranges from about 110 days north to as much as 160 days in the south (USDA - 1981).

Elevation ranges from about 1,500 ft. (500m) on the east to about 4,000 ft. (1300m) on the west in some of the higher parts. The prevailing aspect of the terrain is that of a rolling upland plain. However, in many areas there are moderate to steep slopes and rough broken areas of badlands, especially along the edges of stream and river valleys. Steep-sided, flat-topped buttes occasionally rise 300 to 500 ft (100 to 170m) above the surrounding plains. For the most part soils are medium textured, but over the type as a whole a great range of textures is found. Areas of saline and alkaline (solonetzic) soils are fairly common.

In Saskatchewan and Alberta, at the northern extension of the type, the Fescue grassland and aspen groves, as outliers of the Boreal forest, mingle with this grassland (Looman, 1979). Throughout most of the Canadian portion of the type needlegrasses (*Stipa comata* and *S. spartea*) and blue grama are major dominants with the wheatgrasses relatively minor (Coupland, 1959). At the southern end of the type the short grass component becomes increasingly dominant, and the type grades into the Blue grama-Buffalograss type (Costello, 1944).

Variants and Associated Species: Woodland and shrub types, while not of major importance in this type, are present and small developments are rather widespread. Higher upland areas, steep slopes, and stream valley frequently support deciduous woodlands while portions of the rough, broken areas have juniper woodlands and substantial developments of open pine stands. These are described elsewhere. Big sagebrush (*Artemisia tridentata*) is abundant enough in some places to convert the vegetation essentially to a sagebrush grass type. Bluebunch wheatgrass (*Agropyron spicatum*) enters the type from the west in limited occurrence.

Perennial forbs common to the type include fringed sage (*Artemisia frigida*), golden aster (*Chrysopsis villosa*), scarlet gaura (*Gaura coccinea*), slimflower scurf-pea (*Psoralea tenuiflora*), silverleaf scurf-pea (*P. agrophylla*), skeletonweed (*Lygodesmia juncea*), red false globemallow (*Sphaeralcea coccinea*), locoweeds (*Oxytropis lambertii* and *O. sericea*), hoary and narrowleaf puccoons (*Lithospermum canescens* and *L. incisum*), white wild onion (*Allium textile*), and plains prickly pear (*Opuntia polyacantha*).

Annual forbs are sometimes frequent in the type including such species as stickseed (*Lappula redowski*), peppergrass (*Lepidium densiflorum*), lambsquarters (*Chenopodium album* and *C. leptophyllum*), patagonian plantain (*Plantago patagonica var. patagonica*), and Russian thistle (*Salsola iberica*). In some years several annual grass species may be abundant, especially annual bromes (*Bromus tectorum* and *B. japonicus*), and sixweeks fescue (*Festuca octoflora*).

Warren C. Whitman and
William T. Barker
North Dakota State University
Fargo, ND

WHEATGRASS - GRAMA - NEEDLEGRASS SRM 608

Definition and Composition: The Wheatgrass-Grama-Needlegrass Type, often referred to as the shortgrass, is actually a mixed grass prairie in which the wheatgrasses (*Agropyron smithii* and *A. dasystachyum*), needlegrasses (*Stipa comata, S. spartea, S. viridula*), and Junegrass (*Koeleria pyramidata*) still maintain an important and sometimes dominant role. However, the shortgrass component of the type including blue grama (*Bouteloua gracilis*), Sandberg's bluegrass (*Poa sandbergii*), several sedges (*C. filifolia* and *C. eleocharis* especially), and sometimes toward the south, buffalo grass (*Buchloe dactyloides*), frequently become dominant, with the taller grasses in a minor role. On drier sites the midgrasses are often almost entirely absent in the cover.

The major forbs are those characteristic of the Wheatgrass- Needlegrass type, with plains pricklypear (*Opuntia polyacantha*) frequently becoming one of the major parts of the cover. Big sagebrush (*Artemisia tridentata*) has become a major shrub component of the type, especially in southeastern Montana and northeastern Wyoming (Baumberger, 1977).

Geographic Distribution: This type extends from southeastern Alberta and southwestern Saskatchewan south across most of Montana east of the foothills of the Rockies, and into south central Wyoming west of the Black Hills to the base of the mountains. Over most of the range of the type elevation varies from 2,800 ft. to over 4,000 ft. (930-1300m), rising from east to west. Elevation at some places toward the mountains could reach 5,000 ft (1700m). The general aspect of the terrain varies from nearly level to rolling and steeply rolling. Steep, sharply eroded badlands are frequent along major streams and drainage ways. Buttes, tablelands and terraced uplands are prominent features of the landscape over much of the type. About threefourths of the land area in the type remains in native grass (Garrison et al., 1977).

Ecological Relationships: For the most part through the extent of the type annual precipitation varies from less than 11 inches to about 15 inches (28-38cm). The frost-free period ranges from about 110 days north to as much as 140 days south. Most of the precipitation occurs in spring and early summer and by midsummer the major growth of the vegetation has ceased and drying is widespread. Soils are variable in texture, usually well-drained, generally with moderate profile development. Solonetzic soils occur throughout the range of the type supporting characteristic salt tolerant species.

In the Canadian portion of the type the needlegrasses, especially needle-and-thread (*Stipa comata*) and blue grama (*Bouteloua gracilis*) are the major components of the cover (Coupland, 1950; Watts, 1960). Further south western wheat grass (*Agropyron smithii*) and thickspike wheatgrass (*A. dasystachyum*) become more important.

There is no question but that blue grama grass has increased greatly in importance in the type as the result of grazing. Buffalo grass has also become more important in the type. In addition there has been a general increase in big sagebrush. In some cases this species has increased so much in cover as to give the type the appearance of a sagebrush-grass type.

Variants and Associated Species: In addition to the major grass dominants, other grass species which show increased occurrence include red threeawn (*Aristida purpurea var. robusta*), Indian ricegrass (*Oryzopsis hymenoides*), sand dropseed (*Sporobolus cryptandrus*), plains muhly (*Muhlenbergia cuspidata*), and coming from the west, bluebunch wheatgrass (*Agropyron spicatum*).

On salty soils a typical vegetation is developed which may include western wheatgrass as a frequent species. Such vegetation commonly has inland saltgrass (*Distichlis spicata* var. *stricta*), alkali cordgrass (*Spartina gracilis*), basin wildrye (*Elymus cinereus*), foxtail barley (*Hordeum jubatum*), little barley (*H. pusillum*), alkali sacaton (*Sporobolus airoides*), Nuttall alkaligrass (*Puccinellia nuttalliana*), squirreltail (*Sitanion hystrix*), and tumblegrass (*Schedonnardus paniculatus*) as significant species (Johnston, 1987).

Shrub species on similar salt-affected soils include greasewood (*Sarcobatus vermiculatus*), shadscale (*Atriplex confertifolia*), Nuttall saltbush (*Atriplex nuttallii*), four-wing saltbush (*A. canescens*), and winterfat (*Ceratoides lanata*).

Much abandoned cropland throughout the type has been sown to crested wheatgrass. Many such fields still exist with a cover at least somewhat similar to that established at the time of seeding. For the most part crested wheatgrass (a cool-season bunchgrass) has not spread aggressively into the native vegetation.

On deteriorated rangelands the annual bromegrasses, cheatgrass (*Bromus tectorum*) and Japanese Brome (*B. japonicus*) occur frequently.

In additon to plains pricklypear common forbs in the type include fringed sage (*Artemisia frigida*), white sage (*A. ludoviciana*), pussytoes (*Antennaria* spp.), scurf-peas (*Psoralea* spp.), milk vetches (*Astragalus* spp.), red false globemallow (*Sphaeralcea coccinea*), golden pea (*Thermopsis rhombifolia*), wild onion (*Allium* spp.), golden aster (*Chrysopsis villosa*), broom snakeweed (*Gutierreza sarothrae*), curly-top gumweed (*Grindelia squarrosa*), western yarrow (*Achillea millefolium L.*), phlox (*Phlox* spp.), cinquefoils (*Potentilla* spp.), goldenrods (*Solidago*

spp.), white prairie aster (*Aster ericoides*), skeletonweed (*Lygodesmia juncea*), and narrow-leaved blazing star (*Liatris punctata*). A number of annuals forbs are usually present. In all, the forbs normally make up about 10-15 percent of the herbage volume. The clubmoss (*Selaginella densa*) often contributes substantially to the total ground cover (Ryerson, et al. 1970).

Shrubs are not uncommon in the type, and beside big sagebrush, include such species as dwarf sagebrush (*A. cana*), western snowberry (*Symphoricarpos occidentalis*), and prairie wild rose (*Rosa arkansana*).

Deciduous woodlands mainly occur on the floodplains of the major streams and drainages, while juniper and ponderosa pine developments are common on rough broken areas, steep slopes and higher elevations.

Warren C. Whitman and
William T. Barker
North Dakota State University
Fargo, ND

WHEATGRASS GRAMA
SRM 609

Definition and Composition: This is a mixed grass type commonly with an overstory of western wheatgrass (*Agropyron smithii*) and green needlegrass (*Stipa viridula*) and a definite understory of blue grama (*Bouteloua gracilis*), buffalo grass (*Buchloe dactyloides*) and dryland sedges. Occasionally thickspike wheatgrass (*Agropyron dasystachyum*) and needle-and-thread (*Stipa comata*) may become part of the overstory. Red threeawn (*Aristida purpurea var. robusta*) is often present.

Geographic Distribution: This type is a major grassland type in centraland western South Dakota, west of the Missouri River, extending into extreme northwestern Nebraska and to a limited extent into southeastern Montana (Barker and Whitman, 1989). It is primarily associated with the heavy soils derived from the clayey and silty shales of the rolling uplands characteristic of this region (Baumberger, 1977). The region as a whole is often referred to as the Pierre Shale Plains (USDA, 1981).

General elevation ranges from about 1,600 to 4,000 ft. (530-1300m), increasing from east to west. The terrain aspect is that of relatively long, smooth exposures, sloping to steeply sloping. Along streams and drainage ways steep to very steep slopes are developed with Badlands formations common.

Ecological Relationships: Precipitation over most of the area ranges from about 12 inches (30cm) west to about 16 inches (40cm) east near the Missouri River. The freeze-free period ranges from 130 to 150 days. Toward the extreme eastern edge of the type near the Missouri River where rainfall is more favorable big and little bluestem and side-oats grama (*Bouteloua curtipendula*), along with other prairie species become associates in the type.

The type probably reaches its most typical development on the fine-textured soils derived from the cretaceous shales. However, it is also developed on fine-textured soil materials derived from later geological depositions.

Variants and Associated Species: The eastern boundary of the type would be considered as being the Wheatgrass-Bluestem- Needlegrass type, the transition zone between the bluestem prairie to the east and the mixed grass prairie to the west. However, on lowland sites under favorable conditions grasses from the bluestem prairie can be found far to the west. Toward the west and south the short grasses, blue grama and buffalo grass become increasingly important in the cover. On deteriorated range sites in this type annual grasses, such as Japanese brome (*Bromus japonicus*) may become abundant. Common forbs in the type are red falso globemallow (*Sphaeralcea coccinea*), scurf-peas (*Psoralea* spp.), prairie vetch (*Vicia americana var. minor*), purple coneflower (*Echinacea angustifolia*), white wild onion (*Allium textile*), wild parsley (*Lomatium* spp.), and curly-top gumweed (*Grindelia squarrosa*). Fringed sage (*Artemisia frigida*) and plains pricklypear (*Opuntia polyacantha*) are frequent.

Dwarf sagebrush (*Artemisia cana*) is probably the most common shrub in the type.

Warren C. Whitman and
William T. Barker
North Dakota State University
Fargo, ND

WHEATGRASS
SRM 610

Definition and Composition: The Wheatgrass Type is dominated almost exclusively by western wheatgrass (*Agropyron smithii*) and occurs primarily as an inclusion in the Wheatgrass-Needlegrass Type. Frequently green needlegrass (*Stipa viridula*) is associated with the wheatgrass. The major distinguishing feature of the type, however is the nearly complete lack of a shortgrass component of blue grama or other shortgrasses or sedges.

Geographic Distribution: The primary occurrence of this type is in northwestern and central South Dakota (Baumberger, 1977), where itis essentially restricted to the dense clay soils underlain by the Pierre shale. The type probably occurs elsewhere in the Northern Great Plains to a limited extent, where similar soil conditions prevail, but it has not been described as a type. Almost all the land area of this type is in native grass because the extremely dense nature of the soil makes it unsuitable for cultivation.

Ecological Relationships: The occurrence of this type is primarily determined by soil characteristics and plant

rooting features. The fine roots of blue grama, other shortgrasses, and sedges are severely damaged by the alternate extensive shrinking and swelling of the soil material, while the coarser roots of the wheatgrass and needlegrass can survive these effects (White & Lewis, 1969). In the South Dakota area, where the type is best developed, the short grasses and sedges have been almost entirely eliminated.

On some heavy clay soils elsewhere in South Dakota, western North Dakota, and eastern Montana the major portion of the grass cover is usually made up of western wheatgrass with some green needlegrass, and Junegrass, but a limited shortgrass understory component is usually present. The more extensive developments of this cover type have been referred to the Wheatgrass-Grama type.

Variants and Associated Species: Other wheatgrasses, especially thickspike wheatgrass (*Agropyron dasystachyum*) and bluebunch wheatgrass (*A. spicatum*) may occur in association with western wheatgrass in the type. Principal forbs occurring with the type include wild onion (*Allium* spp.), wild parsley (*Lomatium* spp.), red false globemallow (*Sphaeralcea coccinea*), prairie vetch (*Vicia americana var. minor*), golden pea (*Thermopsis rhombifolia*) western yarrow (*Achillea millefolium*), and plains prickly pear cactus (*Opuntia polyacantha*).

Woody plants normally make up very little of the composition of the type. Winterfat (*Ceratoides lanata*) and fringed sage (*Artemisia frigida*) may occasionally be present.

Warren C. Whitman and
William T. Barker
North Dakota State University
Fargo, ND

BLUE GRAMA - BUFFALO GRASS
SRM 611

Definition and Composition: This is the true shortgrass type of the northern and central plains. The moderately dense, shortgrass cover is dominated primarily by blue grama grass (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). Hairy grama (*Bouteloua hirsuta*) is a common associate. However, some of the midgrasses are almost universally present, especially western wheatgrass (*Agropyron smithii*), side-oats grama (*Bouteloua curtipendula*), little bluestem (*Schizachyrium scoparium*) and red threeawn (*Aristida purpurea var. robusta*) (Weaver and Albertson, 1956). Other midgrasses occasionally present include Indian ricegrass (*Oryzopsis hymenoides*), squirreltail (*Sitanion hystrix*), and sand dropseed (*Sporobolus cryptandrus*). Forbs are common, especially plains prickly-pear (*Opuntia polyacantha*), but woody plants, while present, are not regularly a major component of the northern portion of the type.

Geographic Distribution: Major distribution of the type is from portions of western Nebraska through southeastern Wyoming, eastern Colorado to the foothills of the Rockies, approximately the western quarter of Kansas, and out of the northern plains on south into Oklahoma, Texas and New Mexico, where different species become associates in the type (Garrison, et al. 1977). The general terrain aspect over the range of the type is that of an undulating to rolling plain, with the eastern portion a nearly level plain, level enough to be referred to as a tableland (USDA, 1981). Along the borders of the stream valleys and drainage ways, however, there are steep slopes and rough, broken areas. The larger streams have smooth floodplains and terraces in the valley bottoms.

The general elevation of the region ranges from about 2,500 ft. (800m) to over 5,000 ft (1700m), with the higher elevations to the west and north, especially in southeastern Colorado.

Ecological Realtionships: Over most of the area average annual precipitation ranges from 11 to 20 inches (27-50cm), with the greatest rainfall to the east. Rainfall distribution is somewhat different from that of the more northerly portions of the plains with the major period beginning later in the spring and extending later into the fall. The frost-free period averages 140-160 days over most of the area, with extremes ranging from 120 to 180 days. Soils are mainly medium-textured to fine-textured and moderately deep, having been developed mainly on windblown, alluvial, or outwash materials. In western Kansas about two-thirds of the area is now cropland. In most of the rest of the area 65-75 percent of the land is range (USDA, 1981).

The short grass type is primarily on the upland sites. Rough broken areas, valley edges and bottoms, and sandy soils permit the development of mid and taller grasses especially to the east and north. Species found here would include prairie sandreed (*Calamovilfa longifolia*), sand bluestem (*Andropogon gerdardii* var. *paucipilus*), big bluestem (*A. gerardi*), little bluestem (*Schizachyrium scoparium*) and the three-awns (*Aristida* spp.). The western Nebraska portion of the type is considered to have been a mixed grass prairie originally, but now converted to short grass by continued heavy grazing use (Bose, 1977). On the west the type is mainly bordered by the juniper woodlands and pine forests of the foothills of the Rocky Mountains (Kuchler, 1964).

Variants and Associated Species: The major variation of the type is associated primarily with the greater precipitation toward its eastern border and cooler temperatures toward the north. Eastward little bluestem (*Schizachyrium scoparium*) and even big bluestem (*Andropogon gerardi*) along with sideoats grama may become common associates. Toward the north and east needle-and-thread (*Stipa comata*) western wheatgrass, and

green needlegrass (*Stipa viridula*), along with little bluestem are more common. On sandy soils prairie sandreed (*Calamovilfa longifolia*) is common along with sand dropseed and Indian ricegrass. In this area threadleaf sedge (*Carex filifolia*) often becomes a fairly important component of the short grass cover. The southern portion of the type has fewer mid-grasses in it, and in southwestern Kansas, Kuchler (1974), recognizes a southern variant of the type.

Common forbs include such species as red false globemallow (*Sphaeralcea coccinea*), slimflower scurf-pea (*Psoralea tenuiflora*), narrow-leaved blazing star (*Liatris punctata*), broom snakeweed (*Gutierrezia sarothrae*), ironplant (*Haplopappus spinulosus*), scarlet gaura (*Gaura coccinea*), curly-top gumweed (*Grindelia squarrosa*), prairie coneflower (*Ratibida columnifera*), bahia (*Picradeniopsis oppositifolia*), golden aster (*Chrysopsis villosa*), skeletonweed (*Lygodesmia juncea*), groundsels (*Senecio* spp.), and fringed sage (*Artemisia frigida*). Such annuals as goosefoots (*Chenopodium* spp.), Russian thistle (*Salsola iberica*), stickseed(*Lappula redowski*), patagonian plantain (*Plantago patagonica*), and six-weeks fescue (*Festuca octoflora*) are frequent.

Plains pricklypear and soapweed (*Yucca glauca*) are quite common in the type. Occasionally rabbitbrushes (*Chrysothamnus* spp.)fourwing saltbush (*Atriplex canescens*), winterfat (*Ceratoides lanata*), and sandsage (*Artemisia filifolia*) are present.

Lower areas frequently have sodium-affected soils. On such alkaline soils salt grass (*Distichlis spicata* var. *stricta*), alkali sacaton (*Sporobolus arioides*), and tumblegrass (*Schedonnardus paniculatus*) are frequent.

William T. Barker and
Warren C. Whitman
North Dakota State University
Fargo, ND

SAGEBRUSH-GRASS
SRM 612

Definition and Composition: The Sagebrush-grass type in the Northern Great Plains varies considerably in composition. The major shrub dominant, big sagebrush (*Artemisia tridentata*), is often accompanied by dwarf sagebrush (*A. cana*), and rabbitbrushes (*Chrysothamnus viscidiflorus* and *C. nauseosus*). At the eastern edge of the type dwarf sagebrush may become the principal shrub-dominant forming an essentially different cover type, especially on stream floodplains. In some cases other shrubs such as the saltbushes (*Atriplex* spp.), greasewood (*Sarcobatus vermiculatus*), and winterfat (*Ceratoides lanata*) can become an important part of the cover. The best development of the type has bluebunch wheatgrass (*Agropyron spicatum*) as the major grass dominant. However, western wheatgrass (*Agropyron smithii*), needle-and-thread (*Stipa comata*), blue grama (*Bouteloua gracilis*), and Junegrass (*Koeleria pyramidata*) are often important constituents of the cover (Johnston, 1987). At some of the higher altitudes even Idaho fescue (*Festuca idahoensis*) may be significant enough in the type to represent a distinct phase (Jorgenson, 1979). Principal forbs include fringed sage (*Artemisia frigida*), plains prickly pear (*Opuntia polyacantha*), broom snakeweed (*Gutierrezia sarothrae*), wild vetch (*Vicia americana*), phlox (*Phlox hoodii* and *P. longifolia*), fleabanes (*Erigeron* spp.), scurf-pea (*Psoralea tenuiflora*), red false globemallow (*Sphaeralcea coccinea*), and wild parsley (*Musineon divaricatum*). Clubmoss (*Selaginella densa*) is common.

Geographic Distribution: This type occurs essentially as an inclusion in the Wheatgrass-Grama-Needlegrass and the Wheatgrass-Needlegrass types in the northern plains. The best development of the type is in northeastern Wyoming (Shrader, 1977), but it extends in fragmented occurrence northward into southwestern and central Montana (Ross and Hunter, 1976), and eastward into western South Dakota and southwestern North Dakota. Over most of the range of the type elevation varies from about 3,500 to 4,500 ft. (1200-1500m), although at its eastern extremity in North Dakota elevation is around 2,600 ft. (900m).

The general terrain aspect of the type where it is best developed is that of a nearly level to rolling upland plain. However, developments of the type are common on dissected-uplands, on upper edges and side slopes of rough, broken areas and at the extended bases of steep slopes and butte sides (Mackie, 1970; Watts, Eichhorn, and Mackie, 1987). Where the type becomes dominated by dwarf sagebrush (*A. cana*), big sagebrush is often on older, higher benches along drainage ways, while dwarf sagebrush is on newer sediments closer to the stream (Hazlett and Hoffmann, 1975).

Ecological Relationships: Average annual precipitation over the range of the type varies from less than 11 inches (28cm) to almost 16 inches (40cm) with a general average of about 14 inches (35cm). Most of the precipitation occurs in spring and early summer. Soils are mainly hallow and variable intexture, though the type is perhaps most frequent on silty and clayey soils. Most commonly the soils are underlain by shales and sandstones, though transported materials form the substratum in some cases. Salt-affected soils are relatively common through the type (USDA, 1981).

In general big sagebrush is somewhat reduced in stature in the plains occurrence of the type, the shrubs are often scattered, and there is considerable open grassland. While bluebunch wheatgrass is a characterizing species of the grass component of the type, extending even into western North and South Dakota, the other wheatgrasses, especially western wheatgrass, may largely replace it on some sites. The occurrence of Idaho fescue is rare in the type, and

usually enters the cover only at higher altitudes or near forest borders.

Variants and Associated Species: While big sagebrush and dwarf sagebrush as species have a wide range over the northern plains, the sagebrush-grass as a developed type is of limited extent and except for a few areas of concentrated development is generally fragmented in occurrence. The dominants in the grass cover also show considerable variation, as previously mentioned. One or more wheatgrass species are nearly always present. In addition to needle-and-thread, green needlegrass (*Stipa viridula*) may become a frequently associated species, especially on heavier soils. Squirreltail (*Sitanion hystrix*), Indian ricegrass (*Oryzopsis hymenoides*), and plains muhly (*Muhlenbergia cuspidata*) occur in the type in varying amounts, generally as minor species. Even Kentucky bluegrass (*Poa pratensis*) may rarely reach abundance. More commonly Sandberg's bluegrass (*Poa sandbergii*) occurs as a frequent constituent of the shortgrass portion of the cover. Sedges, such as threadleaf (*Carex filifolia*) and needleleaf sedge (*C. eleocharis*) often are present.

Warren C. Whitman and
William T. Barker
North Dakota State University
Fargo, ND

FESCUE GRASSLAND
SRM 613

Definition and Composition: The true Fescue Grassland is dominated by the tussock-forming rough fescue (*Festuca scabrella*). The species composition of the type as a whole shows considerable variation over its range south to north and west to east. Major grass species in the more typical development of the type, other than rough fescue, include timber oatgrass (*Danthonia intermedia*), Parry's oatgrass (*D. parryi*), spike oat (*Helictotrichon hookeri*), slender wheatgrass (*Agropyron caninum* subsp. *majus*), bluebunch wheatgrass (*A. spicatum*), thickspike wheatgrass (*A. dasystachyum*), western wheatgrass (*Agropyron smithii*), Canada wildrye (*Elymus canadensis*), needlegrass (*Stipa curtiseta*), other needlegrasses (*S. columbiana* and *S. richardsoni*), Junegrass (*Koeleria pyramidata*) and bluejoint (*Calamagrostis canadensis*).

In some places a shorter understory is developed composed to such species as blue grama (*Bouteloua gracilis*), Kentucky bluegrass (*Poa pratensis*), mat muhly (*Muhlenbergia richardsonis*), and the sedges, needleleaf sedge (*Carex eleocharis*), and Penn sedge (*Carex pensylvanica*). A common and striking feature of the type in some sections is the development of a moderately dense to dense overstory of shrubby cinquefoil (*Potentilla fruticosa*) (Watts, 1960). In other sections the shrubby prairie wild rose (*Rosa arkansana*) is moderately abundant.

Forbs are common and for the most part moderately abundant. The club moss (*Selaginella densa*) is common in some portions of the type.

Geographic Distribution: The rough fescue grassland has been called the Submontane Mixed Prairie (Watts, 1960) and the Foothill Prairie (Kuchler, 1964) with primary references to the major area of its occurrence. As a Great Plains type, it is commonly associated with the dark soils fringing the Aspen Parkland and Boreal Forest zone in Alberta and Saskatchewan. Southward it extends along the Rocky Mountain foothills to southern Montana (Mueggler and Stewart, 1980). Eastward in Canada it extends as a narrow band intermingling with the aspen parkland approximately to Saskatoon, Sask. From there on east and south it continues in a fragmented and patchy occurrence with remnants as far south as northern North Dakota (Barker and Whitman, 1989). The type fringes most of the outliers of the Rocky Mountain system in the western Montana plains and has been described north of the Cypress Hills in southwestern Saskatchewan (Coupland and Brayshaw, 1953).

Over the foothills portion of its range the type could be expected to occur at elevations between 3,500 to 7,500 ft (1200-2500m). To the north and east, however, altitudes would be appreciably less than this with remnants occurring at 2,000 ft (700m) or less.

Ecological Relationships: Topography of the foothills area in which the type occurs is generally fairly steep and may be quite rough. However, best development of the type occurs on benches and long gradual slopes. To the north and east along the woodlands border the type occurs on rolling uplands with the soils developed primarily from glacial materials. Over the extent of the type average annual precipitation ranges from about 12 to 19 inches (30-48cm) with higher altitudes, lower temperatures, and lower evaporation compensating for major differences in precipitation (Looman, 1979; 1983). The freeze-free period ranges from about 80 to 120 days over most of range of the type. In the submontane portion of the type primary contact above is with lodgepole pine forest and the Wheatgrass-Grama-Needlegrass below. Eastward at lower altitudes it meets and mingles with the Aspen-Parkland bordering the Boreal Forest on the north and with Wheatgrass-Needlegrass Prairie on the south. On the Rocky Mountain outliers in the northern plains it is bordered by montane forest above and Wheatgrass-Grama-Needlegrass below.

Variants and Associated Species: With the development of the type in the foothills of southwestern Alberta taken as a standard, the vegetative composition varies considerably to the south and to the east. Southward, and toward the eastern fringes, bluebunch wheatgrass (*Agropyron spicatum*) and Idaho fescue (*Festuca idahoensis*) become more common in the cover (Garrison, et al., 1977).

Needle-and-thread (*Stipa comata*), Columbia and Richardson's needlegrasses (*Stipa columbiana* and *S. richardsoni*) also increase. The bluegrasses (*Poa* spp.) become more frequent. On the other hand, the shrubby cinquefoil (*Potentilla fruticosa*) decreases northward. The quaking aspen (*Populus tremuloides*) increases northward and eastward. In addition to shrubby cinquefoil, shrubs associated with the type include western snowberry (*Symphoricarpos occidentalis*), prairie wild rose (*Rosa arkansana*), willows (*Salix* spp.), and to a lesser extent silverberry (*Eleagnus commutata*). Fringed sage (*Artemisia frigida*) is common throughout the type.

Some of the more common forbs in the type include yarrow (*Achillea millefolium*) mouse-eared chickweed (*Cerastium arvense*), northern bedstraw (*Galium boreale*), pussytoes (*Antennaria* spp.), torch flower(*Geum triflorum*), white sage (*Artemisia ludoviciana*), goldenrods (*Solidago* spp.), pasque flower (*Anemone patens*), prairie vetches (*Vicia americana* var. *americana* and *V. americana* var. *minor*), and herbaceous Potentilla spp. In the more typical foothill development of the type such species as lupines (*Lupinus* spp.), tall larkspur (*Delphinium occidentale*), viscid cranesbill (*Geranium viscosissimum*) and arrowleaf balsamroot (*Balsamorhiza saggittata*) commonly occur.

William T. Barker and
Warren C. Whitman
North Dakota State University
Fargo, ND

CRESTED WHEATGRASS
SRM 614

Definition, Composition, and Structure: Crested wheatgrass, as a range cover type in the northern Great Plains, came into existence in the mid to late 1930's. At this time, and subsequently, extensive acreages of abandoned cropland were seeded to this grass. Many of these stands still exist, and numerous other stands have been established since then. Often the existing stands are managed essentially as rangelands.

Crested wheatgrass (*Agropyron desertorum, A. cristatum,* and related *taxa*) is a cool-season, perennial bunchgrass of medium height which produces an abundance of basal leaves and a fair amount of stem leaves. Numerous stems are produced under favorable conditions, with these stems tending to be somewhat tough and wiry at maturity.The dense, comb-like heads give the grass its common name. The grass was introduced from Russia, with the primary introduction being made by the U.S. Dept. of Agriculture in 1906 (Rogler and Lorenz, 1983).

Its persistence and longevity along with its high degree of drought and cold resistance have made it possible for this grass to maintain itself in recognizable stands over periods of many years. Grassland forbs and shrubs can and do invade stands of crested wheatgrass, but in most cases the grass maintains its primary dominance of the stand.

Geographic Distribution: The greatest concentration of crested wheatgrass stands presently existing is primarily in the northern Great Plains, especially in western North and South Dakota, eastern Montana and Wyoming, and the prairies of southern Saskatchewan and southeastern Alberta. Estimates indicate in excess of 12 million acres (4.8 million ha) of the grass in the United States (Rogler and Lorenz, 1983) and over 2 1/2 million acres (1 million ha) in the prairie provinces of Canada (Smoliak and Dormaar, 1985). The grass has been seeded successfully in regions outside the northern plains, and is widely used throughout the arid and semi-arid regions of the west (Lorenz, 1986).

The size of existing stands of crested wheatgrass in the northern plains is extremely variable. For the most part, however, they do not stretch uninterruptedly for any great distance. Since most of the early seedings were on abandoned cropland, stands were seldom more than a section (640 acres) in extent, and for the most part were appreciably less than this. In some cases, however, existing fences around cropland acres were removed prior to seeding, and here some seedings could involve portions or all of several sections.

Ecological Relationships: Crested wheatgrass is primarily a grass of dryland situations and relatively cool temperatures. It has been grown most successfully in the northern plains where conditions are essentially similar in many ways to conditions in its native home - the Russian and Siberian steppe country. It has done well in areas of 9-15 inches (23-38cm) of annual precipitation, and has survived cold temperature extremes of over -60^{o} F (-51^{o} C), which occasionally characterize winters in the northern Great Plains (Rogler and Lorenz, 1983).

While crested wheatgrass does well on a variety of soil types, it does best on soils of medium texture, from sandy loams to clay loams. It does not do well on loose, sandy soils and its growth is somewhat restricted on heavy days. It is not well-adapted to moist situations, where it is at a competitive disadvantage with some other commonly seeded grasses.

Desirable seed characteristics have been of primary importance in making crested wheatgrass so successful in the northern plains. The seed is relatively good-sized and easy to harvest and process. The processed seed feeds well through a drill, so that seeding rate and depth can be controlled to a reasonable degree. Seedlings are vigorous and exceptionally hardy, withstanding heat and dry conditions to a high degree during the establishment year. The fact that harvesting and seeding the grass could be done with available agricultural machinery had much to do with the widespread use of the grass following the drought of the 1930's.

Variants and Associated Species: The original increase of crested wheatgrass was designated as *Agropyron cristatum*. However, it was apparent to scientific workers that the introduced material was quite mixed. A taller, coarser form of the grass was increased and distributed in the United States where it was known as "Standard" crested wheatgrass. In Canada a somewhat shorter and leafier type with broader heads was distributed. This latter was know as "Fairway" crested wheatgrass. It was not until 1950 that the two types were grouped as distinct species (Swallen and Rogler, 1950). The Standard Type was designated *Agropyron desertorum*, while the Fairway Type was classed as *A. cristatum*.

Improved varieties were released in Canada in 1953 and in the U.S. in 1954. The Canadian release was designated "Summit" and the U.S. release "Nordan" (Rogler and Lorenz, 1983). Since then several additional named varieties have become available. It is apparent that most of the seeding took place on abandoned or converted cropland in the 1930's and 1940's involved the "Standard" and the "Fairway" Types. Both seem to share essential combinations of desirable characteristics.

The principal justification for including crested wheatgrass as a vegetation type in the Northern Great Plains lies in the continued existence of stands of this grass which were seeded back in the early period of its use. Rogler and Lorenz (1983) state that the oldest known pasture seeding of crested wheatgrass was made on the Mandan, N.D. ARS Station in 1932. It has been grazed every year since 1933 and its grazing use is being continued as part of scheduled long-term grazing trials. Continuously used stands of this grass approximately 50 years old have been reported from the Canadian prairie area (Smoliak and Dormaar, 1985). On the basis of present evidence it seems likely that many of these early-seeded stands may persist indefinitely.

Warren C. Whitman and
William T. Barker
North Dakota State University
Fargo, ND

WHEATGRASS - SALTGRASS - GRAMA SRM 615

Definition, Composition, and Structure: This type is essentially the vegetation found on upland saline-alkali soils throughout the Northern Great Plains. A number of grass species are of importance throughout the type, but composition is variable in different parts of the plains. The distinguishing feature of the type, however, is that inland saltgrass (*Distichlis spicata* var. *stricta*) is a component of the cover, though sometimes minor, throughout its range.

The type is a mixture of midgrasses and shortgrasses with the principal species of the midgrass component being western and thickspike wheatgrasses (*Agropyron smithii* and *A. dasystachyum*), alkali sacaton (*Sporobolus airoides*) (west and south), inland saltgrass, green needlegrass (*Stipa viridula*), bottlebrush squirreltail (*Sitanion hystrix*), basin wildrye (*Elymus cinerus*), Junegrass (*Koeleria pyramidata*), and tumblegrass (*Schedonnardus paniculatus*).

The principal shortgrasses in the cover are blue grama (*Bouteloua gracilis*), Sandberg bluegrass (*Poa sandbergii*), and buffalograss (*Buchloe dactyloides*). Needleleaf sedge (*Carex eleocharis*), threadleaf sedge (*C. filifolia*), and penn sedge (*C. pensylvanica*) are common and frequently abundant associates.

In some areas shrubs are an important part of the vegetation. Major species include big sagebrush (*Artemisia tridentata*), dwarf sagebrush (*A. cana*), saltbush (*Atriplex nuttallii*), shadscale (*A. confertifolia*), rabbitbrush (*Chrysothamnus* spp.), and greasewood (*Sarcobatus vermiculatus*).

Common forbs in the type include such species as red false globemallow (*Sphaeralcea coccinea*), poverty weed (*Iva axillaris*), wild buckwheat (*Eriogonum pauciflorum* var. *pauciflorum*), white aster (*Aster ericoides*), wild onion (*Allium textile*), silverleaf scurf-pea (*Psoralea argophylla*), curly-top gumweed (*Grindelia squarrosa*), little prickly pear (*Opuntia fragilis*) and plains prickly pear (*O. polyacantha*). A number of annuals are abundant in years of favorable precipitation.

Geographic Distribution: The Wheatgrass-Grama-Saltgrass type occurs throughout the extent of the Northern Great Plains from Nebraska into Canada with special concentrations in western North Dakota and South Dakota and eastern Montana, Wyoming, and Colorado. For the most part it occurs as relatively small fragments from a few acres to several hundred acres in a single piece, although there are areas, as in western North Dakota, where thousands of acres may be involved. Taken in the aggregate, the type can be found on hundreds of thousands of acres throughout the northern plains. Since the type is associated with a specific set of soil conditions related to salt concentrations, its distribution is commonly as a limited inclusion in the broader regional grassland types of the area.

Ecological Relationships: The soils on which this vegetation type occurs are soils with natric properties (Natriborolls) formerly described as the solonetz complex. Kellogg (1934) originally outlined the nature of soil development on these areas. Two features especially distinguish this soil complex. These are: (1) the existence of a dense columnar structure forming the B2 horizon and (2) the presence of characteristic "slickspots" or "panspots" which usually are very sparsely vegetated (Hanson and Whitman, 1937; McGinnies, Osborn, and Berg, 1976). The slickspots actually are shallow pits from a few inches to as much as a foot deep, generally varying in area from a few square feet to over 100 square feet.

On these spots the A horizon has been eroded away exposing the tops of the columns in the dense, impervious B2 horizon.

The result of this specific set of soil conditions is the development of several microsites, of which the three most common are the slickspot-itself, the edges and areas close to the slickspot, and raised areas with varying degrees of A horizon development. Generally the upper soil layers are relatively fine-textured, and the saline-alkali complex is most often, though not always, associated with clayey soils. Vegetation on these sites is extremely variable, since soil characteristics and sodium concentrations over any given area are extremely variable.

The slickspot feature of the type seldom occupies more than 50 percent of the area of any given stand. Vegetation on these areas, if present, usually consists of a sparse scattered stand of the wheatgrasses, saltgrass, sandberg bluegrass, and a few annual and perennial forbs. On the edges of the slickspots, blue grama, alkali sacaton, saltgrass, in some cases buffalo grass, wheatgrasses, and salt-tolerant shrubs are frequent. On the more level and somewhat raised areas between slickspots, blue grama, wheatgrasses, inland saltgrass, green needlegrass, needle-and-thread, Junegrass, often alkali sacaton, and the sedges are abundant. Big sagebrush, dwarf sagebrush, and salt-tolerant shrubs become more frequent.

Variants and Associated Species: Not only is the vegetation on any one site of this type variable, but there is considerable variation in the composition of the vegetation at different parts of the northern plains. The most obvious difference is in the presence of alkali sacaton. This species does not occur in North Dakota, but Ross and Hunter (1976) report it as a major component of the type in Montana,and McGinnies, Osborn, and Bert (1976) find it a major species of the type in Colorado. Buffalo grass is almost a characterizing species of the type in North Dakota, but again, it seems to be relatively unimportant in the type elsewhere. A forb, little prickly pear (*Opuntia fragilis*), often occurs in the type in North Dakota, common even on the slickspots, but it seems to be scarce elsewhere.

Such grass species as squirreltail (*Sitanion hystrix*) and basin wildrye, are common in the type west and south, but again are not part of the type in North Dakota.

In addition to the characteristic perennial forbs associated with the type, the annual forbs commonly found on the type are of interest. Russian thistle (*Salsola iberica*) and kochia (*Kochia scoparia*) are frequently abundant, though usually of small stature. The small prairie plantains, (*Plantago patagonica* and *P. elongata*) are sometimes common, even on the surface of the slickspot. Lambsquarters (*Chenopodium leptophyllum*), peppergrass (*Lepidium densiflorum*), and the knotweeds (*Polygonum aviculare* and *P. achoreum*) are often present.

Inland saltgrass also is usually a major species in wet saline-alkali situations. Under these conditions, it is often associated with such species as alkali grass (*Puccinellia nuttalliana*), foxtail barley (*Hordeum jubatum*), and alkali cordgrass (*Spartina gracilis*). In some cases portions of this wetland type may be associated with the Wheatgrass-Saltgrass-Grama type.

Warren C. Whitman and
William T. Barker
North Dakota State University
Fargo, ND

Rangeland Cover Types of the SOUTHERN GREAT PLAINS REGION

INTRODUCTION SRM 700

The Southern Great Plains includes Texas, Oklahoma, and portions of New Mexico. The Southern Great Plains is a diverse area due to soils, climate, and geographic location. This region ranges in elevation from sea level along the Gulf of Mexico, to over 6,000 ft (2000m). in New Mexico and to 8,751 ft (2917m) at Guadelupe Peak in far-west Texas. The growing season extends from an average of 330 days per year in the Lower Rio Grande Valley of Texas to less than 180 days per year in northern New Mexico and the northwestern Panhandle of Texas. Generally, the rainfall is quite variable, ranging from about 8 inches (20cm) per year in far west Texas to more than 40 inches (100cm) per year along the Gulf Coast.

Geographically, the Southern Great Plains includes eastern New Mexico from Raton to Carlsbad; the plains east of the Sangre de Cristo, Capitan, and Sacramento Mountains. Also included is Oklahoma with the exception of some of the Post Oak and Blackjack Oak forests in the eastern part of the state where very little, if any, grazing lands occur. Texas is included with the exception of the Chihuahuan Desert of the Trans Pecos region and the Pineywoods of east Texas. Grasslands in the Trans Pecos region, however, are included.

Plants generally follow Gould and Box (1956), Correll and Johnston (1970), and Jones (1982).

Ronald E. Sosebee
Texas Tech University
Lubbock, TX

ALKALI SACATON-TOBOSAGRASS SRM 701

Definition, Composition, and Structure: This cover type has the aspect of a short and mid-grass prairie. It is composed of a mixture of warm and cool season perennial grasses. There are very few shrubs and half-shrubs throughout the area. Annual forbs fluctuate considerably from year to year with seasonal variation in amount and distribution of rainfall. This type is dominated by alkali sacaton (*Sporobolus airoides*) and tobosagrass (*Hilaria mutica*). Dominant shrubs include winterfat (*Ceratoides lanata*) and four-wing saltbush (*Atriplex canescens*).

Geographic Distribution: This type is best represented in the Pecos-Canadian Plains and valleys of east central New Mexico. It occurs on level to gently sloping plains and alluvial fans. Slopes can range to 15%, but are generally less than 5%. Elevations range from 3,800 to 6,300 ft (1300-2100m).

Ecological Relationships: Climate of the area is semiarid continental. The annual average precipitation ranges from 13 to 16 inches (32-40cm). Variations of 5 inches (12.5cm), more or less, are common. Approximately 75% of the precipitation falls from April to October. Temperatures are characterized by distinct seasonal changes and large annual and diurnal temperature changes. The average annual temperature is 50^{o} to 58^{o} F (10^{o} to 15^{o} C) with extremes of -30^{o} F (-36^{o} C) in the winter to 108^{o} F (42^{o} C) in the summer. Strong winds blow from February to May from the southwest, which rapidly dry out the soil during a critical period for initiation of plant growth.

The soils are well-drained and moderately deep to shallow. They may be over a petrocalcic layer or over limestone bedrock. Surface textures are typically clay loams to fine sandy loams. The effective rooting depth is generally less than 40 inches (100cm).

This cover type provides a wildlife habitat which supports a resident animal community characterized by pronghorn antelope, coyote, black-tailed jackrabbit, and scaled quail.

Variants and Associated Species: Many variations occur in this cover type. Variations are due to past and present management being applied to the land and the potential of the individual soils to produce a unique plant community. Associated grasses in this type include sand dropseed (*Sporobolus cryptandrus*), threeawns (*Aristida* spp.), blue grama (*Bouteloua gracilis*), and vine mesquite (*Panicum obtusum*). The most common shrubs associated with this type are skunkbush sumac (*Rhus trilobata*) and catclaw mimosa (*Mimosa biuncifera*). Broom snakeweed (*Gutierrezia sarothrae*) readily invades this cover type and can become completely dominant. Mesquite (*Prosopis glandulosa*) can also invade this cover type.

Pat Shaver
Roswell, NM

BLACK GRAMA-ALKALI SACATON
SRM 702

Definition, Composition, and Structure: This cover type has the aspect of a short grass prairie. It is composed of a mixture of warm and cool season perennial grasses. There are a large number of shrubs and half-shrubs throughout the area. Annual forbs fluctuate considerably from year to year with seasonal variation in amount and distribution of rainfall. This type is dominated by black grama (*Bouteloua eriopoda*) and alkali sacaton (*Sporobolus airoides*). Gyp grama (*B. breviseta*) and gyp dropseed (*S. nealleyi*) are also prevalent. Dominant shrubs include coldenia (*Coldenia* sp.), winterfat (*Ceratoides lanata*), Bigelow sagebrush (*Artemisia bigelovii*), and four-wing saltbush (*Atriplex canescens*).

Geographic Distribution: This type is best represented in the Pecos-Canadian Plains and valleys of east central New Mexico. It occurs on a complex landscape of flat to steep, unevenly sloping terrain. Drainage channels often dissect this type. Exposed outcrops of interbedded gypsum are common. Slopes can range to 35%, but are generally less than 10%. Elevations range from 3,800 to 6,300 ft (1300 to 2100m).

Ecological Relationships: Climate of the area is semi-arid continental. The annual average precipitation ranges from 13 to 16 inches (32-40cm). Variations of 5 inches (12cm), more or less, are common. Approximately 75% of the precipitation falls from April to October. Temperatures are characterized by distinct seasonal changes and large annual and diurnal temperature changes. The average annual temperature is 50° to 58° F (10°-15° C) with extremes of -30° F (-36° C) in the winter to 108° F (42° C) in the summer. Strong winds blow from February to May from the southwest, which rapidly dry out the soil during a critical period for initiation of plant growth.

The soils are well-drained and shallow to very shallow over gypsum. Surface textures are typically loams and silt loams. The effective rooting depth is generally less than 10 inches.

This cover type provides a wildlife habitat which supports a resident animal community characterized by coyote, spotted skunk, black-tailed jackrabbit, and scaled quail.

Variants and Associated Species: Many variations occur in this cover type. Variations are due to past and present management being applied to the land and the potential of the individual soils to produce a unique plant community. Associated grasses in this type include sand dropseed (*Sporobolus cryptandrus*), threeawns (*Aristida* sp.), blue grama (*Bouteloua gracilis*), sideoats grama (*B. curti-pendulua*), and hairy grama (*B. hirsuta*). The most common shrubs associated with this type are skunkbush sumac (*Rhus trilobata*) and morman tea (*Ephedra* sp.).

Pat Shaver
Roswell, NM

BLACK GRAMA-SIDEOATS GRAMA
SRM 703

Definition, Composition, and Structure: This cover type has the aspect of a short grass prairie. It is composed largely of short and mid-grasses with lesser amounts of perennial forbs and a few scattered shrubs and half-shrubs. Annual forbs fluctuate considerably from year to year with seasonal variation in amount and distribution of rainfall. This type is dominated by black grama (*Bouteloua eriopoda*) and sideoats grama (*B. curtipendula*). Blue grama (*B. gracilis*) is also very common.

Geographic Distribution: This type is best represented on the southern extension of the High Plains of eastern New Mexico. It occurs on level to gently sloping plains. It usually occurs on the convex position of low ridges between areas of deep soils. Slopes can range to 9%, but are generally less than 5%. Elevations range from 3,450 to 4,275 ft (1150-1425m).

Ecological Relationships: Climate of the area is semi-arid continental. The annual average precipitation ranges from 14 to 18 inches (35-45cm). Variations of 5 inches (12.5cm), more or less, are common. Approximately 85% of the precipitation occurs April to October. Temperatures are characterized by distinct seasonal changes and large annual and diurnal temperature changes. Strong winds blow from February to May from the southwest that rapidly dry out the soil during a critical period for initiation of plant growth. The soils are well-drained and shallow over petrocalcic layers. Surface textures are typically loams to sandy loams. They may also have gravels in the surface or throughout the soil. The effective rooting depth is 6 to 20 inches (15-50cm).

This type provides a wildlife habitat which supports a resident animal community characterized by pronghorn antelope, coyote, black-tailed jackrabbit, and scaled quail.

Variants and Associated Species: Many variations occur in this cover type. Variations are due to past and present management being applied to the land and the potential of the individual soils to produce a unique plant community. Associated grasses in this type include buffalograss (*Buchloe dactyloides*), plains bristlegrass (*Setaria macrostachya*), sand dropseed (*Sporobolus cryptandrus*), threeawns (*Aristida* sp.), and tridens (*Tridens* sp.). New Mexico feathergrass (*Stipa neomexicana*) can be found in areas that have received good management for several years. The most common shrub is small soapweed (*Yucca glauca*). Other shrubs include feather dalea (*Dalea formosa*), four-wing saltbush (*Atriplex canescens*), winterfat (*Ceratoides lanata*), and broom snakeweed (*Gutierrezia sarothrae*). Mesquite (*Prosopis glandulosa*) can be completely dominant when

poor management has been applied for several years or the weather patterns favor its invasion.

Herman B. Garcia
Tucumcari, NM

BLUE GRAMA-WESTERN WHEATGRASS SRM 704

Definition, Composition, and Structure: This cover type has the aspect of mixed short and mid-grasses with an occasional woody species. It is dominated by blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), galleta (*Hilaria jamesii*), and vine mesquite (*Panicum obtusum*). Buffalograss (*Buchloe dactyloides*) and sideoats grama (*B. curtipendula*) are common. Shrubs which occur in the type include fringed sagewort (*Artemisia ludoviciana*) and four-wing saltbush (*Atriplex canescens*). Cool season grasses and forbs are also important com-ponents of this cover type.

Geographic Distribution: This type is best represented on the northern end of the High Plains in northeastern New Mexico and the Texas Panhandle north of the Canadian River. It also occurs in the southwest portion of Oklahoma. This cover type occurs on level to gently sloping upland plains and drainages. Slopes can range from 0 to 9%, but are generally less than 4%. Elevation ranges from 3,300 to 4,900 ft (1100-1630m).

Ecological Relationships: Climate of the area is semiarid continental. The annual average precipitation ranges from 23 to 25 inches (48-63cm). Approximately 75% of the moisture occurs during May to October. Winters average about 20 inches (50cm) of snow, which may remain for several days and occasionally result in blizzard conditions and heavy drifting. Summers are generally mild.

The soils are deep to moderately deep and well-drained. Surface textures are typically silty clay loam, clay loam, and loam. The effective rooting depth is 40 to 60 inches (100-150cm).

This cover type provides a wildlife habitat which supports pronghorn antelope, black-tailed jackrabbit, badger, and coyote.

