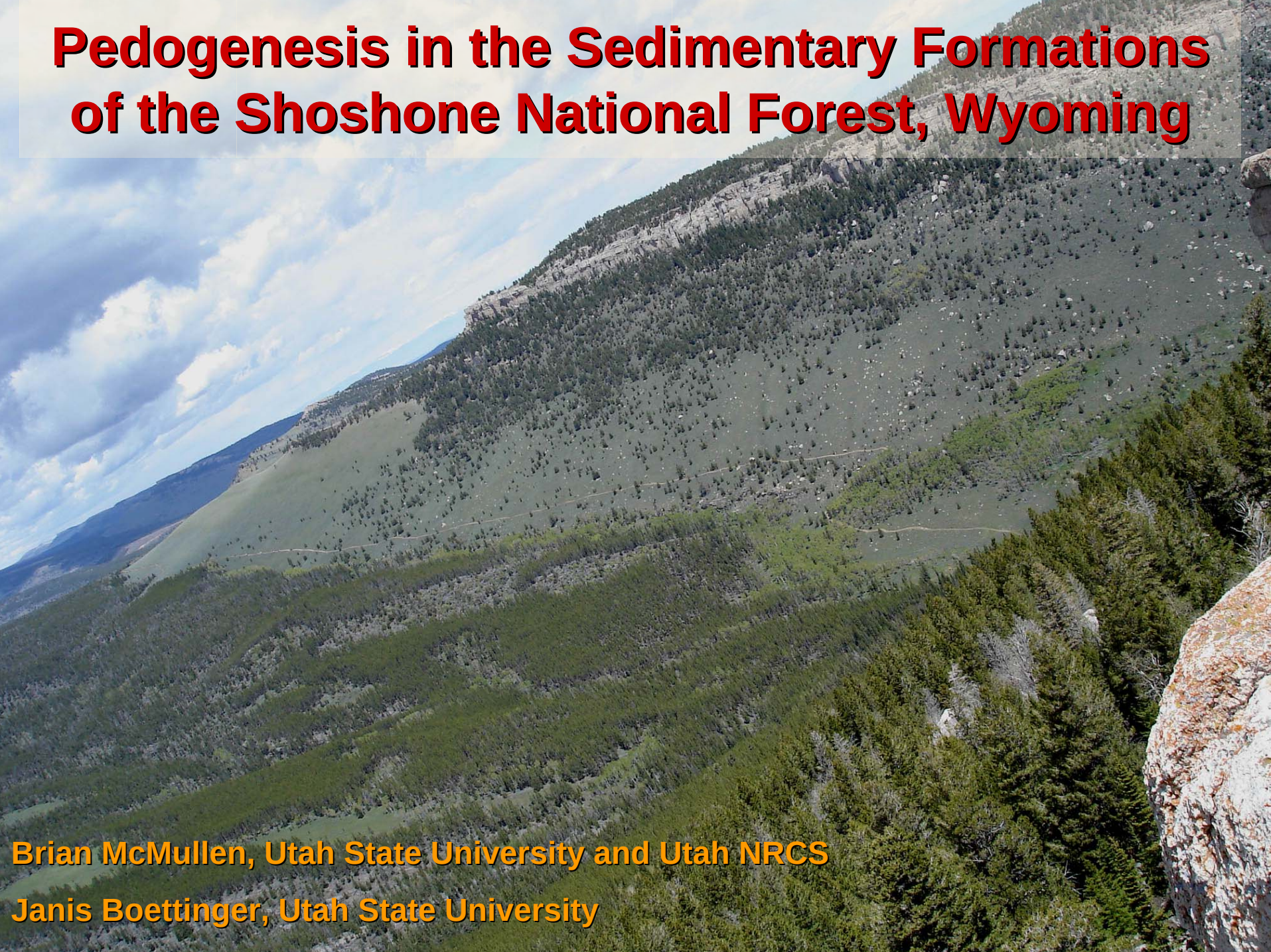
Pedogenesis in the Sedimentary Formations of the Shoshone National Forest, Wyoming