Variants and Associated Species: Many variants occur in this type ranging from blue grama-western wheatgrass to blue grama-galleta codominant communities. Variations are due to past and present management and to the potential of the individual soils to produce a unique plant community. Associated grasses include bottlebrush squirreltail (*Sitanion hystrix*), sideoats grama, and mat muhly (*Muhlenbergia richardsonis*). Shrubs and half-shrubs may include winterfat (*Ceratoides lanata*) which will increase under good management, broom snakeweed (*Gutierrezia sarothrae*) and threadleaf goundsel (*Senecio longilobus*) which will increase under poor management coupled with good winter and spring moisture. Important forbs include prairie coneflower (*Ratibida columnifera*), annual sunflower (*Helianthus annus*), and scurfpea (*Psoralea tenuiflora*).

Herman B. Garcia
Tucumcari, NM

BLUE GRAMA-GALLETA SRM 705

Definition, Composition, and Structure: This cover type has the aspect of a short grass prairie. It is composed largely of short and mid-grasses with lesser amounts of perennial forbs and a few scattered shrubs and halfshrubs. Annual forbs fluctuate considerably from year to year with seasonal variation in amount and distribution of rainfall. This type is dominated by blue grama (*Bouteloua gracilis*) and galleta (*Hilaria jamesii*). Black grama (*B. eriopoda*), sideoats grama (*B. curtipendula*), alkali sacaton (*Sporobolus airoides*), and four-wing saltbush (*Atriplex canescens*) are very common.

Geographic Distribution: This type is best represented in the Pecos-Canadian Plains and valleys of east central New Mexico. It occurs on level to gently sloping plains and alluvial fans. Slopes can range to 15%, but are generally less than 5%. Elevations range from 3,800 to 6,300 ft (1300-2100m).

Ecological Relationships: Climate of the area is semiarid continental. The annual average precipitation ranges from 13 to 16 inches (32-40cm). Variations of 5 inches (12.5cm), more or less are common. Approximately 75% of the precipitation falls from April to October. Temperatures are characterized by distinct seasonal changes and large annual and diurnal temperature changes. The average annual temperature is 50^{o} to 58^{o} F (10^{o} to 15^{o} C) with extremes of -30^{o} F (-36^{o} C) in the winter to 108^{o} F (42^{o} C) in the summer. Strong winds blow from February to May from the southwest which rapidly dry out the soil during a critical period for initiation of plant growth.

The soils are well-drained and deep to moderately deep. Surface textures are typically clay loams to fine sandy loams. The effective rooting depth varies from 40 to 60 inches (100-150cm).

This type provides a wildlife habitat which supports a resident animal community characterized by pronghorn antelope, coyote, black-tailed jackrabbit, and scaled quail.

Variants and Associated Species: Many variations occur in this type. Variations are due to past and present management being applied to the land and the potential of the individual soils to produce a unique plant community. Associated grasses in this type include buffalograss (*Buchloe dactyloides*), plains bristlegrass (*Setaria macrostachya*), sand dropseed (*Sporobolus cryptandrus*), threeawns (*Aristida* sp.), tobosagrass (*Hilaria mutica*), and

western wheatgrass (*Agropyron smithii*). New Mexico feathergrass (*Stipa neomexicana*) can be found in areas that have received good management for several years. Common shrubs associated with this type are winterfat (*Ceratoides lanata*) and broom snakeweed (*Gutierrezia sarothrae*). Mesquite (*Prosopis glandulosa*) can be completely dominant when poor management has been applied for several years or the weather patterns favor its invasion.

Pat Shaver
Roswell, NM

BLUE GRAMA-SIDEOATS GRAMA SRM 706

Definition, Composition, and Structure: This cover type has the aspect of a mixed mid- and short grass prairie. It is dominated by blue grama (*Bouteloua gracilis*) and sideoats grama (*B. curtipendula*). Black grama (*B. eriopoda*) and buffalograss (*Buchloe dactyloides*) are common. Shrubs and half-shrubs are inconspicuous and widely scattered. Forb production is variable from year to year and season to season due to variations in amount and distribution of rainfall.

*Geographic Distribution: Th*is type is best represented on the southern end of the High Plains in southeast New Mexico. This type occurs on nearly level to gently sloping upland plains, footslopes of low ridges, and valley plains. It may occur on both convex and concave or slightly depressed positions in the landscape. Slopes can range to 10%, but are typically less than 5%. Elevations range from 3,450 to 4,300 ft (1150-1430m).

*Ecological Relationships: Cli*mate of the area is semi-arid continental. The annual average precipitation ranges from 14 to 16 inches (35-40cm). Variations of 5 inches (12.5cm), more or less, are common. Approximately 85% of the precipitation falls from April to October. Temperatures are characterized by distinct seasonal changes and large annual and diurnal changes. Strong winds blow from February to May from the southwest that rapidly dry out the soil during a critical period for initiation of plant growth.

The soils are deep and well-drained. Surface textures are typically loams and clay loams. The effective rooting depth is 40 to 60 inches (100-150cm).

This cover type provides a wildlife habitat which supports a resident animal community characterized by prong-horn antelope, coyote, black-tailed jackrabbit, and scaled quail.

Variants and Associated Species: Many variations occur in this type. Variations are due to past and present management being applied to the land and the potential of the individual soils to produce a unique plant community. Associated grasses in this type include hairy grama (*Bouteloua hirsuta*), little bluestem (*Schizachyrium scoparium*), vine mesquite (*Panicum obtusum*), and alkali sacaton (*Sporobolus airoides*). Shrubs are inconspicuous except in areas where mesquite (*Prosopis glandulosa*) has invaded the site. Four-wing saltbush (*Atriplex canescens*) and winterfat (*Ceratoides lanata*) occur on sites that received good management for several years. Buffalograss can become a codominant with blue grama in this type.

Herman B. Garcia
Tucumcari, NM

BLUE GRAMA-SIDEOATS GRAMA-BLACK GRAMA SRM 707

Definition, Composition, and Structure: This cover type has the aspect of a grassland dominated by warm season short and mid-grasses. It is dominated by blue grama (*Bouteloua gracilis*), sideoats grama (*B. curtipendula*), and hairy grama (*B. hirsuta*). Perennial and annual forbs are important components of this type. Shrubs and half-shrubs comprise only a minor portion of this type.

Geographic Distribution: This type occurs on nearly level to undulating plains. It is best represented by the eastern-most drainage of the Canadian River in New Mexico and the western-half drainage of the Canadian River in the Panhandle of Texas. Slopes range from 0 to 9%, but can occasionally be as high as 35% on gravelly convex sites. Elevations range from 3,250 to 4,600 ft (1080-1530m).

Ecological Relationships: Climate of the area is semi-arid continental. The annual average precipitation ranges from 20 to 25 inches (50-63cm). Approximately 78% of the precipitation falls during May to October. Most of the summer precipitation falls in the form of brief and intense thundershowers. Temperatures are characterized by a distinct seasonal change and large annual and diurnal temperature ranges. Summers vary from 59° F (15° C) at night to maximum daytime temperatures averaging over 86° F (30° C). Winters are mild, sunny, and dry.

The soils are moderately deep and well-drained. Surface textures are typically loam and sandy loam. The effective rooting depth varies from about 3 to 9.5 inches (7.5-24cm).

This type provides a wildlife habitat which supports a resident animal community that is characterized by prong-horn antelope, black-tailed jackrabbit, coyote, badger, scaled quail, and roadrunner.

Variants and Associated Species: Many variants occur in this type ranging from shallow sand over caliche to deep sands and sand hills. The shallow sands generally occur near escarpment foothills with black grama (*Bouteloua eriopoda*) and little bluestem (*Schizachyrium scoparium*) increasing in composition. The deep sands and sand hills occur on the eastern side of the drainage associated with sandy plains sites and Canadian River escarpment.

Typically, the vegetation is sand bluestem (*Andropogon gerardii* var. *paucipilus*), little bluestem, and sand sagebrush (*Artemisia filifolia*). In addition to sand sagebrush, other shrubs and half-shrubs which occur include broom snakeweed (*Gutierrezia sarothrae*), mesquite (*Prosopois glandulosa*), yucca (*Yucca glauca*), and winter-fat (*Ceratoides lanata*). Cholla (*Opuntia imbricata*) mes-quite, and sand sagebrush can become codominant species when poor management is applied for several years or the climatic conditions favor their invasion.

Herman B. Garcia
Tucumcari, NM

BLUESTEM-DROPSEED
SRM 708

Definition, Composition, and Structure: This cover type has the aspect of a mid-grass prairie. It is composed of a mixture of cool and warm season perennial mid- and short grasses. There are a large number of shrubs in this type. Annual forbs fluctuate considerably from year to year with seasonal variation in amount and distribution of rainfall. This type is dominated by little bluestem (*Schizachyrium scoparium*) and giant dropseed (*Sporobolus giganteus*). Grasses such as sand bluestem (*Andropogon gerardii* var. *paucipilus*), spike dropseed (*S. contractus*), and sand drop-seed (*S. crytandrus*) are also abundant. Dominant shrubs include sand shinnery oak (*Quercus havardii*) and sand sagebrush (*Artemisia filifolia*).

Geographic Distribution: This is best represented in the Pecos-Canadian Plains and valleys of east, central New Mexico. It occurs on level to gently sloping plains and allu-vial fans. Slopes can range to 15%, but are generally less than 5%. Elevations range from 3,800 to 6,300 ft (1300-2100m).

Ecological Relationships: Climate of the area is semiarid continental. The annual average precipitation ranges from 13 to 16 inches (32-40cm). Variations of 5 inches (12.5cm), more or less, are common. Approximately 75% of the precipitation falls from April to October. Temperatures are characterized by distinct seasonal changes and large annual and diurnal temperature changes. The annual average tem-perature is 50^{o} to 58^{o} F (10^{o}-15^{o} C) with extremes of -30^{o} F (-36^{o} C) in the winter to 108^{o} F (42^{o} C) in the summer. Strong winds blow from February to May from the south-west which rapidly dry out the soil during a critical period for initiation of plant growth.

The soils are well-drained and deep to moderately deep. Surface textures are typically clay loams to fine sandy loams. The effective rooting depth varies from 40 to 60 inches (100-150cm).

This type provides a wildlife habitat which supports a res-ident animal community characterized by pronghorn antelope, coyote, black- tailed jackrabbit, and scaled quail.

Variants and Associated Species: Many variations occur in this type. Variations are due to past and present manage-ment being applied to the land and the potential of associat-ed grasses in this type include hairy grama (*Bouteloua hir-suta*), sideoats grama (*B. curtipendula*), New Mexico feathergrass (*Stipa neomexicana*), and black grama (*B. eri-opoda*). Shrubs that are common on this type include four-wing saltbush (*Atriplex canescens*), various species of yucca (*Yucca* sp.), and rabbitbrush (*Chrysothamnus* sp.). Mesquite (*Prosopis glandulosa*) can occur on this type and at times dominate the aspect. Broom snakeweed (*Guti-errezia sarothrae*) can also occur and become an aspect dominant.

Pat Shaver
Roswell, NM

BLUESTEM-GRAMA
SRM 709

Definition, Composition, and Structure: This cover type is an open grassland with a tall grass to mid-grass aspect. Little bluestem (*Schizachyrium scoparium*), big bluestem (*Andropogon gerardii*), or sand bluestem (*A. gerardii var. paucipilus*) dominate the vegetation when the site is near climax. Sideoats grama (*Bouteloua curtipendula*) and blue grama (*B. gracilis*) are major subdominants and often become dominant in lower seral stages. Additional impor-tant plants include switchgrass (*Panicum virgatum*) and Indiangrass (*Sorghastrum nutans*) in high seral stages; and buffalograss (*Buchloe dactyloides*), silver bluestem (*Bothriochloa saccharoides*), threeawns (*Aristida* sp.), annual bromegrasses (*Bromus* sp.), and western ragweed (*Ambrosia psilostachya*) in lower seral stages. Annual herbaceous plant production ranges from 2,200 to 5,200 lb/acre (2400-5700kg/ha) depending on weather conditions.

Geographic Distribution: The bluestem-grama cover type is found throughout the southwestern quadrant of Oklahoma. Soils are deep upland types that are loamy throughout the profile. Water infiltration and percolation are moderate and inherent fertility is high. Topography varies from nearly level to steeply rolling. Annual average precipi-tation is 23.5 to 30 inches (59-75cm). About 75% of the precipitation falls between April and October, but July and August are generally droughty with unfavorable growing conditions. Snowfall measures 1 inch or more 4 to 6 days per year. Wind movement is relatively high with southerly winds in spring/summer and north-northwest winds in fall/winter.

Ecological Relationships: Approximately 60% of the bluestem- grama cover type has been converted to cropland. Cropland conversion has been concentrated on areas with-less than 3% slope. Major crops include wheat, cotton,

and sorghum.

Less than 25% of the current vegetation is near a climax state. Fragmentation by cropland and roads has resulted in many small units, 160 acres or less, which are more difficult to manage than larger unbroken tracts. The majority of this cover type is currently dominated by sideoats grama, blue grama, little bluestem, and silver bluestem. Woody vegetation was not historically prominent, but eastern redcedar (*Juniperus virginiana*) has increased dramatically since 1960. Herbaceous production has been seriously reduced in many areas due to increases of this evergreen tree.

Prescribed burning is an effective management tool in the bluestem-grama cover type. It stimulates the big bluestem, switchgrass, and Indiangrass while reducing annual forb populations. Prescribed burning is the most efficient tool available for the management of eastern redcedar.

Variants and Associated Species: Big bluestem is more prominent on loamy soils, while sand bluestem is more prominent on sandy soils in this region. The two species are very similar and appear to completely intergrade. Sand bluestem tends to have longer, more vigorous rhizomes than big bluestem, but for practical management purposes, these grasses can be considered a single species.

As moisture relations improve, big and sand bluestem, switchgrass, and Indiangrass become more prominent in the vegetation. Total herbaceous production also increases. This occurs when the soils become more sandy or are located in bottomland areas. On shallow loamy soils sideoats grama and little bluestem become dominant, and the tall grasses are not present. Mesquite (*Prosopis glandulosa*) invades the bluestem-grama type in the southern portion of this region.

Associated vegetation on clay soils consists of open stands of mesquite with an understory of sideoats grama and blue grama. Sandy soils support the same grassy vegetation as the bluestem-grama type with the addition of sand shinnery oak (*Quercus havardii*) and sand sagebrush (*Artemisia filifolia*).

Robert Gillen
Oklahoma State University
Stillwater, OK

BLUESTEM PRAIRIE
SRM 710

Definition, Composition, and Structure: The Bluestem Prairie (also known as the Osage Hills) is an extension of the Kansas Flint Hills. Dominant grasses of this tall grass prairie region are big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), Indiangrass (*Sorghastrum nutans*), and switchgrass (*Panicum virgatum*). These grasses may comprise greater than 60% of the vegetation on a typical site. Secondary grasses include tall dropseed (*Sporobolus asper*), sideoats grama (*Bouteloua curtipendula*), blue grama (*B. gracilis*), and buffalograss (*Buchloe dactyloides*). Although the area is dominated by warm season grasses, cool season species such as Scribner panicum (*Dichanthelium oligosanthes scribnerianum*), Canada wildrye (*Elymus canadensis*), and western wheatgrass (*Agropyron smithii*) are found on certain sites. Shrubs vary in abundance with the major species being smooth sumac (*Rhus glabra*), buckbrush (*Symphoricarpos orbiculatus*), leadplant (*Amorpha canescens*), and wild plum (*Prunus* sp.). Forbs include pitcher sage (*Salvia azurea var. grandiflora*), dotted gayfeather (*Liatris punctata*), heath aster (*Aster ericoides*), goldenrods (*Solidago* sp.), purple prairieclover (*Petalostemum pur-pureum*), slimflower scurfpea (*Psoralea tenuiflora*), and many others. Common weeds include western ragweed (*Ambrosia psilostachya*), annual broomweed (*Xantho-cephalum dracunculoides*), and ironweed (*Vernonia* sp.). Forage production is highly variable with the shallow soils annually producing less than 2,200 lb/acre (2400kg/ha) and the deeper, loamy soils yielding near 5,500 lb/acre (6000kg/ha).

Geographic Distribution: The Bluestem Prairie occupies 988,000 acres primarily in the northern half of Osage County and eastern Kay County, Oklahoma between 96 and 97 west longitude and 36 and 37 north latitude. Annual precipitation ranges from 32 to 35 inches (80-88cm) with two-thirds of the amount falling during the growing season (April to September). Mean annual temperature is about 61° F (16° C) with the lowest monthly average of 40° F (5° C) in January and the highest of 84° F (29° C) in July. Topography varies from nearly level uplands to sloping terrain (up to 25%) on and adjacent to escarpment areas. Elevation is generally between 690 and 1,300 ft (230-1230m).

Ecological Relationships: Soils of the region are very shallow to deep, nearly level to steep, loamy in texture, and formed over limestone and limy shales. The Sogn-Summit-Labette and Shidler-Summit-Foraker associations typify the region. These soils are all Mollisols and belong to the great soil groups Halpl and Argiustolls and Hapl and Agriudolls. Shallow soils such as the Sogn and Shidler series have low water-holding capacity and can be dominated by short and mid-grasses.

Vegetation of the Bluestem Prairie was undoubtedly influenced by the occurrence of fires and grazing by native herbivores, such as bison and deer. Today, trees in the area are generally confined to the lower slopes and along the streams and rivers. Prescribed burning and proper grazing of the prairie greatly reduces encroachment by shrubs and trees.

Variants and Associated Species: A number of plant communities dominated by tall grasses can be found in central and eastern Oklahoma. The crosstimbers are wooded areas on rolling to hilly sandstone extending from the Kansas line

to Texas. Post oak (*Quercus stellata*) and blackjack oak (*Quercus marilandica*) dominate, but open areas within this region are vegetated with tall grasses. The Cherokee Prairie in northeastern Oklahoma occurs between the Crosstimbers and the oak-hickory- pine (*Quercus-CaryeaPinus*) forests of the Ozark Highlands. The Grand Prairie region of south central Oklahoma has dark loamy and clayey soils that developed in marine clay and limestones under tall grasses. The Arbuckle Mountains occur in this region and are dominated by post and blackjack oak but have an understory of tall and mid-grasses. The Reddish Prairies occur throughout most of central Oklahoma. The area has smooth to rolling topography with clayey to loamy subsoils. Tall grasses tend to occur on the loamy sites but midgrasses such as little bluestem and sideoats grama dominate on the clay soils.

Walter H. Fick
Kansas State University

BLUESTEM-SACAHUISTA PRAIRIE SRM 711

Definition, Composition, and Structure: Although generally considered a grassland, the Bluestem-Sacahuista Prairie today is actually a shrub-grass complex. Mid-grasses and medium forbs dominate the grassland portions of this type. Dominant species include: little bluestem (*Schiza-chyrium scoparium*), seacoast bluestem (*S. scoparium var. littoralis*), and Gulf cordgrass (*Spartina spartinae*). Other grasses include: bushy bluestem (*Andropogon glomeratus*), splitbeard bluestem (*A. tenarius*), broomsedge bluestem (*A. virginicus*), purple threeawn (*Aristida purpurea*), Roemer threeawn (*A. roemeriana*), silver bluestem (*Bothriochloa saccharoides*), buffalograss (*Buchloe dactyloides*), saltgrass (*Distichlis spicata* var. *stricta*), Pan American balsamscale (*Elyonurus tripsacoides*), longtom (*Paspalum lividum*), brownseed paspalum (*P. plicatulum*), tall dropseed (*Sporobolus asper*), rattail smutgrass (*S. Poiretii*), Padre Island dropseed (*S. tharpii*), Texas wintergrass (*Stipa leucotricha*), and pink tridens (*Tridens congestus*). Grasslike species include: sedges (*Carex* sp.), spikerushes (*Eleocharis* sp.), fimbry (*Fimbristylis* sp.), and bulrush (*Scirpus* sp.). Forbs include: western ragweed (*Ambrosia psilostachya*), doveweed (*Croton* sp.), ponyfoot (*Dichondra micrantha*), annual buckwheat (*Eriogonum multiflorum*), sumpweed (*Iva annua*), Mexican hat (*Ratibida columnaris*), snoutbean (*Rhynchosis* sp.), and arrowhead (*Sagittaria* sp.).

Geographic Distribution: This once extensive prairie type occurs in a belt from 50 to 150 miles (80-240km) inland along the Gulf coastal plains of Texas and Louisiana to the mouth of the Mississippi River. Since these are highly productive agricultural soils, much of the area nearest the coast is now in cultivation to grain sorghum, corn, cotton, and rice. Typical prairies still occur near Goliad (*Goliad Prairie*), Victoria (*McFadden Prairie*), east of Tivoli, and south of Houston.

Ecological Relationships: The Bluestem-Sacahuista Prairie is still basically a grassland with woody shrubs of various densities covering almost all sites except on sandy soils. The area was described as an *Andropogon saccharoides-Stipa leucotricha* climax by Weaver and Clements (1938), a coastal grassland climax by Box (1961), and a tall grass prairie by Thomas (1975). Recently, the area has been described as upland prairies and woods by Diamond et al. (1987). Differences of opinion exist as to the relationship of woody shrubs and grassland in the past, some stating that there was considerable encroachment of woody vegetation into the native prairies during the late 1800's (Bray 1901, Allred and Mitchell 1955). Others suggest that woody shrubs have not appreciably increased their range, but that their density has increased in recent years as a result of reduction of fires and increased cattle grazing pressure (Box et al. 1978). Sacahuista (*Spartina spartinae*) occurs primarily along the flood plains of the several rivers that bisect the area and in low-lying areas near the coast (Scifres et al. 1980).

Climate of the region is subtropical to semiarid. The seasons are poorly differentiated. Mean annual rainfall ranges from 36 inches (90cm) in the eastern portion of the region to 24 inches (60cm) in the southwestern portion. Annual variation in rainfall can be great due to tropical storms and hurricanes. Relative humidity is high (around 50 to 60% in the afternoons) because of the proximity to the Gulf of Mexico. Summers are long and hot, while winters are short and mild. Average maximum temperatures in July vary from 91° to 98° F (32°-37° C) with average minimums ranging from 76° to 78° F (24° - 26° C). Winter temperatures fall below freezing only a few days per year; the average maximum in January ranges from 65° to 70° F (18° - 21° C).

This cover type occurs on a variety of soils from sands to clays, but the most typical stands are found on vertisols (Drawe et al. 1978, Daimond and Smeins 1984). Much of the region is flat and poorly drained. The soils are usually underlain with either calcareous clays with lentils of sand or thick beds of sand with lentils of gravel and interbedded with clay and silt.

Variants and Associated Species: This prairie type may be highly variable locally. Drawe et al. (1978) described 16 distinct plant communities in the Coastal Prairie near Corpus Christi. This variety occurs because of proximity to the Arkansas River. Woody species have invaded the original prairie to varying degrees to the extent that some woody stands have a ground cover of 40 to 60% (Drawe et al. 1978). Predominant woody invaders include: huisache (*Acacia farnesiana*), honey mesquite (*Prosopis glandulosa*), and McCartney rose (*Rosa bracteata*).

D. Lynn Drawe
Welder Wildlife Foundation
Sinton, TX

GALLETA-ALKALI SACATON
SRM 712

Definition, Composition, and Structure: This cover type has the aspect of a grassland dominated by mid- and tall grasses. It is dominated by alkali sacaton (*Sporobolus airoides*), galleta (*Hilaria jamesii*), and tobosagrass (*Hilaria mutica*). Blue grama (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*) are common. Shrubs and half-shrubs are sparsely scattered. Perennial and annual forbs are a minor component of the type.

Geographic Distribution: This type occurs on nearly level flood plains to undulating uplands and alluvial fans. This type is best represented by the most eastern drainage of the Canadian River in New Mexico and western-half drainage of the Canadian River in the Panhandle of Texas. Slopes can range from 0 to 5%, but are usually less than 3%. Elevations range from 3,200 to 4,600 ft (1100-1500m).

Ecological Relationships: Climate of the area is semiarid continental. The annual average precipitation ranges from 13-16 inches (32-40cm). Approximately 78% of the moisture usually falls during May to October. The soils are deep and well-drained. Surface texture is typically clay loam and clay. The effective rooting depth is 40 to 60 inches (100-150cm). This type provides a wildlife habitat which supports a resident animal community that is characterized by pronghorn antelope, black-tailed jackrabbit, coyote, thirteen-lined ground squirrel, banner-tailed kangaroo rat, woodhouse toad, and coach whip snake.

Variants and Associated Species: Many variants occur in this type ranging from essentially monocultures of galleta or alkali sacaton to mixed stands of galleta and buffalograss. Variations are due to past and present management being applied to the land and the potential of the individual soils to produce a unique plant community. Associated grasses in this type include sideoats grama (*Bouteloua curtipendula*), vine mesquite (*Panicum obtusum*), giant sacaton (*Sporobolus giganteus*), and western wheatgrass (*Agropyron smithii*). Shrubs and half-shrubs which occur include four-wing saltbush (*Atriplex canescens*) and winterfat (*Ceratoides lanata*). Mesquite (*Prosopis glandulosa*), cholla (*Opuntia imbricata*), pricklypear (*Opuntia macrorhiza*), and broom snakeweed (*Gutierrezia sarothrae*) can become codominant when poor management has been applied for several years or the climatic conditions favor their invasion.

Herman B. Garcia
Tucumcari, NM

GRAMA-MUHLY THREEAWN
SRM 713

Definition, Composition, and Structure: This cover type, along with others in the Trans Pecos area of far west Texas, has been included in a grama-tobosagrass (*Bouteloua-Hilaria mutica*) association. However, the area is codominated by several species of grama and forms a prairie. The grama-muhly-threeawns (*Bouteloua-Muhlenbergia-Aristida*) association has represented this cover type since prior to 1900. Dominant grasses include blue grama (*B. gracilis*), black grama (*B. eriopoda*), hairy grama (*B. hirsuta*), and sideoats grama (*B. curtipendula*). Blue grama grows in the deeper soils of the broad valleys, while the gravelly soils of the low, rolling terrain are dominated by black grama. Hairy grama and sideoats grama grow primarily in association with black grama. Cane bluestem (*Bothriochloa barbinoidis*) and silver bluestem (*B. saccharoides*) often grow in the valley bottoms with blue grama. Common muhlys include ring-grass (*Muhlenbergia torreyi*), sandy muhly (*M. arenicola*), and Wright's threeawn (*Aristida wrightii*) on the sandy soils. Associated species include several muhlys (depending upon soil) and Wright's threeawn. Tobosagrass is largely nonexistent, except in broad valley bottoms with deeper soil and run-in water. Trees and shrubs invade the tobosagrass "flats".

Geographic Distribution: The grama-muhly-threeawn cover type occurs throughout the Trans Pecos region of far west Texas. In Hudspeth County, it occurs along the Texas-New Mexico state line between the Hueco and Cornudas Mountains and in the central part of the county bordered on the northwest by the Hueco Mountains, on the southwest by the Finley and Sierra Blanco Mountains, and on the east by the Sierra Diablo Mountains. In Culberson County, it lies east of the Delaware and Apache Mountains in the central portion of the county. This cover type occurs throughout Jeff Davis County and extensively in the northern portions of Presidio and Brewster Counties.

The annual rainfall averages between 8.5 and 15 inches (26-38cm) and occurs primarily in July, August, and September. Soils representative of this cover type range from clay loams to sandy loams with some alkali soils and gravelly ridges.

Ecological Relationships: In areas where the stocking rate is excessive, such as around stock water, fluffgrass (*Erioneuron pulchellum*) and burrograss (*Sclerepogon brevifolius*) are found. Many of the gravelly bottomlands have sacahuista (*Nolina texana*) and Spanish dagger (*Yucca treculeana*). As grasses decrease, soaptree yucca (*Y. elata*) increase as well as catclaw mimosa (*Mimosa biuncifera*), whitebrush (*Aloysia gratissima*), and Apache plume (*Fallugia paradoxa*).

Variants and Associated Species: Tobosagrass is a vanishing coarse perennial that occupies broad valley bottoms with deeper soils. Creosotebush (*Larrea tridentata*),

tarbush (*Flourensia cernua*), and mesquite (*Prosopis glandulosa*) are creeping into the bottomlands and either have or soon will replace the tobosagrass. Bush muhly (*Muhlenbergia porterii*) can sometimes be found growing around the base of these woody plants. Arroya vegetation includes netleaf hackberry (*Celtis reticulata*), desert willow (*Chilopsis linearis*), whitebrush, Apache plume, black cherry (*Prunus serotina var. virens*), Texas kidneywood (*Eysenhardtia texana*), and occasionally Warnock mimosa (*Mimos warnockii*), and Mexican buckeye (*Ungnadia speciosa*).

Additional associated desert scrub vegetation includes ocotilla (*Fouquieria splendens*), pricklypear (*Opuntia* sp.), little-leaf sumac (*Rhus microphylla*), and allthorn (*Koeberlinia spinosa*).

Barton Warnock (retired)
Sul Ross State University
Alpine, TX

GRAMA-BLUESTEM
SRM 714

Definition, Composition, and Structure: This cover type has the aspect of a tall and mid-grass prairie. It is composed largely of tall and mid-perennial grasses. There are scattered shrubs in this type. Forbs can make up a large part of the aspect and composition during years of above average rainfall. This type is dominated by sand bluestem (*Andropogon gerardii* var. *paucipilus*), little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), needle-and-thread (*Stipa comata*), and black grama (*B. eriopoda*). The shrub and half-shrub component of the type is dominated by small soapweed (*Yucca glauca*) and winter fat (*Ceratoides lanata*).

Geographic Distribution: This type is best represented in the Pecos-Canadian Plains and valleys of east central New Mexico. It occurs on level to gently sloping plains and alluvial fans. Slopes can range to 15%, but are generally less than 5%. Elevations range from 3,800 to 6,300 ft (1300-2100m).

Ecological Relationships: Climate of the area is semiarid continental. The annual average precipitation ranges from 13 to 16 inches (32-40cm). Variations of 5 inches (12.5cm), more or less, are common. Approximately 75% of the precipitation falls from April to October. Temperatures are characterized by distinct seasonal changes and large annual and diurnal temperature changes. The average annual temperature is 50° to 58° F (10°-15° C) with extremes of -30° F (-36° C) in the winter to 108° F (42° C) in the summer. Strong winds blow from February to May from the southwest, which rapidly dry out the soil during a critical period for initiation of plant growth.

The soils are well-drained and deep to moderately deep. Surface textures are typically clay loams to fine sandy loams. The effective rooting depth varies from 40 to 60 inches (100-150cm).

This type provides a wildlife habitat which supports a resident animal community characterized by pronghorn antelope, coyote, black-tailed jackrabbit, and scaled quail.

Variants and Associated Species: Many variations occur in this type. Variations are due to past and present management being applied to the land and the potential of the individual soils to produce a unique plant community. Associated grasses in this type include Indiangrass (*Sorghastrum nutans*), blue grama (*Bouteloua gracilis*), threeawns (*Aristida* sp.), and dropseeds (*Sporobolus* spp.). Associated shrubs include skunkbush sumac (*Rhus trilobata*), four-wing saltbush (*Atriplex canescens*), and sacahuista (*Nolina microcarpa*).

Pat Shaver
Roswell, NM

GRAMA-BUFFALOGRASS
SRM 715

Definition, Composition, and Structure: This range cover type is a short grass prairie consisting of predominantly blue grama (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*). Blue grama is most often dominant. The grasses are short in stature, generally from 2.5 to 10 inches (6-25cm) in height. Annual production of herbage ranges from 650 to 3,000 lb/acre (715-3300kg/ha) (air dry) de-pending upon soil moisture and growing conditions. The appearance is homogeneous and the habit is sodforming to semi-bunchgrass. Percent ground cover is usually high unless abuse or die-off has occurred. In excellent range condition, there will be small amounts (10% total) of other species such as western wheatgrass (*Agropyron smithii*) and vine mesquite (*Panicum obtusum*) scattered throughout the vegetation type usually in microdepressions and drainages. There will also be a small amount of perennial forbs such as Engelmann daisy (*Engelmannia pinnatifida*), dotted gayfeather (*Liatris* sp.), scurfpea (*Psoralea* sp.), scarlet globemallow (*Sphaeralcea* sp.), and low growing aster species present (5% total). Woody vegetation is practically nonexistent in climax. However, there are areas where shrub invasion is significant. The major noxious species are mesquite (*Prosopis* sp.), plains pricklypear (*Opuntia polycantha*), and broom snakeweed (*Gutierrezia sarothrae*).

Geographic Distribution: This cover type occurs on the High Plains of Texas and extends into the eastern part of New Mexico and into the Oklahoma Panhandle. It prevails on a major portion of the native rangeland in that region; however, much of the native rangeland on the High Plains has been put into cultivation so that the large expanses of

unbroken grassland recorded by historians no longer exist.

Ecological Relationships: This cover type parallels the "deep hardland" or "clay loam" range site as used by the USDA-SCS. It is generally confined to deep soils of a heavier nature namely loams, clay loams, silty clay loams, and in some cases "tight" fine sandy loams. Where soil changes grade toward sandier conditions or where an increase in carbonates in the surface layer prevail (shallow soils), the vegetative composition shifts in favor of other species.

Precipitation varies from 14 to 24 inches (35-60cm) annually; elevation ranges from approximately 2,450 to 4,750 ft (800-1600m) above sea level. Snowfall ranges from 6 inches (15cm) (south) to 24 inches (60cm) (north) on the average with great variation from year to year. Most of the precipitation comes during the growing season (May to October) with the majority coming in May/June and September/October. Since this type occurs on the deep, fine textured soils on nearly level to gently rolling terrain, infiltration is moderate to slow. Runoff from intense rain-storms is generally slow, but often significant in amount. The amount and density of vegetative material on the surface most affects the hydrology. Removal of vegetation by grazing and increased trampling affects runoff and infiltration appreciably.

Absence of shrub cover limits wildlife species to those indigenous to the plains country. Scaled quail, pronghorn, coyote, jackrabbits, prairie dogs, and various ground nesting songbirds frequent this cover type. Occasionally mule deer will be observed near the edge of contiguous "breaks". The short grasses are nutritious to livestock and usually constitute preferred sites for grazing.

Variants and Associated Species: Occurring among the heavier soils typifying the grama-buffalograss type are areas of sandier soils (sandy loams to loamy sands) that support mid and tall grass vegetation. These generally occur in the southwestern part of the southern High Plains and also in the northwestern corner of the Texas Panhandle. Such species as little bluestem (*Schizachyrium scoparium*), sideoats grama (*Bouteloua curtipendula*), sand dropseed (*Sporobolus cryptandrus*), and sand sagebrush (*Artemisia filifolia*) are the most common. There are also areas of rolling sand hills found in this same general locale. In the sand, hills sand shinoak (*Quercus havardii*), skunkbush (*Rhus trilobata*), sand bluestem (*Andropogon gerardii* var. *paucipilus*), little bluestem, spike dropseed (*Sporobolus contractus*), giant sandreed (*Calamovilfa gigantea*), and sand sagebrush typify the vegetation. The Canadian River Breaks cut through the High Plains from west to east, which also varies from the short grass plains of the grama- buffalograss type. The Breaks are a combination of loamy, sandy, and gravelly sediments overlying the "redbeds". These sandy and gravelly members are referred to as Ogallala sediments. They afford a mixture of vegetation varying from the short grass to tall and mid-grasses. Bottomland subirrigated areas occur frequently at the lowest position on the landscape.

The grama-buffalograss type is predominantly a grassland type with woody shrubs invading in some areas. The more common shrub species are mesquite, cholla (*Opuntia imbricata*), plains pricklypear, yucca (*Yucca glauca*), and broom snakeweed. In climax this vegetative type had little woody vegetation present. Forbs are present, but make up generally less than 5% of the total vegetation. Where overuse has frequently occurred, there are usually more annual forbs present, but the higher successional perennial forbs are usually absent.

J.R. Bell
Amarillo, TX

GRAMA-FEATHERGRASS
SRM 716

Definition, Composition, and Structure: This type has the aspect of a short grass prairie. It is composed of a mixture of warm and cool season perennial grasses. There are a large number of shrubs and half-shrubs throughout the area. Annual forbs fluctuate considerably from year to year with seasonal variation in amount and distribution of rainfall. This type is dominated by black grama (*Bouteloua eriopoda*), sideoats grama (*B. curtipendula*), and New Mexico feathergrass (*Stipa neomexicana*). Dominant shrubs include winterfat (*Ceratoides lanata*), Bigelow sagebrush (*Artemisia bigelovii*), and sacahuista (*Nolina microcarpa*).

Geographic Distribution: This type is best represented in the Pecos-Canadian Plains and valleys of east central New Mexico. It occurs on level to gently sloping plains and alluvial fans. Slopes can range to 15%, but generally less than 5%. Elevations range from 3,800 to 6,300 ft (1300-2100m).

Ecological Relationships: Climate of the area is semiarid continental. The annual average precipitation ranges from 13 to 16 inches (32-40cm). Variations of 5 inches (12.5cm), more or less are common. Approximately 75% of the precipitation falls from April to October. Temperatures are characterized by distinct seasonal changes and large annual and diurnal temperature changes. The average annual temperature is 50^{o} to 58^{o} F (10^{o}-15^{o} C) with extremes of -30^{o} F (-36^{o}C) in the winter to 108^{o} F (42^{o} C) in the summer. Strong winds blow from February to May from the southwest which rapidly dry out the soil during a critical period for initiation of plant growth.

The soils are well-drained and moderately deep to shallow. They may be over a petrocalcic layer or over limestone bedrock. Surface textures are typically clay loams to fine sandy loams. The effective rooting depth is generally less than 40 inches. This cover type provides a wildlife habitat which supports a resident animal community

characterized by pronghorn antelope, coyote, black-tailed jackrabbit, and scaled quail.

Variants and Associated Species: Many variations occur in this type. Variations are due to past and present management being applied to the land and to the potential of the individual soils to produce a unique plant community. Associated grasses in this type include sand dropseed (*Sporobolus cryptandrus*), threeawns (*Aristida* sp.), blue grama (*Bouteloua gracilis*), hairy grama (*B. hirsuta*), and little bluestem (*Schizachyrium scoparium*). The most common shrubs associated with this type are four-wing saltbush (*Atriplex canescens*), skunkbush sumac (*Rhus trilobata*), and catclaw mimosa (*Mimosa biuncifera*). Broom snakeweed (*Gutierrezia sarothrae*) readily invades this type and can become completely dominant. Mesquite (*Prosopis glandulosa*) can also invade this type.

Pat Shaver
Roswell, NM

LITTLE BLUESTEM-INDIANGRASS-TEXAS WINTERGRASS SRM 717

Definition, Composition, and Structure: Excellent condition pristine Blackland Prairie remnants represent a species rich grassland dominated by a mixture of tall and mid-grasses which form a nearly closed canopy cover in most areas. The prevailing dominant throughout is little bluestem (*Schizachyrium scoparium*). Secondary dominants vary depending upon soil and precipitation. In the eastern portions of the prairie over Vertisols, Indiangrass (*Sorghastrum nutans*) is an important secondary species where annual precipitation is less than 35 inches (88cm); while above this amount, in the north-eastern part of the Prairie, switchgrass (*Panicum virgatum*) and gamagrass (*Tripsacum dactyloides*) are upland dominants. Within these Vertisols considerable local site variation exists due to the shrink-swell clays which produce gilgai microtopography. The microhighs may have significant amounts of sideoats grama (*Bouteloua curtipendula*), hairy grama (*B. hirsuta*), and Texas grama (*B. rigidiseta*); while microlows have greater amounts of Indiangrass, big bluestem (*Andropogon gerardii*), Florida paspalum (*Paspalum floridanum*), and sedges (*Carex* sp.). Mollisols in the eastern portions have big bluestem as an important secondary species, and westward across the Mollisols of the Grand Prairie and north central prairies big bluestem, sideoats grama, and Texas wintergrass (*Stipa leucotricha*) take on greater importance. Westward in low rainfall areas hairy grama may contribute significantly to the composition. In the northeast, over Alfisols that receive more than 35 inches (88cm) of annual precipitation, Silveanus dropseed (*Sporobolus silveanus*) becomes a dominant to form a unique grassland community. Tall dropseed (*S. asper*) is an ubiquitous secondary grass across nearly all sites, but rarely provides more than 5% of the biomass composition in climax communities. Species richness is great in these grasslands. The families Poaceae, Leguminosae, and Compositae are represented by many species. Woody species are absent or occur only as scattered individuals in excellent condition grasslands. Species of the genera Quercus, Ulmus, Celtis, Juniperus, Prosopis and others may occur. Annual production varies from a maximum of 10,000 lb/acre (11,000kg/ha) in the northeast to less than 3,000 lb/acre (3300kg/ha) in the west. The grasslands are dissected by several major rivers and their tributaries. These riparian areas are dominated by an oak-elm-ash-pecan (*Quercus-Ulmus-Fraxinus-Carya*) flood-plain forest; however, in forest openings and at lower slopes of the uplands, switchgrass and gamagrass may be dominants. Bottomland communities have not been adequately described for this region. Much of the upland and bottomland was converted to cropland for production of cotton, sorghum, wheat, and corn. Some cropland has been returned to permanent pastures of introduced species including Bermudagrass (*Cynodon dactylon*), Bahiagrass (*Paspalum notatum*), Kleingrass (*Panicum coloratum*), KR bluestem (*Bothriochloa ischaemum*) and others.

Geographic Distribution: The Blackland Prairie, as defined here, includes three separate units: 1) the main and largest 11.1 million acres (4.4 million ha) forms as a northeast to southwest belt which begins at the Red River (Oklahoma border) and extends southward to near San Antonio; 2) the Grand Prairie 4.2 million acres (1.7 million ha) is separated from the main unit by the Eastern Cross Timbers and forms a north-south belt to the west of Ft. Worth; and 3) the North Central Prairie 4.6 million acres (1.8 million ha) which is located west of the Western Cross Timbers. The main unit occurs primarily over deep Vertisols; but Alfisols, particularly on the eastern border, and Mollisols on the west, cover extensive areas. The Grand Prairie occurs over relatively shallow Mollisols overlying limestone parent material. The North Central Prairies occur over mainly Mollisols and Alfisols derived from a variety of parent materials.

Precipitation decreases from north to south and east to west. Northeastern portions of the main belt may receive in excess of 40 inches (100cm) per annum, while the western margins of the North Central Prairies receive less than 28 inches (70cm). Drought is a recurrent feature of the climate with increased frequency and duration as one moves westward. The landscape of all units is generally gently rolling with dissection of all units by major rivers and their tributaries. Little natural wetland occurs, but many stock ponds and large reservoirs have developed across the region.

Ecological Relationships: The Blackland Prairies are considered southern extensions of the True Prairie grassland of central North America. Although species of western affinity do occur, the dominant grass species as well as most forbs have definite eastern biogeographic affinities. The regional areas of greatest available moisture are dominated by tall grasses, intermediate sites by a mixture of tall and mid-grasses, and on drier sites primarily mid-grasses with some short grass species. While most species have relatively high grazing resistance under deferred grazing regimes, most of the late-successional dominants are greatly reduced in abundance and vigor or totally eliminated by heavy, continuous grazing. With reduction in the climax dominants, mid and short perennial grasses increase. Included are: sideoats grama, Texas wintergrass, tall dropseed, hairy grama, buffalograss (*Buchloe dactyloides*), and threeawns (*Aristida* sp.). If grazing pressure is intense for a long period, these species may be replaced by annual grasses such as oldfield threeawn (*Aristida oligantha*), Japanese Brome (*Bromus japonicus*), and annual forbs. Large areas of native rangeland exist across the area but most are dominated by mid- to low successional species due to past overgrazing. Less than 1% of the area could be classified as excellent condition rangeland. Overgrazing and removal of naturally occurring fires enhances the invasion of woody species; however, even excellent condition communities, in the absence of fire, are ultimately invaded by woody species albeit at a much slower rate than overgrazed areas. Once invaded, return to a grassland type is a very difficult conversion to make, particularly if the resprouting honey mesquite (*Prosopis glandulosa* var. *glandulosa*) is the invader. However, honey mesquite has historically been a component in many of these grasslands, although at lower densities and stature than observed today.

Variants and Associated Species: A great variety of major and minor plant communities occur across the Blackland Prairie. While they are all similar in physiognomy, there are great variations in the kind, proportion, and amount of the component species in the climax communities; and, of course, an almost infinite combination of species can be found in the various retrogression and secondary successional pathways. The great interspersion of the prairies with bottomland forests and upland savannahs and woodlands adds a great deal of variety to vegetational patterns of the region and provides a great deal of edge, which contributes to plant and animal diversity.

Fred Smeins
Texas A&M University
College Station, TX

MESQUITE-GRAMA
SRM 718

Definition, Composition, and Structure: Mesquite (*Prosopis glandulosa*) forms an open canopy of medium to tall shrubs over mid- and short grasses in this cover type. Sideoats grama (*Bouteloua curtipendula*) and blue grama (*B. gracilis*) dominate the understory vegetation when the site is near climax. Buffalograss (*Buchloe dactyloides*) and western wheatgrass (*Agropyron smithii*) are important subdominants. Sand bluestem (*Andropogon gerardii* var. *paucipilus*), little bluestem (*Schizachyrium scoparium*), and vine mesquite (*Panicum obtusum*) occur in local areas that receive additional runoff. In lower seral stages, grasses such as buffalograss, threeawns (*Aristida* sp.), hairy tridens (*Erioneuron pilosum*), and annual bromegrasses (*Bromus* sp.) increase in importance. Broom snakeweed (*Gutierrezia sarothrae*), pricklypear cactus (*Opuntia* sp.), and western ragweed (*Ambrosia psilostachya*) are also common in lower seral stages. Annual herbaceous plant production ranges from 1,800 to 3,600 lb/acre depending on weather conditions.

Geographic Distribution: The mesquite-grama cover type is found in far southwestern Oklahoma in an area stretching 70 miles (112km) north from the Red River and 80 miles (128km) east from the eastern Texas Panhandle border. Mean annual precipitation is 24 to 30 inches (60-75cm). About 75% of the precipitation falls between April and October, but July and August are generally droughty with unfavorable growing conditions. Snowfall is uncommon and wind movement is relatively high. This cover type occurs on deep upland soils. The surface horizons are loamy to clayey, while the subsoils are clayey. Water infiltration and percolation are slow.

Ecological Relationships: Approximately two-thirds of the mesquite-grama cover type has been converted to cropland. Cropland conversion has been concentrated on areas with less than 3% slope. Major crops include wheat, cotton, and sorghum.

This cover type is considered to have the potential to be an open mixed grassland with a sparse shrub cover of mesquite. Less than 20% of the current vegetation is in this category. Improper grazing management, fire suppression, fragmentation by human development, and drought have resulted in an increase in mesquite and herbaceous plants of lower seral stages. Economic management of mesquite populations is considered to be the major objective for this type. Attainment of this objective is made more difficult by the sprouting nature of mesquite, the difficulty in obtaining high root-kill with herbicides, and the interspersion of herbicide-intolerant crops (especially cotton).

Variants and Associated Species: One variation of this cover type occurs on shallow, heavy clay upland soils. Overall vegetation production is lower on these sites because of less favorable moisture relations, but species

composition is similar. A second variation occurs on heavy clay bottomland soils. Available run-in water results in a shift in climax species composition to switchgrass (*Panicum virgatum*), little bluestem, and vine mesquite and an increase in total productivity. Species composition in lower seral stages is similar to the central mesquite-grama cover type.

Associated vegetation on loamy soils is mainly open grassland dominated by little bluestem, big bluestem (*Andropogon gerardii*), sand bluestem (*A. gerardii* var. *paucipilus*), and sideoats grama. Sandy soils support the same herbaceous vegetation as the loamy soils with the addition of sand shinnery oak (*Quercus havardii*) and sand sagebrush (*Artemisia filifolia*).

Robert Gillen
Oklahoma State University
Stillwater, OK

MESQUITE-LIVEOAK SEACOAST BLUESTEM SRM 719

Definition, Composition, and Structure: Honey mesquite (*Prosopis glandulosa*) and live oak (*Quercus virginiana*) mottes are interspersed with seacoast bluestem (*Schizachyrium scoparium var. littoralis*) and dominate the prairie in the Mesquite-Liveoak-Seacoast Bluestem Savannah. Honey mesquite may reach more than 30 ft. in height (El Fadl et al., In Press) and frequently occurs in mottes with an understory of smaller shrubs. Liveoak occurs in mottes ranging in size from .01 to more than 200 acres (.004-80ha). The mottes may be isolated from one another by grassland or may connect with one another forming dense forests. Liveoak stem densities in the mottes range from 750 to 3,050 stems acre-1 (Beasom and Haucke 1975).

Seacoast bluestem is the prevailing dominant of upland grasslands that are not overgrazed (Johnston 1963). Frequency of seacoast bluestem on upland grasslands in good range condition averages 95% in 10 X 20 inch (25x50cm) plots (Diamond and Fulbright, unpublished data). Poorly drained areas and lower swales are dominated by gulf cordgrass (*Spartina spartinae*).

Geographic Distribution: The Mesquite-Liveoak-Seacoast Bluestem Savannah occupies about 2.5 million acres (1 milliom ha) in southern Texas. The Savannah borders the Laguna Madre on the east, Baffin Bay and the Coastal Prairie on the north, and the Rio Grande Delta on the south (Godfrey et al. 1973). It extends inland about 60 miles (96km) and contacts Mesquite-Acacia Savannah on the west (Brown et al. 1977).

Ecological Relationships: The Savannah is underlaid by Quarternary eolian sands. Soils of the dune ridges are Entisols and Alfisols.

Dune and swale or hummocky topography alternating with broad flats dominate the region. Numerous active sand dunes are distributed throughout the eastern part of the region. Active and relict sand dunes and wind-deflation troughs are aligned with the prevailing southeasterly winds (Brown et al. 1977).

Climate of the region is subhumid, subtropical (Larkin and Bomar 1983) with mild, dry winters and hot, humid summers (NOAA 1972). Average annual rainfall ranges from 22 inches on the west to 25 inches (55-63cm) on the east (Texas Agricultural Extension Service, not dated). Rainfall is bimodal with spring maxima in May and a fall maximum in September. The erratic nature of the pre-cipitation is accentuated by periodic droughts and occasional hurricanes (Rappole et al. 1986). High temper-atures and low rainfall result in an annual precipitation deficit (rainfall -evaporation) ranging from -24 inches (-60cm) on the east to -28 inches (-70cm) on the west (Texas Agricultural Extension Service, not dated). The daily mean maximum temperature is 70° F (21° C) in January and 96° F (36° C) in August (NOAA 1972).