Brian McMullen, Utah State University and Utah NRCS

Janis Boettinger, Utah State University

Louis Sachar, *Holes*

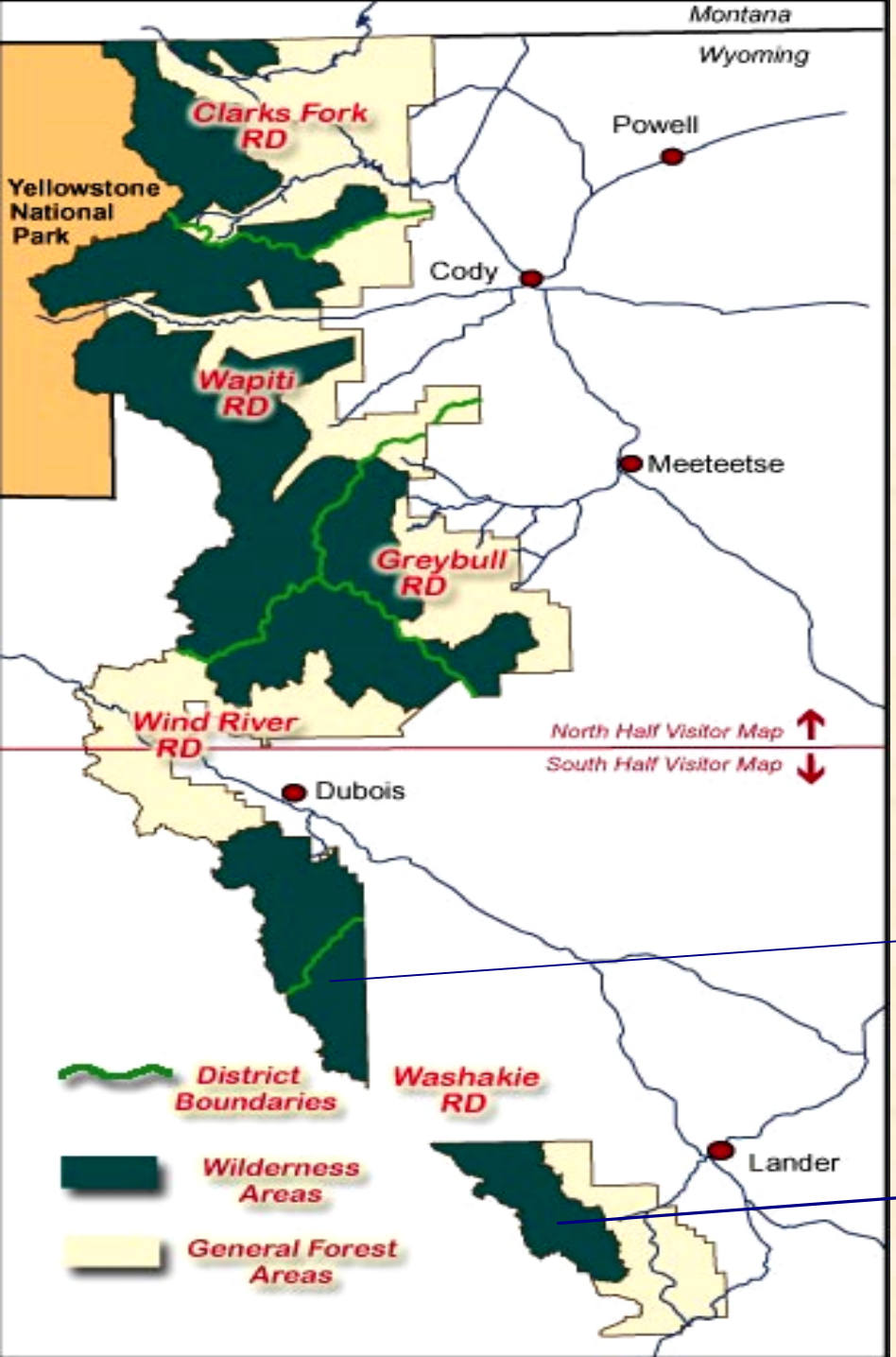
“…if you take a bad boy and make him dig a hole every day in the hot sun, he’ll become a good boy”

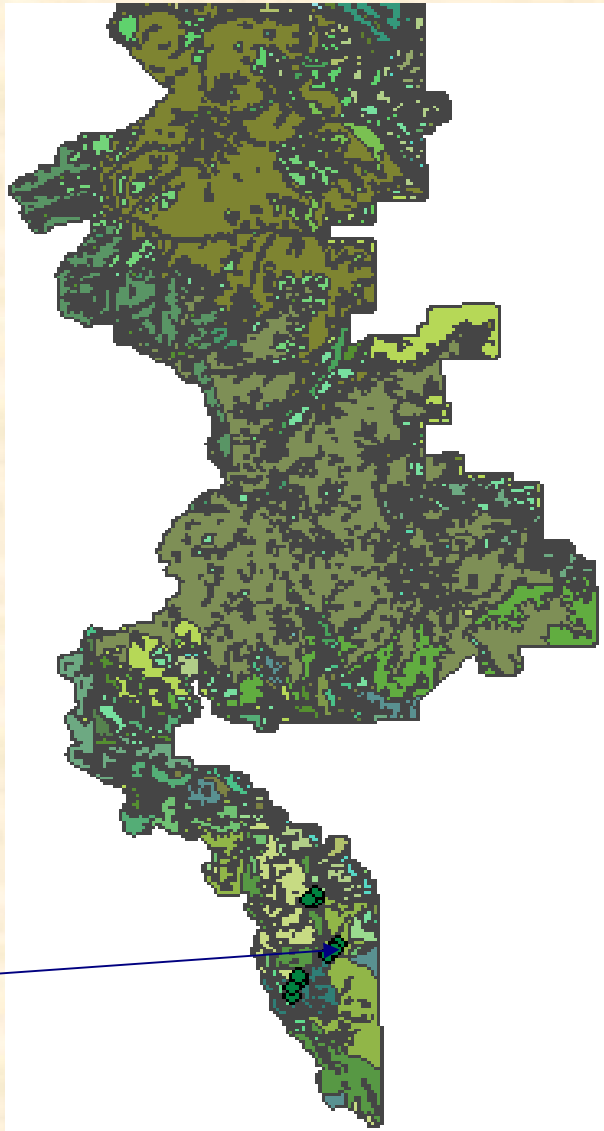
…or maybe he'll help elucidate the connection between soils, vegetation, and parent material in the Wind River Mountains