Several of the major plant species in the Mesquite-Liveoak Savannah are shared with the Coastal Prairie to the northeast. Seacoast bluestem is a rhizomatous variety of little bluestem (*Schizachyrium scoparium*), the prevailing dominant of the Coastal Prairie. Other species shared with the Coastal Prairie include big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), Indiangrass (*Sorghastrum nutans*), and brownseed paspalum (*Paspalum plicatulum*). The clay-textured soils of the Coastal Prairie do not support certain major plant species of the sandy Savannah, including gulfdune paspalum (*Paspalum monostachyum*) and camphor daisy (*Heter-otheca subaxillaris*).

Liveoak mottes were present when the first Spanish settlers arrived and have invaded large areas of former grassland in recent times (Johnston 1963). Honey mesquite has also increased in abundance, probably because of overgrazing and the restriction of naturally occurring fires.

Moderately to severely grazed Savannah is dominated by sandbur (*Cenchrus incertus*), hooded windmillgrass (*Chloris cucullata*), red lovegrass (*Eragrostis secundiflora*), and threeawns (*Aristida* sp.). Seacoast bluestem is virtually absent (Johnston 1963) under these grazing pressures.

The region abounds in wildlife. Common native species include white-tailed deer (*Odocoileus virginianus*), javelina (*Dicotyles tajacu*), coyotes (*Canis latrans*), bobcats (*Felis rufus*), Rio Grande turkey (*Meleagris gallopavo*), and bobwhite quail (*Colinus virginianus*). Exotic species include feral pigs (*Sus scrofa*) and nilgai antelope (*Boselaphus tragocamelus*). Nilgai were introduced by the King Ranch in 1924 and have established a large population in the eastern half of the Savannah (Sheffield et al. 1971).

Variants and Associated Species: Grasses associated with seacoast bluestem on dune ridges and well-drained flats

include Dichanthelium sp., crinkleawn (*Trachypogon secundus*), brownseed paspalum, thin paspalum (*Paspalum setaceum*), Pan American balsamscale (*Elyonurus tripsacoides*), and threeawns. Camphor daisy (*Machaeranthera phyllocephala*) is a weed problem in much of the association. Gulfdune paspalum dominates with seacoast bluestem in swales and moderately drained flats. Important associates include big bluestem, gulf muhly (*Muhlenbergia capillaris*), and Indiangrass.

Mesquite occupies the shallower sands (<6 ft.), while liveoak occurs on the deeper sands (>6 ft.) (Hanselka, not dated). Typical understory woody species of mesquite mottes include spiny hackberry (*Celtis pallida*), lime pricklyash (*Zanthoxylum fagara*), huisache (*Acacia farnesiana*), Texas persimmon (*Diospyros texana*), and herculesclub (*Zanthoxylum clava-herculis*) (Beasom and Haucke 1975). Texasgrass (*Vaseyochloa multinervosa*) is a dominant herbaceous plant in the understory of liveoak mottes.

Portions of the area have been rootplowed and seeded to exotic grasses, principally King Ranch bluestem (*Bothriochloa ischaemum*), buffelgrass (*Cenchrus ciliaris*), and coastal bermuda (*Cynodon dactylon*) (Sheffield et al. 1971, Sheffield 1983).

Timothy E. Fulbright
Texas A&I University
Kingsville, TX

SAND BLUESTEM-LITTLE BLUESTEM (DUNES) SRM 720

Definition, Composition, and Structure: This type has the aspect of a mid- and tall warm season grass prairie. Cool season grasses and forbs make up an important component of the plant community. This type is dominated by sand bluestem (*Andropogon gerardii* var. *paucipilus*), little bluestem (*Schizachyrium scoparium*), sand dropseed (*Sporobolus cryptandrus*), and hairy grama (*Bouteloua hirsuta*). Shrubs and half-shrubs which typify the site include sand sagebrush(*Artemisia filifolia*), small soapweed (*Yucca glauca*), and skunkbrush sumac (*Rhus trilobata*). Forbs include annual sunflower (*Helianthus annus*), western ragweed (*Ambrosia psilostachya*), and annual buckwheat (*Eriogonum annuum*).

Geographic Distribution: This type is best represented by chains of dunes and hummocky sands and level to undulating areas north of the Canadian River in northeastern New Mexico and the Panhandle of Texas. Slopes can range from 0 to 8%. Elevation ranges from 3,600 to 5,250 ft (1200-1750m).

Ecological Relationships: Climate of this area is semiarid continental. The average annual precipitation ranges from 23 to 25 inches (58-63cm). Approximately 75% of the precipitation usually falls during May to October. Winters average 20 inches (50cm) of snow, which may remain on the ground for several days and occasionally result in blizzard conditions and heavy drifting.

The soils are deep and well-drained. Soil textures include loam, sandy loam, and sands. The effective rooting depth is greater than 60 inches (150cm). This cover type is particularly susceptible to wind erosion when vegetative cover is reduced. This type provides a wildlife habitat which supports antelope, badger, fox, bobcat, skunks, and prairie rattlesnakes.

Variants and Associated Species: Many variants occur in this type. Variations are due to past and present management being applied to the land and the potential of the individual soils to produce a unique plant community. Associated grasses include needle-and-thread (*Stipa comata*), Indiangrass (*Sorghastrum nutans*), blue grama (*Bouteloua gracilis*), hairy grama, and sideoats grama (*B. curtipendula*). On areas that have received good management for several years, needle-and-thread, Indiangrass, and sand bluestem will increase. Sand sagebrush, yucca, and threeawn sp. (*Aristida* sp.) will increase when the type is overgrazed and abused.

Herman G. Garcia
Tucumcari, NM

SAND BLUESTEM-LITTLE BLUESTEM (PLAINS) SRM 721

Definition, Composition, and Structure: This type has the aspect of a rolling tall and mid-grass prairie. It is dominated by sand bluestem (*Andropogon gerardii* var. *paucipilus*) and little bluestem (*Schizachyrium scoparium*). Sideoats grama (*Bouteloua curtipendula*), sand shinnery oak (*Quercus havardii*), and sand sagebrush (*Artemisia filifolia*) are common in this type. Forb production and composition are extremely important, but vary greatly from season to season and year to year. Forbs may achieve a dominant aspect in years of abundant winter and spring moisture.

Geographic Distribution: This type is best represented in the extreme southern end of the High Plains in southeast New Mexico. This type occurs on nearly level to hilly landscapes on upland plains. Slopes range as high as 30% on dunes, but are generally between 3 and 12%. Hummocks of 2 ft. (.7m) and dunes several feet tall are common. Elevations range from 3,450 to 4,300 ft (1150-1430m).

Ecological Relationships: Climate of the area is semiarid continental. The average annual precipitation ranges from 14 to 18 inches (35-45cm). Variations of 5 inches (12.5), more or less, are common. Approximately 85% of the precipitation falls from April to October. Without a good

cover of vegetation, this type is easily eroded by wind, forming hummocks and dunes.

The soils are deep and excessively drained. Surface textures are finesandy loam to fine sand. The effective rooting depth is greater than 40 inches (100cm).

This type provides a wildlife habitat which supports a resident animal community characterized by pronghorn antelope, badger, swift fox, desert cottontail, lesser prairie chicken, and scaled quail.

Variants and Associated Species: Many variations occur in this type. Variations are due to the past and present management being applied to the land and the potential of the individual soils to produce a unique plant community. Variants range from sandhills with an aspect of shinnery oak in the south to level plains with an aspect of black grama (*Bouteloua eriopoda*). Associated grasses include black grama, hairy grama (*B. hirsuta*), giant dropseed (*Sporobolus giganteus*), sand paspalum (*Paspalum setaceum*), and giant sandreed (*Calamovilfa gigantea*).

On areas that have received good management for several years, needle-and-thread (*Stipa comata*) is present. Mesquite (*Prosopis glandulosa*) and small soapweed (*Yucca glauca*) are associated shrubs. Mesquite and/or sand shinnery oak can completely dominate this type when poor management has been applied for several years.

Herman B. Garcia
Tucumcari, NM

SAND SAGEBRUSH-MIXED PRAIRIE SRM 722

Definition, Composition, and Structure: Sand sagebrush (*Artemisia filifolia*) growing to a height of 3 ft (1m). is the visual dominant (Parker and Savage, 1944) in this cover type where it may attain 7 to 50% canopy cover (Sims et al. 1976, Hyder 1979, Collins et al. 1987). Perennial grasses (short, mid, and tall) are the major complement to the sagebrush. Blue grama (*Bouteloua gracilis*) and sand dropseed (*Sporobolus cryptandrus*) often provide much of the basal cover and forage production (Sims et al. 1976, McIlvain and Shoop 1961). Sand bluestem (*Andropogon gerardii* var. *paucipilus*), little bluestem (*Schizachyrium scoparium*), and switchgrass (*Panicum virgatum*) can be important forage producers and provide a tall grass aspect, if grazing by domestic livestock has not been excessive (Kuchler 1974).

Prairie sandreed (*Calamovilfa longifolia*) is a major warm season grass in the northern part of this cover type (Wallace et al. 1973, Hyder 1979, Daley 1972); and the cool season grasses western wheatgrass (*Agropyron smithii*) (Hyder 1979) and needle-and-thread (*Stipa comata*) (Wallace et al. 1973) are important. Sand paspalum (*Paspalum setaceum*), fall witchgrass (*Leptoloma cognatum*), and sand lovegrass (*Eragrostis trichodes*) are important warm season grasses in the southern part of this cover type; and Texas bluegrass (*Poa arachnifera*) is the only important cool season perennial (McIlvain and Shoop 1961, Collins et al. 1987).

Seasonally abundant annuals may include hairy Indianwheat (*Plantago purshii*), sixweeks fescue (*Vulpia octoflora*), annual bromes (*Bromus japonicus, B. tectorum*), lambsquarter (*Chenopodium* sp.), buckwheat (*Eriogonum* sp.), mint(*Monarda* sp.), and sunflower (*Helianthus petiolaris*). Perennial forbs, usually not abundant, may include western ragweed (*Ambrosia psilostachya*), stickleaf (*Mentzelia* sp.), hairy goldenaster (*Chrysopsis villosa*), spider wort (*Tradescantia occidentalis*), and scurfpea (*Psoralea lanceolata*).

Geographic Distribution: This type covers approximately 12 million acres (4.8 million ha) in the central and southern Great Plains from southwest Nebraska, through eastern Colorado, southwest Kansas, and northwest Oklahoma. Much of this cover type is in bands of sandy mantle 3 to 12 miles (4.8-18.2 km) wide parallel to major drainages (South Platte, Arkansas, and North Canadian Rivers) and in narrower bands parallel to smaller drainages.

Ecological Relationships: Deep sandy soils (loamy sands and sands) on hilly landscapes without well-defined surface drainageways are the substrates for this cover type. Faster infiltration and less water loss to evaporation make sandy soils more efficient than finer textured soils in supplying water to perennial plants in this region where much of the precipitation (average annual precipitation 12 to 24 inches) falls during the growing season; high winds are common, and summers are hot. The more favorable soil water relationship allows this cover type to extend westward as stringers into the short grass prairie.

The major range management practices in this cover type are: controlling stocking rate and season of use, use of complementary farmed forages, and controlling sand sagebrush with herbicides. Sand sagebrush is believed to increase in density as grazing pressure increases (Harlen 1958, Costello 1964), however, canopy cover by sand sagebrush showed no major trend over 40 years under moderate grazing or in exclosures (Collins et al., 1987). he wind erosion potential is high on drastically disturbed areas and on limited areas farmed within this cover type. Most of the farming is with sprinkler irrigation; areas that were dryland farmed have largely been reseeded to native grasses, or on the southern edge of the type, to weeping lovegrass (*Eragrostis curvula*).

W.A. Berg
Woodward, OK

SEA OATS
SRM 723

Definition, Composition, and Structure: The Sea Oats Prairie is an open, short to medium grassland with occasional shrubs. Dominants include seacoast bluestem (*Schizachyrium scoparium* var. *littoralis*), sea oats (*Uniola paniculata*), and gulfdune paspalum (*Paspalum monostachyum*). Other grasses include *Aristida intermedia*, red lovegrass (*Eragrostis oxylepis*), stiffleaf eustachys (*Eustachys petraea*), shoregrass (*Monanthochloe littoralis*), thin paspalum (*Paspalum setaceum*), and seashore dropseed (*Sporobolus virginicus*). Grass like species include: spikerush (*Eleocharis montevidensis*), fimbry (*Fimbristylis castanea*), and sword-grass (*Scirpus americanus*). Forbs include: partridge pea (*Cassia fasciculata*), beach tea (*Croton punctatus*), Corpus Christi fleabane (*Erigeron myrionactus*), salt heliotrope (*Heliotropium curassavicum*), large leaf pennywort (*Hydrocotyle bonariensis*), sweet morning-glory (*Ipomoea pescaprae*), fiddleleaf morning-glory (*I. stolonifera*), beach evening primrose (*Oenothera drummondii*), beach carpet (*Philoxerus vermicularis*), frogfruit (*Phyla nodiflora*), and woolly stemodia (*Stemodia tomentosa*). Several authors have recently described the flora, including Gillespie (1976), Lonard et al. (1978), Lonard and Judd (1980), and Drawe et al. (1981).

Geographic Distribution: This cover type is found on the barrier islands, including the major islands of Padre, Mustang, Matagorda, St. Joseph's, and Galveston, off the southern coast of Texas. It occurs on a range of soils from sands to clays, but the predominant soil type is sand (Drawe et al. 1981).

Ecological Relationships: The barrier islands provide an extremely harsh environment for plant growth and vegetation development. This, combined with continuous grazing bycattle since about 1850 (Rechenthin and Passey 1967), has caused severe retrogression of the vegetation. Recreation and development have destroyed much of the original vegetation on southern Padre, northern Padre, and southern Mustang Islands. Tropical storms wreak havoc with the vegetation (Judd and Sides 1983). Gulf currents continually add sand and shell to the islands, and wind moves sand toward the mainland (Dahl et al. 1975). Fortunately, because of the value of the barrier islands as protection against storm surges, dune establishment has become a subject of research (Dahl et al. 1975).

In 1972 Padre Island National Seashore was established, thus protecting a large portion of northern Padre Island. Secondary succession following removal of livestock has been very slow (Drawe et al. 1981, and Drawe unpublished data), and the vegetation has not yet regained mid-grass status. Burning made existing plants more vigorous, but did not advance or retard succession (Drawe and Kattner 1978). With the recent acquisition of large portions of Matagorda Island by the Federal government for protection of the endangered whooping crane, an additional area is now available on which vegetation improvement can be promoted.

The annual rainfall averages 30 inches (75cm) and occurs in a bimodal pattern. The early peak is in April and May, and the later peak occurs in September and October. Many days in the winter and spring are foggy, and the relative humidity is high. Southeast winds prevail, averaging 30 to 40 mph, carrying salt spray inland. The temperatures are generally moderate, and killing frost does not occur every winter. The growing season is 300+ days.

Variants and Associated Species: Judd et al. (1977) recognized 6 major terrestrial topographic zones and described a flora of 204 species on south Padre Island. Rechenthin and Passey (1967) described 6 habitat types for Padre Island, and Drawe et al. (1981) gave the relative percent of the island covered by each type: (1) gulf beach, 5%; (2) coastal dunes, 18%; (3) low coastal sands, 61%; (4) salt marsh, 1%; (5) salty sands, 2%; and (6) shoregrass flats, 13%. These types are representative of the vegetation of other barrier islands off the Texas coast although the relative amounts of each type may vary. Woody plants are scarce on the islands. Following removal of cattle from Padre Island, false willow (*Baccharis salicina*) became more abundant. Live oak (*Quercus virginiana*) has been removed by tropical storm activity and moving dunes. An occasional huisache (*Acacia farnesiana*) breaks the landscape.

D. Lynn Drawe
Welder Wildlife Foundation
Sinton, TX

SIDEOATS GRAMA-NEW MEXICO FEATHERGRASS-WINTERFAT
SRM 724

Definition, Composition, and Structure: This type has the aspect of a short and mid-grass prairie with forbs and cool season grasses occupying an important component of the plant community. It is dominated by sideoats grama (*Bouteloua curtipendula*), New Mexico feather grass (*Stipa neomexicana*), blue grama (*B. gracilis*), and little bluestem (*Schizachyrium scoparium*). Shrubs and half-shrubs which typify the site include gambel oak (*Quercus gambelii*), winterfat (*Ceratoides lanata*), and skunkbrush sumac (*Rhus trilobata*). Forbs include dotted gayfeather (*Liatris punctata*), prairie coneflower (*Ratibida columnifera*), and globe mallow (*Sphaeralcea coccinea*).

Geographic Distribution: This type is best represented on the northern extension of the southern High Plains in northeastern New Mexico. This type occurs on convex terraces, hillsides, and slopes of ridges. Slopes can range from 5 to 15%, but may range 0 to 25% with inclusions of steeper slopes. Elevations range from 3,200 to 5,750 ft

(1100-1900m).

Ecological Relationships: Climate of this area is semiarid continental. The average precipitation ranges from 23 to 25 inches (58-63cm). Approximately 75% of the precipitation falls during May to October. Winters average 20 inches (50cm) of snow, which may remain on the ground for several days and occasionally result in blizzard conditions and heavy drifting.

The soils are well-drained, shallow to caliche or bedrock. Soil textures include loamy sand and sandy loam. Within this type is included a "gravelly" range site as used by the USDA-SCS which is a deep and well-drained soil. Effective rooting depth is mostly 6 to 20 inches (15-50cm) with the gravelly site extending to 60 inches (152cm).

This cover type provides a wildlife habitat which supports mule deer, coyote, cottontail rabbits, quail, rock squirrel, forruginous hawk, and diamondback rattlesnakes.

Variants and Associated Species: Many variants occur in this type. Variations are due to past and present management being applied to the land and the potential of the individual soils to produce a unique plant community. Associated grasses include hairy grama (*Bouteloua hirsuta*), wolftail (*Lycurus phleoides*), big bluestem (*Andropogon gerardii*), and needle-and-thread (*Stipa comata*). Trees and half-shrubs may include pinyon pine (*Pinus edulis*), one-seeded juniper (*Juniper monosperma*), and broom snakeweed (*Gutierrezia sarothrae*). Forbs may include locoweeds (*Astragalus* sp.), wild buckwheat (*Eriogonum jamesii*), and Indian paintbrush (*Castilleja integra*).

Herman B. Garcia
Tucumcari, NM

VINE MESQUITE-ALKALI SACATON
SRM 725

Definition, Composition, and Structure: This type has the aspect of a short and mid-grass prairie. It is composed of a mixture of warm and cool season perennial grasses. There are only a few scattered shrubs and halfshrubs throughout the area. Annual forbs fluctuate considerably from year to year with seasonal variation in amount and distribution of rainfall. This type is dominated by vine mesquite (*Panicum obtusum*) and alkali sacaton (*Sporobolus airoides*). The dominant shrubs are four-wing saltbush (*Atriplex canescens*) and winterfat (*Ceratoides lanata*).

Geographic Distribution: This type is best represented in the area known as the Pecos-Canadian Plains and valleys of east central New Mexico. It occurs on a complex landscape of flat to steep, unevenly sloping terrain. Drainage channels often dissect this type. Exposed outcrops of interbedded gypsum are common. Slopes can range to 35%, but are generally less than 10%. Elevations range from 3,800 to 6,300 ft (1300-2100m).

Ecological Relationships: Climate of the area is termed as semiarid continental. The annual average precipitation ranges from 13 to 16 inches (32-40cm). Variations of 5 inches (12.5cm), more or less, are common. Approximately 75% of the precipitation falls from April to October. Temperatures are characterized by distinct season changes and large annual and diurnal temperature changes. The average annual temperature is 50^{o} to 58^{o} F (10^{o}-15^{o} C) with extemes of -30^{o} F (-36^{o} C) in the winter to 108^{o} F (42^{o} C) in the summer. Strong winds blow from February to May from the southwest, which rapidly dry out the soil during a critical period for initiation of plant growth.The soils are well-drained and shallow to very shallow over gypsum. Surface textures are typically loams and silt loams. The effective rooting depth is generally less than 10 inches (25cm). This type provides a wildlife habitat which supports a resident animal community characterized by coyote, spotted skunk, black-tailed jackrabbit, and scaled quail.

Variants and Associated Species: Many variations occur in this type. Variations are due to past and present management being applied to the land and the potential of the individual soils to produce a unique plant community. Associated grasses in this type include blue grama (*Bouteloua gracilis*), sideoats grama (*B. curtipendula*), and western wheatgrass (*Agropyron smithii*). The most common shrubs associated with this type are skunkbush sumac (*Rhus trilobata*) and cholla (*Opuntia* sp.). Broom snakeweed (*Gutierrezia sarothrae*) can control the aspect of this site when the management and weather have favored its establishment.

Pat Shaver
Roswell, NM

CORDGRASS
SRM 726

Definition, Composition, and Structure: The Southern Cordgrass Prairie is a medium to tall grassland with medium to dense stands of wetland species of plants. Dominants include smooth cordgrass (*Spartina alterniflora*) and marsh-hay cordgrass (*S. patens*). Other grasses include: seashore saltgrass (*Distichlis spicata* var. *stricta*), maiden-cane (*Panicum hemitomon*), torpedo grass (*P. repens*), switchgrass (*P.virgatum*) longtom (*Paspalum lividum*), seashore paspalum (*P. vaginatum*), big cordgrass (*Spartina cynosuroides*), gulf cordgrass (*S. spartinae*), and marsh-millet or giant cutgrass (*Zizanopsis miliacea*). Grasslike species include: sedges (*Carex* sp.), Jamaica sawgrass (*Cladium jamaicensis*), rushes (*Juncus* sp.), bulrushes (*Scirpus* sp.), and cattails (*Typha* sp.). Forbs include: spiny aster (*Aster spinosus*), saltmarsh aster (*A. subulatus*), bushy sea-oxeye (*Borrichia frutescens*), burhead (*Echinodorus* sp.), large leaf pennywort (*Hydrocotyle bonariensis*), arrowhead

(*Saggitaria* sp.), and greenthread (*Thelesperma* sp.).

Geographic Distribution: The Southern Cordgrass Prairie is found in a narrow band adjacent to the Gulf Coast of Texas and in Louisiana to the mouth of the Mississippi River. This type occurs as both freshwater and brackish marshes in the lowlands near the coast.

Ecological Relationships: Marshlands provide some of the most fertile and productive habitats in the world, but also are among the areas of the world most vulnerable to man's disturbances (Gosselink 1980). Climate of this cover type is warm and wet with an average growing season of 261 days a year. The average annual rainfall is about 50 inches (125cm). The area is flat (<3% slope) and poorly drained. Soils of the type are predominantly clays and silt loams.

Evidence of a rapid decline in the Southern Cordgrass Prairie type exists in the literature. Shiflet (1963) estimated 2.5 million acres (1 million ha); then 23 years later, Mitsch and Gosse link (1986) estimated less than 1.25 million acres (0.5 milllion ha) on the Mississippi Delta. Reasons for this decline include: (1) rice farming, (2) land subsidence, (3) grazing, (4) industrial development, (5) flood control, (6) opening channels for access to petroleum activity and for access to the Gulf of Mexico, and (7) pollution (Shiflet 1963, Harcombe and Neaville 1977, Gosselink 1980, Mitsch and Gosselink 1986). Water depth and salinity exert major influences on plant composition of marshlands. Shiflet (1963) converted giant cutgrass tolongtom by lowering water level, preventing salt water intrusion, and mowing. Southern Cordgrass Prairies lie on gradients of decreasing salinity from the ocean inland. Tidal freshwater marshes experience tides but are above the salt boundary. Further inland, marshes experience neither salt nor tides (Mitsch and Gosselink 1986). Along the Gulf Coast, the tide range attenuates inland. The land slope is also small, and freshwater marshes for inland may experience tides. The future for the Southern Cordgrass Prairie is bleak as urban and industrial developments continue to encroach into the area.

Variants and Associated Species: At its eastern extension near the mouth of the Mississippi River, the Southern Cordgrass Prairie is represented primarily by the taller species, big cordgrass and common reed (*Phragmites communis*), whereas at its southern extension near the mouth of the Rio Grande it is represented by shorter species, such as marshhay cordgrass and seashore saltgrass. Shiflet (1963) described 9 plant communities: (1) smooth cordgrass, (2) seashore saltgrass, (3) marshhay cordgrass, (4) big cordgrass, (5) gulf cordgrass, (6) giant cutgrass, (7) paillefine or maidencane, (8) cattail bullrush, and (9) Jamaica sawgrass.

D. Lynn Drawe
Welder Wildlife Foundation
Sinton, TX

MESQUITE-BUFFALOGRASS
SRM 727

Definition, Composition, and Structure: Honey mesquite (*Prosopis glandulosa*) is the dominant understory plant in this cover type. Lotebush (*Ziziphus obtusifolia*) is a common understory shrub as is cholla cactus (*Opuntia imbricata*). The understory species characteristically are mid and short grasses with a rich complement of forbs. Areas approaching climax vegetation have sideoats grama (*Bouteloua curtipendula*) as the dominant grass with lesser amounts of buffalograss (*Buchloe dactyloides*), blue grama (*B. gracilis*), vine mesquite (*Panicum obtusum*), Arizona cottontop (*Digitaria californica*), tobosagrass (*Hilaria mutica*), and Texas wintergrass (*Stipa leucotricha*). As retrogression occurs, buffalograss, Texas wintergrass, tobosa grass, threeawns (*Aristida* sp.), and forbs characteristic of lower successional stages increase and often dominate the understory. The complement of plant dominants depends mainly on soil texture, degree of past grazing use, and timing of rainfall. Annuals such as annual broomweed (*Xanthocephalum* sp.), Texas thistle (*Circium texanum*), and little barley (*Hordeum pusillum*) are abundant during years with high soil moisture that is available during periods with favorable germination temperatures in the fall and winter. The sandy soils and mixed land slopes near limestone escarpments support mixtures of tall and midgrasses with few short grasses. Bottomland areas produce about the only other trees beside honey mesquite.

Geographic Distribution: This cover type is approximately the Texas portion of the Central Rolling Red Plains U.S. Land Resource Region. The limestone escarpment separating the High and Rolling Plains forms its west boundary. The Edwards Plateau is its southern boundary. The cities of Wichita Falls, Throckmorton, Albany, Baird, and Coleman (approximately 99th meridian) mark its eastern edge, with the north fork of the Red River and Highway I-40 in the Texas Panhandle being its approximate northern boundary.

Ecological Relationships: Past grazing use has changed the proportions of plant species in this cover; however, topography, soil texture, soil depth, and rainfall dictate the kind of plants that occur on uncultivated rangeland of the area. Elevations range from 1,000 ft (330m) above mean sea level on the east to 2,900 ft (1000m) on the west. Topography is steep and dissected where this area joins the limestone escarpments of the High Plains and the Edwards Plateau. The bulk of the area is a dissected plain. The broad drainage divides are nearly level to gently sloping, and the valleys have short but steep slopes. In places, the valleys are

bordered by rolling to steep irregular dune topography.

Annual rainfall varies from 27 to 18 inches (68-45cm) from east to west. Climate is semiarid and subtropical with mild winters and hot, humid summers. Maximum rainfall peaks are in May and June with secondary peaks in September and October; 70 to 80% of the annual rainfall occurs April to October.

Soils tend to be quite mixed in this cover type varying from deep sands to clays and from shallow redlands, deep clay loams to mixedland slopes. The most characteristic development of the mesquite-buffalograss cover type is on the clay loams and loams. Soil series representative of the soil variations are Vernon clays of shallow redland areas; Woodward and Quinland loams of mixedland slopes; Miles, Springer, and Brownfield in the sandy soil areas; Abilene, Rowena, Tarrant, and Tillman clay loams of the more productive agricultural soils; and Mereta clay loams on hardland slopes. Grass species that occur on most all sites are: sideoats grama, buffalograss, bluegrama, Wright's and purple threeawns (*A. Wrightii* and *A. purpurea*, respectively), vine mesquite, cane and silver bluestem (*Bothriochloa barbinodis* and *B. saccharoides*, respectively), Texas wintergrass, sand dropseed (*Sporobolus cryptandrus*), and tobosa grass. Depending on favorable rainfall or in areas with favorable soil moisture relations, Arizona cottontop, plains bristlegrass (*Setaria macro-stachya*), Texas cupgrass (*Eriochloa Sericea*), white tridens (*Tridens albescens*), Canada wildrye (*Elymus canadensis*), Texas bluegrass (*Poa arachnifera*), Alkali sacaton (*Sporobolus airoides*), and western wheatgrass (*Agropyron smithii*) also occur. Forbs that grow in this cover type are: dotted gayfeather (*Liatris punctata*), green thread (*Thele-sperma megapotamicum*), western ragweed (*Ambrosia psilostachya*), milkvetch (*Astragalus* sp.), various gaura (*Gaura* sp.), heath aster (*Aster ericoides*), curly cup gumweed (*Grindelia squarrosa*), ground cherry (*Physalis* sp.), annual broomweed, Louisiana sagewort (*Artemisia ludoviciana*), plains blackfoot (*Melampodium leucanthum*), trailing ratany (*Krameria lanceolata*), goldaster's (*Heterotheca* sp.), wild mercury (*Argythamnia humilis*), dozedaisy (*Aphanostephus* sp.), catclaw sensitive briar (*Schrankia uncinata*), and bundleflowers (*Desmanthus* sp.). Woody plants common in the cover type include: honey mesquite, lotebush, vine ephedra (*Ephedra pedunculata*), tasajillo (*Opuntia leptocaulis*), hackberry (*Celtis reti-culata*), algerita (*Berberis trifoliolata*), broom snakeweed (*Gutierrezia sarothrae*), pricklypear (*Opuntia* sp.), and cholla cactus.

Englemann daisy (*Engelmannia pinnatifida*), bush sunflower (*Simsia calva*), orange zexmenia (*Zexmenia hispida*), and maxmilian sunflower (*Helianthus maximiliani*) are forbs expected in this area on ranges in near climax condition. However, they are only occasionally found in grazed areas of this cover type.

This cover type supports good populations of quail, dove, turkey, and many nongame birds, as well as other animals. While deer and antelope are found, their numbers are minimal compared to cover types further south in Texas.

Variants and Associated Species: This cover type has significant areas of rough broken land, sandy soils, bottomlands, and shallow soils each with its unique combination of species. The areas with sandy soils, mixedland slope areas, and rough breaks tend to support taller growing grasses such as big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatuum*), and Indiangrass (*Sorghastrum nutans*). Needle-and-thread grass (*Stipa comata*), hairy grama (*Bouteloua hirsuta*), black grama (*B. eriopoda*), sand lovegrass (*Eragrostis trichodes*), sand paspalum (*Paspalum setaceum*), fall witchgrass (*Leptoloma cognatum*), hooded windmillgrass (*Chloris cucullata*), and Texas bluegrass are shorter grasses that occur on these sites. Various prairie clovers (*Petalostemon* sp.) and (*Psoralea* sp.), evening primroses (*Oenothera so.*), sand lily (*Mentzelia* sp.), wild buckwheat (*Eriogonum annuum*), queen's delight (*Stillingia sylvatica*), and wooly white (*Hymen-opappus flavenscens*) are additional forbs occurring here. These coarser textured soils also support a more varied woody plant component. In addition to scattered honey mesquite, sand sagebrush (*Artemisia filifolia*), sand shinnery oak (*Quercus havardii*), yucca (*Yucca glauca*), skunkbush sumac (*Rhus trilobata*), littleleaf sumac (*R. microphylla*), western soapberry (*Sapindus saponaria*), catclaw mimosa (*Mimosa biuncifera*), sand plum (*Prunus angustifolia*), and four-wing salt-bush (*Atriplex canescens*) are commonly occurring shrubs.

Redberry juniper (*Juniperus pinchotii*) is a dominant shrub on rough broken land, badlands, and limestone escarpments. It also spreads into the less rough grasslands with deeper soils where fire has been suppressed for long periods. Feather dalea (*Dalea formosa*), New Mexico feathergrass (*Stipa neomexicana*), and javelina bush (*Condalia ericoides*) are characteristic species of shallow sites of rough broken land areas. Bottomland areas have most of the species occurring elsewhere in this cover type, but here one can find the tall prairie grasses, plus Canada wildrye, western wheatgrass (*Agropyron smithii*), Texas bluegrass, tall or meadow dropseed (*Sporobolus asper*), white tridens, and vine mesquite. Trees found here that usually do not exist on other sites are cottonwood (*Populus deltoides* var. *monilifera*), pecan (*Carya illinoiensis*), and bumelia (*Bumelia lanuginosa*).

Bill Dahl
Texas Tech University
Lubbock, TX

MESQUITE-GRANJENO-ACACIA SRM 728

Definition, Composition, and Structure: This cover type exists as an open to dense shrubland with 3 to 4 strata. The upper strata shrubs vary from 6 to 30 ft (2-10m) in height and are primarily mesquite (*Prosopis glandulosa*). The lower strata shrubs vary from 3 to 12 ft (1-4m) and are more species diverse, although granjeno (*Celtis pallida*) and several species of acacia are most common. The herbaceous strata generally consist of an upper strata (3 to 6 ft.) dominated by tall forbs and scattered clumps of mid-grasses, and a lower strata (3 ft.) dominated by forbs and short grasses. The upper herbaceous stratum is most developed in the eastern (*mesic*) regions and becomes discontinuous and then absent as one moves southwestward across south Texas except along waterways. Herbaceous productivity and canopy cover within this type vary greatly with shrub density, soil depth, and rainfall level.

Mesquite is always the dominant or codominant species within this type. Granjeno is the second most common shrub, at times achieving codominant status. If not co-dominant, granjeno will commonly be the major subdominant. Other common subdominants are huisache (*Acacia farnesiana*), blackbrush (*A. rigidula*), twisted acacia (*A. tortuosa*), whitebrush (*Aloysia lycioides*), bluewood (*Condalia obovata*), Texas persimmon (*Diospyros texana*), pricklypear (*Opuntia* sp.), colima (*Zanthoxylum fagara*), and lotebush (*Ziziphus obtusifolia*). Important understory species include agarito (*Berberis trifoliolata*), guayacan (*Porlieria angustifolia*), silver bluestem (*Bothriochloa saccharoides*), trichloris (*Chloris pluriflora*), hooded windmillgrass (*C. cucullata*), pappusgrass (*Pappophorum bicolor*), plains bristlegrass (*Setaria leucopila*), Texas bristlegrass (*S. texana*), curly mesquite (*Hilaria belangeri*), buffalograss (*Buchloe dactyloides*), sideoats grama (*Bouteloua curtipendula*), hairy grama (*B. hirsuta*), Texas grama (*B. rigidiseta*), red grama (*B. trifida*), red threeawn (*Aristida longiseta*), purple threeawn (*A. purpurea*), vine mesquite *Panicum obtusum*), buffelgrass (*Cenchrus ciliaris*), sandbur (*C. incertus*), Kleberg bluestem (*Dichanthium annulatum*), tall mistflower (*Eupatorium odoratum*), small mistflower (*E. incantum*), false ragweed (*Parthenium* sp.), annual broomweed (*Xanthocephalum* sp.), false broomweed (*Ericameria austrotexana*), orange zexmenia (*Zexmenia hispida*), parietaria (*Parietaria floridana*), old man's beard (*Clematis drummondii*), bundleflower (*Desmanthus* sp.), sarcostemma (*Sarcostemma cynanchoides*), bindvine (*Cynanchium barbigerum*), lantana (*Lantana horrida*), dogweed (*Dyssodia tenuilobia*), and cudweed (*Gnaphalium pensilvanicum*).

Geographic Distribution: This is the major cover type of south Texas from the Balcones Escarpment and the Gulf Coast in the north and east, respectively, to the Rio Grande (and continuing in the Tamaulipas Plains of northeastern Mexico). It covers over $30,000^2$ miles in south Texas, forming the typical "brush country" of the region. A less species diverse variant (at times the shrubs are almost exclusively mesquite) extends northward into the Edwards Plateau and eastward up the coast as far as Matagorda County. The type is best developed in a 24 to 32 inch (60-80cm) annual rainfall zone, but can be found in areas receiving as little as 14 inches annually. In the lower rainfall regions, xeric shrubs dominate the understory; and the overstory mesquite are less dense or shorter.

Ecological Relationships: Shrublands have often been considered only as transitional types or types resulting from disturbance. Some areas of mesquite shrubland in south Texas are the result of mismanagement-destruction of grassland by overgrazing, exclusion of fire, use of grazers instead of browsers-especially along the eastern edge. Most, however, are climax types. Failure to recognize this point has led to many management problems.

The mesquite-granjeno-acacia type is characteristically found on mediumdepth loams. Sands, especially deep sands, within the region tend to be dominated by oak types with mesquite found along the sandy loam edges. Deep clay soils are dominated by grassland types with mesquite invasion following overgrazing. Shallow soils where caliche approaches the surface are dominated by a variation of the Cenizo shrub community.

Most mesquite-granjeno-acacia sites are grazed by cattle. Grass production can be relatively high on those sites where shrub density is low to moderate. However, on some sites shrub density is so great that understory production is very limited. In addition to the traditional use of these sites for cattle production, this type is very important as wildlife habitat. The dense stands are used as shelter for numerous wildlife species; and the shrubs provide a major portion of the diets of many species, especially during winter and dry seasons.

Terry McLendon
Kingsville, TX

MESQUITE SRM 729

Definition, Composition, and Structure: Honey mesquite (*Prosopis glandulosa*) is the dominant over-story plant in this cover type. The understory is desert grassland, but the variety of species found is representative of both the mid and short grass prairie as well. Shrubs and forbs abound with the grasses. Sideoats grama (*Bouteloua curtipendula*) is the most common grass in areas near climax condition. The dominants vary depending mainly on topographic location and past use. The desert shrubs, creosotebush (*Larrea tridentata*) and tarbush (*Flourensia cernua*), commonly occur in the plant communities in the western

portion of the cover type, but they are essentially absent in the eastern part.

Geographic Distribution: This vegetation type covers the western portion of the Edwards Plateau land resource area (also sometimes called the Stockton Plateau). The limestone escarpment south of Sweetwater and Big Springs sharply mark its northern boundary. San Angelo is its middle eastern extent. The following are some of the towns that occur within its borders: Winters, Nolan, Maryneal, Blackwell, Bronte, Sterling City, Garden City, Rankin, Big Lake, Ozona, Eldorado, Mertzon, and Christoval.

Elevations range from about 1,575 ft (525m) above mean sea level on the east to almost 2,950 ft (950m) to the west. Rainfall varies from 20 to 13 inches (50-32cm) from east to west. Climate is subtropical and semiarid with dry, mild winters and hot summers. About 75% of the annual rainfall occurs from April through October. Rainfall peaks are in May and again in October.

Ecological Relationships: Past grazing use has changed the proportions of plant species occurring in this cover type. Topographic features, soil depth, and rainfall largely dictate the species that currently exist. Topography varies from steeply sloping stony hills of hard limestone, to nearly level plateaus, to gently sloping broad drainage areas. Sandy soils are almost nonexistent, with most soils being the finer textured loams, clay loams, and clays. Gravelly and stony soils are associated with the limestone hills. Representative soils that commonly occur throughout the extent of this cover type are Ector gravelly and stony loams on the hills and ridges, Conger clay loam on gently sloping areas at the base of hills, Reagan clay loam on more level areas, and Rio Concho clay loam along flood plains.

Grasses commonly found on these soils include: sideoats grama, cane bluestem (*Bothriochloa barbinodis*), buffalograss (*Buchloe dactyloides*), tobosa grass (*Hilaria mutica*), curly mesquite (*H. belangeri*), black grama (*Bouteloua eriopoda*), hairy grama (*B. hirsuta*), sand dropseed (*Spo-robolus cryptandrus*), plains bristlegrass (*Setaria macrostachya*), fall witchgrass (*Leptoloma cognatum*), Wright's threeawn (*Aristida wrightii*), purple threeawn (*A. purpurea*), vine mesquite (*Panicum obutusm*), Texas wintergrass (*Stipa leucotricha*), and slim tridens (*Tridens muticus*). Commonly occurring shrubs, in addition to honey mesquite, are: cholla (*Opuntia imbricata*), catclaw (*Acacia greggii*), vine ephedra (*Ephedra pedunculata*), tasajillo (*O. leptocaulis*), four-wing saltbush (*Atriplex canescens*), hackberry (*Celtis reticulata*), redberry juniper (*Juniperus Pinchotii*), littleleaf sumac (*Rhus microphylla*), and various pricklypear (*Opuntia* sp.). The following are a few of the many forbs that can usually be found in this cover type: croton (*Croton pottsii*), annual broomweed (*Xantho-cephalum texanum*), broom snakeweed (*Gutierrezia sarothrae*), desert holly (*Perezia nana*), huisache daisy (*Amblyolepis setigera*), doze daisy (*Aphanostephus riddellii*), horehound (*Marrubium vulgare*), Texas thistle (*Cirsium texensis*), Mexican sagewort (*Artemisia ludoviciana*), Gaura (*Gaura coccinea, G. parviflora*), threadleaf groundsel (*Senecio longilobus*), various evening primroses (*Oenothera* sp.), velvet bundleflower (*Desman-thus velutinus*), plains zinnia (*Zinnia grandiflora*), orange zexmenia (*Zexmenia hispida*), bush sunflower (*Simsia calva*), Menodora (*Menodora* sp.), trailing ratany (*Krameria lanceolata*), Englemann daisy (*Englemannia pinnatifida*), filaree (*Erodium* sp.), and tallowweed (*Plantago* sp.).

The wide and varied vegetation along with the vast topographic differences support good populations of deer, turkey, quail, dove, squirrel, many nongame birds, and other animals including javelina.

Variants and Associated Species: Because of the wide ranging environmental conditions, the vegetation, particularly the shrub component, also varies widely. With increased grazing pressure and lack of fuel to carry fires, shrubs have increased in the vegetative composition. Creosotebush and tarbush commonly occur in the western portions of the type along with honey mesquite and four-wing saltbush. Burrograss (*Scleropogon brevifolius*) also becomes more common and is often an understory dominant. Bush muhly (*Muhlenbergia porteri*) also grows intermingled with the shrubs in such areas. In the shallower rocky soils redberry juniper, feather dalea (*Dalea formosa*), javelina bush (*Condalia ericoides*), skeletonleaf goldeneye (*Viguiera stenoloba*), mariola (*Parthenium incanum*), sotol (*Dasylirion* sp.) and lechuguilla (*Agave lecheguilla*) are additional species. In the northern and eastern part of this type, shin oak (*Quercus mohriana*) occurs with the junipers on rocky slopes and ridges. On bottomlands and in valleys along major streams are the only places tall grasses and large trees can grow. Here one can find Indiangrass (*Sorghastrum nutans*), little bluestem (*Schizachyrium scoparium*), switchgrass (*Panicum virgatum*), Canada wildrye (*Elymus canadensis*), Columbia needlegrass (*Stipa columbiana*), elm (*Ulmus americana*), pecan (*Carya illinoinensis*), black walnut (*Juglans nigra*), live oak (*Quercus virginiana*), Bumelia (*Bumelia lanuginosa*), willow (*Salix* sp.), greenbriar (*Smilax* sp.), mustang grape (*Vitis mustangensis*), and button bush (*Cephalanthus occi-dentalis*) along with the ubiquitous honey mesquite.

Bill E. Dahl
Texas Tech University
Lubbock, TX

SAND SHINNERY OAK
SRM 730

Definition, Composition, and Structure: This cover type is dominated throughout its range by the low-growing sand shinnery oak (*Quercus havardii*). The dominant grass in good condition range is sand bluestem (*Andropogon gerardii* var. *paucipilus*) to the north, while mixed dropseeds (*Sporobolus* sp.) are most abundant to the south. According to Allred (1956), this type is known as the High Plains Bluestem Community which is considered post-climax vegetation because of the course-textured soils of the area.

Geographic Distribution: The type is best represented in central west Texas, Southern High Plains of Texas, and eastern New Mexico, the Canadian River breaks, and western Oklahoma. It occurs on sandy soils in areas characterized by precipitation ranging from 14 to 22 inches (35-55cm) per year.

Ecological Relationships: Soils are generally classified as Entisols on the dunes, while level landscape positions are Alfisols. Dunal sands are lighter colored which reflect the abrasive action of wind upon individual sand grains. In the more northern parts of this cover type, the soil color becomes brown-red reflecting sand grain coatings of iron oxides and similar minerals. Water infiltration is high and essentially no surface runoff occurs. Fertility is low, and soil organic matter may be as low as 0.20% (Small, 1975).

The oak seldom grows more than 3 ft (1m) tall, yet there may be isolated colonies up to 10 ft. tall. These taller mottes are purported to be hybrids. Canopy cover may approach 90% on some sands, but averages 20 to 30% throughout its range. Biomass of oak usually will be between 1,000 to 2,200 lb/acre (1100-2400kg/ha). Only traces of other shrubs are found in this community with *Artemisia, Rhus, Chrysothamnus*, and *Prunus* scattered throughout. Herbaceous yields vary with range condition, soil type, and precipitation. In a typical oak-bluestem type, grasses may yeild up to 550 lb/acre (600kg/ha) with forbs averaging less than 100 lb/acre (110kg/ha).

The type is sometimes cultivated, but becomes an erosion hazard when the vegetative cover is removed. Principal use is summer grazing for cattle. The major wildlife species using this habitat are the lesser prairie chicken (*Tympanachus pallindinctus*) and the pronghorn antelope (*Antelocapra americana*). Cattle stocking rates will range from 60 to 25 acres (24-10ha) per animal unit per year.

Resource uses other than grazing and wildlife are limited in this type. No mining-other than petroleum, forestry, or watershed values exist. Recreational use is very limited.

Variants and Associated Species: As grazing intensity increases, the taller grasses sand bluestem, giant dropseed (*Sporobolus giganteus*), Havard's panicum (*Panicum havardii*), little bluestem (*Schizachyrium scoparium*), and giant sandreed (*Calamovilfa gigantea*) decrease. In poor to fair range condition purple threeawn (*Aristida purpurea*), sand dropseed (*S. cryptandrus*), hairy grama (*Bouteloua hirsuta*), red lovegrass (*Eragrostis secundiflora*), and thin paspalum (*Paspalum setaceum*) become more important. The annuals are false buffalograss (*Munroa squarrosa*), grass bur (*Cenchrus incertus*), and purple sandgrass (*Triplasis purpurea*) which are locally abundant around watering facilities or after heavy rainfall (Pettit, 1979).

The most common forb component includes prairie greenthread (*Thelesperma megapotimicum*), James' cryptantha (*Cryptantha jamesii*), James' nailwort (*Paronychia jamesii*), and western ragweed (*Ambrosia psilostachya*) (Jones and Pettit, 1984). Occasionally, annual buckwheat (*Eriogonum annuum*) is aspect dominant in late summer. About 40 other forb species are regularly found in this type.

With herbicidal control, large areas of the oak-bluestem type can be converted to a mid to tall grass prairie aspect. A new hazard to converted acreage is wildfire caused by lightning and man.

Russ Pettit (Retired)
Texas Tech University
Lubbock, TX

CROSS TIMBERS—OKLAHOMA
SRM 731

Definition, Composition, and Structure: Noncommercial timber oak (*Quercus* sp.) trees characterize this vegetation type, which is sometimes called upland forest or oak savannah. Post oak (*Q. stellata*) and blackjack oak (*Q. marilandica*) are universal overstory codominants, and shrubs and vines dominate the understory (Bruner 1931, Penfound 1963, Rice and Penfound 1959, and Dwyer and Santelmann 1964). Species diversity generally increases in the east, and black hickory (*Carya texana*) becomes increasingly important eastward (Rice and Penfound 1959). This type is distinguished from the mesic deciduous forest types to the east by lower-statured trees and by composition of the overstory. Little bluestem (*Schizachyrium scoparium*) and tall grasses dominate the herbaceous layer (Dwyer and Santelmann 1964, Ewing et al. 1984).

The Cross Timbers is generally a closed forest, although the original character was likely a mosaic of grassland, savannah-like grassland with oak mottes, and oak thickets (Johnson and Risser 1975, Penfound 1962, Rice and Penfound 1959). Periodic dormant season fires may have produced prolific resprouting on upland sites (Dyksterhuis 1948, Harlan 1958) resulting in a patchwork of thickets which were a formidable obstacle to early travel (Rice and Penfound 1959). Fire may have maintained a savannah on mesic sites where fuels accumulated to produce fires with sufficient intensity to cause high tree mortality and convert the closed forest to savannah (Rice and Penfound 1959,

Johnson and Risser 1975, Anderson and Brown 1986). Frequent intense fires ceased after settlement, because livestock reduced fuel accumulations and a closed canopy of trees developed which further reduced the likelihood of fuel accumulation to support intense fire (Rice and Penfound 1959, Ehrenreich and Crosby 1960, Box 1967, Johnson and Risser 1975).

Geographic Distribution: The Cross Timbers is the western extension of the Ozark Plateaus, a portion of the oak-hickory forest, which comprises an area of 47 million acres (19 million ha) west of the Mississippi River and south of the Missouri River (Rice and Penfound 1959, Garrison et al. 1977). This cover type occurs in a band generally less than 100 miles (160km)wide from northeast Kansas, across northeast to south central Oklahoma, and into north central Texas. Stands of the type are found on deep sands or fractured sandstone more than 100 miles (160km) to the west of this band.

Ecological Relationships: The Cross Timbers is the focus of a broad eco- tone between forest and grassland. The climate has been termed savannah in that it is neither forest nor grassland (Dyksterhuis 1957, Rice and Penfound 1959). Factors that affect plant-available moisture, particularly soil texture, influence the vegetation (Johnson and Risser 1972). A mosaic of low-statured upland forest and prairie is, therefore, typical of much of the Cross Timbers because of the heterogeneity of the soils, which are derived from interbedded sandstones and shales (Gray and Galloway 1959, Gray and Stahnke 1970, Powell and Lowry 1980). In the central and southern portions of the Cross Timbers, grasslands result from past clearing and subsequent abandonment. Site potential has generally been lowered because of severe topsoil erosion and much of these lands continue to be dominated by lower successional herbaceous species typical of abandoned cropland in the tall grass prairie (Booth 1941, Rice 1971).