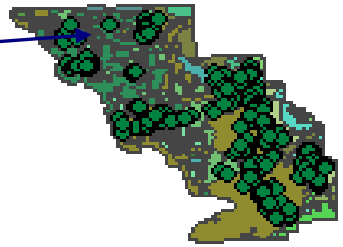
Introduction

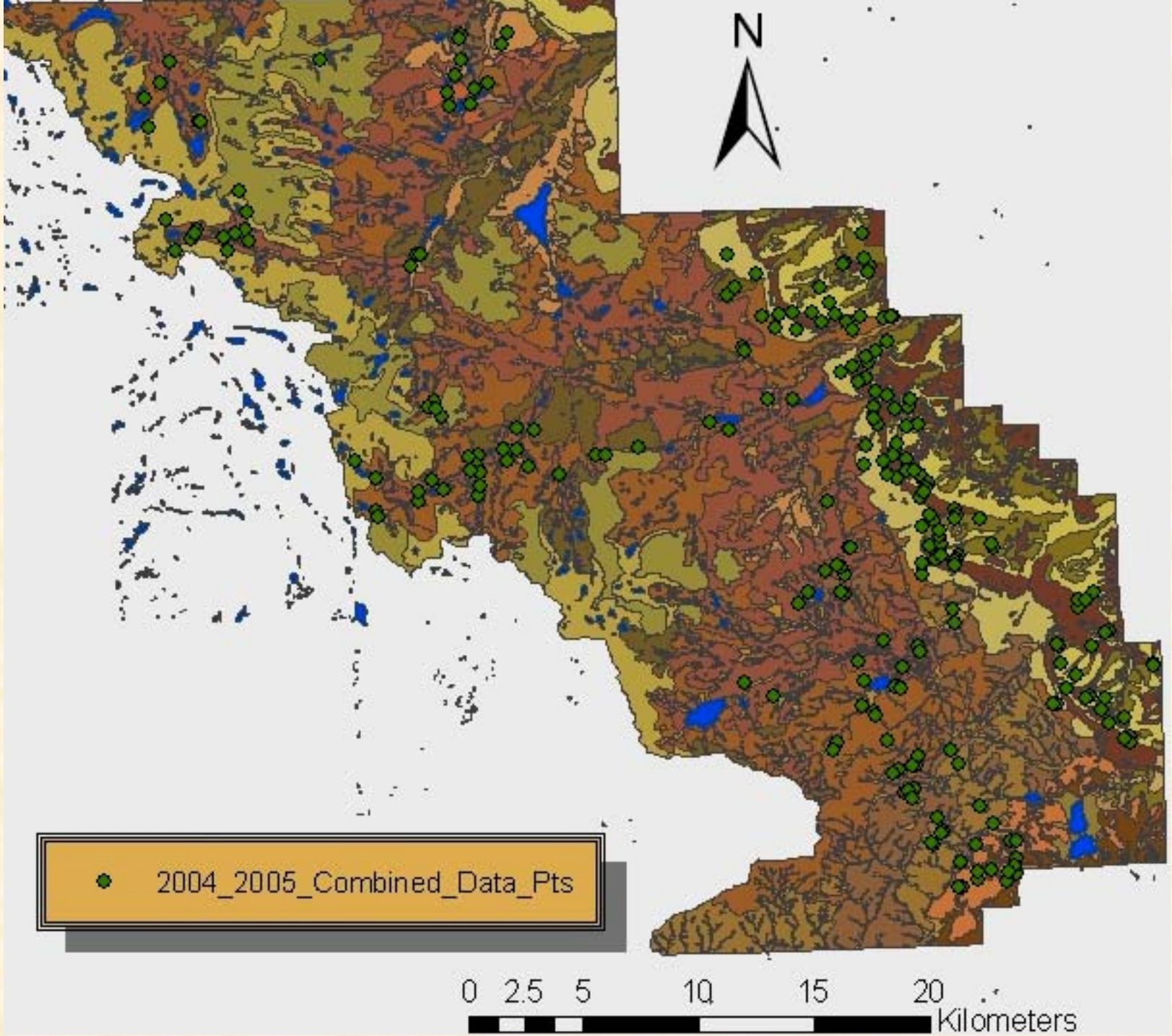
- **Terrestrial Ecosystems Unit Inventory (TEUI)**
  - United States Forest Service (USFS)
  - "…management decisions based on *scientific understanding of ecosystems* on and surrounding National Forest lands"
- **Comprehensive ecological survey**
  - Soil
  - Vegetation
  - Parent Material / landforms

Project Location


Montana
Wyoming
Clarks Fork RD
Powell
Yellowstone National Park
Cody
Wapiti RD
Meeteetse
Greybull RD
Wind River RD
North Half Visitor Map
South Half Visitor Map
Dubois
District Boundaries
Washakie RD
Wilderness Areas
Lander
General Forest Areas






N
2004_2005_Combined_Data_Pts
0 2.5 5 10 15 20
Kilometers

Hans Jenny (1941)- *Factors of Soil Formation*

S = *f* (clorpt)

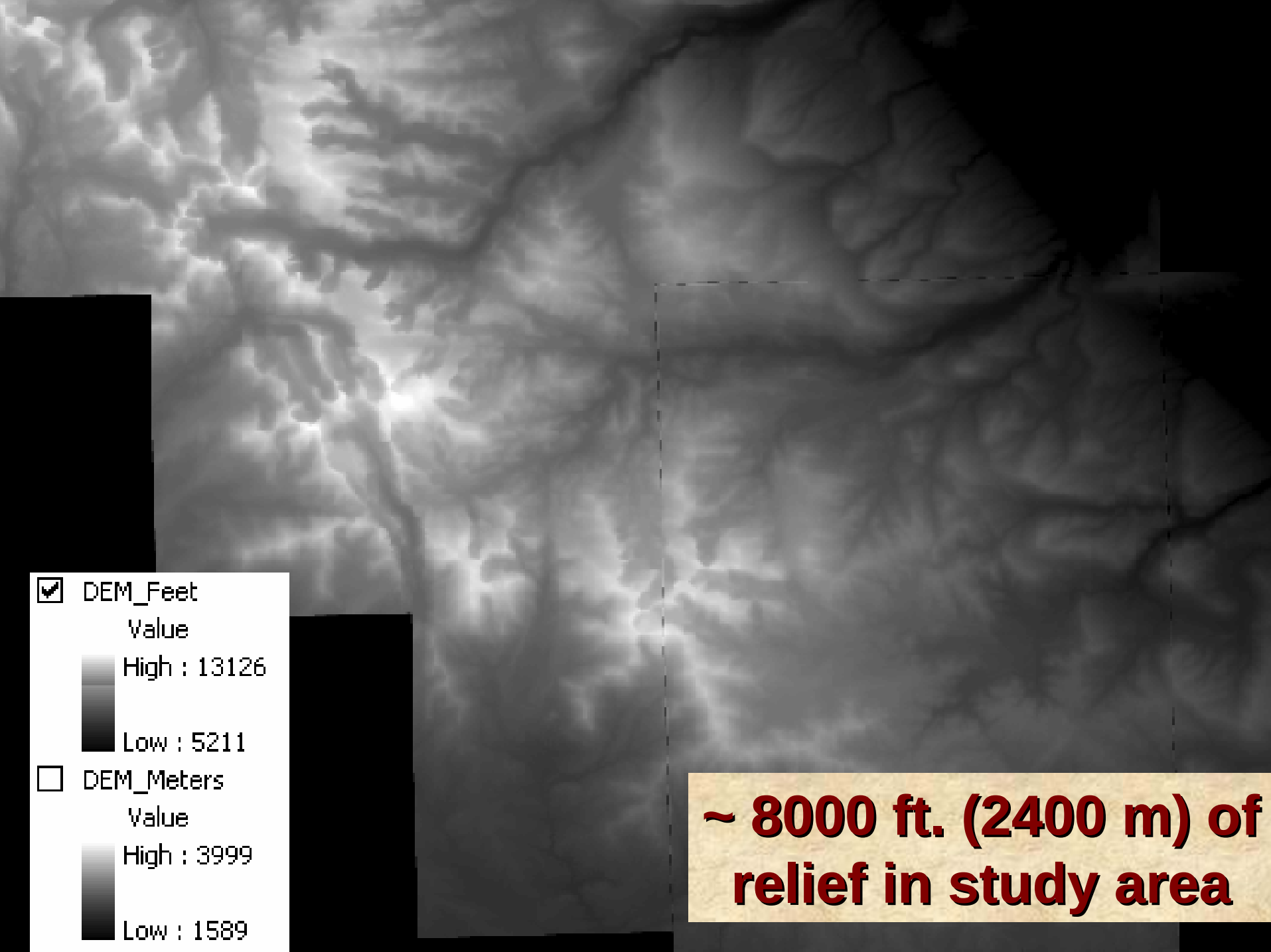
- **C**limate
- **O**rganisms
- **R**elief
- **P**arent Material
- **T**ime