Climate of the Cross Timbers, with only 25 to 40 inches (63-100cm) average annual precipitation, is marginal for tree survival, so deciduous trees are generally restricted to coarse textured soils (Rice and Penfound 1959). Fine textured soils of adjacent and interspersed grasslands are sufficiently droughty in late summer to prevent direct invasion of deciduous trees. Drought intolerant tree species will indirectly invade prairies following microclimate modification by eastern red cedar (*Juniperus virginiana*) and various shrubs which invade these sites in the absence of fire (Bragg and Hulbert 1976, Petranka and McPherson 1979). Large trees die in periods of severe drought (Albertson 1940, Dyksterhuis 1948, Rice and Penfound 1959), a long-term control feature in the prairie-forest ecotonal balance.

Brush control with herbicides is the major range improvement practice in the Cross Timbers (Engle 1987). Significant increases in herbaceous species and forage production follow control of the overstory trees. A major concern is the secondary brush control problem which results from resprouting of oaks and the release of species not susceptible to the herbicide. Follow-up control measures are necessary, because woody plant growth will eventually cause forage production to decline to pretreatment levels or below.

Variants and Associated Species: Bottomland forest, which includes the upland woody species mixed with oak-hickory forest species, occupies narrow bands along stream courses (Rice 1965, Garrison et al. 1977, Ewing et al. 1984). Prairies dominated by little bluestem and tall grasses are naturally occurring on fine textured soils in the region.

David Engle
Oklahoma State University
Stillwater, OK

CROSS TIMBERS—TEXAS LITTLE BLUESTEM—POST OAK SRM 732

Definition, Composition, and Structure: The Cross Timbers vary in structure from mid- and tall grassland with a few scattered oak trees to nearly closed canopy woodlands with a sparse herbaceous layer. A shrub layer of varying density may also be present. Trees are generally somewhat stunted in growth form and rarely exceed 30 ft (10m) in height on upland sites. Closed woodlands are considered to be more common today as compared to pristine conditions, however, historical records indicate the presence of areas of dense woods at the time of first observation by European man. Post oak (*Quercus stellata*) is the most abundant and widespread tree species. Blackjack oak (*Q. marilandica*) is also widespread, but not nearly so abundant. Trees of lesser importance, but sometimes of local abundance, are hackberry (*Celtis laevigata*), cedar elm (*Ulmus crassifolia*), eastern red cedar (*Juniperus virginiana*), Texas oak (*Q. texana*), and liveoak (*Q. virginiana*). Important shrubs are coralberry (*Symphoricarpos orbiculatus*), fragrant sumac (*Rhus aromatica*), and stunted saplings of the tree species; while greenbriar (*Smilax* sp.) is a widespread and locally abundant vine. The herbaceous layer in late-successional communities is dominated by little bluestem (*Schizachyrium scoparium*) with Indiangrass (*Sorghastrum nutans*) and big bluestem (*Andropogon gerardii*) as important secondary species. Sideoats grama (*Bouteoula curtipendula*), hairy grama (*B. hirsuta*), and tall dropseed (*Sporobolus asper*) may be locally abundant. In many places the Cross Timbers inter-digitate with or form a mosaic with Blackland Prairie communities. The Cross Timbers occur on Alfisols while the Prairies occur on Mollisols and Vertisols. Several major rivers and their tributaries cross the region and add diversity to the landscape and the vegetation. Riparian areas are

characterized by Elm-Ash-Oak-Pecan (*Ulmus-Fraxinus-Quercus-Carya*) forests. Much of the upland and bottomland was converted to cropland for production of corn, cotton, wheat, sorghum, and peanuts. Some cropland has been returned to permanent pastures of introduced species including Bermudagrass (*Cynodon dactylon*), KR bluestem (*Bothriochloa ischaemum*), and Kleingrass (*Panicum coloratum*).

Geographic Distribution: The Cross Timbers, as defined here, occur in north central Texas. There are two major subdivisions; the eastern, 864,000 acres (345,600ha) and western 2,000,000 acres (800,000ha) Cross Timbers. Both extend from the Red River (Oklahoma) to central Texas. The two areas are separated by the Grand Prairie, a division of the Blackland Prairies. Precipitation varies from 35 inches (88cm) on the east to 30 inches (75cm) on the west. Drought is a recurrent feature of the region. Soils are primarily Alfisols, and the landscape is generally gently rolling with dissection by many rivers and streams. Little natural wetland exists, however, there are numerous stock tanks and some larger reservoirs across the area.

Ecological Relationships: The Cross Timbers occur on the dry western margin of the oak-hickory forests of eastern North America. Similar vegetation extends into eastern Oklahoma and southeastern Kansas. Most species have eastern biogeographic affinities. While most late-suc-cessional herbaceous species have relatively high grazing resistance under deferred grazing regimes, most are greatly reduced in abundance or vigor by heavy continuous grazing. With reduction in the climax dominants, mid or short perennial grasses increase. Included are: sideoats grama, Texas wintergrass (*Stipa leucotricha*), tall dropseed, hairy grama, buffalograss (*Buchloe dactyloides*), and threeawns (*Aristida* sp.). If grazing pressure is intense for a long period, these species may be replaced by annual grasses such as oldfield threeawn (*A. oligantha*) and Japanese brome (*Bromus japonicus*), and annual forbs. Large areas of native rangeland exist across the area but most are dominated by mid to low successional species due to past overgrazing. Overgrazing and removal of naturally occurring fires enhances the invasion of woody species. However, in the absence of fire even excellent condition communities are ultimately invaded by woody species, albeit at much slower rate than overgrazed areas.

Variants and Associated Species: A great variety of major and minor plant communities occur across the area. There are great variations in the kind, proportion, and amount of the component species in the climax communities and in the degree of closure of the tree stratum. Combinations of species can be found in the various retrogression and secondary successional pathways. The great interspersion of upland savannahs and prairies with bottomland forests adds a great deal of variety to the vegetational pattern of the region, and provides a great deal of edge which contributes to plant and animal diversity.

Fred Smeins
Texas A&M University
College Station, TX

JUNIPER-OAK
SRM 733

Definition, Composition, and Structure: Ashe juniper (*Juniperus ashei*) and liveoak (*Quercus virginiana*) are the dominant overstory plants in this cover type and may attain heights of more than 30 ft. (10m). A rich variety of grasses and forbs form the understory. Little bluestem (*Schizachyrium scoparium*) is the most common component of the understory in areas of near climax condition. The dominants vary in importance from location to location depending on slope, exposure, soil characteristics and grazing history.

Geographic Distribution: This cover type is best represented in central Texas on the Edwards Plateau that lies north and west of the Balcones Escarpment. The major area covered is about 200 miles (320km) east to west and 250 miles (400km) north to south. The area is bounded by Austin on the east, San Antonio on the south, Del Rio to the west, and Brownwood on the north.

This type is bordered by the TransPecos on the west, the Rolling Plains to the north, the Blackland Prairies on the east, and the South Texas Plains to the south.

Ecological Relationships: The proportional representation of Ashe juniper and liveoak in the stand varies with slope, exposure, soil conditions, and past grazing history. Ashe juniper reaches its greatest development on the steeper slopes and shallow soils, while liveoak is best developed on the more level sites with deeper soils. Properly grazed, well-managed areas have an understory dominated by little bluestem often accompanied by big bluestem (*Andropogon gerardii*) and Indiangrass (*Sorghastrum nutans*). There is a rich array of grasses including sideoats grama (*Bouteloua curtipendula*), buffalograss (*Buchloe dactyloides*), curly mesquite (*Hilaria belangeri*), plains lovegrass (*Eragrostis intermedia*), Texas wintergrass (*Stipa leucotricha*), green sprangletop (*Leptochloa dubia*), Texas grama (*B. rigidiseta*), vine mesquite (*Panicum obtusum*), plains bristlegrass (*Setaria leucopila*), Hall's panicum (*P. Hallii*), and several threeawns (*Aristida* sp.). The understory also contains a wide variety of shrubs including agarito (*Berberis trifoliolata*), Texas persimmon (*Diospyros texana*), Texas pricklypear (*Opuntia lindheimeri*), tasajillo (*O. leptocaulis*), hackberry (*Celtis reticulata*), redbud (*Cercis occidentalis*), Texas ash (*Fraxinus texensis*), kidney wood (*Eysenhardtia texana*), and whitebrush (*Aloysia lycioides*). Forbs such as filaree (*Erodium* sp.), bur clover (*Medicago hispida*), tallow weed (*Plantago* sp.), greenbriar (*Smilax* sp.), senna (*Cassia* sp.), and sage (*Salvia* sp.) are common. This very wide variety of vegetation supports good populations of quail, dove,

turkey, and deer.

The climate is characterized by hot summers and relatively mild winters. Annual precipitation varies from about 20 inches (50cm) on the western edge to about 32 inches (80cm) on the east. Peak rainfall occurs in April, May, and June with a second peak in September and October. Hot, dry summers are typical, and drought is a common occurrence. The topography varies from a level plateau to very steep canyons and rough drainages.

Most of the area is underlain by fractured limestone. The soils are predominantly shallow, rocky, fine-textured, and rich in calcium. The majority of the soils are Mollisols which are representative of grasslands. A few of the soils are Vertisols and many other have vertic properties.

Variants and Associated Species: The Juniper-Oak Savanna covers a great expanse of country and varies accordingly. The extremes vary from stands of open grassland to closed canopy almost pure stands of liveoak or Ashe juniper. Ashe juniper tends to invade and dominate areas that are mismanaged, overgrazed with cattle, and protected from fire. As a rule, areas that are heavily used by sheep, goats, and deer move toward a dominance of the grasses. There is some geographic variation in this cover type. The vegetation tends toward smaller stature in the western portions of the cover type. Mesquite (*Prosopis glandulosa*) increases in importance along with redberry juniper (*Juniperus pinchotii*). Cedar elm (*Ulmus crassi-folia*) is very common on the east side and declines rapidly toward the west.

All of this cover type is extensively grazed for the production of cattle, sheep, goats, and deer. Stocking rates have been excessive historically and have resulted in vegetational changes. Taller grasses have given way to the shorter grasses such as Texas winter grass, buffalograss, curly mesquite, and sideoats grama.

Roy V. Miller, Jr.
Southwest TX State University
San Marcos, TX

MESQUITE-OAK
SRM 734

Definition, Composition, and Structure: Live oak (*Quercus virginiana*), post oak (*Q. stellata*), and honey mesquite (*Prosopis glandulosa*) are the dominant woody species, and they provide the visual aspect to the area. A rich variety of grasses and forbs are common understory in more advanced successional stages. In climax, the grasses would typically be tall grass species, but vary according to soils and sites.

Geographic Distribution: The Mesquite-Oak Savannah occupies a relatively small area of approximately 1.7 million acres (0.68 million ha) in the Central Basin Major Land Resource Area of Texas. It includes parts of Llano, Mason, Gillespie, Burnet, San Saba, and McCullock counties. Approximately 90% of the area is rangeland.

The landscape is typically rolling to hilly with an elevation of 975 to 1,800 ft (325-600m). Annual rainfall averages from 25 to 30 inches (63-75cm).

The upland soils of this area are characterized by reddish brown to brown neutral to slightly acid, mostly gravelly and stony sandy loams. These soils are shallow over granite, limestone, gneiss and schist. Deeper, less stony sandy loam soils occur in the valleys. The major soil series of the uplands and valleys include Pontotoc, Pedernales, Ligon, Castell, Katemcy, Hensley, and Voca. The bottomland soils are minor areas of dark gray, alluvial soils including the Frio, Gowen, and Oakalla series.

Ecological Relationships: Typical existing vegetation in this region consists of scrubby woody species, short and mid-grasses, and a variety of annual and perennial forbs. Live oak, post oak, and honey mesquite are the dominant woody species. Other woody shrubs which are found in lesser amounts, include bumelia (*Bumelia lanuginosa*), Texas persimmon (*Diospyros texana*), agarito (*Berberis trifoliolata*), whitebrush (*Aloysia lycioides*), and cedar elm (*Ulmus crassifolia*0. Ashe juniper (*Juniperus ashei*) is found on rocky slopes and hilltops.

The major native grass species found in this area are sideoats grama (*Bouteloua curtipendula*), little bluestem (*Schizachyrium scoparium* var. *frequens*), buffalograss (*Buchloe dactyloides*), curly mesquite (*Hilaria belangeri*), hairy grama (*Bouteloua hirsuta*), Texas wintergrass (*Stipa leucotricha*), purple threeawn (*Aristida purpurea*), and Texas grama (*B. rigidiseta*). Many sedges (*Carex* sp.) are found beneath dense overstory canopy.

The native forbs which typify this area include Texas bluebonnet (*Lupinus texensis*), rosering gaillardia (*Gaillardia pulchella*), orange zexmenia (*Zexmenia hispida*), bush sunflower (*Simsia calva*), Engelmann daisy (*Engelmannia pinnatifida*), Mexican sagewort (*Artemisia mexicana*), and numerous annuals.

Climax vegetation includes most of the previously mentioned species, but also includes Indiangrass (*Sorghas-trum nutans*), big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), sand lovegrass (*Eragrostis trichodes*), green sprangeltop (*Leptochloa dubia*), purpletop (*Tridens flavus*), and Texas cupgrass (*Eriochloa sericea*). King Ranch bluestem (*Bothriochloa ischaemum*) has been seeded on thousands of acres in this region. It is well adapted and has spread to adjacent pastures and fields, where it is managed like a native range species. Kleingrass (*Panicum coloratum*) is another introduced species which has been seeded in this region and is managed as a native species.

Dan M. Caudle
Temple, TX

SIDEOATS GRAMA-SUMAC-JUNIPER SRM 735

Definition, Composition, and Structure: This type has the aspect of a community dominated by warm season grasses with a variety of shrubs, halfshrubs, and trees. Often the woody species include true mountain mahogany (*Cercocarpus montanus*), skunkbush sumac (*Rhus trilobata*), one-seeded juniper (*Juniperus monosperma*), and shrub live oak (*Quercus turbinella*) and will give an aspect of dominance. This site is dominated by sideoats grama (*Bouteloua curtipendula*), black grama (*B. eriopoda*), blue grama (*B. gracilis*), and little bluestem (*Schizachyrium scoparium*). Forbs and cool season grasses comprise a minor part of the community.

Geographic Distribution: This type occurs on steep and very steep slopes along the sides of valleys, streams, and mesas. It also occurs on mesa tops, hillsides, and fans at the foot of escarpments. Slopes can range from 5 to 25%, but can range to more than 80% at escarpments. Elevations range from 3,280 to 4,600 ft (1100-1530m).

Ecological Relationships: Climate of the area is semiarid continental. The average annual precipitation ranges from 13 to 16 inches (32-40cm). Approximately 75% of the precipitation occurs May to October. The soils are well-drained, shallow to very shallow over caliche or sandstone. Surface texture is typically medium to fine-textured and is often stony or gravelly. Surface runoff is rapid. This cover type often has "live water" from drainages and springs along escarpment with good feeding and nesting cover for wildlife. Resident animals include mule deer, bobcat, spotted skunk, eastern cottontail, ringtail cat, white throated raven, and prairie and diamondback rattlesnakes.

Variants and Associated Species: Many variants occur in this type, ranging from monocultures of grasses in concave sites within the escarpment area to dense stands of juniper and skunkbush sumac. There is little grass understory. Past management, limited to livestock access, has resulted in heavily utilized and lightly utilized areas. Associated grasses that might be present include bottlebrush squirreltail (*Sitanion hystrix*), New Mexico feathergrass (*Stipa neomexicana*), and wolftail (*Lycurus phleoides*). Pinyon pine (*Pinus edulus*) and mesquite (*Prosopis glandulosa*) also occur. Mesquite, juniper, cholla (*Opuntia imbricata*), and skunkbush sumac can become codominant when poor management conditions favor their invasion.

Herman B. Garcia
Tucumcari, NM

Rangeland Cover Types of the SOUTHEASTERN REGION

INTRODUCTION SRM 800

This region includes eastern Texas, eastern Oklahoma, and states east, including Missouri, that have significant range cover types. This is a diverse area in that it extends from the Florida flatwoods and freshwater marshes to the Missouri savanna and prairies. The gulf salt marsh which runs along the Gulf of Mexico from Texas to Florida is also included. Most of the true range cover types in the southeast have been plowed up and are now classified as cropland or introduced forages (pasture). The rainfall is normally abundant and ranges from 36 inches in northwest Missouri to more than 60 inches in northwest Florida.

David W. Sanders
Soil Conservation Service
Jackson, Mississippi

SAVANNA SRM 801

Definition and Composition: Savanna is characterized by an understory of mid to tall prairie grass and almost completely absent of a shrub layer. The overstory consists of oak-hickory-conifer canopy that covers 10 to 50 percent of the area. This cover type is quite varied and depends on the soil moisture and various soil substrates.

Geographic Distribution: Savanna cover type occurs throughout Missouri, but has become rare, as an obvious feature in Missouri, especially in the northern half of the state where it formerly may have occupied millions of acres. This cover type has a great potential for recovery under proper management techniques.

Ecological Relationships: Savanna is generally regarded as successional area between forest and true tall grass prairie. This cover type was maintained by herbivores, fire and local edaphic features. With the introduction of row cropping, logging, overgrazing and prevention of fire most of this cover type has been destroyed or succeeded to timber and lost much of its prairie character.

Very few acres of high quality easily recognized savanna remain in Missouri. Many acres of isolated but im-poverished tracts can still be found. This cover type, through proper grazing and judicious use of fire, could be returned to a highly productive range site.

Variants and Associated Species: Nine separate types of savanna are recognized by Nelson (1987). Because most of these types are now very rare they will be considered as variants of the major type. Soil moisture and near surface substrate which affected rooting and soil moisture appear to be major factors determining the vegetation associations of this type.

Variants occur in all ecological settings where forest and tall grass prairie occur in association. The deeper and loess and glacial till soils of northern Missouri produced a bur oak (*Quercus macrocarpa*), shingle oak (*Q. imbricaria*), post oak (*Q. stellata*), white oak (*Q. alba*) overstory. In the more mesic sites pecan (*Carya illinoensis*) and black willow (*Salix nigra*) replace some of the species of trees from the drier sites. South of the Missouri River on the shallower (0-40 in.) soils eastern red cedar (*Juniperus virginiana*), post oak (*Q. stellata*), black jack oak (*Q. velutina*) and shortleaf pine (*Pinus echinata*) dominate the overstory.

Frederick D. Hassien
Lincoln University
Jefferson City, MO

MISSOURI PRAIRIE SRM 802

Definition and Composition: Nelson (1987) identifies fourteen prairie natural communities that in presettlement Missouri covered 18,484 square miles (48.058 sq. ha) or 26.7 percent of the state (Schroeder 1981). Nelson described these fourteen communities using soil moisture and various substrate modifiers such as underlying rock or hardpans.

Much of the former prairie has been eliminated by agriculture, urban development and lack of fire. Most of the fourteen communities recognized by Nelson are now very rare or at least uncommon. There still exist well in excess of 25,000 acres (10,000ha) of native warm season grass prairie in Missouri. Most of this prairie occurs in small tracts of 5 to a few 100 acres (2-40ha). A number of larger tracts (>1000 acres) are preserved in state and federal parks.

Numerous efforts are being made to reestablish prairie grasses in Missouri. Some authorities in Missouri include the glade as prairie cover type but because of the uniqueness and distinctive quality of the glades they should be considered as a separate cover type.

Geographic Distribution: Prairie historically occurred throughout the state but with greatest concentrations in the north and western half of the state. Much of the former

prairie are now Missouri's prime farm lands.

Ecological Relationships: Prairie in Missouri is diverse and ranges from the dry or "loess hills" prairie dominated by buffalograss (*Buchloe dactyloides*), blue grama (*Bouteloua gracilis*), little bluestem (*Schizachyrium scoparium*), hairy grama (*Bouteloua hirsuta*), and sideoats grama (*Bouteloua curtipendula*) to wet prairie dominated by cord grass (*Spartina pectinata*), reed canary grass (*Phalaris arundinacea*) and sedges (*Carex* spp.). The mesic prairie occur on rich, well drained deep soils which are dominated by big bluestem (*Andropogon gerardii*), indian grass (*Sorghastrum nutans*) and prairie dropseed (*Spo-robolus heteroplepis*). Missouri is ecologically centered in the U.S. and contains many plants that are restricted, rare, or endangered in Missouri but may be common in other states. The "loess hills" prairie have many plants that are typically found in the Great Plains and are adapted to low moisture availability even though the annual precipitation in Missouri ranges from approximately 35 to over 50 inches (88-125cm) per year.

Frederick D. Hassien
Lincoln University
Jefferson City, MO

MISSOURI GLADES
SRM 803

Definition and Composition: Missouri glades occupy approximately 0.5 million acres (0.2 million ha) and are divided into six types based on substrate composition: dolomite, limestone, sandstone, igneous rocks, chert, and shale. Missouri glades have a unique flora possessing many adaptations for survival in widely fluctuating environments.

The vegetation is composed primarily of herbaceous plants such as big bluestem (*Andropogon gerardii*), little bluestem (*Schizachyrium scoparium*) and sideoats grama (*Bouteloua curtipendula*). The dolomite glades represent nearly 98 percent of the total glade area in Missouri the other five account for less than 25,000 acres (10,000 ha). The dolomite glades will be described for Missouri range type - Missouri Glades. Dolomite glades are typically unforested xeric rocky sites dominated by a distinctive non-woody flora. They are characterized by shallow soils with exposed bedrock. Glades typically occur on hilly or mountainous terrain with deeply dissected drainages. Most occur on moderate to steep slopes especially those with southern or western exposure.

Geographic Distribution: Dolomite glades occur south of the Missouri River throughout all the central counties. Large expanses of dolomite glades occur in the vicinity of Ava, Missouri.

Ecological Relationships: Dolomite glades often occur on southern or western exposures and are characterized by bedrock at or near the surface. Soil cover is thin and interspersed with exposed barren bedrock or rock fragments.

Vascular plants dominate the glades and are strongly influenced by tall grass prairie species such as little bluestem (*Schizachrium scoparium*), sideoats grama (*Bouteloua curtipendula*) and indian grass (*Sorghastrum nutans*). Restricted or endemic species occur in various areas of the glades associated with specific substrate or ecological conditions.

Many glade plants exhibit adaptations characteristic of desert plants such as succulence, reduced leaf area, dense pubescence and ephemeral life cycle. Saxicolous and terricolous macrolichens are common occurrences throughout the glades (Ladd and Nelson 1982).

Fire is an important factor in the ecological relationship of the glades. But, because of the xeric nature and shallow soils that are frequently disrupted by frost upheavals, glades may not be as dependent on frequent fires as are the prairies.

Frederick D. Hassien
Lincoln University
Jefferson City, MO

TALL FESCUE
SRM 804

Definition and Composition: The Tall Fescue (*Festuca arundinacea*) cover type is extremely variable in Missouri, this cover type occupies over 6 million acres (2.4 million ha) of introduced grass. It is found in virtually every grazing site, along road borders, in yards and as a weed in warm season grass plantings and native prairies.

Tall Fescue now occupies land formerly vegetated with trees or savanna and frequently found as the dominant understory on land that far exceeds the 16.7 percent stocking that is used by the U.S. Forest Inventory to define improved pasture and rangeland with trees (ground land use item 52). Much of this land, especially in the Ozarks, is extensively managed and frequently occurs as large pastures (>640 acres) and have been maintained as pasture for many years. The fescue in combination with grazing is very competitive with woody plants and can be maintained as grazing lands with only extensive management.

Considerable acreage, well in excess of 25,000 acres (10,000ha), meet the criteria of the USDA regulation number 9500-5 Policy on Range, definition "a". Much of the Ozark fescue pasture occurs on lands defined by the U.S. Forest Ecological Classification System for Missouri as; oak-hickory forest, oak-hickory pine forest, and to some extent as cedar glades.

The Tall Fescue cover type can be broadly divided into two major categories: 1. North Missouri Fescue Cover

Type, and 2. Fescue-Broomsedge Cover Type.

North Missouri Fescue Cover Ozark Type: This cover type is predominantly highly productive and intensively managed. Very little could be referenced as a "Rangeland Cover Type".

Ozark Fescue-Broomsedge Cover Type:

Definition and Composition: The Ozark Fescue-Broomsedge cover type comprises an area in excess of 2 million acres (0.8 million ha). Historically the vegetation consisted of pure forest interspersed with savanna like grasslands. This area is interspersed with intensively managed and extensively managed pastures. Virtually all the grazing lands are dominated by tall fescue. This cover type is very persistent and wide spread and probably will remain indefinitely under moderate maintenance. The likelihood of the type changing is in proportion to the likelihood of finding another grass that could replace fescue's adaptability, resistance to abuse, forage quality and response to fertilizer. Broomsedge (*Andropogon virginicus*) and Purple-top (*Tridens flavus*) are major native grass increasers in acidic and low fertility sites. Honey Locust (*Gleditsia triacanthos*) and Osage Orange (*Maclura pomifera*) are common wood increaser. Multiflora Rose (*Rosa multiflora*), an introduced species, is a common woody invader.

Geographic Distribution: The Ozark Fescue-Broomsedge cover type is part of the Tall Fescue cover type that has been introduced as the major cover type throughout Missouri.

This type is principally defined as that portion of Missouri lying south of the Missouri River encompassing all the southern counties except portions of the Boot Heel in the south east. This geographic area is defined by Fenneman (1938) as the Ozark Plateau Province and is further defined as the St. Francis Mountains Section, the Salem Plateau Section and the Springfield Plateau Section by the USDA Forest Service (1981). The type extends into northern Arkansas.

The area east of Springfield, Missouri and west of Poplar Bluff, Missouri is the heart of the Ozark Fescue-Broomsedge cover type.

Missouri Glades lie within the boundary of the Ozark Fescue-Broomsedge cover type. Many of the glades have been converted to fescue. Because of the difficulty in maintaining these sites many are reverting back to prairie or cedar.

Ecological Relationship: In general the Ozark Fescue-Broomsedge cover type can be defined in direct relationship to topography, aspect and former natural vegetation. All of these relate directly to the soil.

The Ozark Plateau Province is a dissected upland resulting in a topograph that can generally be represented as bottoms, flats, hills and breaks.

The bottoms and flats are the most intensively managed portion of this cover type because of easy accessibility with farm equipment. They are used for seed production, hay and grazing. In many cases all three production processes occur on the same pasture each year.

The bottoms (0 to 4% slope) are frequently broad (>.5 mile) and occur in relationship to drainage patterns. The bottoms have a wide ecological variation ranging from narrow bottoms encompassed primarily by riparian habitat to broad stream basins displaying second bottoms or terraces. Soil depth in these bottoms depend upon the depositional history and may have deep fertile soils or shallow soils underlaid or mixed with stream washed gravel. The shallow gravel underlaid soils are droughty and subject to obvious water stress conditions.

The flats (0 to 10% slope) are represented by narrow ridges (few feet) to broad (>.25 mile) gently rolling and were historically vegetated with white and red oaks in the permeable soils and with savanna like grasslands in soils with an impermeable fragipan.

The hills and breaks are steeper and frequently have surface rock. These sites are more extensively managed due to the steeper and broken terrain. The native vegetation of the hills and breaks was predominantly forest with interspersions of savanna type prairie. The northern slopes predominated in white and red oak with true forest understory. Prairie grass grasslands tended to occur on the south and southwest slopes. The north slopes provide the most productive sites for the Ozark fescue type becuase of its cooler more moderated micro-climatic conditions.

Frederick D. Hassien
Lincoln University
Jefferson City, MO

RIPARIAN
SRM 805

There are 56,000 miles (89,600km) of active streams and rivers in Missouri. This does not include many small drainages and associated areas that could be classified as riparian. When these associated areas are included in the calculation the estimated riparian habitat exceeds 80,000 miles.

No classification of these riparian cover types have been attempted in Missouri. Just recently (approx. 1985) two agencies joined efforts to develop management recom-mendations. No other valid information for the riparian cover type is available at present in Missouri.

Frederick D. Hassien
Lincoln University
Jefferson City, MO

GULF COAST SALT MARSH
SRM 806

Definition, Composition, and Structure: Natural plant community composition and productivity is essentially a grass-forb (grass - 76 percent, forbs - 25 percent) community that is tolerant to high salinity and frequent flooding by wind and lunar tides. This type has been formed under a long frost-free growing season with a super abundance of moisture. This vegetation starts at the edge of the Gulf in some cases and extends inland from .5 to 23 miles (0.8-37km). The further inland it extends, the less salinity and tidal flooding this community receives.

The main constituents of this marsh are smooth (*Spartina alterniflora*), marshhay (*S. patens*) and big cordgrass (*S. cynosuroides*), seashore saltgrass (*Distichlis spicata*), saltmarsh (*Scirpus robustus*) and Olney bulrush (*S. olneyi*), common reed (*Phragmites communis*), and seashore paspalum (*Paspalum vaginatum*). Smooth and marshhay cordgrass and seashore saltgrass are the most numerically abundant.

This site can be used for grazing wherever soils are firm enough to support livestock. Mosquitos are a problem during the late spring, summer and early fall. Most cattle are removed from the marsh during this time and taken to the piney woods. In some instances, cattle raised on marshland have been afflicted by rickets. To be safe, mineral supplements should be made available the entire time they are in the marsh area.

Geographic Distribution: The Gulf Coast Salt Marsh extends the entire length of the coast along the Gulf of Mexico. It is more extensive along southeast Texas, Louisiana, and Florida coasts.

Ecological Relationships: The relief is flat or conclave, with slopes of less than .5 percent. Elevation ranges from +2 to -2 feet mean Gulf level. Minor differences in elevation have a great affect on dominant vegetation.

The soils of the salt marsh consist of deep, fine-textured materials with some deposits of peat or muck over a mineral substratum. Runoff is very slow due to the elevation. Permeability is very slow, with no internal drainage.

Principal invading species are annuals such as fall panicum (*Panicum dicholomiflorum*), cockspur (*Echo-nochloa* sp.), pluchea (*Pluchea* sp.), and others. Perennial invaders include slim aster (*Aster* sp.), smartweeds (*Polygonum* sp.), dogfennel (*Eupatorium capillifoluim*), bigleaf sumpweed (*Iva fruitescens*), and rattlebox (*Daubentonia texana*). The latter two are woody plants which greatly reduce forage production.

This natural plant community provides a potential habitat for the following species of wildlife on a year-long or seasonal basis. The dominant species being: Muskrat, nutria, raccoon, otter, mink, swamp rabbit, alligator, ducks, geese and others.

References include Charbreck, 1972; Lynn et al, 1974; Newsom, 1967; Shiflet, 1963; Slusher et al, 1974; and Soil Survey Staff, 1975.

Jack R. Cutshall
Soil Conservation Service
Alexandria, LA

GULF COAST FRESH MARSH
SRM 807

Definition, Composition, and Structure: The natural plant community composition and productivity is essentially a grass-forb community with a small percent of woody vegetation present (grass-36 percent, forbs-63 percent, and woody-1 percent). This community is very intolerant to salinity. When it is flooded by sea-strength water, the whole community is destroyed for quite some time. Generally, this area is flooded by runoff from the uplands.

The most common plants to be found in this site are: alligatorweed (*Alternanthera philoxeroides*), coastal waterhyssop (*Bacopa monnieri*), fragrant flatsedge (*Cyperus odoratus*), waterhyacinth (*Eichornia crassipes*), spikesedge (*Eleocharis* sp.), pennywort (*Hydrocotyle* sp.), sprangletop (*Leptochloa* sp.), maidencane (*paille fine*) (*Panicum hemitomon*), common reed (*Phragmites communis*), bulltongue (*Sagittaria falcata*), marshhay cordgrass (*Spartina patens*), cattails (*Typha* sp.), hairypod cowpea (*Vigna repens*), and giant cutgrass (*Zizaniopsis miliacea*).

The fresh marsh is used for grazing during the fall, winter, and early spring. The rest of the year the mosquitos are too abundant. The soils of this fresh marsh site are generally firm enough for cattle, but soft spots may be present which will not be usable.

To assure that cattle receive abundant nutrition, mineral supplements should be available on a year-round basis.

Geographic Distribution: The Gulf Coast Fresh Marsh extends the entire length of the coast along the Gulf of Mexico. It is more extensive along southeast Texas, Louisiana, and Florida.

Ecological Relationships: Relief is flat or concave. The area is nearly flat with slopes of less than .5 percent. Elevations range from 0 to 5 feet above mean gulf level.

The soils are pure to mixed peat, muck and mineral material. The surface ranges from peat to a dark gray or black clay, and from very strongly to slightly acid. The water table is near or above the surface during most of the year. Fresh marsh site soils are generally firm (particularly in southwest coastal marshes) enough to permit their use by livestock.

Increaser plants include longtom (*Paspalum lividum*), torpedograss (*Panicum repens*), needlegrass rush (*Juncus roemerianus*), California bulrush (*Scirpus californicus*), alligatorweed, and bulltongue arrowhead (*Sagittaria falcata*). Longtom is the most important forage plant among

increasers. Smartweeds (*Polygonium* sp.), asters (*Aster* sp.), and annuals are prominent invaders.

Rattlebox (*Daubentonia texana*) is a wood invader which appears with overuse conditions and greatly reduces forage production.

The fresh marsh site provides a potential habitat for the following species of wildlife on a permanent or seasonal basis: whitetail deer, muskrat, nutria, raccoon, otter, mink, swamp rabbit, alligator, ducks, geese, and others.

References include Charbreck, 1972; Lynn et al, 1974; Newsom, 1967; Shiflet, 1963; Slusher et al, 1974; and Soil Survey Staff, 1975.

Jack R. Cutshall
Soil Conservation Service
Alexandria, LA

SAND PINE SCRUB
SRM 808

Definition, Composition, and Structure: This type occurs on nearly level to strongly sloping land. Water movement is rapid through the soil. It is easily identified by the even-aged stands of sand pine (*Pinus clausa*) or by the thick scrubby oak (*Quercus* spp.) growth that compromise this association.

The natural vegetation of this type may be typically even-aged sand pine trees with a dense understory of oaks, sawpalmetto, and other shrubs. Ground cover under the trees and shrubs is scattered and large areas of light colored sand are often noticeable. In other cases, the sand pine are scattered or absent, with oaks being the dominant vegetation. Satellite soils, which have a high water table for part of the year, support a scrubby growth also, but the myrtle oak, Chapman oak, and sand pine become infrequent and gallberry becomes prominent. Plants which characterize this type are:

Trees - Bluejack oak (*Quercus incana*); Chapman oak (*Quercus chapmannii*); Myrtle oak (*Quercus myrtifolia*); Sand live oak (*Quercus virginiana* var. *geminata*); Sand pine (*Pinus clausa*).

Shrubs - Dwarf huckleberry (*Gaylussacia dumosa*); Gopher apple (*Chrysobalanus oblongifolius*); Prickly pear (*Opuntia* spp.); Sawpalmetto (*Serenoarepens*).

Herbaceous Plants and Vines - Grassleaf goldenaster (*Heterotheca graminifolia*); Deermoss (*Cladonia* spp.); Cat greenbriar (*Smilax glauca*).

Grasses and Grasslike Plants - Yellow indiangrass (*Sorghastrum nutans*); Low panicum (*Panicum* spp.).

Geographic Distribution: The Sand Pine Scrub type occurs throughout Florida. It is most commonly found inland from the coast and in the central portion of the state in and around Marion County. Individual types are gen-erally small in size, i.e., several hundred acres. A large type, several thousands of acres in size, occurs just east of Ocala in the Ocala National Forest. It typically has a few smaller types of wetland types interspersed throughout.

Ecological and Seral Relationships: This type supports a fairly dense stand of trees and shrubs and therefore has a limited potential for producing native forage. Livestock do not use this site if other areas are available. Variation depends on plant growth conditions. The relative percentage of annual vegetative production by weight is 40 percent grasses, 40 percent trees and shrubs, and 20 percent herbaceous plants and vines.

This type is suited for deer and turkey, especially for use as escape cover. Many birds inhabit this area including warblers, rufous-sided towhees, great crested flycatchers, scrub jays, and quail. Several varieties of native legumes furnish food (seeds) for bird life. The palmetto, gopher apple and various species of oak provide good food when they are fruiting.

This type has a low potential for commercial wood production.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

MIXED HARDWOOD AND PINE
SRM 809

Definition, Composition, and Structure: This type occurs on rolling uplands. Water movement is gradual to the natural drainageways. It can be easily identified by the mixed hardwood and pine vegetation occurring in a predominantly well drained area.

There is a variation in the type and amount of vegetation depending on the successional stage. In the early successional stages of this association, pine is present with shortleaf and loblolly predominating. As the system matures, hardwoods replace pines. The natural climax vegetation is thought to be a beach-magnolia-maple association. Plants which characterize this type are:

Trees - American beech (*Fagus grandiflora*); American holly (*Ilex opaca*); Eastern hophorn-bean (*Ostrya vir-giniana*); Flowering dogwood (*Cornus florida*); Hawthorns (*Crataegus* spp.); Loblolly pine (*Pinus taeda*); Mockernut hickory (*Carya tomentosa*); Pignut hickory (*Carya glabra*); Southern red oak (*Quercus falcata*); Southern magnolia (*Magnolia grandiflora*); White oak (*Quercus alba*); Water oak (*Quercus nigra*).

Shrubs - Shining sumac (*Rhus copallina*); Sparkleberry (*Vaccinium arboreum*).

Herbaceous Plants and Vines - Aster (*Aster* spp.); Common ragweed (*Ambrosia artemisiifolia*); Partridge

berry (*Mitchella repens*); Partridge pea (*Cassia* spp.); Poison ivy (*Toxicodendron radicans*); Violet (*Viola* spp.); Virginia creeper (*Parthenocissus quinquefolia*); Wild grape (*Vitis* spp.).

Grasses - Broomsedge bluestem (*Andropogon virginicus*); Longleaf uniola (*Chasmanthium sessiliflorium*); Low panicum (*Panicum* spp.); Spike uniola (*Chasmanthium laxium*).

Geographic Distribution: The Mixed Hardwood and Pine association is an extension of the middle coastal plains hardwoods forest. It occurs only in west and north Florida. Individual types vary in size and are interspersed with other types and natural drainageways.

Ecological and Seral Relationships: The soil's moisture-holding capacity and natural fertility is relatively high and good quality forages are produced. This association is preferred for grazing by livestock in the earlier stages of succession. Tree canopy cover can become excessive and drastically reduce forage quality. There is little or no grazing when the canopy cover exceeds 60 percent. The relative percentage of annual vegetative production by weight is 50 percent grasses, 30 percent trees and shrubs, and 20 percent forbs.

Mixed hardwood and pine are very good habitat for deer, turkey, squirrel, and many songbirds. Hardwood mast (acorns, nuts, fruits, buds, and berries) furnish a good source of wildlife food. Mature hardwoods and snags provide good nesting sites for birds. Habitat is good for raccoons, opposums, bobwhite quail and dove, fair for reptiles, and poor for most amphibians.

This type has a high potential productivity for commercial wood production. There are no serious management problems.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

LONGLEAF PINE-TURKEY OAK HILLS SRM 810

Definition, Composition, and Structure: This type occurs on rolling land with nearly level to strong slopes. Water movement is rapid through the soil. It is easily identified by the land form and dominant vegetation of longleaf pine (*Pinus palustris*) and turkey oak (*Quercus laevis*).

There are several variations of this type. Mature, natural stands of trees which have not been logged have scattered longleaf pine as an overstory. Areas on which pines have been removed are predominantly oaks. Ground cover under the trees and shrubs is scattered and numerous bare areas are noticeable. Plants which characterize this type are:

Trees - Longleaf pine (*Pinus palustris*); turkey oak (*Quercus laevis*).

Herbaceous Plants and Vines - Aster (*Aster* spp.); Blazing star (*Liatris tenuifolia*); Bracken fern (*Pteridum aquilinum*); Butterfly pea (*Centrosema virginianum*); Butterfly pea (*Clitoria mariana*); Elephant's foot (*Elephantopus* spp.); Grassleaf goldenaster (*Heterotheca graminifolia*); Partridge pea (*Cassia* spp.); Pineland beggarweed (*Desmodium strictum*); Sandhill milkweed (*Asclepias humistrata*); Showy crotalaria (*Crotalaria spectabilis*); Wild indigo (*Baptista* spp.).

Grasses and Grasslike Plants - Curtiss dropseed (*Sporobolus curtissii*); Hairy panicum (*Panicum anceps*); Yellow indiangrass (*Sorghastrum nutans*); low panicum (*Panicum* spp.); Pinewoods dropseed (*Sporobolus junceus*).

Geographic Distribution: The Longleaf Pine-Turkey Oak Hills association occurs throughout Florida. It is most commonly found in the central part of the state north of Lake Placid and in the Florida panhandle inland from the Gulf of Mexico. Individual types vary widely in size and limited numbers of other types may occur within it.

Ecological and Seral Relationships: The natural fertility of this type is low due to adverse soil conditions. Forage production and quality are poor and cattle do not readily utilize this area if other associations are available. The variation depends on plant growth conditions. There is little or no grazing when the canopy cover exceeds 60 percent. The relative percentage of annual vegetative production by weight is 60 percent grasses, 20 percent trees and shrubs, and 20 percent forbs.

The type is suited for deer and turkey, especially for use as escape cover. Many songbirds inhabit this area including warblers, towhees, crested flycatchers, and quail. Several varieties of native legumes furnish food (seeds) for bird life.

This type has a moderately high potential for commercial woodland production. There are moderate equipment limitations and seedling mortality due to loose, well drained and infertile soil conditions.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

SOUTH FLORIDA FLATWOODS SRM 811

Definition, Composition, and Structure: The South Florida Flatwoods type occurs on nearly level land. Water movement is very gradual to the natural drainageways, swamps, marshes, and ponds common to this association. During the rainy season, usually June through September, this association may have water on or near the soil surface. It is easily identified by the flat topography and pine and palmetto vegetation that comprise this type.

The landscape position of this type affects plant-water relationships and causes slight differences in plant composition from wetter to drier areas. Although these differences are recognized, they are not significant enough to delineate as separate types. The natural vegetation of this type is typically scattered pine trees with an understory of sawpalmetto and grasses. Some areas in extreme south Florida have few, if any, trees. These areas are often called prairies or dry prairies. The largest of these areas occur north and west of Lake Okeechobee. Plants which characterize this type are:

Trees - Live oak (*Quercus virginiana*); Slash pine (*Pinus elliottii*); South Florida slash pine (*Pinus elliottii* var. *densa*).

Shrubs - Dwarf huckleberry (*Gaylussacia dumosa*); Gallberry (*Ilex glabra*); Sawpalmetto (*Serenoa repens*); Tarflower (*Befaria racemosa*); Shining sumac (*Rhus copallina*); Waxmyrtle (*Myrica cerifera*).

Herbaceous Plants and Vines - Chalky bluestem (*Andropogon capillipes*); Creeping bluestem (*Schizachyrium stoloniferum*); Lopsided indiangrass (*Sorghastrum secundum*); Fall panicum (*Panicum dichotomiflorium*); Low panicum (*Panicum* spp.); Pineland threeawn (*Aristida stricta*).

Geographic Distribution: The South Florida Flatwoods type occurs throughout south and central Florida. The northern limit of its occurrence is approximately on a line from Levy county on the west to St. Johns county on the east. This association covers more land area than any other in south Florida. Individual types may comprise several thousand acres and are typically interspersed with smaller types of other types, especially wetlands.

Ecological and Seral Relationships: This type has the potential for producing significant amounts of high quality forage such as creeping bluestem, chalky bluestem, and indiangrass. It is Florida's most important type for the production of cattle on native range. Variation depends on plant growth conditions. There will be little forage available if the canopy cover exceeds 60 percent. The relative percentage of annual vegetative production by weight is 75 percent grasses and grasslike plants, 15 percent trees and shrubs, and 10 percent herbaceous plants.

The South Florida Flatwoods is well suited for deer, quail, and turkey. It is fair for squirrels and well suited for many songbirds, particularly warblers. It is also well suited for bobcat, skunks, opossums, and raccoons. It is poorly suited for dove.

This type has a moderate potential productivity for commercial wood production. There are moderate equip-ment limitations and seedling mortality due to wet soil conditions.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

NORTH FLORIDA FLATWOODS SRM 812

Definition, Composition, and Structure: The North Florida Flatwoods occurs on nearly level land. Water movement is very gradual to the natural drainageways, swamps, ponds, and marshes common to this association. Wet conditions prevail during the rainy season with the water table on or near the surface. It is easily identified by the flat topography, slash pine and sawpalmetto vegetation that comprise this association.

Slight differences in plant composition occur in this type depending upon location but these differences are of minor consequence. As this community is observed, a moderate to dense stand of pine trees is usually noted. An understory of sawpalmetto and grasses are also evident. Compared to the South Florida Flatwoods several differences are apparent. A shorter growing season and colder temperature have helped cause significant vegetative differences. More frequent interspersion of hardwood and cypress stands coupled with higher pine tree density reduces the open appearance.

Close study reveals the following characteristic plants:

Trees - Live oak (*Quercus virginiana*); Slash pine (*Pinus elliottii*).

Shrubs - Dwarf Huckleberry (*Gaylussacia dumosa*); Gallberry (*Ilex glabra*); Sawpalmetto (*Serenoa repens*); Shining sumac (*Rhus lanceoluta*); Tarflower (*Befaria racemosa*); Waxmyrtle (*Myrica cerifera*).

Herbaceous Plants and Vines - Blackberry (*Rubus* spp.); Bracken fern (*Pteridum aquilinum*); Creeping beggarweed (*Desmodium incanum*); Deer tongue (*Trilisa odoratissima*); Dog fennel (*Eupatorium capillifolium*); Gayfeather (*Liatris gracilis*); Greenbriar (*Smilax auriculata*); Milkwort (*Polygala* spp.).

Grasses and Grasslike Plants - Chalky bluestem (*Andropogon capillipes*); Broomsedge bluestem (*Andropogon virginicus*); Yellow indiangrass (*Sorghastrum nutans*); Lopsided indiangrass (*Sorghastrum secundum*); Low panicum (*Panicum* spp.); Pineland threeawn (*Aristida stricta*); Sedges (*Cyperus* spp.).

Geographic Distribution: The North Florida Flatwoods occurs north of a line from Levy County on the west to St. Johns County on the east, and in the northwest portion of the state. It is quite extensive, occurring most frequently in the northeastern region of the state and the southern portion of the northwest region. Individual types may comprise several thousand acres and are typically interspersed with smaller associations of other types, especially wetlands.

Ecological and Seral Relationships: This type has the potential for producing significant amounts of high quality forage such as chalky bluestem, indiangrass, and several of the panicum species. More pines occur in this association than in South Florida Flatwoods. Vegetative production differs from the South Florida Flatwoods association due to a shorter growing season and lower winter temperatures. There is little forage available if the canopy cover exceeds 60 percent. The relative percentage of annual vegetative production by weight is 65 percent grasses and grasslike plants, 25 percent trees and shrubs, and 10 percent herbaceous plants.

The North Florida Flatwoods is well suited for deer, quail and turkey. It is fair for squirrels and well suited for many songbirds, particularly warblers. It is also well suited for bobcat, skunks, opossums, and raccoons. It is poorly suited for dove.

This type has a moderate potential productivity for commercial wood production. There are moderate equip-ment limitations and seedling mortality due to wet soil conditions.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

CUTTHROAT SEEPS
SRM 813

Definition, Composition, and Structure: Cutthroat Seeps occur on nearly level to gently sloping or depressed areas where water seeps from the adjacent Sand Pine Scrub and Longleaf-Turkey Oak Hills associations. The soil profile is wet most of the time.

The appearance of this type is distinctive. It has open scattered pine trees, isolated sawpalmetto and waxmyrtle and a dense cover of cutthroat grass that stays green the year round. Plants which characterize this association are:

Trees - Slash pine (*Pinus elliottii*).

Shrubs - Waxmyrtle (*Myrica cerifera*).

Grasses - Cutthroat grass (*Panicum abscissium*); Chalky bluestem (*Andropogon capillipes*); Creeping bluestem (*Schizachyrium stoloniferum*); Maidencane (*Panicum hemitomon*); Toothache grass (*Ctenium aromaticum*); Low panicums (*Panicum* spp.).

Geographic Distribution: The Cutthroat Seeps type is found mostly in Polk and Highlands Counties. It occurs to a limited extent in adjoining counties. Individual size of the association is normally less than 100 acres. Much of the original association has been destroyed and developed to intensive uses.

Ecological and Seral Relationships: This type has the potential for producing significant amounts of good quality forage. Variation depends on plant growth conditions. The relative percentage of annual vegetative production by weight is 75 percent grasses and grasslike plants, 10 percent trees and shrubs, and 15 percent herbaceous plants.

Cutthroat Seeps are well suited for deer, turkey, and songbirds. They are fair for quail and good for many mammals, such as skunks, opossums, and raccoons. Reptiles such as ratsnakes and rattlesnakes find suitable habitat in the association. It is poorly suited for squirrel and dove.

This type has a moderate potential productivity for commercial woodland production. There are severe equipment limitations and seedling mortality due to wet soil conditions.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

CABBAGE PALMS FLATWOODS
SRM 814

Definition, Composition, and Structure: The Cabbage Palm Flatwoods type occurs on nearly level land. Water movement is very gradual to and through the natural drainageways, swamps, ponds, and marshes common to the association. During the rainy season, usually June through September, the water table is on or near the soil surface.

Slight differences in plant composition occur depending upon water relationships. The wetter sites contain a higher percentage of grasses and herbaceous plants. Although these differences are recognized, they are not significant enough to delineate as separate types.

The natural vegetation of this type is typically scattered pine and cabbage pine with an understory of palmetto and grasses. There is considerable uniformity and openness. It is similar to the South Florida Flatwoods association except for a higher percentage of herbaceous plants and the presence of cabbage palms. The plants which characterize this community are:

Trees - Cabbage palm (*Sabal palmetto*); Slash pine (*Pinus elliottii*).

Shrubs - Sawpalmetto (*Serenoa repens*); Tarflower (*Befaria racemosa*); Waxmyrtle (*Myrica cerifera*).

Herbaceous Plants and Vines - Caesar weed (*Urena*

lobata); Creeping beggarweed (*Desmodium incanum*); Deer tongue (*Trilisa odoratissima*); Gayfeather (*Liatris gracillis*); Greenbriar (*Smilax auriculata*).

Grasses and Grasslike Plants - Creeping bluestem (*Schiza-chyrium stoloniferum*); Lopsided indiangrass (*Sorghastrum secundum*); Saltmarsh windmillgrass (*Estachys glauca*); Stiffleaf windmillgrass (*Estachys petraea*); Pineland threeawn (*Aristida stricta*).

Geographic Distribution: The Cabbage Palm Flatwoods association occurs throughout south Florida and, to a limited extent, in central Florida. The northern limit of its occurrence is approximately on a line from Levy County on the west to St. Johns County on the east. Small, isolated areas are found north of this line. Locally, it most often occurs adjacent to coastal areas, major drainageways, and lakes. Individual types are typically interspersed with smaller units of wetland types.

Ecological and Seral Relationships: This type has the potential for producing significant amounts of high quality forage. Variation depends on plant growth conditions. There is little forage available if the canopy cover exceeds 60 percent. The relative percentage of annual vegetative production by weight is 70 percent grasses and grasslike plants, 15 percent trees and shrubs, and 15 percent herbaceous plants.

Cabbage Palm Flatwoods offer good food and cover to many species of wildlife. Food value comes from palm and palmetto fruit, pine mast, and acorns from associated oaks. Legumes and grasses furnish good food sources to quail and other small birds. Habitat is well suited for deer and turkey and offers refuges to migrating birds during winter months.

This type has a moderately high potential productivity for commercial wood production. There are moderate equipment limitations and seedling mortality due to wet soil conditions and plant competition.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

UPLAND HARDWOOD HAMMOCKS SRM 815

Definition, Composition, and Structure: The Upland Hardwood Hammocks occur on rolling terrain with nearly level to strong slopes. Moderately moist regimes without excessive water or drought conditions characterize this association. It can be readily identified by the occurrence of thick stands of shade tolerant hardwoods and few pines. There is usually more organic material and litter present than on drier sites.

This type is considered to be in a climax stage of vegetation when only a few pines occur with hardwoods dominating. Under climax conditions, understory vegetation may be quite sparse. Plants which characterize this type are:

Trees - American beech (*Fagus grandifolia*); American holly (*Ilex opaca*); Black cherry (*Prunus serotina*); Eastern hophornbean, (*Ostrya virginiana*); Flowering dogwood (*Cornus florida*); Hawthorns (*Crataegus* spp.); Laurel oak (*Quercus laurifolia*); Live oak (*Quercus virginiana*); Pignut hickory (*Carya glabra*); Southern magnolia (*Magnolia grandiflora*); Sweetgum (*Liquidambar styraciflua*).

Shrubs - American beautyberry (*Callicarpa americana*); Arrowwood (*Viburnum dentatum*); Sparkleberry (*Vaccinium arboreum*); Waxmyrtle (*Myrica cerifera*).

Herbaceous Plants and Vines - Aster (*Aster* spp.); Cat greenbriar (*Smilax glauca*); Common Greenbriar (*Smilax rotunidifolia*); Crossvine (*Bignoniu capreolata*); partridge berry (*Mitchella repens*); Partridge pea (*Cassia* spp.); Poison ivy (*Toxicodendron radicans*); Ragweed (*Ambrosia artemisiifolia*); Spanish moss (*Tillandsia usneoides*); Virginia creeper (*Parthenocissus quinquefolia*); Wild grape (*Vitis* spp.); Yellow jessamine (*Gelsemium sempervirens*); Dotted horsemint (*Monarda punctata*); Blackberry (*Rubus* spp.).

Grasses and Grasslike Plants - Low panicum (*Panicum* spp.); Switchgrass (*Panicum virgatum*).

Geographic Distribution: The Upland Hardwood Hammock type occurs commonly in north central Florida and sparingly in north and west Florida. Individual associations vary in size from a few acres to several hundred. The largest associations occur near Brooksville, Gainesville, and Ocala. This association is generally considered to be a climax vegetation of ecological succession in the Southern Coastal Plains. A climax type is one that perpetuates its kind in equilibrium with the environment without influence of man.

Ecological and Seral Relationships: Upland Hardwood Hammocks have very poor potential for grazing and are therefore not used for this purpose.

Hardwood mast (acorns, nuts, fruits, buds, and berries) makes Upland Hardwood Hammocks good habitat for deer, turkey, squirrel, black bear, and many songbirds. Maturing hardwoods and snags provide good nesting sites for squirrels, owls, and most woodpeckers. Habitat is good for raccoons and opossums; poor for bobwhite quail and dove; fair for reptiles and poor for most amphibians.

When managed for hardwood production, this type produces quality products. However, there has been a tendency to maintain these areas in predominantly pine through species management due to quicker returns on investment. The type has a high potential for commercial woodland production. There are no significant management hazards and limitations.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

CABBAGE PALM HAMMOCKS
SRM 816

Definition, Composition, and Structure: The Cabbage Palm Hammocks type is easily identified by the occurrence of thick stands of cabbage palm with a few scattered oak. It occurs mostly on slightly elevated areas within the Slough and South Florida Flatwoods types.

The natural vegetation is dominated by tree species, especially cabbage palms. Plants that characterize this association are:

Trees - Cabbage palm (*Sabal palmetto*); Laurel oak (*Quercus laurifloia*); Live oak (*Quercus virginiana*).

Shrubs - American beautyberry (*Callicarpa americana*); Sawpalmetto (*Serenoa repens*); Waxmyrtle (*Myrica cerifera*).

Herbaceous Plants and Vines - Caesar weed (*Urena lobata*); Poison ivy (*Toxicodendron radicans*); Wild grape (*Vitis* spp.); Yellow jessamine (*Gelemium sempervivens*).

Grasses - Creeping bluestem (*Schizachyrium stolon-iferum*); Low panicums (*Panicum* spp.); Stiffleaf wind-millgrass (*Estachys petraea*).

Geographic Distribution: The Cabbage Palm Hammock type occurs predominantly in south Florida. Counties having the most significant associations of this type are Highlands, Okeechobee and surrounding counties. Stands are usually one to several acres and rarely extensive in size.

Ecological and Seral Relationships: This type has low potential for producing forage due to the dense canopy of palm trees. It does provide protection during cold, rainy weather and shade during hot weather. It is usually severely grazed due to the above factors. Variation depends on plant growth conditions. There is little forage available when the canopy cover exceeds 60 percent. The relative percentage of annual vegetation production by weight is 55 percent grasses and grasslike plants, 25 percent trees and shrubs, and 20 percent herbaceous plants.

Cabbage palm hammocks are productive communities for many wildlife species. They are good habitat for wild hogs, deer, turkey, woodpeckers, and owls and poor for quail and dove, but fair for most songbirds and squirrels.

This type has a moderately high to high potential productivity for commercial wood production. There are moderate equipment limitations and seedling mortality due to wet soil conditions and plant composition.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

OAK HAMMOCKS
SRM 817

Definition, Composition, and Structure: The Oak Hammocks type is readily identified by the dense canopy of predominantly laurel and live oak trees on nearly level to rolling topography. The understory is usually sparse.

Tree species consist of mostly laurel and live oaks associated with other oaks and pine. There are few understory plants. Plants that characterize this type are:

Trees - Live Oak (*Quercus virginiana*).

Shrubs - American beautyberry (*Callicarpa americana*); Sawpalmetto (*Serenoa repens*).

Herbaceous Plants and Vines - Poison ivy (*Toxicodendron radicans*); Resurrection fern (*Polypodium polypodioides*); Spanish moss (*Tillandsia usneoides*); Stiffleafed wild pine (*Tillandsia utriculata*).

Grasses and Grasslike Plants - Yellow indiangrass (*Sorghastrum nutans*); Purple nutsedge (*Cyperus planifolius* and *C. rotundus*); Longleaf uniola (*Chasmanthium sessil-iflorium*); Low panicum (*Panicum* spp.).

Geographic Distribution: The Oak Hammock association occurs through central Florida in scattered locations, south to the Everglades and west to about Tallahassee. Typical examples of this association occur in Marion and Sumter Counties. Although this type is a recognizable feature in the landscape, there is some feeling that it may not be a separate, available type, but simply a variation of either the upland or wetland hardwood hammock, induced by man's influence.

Ecological and Seral Relationships: Due to the usually dense canopy cover and relatively open understory, cattle use these areas primarily for shade and resting areas. This variation depends on plant growth conditions. The relative percentage of annual vegetative production by weight is 40 percent grasses and grasslike plants, 40 percent trees and shrubs, and 20 percent herbaceous plants.

Hardwood mast (acorns, nuts, fruits, buds and berries) make Oak Hammocks good habitat for deer, turkey, squirrel, black bear, and many songbirds. Maturing hardwoods and snags provide good nesting sites for squirrel, owls, and most woodpeckers. Habitat is good for raccoons and opossums; poor for bobwhite quail and dove; fair for reptiles and poor for most amphibians.

This type has a high potential productivity for commercial wood production. There are moderate equipment limitations and seedling mortality problems due to poorly drained soil conditions.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

FLORIDA SALT MARSH
SRM 818

Definition, Composition, and Structure: The Salt Marsh type appears as an open expanse of grasses, sedges, and rushes. Usually there is a matrix of interconnected shallow natural channels that aid tidal influx.

Vegetation often occurs in distinct zones within the Salt Marsh as a result of water levels from tidal action and salinity concentrations in water and soils. Some species have a wide tolerance range and may be found throughout the grass marsh. Plants in this group are black needlerush and seashore saltgrass. Smooth cordgrass is more indicative of low, regularly flooded marsh, while the high marsh supports salt myrtle, marsh-hay cordgrass, marshelder, saltwort and sea oxeye. Along the Gulf Coast, most marshes are dominated by black needlerush. Along the North Atlantic Coast, smooth cordgrass is usually dominant. Plants that characterize the Salt Marsh type are:

Herbaceous Plants and Vines - Sea blite (*Suaeda linearis*); Sea purslane (*Sesuvium portulacastrum*).

Grasses and Grasslike Plants - Big cordgrass (*Spartina cynosuroides*); Black needlerush (*Juncus roemeiranus*) Gulf cordgrass (*Spartina spartinae*); Marshhay cordgrass (*Spartina patens*); Olney bulrush (*Scripus americanus*); Seashore dropseed (*Sporobolus virginicus*); Seashore paspalum (*Paspalum vaginatum*); Seashore saltgrass (*Distichlis spicata*); Shoregrass (*Monanthochole littoralis*); Smooth cordgrass (*Spartina alterniflora*).

Geographic Distribution: This type occurs along the Atlantic and Gulf Coasts and inland along tidal rivers. An extensive area occurs along the Gulf of Mexico north of Tarpon Springs to St. Marks.

Ecological and Seral Relationships: Salt marshes have a potential for producing significant amounts of cordgrass, saltgrass, and other grasses and forbs. Variation depends on plant growth conditions. The relative percentage of annual vegetative production by weight is 90 percent grasses, 5 percent shrubs and trees, and 5 percent herbaceous plants and vines.

Salt marshes are good habitat for a variety of wildlife. The habitat type is usually maintained by natural forces and influences such as tidal action and periodic hurricanes.

Storms usually cause the creation of "open" water in salt and brackish marshes and also may change salinities. The resulting effect is that plant succession is set back and more favorable habitat may be created for waterfowl, furbearers, and some other forms of wildlife such as wading birds. Artificially created dikes to control salinity are used in managing marsh plants for wildlife. Prescribed burning is also a technique used in marsh management.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

FRESHWATER MARSH AND PONDS
SRM 819

Definition, Composition, and Structure: The Freshwater Marsh and Ponds type appears as an open expanse of grasses, sedges, and rushes, and other herbaceous plants in areas where the soil is usually saturated or covered with surface water for two or more months during the year. The extensive sawgrass marsh that occurs in the Everglades is not included within this association, but smaller sawgrass areas are.

Within Florida, eight major different types of freshwater marshes have been described. Any one marsh may be composed of sections of different major types. Intergrading of these types may also occur. The types are: Flag marshes dominated by pickerel weed, Sawgrass marshes, Arrowhead marshes, Fire flag and other non-grass herbs marsh, Cattail marsh, Spike-rush marsh, Bulrush marsh, and Maidencane marsh.

Plants that characterize this type (depending on type or marsh) include:

Shrubs - St. Johns wort (*Hypericum* spp.); Primrose willow (*Ludwigia* spp.); Elderberry (*Sambucus canadensis lacinutu*).

Herbaceous Plants - Arrowhead (*Saggitaris* spp.); Blue flag (*Iris hexagona savannarum*); Cattail (*Typha* spp.); Fire flag (*Thalia geniculata*); Pickerel weed ((*Pontederia cordata* and *Pontederia lanceolata*); Smartweed (*Polygonum* spp.); Pennywort (*Hydrocotle* spp.).

Grasses and Grasslike Plants - Beak rushes (*Rhychospora* spp.); Blue maidencane (*Amphicarpum muhlenbergianum*); Bottlebrush threeawn (*Aristida spiciformis*); Bulrushes (*Scirpus* spp.); Caric sedges (*Carex* spp.); Clubhead cutgrass (*Leersia hexandra*); Common reed (*Phragmites* spp.); Flat sedge (*Cyperus* spp.); Maidencane (*Panicum hemitomon*); Rush (*Juncus* spp.); Sawgrass (*Cladium jamaicense*); Spike rushes (*Eleocharia* spp.); Umbrella grass (*Fuirena* spp.); Wild millet (*Echinocloa* spp.).

Geographic Distribution: The Freshwater Marsh and Ponds type occurs throughout Florida. Individual stands vary widely in size. The largest areas, several thousand acres in size, generally occur in southeast Florida.

Ecological and Seral Relationships: This type has the potential for producing significant amounts of high quality forage. Variation depends on plant growth conditions. The relative percentage of annual vegetative production by

weight is 80 percent grasses and grasslike plants, 5 percent trees and shrubs, and 15 percent herbs.

This association provides excellent habitat for many wetland wildlife species. It includes several endangered species. Many birds use this association year-round and/or for wintering.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

EVERGLADES FLATWOODS
SRM 820

Definition, Composition, and Structure: The Everglades Flatwoods occurs on nearly level land. It is underlain at shallow depths by a porous pinnacle limestone rock. Many areas have little or no soil and the pinnacle rock occurs on the surface. Water movement is rapid through the porous limestone. Consequently, the sites are wet for only short periods following heavy rains.

The natural vegetation that occurs on this type is dominated by an overstory of South Florida slash pine. The understory is mostly sawpalmetto and grasses. There is considerable uniformity and openness. The specific plants which characterize this type are:

Trees - South Florida slash pine (*Pinus elliotti* var. *densa*).

Shrubs - Marlberry (*Ardisia escallonioides*;) Sawpalmetto (*Serenoa repens*); Waxmyrtle (*Myrica cerifera*).

Herbaceous Plants - Florida peperomia (*Peperomia obtusifolia*).

Grasses - Cabanis bluestem (*Andropogon cabanissi*); Chalky bluestem (*Andropogon capillipes*); Creeping bluestem (*Schizachyrium stoloniferum*); Low panicums (*Panicum* spp.); saltmarsh windmillgrass (*Estachys glauca*).

Geographic Distribution: The Everglades Flatwoods type occurs only in the Everglades region of south Florida. The largest area is west of Homestead in and around the Everglades National Park. The tropical hammock type is generally interspersed throughout this type.

Ecological and Seral Relationships: This type has the potential for producing significant amounts of high quality forage such as creeping bluestem, chalky bluestem, and indiangrass. Variation depends on plant growth conditions. There is little forage available if the canopy cover exceeds 60 percent. The relative percentage of annual vegetative production by weight is 75 percent grasses and grasslike plants, 15 percent trees and shrubs, and 10 percent herbaceous plants.

Due to its geographic position, this association is valuable to migrating bird life headed to South America for wintering. It serves the same purpose on the return trip, acting primarily as resting cover. It is well suited for deer, bobcat, owls, and small rodents. Many reptiles find suitable habitat in this association.

This type has a moderate potential productivity for commercial wood production. There are moderate equipment limitations and severe seedling mortality due to the rocky soil conditions.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

PITCHER PLANT BOGS
SRM 821

Definition, Composition, and Structure: The Pitcher Plant Bogs appear as an open expanse of grasses, sedges, and pitcher plants with scattered, stunted pine and cypress. At times, the bogs are flamboyant with wild flowers. There is a predominance of insect-eating plants, dominated by pitcher plants. The erect "trumpets" of these spectacular plants protrude up through the grasses and sedges. The association occupies generally flat areas or seepage hillsides. Water frequently stands on the surface. The natural vegetation of this type is low-growing grasses and herbaceous plants with scattered trees or shrubs. There is a predominance of pitcher plants. Plants which characterize this type are:

Trees - Slash pine (*Pinus elliottii*).

Shrubs - Waxmyrtle (*Myrica cerifera*); Myrtle-leaved holly (*Ilex cassine* var. *myrtifolia*).

Herbaceous Plants - Hat pin sedge (*Eriocaulon* spp.); Pitcher-plant (*Sarracenia* spp.); Rush featherling (*Pleea tenuifolia*); Sundews (*Drosera* spp.).

Grasses - Blue maidencane (*Amphicarpum muhlenbergianum*); Florida threeawn (*Aristida rhizomophora*); Pineland threeawn (*Aristida stricta*); Toothachegrass (*Ctenium aromaticum*); Warty panicum (*Panicum*).

Geographic Distribution: The Pitcher Plant Bogs association occurs primarily in north Florida. They are most common in northwest Florida just inland from the coast. Individual types vary in size but are usually no more than 100 acres.

Ecological and Seral Relationships: This type has the potential for producing significant amounts of high quality forage. Variation depends on plant growth conditions. The relative percentage of annual vegetative production by weight is 80 percent grasses and grasslike plants, 5 percent trees and shrubs, and 15 percent herbs.

This type is one of the least productive for wildlife, probably due to the low diversity of plant species and

growth forms, which limits food and cover. It provides fair habitat for white-tailed deer and bobwhite quail. It is also suited for raccoons, armadillos, and open grass-country birds.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

SLOUGH
SRM 822

Definition, Composition, and Structure: The Slough type appears as an open expanse of grasses, sedges, and rushes in areas where the soil in saturated during the rainy season. Most sloughs are relatively long and narrow and slightly lower in elevation than the surrounding flatwoods or hammocks.

Grasses are the most common plants found in sloughs. Sedges and rushes also occur, with scattered shrubs in some locations. Plants that characterize this type are:

Shrubs - St. Peters wort (*Ascyrum stans*).

Herbaceous Plants - Pickerel weed (*Pontederia cordata*); Sundew (*Drosera* spp.); Marsh pink (*Sabatia* spp.); Meadowbeauty (*Rhexia* spp.); Milkwort (*Polygala* spp.); Yellow-eyed grass (*Xyris* spp.).

Grasses and Grasslike Plants - Beak rushes (*Rhynchosopra* spp.); blue maidencane (*Amphicarpum muhlenber -gianum*); Bluejoint panicum (*Panicum tenerum*); Bottlebrush threeawn (*Aristida spiciformis*); Panicum(*Dichanthelium dichotomum*); Low panicum (*Panicum* spp.); Sand cordgrass (*Spartina bakeri*); Sloughgrass (*Scleria* spp.); Soft rush (*Juncus effusus*).

Geographic Distribution: The Slough type occurs throughout central and south Florida, but especially in the latter. Individual associations vary widely in size. Most serve as drainageways for water during periods of heavy and prolonged rainfall. This type occurs mostly within the South Florida Flatwoods.

Ecological and Seral Relationships: This type has the potential for producing significant amounts of high quality forage such as blue maidencane, chalky bluestem and bluejoint panicum. Variation depends on plant growth conditions. The relative percentage of annual vegetative production by weight is 85 percent grasses and grasslike plants and 15 percent herbaceous plants.

This type is productive in regards to food for bobwhite quail, deer, and wading birds. Its low growing vegetative growth provides poor cover for most wildlife species, but this is often offset by the "edge effect" of this association when it is located with flatwoods.

References include Soil Conservation Service, 1987a; Soil Conservation Service, 1987b; and Wunderlin, 1982.

R. Gregory Hendricks
Soil Conservation Service
Washington, DC

Rangeland Cover Types of the ALASKA REGION

INTRODUCTION SRM 900

ALASKA is 380 million acres (152 million hectares) in size and stretches over 58 degrees of Latitude (130° W in SE Alaska to 172° E in the Aleutians) and almost 20 degrees on longitude (52° N in the Aleutians to 71.5° N at Barrow).

This vast land mass includes two mountain systems, an intermountain plateau system, extensive lowlands, as well as several deltas and coastal plains. The Brooks range arcs across the state in the north and isolates the Arctic coastal plains or the Arctic region, from the Interior. The Alaska Range stretches from southeast and south central Alaska westward to the Aluetians isolating the narrow southern coastal Regions from the Interior. The Southeast Region is the Alaskan panhandle. The South central Region is the coastal area south of the Alaska Range in the central part of the state. The Aleutians are an island system that stretches westward into the Pacific ocean.

Four climatic zones occur in the state: Arctic, Continental, Maritime, and Transitional. The Arctic zone occurs north of the Brooks Range. It controls the Arctic Region. The Continental zone influences most of the Interior Region. The Maritime zone controls the Southeast, South central and Aleutian Regions. And the Transitional zone influences weather in the Alaska Range, and in the Southwest and Northwest Regions. Mean annual temperatures for the zones range from 10°F (-12° C) in the Arctic zone to 45°F (7° C) in the southern Maritime zone.

Temperature extremes of -75°F (-60° C) and +105°F (41° C) occur in the Continental climatic zone. Annual precipitation varies from 4 inches (10cm) in the Arctic to over 300 inches (750cm) in the maritime of southeast Alaska. A few feet in elevation or a small change in the microclimate; temperature and moisture.

Permafrost, or permanently frozen ground, is found throughout the state except along the southern coast. Three permafrost zones occur in the state: continuous, discon-tinuous, and permafrost free. Continuous permafrost occurs on the North Slope, in the Brooks Range and in most of western Alaska north of the Kuskokwim River. Permafrost is discontinuous in interior and south central Alaska. Little or no permafrost occurs in the Aleutians, Kenai peninsula and along the southern coast.

Permafrost influences the microclimate of a site. It, when present, adds rigidity to many soils, however when it melts many of these sites become unstable and flow. Because these soils are cold and many of them ice rich, they stop root penetration which keeps the root zone near the surface. In addition they act as ice dams that stop internal soil drainage, and force water to drain over the surface and/or to accumulate in peaty material and depressions.

Wildfire burns extensive areas each summer, especially in the interior. Fuels dry easily during the long, hot dry summer days. Lightning caused and man caused fires occur in about equal amounts. Logging and clearcutting also alter the vegetation in localized areas.

Ice fields, glaciers, rivers, large lakes (over 40 acres in site) cover around six percent (6%) of the state. The rest of the state is classified as either as forest or tundra in about equal proportions. Wetlands occur in both types. Viereck et al (1992) divides the state into four biotic zones: coastal forest, boreal forest, lowland tundra, and upland tundra. Within each of these a mosiac of vegetation types exists.

Coastal forests are dominated by evergreen forests, primarily Stitka spruce-western hamlock. Deciduous forests are rare and limited to stands of black cottonwood or red alder on flood plains, stream margins, and recently disturbed sites. Very open or woodland lodgepole pine communities grade into bog types on poorly drained sites. On coastal deltas, extensive areas of halophytic and freshwater sedge and grass wet meadows dominated by (*Carex Lyngbyaei*) are common.

Boreal forest or taiga forms an extensive vegetation zone between the coastal forest and the northern and western limits of forest growth. It is dominated by evergreen forests of black and white spuce, but has extensive areas of deciduous forests of paper birch, aspen, and balsam poplar. Within the Boreal forest extensive mosaics of shrub and herbaceous types occur. These include small patches of grass or lichens, extensive areas of lowland sedge and sedge-moss bog meadows and/or willow, sweetgale, and graminoid bogs. Large alder and willow patches occur as successional communities following alluvial deposition or disturbances such as fire.

Lowland tundra occurs primarily on the coastal plain in northern Alaska and in low-lying deltas and other coastal areas on western Alaska. The dominant vegetation is a wet sedge meadow of *Eriophorum angustifolium* and *Carex aquatilis* interspersed with many lakes. *Eriophorum vaginatum* tussock tundra occurs on the dryer sites.

Upland tundra in Alaska includes moist tundra, dry or alpine tundra, and shrub or high brush tundra. *Eriophorum vaginatum* tundra dominate most of arctic and western Alaska however Dryas dwarf shrub tundra is common on

the more exposed ridges and dry rocky sites. Dry as and ericaceous shrub tundra is widespread in mountainous areas above treeline. Extensive area of shrubland, primarily low shrub dwarf birch occur in western Alaska and near treeline in the Alaska and Brooks Ranges. Empetrum heath is the most widespread community in the Aleutian Islands but extensive areas of *Elymus arenarius, Calamagrostis nutkaensis*, and *Deschampsia beringensis* also occur.

The following treatment is an attempt to order the Alaskan vegetation into a classification system driven by species important to range utilization. The associations format is used to make the classification compatible with rangeland vegetation types used elsewhere in the country and with the vegetation classification system promoted by the Society of American Foresters. This effort is not exhaustive. It emphasizes major rangeland types but does not include many of the minor rangeland types. Some of them are limited to a small segment of one of the four major vegetation zones while other rangeland types occur throughout all four of the major zones.

Joan Foote
US Forest Service
Fairbanks, AK

ALDER
SRM 901

Definition, Composition, and Structure: The dominant species of this association are Sitka alder (*Alnus sinuata*) and American green alder (*A. crispa*), and occasionally thinleaf alder (*A. tenuifolia*). Tree species, primarily balsam poplar (*Populus balsamifera*), black cottonwood (*Populus trichocarpa*), and white spruce (*Picea glauca*), may occasionally overtop the alder canopy. Tall willows (*Salix* spp.) may also be found scattered through the stand canopy. Low shrubs may be present in open alder stands. Resin birch (*Betula glandulosa*), bog blueberry (*Vaccinium uliginosum*), and Labrador tea (*Ledum* spp.) are often common in timberline stands. Understory shrubs are generally absent in closed alder stands, but scattered currant (*Ribes* spp.), prickly rose (*Rosa acicularis*), salmonberry (*Rubus spectabilis*), and devil's club (*Echinopanax hor-ridum*) may occur.

The herb layer is often dominated by bluejoint reedgrass (*Calamagrostis canadensis*) in open lowland stands. Bigelow sedge (*Carex bigelowii*) may be common in open timberline stands. Understory in closed stands may be sparse or dense. Common species in closed stands include bluejoint reedgrass, meadow horsetail (*Equisetum pratense*), monkshood (*Aconitum delphinifolium*), dwarf fireweed (*Epilobium latifolium*), common fireweed (*E. angustifolium*), tall bluebell (*Mertensia paniculata*), twinflower (*Linnaea borealis*), twisted stalk (*Streptopus amplexifolius*), lady fern (*Athryium filixfemina*), spinulose shield fern (*Dryopteris spinulosa*), oak fern (*Gymnocarpium dryopteris*) and wintergreen (*Pyrola* spp.). A discontinuous mat of mosses, largely feathermoss (*Hylocomium splendens*), and a few lichens may also be present.

Geographic Distribution: Sitka alder is found from central Alaska to all points south including the Alaska Peninsula and the southeast archipelago. It is also found on sites near Nome and Kotzebue. The range of American green alder extends south from the Colville River on the North Slope to Bristol Bay and Prince William Sound. Thinleaf alder has been reported in the Bristol Bay area, along the southcentral coastline and along major rivers in the interior of the state. No occurrence of alder has been reported on the North Slope, Aleutian Islands, or in the area of Etolin Strait.

Ecological Relationships: Open, tall alder communities are found near the altitudinal timberline, on old burns, and on creek and river banks in interior and southcentral Alaska. Tall closed stands are common on steep subalpine slopes, drainages, and avalanche tracks, at forest edges, and on floodplains and streambanks. American green alder dominates on uplands and well-drained sites in south-central, interior and western Alaska. Sitka alder dominates well-drained uplands and avalanche tracks in southcentral and southeast Alaska. Occasionally, thinleaf alder will be dominant in shrub swamps and floodplains of southcentral Alaska. Soils associated with alder stands are generally thin, stony, silt loams or moist loams. Permafrost is either absent or fairly deep.

The climate is quite variable over this area with a somewhat mild maritime climate and abundant precipitation typifying the southeast and southcentral coastlines, transitioning to a very harsh, relatively dry, continental climate in the interior areas of the state. South coastal areas average 145 freeze-free days with a range of 100 to 170 days along various portions of the coast. Less than 100 freeze-free days typify the interior lowland basins. Plant growth begins in late May to mid-June with long summer daylength contributing to rapid growth and accumulation of biomass. Growth ceases by late August to mid- September.

Sitka alder commonly colonizes secondary disturbances while thinleaf alder colonizes primary disturbances of floodplains and glacial moraines. Balsam poplar in the understory will eventually overtop the alder, leading to a poplar forest community. Alder communities are instrumental in increasing nitrogen levels and decreasing pH of soils. Although alder is generally unpalatable, it is eaten by wildlife when other browse is lacking. Alder thickets provide good hiding cover, while open stands with bluejoint grass development provide fair grazing.

Variants and Associated Species: American green alder dominates stands in the northern part of the state but integrates with Sitka alder towards the southcentral coast. Sitka

alder dominates in the southern areas. Both are considered pioneer species, and are eventually replaced by spruce. Alder becomes established on mineral soil and develops rapidly on moist sites but also grows on sites too sterile for other trees. The species acts as a nurse tree, improving soil conditions and adding nitrogen and organic matter. Willow communities are frequently found in close association with the alder.

References include Hansen, 1951; Viereck et al, 1986 and Little, 1972; Viereck and Little, 1975; and Watson, 1959.

Frederic R. Larson
USDA Forest Service
Anchorage, Alaska

ALPINE HERB
SRM 902

Definition, Composition, and Structure: Structure and relative topographic position, rather than species compo-sition, are primary in defining this type. It includes types designated as alpine tundra, herbaceous tundra, dry forb herbaceous, fell-field, blockfield, talus, or scree by various authors. Because of much variation in substrate, snow cover, available moisture and altitude, herbaceous, rather than clearly defined sub-strate and micro-climate parameters, is the unifying characteristic of the type.

Saxifrages dominate many associations, e.g., three-toothed (*Saxifraga tricuspidata*), purple mountain (*S. oppositifolia*) and spotted (*S. bronchialis*) in drier, rocky sites, and yellow marsh (*S. hirculus*) and brook (*S. punctata*) in wetter meadow sites. Lapland diapensia (*Diapensia lapponica*), arctic wormwood (*Artemisia arctica*) and arctic cinquefoil (*Potentilla hyparctica*) dominate other rocky sites, while mountain sorrel (*Oxyria digyna*) and Alaska spirea (*Luetkea pectinata*) dominate wetter, less rocky sites.

Numerous subdominants characterize these subtypes, including Ross geum (*Geum rossii*), moss campion (*Silene acaulis*), blackish oxytrope (*Oxytropis nigrescens*), sandwort (*Arenaria arctica*), androsace (*Androsace ochotensis*), hoary arnica (*Arnica lessingii*), prostrate sibbaldia (*Sibbaldia procumbens*), rockcress (*Draba caesia*), alpine rockcress (*D. aleutica*), minuartia (*Minuartia* spp.) and cushion saxifrage (*Saxifraga eschscholtzii*) in the drier, rocky areas. More mesic areas are characterized by northern yarrow (*Achillea borealis*), alpine brook saxifrage (*Saxifraga rivularis*), caespitose saxifrage (*S. caespitosa*), arctic daisy (*Chrysanthemum arcticum*), glacier avens (*Geum glaciale*), calthaleaf avens (*G. calthifolium*), Siberian spring beauty (*Claytonia siberica*), Alaska spring beauty (*C. sarmentosa*), buttercups (*Ranunculus* spp.), pygmy oxytrope (*Oxytropis pygmaea*), Chukchi primrose (*Primula tschukschorum*), fescue (*Festuca brachyphylla*), Aleutian chickweed (*Cerastrium aleuticum*) and Unalaska arnica (*Arnica unalaschensis*).

Snowbed herb associations appear to overlap the moist group above. One, dominated by nagoonberry (*Rubus arcticus*), roseroot (*Sedum rosea*) and bistort (*Polygonum bistorta*), is similarly dominated by meadow-dwelling flowering plants. However, most snowbed associations with herb subdominants are dominated by sedge (*Carex* spp.), lichen (*Cetraria* and *Cladonia* spp.), mosses (*Rhacomitrium* and *Dicranoweisia* spp.), liverwort (*Anthelia* and *Scapania* spp.) or heath (*Cassiope* and *Ledum* spp.).

Geographic Distribution: Alpine herb types occur in mountain sites over most of Alaska and adjacent Yukon and British Columbia. In the Coast Range, Wrangell-St. Elias, Chugach, Talkeetnas and the Alaska Range, variations of this type occur well above tree-line on all slopes, but below permanent snow and ice. Elevations typically are between 3600 and 9000 ft (1,200 and 3,000m), occurring lower on northern exposures, and as the sites progress northward. In the Brooks Range, the Aleutians, and hills of western Alaska, the term "alpine" is less clearly defined, since trees are usually absent and "arctic" types may be adjacent to "alpine". The type may be found at very low elevations of 600 ft (200m) in the southwestern islands.

Ecological Relationships: Widely varying substrate and micro-climate conditions may be found in this complex of subtypes. The dry types are found on exposed and well-drained ridges with soil particle size ranging from sand to talus. Mesic types occupy moderately drained areas with available meltwater, while snowbed types occur in areas with persistent snow in the early part of the growing season. No clearly defined factor accounts for herb dominance in these various subtypes. Few studies have included specific ecological parameters that are comparable, and even within study areas, considerable variation exists. For example, Amchitka herb communities varied in pH from 5.6 in wet snowbed sites to 6.7 in solifluction terraces.

Variants and Associated Species: Disturbed tundra which is rocky and well-drained may develop seral communities, of which eight have been identified. Dwarf fireweed (*Epilobium latifolium*) is dominant in three of these, scurvy grass (*Cochlearia officinalis*) is dominant in two, and the remaining three are dominated by alpine sweetvetch (*Hedysarum alpinum*), variegated scouring rush (*Equisetum variegatum*), and merckia (*Wilhelmsia physodes*) respectively. Arctic wormwood (*Artemisia arctica*) and Tiles mugwort (*A. tilesii*) are subdominants in some of these seral communities. Dwarf hawksbeard (*Crepis nana*) is a subdominant in the drier, and mountain sorrel in the moister, seral communities. No specific study of fire-related succession has been linked to this type, but it can be inferred that alpine herbs would at least temporarily take over from a crowberry (*Empetrum* spp.) dominated community after a fire.

References include Choate, 1986; Johnson et al, 1966; Racine, 1979; Racine and Young, 1978; Scott, 1974;

Shacklette et al, 1969; Viereck et al, 1986; Viereck and Schandelmeier, 1980; and Young, 1974.

Thomas S. Choate and Charlu M. Choate
University of Alaska Anchorage
Anchorage, Alaska

BEACH WILDRYE-MIXED FORB SRM 903

Definition, Composition, and Structure: The floristic composition of this type is predominantly beach wildrye (*Elymus arenarius* subsp. *mollis*). Beach wildrye varies in height from 8 inches (20cm) in the Arctic to over 3 ft (1m) in the southern part of Alaska. Beach wildrye dominates the herbage production and cover in this type. Annual herbage production has been found to average 602 lb/ac (670 kg/ha) (airdry), comprising 64% of the annual production of vascular plants for this type on the Seward Peninsula. Annual production in the southern regions has been found to be 10-20% higher . In some areas, beach wildrye may be associated with beach pea (*Lathyrus maritimus*). Other subdominant grasses are speargrass (*Poa eminens*), arctic bluegrass (*Poa arctica*), red fescue (*Festuca rubra*), bromes (*Bromus* spp.), and polar grass (*Arctagrostis latifolia*).

There are numerous forbs in this type. Some of the more common ones are sea beach sandwort (*Honkenya peploides*), wild celery (*Angelica lucida*), yarrow (*Achillea lanulosa*), wild chive (*Allium schoenoprasum*), western hemlock parsley (*Conioselinum chinense*), field horsetail (*Equisetum arvense*), common fireweed (*Epilobium angustifolium*), beach lovage (*Ligusticum scoticum*), tall Jacob's ladder (*Polemonium acutiflorum*), nagoonberry (*Rubus arcticus*), arctic senecio (*Senecio atropurpureus*), seabeach senecio (*S. pseudoarnica*), Northern goldenrod (*Solidago multiradiata*), chickweed (*Stellaria* spp.) and merckia (*Wilhelmsia physodes*). A few shrubs may occur on the stabilized inland edges of this type such as black crowberry (*Empetrum nigrum*), dwarf arctic birch (*Betula nana*), and dwarf willows (*Salix* spp.). Common bryophytes are (*Rhytidiadelphus squarrosus* and *Tortula* spp.).

Geographic Distribution: This cover type occurs on developing and stabilized beach dunes from the Northwest Territories, Canada, west along the north slope of Alaska, and south along the western coast of Alaska. It extends west along both shores of the Alaska Peninsula, along the entire Aleutian Island chain to the Komandorskiye Islands, and the islands in the Bering Sea. It occupies coastal areas throughout southcentral Alaska, extending to Kodiak and the other islands of the North Pacific immediately south of the Alaska Peninsula.

Elymus arenarius subsp. *mollis* var. *mollis* predominates throughout the Aleutian Islands and Prince William Sound in coves and bays, and continues along the coastal areas to Yakutat, then southeast to British Columbia. It occurs in many of the coastal environments of western Alaska with *Elymus arenarius* subsp. *mollis* var. *villosissimus*, which was described from St. Paul Island in the Bering Sea.

Ecological Relationships: This type occupies elongated beach dunes and gravelly beach ridges. Dunes are developed by windblown sands originating from sandy beaches. The dune and vegetation develop simultaneously; the vegetation catches and traps windblown sand, enlarging the dune area.

Climate over the extent of this range is extremely varied, with mean annual precipitation ranging from 8 inches (20cm) on the North Slope to over 160 inches (400cm) in southeast Alaska. Severe winter storms occur frequently from October through May. During this time, sea ice may erode the dune or dislodge vegetation in low-lying areas. Strong winds may occur during any month. Snow drifts develop between dune systems and on leeward sides. The snowpack from these drifts persists longer into spring, delaying new growth.

The soil pH is usually slightly acid to neutral, and permafrost is normally absent. The elevation where this vegetation type typically occurs is about 6-60 ft (2-20m) above sea level at the average storm-influenced high water mark.

A noticeable phase of plant succession and development of a tundra plant community has been observed on Nunivak and Hagemeister Islands and on the northern portions of the Seward and Baldwin Peninsulas. Typical tundra species from adjacent tundra communities become established on the leeward side of the dune, eventually crowding out beach wildrye. The site becomes occupied with sedges (*Carex* and *Eriophorum* spp.), cloudberry (*Rubus chamaemorus*) black crowberry (*Empetrum nigrum*), and lichens (*Stereocaulon paschale*) and (*Thamnolia subuliformis*).

Variants and Associated Species: The two varieties identified above, *Elymus arenarius mollis mollis* and *E. a. mollis villosissimus*, readily intergrade. Occasionally, small patches consisting of monocultures of beach wildrye and/or downy ryegrass (*Elymus innovatus*) are found established inland along droughty, sandy river and stream channels, gravel road shoulders and trails. These inland stands of beach wildrye are far from coastal influences and out of their typical range. They were probably established from seeds carried to the area by birds. Inland stands of beach wildrye are less productive and vigorous, lacking the typical mixture of forbs of the coastal type, but the Kobuk dunes in northwest Alaska are a notable exception.

Beach wildrye and associated species grow with pacific reedgrass (*Calamgrostis nutkaensis*) in inland valleys on Adak Island that have slight to moderately acid silt loam soils.

References include Hulten, 1968; Viereck et al, 1986; and Swanson et al, 1985.

J. David Swanson
USDA Soil Conservation Service
Anchorage, Alaska

BLACK SPRUCE-LICHEN SRM 904

Definition, Composition, and Structure: This type occurs on palsas (elevated peat mounds) approximately 9 ft (3m) high, 30 ft (10m) wide, and 60 ft (20m) long. The landscape is characterized by numerous palsas that are capped by peat or other organic material. The vegetation is predominantly a sparse, stunted black spruce (*Picea mariana*), or occasionally stunted white spruce (*Picea glauca*), overstory. Mature trees average 90 years old and attain a height of 3 m. The understory is characterized by a dense mat of climax lichens (*Cladina rangiferina, C. arbuscula, C. stellaris,* and *Cetraria islandica*). Lichen cover frequently exceeds 80%. Sedges, such as water sedge (*Carex aquatilis*) and tussock cottongrass (*Eriophorum vaginatum*) are sparse. The dominant shrubs growing in the lichen-dominated under-story are northern Labrador tea (*Ledum decumbens*) and black crowberry (*Empetrum nigrum*). The major forb is cloudberry (*Rubus chamaemorus*). Other plant species found in this type include bog rosemary (*Andromeda polifolia*), dwarf arctic birch (*Betula nana*), arboreal lichens (*Alectoria, Evernia,* and *Usnea* spp.), bog blueberry (*Vaccinium uliginosum*) and lowbush cranberry (*Vaccinium vitisidaea*). Common mosses include (*Aulacomnium palustre, Hylocomium splendens*, and *Dicranum* spp.). The annual understory vascular plant production averages 495 lb/ac (550 kg/ha). Total biomass of lichens will average 6200 lb/ac (7,000 kg/ha).

Geographic Distribution: This cover type occurs at lower elevations as an extensive transition zone between the taiga and wet tundra areas. This type is found on the eastern end of the Seward Peninsula, and the Yukon, Kuskokwim, and Nushagak river drainages at the transition zone of the upland white spruce forests.

Ecological Relationships: This pulsa type is associated with string bogs on coastal plains and inland alluvial valley floors. The bogs are wet, depressed areas with standing water. The dominant plant in the bog is water sedge (*Carex aquatilis*) with a dense understory of moss (*Sphagnum* spp.). Palsas usually make up 25-40% of the area.

Soils of the palsa are classified as Pergelic Cryosaprists; those of the bog are Pergelic Cryofibrists (Peraquic). Palsas are capped by an organic mat 16-28 inches (40-70cm) thick and underlain by extremely acid, very fine sandy loam over an ice-rich permafrost table. Wildfire seldom disturbs this type because of the sparse tree density and associated wet bog areas. As a consequence, arboreal and terrestrial lichen biomass can reach 8900-13,400 lb/ac (10,000 to 15,000 kg/ha).

Variants and Associated Species: A variant of this palsa type has been observed north of Paxson in the Summit Lake area. The small mounds were 12ft x 12ft x 6ft (4m x 4m x 2m) high and were dominated by small black spruce with shrub willows (*Salix* spp.).

Other well-drained upland black spruce-lichen areas exist that are composed of the same plants except that palsas do not occur. These corresponding types can be located in the black spruce Society of American Foresters (SAF) cover type 12.

References include Dall, 1989; Swanson et al, 1985; and Viereck et al, 1986.

J. David Swanson
USDA Soil Conservation Service
Anchorage, Alaska

BLUEJOINT REEDGRASS SRM 905

Definition, Composition, and Structure: This type is dominated by bluejoint reedgrass (*Calamagrostis cana-densis*). Composition varies from nearly pure stands of bluejoint reedgrass (bluejoint meadow) to stands in which forbs and ferns are represented by a large number of species and form a major portion of the vegetation (bluejoint grassland). Common forbs and ferns include common fireweed (*Epilobium angustifolium*), spinulose shieldfern (*Dryopteris spinulosa*), lady fern (*Athyrium filix-femina*), cow parsnip (*Heracleum lanatum*), oak-fern (*Gymno-carpium dryopteris*), horsetail (*Equisetum* spp.), and arctic starflower (*Trientalis europaea*). Grasses other than blue-joint reedgrass and various sedges (*Carex*spp.) may be present in minor amounts.

Bluejoint grasslands usually consist of a dense sward of bluejoint reedgrass interrupted frequently with small to large clumps of ferns and robust forbs. Other ferns and forbs are scattered throughout the grass. In many bluejoint meadows, particularly those which are relatively wet, bluejoint reedgrass forms large tussocks as much as 30 cm in diameter. In both grasslands and meadows, occasional thickets and scattered shrubs may be present. Common shrubs include alder (*Alnus* spp.), Greene mountain ash (*Sorbus scopulina*), Pacific red elderberry (*Sambucus racemosa*), willow (*Salix* spp.), and Beauverd spirea (*Spirea beauverdiana*). Mosses may be absent or common but are never a major component. Lichens are scarce or absent.

In bluejoint grasslands in the subalpine zone of southcentral Alaska, plant growth is initiated in mid to late June. By late July, the vegetation is 2.5 to 6 ft (.8 to 2m) tall with 95% or greater canopy cover. Vascular plant production was determined to range from about 2420 to over 4990 lb/ac (2,690 to over 5,600kg/ha) (air-dry weight). Composition was 49 percent bluejoint reedgrass, 50 percent

herbs, and 1 percent shrubs. (Kautz and Clark 1986)

Geographic Distribution: The bluejoint reedgrass type is found everywhere in Alaska except for the extreme northern arctic (Viereck et al 1986). Bluejoint reedgrass dominated communities are common in all Major Land Resource Areas in the Southern Alaska Region and occasionally in interior Alaska and the western portion of the Arctic and Western Alaska Region (USDA 1981).

Ecological Relationships: The bluejoint reedgrass type occurs over a wide range of annual precipitation, from 15-76 inches (38-190cm). The type is found on nearly level to steep upland slopes, floodplains and stream terraces, shoreline of ponds and lakes, upper intertidal zone, lowland fens and drainages, and drained lakebeds. Elevations range from sea level to over 1650 ft (550m). Soils are usually silts or loams with a relatively thick mulch layer on the surface. Soils are moist or sometimes wet throughout the growing season. The type usually is not found on sites that experience a moisture deficit during the early growing season.

In the subalpine zone of southern Alaska, the type often occurs in a complex with tall alder, low willow, and treeline forest communities. Stands may be of small to large extent, and interrupted frequently by stringers and islands of scrub, forest, or alpine vegetation. Bluejoint grasslands are presumably climax or near climax. These communities occur on the same sites and soils as associated alder communities. If any successional relationships exist between these types, they have not been described.

In the boreal forest, bluejoint reedgrass communities occur as small meadows in forest clearings and as seral vegetation following fires, logging, land clearing, and other site disturbances. Some meadows and seral stands may persist indefinitely, however, most are eventually replaced by scrub and forest.

On wet sites, and probably many mesic sites as well, bluejoint reedgrass meadows may be derived from wet sedge meadows; in time these are in turn replaced by scrub and forest. It has been suggested that bluejoint meadows develop as grass gradually excludes other plants (Viereck et al. 1986).

Variants and Associated Species: In many seral stands in the forest zone in which severe soil disturbance has damaged the bluejoint sod, common fireweed may be the dominant species, almost to the exclusion of bluejoint reedgrass. On convex microsites and near the upper elevation of the type, altai fescue (*Festuca altaica*) often becomes a major component. Elsewhere, blue-joint reed-grass-shrub communities are found on relatively wet sites. Primary shrub components are willow and alder, which may comprise up to 25 percent of the canopy cover.

References include Kautz and Clark, 1986; USDA, 1981; Viereck et al, 1986.

Darrell R. Kautz
USDA Soil Conservation Service
Anchorage, Alaska

BROADLEAF FOREST
SRM 906

Definition, Composition, and Structure: The overstory in broadleaf forests consists of paper birch (*Betula papyrifera*), balsam poplar (*Populus balsamifera*), quaking aspen (*Populus tremuloides*), and mixtures of these species. The most common occurrence is in relatively pure stands. Needleleaf trees, especially white spruce (*Picea glauca*), may also occur, but must account for less than 25% of the tree cover, otherwise, it is considered a mixed forest. Understory and overstory both vary according to site conditions and history.

Geographic Distribution: Broadleaf forests are distributed throughout interior and southcentral Alaska. Isolated stands of balsam poplar are the northernmost patches of trees in Alaska.

Ecological Relationships: Broadleaf forests are indicative of past disturbance, especially on relatively warm sites. Poplar is more common along floodplains, while birch and aspen are associated with upland disturbances. The broadleaf tree species are shade intolerant and require mineral soil for seedling establishment.

Balsam poplar is a frequent colonizer along braided rivers, recently deglaciated lands, abandoned mined lands, and other harsh environments. Its initial growth is less than other species such as thinleaf alder (*Alnus tenuifolia*), but it eventually overtops these species because of its longer life span and continued growth. Poplar stands are usually overgrown by white spruce after 100 years in interior Alaska and by white spruce-paper birch along the Susitna River in southcentral Alaska. Mosses and lichens are usually lacking because of flooding and leaf litter.

Most upland broadleaf stands consist of aspen and/or birch following fire or other severe disturbance. Aspen stands usually occur after fire on the warmest, driest sites. Birch usually occupies colder sites and is common on old landslides. Usually, these forests are replaced by coniferous forests or mixtures of broadleaf and needleleaf trees but the broadleaf stands may be stable on some warm, dry sites. Birch stands occupy 5.15 million acres (2.06 million ha) of interior Alaska uplands and lowlands. Bluejoint reedgrass (*Calamagrostis canadensis*) is an abundant understory species in many birch stands.

Aspen forest types cover almost 1 million ha of upland and bottomland in interior Alaska. Aspen is killed by hot fires, but most fires in pure aspen stands are light, killing only the understory. The permafrost table is usually >1 m below the surface.

All three tree species can be prolific seeders with aspen and poplar dispersing seed during the growing season and birch dispersing seed during the fall and winter. Abundant birch seedlings may be found in recently cleared areas adjacent to existing birch or spruce-birch stands. All of these species can reproduce by sprouting as well. All these tree species are browsed by moose and other wildlife. Aspen regeneration is frequently curtailed by moose browsing. Birch may be hedged into a shrub growth form by browsing.

Older stands may have more forage and browse as the understory develops in gaps. Closed poplar stands in the Susitna River basin of southcentral Alaska contain up to 130 lb/ac (146 kg/ha) of usable forage while open stands may contain up to 205 kg/ha. Thinleaf alder and bluejoint reedgrass are the dominant understory species in 40 to 50 year old poplar stands along rivers in southcentral Alaska. Dominant browse species in understories of poplar forests along floodplains include prickly rose (*Rosa acicularis*) and highbush cranberry (*Viburnum edule*).

Variants and Associated Species: Pure birch stands some-times grade into black spruce-paper birch or white spruce-paper birch types. Poplar communities may grade into poplar-spruce or poplar-birch-spruce as sites age and more species enter the community. Aspen may be found alone or in mixed stands, especially with paper birch. Understory shrubs include American green alder (*A. crispa*), Scouler willow (*Salix scouleriana*), highbush cranberry, Labrador tea (*Ledum palustre groenlandicum*), raspberry (*Rubus idaeus*), prickly rose, and devil's club (*Echinopanax horridum*). Herbaceous understory includes bluejoint reedgrass, tall bluebell (*Mertensia paniculata*), common fireweed (*Epilobium angustifolium*), horsetail (*Equisetum* spp.), bunchberry dogwood (*Cornus cana-densis*), and wintergreen (*Pyrola* spp.).

References include Agricultural and Forestry Experiment Station, 1988; Foster and King, 1986; Helm et al, 1985; Hulten, 1968; Lutz, 1956; Neiland and Viereck, 1977; Viereck, 1980; Viereck and Little, 1972; Viereck et al, 1968; Walker et al, 1986; Yarie, 1983; and Zasada, 1980.

D.J. Helm
University of Alaska Fairbanks
Palmer, Alaska

DRYAS
SRM 907

Definition, Composition, and Structure: Alpine avens (*Dryas octopetala*) and arctic avens (*D. integrifolia*) are major components of this association. Drummond mountain avens (*Dryas drummondii*) is a dominant member of only one recognized vegetation type, which is found on gravelly riverbars, and appears to be an early seral condition. In forest communities, arctic avens is found in association with white spruce (*Picea glauca*), balsam poplar (*Populus balsamifera*), and various mosses under very open (10-25%) tree crown cover. In open, tall shrub communities (25-75% shrub crown cover and >4.5 ft (>1.5 m) arctic avens is found in association with felt-leaf willow (*Salix alaxensis*), soapberry (*Shepherdia canadensis*), red bearberry (*Arctostaphylos rubra*), and lichens (*Cladonia* spp.).

The most common community types with both arctic and alpine avens as major components are low and dwarf shrub scrub and sedge-avens associations. In the low shrub types 8-60 inches (20-150 cm) common shrub associates are dwarf arctic birch (*Betula nana*), bog blueberry (*Vaccinium uliginosum*), willow (*Salix* spp.) and soapberry. In the dwarf shrub types >8 inches (<20 cm) common associates include dwarf willow species, sedge (*Carex* spp.), alpine sedge (*Kobresia* spp.), black crowberry (*Empetrum nigrum*), oxytrope (*Oxytropis* spp.), sweet-vetch (*Hedysarum* spp.), milkvetch (*Astragalus* spp.), bearberry (*Arctostaphylos* spp.), lapland diapensia (*Diapensia lapponica*), blueberry, Drummond's anemone (*Anemone drummondii*), bluegrass (*Poa* spp.), fescue (*Festuca* spp.), lichens, and mosses. In the sedge-avens community, associated species include water sedge (*Carex aquatilis*), Bigelow sedge (*C. bigelowii*) and alpine sedge.

Geographic Distribution: The forest community types that include arctic avens as a major component occur either at the northern limits of tree growth or at elevational tree lines. Drummond avens is found only on well drained, cobbly, abandoned river flood plains. Tall shrub communities that include arctic avens as a major component occur primarily in northern, western, and interior Alaska. Low shrub scrub communities that include alpine and arctic avens as major components occur throughout tundra areas, but some communities are more common in northern, western and interior Alaska. Dwarf shrub scrub communities dominated by arctic and alpine avens are common in alpine areas and on early seral glacial outwash plains over the entire range of *Dryas* (circumpolar). Sedge-avens communities are widely distributed throughout the range of *Dryas* spp., except in coastal maritime climates.

Ecological Relationships: Dryas-dominated types in general are found on wet to dry but always well-drained sites. The forest communities are found on exposed, mostly dry sites. Spruce/poplar/avens river floodplain types are found on well-drained gravels in close association with open tall shrub communities of felt-leaf willow, soapberry, red bearberry, and lichens.

Most of the rest of the low and dwarf shrub/avens-dominated communities are found most often on dry, exposed sites in the mountains. Sedge-avens communities occupy sites similar to these, although usually a bit wetter and less exposed. Soils are generally shallow and/or very immature. A few avens-dominated communities are found on recently disturbed, newly vegetated sites, especially

behind retreating glaciers. *Dryas* is well-suited to the extreme sites where it is most often found. It grows low and compact. It has a woody caudex, flowers early to mid season, and produces fruit early in the short season. It usually provides nearly complete ground cover along with its associates even under the harshest conditions. However, avens communities that are fairly open have been observed.

Variants and Associated Species: Forest types most similar to those with a large avens component have a similar overstory, but the understory is predominantly lichen. Similar tall shrub communities have understories dominated by red bearberry, or sweet vetch and dwarf fireweed (*Epilobium latifolium*).

Low shrub scrub communities similar to those dominated by avens can be found to have the *Dryas* component replaced by such species as bearberry, blueberry, crowberry, Labrador tea (*Ledum palustre*), and dwarf willows. Normally, these other communities are not found on sites quite as exposed as those containing avens.

Dwarf shrub scrub communities similar to those dominated by avens are those dominated by dwarf willow (*Salix rotundifolia, S. ovalifolia, S. reticulata, S. polaris, S. arctica, S. phlebophylla*), lowbush cranberry (*Vaccinium vitisidaea*), alpine bearberry (*Arctostaphylos alpina*), sedges, and various mosses and lichens. Except for those dominated by lichen, these communities are generally found on slighty more protected and wetter sites.

The community most similar to the sedge-avens community is probably sedge-bearberry tundra, where red and alpine bearberry replace avens.

References include hulten, 1986; Murray and Batten, 1977; Viereck et al, 1982; Welsh, 1974.

Kenneth C. Winterberger
USDA Forest Service
Anchorage, Alaska

FESCUE
SRM 908

Definition, Composition, and Structure: Viereck 1986 suggests that the most dominant and conspicuous plant in this association is altai fescue (*Festuca altaica*). Altai fescue stands occur with small numbers of forbs, such as common fireweed (*Epilobium angustifolium*), yarrow (*Achillea borealis*), tall bluebell (*Mertensia paniculata*), tall Jacob's ladder (*Polemonium acutiflorum*), monkshood (*Aconitum delphinifolium*), Richardson geranium (*Ger-anium erianthum*), and oak fern (*Gymnocarpium dryopteris*). In some areas, cow parsnip (*Heracleum lanatum*) and field horsetail (*Equisetum arvense*) are common.

Geographic Distribution: This association typically occupies the drier portions of south and west facing mountain slopes up to 3600 ft (1200m) elevation. It primarily occurs in interior and southcentral Alaska, and often is found as small inclusions within extensive stands of bluejoint reedgrass (*Calamagrostis canadensis*). Shrubs such as American green alder (*Alnus crispa*), Pacific red elderberry (*Sambucus callicarpa*) and willows (*Salix* spp.) may be found throughout this association.

Ecological Relationships: The substrate is usually mesic to dry, and slightly acid. Permafrost is usually absent. Soils may frequently be classified as dystric cryandepts, and typic cryorthods. The association is commonly found on slopes of 20-45 percent but can range from 0-80 percent. Pre-cipitation varies widely, from 12 to over 80 inches (30-200cm) per year. Although most frequently found on mountain slopes, this association has also been seen on flat sites in mountains, mountain terraces, and alluvial fans. More level sites seem to retain greater soil moisture, and longer into the growing season, than the sloped sites.

It has been suggested that fire may be responsible for development of fescue communities on dry slopes in interior Alaska (Hanson 1951). Altai fescue may be replaced by willow and alder in advanced stages of succession.

Variants and Associated Species: At upper elevations on flat to convex microsites, altai fescue can be found growing with black crowberry (*Empetrum nigrum*), as well as cohabiting willow stands. In these sites, altai fescue plants will develop into large tussock forms. These variants may represent transitional zones.

References include Hanson, 1953; Hanson, 1951; Viereck and Batten, 1986.

David Arnegard
USDA Soil Conservation Service
Delta Junction, Alaska

FRESHWATER MARSH
SRM 909

Definition, Composition, and Structure: Freshwater marsh communities are dominated by emergent sedges, grasses, or forbs in a semipermanently or permanently flooded environment. There remains some confusion of the terminology (marshes, swales, fens, mires) but they include level, treeless areas where the water table is frequently above the substrate surface.

Plant species are stratified according to depth of water. Woody plants and lichens are absent. Plant cover may be sparse to dense, and may or may not have open water. Aquatic mosses other than peat mosses (*Sphagnum* spp.) may be common, but are not abundant. Sedgemarshes are primarily dominated by great bulrush (*Scirpus validus*), creeping spikerush (*Eleocharis palustris*), or sedges, particularly water sedge (*Carex aquatilis*). Grass marshes are dominated by pendant grass (*Arctophila fulva*). In

forb-dominated communities, this type of marsh consists primarily of buckbean (*Menyanthes trifoliata*) and marsh fivefinger (*Potentilla palustris*). Floating-leaved or submerged aquatic plants, such as pondweeds (*Potamogeton* spp.), common mare's tail (*Hippuris vulgaris*) and spike water milfoil (*Myriophyllum spicatum*) may be present or even abundant.

Geographic Distribution: Freshwater marshes are found throughout the state; however, species occurrence is not consistent within the various regions. The sedge-dominated communities occur primarily in southcentral and south-eastern Alaska but may be found within all areas of the state. The forb-dominated community types occur in or near forested areas. Marshes dominated by pendant grass are found primarily on the Arctic Coastal Plain.

Small stands of pendant grass can be found on lake margins throughout the state. In the southern part of Alaska, grass marshes may occur in very shallow water or in seasonally flooded mud flats. In coastal areas, freshwater sedge marshes may be infrequently flooded by seawater.

Ecological Relationships: Freshwater marsh is limited by topography, substrate, drainage and climate. They occupy partially-drained lakebeds, small flooded depressions and shallow ponds, lake and stream perimeters, gently sloping terraces and flooded silt bars on floodplains and deltas where water depths exceed several cm forshort to extended periods. Freshwater marsh is also found as wet inclusions in alpine and subalpine wet meadows occurring on mineral soils. Freshwater marsh may occur on mineral soil, peat less than 12 inches thick (30cm), or on shallow muck (less than a meter deep) which are at least semipermanently flooded. Soils underlying freshwater marshes may be mineral silts or sands, or organic. Water pH varies from circumneutral to about 5.

On the Arctic Coastal Plain, Chukchi Sea coast and the Yukon-Kuskokwim Delta, the distribution of vascular plants in wetlands is influenced primarily by water depth, with maximum water depth in June. By August the sediments may be exposed. In southcentral Alaska, fresh-water marshes occur in and around small bowl-like depressions (kettle lakes) and on moraines in deglaciated areas. These small depressions may have developed a substrate consisting of a fibrous-mixed peat mat.

On the Arctic Coastal Plain and Chukchi coastal area, freshwater marshes support such rooted emergents as buckbean, water horsetail (*Equisetum fluviatile*) and yellow marsh marigold (*Caltha palustris*). These species are found in standing water up to 32 inches (80cm) in depth. In shallower water (up to 50 cm) along the fringe of lakes may be found pendant grass (often in pure stands), Pallas buttercup (*Ranunculus pallasii*), arctic buttercup (*R. hyperboreus*), marsh fivefinger and common mare's tail. The majority of freshwater marsh emergents cannot survive in water over 50 cm in depth for long periods of time; however, the roots can tolerate continual inundation. These species include water sedge, tall cottongrass (*Eriophorum angustifolium*), red cottongrass (*E. russeolum*), water horsetail, marsh horsetail (*Equisetum palustre*), and mountain foxtail (*Alopecuris alpinus*). Many larger lakes which include areas of deeper open water <3 ft deep (<1m) may contain such submerged vascular plants as pondweeds, particularly filiform pondweed (*Potamogeton filiformis*) and fennel leaf pondweed (*P. pectinatus*), northern bur weed (*Sparganium hyperboreum*), Gmelin buttercup (*Ranunculus gmelinii*), water buttercup (*R. aquatilis*) and spike water milfoil.

Freshwater marsh plants in southwest Alaska and along the Bering Sea vary little from species inhabiting the extreme northern coastal plains. Deep open water areas may contain northern bur weed, clasping leaf pondweed (*Potamogeton perfoliatus*) and yellow pondlily (*Nuphar polysepalum*) while shallow pond fringe vegetation includes Pallas buttercup, common mare's tail, water horsetail, water sedge, buckbean, water buttercup, marsh five-finger and pendant grass.

In southeast Alaska, freshwater marshes develop from lakes, ponds, sloughs or rivers, moraines and outwash. On recently deglaciated terrain there is a successional trend from a floating vegetation stage - clasping leaf pondweed, northern bur weed, water milfoil (*Myriophyllum* spp.), dwarf waterlily (*Nymphaea tetragona*) to an emergent aquatic stage of common mare's tail, creeping spikerush, variegated scouring rush (*Equisetum variegatum*), alkali buttercup (*Ranunculus cymbalaria*), marsh arrowgrass (*Triglochin palustris*), marsh fivefinger and buckbean. These same species may also be found in shallow ponds within forested areas. In southeast and southcentral Alaska, freshwater marshes persist over time, with many developing into bogs through a successional sequence that acidifies the wetland. Other freshwater marshes are invaded by shrubs and develop into deciduous shrublands, further succeeding to various forest types. In southcentral Alaska, there is a transition from freshwater marsh to bog with a buildup of peat, mostly from Lyngbye sedge (*Carex lyngbyaei*) and water sedge.

Variants and Associated Species: Freshwater marsh communities are early colonizers of open water or aquatic communities, and may eventually be replaced by wet sedge meadow as plant detritus and sediment accumulate. Freshwater sedge marsh communities could also be encroached upon by horizontal growth of peat mats of an adjacent bog, resulting in a laterally expanding floating bog mat, or fen community. Freshwater grass marshes and freshwater forb marshes may follow similar patterns, evolving into wet grass meadows and wet forb meadows. Freshwater marsh frequently intergrades with peatland, ponds and lakes, streams and brackish water.

Wet meadows are similar to freshwater marshes, but have less water due to seasonal flooding and are generally dominated by sedges, tall cottongrass and dupontia

(*Dupontia fischeri*). The forb-dominated freshwater marsh is similar to the subarctic lowland wet meadow and bog meadow. Many of the common secondary species of marshes codominate wet meadows or bog meadows. Bog meadows sometime occur over fairly deep water on partially submerged floating mats. The substrate of the bog is predominantly a sphagnum peat, in contrast to the mineral or well decomposed organic substrate (sedge peat) of marshes.

References include Batten and Murray, 1982; Bergman et al, 1977; DeMeo and Loggy, 1989; Hogan and Tande, 1983; Markon, 1980; and Viereck et al, 1986.

David M. Dall
US Fish and Wildlife Service
Anchorage, Alaska

HAIRGRASS
SRM 910

Definition, Composition, and Structure: These communities are dominated by hairgrass (*Deschampsia* spp.), usually Bering hairgrass (*D. beringensis*) which is closely related to (*D. obensis*, Roshev). Broad-leaved herbs may be common, but not co-dominant. Woody plants and lichens are generally rare. Bering hairgrass has a tufted growth form, with height to around 3 ft (1m).

These are often diverse stands with small numbers of a great many species. Sometimes hairgrass is only weakly dominant, at times even sub-dominant in association with other species in the stand. Associated species, which are not all present at any one site, include sedges (*Carex* spp.), egedii cinquefoil (*Potentilla egedii*), bluejoint reedgrass (*Calamagrostis canadensis*), great bulrush (*Scirpus validus*), largeflower speargrass (*Poa eminens*), yarrow (*Achillea borealis*), red fescue (*Festuca rubra*), alpine sweet vetch (*Hedysarum alpinum*), and bentgrass (*Agrostis* spp.).

Geographic Distribution: The association occurs in coastal or near-coastal settings in southeastern, south-central, and southwestern Alaska, including the Alaska peninsula and Aleutian Islands. It occurs on fringes of coastal marshes, channel levees, on cliff tops and bases. The association occurs in sub-dominant settings on beach dunes and flood plains. It is found on the coastal area of Kuskokwim highlands, and the coastal plains and deltas of western Alaska.

Ecological Relationships: The association is generally found on well drained, mesic soils, possibly with seasonal dry periods. Textures range from clays to sands, and pH is neutral to slightly acid. Some hairgrass communities may be flooded by brackish water during storm surges. Permafrost is absent. Hairgrass communities may be near the middle of several successional sequences. Communities on coastal channel levees probably develop from halophytic herb communities via midgrass-herb communities.

Variants and Associated Species: Hairgrass communities at the upper fringes of coastal marshes may develop from halophytic sedge stands, especially Lyngbye sedge (*Carex lyngbyei*), if drainage is adequate and the marsh is prograding. Some hairgrass communities may be invaded by bluejoint reedgrass and eventually replaced by it, and in this, appear similar to bluejoint-reedgrass meadows or bluejoint-herb meadows. Other stands may eventually be replaced by willows or alders. Hairgrass communities are most similar to midgrass-herb communities, but lack a dominant broad-leaved herb component. Forbs may be common or scarce, but not co-dominant. In the arctic, Bering hairgrass may be replaced by tufted hairgrass (*D. caespitosa*), where it occupies riverbanks, meadows and shores.

References include Hulten, 1968; Viereck et al, 1986; USDA, 1981.

Jim Preston
Certified Range Consultant
Homer, Alaska

LICHEN TUNDRA
SRM 911

Definition, Composition, and Structure: This tundra type is characterized by dense mats of fruticose lichens with a variety of low growing vascular plants. At lower elevations it is associated with wet and moist areas, with the lichen mat frequently growing on, or interspersed with, thick mats of mosses (*Polytrichum* spp.), (*Pleurozium* spp.), (*Hylocomium* spp.) with some hepatics. The major sedges are water sedge (*Carex aquatilis*), Bigelow sedge (*C. bigelowii*), and tussock cottongrass (*Eriophorum vaginatum*). Shrubs are dwarf arctic birch (*Betula nana*), black crowberry (*Empetrum nigrum*), northern Labrador tea (*Ledum palustre decumbens*), bog blueberry (*Vaccinium uliginosum*) and lowbush cranberry (*V. vitis idaea*). The most common forb is cloudberry (*Rubus chamaemorus*). Dominant reindeer lichens are (*Cladina stellaris, C. rangiferina, C. arbuscula,* and *C. mitis*). Usually cetraria lichens, (*Cetraria islandica, C. ericetorum* and *C. laevigata*), are found interspersed throughout the reindeer lichens.

Total lichen biomass typically ranges from 4450-13,350 lb/ac (5,000 to 15,000kg/ha), and on a pristine range has been found to yield over 26,700 lb/ac (30,000kg/ha) (air-dry). Seasonal production of annual plants generally ranges from 270-450 lb/ac (300-500kg/ha) (air-dry).

Geographic Distribution: Although many of the dominant vascular plant species differ from northern and northwest Alaska to the end of the Aleutian Islands, this same lichen tundra type is commonly distributed on island and mainland

areas throughout the state. This type includes lichen dominated mats on the low-lying flat coastal areas 30 ft (10m) elevation, interior valleys, alluvial fan positions and extends part way up gently sloping hills and toe slopes of mountains approximately 1200 ft (400m) elevation.

Ecological Relationships: In areas that support large quantities of lichen biomass, the stature as well as the competitive nature of vascular plants are thought to be reduced from a combination of alleopathic effects, reduced soil temperature, nutrient interception and competition for space. Lichen tundra type is typically underlain by perma-frost on most of the mainland sites, but not on the islands in the Aleutian Chain. The major soil types are Hystic Pergelic Cryaquepts, Pergelic Cryaquepts, Pergelic Cryumbrepts and Pergelic Cryoborolls. Wildfire, overgrazing, and off-road traffic (snow machines and all-terrain vehicles) can destroy healthy lichen-producing areas very quickly. On parts of the Seward Peninsula, and on Nunivak, St. Paul, St. Matthew, and Hagemeister Islands, wildfire and/or over-use by reindeer has resulted in an erratic distribution pattern, with lichen biomass greatly reduced or absent in some plant communities.

Tundra areas occasionally are subjected to hot wildfires in which most vegetation is killed. This results in a loss of the insulating plant cover, a charcoal-blackened landscape and a melting or lowering of the permafrost table. In many instances, this plant community destruction is natural and cyclic in nature. In the most intensely burned areas, bluejoint reedgrass (*Calamagrostis canadensis*) or cottongrass (*Eriophorum* spp.) dominates the site within two growing seasons, eventually followed by an increasing number of shrubs. On severely depleted areas, lichen recovery may be well in excess of 100 years.

In low-lying and mid-elevation valleys, on upland terraces, low hills, and broad alluvial fans of the Yukon and Kuskokwim River regions, this type occurs extensively in its pristine form. There are many areas in this cover type that have not been burned or grazed for many years. In these instances, the fruticose lichens become decadent and the annual growth rate is greatly reduced, even though the total lichen biomass may be high.

Variants and Associated Species: In coastal areas with frequent fog and light rain, cetraria lichens (*C. islandica, C. laevigata, C. cucullata* and *C. richardsonii*), usually make up a greater percent of the lichen cover in the cladina- dominated mat. In isolated areas such as the Lava Beds on the Seward Peninsula, on Nunivak Island, and in mainland areas where tundra and taiga are interspersed, there are areas supporting predominantly *Cladina stellaris,* with lichen biomass exceeding 26,700 lb/ac (30,000kg/ha) (air-dry). These areas possibly represent the climax stage of this type.

References include Preston et al, 1976; Preston et al, 1977; Swanson et al, 1986; and Swanson and LaPlant, 1987.

J. David Swanson
USDA Soil Conservation Service
Anchorage, Alaska

LOW SCRUB SHRUB BIRCH-ERICACEOUS SRM 912

Definition, Composition, and Structure: The low scrub shrub birch-ericaceous shrub cover type is a diverse type dominated by several common species of ericaceous low shrubs, such as bog blueberry (*Vaccinium uliginosum*), Labrador tea (*Ledum palustre groenlandicum*) and resin birch (*Betula glandulosa*). Well-drained sites may contain an overstory of resin birch with the other shrubs forming a mid-layer. Resin birch may be absent from the wetter and colder sites. The dwarf shrub layer consists of black crowberry (*Empetrum nigrum*) and lowbush cranberry (*Vaccinium vitisidaea*). Willows may also form an important component. Shrub cover must be at least 25%.

Geographic Distribution: This type is extensive throughout most of mainland Alaska in the colder environments.

Ecological Relationships: Community composition is quite diverse on a small scale. Although dominant species frequently vary, some of the same patterns are repeated throughout the state. Sites dominated by shrub birch are usually well-drained, with an organic mat less than 12 inches (30cm) thick, and permafrost table usually absent, or deeper than 20 inches (50cm). Deeper organic layers result in colder temperatures and transitions to other vegetation types.

Open birch-ericaceous shrub communities (25 to 75% cover by low shrub) are found over a wide variety of temperature and edaphic conditions. Sites are acid with a permafrost table greater than 20 inches (50cm) below the surface. These stands may form part of a very slow post-fire succession back to forest. As moisture increases, the type grades into shrub-tussock communities. Increased peat deposits cause gradation into a bog. Drier conditions may cause a transition to a dwarf shrub (mat and cushion) fellfield.

Willows may also be important on some sites and increase the value for moose browse. Dwarf resin birch is browsed both by moose and caribou. Berries of the low shrubs may be eaten by bears, birds, and small mammals, and seeds may be spread in their feces.

Variants and Associated Species: Most of the variants were treated as part of the main description because of the extreme variability of this type. Additional species that can be expected in this type include swamp cranberry (*Oxycoccus microcarpus*), diamondleaf willow (*Salix pulchra*), prostrate willows such as (*S. reticulata, S. arctica, S. glauca*), scattered trees of white spruce (*Picea glauca*) or black spruce (*P. mariana*), cloudberry (*Rubus chama-*

emorus), sedges (*Carex* spp.) and cottongrass (*Eriophorum* spp.). Mosses and lichens are important in the ground layer and include peat mosses (*Sphagnum* spp.), feather mosses (*Hylocomium splendens, Pleurozium schreberi*), other mosses (*Aulacomnium* spp.), and lichens (*Cladonia* and *Cetraria* spp.).

References include Hulten, 1968; Viereck and Little, 1972; and Viereck et al, 1986.

D.J. Helm
University of Alaska Fairbanks
Palmer, Alaska

LOW SCRUB SWAMP
SRM 913

Definition, Composition, and Structure: Low scrub swamp communities have 25-75% coverage of low shrubs, and soils which are saturated with water throughout much of the year. The surface of the soil is not deeply submerged but can have standing shallow water. The shrub layer, which ranges from 20 to 100 cm in height, is dominated by sweet gale (*Myrica gale*). Other shrubs associated with sweet gale include leatherleaf (*Chamaedaphne calyculata*), dwarf arctic birch (*Betula nana*), diamondleaf willow (*Salix planifolia*), Barclay willow (*S. barclayi*), and Alaska bog willow (*S. fuscescens*). Occasionally shrubs such as thinleaf alder (*Alnus tenuifolia*) may reach above 4.5 ft (1.5m) tall.

A graminoid-dominated herbaceous layer forms beneath the shrubs. Dominant species include the water sedges, (*Carex aquatilis, C. pluriflora, C. limosa, C. sitchensis*) and tufted clubrush (*Trichophorum caespitosum*). Where the community merges to deeper water, marsh fivefinger (*Potentilla palustris*) and buckbean (*Menyanthes trifoliata*) can be found.

Bryophytes (*Sphagnum* spp., *Aulacomnium palustre* and *Drepanocladus* spp.) often form thick mats at the bases of the vascular plants. Lichens are usually absent.

Geographic Distribution: Low scrub swamp occupies poorly drained lowlands over much of Alaska south of the 67th parallel. Habitats include marshlands, bogs, river bars, stream-edges, pond margins, and high intertidal zones. It can be found from the Tanana and Yukon Rivers to the western coast. The type is especially common in coastal bogs from the Alaska peninsula and Kodiak Island southeastward to British Columbia.

Ecological Relationships: Low scrub swamp dominated by sweet gale is an edaphic climax community maintained by waterlogged soils. Nitrogen fixation occurring in root nodules contributes significantly to maintaining climax status. If the water table lowers, low scrub swamp can become a seral stage of bog succession. As succession proceeds, the substrate surface thickens. The site is typically invaded first by willows (*Salix* spp.), followed by black spruce (*Picea mariana*). As sweet gale does not tolerate shade, it is eliminated. The substrate is a peat composed of sedges, mosses, or both, often with abundant woody frag-ments. The peat layer is 15 to 40 cm thick. In many cases the peat layer forms a floating mat. Soil pH ranges from acidic to nearly neutral (4-6). Permafrost is discontinuous or absent.

Variants and Associated Species: Low scrub swamp develops on a gradient between aquatic and terrestrial systems. As water deepens, the community intergrades with aquatic open water communities characterized with floating leaved emergents such as yellow pond lily (*Nuphar polysepalum*) and pond weed (*Potamogeton* spp.). On the drier side it merges either with a willow dominated community (25-75% shrub cover) or with a bog community (0-25% shrub cover). Common willows are diamondleaf, and undergreen (*Salix commutata*). Both sweet gale and dwarf arctic birch continue to occur, but are of lesser importance. Alternatively, shrub swamp intergrades into an open bog where shrubs are not prominent. Sphagnum moss dominates, associated with swamp cranberry (*Oxycoccus microcarpus*) and round-leaf sundew (*Drosera rotund-ifolia*).

References include Barker, 1990; Sprent and Sprent, 1990; and Viereck et al, 1986.

Dr. Marilyn H. Barker
University of Alaska Anchorage
Anchorage, Alaska

MESIC SEDGE-GRASS-HERB MEADOW TUNDRA
SRM 914

Definition, Composition, and Structure: This type is characterized by a floristically variable species composition but consistently exhibits a dominance and diversity which is evenly divided among the sedge, grass, and herbaceous categories. The structure is usually in two layers. The average height of the upper layer is between 12-20 inches (30-50cm). The understory is primarily moss and small flowering herbs such as arctic starflower (*Trientalis europaea*) with occasional intrusions of heath. It often occurs in a narrow band or region located between more extensive grassland and meadow associations. Diagnostic and dominant species for this type are sedges, usually long-awn sedge (*Carex macrochaeta*), hairgrass (*Deschampsia caespitosa* or *D. beringensis*), fescue (*Festuca rubra* or *F. altaica*), and herbs such as western buttercup (*Ranunculus occidentalis*), swamp willow herb (*Epilobium palustre*), roseroot (*Sedum rosea*), and wild celery (*Angelica lucida*). Beach wildrye (*Elymus arenarius mollis*) and bluejoint reedgrass (*Calamagrostis canadensis*), which are ubiquitous in almost all coastal island habitats, may also

be associated with this type.

Geographic Distribution: This cover type is primarily found on coastal islands along the southwestern Alaska Peninsula and the Aleutian Chain.

Ecological Relationships: Mesic sedge-grass-herb meadows tundra is generally found on deep, well drained sandy loam soils. This type is usually located along the upper portion of gently sloping hillsides. It has also been noted to occur along seacliffs. The type is often bordered on the downslope side by broadleaf vegetation, and on the upper side by grassland associations. The sedge-grass component may exhibit tussock growth forms in some areas, yet in others it will not. Flowering phenology is staggered in this association. Forbs tend to flower earlier than the sedge/grass component if they are shorter at maturity than the grasses and sedges, such as western buttercup, roseroot, arctic sweet coltsfoot (*Petasites frigidus*), or arctic starflower. Other herbs, such as swamp willow herb and wild celery, are usually taller at maturity than the sedge/grass element, and thus flower later.

Variants and Associated Species: Other species that may be associated with this community are the bluegrasses (*Poa* spp.), vanilla grass (*Hierochloe odorata*), Gmelin sedge (*Carex gmelinii*), downy oatgrass (*Trisetum spicatum*), field horsetail (*Equisetum arvense*), Alaska violet (*Viola langsdorffi*), yarrow (*Achillea borealis*), geranium (*Geranium erianthum*), oak fern (*Gymnocarpium dryopteris*), and wood fern (*Dryopteris dilatata*). Species associated with this type tend to vary from island to island but the overall physiognomy of the type tends to remain stable.

The mesic sedge-herb meadow is similar to this type but without the grass component seen in the coastal island habitats.

References include Hatch, 1978; Hatch, 1986; Hulten, 1968; Manuwal, 1979; Reiger and Wunderlin, 1956; and Viereck et al. 1986.

Martha A. Hatch
University of Alaska Anchorage
Anchorage, Alaska

MIXED HERB-HERBACEOUS SRM 915

Definition, Composition, and Structure: This type is dominated by various herbs having nearly complete plant cover and rarely having any woody plants. Common herbs in interior Alaska are monkshood (*Aconitum delphinifolium*), lupine (*Lupinus* spp.), bellflower (*Campanula* spp.), wild celery (*Angelica* spp.), wormwood (*Artemisia* spp.), anemone (*Anemone* spp.), and larkspur (*Delphinium* spp.).

Common herbs in coastal southeast Alaska include monkshood, anemone, willow herb (*Epilobium* spp.), cranesbill (*Geranium* spp.), indian paintbrush (*Castilleja* spp.), burnet (*Sanguisorba* spp.), northern false hellebore (*Veratrum viride*), deer cabbage (*Fauria cristagalli*), peavine (*Lathyrus* spp.), and Sitka valerian (*Valeriana sitchensis*). Sedges, grasses, ferns and mosses are also common at many sites. Lichens may be present.

Geographic Distribution: This association occurs throughout Alaska in small local patches on deep, loamy soils along streambanks, and in sheltered subalpine slopes, as well as open slopes and alpine meadows.

Ecological Relationships: This association is found in widely variable climatic zones within the state, from the relatively mild maritime climate of coastal and southeast Alaska to the harsh continental climate of interior Alaska, with yearly temperatures ranging from -60° to 100° F (-60 to 38 C). Long summer days contribute to rapid growth in the short subarctic growing season. Its patchy occurrence and species diversity probably make this an important type in the habitat requirements of a number of wildlife species.

Variants and Associated Species: More moist sites may have cow parsnip (*Heracleum lanatum*) as well as wild celery. Aleutian island sites have a greater variety of grasses and sedges as a common component.

The alpine variant occurs on poorly developed soils, generally on steep slopes with talus or rock fields. Rockcress (*Draba* spp.), dwarf fireweed (*Epilobium latifolium*), Tiles mugwort (*Artemisia tilesii*), roseroot (*Sedum rosea*), and Alaska boykinia (*Boykinia richardsonii*) are common, while wild sweetpea (*Hedysarum mackenzie*), arnica (*Arnica* spp.) and lousewort (*Pedicularis* spp.) may occur.

References include Hulten, 1978; Viereck et al, 1986; Watson, 1959; and Welsh, 1974.

Bert R. Mead
USDA Forest Service
Anchorage, Alaska

SEDGE-SHRUB TUNDRA SRM 916

Definition, Composition, and Structure: Sedge-shrub tundra is dominated by sedges and has a varying dwarf shrub understory. The shrubs always have a lower stature than the graminoids. Cover may be open or complete. The shrub cover varies from 5 to 50% of the total cover. Perennial herbs are inconspicuous and provide less than 5% total cover. Total vegetation cover is over 100 percent, in multiple layers. Canopy height ranges from 6-24 inches (15-60cm).

The species components of sedge-shrub tundra vary along a moisture gradient. Wetter sites are dominated by water sedge (*Carex aquatilis*), tall cottongrass (*Eriophorum angustifolium*), and fragile sedge (*Carex membranacea*).

The understory consists of arctic willow (*Salix arctica*), oval-leaf willow (*S. ovalifolia*), and diamond-leaf willow (*S. planifolia*). Free standing water is sometimes present, particularly during the early part of the season. Herbaceous plants vary locally but often include horsetails (*Equisetum arvense* and *E. variegatum*) and saxifrages (*Saxifraga hirculus* and *S. cernua*). Typically, the herbaceous plants provide less than 5% total cover. Bryophytes are common, particularly yellow bog moss (*Tomenthypnum nitens*), cycle moss (*Drepanocladus brevifolius*), and *Aulacomnium* spp. Mosses may form a continuous carpet. Sphagnum mosses and lichens are generally scarce.

Drier sites are dominated by the non-tussock forming variant of Bigelow sedge (*Carex bigelowii*) along with water sedge (*C. aquatilis*), dark brown sedge (*C. atrofusca*) and tall cottongrass. The understory consists of dwarf willows (*Salix reticulata, S. lanata, S. rotundifolia* and *S. arctica*), entire-leaf mountain avens (*Dryas integrifolia*), dwarf arctic birch (*Betula nana*), and resin Birch (*B. glandulosa*). Less frequently heaths, such as four-angle heather (*Cassiope tetragona*) and black crowberry (*Empetrum nigrum*), comprise part of the shrub understory. Reindeer lichens (*Cladina rangiferina, C. arbuscula*) and cetraria lichens (*Cetraria islandica, C. cucullata*) are in-creasingly important.

Geographic Distribution: Sedge-shrub tundra is widespread throughout northern ans western Alaska. It is particularly well-developed on the arctic coastal plain, inland portions of the Yukon-Kuskokwim Delta, and foothills north of the Brooks Range.

Sedge-shrub tundra is also common on both the Seward and Alaska Peninsulas and islands of the Bering Sea. It is most common on low elevation coastal plains but can develop inland on flat or slightly depressed terrain at higher elevations.

Ecological Relationships: Sedge-shrub tundra forms relatively stable communities in cold climates where acid soils are underlain by permafrost. Sedge-shrub tundra forms extensive cover on flat, poorly drained habitats and is often associated with patterned ground. Low-centered polygons will often support water sedge and arctic willow in the centers, and Bigelow sedge and mountain avens on the rims.

Soils which support sedge-shrub tundra are classified as histic pergelic cryaquepts, or pergelic cryohemists. Soil pH ranges from 5.5 to 6.8. The permafrost table is 12 to 20 inches (30 to 50cm) deep during the growing season.

Variants and Associated Species: Sedge-shrub tundra varies along a moisture gradient. Both species components and the ratio of sedge to shrubs are affected, forming a continuum from sedge-dominated communities to shrub-dominated communities. In addition, sedge-shrub tundra can merge into tussock tundra by the addition of tussock cottongrass (*Eriophorum vaginatum*) and a change to the tussock-forming Bigelow sedge.

References include Barker, 1989; Swanson et al, 1985; Walker, 1985; Walker et al, 1980; and Viereck et al, 1986.

Dr. Marilyn H. Barker
University of Alaska-Anchorage
Anchorage, Alaska

TALL SHRUB SWAMP
SRM 917

Definition, Composition, and Structure: This association is usually dominated by alder, typically thinleaf alder (*Alnus tenuifolia*). It differs from other shrub types by extreme wetness. It is sometimes dominated by willow, typically diamond leaf willow (*Salix pulchra*). Scattered trees may be present, black cottonwood (*Poplus balsamifera trichocarpa*), paper birch (*Betula papyrifera*), or black spruce (*Picea mariana*). Low shrubs may be absent or may include devil's club (*Echinopanax horridum*), red elderberry (*Sambucus racemosa*), prickly rose (*Rosa acicularis*), Beauverd spirea (*Spiraea beauverdiana*), highbush cranberry (*Viburnum edule*), and red currant (*Ribes triste*). Herbs may include horsetail (*Equisetum* spp.), sedges (*Carex* spp.), bluejoint reedgrass (*Calamagrostis canadensis*), marsh fivefinger (*Potentilla palustris*), arctic starflower (*Trientalis europaea*), bunchberry dogwood (*Cornus canadensis*), and tall jacob's ladder (*Polemonium acutiflorum*). A moss component (*Sphagnum* spp.) and (*Mnium* spp.), is often present. Ground lichens are rare.

Geographic Distribution: This type occurs in strips along riparian zones, along margins of bogs, or in poorly drained forest clearings throughout much of the interior and southeastern Alaska. The soil is usually hummocky, with low areas filled with water.

Ecological Relationships: This association is found in widely variable climatic zones within the state, on very wet sites with moving water present through much of the growing season. These associations probably represent topo-edaphic climaxes in many cases and will persist as long as flooding occurs.

Variants and Associated Species: This type closely resembles other tall shrub types but is much wetter.

References include Viereck et al, 1986; Viereck and Little, 1972; Viereck and Little, 1975; and Watson, 1959.

Bert R. Mead
USDA Forest Service
Anchorage, Alaska

TUSSOCK TUNDRA
SRM 918

Definition, Composition, and Structure: Tussock tundra is defined by physical appearance as well as species composition. The dominant feature is the presence of tussocks which occur in a wide range of density and size. Most commonly there are 2-4 tussocks per square meter and they range in diameter from 8-24 inches (20-60cm) and in height from 4-20 inches (10-50cm). Tussock size shows an inverse relationship to soil moisture: the wetter the soil, the smaller the tussock.

The dominant tussock formers are graminoids: tussock cottongrass (*Eriophorum vaginatum*), and Bigelow sedge (*Carex bigelowii*). Tussock cottongrass is by far the most important. Low shrubs often grow between tussocks. These shrubs, which commonly total less than 30% cover, include heaths, northern Labrador tea (*Ledum palustre decumbens*), lowbush cranberry (*Vaccinium vitisidaea*), bog blueberry (*Vaccinium uliginosum*), four-angle heather (*Cassiope tetragona*), and black crowberry (*Empetrum nigrum*). Common willows are diamondleaf willow (*Salix pulchra*), skeletonleaf willow (*S. phlebophylla*), net-leaf willow (*S. reticulata*) and Richardson willow (*Salix lanata richardsonii*). Avens (*Dryas integrifolia, D. octopetala*), and dwarf arctic birch (*Betula nana*) may be present. Perennial herbs may or may not occur, but comprise less than 5% of the total cover.

Bryophytes and lichens are an integral part of this vegetation type, together, they comprise 15-40% of the total plant cover. Their cover reflects the moisture gradient. Bryophytes such as yellow bog moss (*Tomenthypnum nitens*), sickle moss (*Drepanocladus brevifolius*), and green fingers (*Aulacomnium turgidum*) are important on the wetter sites, while fruticose lichens (*Cladonia rangiferina, Cetraria cucullata, C. islandica*) predominate on drier sites.

Geographic Distribution: Tussock tundra is widespread in western and arctic Alaska on flat or gently sloping terrain. In addition, it occupies the foothills and lower elevations of the Alaska range, much of the Seward and Alaska Peninsulas, the Aleutian Islands and the islands of the Bering Sea.

Ecological Relationships: Tussock tundra forms a stable community in cold climates where acid soils are underlain by permafrost. It forms extensive cover on slopes of less than 5%, low middle slopes, flat uplands, and low semi-drained basins. In northern areas, tussock tundra is often dissected by polygonal patterns created by underlying ice wedges and is frequently associated with high-centered polygons.

Soils which support tussock tundra are typically poorly drained gleyed soils (histic pergelic cryaquept or pergelic cryaquepts) with a weakly decomposed organic horizon at the surface. Soil pH is usually in the range of 4.4 to 6.0, and the permafrost table is usually at depths of 6-20 inches (15 to 50cm) during the growing season.

Variants and Associated Species: Along the moisture gradient from wet to dry, tussock tundra vegetation shows a corresponding shift in dominance from tussock cottongrass to Bigelow sedge. The Bigelow sedge-tussock cottongrass community is characterized by an increase in the importance of perennial herbs such as meadow bistort (*Polygonum bistorta*), arctic wormwood (*Artemisia arctica*) and arctic senecio (*Senecio atropurpureus*).

In some locations the dwarf shrub component, including northern Labrador tea and blueberry, can increase to 50% coverage. On these sites, the graminoid component is still dominant.

References include Barker, 1989; Hulten, 1968; Racine and Anderson, 1976; and Viereck et al, 1986.

Dr. Marilyn H. Barker
University of Alaska Anchorage
Anchorage, Alaska

WET MEADOW TUNDRA
SRM 919

Definition, Composition, and Structure: Wet meadow tundra is inundated with standing water for most of the growing season in normal years. Woody plants are generally absent, though sometimes prostrate willows (*Salix* spp.) will occur. Tussocks of cottongrass (*Eriophorum vaginatum*) are poorly developed or absent. Mosses, commonly (*Scorpidium* spp. or (*Drepanocladus* spp.), may be abundant, and peatmoss (*Sphagnum* spp.) may occasionally be present. Plant cover is usually fairly high in the sedge and grass dominated types, becoming open or sparse in the forb-dominated areas.

Wet meadow tundra is dominated primarily by water sedge (*Carex aquatilis*) and/or tall cottongrass (*Eriophorum angustifolium*). If the type is dominated by grasses, prominent species would usually include dupontia (*Dupon-tia fischeri*) or mountain foxtail (*Alopecurus alpinus*). A wide variety of broad-leaved forbs may be plentiful in some areas; the most common being buckbean (*Menyanthes trifoliata*), arctic sweet coltsfoot (*Petasites frigidus*), marsh fivefinger (*Potentilla palustris*) and Pallas buttercup (*Ranunculus pallasii*). Associated species may include pendant grass (*Arctophila fulva*), round sedge (*Carex rotundata*), Lyngbye sedge (*C. lyngbyei*), beaked sedge (*C. rostrata*), russet cottongrass (*Eriophorum russeolum*), northland cottonsedge (*E. brachyantherum*), white cottongrass (*E. scheuchzeri*), Mackenzie water hemlock (*Cicuta mackenzieana*) and reed grass (*Calamagrostis* spp.). Shrub willows (*Salix arctica* and *S. pulchra*) may be prominent on polygon ridges.

Geographic Distribution: Extensive stands of wet meadows are common in tundra depressions in interior Alaska

and along the coast from southwest Alaska to the Chukchi Sea coast, east across the Arctic lowlands to the Canadian border. Small stands are locally common in alpine areas everywhere except southeast Alaska. Species diversity tends to decrease with increasing latitude.

Ecological Relationships: Wet meadow tundra occurs within drained lake basins and small depressions, around lake margins, the inside bends of old river meanders, and on level to gently sloping floodplains and terraces. Those communities co-dominated by grasses are generally found within the Arctic Coastal Plain, where they occupy shallow polygon centers and troughs, stream banks and other low wet areas. Areas co-dominated by forbs are locally common in both arctic and alpine areas throughout the state in such features as oxbow lakes, lake and pond margins, kettles and small depressions, and very wet polygon pans. Standing water is usually shallow 6 inches (15cm) or less in the sedge-forb communities, increasing in depth within the sedge and sedge-grass communities. Areas dominated by sedge-forb stands are smaller in size, with reduced cover, than those stands of pure sedge.

Soils are very poorly drained, are of fine texture, and generally flooded by up to 6 inches (15cm) of standing water well into the growing season. They are not, however, permanently flooded (see "Freshwater Marsh"). They may be mineral (humic) or organic (histolic) or may consist of a few centimeters of organic matter over mineral soil. These wet, gleyed soils generally lack a deep mat of decayed organic material such as is found in bogs and muskegs. Soils under these wet sedge-dominated communities tend to be somewhat acidic (as low as pH 4.1) but may reach into the circumneutral zone (pH 7.5).

The rhizomes of water sedge and tall cottongrass may form an interwoven mass several cm thick which becomes firmly anchored in a shallow layer of fibrous peat. The peat is an accumulation of partially decomposed sedge, cottongrass and sphagnum moss.

A permafrost table is usually present, 15 to 22 inches (38-56cm) below the surface, in the sedge and grass-dominated communities. Depth to the permafrost table increases towards the southern range of its boundary. Sites co-dominated by broad-leaved forbs have a greater depth to permafrost of 22 to 26 inches (56-64 cm). Permafrost is absent from the southeastern and southcentral Alaska alpine sites. Because of the permafrost condition, lateral movement of groundwater is restricted.

Variants and Associated Species: Successional relationships among tundra communities are complex. However, it appears that wet sedge and sedgegrass meadows may replace the pendant grass-dominated marshes if sedi-mentation or drainage causes a lowering of the water table. A further decrease in moisture may allow tussock tundra to replace wet sedge or sedge-grass meadow. Overall, sedge and sedge-grass wet meadow communities appear to be relatively stable.

Wet meadow tundra is similar to subarctic lowland wet meadow, which occupies similar sites within the treeline. Although some species commonly dominate both (e.g. water sedge), many species dominating the subarctic sites (Lyngbye sedge) are not as abundant in the arctic. Also, tall cottongrass is less commonly dominant in the subarctic sites than it is in the arctic. While the freshwater marsh type is similar to the wet meadow tundra, it does not include any arctic tundra communities, it is permanently flooded, and it is dominated by genera other than the sedges, cottongrass, dupontia or foxtail.

Reference include Batten and Murray, 1982; Bergman et al, 1977; DeMeo and Loggy, 1989; Hogan and Tande, 1983; Markon, 1980; and Viereck et al, 1986.

David M. Dall
U.S. Fish and Wildlife Service
Anchorage, Alaska

WHITE SPRUCE-PAPER BIRCH SRM 920

Definition, Composition, and Structure: The white spruce-paper birch type varies in both overstory and understory composition. Either paper birch (*Betula papyrif-era*) or white spruce (*Picea glauca*) may dominate, but each must contribute at least 25% of the relative canopy cover. Other tree species that may be present include black spruce (*Picea mariana*), poplar (*Populus balsamifera*), and quaking aspen (*Populus tremuloides*). Understories are quite variable, from herbaceous to shrubby and intermediate mixes.

Geographic Distribution: The type occurs in all forested areas of the state from the Kenai Peninsula north to the Brooks Range.

Ecological Relationships: This is one of the predominant vegetation types in southcentral Alaska and occurs in both upland and riparian sites. It is a seral type between earlier paper birch (fire, upland sites) or poplar (riparian) communities, and the later white spruce communities in many portions of the state. The white spruce-paper birch type is the predominant vegetation on floodplain sites over 175 years old along the Susitna River. It is considered a disclimax in southcentral Alaska and portions of western Canada, where it forms a mosaic with variable canopy cover. Tree falls open gaps where herbaceous, shrubby or tree reproduction may occur, depending on the size of the gap and age of the surrounding vegetation. These openings are important for herbaceous and woody reproduction and hence for grazing and other aspects of wildlife habitat. Fire, logging, and moose browsing are important aspects of the vegetation dynamics. Spruce cover is important for hiding and thermal cover for wildlife.

White spruce is more shade tolerant than paper birch, and

may reproduce in the understory of some birch stands. Paper birch requires mineral soil and more sunlight, and is dependent on gaps in the cover for reproduction. Birch does not enter the floodplain poplar communities until poplar or spruce trees are uprooted. This creates a gap in the canopy and the litter where seedlings can become established on mineral soil. Bluejoint reedgrass (*Calamagrostis cana-densis*) is the primary forage species and is most important where birch is dominant in the canopy. It occurs both in the understory and in gaps. Shrubs, especially prickly rose (*Rosa acicularis*), highbush cranberry (*Viburnum edule*), and birch, regenerate in gaps and are important sources of moose browse. Overbrowsing in some areas may restrict paper birch to a shrub growth form for twenty years. Herbaceous production is lower than in bluejoint reedgrass meadows, but the broader range of the spruce-birch type makes it an important cover type on rangeland. Mixed white spruce-paper birch forests may produce more than 202 lb/ac (224 kg/ha) of usable herbaceous forage, and nearly 302 lb/ac (336 kg/ha) if shrubs are included. Because of the large area occupied by this cover type in the populated portion of the state, it may be one of the most important range cover types in the boreal region. It is used both by wildlife and domestic livestock.

Variants and Associated Species: This type grades into the earlier successional paper birch, poplar, poplar-spruce, and poplar-birch-spruce types as well as the later successional white spruce types.

Shrub species common in the understory include several species of willow (*Salix* spp.), and alder (*Alnus* spp.), highbush cranberry, prickly rose, lowbush cranberry (*Vaccinium vitis-idaea*), and Labrador tea (*Ledum palustre groenlandicum*). The most common herbaceous species include bluejoint reedgrass, common fireweed (*Epilobium angustifolium*), bunchberry dogwood (*Cornus canadensis*), and horsetail (*Equisetum* spp.). Ferns are important under some conditions, while feather mosses and lichens are important primarily where white spruce is dominant.

References include Agricultural and Forestry Experiment Station, 1988; Helm et al, 1985; Hulten, 1968; Viereck et al, 1986; and Zasada,1980.

D.J. Helm
University of Alaska Fairbanks
Palmer, Alaska

WILLOW
SRM 921

Definition, Composition, and Structure: Grayleaf willow (*Salix glauca*), diamondleaf willow (*S. pulchra*), and Richardson willow (*S. lanata richardsonii*) are the common species dominating low willow sites (shrubs <1.5 meters height). Feltleaf willow (*Salix alaxensis*), Barclay willow (*S. barclayi*), and Bebb willow (*S. bebbiana*) are common on the taller (>1.5 m) willow sites. Tree species, primarily black cottonwood (*Populus balsamifera trichocarpa*), balsam poplar (*Populus balsamifera*), white spruce (*Picea glauca*), and black spruce (*Picea mariana*), may be present as scattered individuals, especially on riparian sites. Other low shrubs are unusual, but soapberry (*Shepherdia canadensis*), prickly rose (*Rosa acicularis*), and bog blueberry (*Vaccinium uliginosum*) may be present.

Sweet gale (*Myrica gale*) and leatherleaf (*Chamaedaphne calyculata*) may also be present on open wet sites dominated by willow under 4.5 ft (1.5m) tall. The herb layer may be sparse, but is usually quite diverse. If it occurs in early seral stages, the common herbs are oxytrope (*Oxytropis* spp.), dwarf fireweed (*Epilobium latifolium*), milkvetch (*Astragalus* spp.), and wormwood (*Artemisia* spp.). Other sites may contain monkshood (*Aconitum delphinifolium*, bluejoint reedgrass (*Calamagrostis canadensis*), Mackenzie water hemlock (*Cicuta mackenzieana*), common fireweed (*Epilobium angustifolium*), horsetail (*Equisetum* spp.), as well as less common herbs. Mosses may be common or absent. Moss (*Rhacomitrium canescens*) may be present on dry sites. Other mosses (*Hylocomium splendens*), (*Polytrichum* spp.), (*Dicranum* spp.), (*Aulo-comnium* spp.), *Pleurozium schreberi* and *Sphagnum* spp. may be found on mesic to wet sites. Lichens are usually sparse to rare, but (*Cladonia* spp.) and (*Peltigera* spp.) do occur.

Geographic Distribution: Feltleaf willow occurs throughout Alaska. Grayleaf willow and diamondleaf willow occur throughout the state except for the southern part of the Alaska panhandle. Richardson willow occurs in most of the state except the southcentral coastal area, the Alaska Peninsula, and the southeast archipelago. Barclay willow occurs in the southern half of Alaska, and Bebb willow in central Alaska, but not in the coastal areas. Many less common willow species occur in all areas of the state.

Open tall willow associations occur on floodplains, sand dunes, in drainageways, and on sheltered slopes. Closed low willow associations occur in moist gullies, streambanks, and on steep scarps around lakes and ponds in the arcticand alpine tundra. They are also present on major river deltas and on the fringes of other low-elevation wetlands in south-central and interior Alaska.

Ecological Relationships: Feltleaf willow, Bebb willow and Scouler willow (*Salix scouleriana*) are tree-like willows found in many parts of the state, occurring as scattered individuals in many forest types, and extending up valleys beyond the limits of spruce birch forests. Feltleaf willow, grayleaf willow, and Bebb willow are important pioneer species following fire on upland sites in interior Alaska. Feltleaf willow is a frequent colonizer of floodplains. Barclay willow and Richardson willow are common thicket-forming shrubs in riparian zones and above treeline. Diamondleaf willow is a common species in wetland bogs

and in treeless alpine areas. In alpine areas, it is an important food source for snowshoe hare, and its persistent leaves are often eaten by Dall sheep and moose. Willows are important browse species for moose in all physiographic areas of the state.

The climate varies from maritime with abundant precipitation along coastal areas in the southcentral and southeast regions of the state, to a harsh, dry continental climate in the interior, typified by temperature extremes. The record high and low temperature range is more than 100 degrees (38 C to - 62 C). Abrupt spring and fall tem-perature changes are common. South coastal areas average 145 freeze-free days, with a range of 100 to 170 days. Less than 100 freeze-free days occur in interior lowland basins. Some sites are snowcovered most of the year. Plant growth begins in late May in the basins, to late June in alpine areas, and ceases in early August in alpine areas and mid-September in the basins. The long summer daylength contributes to rapid plant growth during this short growing season.

Variants and Associated Species: Tall willows are sometimes found in association with alder (*Alnus* spp.), and dwarf willows with shrub birch (*Betula nana, B. glandulosa*). Less common dwarf willows to be found in alpine or arctic sites are netleaf willow (*Salix reticulata*), polar willow (*S. polaris*), skeleton-leaf willow (*S. phlebophylla*), least willow (*S. rotundifolia*), arctic willow (*S. arctica*), Alaska bog willow (*S. fuscescens*), oval-leaf willow (*S. ovalifolia*), barren ground willow (*S. brachy-carpa*), halberd willow (*S. hastata*), and low blueberry willow (*S. myrtillifolia*). Less common low shrub to tall willows are tall blueberry willow (*S. novaeanglicae*), Hooker willow (*S. hookeriana*), Barratt willow (*S. barrattiana*), silver willow (*S. candida*), Sitka willow (*S. sitchensis*), littletree willow (*S. arbusculoides*), sandbar willow (*S. interior*), and Pacific willow (*S. lasiandra*). Willows are quite versatile, as they can be pioneer species following fire or disturbance, or they can be climax species on harsh alpine sites.

References include Viereck et al, 1986; Viereck and Little, 1972; Viereck and Little, 1975; and Watson, 1959.

Bert R. Mead
USDA Forest Service
Anchorage, Alaska

LITERATURE CITED

Adams, A.W. 1975. A brief history of juniper and shrub populations in southern Oregon. Wildlife Res. Rep. No. 6, Oregon State Wildlife Commission, Corvallis, Ore. 33 pages.

Agricultural and Forestry Experiment Station. 1988. Summarization of data on grazing lands of the Matanuska-Susitna Borough. University of Alaska Fairbanks in Cooperation with Upper Susitna Soil and Water Conservation District and USDA Soil Conservation Service. 96 p.

Albee, B.J. and L.M. Shultz. 1988 Atlas of the vascular plants of Utah. Utah Museum of Natural History Occasional Publication No. 7. University of Utah, Salt Lake City. 670 p.

Albertson, F.W. 1940. Studies of native red cedars in west central Kansas. Trans. Kans. Acad. Sci. 43:85-95.

Alderfer, J.M. 1977. A taxonomic study of bitterbrush (*Purshia tridentata* (Pursh) *DC.*) in Oregon. MS Thesis. Oregon State University, Corvallis, Oregon. 197 pp.

Allen, B.H. 1987. Forest and meadow ecosystems in California. Rangelands 9:125-128.

Allen, B.H., R.R. Evett, B.A. Holzman, and A.J. Martin. 1989. Rangeland Cover Type Descriptions for California Hardwood Rangelands. A report prepared for the Forest and Rangeland Resources Assessment Program, Dept. Forestry and Fire Protection Contract #8CA63912. Sacramento, CA. 318p.

Allen, B.H. 1989b. Ten years of change in Sierran stringer meadows; an evaluation of range condition models. Gen. Techn. Rept. PSW-110.Proc. Riparian Systems Conference. Sept. 22-24, 1988. Davis, CA. Gen. Tech. Rep. PSW-110. pp. 102-108.

Allen, B.H. 1991. Water table and plant species relationships in Sierra Nevada meadows. Amer. Midland Naturalist 126(1): 30-43 in press.

Allred, B.W., and H.C. Mitchell. 1955. Major plant types of Arkansas, Louisiana, Oklahoma, and Texas and their relation to climate and soils. Texas J. Sci. 7:7-19.

Anderson, B.W., R.D. Ohmart, and J. Disano. 1979. Revegetating the riparian flood plain for wildlife, pp. 318-331. In Strategies for Protection and Management of Floodplain Wetlands and other Riparian Ecosystems, E.R. Johnson and J.F. McCormick, tech. coord. U.S. Dep. Agric. Gen. Tech. Rep. WO-12. Washington, D.C.

Anderson, R.C., and L.E. Brown. 1986. Stability and instability in plant communities following fire. Amer. J. Bot. 73:364-368.

Armentrout, S.M. and R.D. Pieper. 1988. Plant distribution surrounding Rocky Mountain pinyon and oneseed juniper in southcentral New Mexico. J. Range Manage. 41: (In press).

Arnold, J.F. 1964. Zonation of understory vegetation around a juniper tree. J. Range Manage.
17:41-42

Bailey, Robert G. 1978. Description of the Ecoregions of the United States. USDA For. Serv. Intermountain Region. Ogden, UT. 77 pp.

Baker, H.G. 1989. Sources of the Naturalized grasses and herbs in California grasslands. In Huenneke, L.F. and H. Mooney (eds.) Grassland structure and function: California annual grassland. Kluwer Academic Publishers, Dordrecth, pp. 29-38.

Baker, A.G., P.W. Rundel, and D.J. Parsons. 1981. Ecological relationships of *Quercus douglasii* (Fagacea) in the foothill zone of Sequoia National Park, California. Madrono 28:1-12.

Bakker, E. 1984. An island called California, 2nd ed. Univ. California Press, Berkeley. 484 p.

Barbour, M.G., and J. Major, eds. 1977. Terrestrial vegetation of California. John Wiley and Sons, New York.

Barbour, M.G., A. Shmida, A.F. Johnson, and B. Holton, Jr. 1981. Comparison of coastal dune scrub in Israel and California. Israel J. Bot. 30:181-198.

Barbour Michael G. 1968. Germination requirements of the desert scrub Larrea divaricata. Ecology 49:5, 915-923.

Barbour, M.G. 1984. Can a red fir forest be restored? Fremontia 11(4):18-19.

Barbour, M.G., and A.F. Johnson. 1988. Beach and dune. In M.G. Barbour and J. Major (eds.) Terrestrial vegetation of California, 2nd ed., pp. 223-262. California Native Plant Society, Sacramento.

Barbour, M.G. 1987. Community ecology and distribution of California hardwood forests and woodlands. In T.R. Plumb and N.H. Pillsbury (tech. coords.) Multiple-use management of California's hardwood resources. U.S. For. Serv. Gen. Tech. Rep. PSW-100. pp. 18-25.

Barchenger, E.J. 1983. The physical and vegetative characteristics of sandhill areas in or near the northern Great Plains. M.S. Thesis, Dept. Botany. N. Dak. State Univ., Fargo. 151 pp.

Barker, W.T. and W.C. Whitman. 1989. Vegetation of the northern Great Plains. N. Dak. Agr. Exp. Sta. Res. Rept. 111. 26 pp.

Barker, M. 1982-1989. Unpub. field notes.

Barker, William T. 1969. The flora of the Kansas Flint Hills. Univ. Kans. Sci. Bul. XLVIII. 525-584. Lawrence, Kans.

Barker, M. 1975-90. Unpub. field notes.

Barry, W.J. 1972. The Central Valley prairie. Calif. Dept. Parks and Rec., Sacramento. 82 p.

Barry, W.J. 1991. California wetland formation types. Natural Heritage Section. Department of Parks and Recreation, Sacramento, CA. Unpublished manuscript, 34 p.

Bartholomew, B. 1970. Bare zone between California shrub and grassland communities, the role of animals. Science 170:1210-1212.

Bartolome J.W., and B. Gemmill. 1981. The ecological status of *Stipa pulchra* (Poaceae) in California, Madrono 28:172-184.

Bartolome, J.W. 1987. California grassland and oak savannah, Rangelands 9:122-125.

Bartolome, J.W., S.E. Klukkert, W.J. Barry. 1986. Opal phytoliths as evidence for displacement of native Californian grassland, Madrono 33:217-222.

Bartolome, J.W. 1986. Herbaceous productivity in oak woodland. In J.G. Kie and F. Laudenslayer, Jr. (eds.) Trans. of West. Sec. of the Wildlife Soc. Vol. 22, 112-116.

Bartolome, J.W., P.C. Muick, and M. McClaran. 1987. Natural regeneration of California hardwoods. In T.R. Plumb and N.H. Pillsbury (tech. coords.) Multipleuse management of California's hardwood resources. U.S. For. Serv. Gen. Tech. Rep. PSW-100. pp. 26-31.

Bartolome, J.W., M.C. Stroud, and H.F. Heady. 1980. Influence of natural mulch on forage production on differing California annual range sites. J. Range Manage. 33:4-8.

Bates, Patricia C. 1984. The role and use of fire in blackbrush (Torr.) communities in California. M.S. thesis, Univ. of Calif., Davis. 56 p.

Batten, A.R., and D.F. Murray. 1982. A Literature Survey on the Wetland Vegetation of Alaska. Institute of Arctic Biology and Museum, University of Alaska Fairbanks.

Batzli, G.O., and F.A. Pitelka. 1970. Influence of meadow mouse populations on California grassland. Ecology 51:1027-1039.

Baumberger, Rodney. 1977. South Dakota rangeland resources. Soc. for Range Manage. - Old West Regional Commission Joint Publ. Soc. Range Manage. Denver. 150 pp.

Beasom, S.L., and H.H. Huacke. 1975. A comparison of 4 distance sampling techniques in south Texas liveoak mottes. J. Range Manage. 28:142-144.

Beetle, A.A. 1960. A study of sagebrush, the section Tridentatae of *Artemisia*. Bull. 368. Laramie, WY: University of Wyoming, Agricultural Experiment Station. 83 p.

Beetle, A.A. and K.L. Johnson. 1982. Sagebrush in Wyoming. Bulletin 779. Laramie, Wyo. University of Wyoming, Agricultural Experiment Station. 68 p.

Beetle, A.A. and A. Young. 1965. A third subspecies in the *Artemisia tridentata* complex. Rhodora. 67:405-406.

Benedict, N.B. 1982. Mountain meadows: stability and change. Madrono 29:148153.

Benedict, N.B. 1983. Plant associations of subalpine meadows, Sequoia National Park, California. Artic & Alpine Res. 15(3):383-396.

Benedict, N.B., and J. Major 1982. A physiographic classification of subalpine meadows of the Sierra Nevada, California. Madrono 29(1):1-12.

Benson, L. 1981. The cacti of Arizona, 4th Printing. The Univ. of Arizona Press, Tucson. 218 pp.

Benson, L. and R.A. Darrow. 1981. Trees and shrubs of the Southwestern Deserts, 3rd. ed. 1981. Univ. of Ariz. Press., Tucson, Arizona. 415 pp.

Bentley, J.R., and M.W. Talbot. 1951. Efficient use of annual plants on cattle ranges in the California foothills. U.S. Dept. Agric. Cir. 870, 52 pp.

Bergman, R.D., R.L. Howard, K.F. Abraham, and M.W. Walker. 1977. Water Birds and their Wetland Resources in Relation to Oil Development at Storkersen Point, Alaska. USDI Fish and Wildlife Service. Resource Publication 129.

Billings, W.D. 1988. Chapter 13, Alpine vegetation. In Barbour, M.G. & W.D. Billings, eds. North American terrestrial vegetation. Cambridge Univ. Press, New York. pp. 391-420.

Billings, W.D. 1978. Alpine phytogeography across the Great Basin. Great Basin Nat. Memoirs 2:105-117.

Billings, W.D. 1949. The shadscale vegetation zone of Nevada and eastern California in relation to climate and soils. Am. Midl. Nat. 42:87-109.

Billings, W.D. 1964. Plants and the ecosystem. Wadsworth Publishing Company, Inc. Belmont, Californica. 154 pp.

Billow, C.R. 1987. Nitrogen dynamics beneath a deciduous (*Quercus lobata Nee*) and an evergreen (*Q. agrifolia Nee*) oak in California. Thesis, San Francisco State University, San Francisco, CA.

Biswell, H.H. 1969. Prescribed burning for wildlife in California brushlands. Trans. North Amer. Wildl. and Natur. Res. Conf. 34:438-446.

Biswell, H.H., and J.H. Gilman. 1961. Brush management in relation to fire and other environmental factors on the Tehama deer winter range. Calif. Fish and Game 47:357-389.

Bjugstad, Ardell J., Dean A. Murphy, and Hewlette S. Crawford. 1968. Poor returns from Ozark woodland grazing. Res. Note NC-60. St. Paul, MN: USDA Forest Service, North Central Forest Experiment Station.

Blaisdell, J.P. and R.C. Holmgren. 1984. Managing Intermountain Rangelands-Salt Desert Shrub Ranges. USDA Forest Service. General Technical Report INT-163 52 pp.

Bolsinger, C.L. 1988. The hardwoods of California's timberlands, woodlands, and savannas. U.S. For. Serv. Res. Bull. PNW-148. 148 p.

Booth, W.E. 1941. Revegetation of abandoned fields in Kansas and Oklahoma. Amer. J. Bot. 38:415-422.

Borchert, M., F.W. Davis, and B. Allen-Diaz. 1991. Environmental relationships of herbs in blue oak (*Quercus douglasii*) woodlands of central coastal California. Madrono: in press.

Bose, Dan R. 1977. Rangeland resources of Nebraska. Soc. for Range Manage. - Old West Regional Commission Joint Publ., Soc. for Range Manage. Denver. 121 pp.

Bowns, J.E. 1973. An autecological study of blackbrush (Torre.) in southwestern Utah. Ph.D. dissertation, Utah State Univ., Logan. 115 p.

Bowns, J.E., and N.E. West. 1976. Blackbrush on southwestern Utah rangelands. Utah Agric. Exp. Sta. Res. Rep. 27. Logan. 27 p.

Box, T.W. 1967. Brush, fire, and west Texas rangeland. Tall Timbers Fire Ecology Conf., Proc. 6:7-19.

Box, Thadis W., George M. Van Dyne, and Neil E. West. 1966. Syllabus on Range Resources of North America. Unpublished Manuscript.

Box, T.W. 1961. Relationships between plants and soils of four range plant communities in south Texas. Ecology 42:794-810.

Box, T.W., D.L. Drawe, and D.K. Mann. 1979. Vegetation change in south Texas-The Welder Wildlife Refuge case study. p.5-14—In: Proceed. First Welder Wildlife Foundation Sym. Proc., Welder Wildlife Found., Sinton, Texas.

Bragg, T.D., and L.C. Hulbert. 1976. Woody plant invasion of unburned Kansas bluestem prairie. J. Range Manage. 29:19-24.

Brandegee, K. 1891. The vegetation of "burns". Zoe 2:118-122.

Branson, Farrel A. 1985. Vegetation changes on western rangelands. Soc. Range Manage. Range Monogr. No. 2. Soc. for Range Manage. Denver. 76 pp.

Branson, F.A., R.F. Miller, and I.S. McQueen. 1967. Geographic distribution and factors affecting the distribution of salt desert shrubs in the United States. J. Range Manage. 20:287-296.

Bray, W.L. 1901. The ecological relations of the vegetation of western Texas. Bot. Gaz. 32:195-217, 262-291.

Brayton, R. and H.A. Mooney. 1966. Population variability in *Cercocarpus* in the White Mountains of California as related to Habitat. Evolution 20:383-391.

Briggs, George M. and James MacMahon. 1983. Alpine and subalpine wetland plant communities of the Uinta Mountains, Utah. Great Basin Nat. 43:523-530.

Brotherson, J.D., S.R. Rushforth, W.E. Evanson, J.R. Johansen, and C. Morden. 1983. Population dynamics and age relationships of eight tree species in Navajo National Monument, Arizona. J. Range Manage. 36:250-256.

Brotherson, J.D., J.N. Davis and L. Greenwood. 1980. Diameter-age relationships of two species of mountain mahogany. J. Range Manage. 33:367-370.

Brown, H.E. 1958. Gambel oak in west central Colorado. Ecology 39:317-327.

Brown, D.E. and C.H. Lowe. 1980. Biotic communities of the Southwest. U.S. Dept. Agric. Gen. Tech. Rep. RM-78. Map.

Brown, D.E., C.H. Lowe, and J.F. Hausler. 1977. Southwestern riparian communities: Their biotic importance and management in Arizona, pp. 201-211. In Importance, Preservation, and Management of Riparian Habitat: A Symposium. U.S. Dep. Agric. Gen. Tech. Rep. RM-43. Fort Collins, Colorado.

Brown, D.E. (ed). 1982. Biotic communities of the American Southwest - United States and Mexico. Desert Plants 4:1-342.

Brown, L.F., Jr., J.H. McGowen, T.J. Evans, C.G. Groat, and W.L. Fisher. 1977. Environmental and geologic atlas of the Texas coastal zone—Kingsville area. Bur. Econ. Geol. Univ. of Texas, Austin, Texas.

Bruner, W.E. 1931. The vegetation of Oklahoma. Ecol. Monogr. 1:188.

Burcham, L.T. 1957. California range land. State of Calif., Div. For., Sacramento. 261 p.

Burtt-Davy, J. 1902. Stock ranges of northwestern California. USDA Bur. Plant. Industry Bull 12. 81 p.

Cable, D.R. 1975. Range management in the chaparral type and its ecological basis: The status of our knowledge. U.S. Dept. Agric. Res. Paper RM-155. 30 pp.

Chabreck, R.H. 1972. Vegetation, Water and Soil Characteristics of the Louisiana Coastal Region. Bulletin 664, Baton Rouge, LA.

Cheatham, N.H., and J.R. Haller. 1975. An annotated list of California habitat types. Univ. of California Natural Land and Water Reserve System, unpubl. manuscript.

Choate, T.S. 1986. Unpublished field notes. University of Alaska Anchorage.

Cladwell, M.M. 1974. Physiology of desert halophytes. p. 355-379. In: R.J. Reimold and W.H. Queen (eds.), Ecology of halophytes. Academic Press, New York.

Clary, W.P. and D.C. Morrison. 1973. Large alligator juniper benefits early spring forage. J. Range Manage. 26:70-71.

Clausnitzer, R.R., and B.A. Zamora. 1987. Forest Habitat Types of the Colville Indian Reservation. Ag. Res. Center, Washington State University, Pub. No. MISC 0110. 81 pp.

Cole, K. 1980. Geologic control of vegetation in the Purisima Hills, California. Madrono 27:79-89.

Collins, S.L., J.A. Bradford, and P.L. Sims. 1987. Succession and fluctuation in *Artemisia* dominated grassland. Vegetatio 73:89-99.

Conrad, S.G., R.L. MacDonald and R.F. Holland. 1977. Riparian vegetation and flora of the Sacramento Valley, p. 47-55. In A. Sands (ed.) Riparian forests in California. Univ. Calif., Davis.

Cooke, W.B. 1962. On the flora of the Cascade Mountains. Wasmann J. Biol. 20:1-67.

Cooper, D.W. 1960. Fort Baker ranges returned to champagne grasses. J. Range Manage. 13:203-205.

Cooper, D.W., and H.F. Heady. 1964. Soil analysis aids grazing management in Humboldt County. Calif. Agric. 18(6):4-5.

Cooper, W.S. 1922. The broad-sclerophyll vegetation of California - an ecological study of the chaparral and its related communities. Carnegie Inst. Wash. Pub. 122 p.

Correll, D.S., and M.C. Johnston. 1970. Manual of the Vascular plants of Texas. Texas Research Foundation. Renner, Texas.

Costello, D.F. 1964. Vegetation zones in Colorado, p. iii-x. In: H.D. Harrington, Manual of the Plants of Colorado. Sage Books. Denver, Colorado.

Costello, D.F. 1944. Important species of the major forage types in Colorado and Wyoming. Ecol. Monog. 14:107-134.

Cottam, W.P., J.M. Tucker, and R. Drobnick. 1959. Some clues to Great Basin post pluvial climates provided by oak distribution. Ecology 40:171-181.

Cottam, W.P., J.M. Tucker, and F.S. Santamour, Jr. 1982. Oak hybridization at the University of Utah. State Arboretum of Utah Publication No. 1. University of Utah, Salt Lake City. 82 p.

Coupland, Robert T. and T.C. Brayshaw. 1953. The fescue grassland in Saskatchewan. Ecology 34:386-405.

Coupland, Robert T. 1950. Ecology of mixed prairie in Canada. Ecol. Monogr. 20:271-315.

Coupland, R.T. 1959. Effects of changes in weather conditions upon grasslands in the northern Great Plains. pp. 291-306. In: Grasslands. Am. Assoc. Adv. Sci.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. USDI Fish and Wildlife Service, FWS\OBS- 79\31.

Critchfield, W.B. 1971. Profiles of California vegetation. USDA For. Serv. Pac. SW For. and Range Expt. Sta., Misc. Paper PSW-76. Berkeley, CA. 54 p.

Cronquist, Arthur, Arthur H. Holmgren, Noel H. Holmgren and James L. Reveal. 1972. Intermountain Flora - Vascular Plants of the Intermountain West, U.S.A., Volume One. Hafner Publishing Company, Inc., New York.

Dahl, B.E., B.A. Fall, A. Lohse, and S.G. Appan. 1975. Construction and stabilization of coastal foredunes with vegetation: Padre Island, Texas. Misc. Paper No. 9-75, U.S. Army, Corps of Engineers, Coastal Engineering Res. Ctr. Ft. Belvoir, Virginia.

Daley, R.H. 1972. The native sand sage vegetation of eastern Colorado. M.S. thesis. Colorado State Univ. Ft. Collins, Colorado.

Dall, Dave. 1989. Personal communication. Description of a pulsa variant north of Paxson, Alaska.

Daubenmire, R.F. 1970. Steppe vegetation of Washington. Wash. Agr. Exp. Sta. Tech. Bull. 62, 131 pp.

Daubenmire, R. and J.B. Daubenmire. 1968. Forest vegetation of eastern Washington and northern Idaho. Wash. Agr. Exp. Sta. Tech. Bull. 60, 104 pp.

Davidson, E.D., and M.G. Barbour. 1977. Germination, establishment, and demography of coastal bush lupine (*Lupinus arboreus*) at Bodega Head, California. Ecology 58-592-600.

Davis, J. 1967. Some effects of deer browsing on chamise sprouts after fire. Amer. Midl. Nat. 77:234-238.

Davis, J.N. 1976. Ecological investigations in *Cercocarpus ledifolius* Nutt. communities of Utah. Unpublished M.S. Thesis, Dept. Botany and Range Science, Brigham Young Univ., Provo, Utah.

Dealy, E.J. 1975. Ecology of curlleaf mountain-mahogany (*Cercocarpus ledifolius* Nutt.) in eastern Oregon and adjacent areas. Ph.D. dissertation, Oregon State Univ., Corvallis.

Dealy, J.E., J.M. Geist, and R.S. Driscoll. 1977. Communities of western juniper in the intermountain northwest. In: Martin, R.E. Dealy, E.J. Carahaer, D.L. (Eds.) Proceedings of the western juniper ecology and management workshop. USDA For. Serv. Pacific Northwest Forest and Range Exp. Sta. Gen. Tech. Rep. PNW-74. Portland, Ore. Pages 11-29.

DeMeo, T.E., and W.D. Loggy. 1989. Identification, Classification, and Delineation of Wetlands Using Soils and Vegetation Data, for Tongass land management Plan. USDA Forest Service. Juneau, Alaska.

Despain, D.G. 1973. Vegetation of the Big Horn Mountains, Wyoming, in relation to substrate and climate. Ecol. Monog. 43:329-355.

Diamond, D.D., and F. E. Smeins. 1984. Remnant grassland vegetation and ecological affinities of the upper Coastal Prairie of Texas. Southwestern Nat. 29:321-334.

Dixon, H. 1935. Ecological studies on the high plateaus of Utah. Bot. Gaz. 97:234-239.

Donart, G.B., D.D. Sylvester and W.C. Hickey. 1978. Potential natural vegetation in New Mexico. New Mex. Interagency Range Comm. Rep. No. 11. U.S. Dept. Agr. Soil Cons. Serv., Albuquerque, N.M.

Drawe, D.L., A.D. Chamrad, and T.W. Box. 1978. Plant communities of the Welder Wildlife Refuge. Contrib. B-5, Welder Wildlife Foundation. Sinton, Texas.

Drawe, D.L., and K.R. Kattner. 1978. Effect of burning and mowing on vegetation of Padre Island. Southwestern Nat. 23:273-278.

Drawe, D.L., K.R. Kattner, W.H. McFarland, and D.D. Neher. 1981. Vegetation and soil properties of 5 habitat types on north Padre Island. Texas. J. Sci. 33:145-157.

Driscoll, R.S. 1964. Vegetation-soil units in the central Oregon juniper zone. USDA For. Serv., Pacific Northwest Forest and Range Exp. Sta. Research Paper PNW-19. Portland, Ore. 60 pages.

Dwyer, D.D., and P.W. Santelmann. 1964. A comparison of post oak-blackjack oak communities on 2 major soil types in north central Oklahoma. Oklahoma Agr. Exp. Sta. Bull. 626.

Dyksterhuis, E.J. 1948. The vegetation of the western cross timbers. Ecol. Monogr. 18:325-376.

Dyksterhuis, E.J. 1957. The savannah concept and its use. Ecology 38:435-442.

Eddleman, L.E. 1987. Establishment and stand development of western juniper in central Oregon. In: R.L. Everett (Comp.), Proceedings, piny-on-juniper conference. USDA For. Serv. Intermountain Res. Sta. Gen. Tech. Rep. INT-215. Ogden, Ut. Pages 255-265.

Ehrenreich, J.H., and J.S. Crosby. 1960. Forage production on sprayed and burned areas in the Missouri Ozarks. J. Range Manage. 13:68-70.

El Fadl, M.A., S. Gronski, H. Asah, A. Tipton, T.E. Fulbright, and P. Felker. Prediction of green weight, total volume and clear cutting lumber volume of mature mesquite (Prosopis glandulosa var. glandulosa M.C. Johnston) in Texas. For. Ecol. and Manage. (In Press)

Elliott, H.W., and J.D. Wehausen. 1974. Vegetational succession on coastal rangeland of Point Reyes peninsula. Madrono 22:231-238.

Ellison, L. 1954. Subalpine vegetation of the Wasatch Plateau, Utah. Ecol. Monog. 24:89- 184.

Engle, D.M. 1987. The Cross Timbers Experimental Range—tomorrow's research today, p. 4-12. In: D. Rollins (ed.), Brush Management in the Cross Timbers, Proc. Oklahoma Coop. Ext. Serv. Circ. E-862.

Epling, C., and H. Lewis. 1942. The centers of distribution of the chaparral and coastal sage associations. Amer. Midl. Natur. 27:445-462.

Ewing, A.L., J.F. Stritzke, and J.D. Kulbeth. 1984. Vegetation of the Cross Timbers Experimental Range, Payne County, Oklahoma. Oklahoma Agr. Exp. Sta. Res. Rep. P-856.

Fairchild, J.A. and J.D. Brotherson. 1980. Microhabitat relationships of six major shrubs in Navajo National Monument, Arizona. J. Range Manage. 33:423-427.

Felger, R.S. 1980. Vegetation and flora of the Gran Desierto, Sonora, Mexico. Desert Plants 2:87-114.

Fenneman, N.M. 1931. Physiography of the western United States. McGraw Hill, New York 534 pp.

Fenneman, Nevin M. 1938. Physiography of eastern United States. McGraw-Hill Book Company, Inc., New York.

Finch, S.J., and D. McCleery. 1980. California coast live oak. In Eyre, F.H. (ed.) Forest cover types of the United States and Canada, pp. 127-128. Soc. Amer. For., Washington, DC.

Floyd, M.E. 1982. The interaction of pinyon pine and Gambel oak in plant succession near Dolores, Colorado. Southwest. Nat. 27:143-147.

Foin, T.C., and M.M. Hektner. 1986. Secondary succession and the fate of native species in a California coastal prairie community. Madrono 33:189-206.

Foster, R.H. 1968. Distribution of the major plant communities of Utah. Ph.D. dissertation, Brigham Young Univ., Provo, Utah.

Foster, D.R., and G.A. King. 1986. Vegetation pattern and diversity in southeast Labrador, Canada: *Betula papyrifera* forest development in relation to fire history and physiography. Journal of Ecology 74:465-484.

Francis, R.E. and E.F. Aldon. 1983. Preliminary habitat types of a semi-arid grassland. In: Moir, W.H. and L. Hendzel (Tech. Coord.). Proc. of the Workshop on Southwestern Habitat types. U.S. Dept. Agr. For. Serv.,

Albuquerque, N.M.
Francis, R.E. 1986. Phyto-edaphic communities of the upper Rio Puerco watershed, New Mexico. USFS Rocky Mtn. Forest and Range Expt. Sta. Res. Paper RM-272.
Franklin, J.F., and C.T. Dyrness. 1973. Natural vegetation of Oregon and Washington. USDA For. Ser. Gen. Tech. Rep. PNW-8, Portland, OR, 417 p.
Frolik, A.L. and W.O. Shepherd. 1940. Vegetative composition and grazing capacity of a typical area of Nebraska Sandhill range land. Univ. Nebr. Agr. Exp. Sta. Res. Bul. 117. Lincoln. 39 p.
Furguson, R.B., M.M. Furniss, and J.V. Basile. 1963. Insects destructive to bitterbrush flowers and seeds in southwestern Idaho. J. Econ. Entom. 56:459-462.
Garcia, G., and W.C. Hickey, Jr. 1964. Controlling cane cactus with 2,4-DP. Research Note RM 15. U.S. Forest Service. 2pp.
Garrison, G.A., Ardell J. Bjugstad, D.A. Duncan, M.E. Lewis, and D.R. Smith. 1977. Vegetation and environmental features of forest and range ecosystems. Agr. Handbook 475. For. Serv., U.S. Dept. Agr. Wash., D.C. 68 pp.

Gates, D.H., L.A. Stoddart, and C.W. Cook. 1956. Soil as a factor influencing plant distribution on salt-deserts of Utah. Ecol. Monog. 26(2):155-175.
George, M.R., W.J. Clawson, J.W. Menke, and J.W. Bartolome. 1985. Annual grassland forage productivity. Rangelands 7:17-19.
George, M.R., C.R. Raguse, W.J. Clawson, C.B. Wilson, R.L. Willoughby, N.K. McDougald, D.A. Duncan, and A.H. Murphy. 1988. Correlation of degree-days with annual herbage yields and livestock gains. J. Range Manage. 41:193-197.
Gillespie, T.S. 1976. The flowering plants of Mustang Island, Texas—An annotated checklist. Texas J. Sci. 26:132-148.
Girard, M.M. 1985. Native woodland and habitat types of southwestern North Dakota. Ph.D. Thesis. N. Dak. State Univ., Fargo, ND. 314 pp.
Giunta, B.C., R. Stevens, K.R. Jorgenson, and A.P. Plummer. 1978. Antelope bitterbrush - an important wildland shrub. Utah State Division of Wildlife Resources. No. 78-12. 47 pp.
Godfrey, C.L., A.S. McKee, and H. Oakes. 1973. General soils map of Texas. Tex. Agr. Exp. Sta. Misc. Publ. MP 1034. 1:1,500,000, color map.
Goetz, Harold. 1988. Rangelands of the Northern Great Plains - an overview. Pp. 4-10 in: Achieving efficient use of rangeland resources. Fort Keogh Res. Symp., Mont. Agr. Exp. Sta., Bozeman. 132 pp.

Goodrich, Sherel, E.D. McArthur, A.H. Winward. 1985. A new combination and a new variety of *Artemisia tridentata*. Great Basin Naturalist. 45:99-104.
Gordon, D.R., J.M. Welkes, J.W. Menke, and K.J. Rice. 1989. Competition for soil water between annual plants and blue oak (*Quercus douglasii*) seedlings. Oecologia 79:533-541.
Gosselink, J. 1980. Tidal marshes—The boundary between land and ocean. USDI-Fish and Wildl. Ser., NASA-Slidell Computer Complex, 1010 Gause Blvd. Slidell, Louisiana.
Gould, Frank W. and Thadis W. Box. 1965. Grasses of the Texas Coastal Bend. Texas A&M Press.
Grams, H.J., K.R. McPherson, V.V. King, S.A. MacLeod, and M.G. Barbour. 1977. Northern coastal scrub on Point Reyes Peninsula, California. Madrono 20:18-24.
Gratkowski, H. 1961. Brush seedlings after controlled burning of brushlands in southwestern Oregon. J. Forestry. 59-885-888.
Gray, F., and H.M. Galloway. 1959. Soils of Oklahoma. Oklahoma Agr. Exp. Sta. Misc. Pub. 56.
Gray, F., and C. Stahnke. 1970. Classification of soils in the savannah-forest transition in eastern Oklahoma. Oklahoma Agr. Exp. Sta. Bull. 672.
Gray, J.T. 1982. Community structure and productivity in *Ceanothus* chaparral and coastal sage scrub of southern California. Ecol. Monogr. 52:415-435.
Gray, J.T., and W.H. Schlesinger. 1981. Biomass, production, and litterfall in the coastal sage scrub of southern California. Amer. J. Bot. 68:24-33.
Gray, J.T. 1983. Competition for light and a dynamic boundary between chaparral and coastal sage scrub. Madrono 30:43-39.
Great Plains Flora Assoc. 1977. Flora of the Great Plains. Univ. Press of Kansas, Lawrence. 1392 pp.
Green, A.W. and D.D. Van Hooser. 1983. Forest resources of the Rocky Mountain States. U.S. Dept. Agric., For. Serv. Res. Bull. INT-33, 127 pp.
Gregory, S. n.d. Subalpine forb community types of the Bridger-Teton National Forest, Wyoming. USDA-Forest Service, Intermountain Region, Ogden, Utah.
Griffin, J.R. 1971. Oak regeneration in the upper Carmel Valley, California. Ecology 52:862-868.
Griffin, J.R. 1973. Xylem sap tension in three woodland oaks of central California. Ecology 54:152-159.
Griffin, J.R.1977. Oak woodland. In M.G. Barbour and J. Major (eds.) Terrestrial Vegetation of California. pp. 383-415. Wiley, New York.
Hall, F.C. 1973. Plant communities of the Blue Mountains in eastern Oregon and southeastern Washington. USDA For. Serv. Pacific Northwest Region, R6 Area Guide 3-1. Portland, Ore. 62 pages.
Hall, F.C. 1977. Western juniper in association with other tree species. In: Martin, R.E. Dealy, E.J. Caraher, D.L. (Eds.) Proceedings of the western juniper ecology and management workshop. USDA For. Serv. Pacific Northwest Forest and Range Exp. Sta. Gen. Tech. Rep. PNW-74. Portland, Ore. 272 pages.
Halligan, J. 1974. Relationship between animal activity and bare areas associated with California sagebrush in annual grassland. J. Range Manage. 27:358-362.
Hanes, T. L. 1971. Succession after fire in the chaparral of southern California. Ecol. Monogr. 41:27-52.
Hanes, T.L., and H.W. Jones. 1967. Postfire chaparral succession in southern California. Ecology 48:259-264.
Hanes, T.L. 1977. California chaparral. In M.G. Barbour and J. Major (eds.) Terrestrial vegetation of California, pp. 417-469, 1011-1012.
Hanes, T.L. 1976. Vegetation types of the San Gabriel Mountains. In J. Lattnig (ed.) Plant communities of southern California, Special Pub. 2, pp. 65-76. Calif. Native Plant Soc., Berkeley.
Hanselka, C.W. Not dated. The Coastal Prairie: Southern extensions and associated contacts. Unpublished.
Hansen, H.H. 1951. Characteristics of some grassland, marsh and other plant communities in western Alaska. Ecol. Monogr. 21:317-378.
Hanson, H.C. and W. Whitman. 1937. Plant succession on solonetz soils in western North Dakota. Ecol. 18:516-522.
Harcombe, P.A., and J.E. Neaville. 1977. Vegetation types of Chamber, Co., Texas. Texas J. Sci. 29:210-234.
Harlan, J.R. 1958. Grasslands of Oklahoma. Processed teaching manual, Agronomy Department, Oklahoma State Univ. Stillwater, Oklahoma.
Harlan, A.D.S. 1977. *Arctostaphylos* species in the Santa Catalina Mountains of Arizona. Ph.D. Diss., Univ. Arizona, Tucson, Arizona. 173 pp.
Harper, K.T., F.J. Wagstaff, and L.M. Kunzler. 1985. Biology and management of the Gambel oak vegetative type: a literature review. USDA For. Serv. Gen. Tech. Rep. INT-179. Intermountain Forest and Range Experiment Station, Ogden, Utah. 31 p.
Hassien, Fred. 1988. Taxonomic key for Missouri grazing lands. Quarterly Report. Cooperative Research Lincoln University, Jefferson City.
Hassien, Fred and Ken McCarty. 1986. Prairie grazing study. Unpublished Report. Lincoln University, Jefferson City, MO.
Hatch, M.A. 1978. Unpub. field notes. Sitkalidak Island, Alaska.
Hatch, M.A. 1986. Vegetation and flora of the Semidi Islands, Alaska. M.S. thesis. University of Alaska Fairbanks. 124 p.
Hauxwell, D.L. 1977. Sagebrush soils study, Birch Creek Valley, Idaho. Unpublished Report, University of Idaho, Department of Range Resources. 22 p.
Hazlett, D.L. and G.R. Hoffman. 1975. Plant species distributional patterns in *Artemisia tridentata* and *Artemisia cana*-dominated vegetation in western North Dakota. Bot. Gaz. 136:72-77.
Heady, H.F. 1977. Valley grassland. In M.G. Barbour and J. Major (eds.) Terrestrial vegetation of California, pp. 491-514. Wiley, NY.

Heady, H.F., T.C. Foin, M.M. Hektner, D.W. Taylor, M.G. Barbour, and W.J. Barry. 1977. Coastal prairies and northern coastal scrub. In M.G. Barbour and J. Major (eds.) Terrestrial vegetation of California, pp. 733-760. Wiley, NY.

Heady, H.F., T.C. Foin, M.M. Hektner, D.W. Taylor, M.G. Barbour, and W.J. Berry. 1988. Coastal prairie and northern coastal scrub. In M.G. Barbour and J. Major (eds.) Terrestrial vegetation of California, 2nd ed., pp. 733-760. California Native Plant Society, Sacramento.

Heady, H.F. 1961. Continuous versus specialized grazing systems. A review and application to the California annual type. J. Range Manage. 14:182-193.

Heady, H.F. 1956. Changes in a California annual plant community induced by manipulation of natural mulch. Ecology 37:798-812.

Hektner, M.M., and T.C. Foin. 1977. Vegetational analysis of a northern California coastal prairie: Sea Ranch, Somoa County, California. Madrono 24:83-103.

Hellmers, H., J. Horton, G. Juhren, and J. O'Keefe. 1955. Root systems of some chaparral plants in southern California. Ecology 36:667-678.

Helm, D.J., W.B. Collins, and J.C. LaBelle. 1985. Riparian vegetation succession. Draft Report. Alaska Power Authority. Susitna Hydroelectric Project. Prepared for Harza-Ebasco Susitna Joint Venture. 185 p.

Henrickson, J. and M.C. Johnston. 1986. Vegetation and community types of the Chihuahuan Desert. p. 20-29. In: J.C. Barlow, A.M. Powell and B.N. Timmermann (eds.) Second Symposium on Resources of the Chihuahuan Desert Region - United States and Mexico. Chihuahuan Desert Res. Inst., Sul Ross State Univ., Alpine, Texas.

Henson, Herbert. 1953. Vegetation Types in Northwestern Alaska and Comparisons with Communities in other Arctic Regions. Ecology 34:137.

Herbel, C.H. 1979. Utilization of grass and shrublands of the southwestern United States, pp. 161-203. In Management of Semi-arid Ecosystems, B.H. Walker, ed. Elsevier Scientific Publ. Co., Amsterdam, The Netherlands.

Herbel, C.H., G.H. Abernathy, C.C. Yarbrough, and D.K. Gardner. 1973. Rootplowing and seeding arid rangelands in the Southwest. J. Range Manage. 26:193-197.

Herbel, C.H. 1984. Successional patterns and productivity potentials of the range vegetation in the warm, arid portions of the southwestern United States, pp.1333-1365. In Developing Strategies for Rangeland Management: A Report Prepared by the Committee on Developing Strategies for Rangeland Management. Nat. Res. Coun./Nat. Acad. Sci. Westview Press, Boulder, Colorado.

Hermann, F.J. 1970. Manual of the Carices of the Rocky Mountains and Colorado Basin. USDA For. Serv. Agric. Handbook 374:ii+397

Hickey, W.C. and G. Garcia. 1964. Changes in perennial grass cover following conversion from yearlong to summer-deferred grazing in west-central New Mexico. U.S. Dept. Agr. U.S. For. Serv. Res. Note RM-33.

Hickman, O.E. 1975. Seasonal trends in the nutritive content of important range forage species near Silver Lake, Oregon. U.S. Dep. Agric., For. Serv., Res. Pap. PNW-187.

Hironaka, M., M.A. Fosberg, and A.H. Winward. 1983. Sagebrush-grass habitat types of southern Idaho. Forest, Wildlife and Range Exper. Sta., U. of Idaho. Moscow, Idaho. Bull. 35. 44 pp.

Hitchcock, Leo C. and Arthur Cronquist. 1973. Flora of the Pacific Northwest. University of Washington Press. Seattle, WA. 730 p.

Hobbs, R.J., and H.A. Mooney. 1986. Community changes following shrub invasion of grassland. Oecologia 70:508-513.

Hodkinson, H.S. 1982. Big sagebrush subspecies and management implications. Rangelands 11:20-22.

Hoeppel, R.E. and A.G. Wollum. 1971. Histological studies of ectomycorrhizae and root nodules from *Cercocarpus montanus* and *Cercocarpus paucidentatus*. Can. J. of Bot. 49:1315-1318.

Hogan, M., and G.F. Tande. 1983. Vegetation Types and Bird Use of Anchorage Wetlands. U.S. Fish and Wildlife Service. Anchorage, Alaska.

Holland, V.L. 1973. A study of vegetation and soils under blue oak canopy compared to adjacent open grassland. Ph.D. dissertation, Univ. of California, CA. 369 p.

Holland, V.L., and J. Morton. 1980. Effect of the blue oak on nutritional quality of rangeland forage in central California. In T.R. Plumb (tech. coord.) Ecology, management and utilization of California oaks. U.S. For. Serv. Gen. Tech. Rep. PSW-44. pp. 319-322.

Holmgren, Noel H. 1972. Plant geography of the Intermountain Region. In: Cronquist, Arthur, Arthur H. Holmgren, Noel H. Holmgren, and James L. Reveal. Intermountain Flora, vol. 1. Hafner Publishing Company Inc. New York. 77-175.

Holmgren, N.H. 1972. Plant geography of the Intermountain region. p. 77-161. In: A. Cronquist, A.H. Holmgren, N.H. Holmgren, and J.L. Reveal, Intermountain flora, volume one. Hafner Publishing Co., Inc., New York. 270 p.

Holton, B. Jr., and A.F. Johnson. 1979. Dune scrub communities and their correlation with environmental factors at Point Reyes National Seashore, California. J. Biogeog. 6:317- 328.

Hopkins, W.E. 1979. Plant Associations of the Fremont National Forest, USDA Forest Service, PNW Region, R6-ECOL-79-005. 106 pp.

Hopkins, W.E. 1979. Plant Associations of South Chiloquin and Klamath Ranger Districts (Winema NF), USDA Forest Service, PNW Region, R6-Ecol-79-005, 96 pp.

Horton, L.E. 1971. Vegetation and ecological relationships: West slope of the Tetons Study Area Targhee National Forest. USDA-Forest Service, Intermountain Region, Ogden, Utah. Kuramoto, R.I. and L.C. Bliss. 1970. Ecology of subalpine meadows in the Olympic Mountains, Washington. Ecol. Monog. 40:317-347.

Horton, J.S. 1960. Vegetation types of the San Bernardino Mountains. USDA For. Serv., Pac. SW For. and Range Expt. Sta., Tech. Pap. No. 44:29 pp.

Howell, J.T. 1970. Marin flora, 2nd ed. University of California Press, Berkeley, 366 p.

Hubbard, R.L. 1956. The effects of plant competition upon the growth and survival of bitterbrush seedlings. U.S. Dep. Agric. For. Serv. (Berkeley, Calif.) Res. Note 109.

Huffaker, C.B., and C.E. Kennett. 1959. A ten-year study of vegetational changes associated with biological control of Klamath weed. J. Range Manage. 12:69-82.

Hulten, E. 1968. Flora of Alaska and Neighboring Territories. Stanford University Press. Stanford, California. 1008 p.

Hyder, D.N. 1979. Vegetation. p.14-23. In: Soil and Vegetation Inventory and Revegetation Research on the Proposed Keenesburg Surface Coal Mine. Agronomy Dept., Colorado State Univ., Ft. Collins. Unpublished.

Jackson, L.E. 1985. Ecological origins of California's Mediterranean grasses. J. Biogeog. 12:349-361.

Jain, S.K., and P. Moyle. 1984. Vernal pools and intermittent streams. Univ. Calif., Davis, Inst. Ecol. Spec. Pub. 28, 280 p.

John, T. and D. Tart. 1986. Forested Plant Associations of the Yakima Drainage within the Yakima Indian Reservation. 195 pp.

Johnson, C.G. and S.A. Simon. 1987. Plant associations of the Wallowa-Snake Province. USDA Forest Service, PNW Region, R-6 ECOL-TP-225A-86, 400 pp.

Johnson, F.L., and P.G. Risser. 1972. Some vegetation-environment relationships in the upland forests of Oklahoma. J. Ecol. 60:655-663.

Johnson, W., C.M. McKell, R. Evans, and L. Berry. 1959. Yield and quality of annual range forage following 2, 4-D application on blue oak trees. J. Range Manage. 9:18-20.

Johnson, A.W., et al. 1966. Vegetation and Flora in the Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission.

Johnson, C.G., and R. Clausnitzer. 1991. Plant Associations of the Blue and Ochoco Mountains. USDA Forest Service. PNW Region, 159 pp.

Johnson, C.G. 1982. An interpretation of synecologic relationships in the Billy Meadows Area of the Wallowa-Whitman National Forest. PhD thesis on file at Oregon State University, Corvallis, Oregon, 381 pp.

Johnson, F.L., and P.G. Risser. 1975. A quantitative comparison between an oak forest and an oak savannah in central Oklahoma. Southwest. Nat. 20:75-84.

Johnston, M.C. 1963. Past and present grasslands of southern Texas and northeastern Mexico. Ecology 44:456-466.

Johnston, Barry C. 1987. Plant associations of Region 2. Potential plant communities of Wyoming, South Dakota, Nebraska, Colorado, and Kansas. Ed. 4, U.S. Dept. Agr., Forest Serv. Lakewood, Colo. 429 pp.

Jones, J.R. and N.V. DeByle. 1985. Climates. Pages 57-64 In: DeByle, N.V. and R.P. Winokur, (eds.) Aspen: Ecology and management in the western United States. U.S. Dept. Agric., For. Serv. Gen. Tech. Rep. RM-119.

Jones, F.B. 1982. Flora of the Texas Coastal Bend. Mission Press. Corpus Christi, TX. Jones, V.E., and R.D. Pettit. 1984. Low rates of tebuthiuron for control of sand shinnery oak. J. Range Manage. 37:488-490.

Jones and Stokes, Assoc. 1987. Sliding toward extinction: the state of California's natural heritage. The Nature Conservancy, San Francisco, CA 105 p.

Jorgenson, Henry E. 1979. Vegetation of the Yellow Water Triangle, Montana. Mont. Dept. of Fish and Game and B.L.M., U.S. Dept. of Int. 57 pp.

Judd, F.W., and S.L. Sides. 1983. The effect of hurricane Allen on the nearshore vegetation of south Padre Island. Southwestern Nat. 28(3):365-369.

Judd, F.W., R.I. Lonard, and S.L. Sides. 1977. The vegetation of south Padre Island, Texas in relation to topography. Southwestern Nat. 22:31-48.

Kaul, Robert B. 1975. Vegetation of Nebraska (Circa 1850). Map. Cons. and Surv. Div., Inst. of Agr. and Nat. Res., Univ. of Nebraska, Lincoln.

Kautz, D.R., and M.H. Clark. 1986. Soil and range survey of the Hatcher Pass area, Alaska. Interim Report. USDA Soil Conservation Service, Palmer, Alaska.

Kay, B.L., and O.A. Leonard. 1980. Effect of blue oak removal on herbaceous forage production in the north Sierra foothills. In T.R. Plumb (tech. coord.) Ecology, management and utilization of California oaks. U.S. For. Serv. Gen. Tech. Rep. PSW-44. pp. 323-328.

Keeley, J.E., and P.H. Zedler. 1978. Reproduction of chaparral shrubs after fire: a comparison of sprouting and seeding strategies. Am. Midl. Nat. 99:142160.

Kellogg, Charles E. 1934. Morphology and genesis of the solonetz soils of western North Dakota. Soil Sci. 38:483-501.

Knipe, O.D., C.P. Pase and R.S. Carmichael. 1979. Plants of the Arizona chaparral. U.S. Dept. Agric. Gen. Tech. Rep. RM-64. 54 pp.

Kramer, G. 1988. Fresh emergent wetland. In: A Guide to Wildlife Habitats of California. California Dept. Forestry and Fire Protection, Sacramento, CA. 199 p.

Krebs, C.J. 1972. The experimental analysis of distribution and abundance. Harper and Row, New York.

Kruckeberg, A.R. 1984. California serpentines: flora, vegetation, geology, soils, and management problems. Univ. Calif. Pub. in Botany 78, 180 p.

Kuchler, A.W. 1974. A new vegetation map of Kansas. Ecology 55:586-604.

Kuchler, A.W. 1964. Potential natural vegetation of the conterminous United States. Amer. Geog. Soc. Spec. Publ. 36. 38 pp. + app. + map.

Kuchler, A.W. 1988. The map of the natural vegetation of California. In M. Barbour and J. Major (eds.) Terrestrial vegetation of California, 2nd ed., pp. 909-938 + map. California Native Plant Society, Sacramento.

Ladd, Douglas and Paul Nelson. 1982. Ecological synopsis of Missouri glades. Proceedings of Cedar Glade Symposium. The Missouri Academy of Science. Occassional Paper 7:1-21.

Lamb, S.H. 1975. Woody plants of the Southwest. The Sunstone Press. Santa Fe, New Mexico. 177 pp.

Langenheim, J.H. 1962. Vegetation and environmental patterns in the Crested Butte area, Gunnison County, Colorado. Ecol. Monog. 32:249-284.

Lanner, R.M. 1981. The Pinyon Pine: A Natural and Cultural History. Univ. Nev. Press, Reno.

Larkin, T.J., and G.W. Bomar. 1983. Climatic atlas of Texas. Tex. Dept. Water Resources. Austin, Tex.

Lathrop, E.W., and H.A. Zuill. 1984. Southern oak woodlands of the Santa Rosa Plateau, Riverside County, California. Aliso: 603-611.

Leopold, A.S. 1950. Deer in relation to plant succession. Trans North Amer. Wildl. Conf. 15:571-580.

Lepper, M.G. and M. Fleschner. 1977. Nitrogen fixation by *Cercocarpus ledifolius* (Rosaceae) in pioneer habitats. Oecologia (Berl.) 27:333-338.

Lewis, M.E. 1975. Plant communities of the Jarbridge Mountain complex; Humboldt National Forest. USDA-Forest Service, Intermountain Region, Ogden, Utah.

Lewis, M.E. 1971. Flora and major plant communities of the Ruby-East Humboldt Mountains; with special emphasis on Lamoille Canyon. USDA-Forest Service, Humboldt National Forest, Ogden, Utah.

Lewis, Mont E. 1979. Alpine Rangelands of the Uinta Mountains Ashley and Wasatch National Forests. USDA Forest Service, Ogden, Utah. 75 pp.

Lewis, D.C., and R.H. Burghy. 1964. The relationship between oak tree roots and ground water in fractured rock as determined by tritium tracing. J. Geophys. Res. 69:2579-2588.

Little, E.L., Jr. 1971. Atlas of United States trees, vol. 1. Conifers and important hardwoods. USDA For. Serv. Misc. Pub. 1146. Washington, 19 p. + 200 maps.

Little, E.L. 1950. Southwestern trees. A guide to the native species of New Mexico and Arizona. U.S. Dept. Agr. For. Serv. Agr. Handbook No. 9.

Lonard, R.I., and F.W. Judd. 1980. Phytogeography of south Padre Island, Texas. Southwest. Nat. 25:313-322.

Lonard, R.I., F.W. Judd, and S.L. Sides. 1978. Annotated checklist of the flowering plants of south Padre Island, Texas. Southwest. Nat. 23:497-510.

Longhurst, W.A., A.S. Leopold, and R.F. Dasmann. 1952. A survey of California deer herds, their ranges and management problems. Calif. Dep. Fish and Game Bull. 6.

Longhurst, W.H., E.O. Garton, G.E. Connolly, B.M. Browning, and E.O. Garton. 1976. The California deer decline and possibilities for restoration. Cal-Neva Section Wildlife Transactions, Annual Meeting California-Nevada Section of the Wildlife Society. pp. 74-103.

Looman, J. 1979. The vegetation of the Canadian prairie provinces. Phytocoenologia 5:347-366.

Looman, J. 1983. Distribution of plant species and vegetation types in relation to climate. Vegetatio 54:17-25.

Looper, L.E. 1970. Subalpine and alpine vegetation of northeastern Nevada. Ph.D. dissertation, Duke University. 292 p.

Lorenz, Russell J. 1986. Introduction and early use of crested wheatgrass in the northern Great Plains. In: Symposium Proc. crested wheatgrass: its values, problems and myths (Johnson, K.L., ed.). Pp. 9-20. Utah State Univ., Logan.

Lowe, C.H. 1964. Arizona's natural environment - landscapes and habitats. Univ. Arizona Press, Tucson, Arizona. 136 pp.

Lowe, C.H. and D.E. Brown. 1973. The natural vegetation of Arizona. Arizona Resources Information System Pub. 2. 53 pp. Accompanies map: Natural Vegetative Communities of Arizona (C) 1973.

Lutz, H.J. 1956. Ecological effects of forest fire in the Interior of Alaska. USDA Tech. Bull. No. 1133. Govt. Print. Ofc. Washington D.C. 121 p.

Lynn, W.C., W.E. McKinzie, and R.B. Grossman. 1974. Field Laboratory Tests for Characterization of Histosols. Histosols: Their Characteristics, Classification, and Use. Soil Science Society of America Special Publication No. 6.

Lyon, L.J. 1969. Wildlife habitat research and fire in the northern Rockies. Pages 213-227 in Proc. Tall Timbers Fire Ecol. Conf.

Mackie, Richard J. 1970. Range ecology and relationships of mule deer, elk, and cattle in the Missouri Breaks, Montana. Wildlife Monogr. 20. The Wildlife Soc. 79 pp.

Major, J., and D.W. Taylor. 1977. Chapter 18 Alpine. In M.G. Barbour, and J. Major, (eds.) Terrestrial vegetation of California. Calif. Native Plant Soc. Special Publ. 9. pp. 601-1030. Supplement, 1988:1015-1016.

Manuwal, N.J. 1979. Vegetation of the Barren Islands, Alaska. Syesis 12:131146.

Marchand, L.S., A. McLean and E.W. Tisdale. 1966. Uniform garden studies on the *Artemisia tridentata* Nutt. complex in interior British Columbia. Canadian Journal of Botany. 44:1623-1632.

Markon, C.J. 1980. Terrestrial and Aquatic Habitat Mapping Along the Alaska Natural Gas Pipeline System. USDI Fish and Wildlife Service. Anchorage, Alaska.

Martin, R.E. 1983. Antelope bitterbrush seedling establishment follows prescribed burning in the pumice zone of the southern Cascade mountains. Pages 82-90 in A.R. Tiedemann and K.L. Johnson, (eds.) Proceedings Research and management of bitterbrush and cliffrose in western North America. U.S. Dep. Agric., For. Serv. (Ogden, Utah). Gen. Tech. Rep. INT-152.

Martin, S.C., and F.H. Tschirley. 1969. Changes in cactus numbers after cabling. Progressive Agr. in Arizona. 21(1):16-17.

Martin, F.L. 1950. A revision of *Cercocarpus*. Brittonia 7:91-111.

Martin, S.C., J.L. Thames, and E.B. Fish. 1974. Changes in cactus numbers and herbage production after chaining and mesquite control. Progressive Agric. in Arizona. 26(6):3-6.

McBride, J. 1974. Plant succession in the Berkeley Hills, California. Madrono 22:317-329. McBride, J., and H.F. Heady. 1968. Invasion of grassland by Baccharis pilularis D.C. J. Range Manage. 21:106-108.

McBride, J. and J. Strahan. 1984a. Establishment and survival of woody riparian species on gravel bars of an intermittent stream.

McBride, J.R. and J. Strahan. 1984b. Influence of fluvial processes on patterns of woodland succession along Dry Creek, Sonoma County, California. In R.E. Warner and K.M. Hendrix (eds.) California Riparian Systems. U.C. Press. pp. 110-119.

McBride, J.R. and J. Strahan. 1982. Effects of the December 1981 and January, 1982 storms on streambank stability along Dry Creek, Sonoma County, California. Report to the U.S. Army Corps of Engineers, San Francisco, CA. 4 p.

McClaran, M.P., and J.W. Bartolome. 1989. Effect of *Quercus douglasii* (Fagaceae) on herbaceous understory along a rainfall gradient. Madrono 36:141-153.

McGinnies, W.J., L.W. Osborn, and W.A. Berg. 1976. Plant-soil-microsite relationships on a saltgrass meadow. Range Manage. 29:395-400.

McIlvain, E.H., and M.C. Shoop. 1961. Stocking rates and grazing systems for producing forage and beef on sand sage rangelands...A 20-year study. Unpublished manuscript. Southern Plains Range Research Station, Woodward, Oklahoma.

McLean, A. and L. Marchand. 1968. Grassland ranges of the southern interior of British Columbia. Publication 1319. Ottawa, Canada. Canadian Department of Agriculture. 28 p.

McLeary, J.A. 1968. The biology of desert plants. In G.W. Brown, Jr. (ed.) Desert Biology. Academic Press, New York. pp. 141-194.

McNaughton, S.J. 1968. Structure and function in California grasslands. Ecology 49:962-972.

McPherson, J.K., and C.H. Muller. 1967. Light competition between Ceanothus and Salvia shrubs. Bull. Torrey Bot. Club 94:41-55.

Mehringer, P.L. Jr., 1987. Late Holocene environments on the northern periphery of the Great Basin. Final report to the U.S.D.I. Bureau of Land Management, Oregon State Office, Portland, Oreg. Contract No. YA551-CT5-340075. 71 pages.

Milbrath, G.M., M.R. Nelson, and R.E. Wheeler. 1973. The distribution and electron microscopy of viruses of cacti in southern Arizona. Phytopath. 63:11331139.

Miller, Alden H., and Robert Stebbins. 1964. The lives of desert animals in Joshua Tree National Monument. University of California Press, Berkeley, California.

Mitsch, W.J., and J.G. Gosselink. 1986. Wetlands. Van Nostrand Reinhold Co. New York, New York.

Mooney, H.A. 1988. Southern coastal scrub. In M.G. Barbour and J. Major (eds.) Terrestrial vegetation of California, 2nd ed., pp. 471-489. California Native Plant Society, Sacramento.

Morris, M.S., R.G. Kelsey, and D. Griggs. 1976. The geographic and ecological distribution of big sagebrush and other woody *Artemisias* in Montana. In Proc. Mt. Acad. Sciences. 36:56-79.

Mueggler, W.F. and W.L. Stewart. 1980. Grassland and shrubland habitat types of western Montana. USDA Forest Service, Gen. Tech. Report INT-66. 154 pp.

Mueggler, W.F. 1985b. Vegetation associations. Pages 45-55 In: DeByle, N.V. and R.P. Winokur (eds.) Aspen: Ecology and management in the western United States. U.S. Dept. Agric., For. Serv. Gen. Tech. Rep. RM-119.

Mueggler, W.F. 1988. Aspen community types of the Intermountain Region. U.S. Dept. Agric., For. Serv. Gen. Tech. Rep. INT-250, 135 pp.

Mueggler, W.F. 1985a. Aspen communities in the interior West. Pages 106-111 In: Proceedings of the 1985 Society of American Foresters National Convention, Fort Collins, Colo. pp. 106-111.

Muick, P.C., and J.W. Bartolome. 1987. Factors associated with oak regeneration in California. In T.R. Plumb and N.H. Pillsbury (tech. coords.) Multiple-use management of California's hardwood resources. U.S. For. Serv. Gen. Tech. Rep. PSW-100. pp. 86-91.

Mulroy, T.W., P.W. Rundel, and P.A. Bowler. 1979. The vascular flora of Punta Banda, Baja California Norte, Mexico. Madrono 26:69-90.

Munn, L.C., G.A. Nielson, and W.F. Mueggler 1978. Relationships of soils to mountain and foothill range habitat types and production in western Montana. V. Soil Sci. Soc. of America Journal 42(1):135-139.

Munz, Philip and David D. Keck. 1973. A California Flora. University of California Press, Berkeley, CA. 1681 p.

Murphy, A.H., and B. Crampton. 1964. Quality and yield of forage as affected by chemical removal of blue oak (*Quercus douglasii*). J. Range Manage. 17:142144.

Murray, D.F., and A.R. Batten. 1977. A Provisional Classification of Alaskan Tundra. Unpub. report. Institute of Arctic Biology, University of Alaska Fairbanks. 134 p.

Neal, D.L. 1981. Improvement of Great Basin deer winter range with livestock grazing. Pages 61-73 in L. Nelson, Jr. and J.W. Peek, (eds.) Proceedings of the Symposium on Wildlife-Livestock Relationships. Forest Wildl. and Range Exp. Sta., Univ. of Idaho, Moscow.

Neiland, B.J., and L.A. Viereck. 1977. Forest types and ecosystems. pp. 109-136. IN: North American Forest Lands at Latitudes North of 60 degrees. Symposium Proceedings, University of Alaska Fairbanks.

Neilson, R.P. and L.H. Wullstein. 1985. Comparative drought physiology and biogeography of *Quercus gambelii* and *Quercus turbinella*. Amer. Midl. Nat. 114:259-271.

Neilson, R.P. and L.H. Wullstein. 1983. Biogeography of two southwestern oaks in relation to seedling drought response and atmospheric flow structure. Biogeography 10:275-297.

Neilson, R.P. and L.H. Wullstein. 1980. Catkin freezing and acorn reproduction in Gambel oak in Utah. Amer. J. Bot. 67:426-428.

Nelson, Paul W. 1987. The terrestrial natural communities of Missouri. Missouri Department of Natural Resources, Jefferson City.

Nelson, D.O. 1964. A comparison of forb-grass sites with sagebrush sites in the Centennial Mountains of southern Montana. MS Thesis, University of Idaho, Moscow. 65 p.

Nelson, J.R. 1961. Composition and structure of the principal woody vegetation types in the North Dakota Badlands. M.S. Thesis, N. Dak. State Univ., Fargo. 195 pp.

Newsom, J.D. 1967. Proceedings of the Marsh and Estuary Management Symposium. Baton Rouge, LA.

Nichol, A.A. 1952. The natural vegetation of Arizona. Univ. Arizona Agric. Exp. Sta. Tech. Bull. 127. 230 pp.

NOAA. 1972. Climatological summary, Kingsville, Texas. Climatologist for Texas, National Weather Service, Austin, Texas.

Nord, E.C. 1965. Autecology of bitterbrush in California. Ecol. Monogr. 35:307-334.

Oosting, Henry J. 1956. The study of plant communities. W.H. Freeman and Compayn, San Francisco, California. 440 pp.

Ornduff, R. 1974. Introduction to California plant life. Univ. California Press, Berkeley, 152 p.

Padgett, Wayne G. and Mary E. Manning. 1991. Riparian community type classification for the Humboldt and Toiyabe National Forests, Nevada and eastern California. USDA Forest Service (In Press).

Padgett, Wayne G., Andrew P. Youngblood, and Alma H. Winward. 1989. Riparian Community type classifications of Utah and southeastern Idaho. USDA, Forest Service, Intermountain Region, Ogden, UT R4-Ecol-89-01. 191 p.

Parker, V.T., and C.H. Muller. 1982. Vegetation and environmental changes beneath isolated live oak trees (*Quercus agrifolia*) in a California annual grassland. Amer. Midl. Nat. 107:69-81.

Parker, I., and W.J. Matyas. 1981. CALVEG: a classification of California vegetation. U.S. Dep. Agric., For. Serv., Reg. Ecol. Group, San Francisco.

Parker, V.T., and C.R. Billow. 1987. Survey of soil nitrogen availability beneath evergreen and deciduous species of Quercus. In T.R. Plumb and N.H. Pillsbury (tech. coords.) Multiple-use management of California's hardwood resources, pp. 98-102. USDA For. Serv. Gen. Tech. Rep. PSW-100, Washington, DC.

Parker, K.W., and D.A. Savage. 1944. Reliability of the line interception method in measuring vegetation on the Southern Great Plains. J. Amer. Soc. Agron. 36:97-110.

Pase, C.P. and D.E. Brown. 1984. Interior Chaparral. In: Biotic Community of the American Southwest-United States and Mexico. D.E. Brown (Ed.), Desert Plants 4(1-4):95-99.

Passey, H.B., V.K. Hugie, E.W. Williams, and D.E. Ball. 1982. Relationships between soil, plant community and climate on rangelands of the Intermountain West. Technical Bulletin Number 1669, Washington, D.C. United States Department of Agriculture, Soil Conservation Service. 123 p.

Patric, J.H., and T.L. Hanes. 1964. Chaparral succession in a San Gabriel Mountain area of California. Ecology 45:353-360.

Patric, J.H. and J.D. Helvey. 1986. Some effects of grazing on soil and water in the eastern forest. USDA Forest Service. Northeastern Forest Experiment Station NE-GTR-115.

Patten, D.T. 1963. Vegetational pattern in relation to environments in the Madison Range, Montana. Ecol. Monog. 33:375-406.

Payne, G.F. 1973. Vegetative rangeland types in Montana. Mont. Agr. Exp. Sta. Bul. 671, 16 pp.

Paysen, T.E., J.A. Derby, H. Black, Jr., V.C. Beich, and J.W. Mincks. 1980. A vegetation classification system applied to southern California. Gen. Tech. Rept. PSW-45. USDA Forest Service, Pacific Southwest Forest and Range Experiment Station, Berkeley, CA.

Peart, D.R., and T.C. Foin. 1985. Analysis and prediction of population and community change: a grassland case study. In J. White (ed.) The population structure of vegetation. Dr. W. Junk, Dordrecht. pp. 313-339.

Pendleton, R.L., S.C. Sanderson, and E.D. McArthur. 1985. Morphologic and enzymatic variability among Gambel oak clones in northcentral Utah. p. 19-28, In: K.L. Johnson (ed.), Proceedings of the Third Utah Shrub Ecology Workshop. College of Natural Resources, Utah State University, Logan. 64 p.

Pendleton, D.F., J.W. Menke, W.A. Williams, and R.G. Woodmansee. 1983. Annual grassland ecosystem mode. Hilgardia 51:1-44.

Penfound, W.T. 1963. The savannah concept in Oklahoma. Ecology 43:774-775.

Penfound, W.T. 1963. The composition of a post oak forest in south central Oklahoma. Southwest. Nat. 8:114-115.

Petranka, J.W., and J.K. McPherson. 1979. The role of *Rhus copallina* in the dynamics of the forest-prairie ecotone in north central Oklahoma. Ecology 60:956-965.

Pettit, R.D. 1979. Effects of picloram and tebuthiuron pellets on sand shinnery oak communities. J. Range Manage. 32:196-200.

Pieper, R.D. 1977. The southwestern pinyon-juniper ecosystem. In: Aldon, E.F. and T.J. Loring (Tech. Coord.) U.S. Dept. Agr. For. Serv. Gen. Tech. Rep. RM-39.

Pitelka, L.F. 1974. Energy allocation in annual and perennial lupines (Lupinas Leguminosae). Ph.D. dissertation, Stanford University, Stanford, California, 126 p.

Pitt, M.D., and H.F. Heady. 1978. Response of annual vegetation to temperature and rainfall patterns in northern California. Ecology 59:335-350.

Plumb, T.R. 1980. Response of oaks to fire. In T.R. Plumb (tech. coord.) Ecology, management, and utilization of California oaks, pp. 136-142. USDA For. Ser. Gen. Tech. Rep. PSW-44, Washington, DC.

Pond, F.W. and E.M. Schmutz. 1984. The Arizona chaparral — its growth and nutritive value. Univ. Arizona Agric. Exp. Sta., Tucson, Arizona. 90 pp.

Pond, F.W. and J.W. Bohning. 1971. The Arizona chaparral. Arizona Catalog Part I 27(9): 16, 18, 20, 22-28; Part 2 27(11):13-16, 18-24.

Powell, J., and D.P. Lowry. 1980. Oak (*Quercus* sp.) sprouts growth rates on a central Oklahoma shallow savannah range site. J. Range Manage. 33:312-313.

Preston, J.E., W.R. Fibich, T.H. George, and P.C. Scorup. 1977. Range Sites and Soils of the Kotzebue Sound Area, Alaska. USDA Soil Conservation Service. Anchorage, Alaska. 64 pgs.

Preston, J.E., et al. 1976. Soil and Range Survey of Umnak and Unalaska Islands. USDA Soil Conservation Service. Anchorage, Alaska.

Quinsey, S.D. 1984. Fire and grazing effects in western juniper woodlands in central Oregon. M.S. Thesis, University of Washington, Seattle, Wash. 151 pages.

Racine, C.H., and J.H. Anderson. 1976. Flora and Vegetation of the Chukchi-Imuruk Area. pp. 38-113. IN: H.R. Melchior, ed. Biological Survey of the Bering Land Bridge National Monument. USDI National Park Service.

Racine, C.H. 1979. The 1977 Tundra Fires in the Seward Peninsula, Alaska. Alaska Tech. Report #4. USDI Bureau of Land Management.

Racine, C.H., and S.B. Young. 1978. Ecosystems of the proposed Lake Clark National Park, Alaska. Contrib. of the Center for Northern Studies, No. 16.

Ralston, R.D. 1969. The grasslands of the Red River Valley. Ph.D. Diss. Univ. of Sask., Saskatoon. 159 pp.

Rappole, J.H., C.E. Russell, J.R. Norwine, and T.E. Fulbright. 1986. Anthropogenic pressures and impacts on marginal, neotropical ecosystems: The case of south Texas. The Sci. Tot. Environ. 55:91-99.

Ratliff, R.D. 1985c. Meadows in the Sierra Nevada of California: state of knowledge. U.S. For. Serv. Pacific SW For. & Range Exp. Sta. Gen. Tech. Rep. PSW-84.

Ratliff, R.D. 1982. A meadow site classification for the Sierra Nevada, California. U.S. For. Serv., Pacific SW For. & Range Expt. Sta. Gen. Tech. Rep. PSW-60.

Ratliff, R.D. 1983. Nebraska sedge (*Carex nebraskensis* Dewey): observations on shoot life history and management. J. Range Manage. 36(4):429-430.

Ratliff, R.D. 1985b. Rehabilitating gravel areas with short-hair sedge sod plugs and fertilizer. U.S. For. Serv. Pacific SW For. & Range Expt. Sta. Res. Note PSW-371.

Ream, R.R. 1964. The vegetation of the Wasatch Mountains, Utah and Idaho. Ph.D. Dissertation, University of Wisconsin. 177 p.

Rechenthin, C.A., and H. Passey. 1967. The vegetation of Padre Island National Seashore. USDA, Soil Conserv. Ser. Temple, Texas. (Mimeo)

Redmann, R.E. 1972. Plant communities and soils of an eastern North Dakota prairie. Bul. Torrey Bot. Club. 99:65-76.

Reid, E.H. 1942. Important plants on National Forest ranges of eastern Oregon and eastern Washington. Range Research Report No. 1. USDA For. Serv. 64 p.

Reiger, S., and R.E. Wunderlich. 1956. Soil survey and vegetation of northeastern Kodiak Island area, Alaska. USDA/USDI Soil Survey Series, No. 17. 46 p.

Rice, E.L., and W.T. Penfound. 1959. The upland forests of Oklahoma. Ecology 40:593-608.

Rice, E.L. 1965. Bottomland forests of north central Oklahoma. Ecology 46:708714.

Rice, E.L. 1971. Inhibition of nodulation of inoculated legumes by leaf leachates from pioneer species from abandoned fields. Amer. J. Bot. 58:368-371.

Rogler, George A. and R.J. Lorenz. 1983. Crested wheatgrass - early history in the United States. Range Manage. 36:91-93.

Ross, Robert L. and H.E. Hunter. 1976. Climax vegetation of Montana based on climate and soils. U.S. Dept. Agr., Soil Cons. Serv. Bozeman, Mont. 64 pp. + map.

Rottman, Mary Lou, and Emily L. Hartman. 1987. Tundra vegetation of three cirque basins in the northern San Juan Mountains, Colorado. Great Basin Nat. 45:87-93.

Roundy, B.A. 1984. Estimation of water potential components of saline soils of Great Basin rangelands. Soil Sci. Soc. Amer. J. 48:645-650.

Roundy, Bruce A. and James A. Young. 1985. Salt deserts of the Great Basin. Proceedings 39th Annual Meeting of the Society for Range Management, Salt Lake City, February. 39-49 pp.

Ryerson, D.E., J.E. Taylor, L.O. Baker, H.A.R. Houlton, and D.W. Strand. 1970. Clubmoss on Montana rangelands: Distribution, control, range relationships. Mont. Agr. Exp. Sta. Bul. 645. 166 pp.

Sabinske, D.W. and D.H. Knight. Variation within the sagebrush vegetation of Grand Teton National Park, Wyoming. Northwest Science 52:195-204.

Sampson, A.W. and B.S. Jespersen. 1963. California range brushlands and browse plants. Calif. Agric. Expt. Station Manual 33. Univ. of Calif. Div. of Agric. Sciences 163 p.

Sampson, A.W. 1944. Plant succession on burned chaparral lands in northern California. Univ. Calif. Agr. Exp. Sta. Bull. 685.

Sanderson, H.R. 1962. Survival of rodent cached bitterbrush seed. U.S. Dep. Agric. For. Serv. (Berkeley, Calif.), Res. Note 211.

Sauer, J.D. 1977. Fire history, environmental patterns, and species patterns in Santa Monica Mountain chaparral. In H.A. Mooney and C.E. Conrad (tech. coords.) Symposium on the environmental consequences of fire and fuel management in Mediterranean ecosystems, pp. 383-386. USDA For. Ser. Gen. Tech. Rep. WO-3, Washington, DC.

Schott, M.R. and R.D. Pieper. 1985. Influence of canopy characteristics of oneseed juniper on understory grasses. J. Range Manage. 38:328-331.

Schott, M.R. and R.D. Pieper. 1987. Succession of pinyon-juniper communities after mechanical disturbance in southcentral New Mexico. J. Range Manage. 40:88-94.

Schott, M.R. and R.D. Pieper. 1986. Succession in pinyon-juniper vegetation in New Mexico. Rangelands 8:126-128.

Schroeder, Walter A. 1981. Presettlement prairie of Missouri. Natural History Series, No. 2. Missouri Department of Conservation, Jefferson City.

Scifres, C.J., J.W. McAtee, and D.L. Drawe. 1980. Botanical, edaphic, and water relationships of gulf cordgrass (*Spartina spartinae*) and associated communities. Southwest. Nat. 25:397-410.

Scott, R.W. 1974. Icefield Ranges Research Project Scientific Studies, Vol. 4. American Geographical Society, New York.

Shacklette, H.T., et al. 1969. Vegetation of Amchitka Island, Aleutian Islands. U.S. Geological Survey Prof. Paper 648.

Shantz, H.L. and R.L. Piemeisel. 1940. Types of vegetation in Escalante Valley, Utah, as indicators of soil conditions. USDA Tech. Bull. 713. 46 p.

Sharp, L.A. and K.D. Sanders. 1978. Rangeland resources of Idaho. Univ. Idaho for., Wildl. and Range Exp. Sta. Contrib. 141, 74 pp.

Sharsmith, H.K. 1945. Flora of the Mt. Hamilton Range of California. Amer. Midl. Nat. 34:289-382.

Sheffield, W.J. 1983. Food habits of nilgai antelope in Texas. J. Range Manage. 36: 316-322.

Sheffield, W.J., E.D. Ables, and B.A. Fall. 1971. Geographic and ecologic distribution of nilgai antelope in Texas. J. Wildl. Manage. 35:257.

Shelford, V.E. 1963. The Ecology of North America. University of Illinois Press, Urbana. 610 pp.

Shiflet, T.N. 1963. Major ecological factors controlling plant communities in Louisiana marshes. J. Range Manage. 16:231-235.

Shrader, John A. 1977. Wyoming rangeland resources. Soc. for Range Manage. - Wyo. Agr. Exp. Sta. Joint Publ. Wyo, Agr. Exp. Sta. Sci. Rept. 854. Laramie. 87 pp.

Shreve, F. 1936. The transition from desert to chaparral in Baja California. Madrono 3:257-264.

Shreve, F. and I.L. Wiggins. 1964. Vegetation and Flora of the Sonoran Desert. Stanford Univ. Press, Stanford, Calif. 1740 pp., 2v.

Shreve, Forrest. 1942. The vegetation of Arizona. pp. 10-23. In: Flowering Plants and Ferns of Arizona by T.H. Kearney and R.H. Peebles. U.S. Dep. Agric. Misc. Pub. 423.

Shreve, F., and I.L. Wiggins. 1964. Vegetation and flora of the Sonoran Desert. Stanford Univ. Press, Palo Alto, Calif. 1740 p.

Sims, P.L., B.E. Dahl, and A.H. Denham. 1976. Vegetation and livestock response at three grazing intensities on sandhill rangeland in eastern Colorado. Colorado State Univ. Exp. Sta. Tech. Bull. 130.

Slusher, D.F., W.L. Cockerham, and S.D. Matthews. 1974. Mapping and Interpretation of Histosols and Hydraquents for Urban Development. Histosols: Their Characteristics, Classification, and Use. Soil Science Society of America Special Publication No. 6.

Small, M.W. 1975. Selected properties of contiguous soils supporting and devoid of sand shinnery oak. M.S. Thesis. Texas Tech. Univ., Lubbock, Texas.

Smith, C.F. 1976. A flora of the Santa Barbara Region, California. Santa Barbara Museum of Natural History, Santa Barbara. 331 p.

Smoliak, S. and J.F. Dormaar. 1985. Productivity of Russian wildrye and crested wheatgrass and their effect on prairie soils. Range Manage. 38:403-405.

Snow, G.E. 1980. The fire resistance of Engelmann and coast live oak seedlings. In T.R. Plumb (tech. coord.) Ecology, management and utilization of California oaks, pp. 621-66. USDA For. Ser. Gen. Tech. Rep. PSW-44, Washington, DC.

Snyder, C., Hardman, T.G., and F.F. Zdenek. 1964. Pleistocene Lakes in the Great Basin. USDI Geological Survey Miscellaneous Geologic Investigations MAP I-416.

Society for Range Management. 1989. A Glossary of Terms Used in Range Management. (Peter W. Jacoby, Chm.) Denver, CO. 20p.

Society of Am. Foresters. 1980. F.H. Eyre, Editor. Forest cover types of the United States and Canada. Soc. Am. For., Wash., D.C. 148 pp. + map.

Soil Survey Staff. 1975. Soil Taxonomy: A basic system of soil classification for use in making and interpreting soil surveys. Soil Conservation Service, USDA, Agriculture Handbook No. 436.

Soil Conservation Service. 1987. Range Management for Important Native Grasses of Florida.

Soil Conservation Service. 1987. 26 Ecological Communities of Florida.

Sprent, J.I. and P. Sprent. 1990. Nitrogen Fixing Organisms: Pure and Applied. Chapman and Hall. 256 p.

Springer, P.F. 1988. Saline emergent wetland. In: A Guide to Wildlife Habitats of California. California Dept. Forestry and Fire Protection, Sacramento, CA. 166 p.

Springfield, H.W. 1976. Characteristics and management of southwestern pinyonjuniper ranges: The status of our knowledge. U.S. Dept. Agr. For. Serv. Res. Paper RM-160.

Strahan, J. 1984. Regeneration of riparian forests of the Central Valley. In R.E. Warner and K.M. Hendrix (eds.) California Riparian Systems. U.C. Press. pp. 59-70.

Stubbendieck, J., Stephan L. Hatch, and Kathie J. Hirsch. 1986. North American Range Plants. University of Nebraska Press, Lincoln, NE.

Swallen, J.R. and G.A. Rogler. 1950. The status of crested wheatgrass. Agron. J. 42:571.

Swanson, J.D., M. Schuman, and P.C. Scorup. 1985. Range Survey of the Seward Peninsula Reindeer Ranges, Alaska. USDA Soil Conservation Service. Anchorage, Alaska. 76 pgs + 62 maps.

Swanson, J.D., D. Lehner, and J. Zimmerman. 1986. Range Survey of Nunivak Island, Alaska. USDA Soil Conservation Service. Anchorage, Alaska. 355 pgs.

Swanson, J.D. and D.J. LaPlant. 1987. Range Survey of Hagemeister Island, Alaska. USDA Soil Conservation Service. Anchorage, Alaska. 68 pgs.

Sweeney, J.R. 1968. Ecology of some "fire type" vegetation in northern California. Pages 111-125 in Proc. Tall Timbers Fire Ecology Conf.

Sweeney, J.R. 1956. Responses of vegetation to fire: a study of the herbaceous vegetation following chaparral fires. Univ. Calif. Publ. Bot. 28:143-250.

Tart, D., Kelley, P., and Schlafly, P. 1987. Rangeland vegetation of the Yakima Indian Reservation (Review Draft - 1987), 212 pp.

Tew, Ronald K. 1983. Bitterbrush distribution and habitat classification on the Boise National Forest. In: Proceedings - research and management of bitterbrush and cliffrose in Western North America. USDA Forest Service, Intermountain Forest and Range Experiment Station, Gen. Tech. Report INT-153. 279 pp.

Texas Agricultural Extension Service. Not dated. Rainfall belts in Texas. Texas Agricultural Extension Service, Texas Agricultural Experiment Station. College Station, Texas.

Thorne, R.F. 1976. The vascular plant communities of California. In J. Latting (ed.) Plant communities of southern California, Special Pub. 2, pp. 1-31. California Native Plant Society, Berkeley.

Tiedemann, A.R., W.R. Clary, and R.J. Barbour. 1987. Underground systems of Gambel oak (Quercus gambelii) in central Utah. Amer. J. Bot. 74:1065-1071.

Tiedemann, A.R. and E.M. Schmutz. 1966. Shrub control and reseeding effects on the oak chaparral of Arizona. J. Range Manage. 19:191-195.

Tisdale, E.W. 1986. Canyon grasslands and associated shrublands of westcentral Idaho and adjacent areas. Bulletin No. 40. Moscow, ID: University of Idaho, Forest, Wildlife and Range Experiment Station. 42p.

Tisdale, E.W. 1947. The grasslands of southern interior British Columbia. Ecology 28:346-382.

Topik, C., N. Halverson, and T. High. 1988. Plant Association and Management Guide for the Ponderosa Pine, Douglas-fir and Grand Fir Zones. Mt. Hood NF; R6-ECOL-TA-004-88. 121 pp.

Tueller, Paul T. 1989. Vegetation and land use in Nevada. Rangelands 11:5, p. 204-210.

Tueller, P.T. 1975. The natural vegetation of Nevada. Mentzelia 1(1):3-6, 23-28 pp.

Turner, R.M. and D.E. Brown. 1982. Tropical-Subtropical Desertlands: Sonoran Desertscrub. Desert Plants 4:180-222.

USDA 1981. Land resource regions and major land resource areas of the United States. Agr. Handbook 296. Soil Cons. Serv., U.S. Dept. Agr. Wash., D.C., 156 pp. + map.

USDA 1986. North Central forest experiment station forest inventory analysis field manual.

USDA 1981. Ecological land classification terrestrial subsystem. Rolla, Missouri.

USDA Forest Service. 1937. Range Plant Handbook, U.S. Government Printing Office, Washington, D.C. p. B47 and B 48.

USDA-FS-R4. 1981. Forest Service Handbook. FSH 2209.21 R-4 Range Analysis. Amendment No. 11. USDA Forest Service, Intermountain Region, Ogden, Utah.

USDA Forest Service. 1937. Range Plant Handbook, United States Government Printing Office, Washington, D.C. p. B115 and B116.

USDA Forest Service. 1988. Riparian Action Program. Intermountain Region 1988 1992. Ogden, UT 8 p.

USDA Soil Conservation Service. 1982. National List of Scientific Plant Names, Vol 1 & 2. SCS-TP 159. Washington, D.C. 854pp.

VanHorn Ecret, R.L. 1986. An ecological analysis of the tall forb community of the Centennial Mountains, Montana. MS Thesis, University of Idaho, Moscow. 84 p.

Vankat, J.L., and J. Major. 1978. Vegetation changes in Sequoia National Park, California. J. Biogeo. 5:377-402.

Vasek, Frank C., and Michael Barbour. 1977. Mojave desert scrub vegetation. In M. Barbour and J. Major (eds.). Terrestrial Vegetation of California. John Wiley and Sons, New York. pp. 835-866.

Vasek, Frank and Larry Lund. 1980. Soil Characteristics associated with primary plant succession on a Mojave desert dry lake. Ecology 61:5, 1013-1018.

Vasek, F.C. 1966. The distribution and taxonomy of three western junipers. Brittonia 18:350-372.

Vasek, Frank, H.B. Johnson, and D.H. Esslinger. 1975. Effects of pipeline construction on creosote bush scrub vegetation of the Mojave desert. Madrono 23:1, 1-64.

Viereck, L.A., C.T. Dyrness, and A.R. Batten. 1986. The 1986 revision of the Alaska Vegetation Classification. Unpub. report. USDA Forest Service. Institute of Northern Forestry. Fairbanks, Alaska. 204 p.

Viereck, L.A., Dyrness, C.T., Batten, A.R., and Wenzlick, K.J. 1992, The Alaska Vegetation Classification. Gen. Tech. Rep. PNW-GTR-286. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 219 p.

Viereck, L.A., and E.L. Little. 1972. Alaska Trees and Shrubs. USDA Forest Service. Agric. Handbook No. 410. 265 p.

Viereck, L.A., and L.A. Schandelmeier. 1980. Effects of Fire in Alaska and Adjacent Canada. Alaska Tech. Report No. 6. USDI Bureau of Land Management.

Viereck, L.A., and E.L. Little, Jr. 1975. Atlas of United States Trees, Vol. 2. Alaska Trees and Common Shrubs. Misc. Pub. No. 1293. USDA Forest Service, Washington, D.C. 124 p.

Viereck, L.A. 1980. Balsam Poplar. p. 83. IN: Eyre, F.H. (ed.). Forest Cover Types of the United States and Canada. Society of American Foresters.

Volland, L.A. 1976. Plant communities of the central Oregon pumice zone. USDA Forest Service, PNW Region. R-6 Area Guide 4-2. 113 pp.

Volland, L.A. 1982. Plant associations of the central Oregon pumice zone. USDA For. Serv., Pacific Northwest Region, R6-ECOL-104-1985. Portland, Ore. 138 pages.

Walker, L.R., J.C. Zasada, and F.S. Chapin, III. 1986. The role of life history processes in primary succession on an Alaskan floodplain. Ecology 67:1243-1253.

Walker, D.A., K.R. Everett, P.J. Webber, and J. Brown. 1980. Geobotanical Atlas of the Prudhoe Bay Region, Alaska. CRREL Report 80-14.9.

Walker, D.A. 1985. Vegetation and environmental gradients of the Prudhoe Bay region, Alaska. CRREL Report 85-14.

Wallace, J.D., J.C. Free, and A.H. Denham. 1973. Seasonal changes in herbage and cattle diets on sandhill grasslands. J. Range Manage. 25:100-104.

Watson, C.E. 1959. Climates of the States: Alaska. Climatography of the United States. No. 60-49. Weather Bureau. U.S. Dept. Commerce. Washington D.C. 24 p.

Watts, C.R., L.C. Eichhorn, and R.J. Mackie. 1987. Vegetation trends within rest-rotation and season-long grazing systems in the Missouri River Breaks, Montana. J. Range Manage. 40:393-396.

Watts, F.B. 1960. The natural vegetation of the southern great plains of Canada. Geog. Bull. 14:25-43.

Weaver, J.E. and F.W. Albertson. 1956. Grasslands of the Great Plains. Johnsen Publ. Co., Lincoln, Nebr. 395 pp.

Weaver, J.E. and G.W. Tomanek. 1951. Ecological studies in a midwestern range: The vegetation and effects of cattle on its composition and distribution. Univ. Nebr. Conserv. and Surv. Div. Bul. 31. 82p.

Weaver, J.E., and F.E. Clements. 1938. Plant ecology. McGraw-Hill. New York, New York.

Weaver, J.E. 1960. Comparison of vegetation of the Kansas-Nebraska drift-loess hills and loess plains. Ecology 41:73-88.

Weaver, T. 1979. Climates of fescue grasslands of mountains in the western United States. Great Basin Naturalist. 39(3):284-288.

Welch, S.L., N. Duane Atwood, Larry C. Higgens, and Sherel Goodrich. 1987. The Utah Flora. Great Basin Naturalist Memoir No. 9, Brigham Young Univ. Press. Provo, UT. 894 p.

Wells, P.V. 1962. Vegetation in relation to geologic substratum and fire in the San Luis Obispo Quadrangle, California. Ecol. Monogr. 32:79-103.

Wells, P.V. 1960. Physiognomic intergradiation of vegetation on the Pine Valley Mountains in southwestern Utah. Ecology 41:553-556.

Welsh, S.L., N.D. Atwood, L.C. Higgins and S. Goodrich. 1987. A Utah Flora. Great Basin Nat. Memoir No. 9. 894 p.

Welsh, Stanley L. 1974. Anderson's Flora of Alaska and adjacent parts of Canada. Brigham Young University Press. Provo, Utah. 724 p.

Welsh, Stanley L., N. Duane Atwood, Sherel Goodrich, and Larry C. Higgens. 1987. A Utah Flora. Great Basin Naturalist Memoirs No. 9. Brigham Young University Press. Provo, UT. 894 p.

West, N.E. and N.S. Van Pelt. 1988. Successional patterns in pinyon-juniper woodlands. pp. 43-52. In: R.L. Everett (comp.) Proceedings Pinyon-Juniper Conference. U.S. Dept. Agric., Forest Service. Gen. Tech. Rep. INT-215. Intermountain Res. Sta., Ogden, Utah.

West, N.E. 1984b. Factors affecting treatment success in the pinyon-juniper type. pp. 21-33. In: Proceedings of the Second Utah shrub Ecology Workshop. College of Natural Resources, Utah State University, Logan.

West, N.E. 1984a. Successional patterns and productivity potentials of pinyonjuniper ecosystems. pp. 1301-1322 In: National Acad. Sci. Nat. Res. Council. Developing strategies for range management. Westview Press. Boulder, Colo.

West, N.E. 1988. Intermountain deserts, shrub steppes and woodlands. pp. 207-230. In: M.G. Barbour and W.D. Billings (eds.) Terrestrial vegetation of North America. Cambridge Univ. Press, N.Y.

West, N.E., K.H. Rea and R.J. Tausch. 1975. Basin synecological relationships in pinyon- juniper woodlands. pp. In: G.F. Gifford and F.E. Busby (eds.) The Pinyonjuniper ecosystem: A symposium. Utah State Univ., Logan, Utah.

West, N.E. (Ed.). 1972. Galleta: Taxonomy, ecology and management of Hilaria jamesii on western rangelands. Utah Agr. Exp. Sta. Bull 487.

West, N.E., K.H. Rea and R.J. Tausch. 1975. Basic synecological relationships in pinyon-juniper woodlands. In: Gifford, G.E. and F.E. Busby (eds.). The pinyonjuniper ecosystem: A symposium. Utah State Univ., Logan.

West, N.E. 1982. Intermountain salt-desert shrublands. In: Ecosystems of the World. Elsevier Press. Vol. 5:375-398.

Westman, W.E. 1983a. Xeric mediterranean-type shrubland associations of Alta and Baja California and the community/continuum debate. Vegetation 52:3-19.

Westman, W.E. 1981b. Factors influencing the distribution of species of Californian coastal sage scrub. Ecology 62:439-455.

Westman, W.E. 1983b. Island biogeography: studies on the xeric shrublands of the inter Channel Islands, California. J. Biogeg. 10:97-118.

Westman, W.E. 1979. A potential role of coastal sage scrub understories in the recovery of chaparral after fire. Madrono 26:64-68.

Westman, W.E. 1981a. Diversity relations and succession in Californian coastal sage scrub. Ecology 62:170-184.

White, E.M. and J.K. Lewis. 1969. Ecological effect of a clay soil's structure on some native grass roots. J. Range Manage. 22:401-404.

White, K.L. 1966. Structure and composition of foothill woodland in central coastal California. Ecology 47:229-237.

White, T.C. 1988. Unpublished data. Cleveland National Forest.

Wieslander, A.E., and C.H. Gleason. 1954. Major brushland areas of the coast ranges and Sierra-Cascade foothills of California. Calif. For. and Range Expt. Sta. Misc. Pap. No. 15, 8 pp.

Williams, C.K., T.R. Lillybridge and B.G. Smith. 1990. Forested Plant Associations of the Colville National Forest. 101 pp.

Williams, C.K. and T.R. Lillybridge. 1983. Forested plant associations of the Okanogan National Forest. USDA-Forest Service, Pacific NW Region, R6-Ecol-132b.

Williams, C.K., and B. Smith. 1991. Review Draft - Forested Plant Associations of the Wenatchee National Forest. USDA Forest Service, PNW Region.

Winward, A.H. 1982. Unpublished report. USDA Forest Service, Ogden, UT. 2 p.

Winward, A.H., and Youtie, B.A. 1978. Community analysis of higher plants on the Lawrence Memorial Grassland Preserve. Ore. Acad. Sci. 14:50-65.

Winward, A.H. 1980. Taxonomy and ecology of sagebrush in Oregon. Bulletin 642, Corvallis, Oregon: Oregon State University, Agricultural Experiment Station. 15 p.

Wood, S.H. 1975. Holocene stratigraphy and chronology of mountain meadows, Sierra Nevada, California. Ph.D. thesis. Calif. Institute of Technology, Pasadena. USDA For. Serv. Region 5, Earth Resources Monograph #4. 179 p.

Wright, Henry A., and A.W. Bailey. 1982. Fire Ecology. John Wiley & Sons. New York, New York. 501 pp.

Wunderlin, Richard P., Guide to the Vascular Plants of Central Florida, University of South Florida, 1982.

Yarie, J. 1983. Forest community classification of the Porcupine River drainage, interior Alaska, and its application to forest management. USDA Forest Service. Pacific Northwest Forest and Range Experiment Station. GTR PNW 154. 68 p.

Yound, S.B. 1974. The Environment of the Noatak River Basin, Alaska. Contrib. of the Center for Northern Studies, No. 1.

Young, J.A., R.A. Evans, and J. Major. 1977. Sagebrush steppe, p. 763-793 in: Barbour, M.G.; J. Major. Terrestrial vegetation of California. John Wiley and Sons. New York.

Youngberg, C.T. and L. Hu. 1972. Root nodules on mountain mahogany. Forest Sci. 18:211-212.

Youngblood, Andrew P., Wayne G. Padgett, and Alma H. Winward. 1985. Riparian Community type classification of eastern Idaho-western Wyoming. USDA Forest Service, Intermountain Region, Ogden, UT R4-Ecol-85-01. 78 p.

Zamora, B. and P.T. Tueller. 1977. *Artemisia arbuscula, A. longiloba* and *A. nova* habitat types in northern Nevada. Great Basin Naturalist. 33:225-242.

Zasada, J. 1980. White Spruce-Paper Birch. p. 82. IN: Eyre, F.H. (ed.). Forest Cover Types of the United States and Canada. Society of American Foresters.

Zasada, J. 1980. Paper Birch. p.83. IN: Eyre, F.H. (ed.). Forest Cover Types of the United States and Canada. Society of American Foresters.

Zavitovski, J., and M. Newton. 1968. Ecological importance of snowbrush, *Ceanothus velutinus* in the Oregon Cascades. Ecology 49:1135-1145.

Zedler, P.H., C.R. Gautier, and G.S. McMaster. 1983. Vegetation change in response to extreme events: the effect of a short interval between fires in California chaparral and coastal scrub. Ecology 64(4):809-818.

Zuill, H.J. 1967. Structure of two cover types of southern oak woodland in California. Thesis, Loma Linda University, Loma Linda, CA.