The sedimentary flanking rocks of the southern Shoshone N.F. are an ideal place to study the soil forming factors due to the wide range and interplay of these factors

Physiography

Wind River Range, Eastern Slope

- Elevation range (low to high)
  - 4,600 feet (1402 m)- mouth of Clarks Fork Canyon
  - 13,804 feet (4207 m)- Gannett Peak, WY's highest point.
- Range straddles the Continental Divide
    - Green River Basin to the east, Wind River Basin to the West

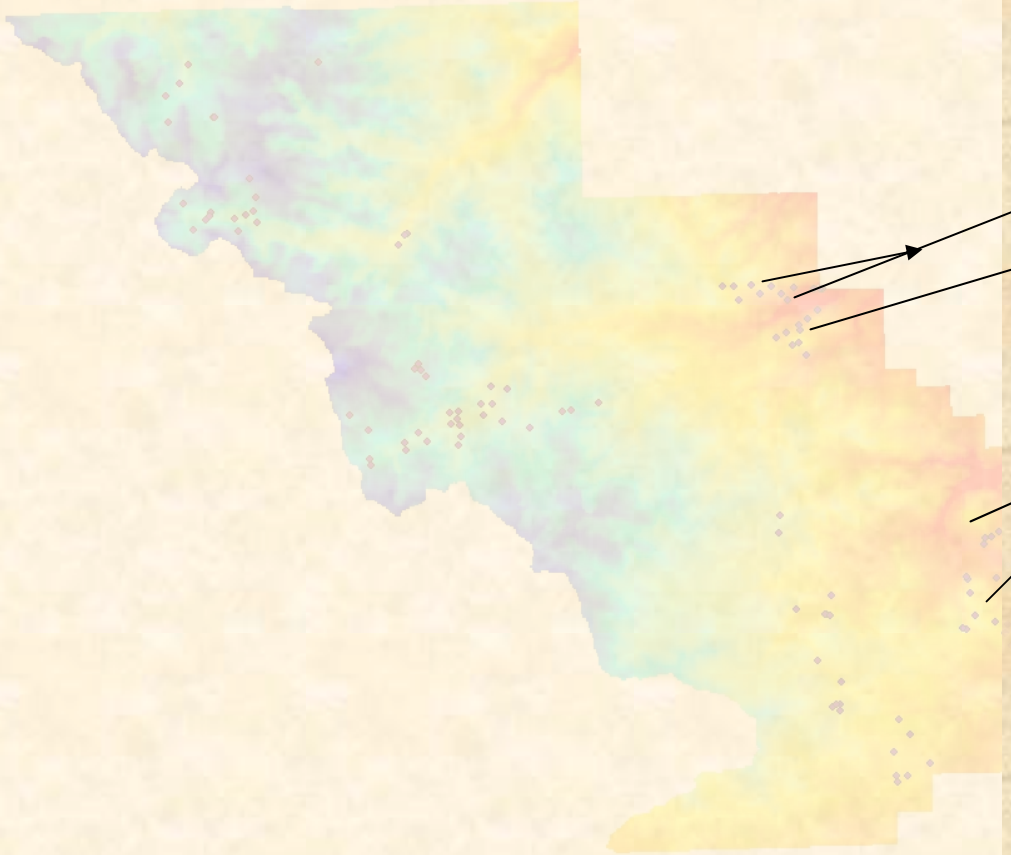


~ 8000 ft. (2400 m) of relief in study area

Summer Field Seasons- 2004/2005

- 2 field crews, each with:
  - 1 Botanist
  - 1 Soil scientist
- Late May to early September
  - Sampling followed floristics
  - Low to high elevation
- Logistics
  - Day trips (low elevation)
  - Backcountry camping (high elevation)
    - 1 to 2 weeks

Sedimentary Plots



6700-8000 ft.

(2300 m)

Calcareous sedimentary rocks (mainly)

Frigid/Ustic Soils

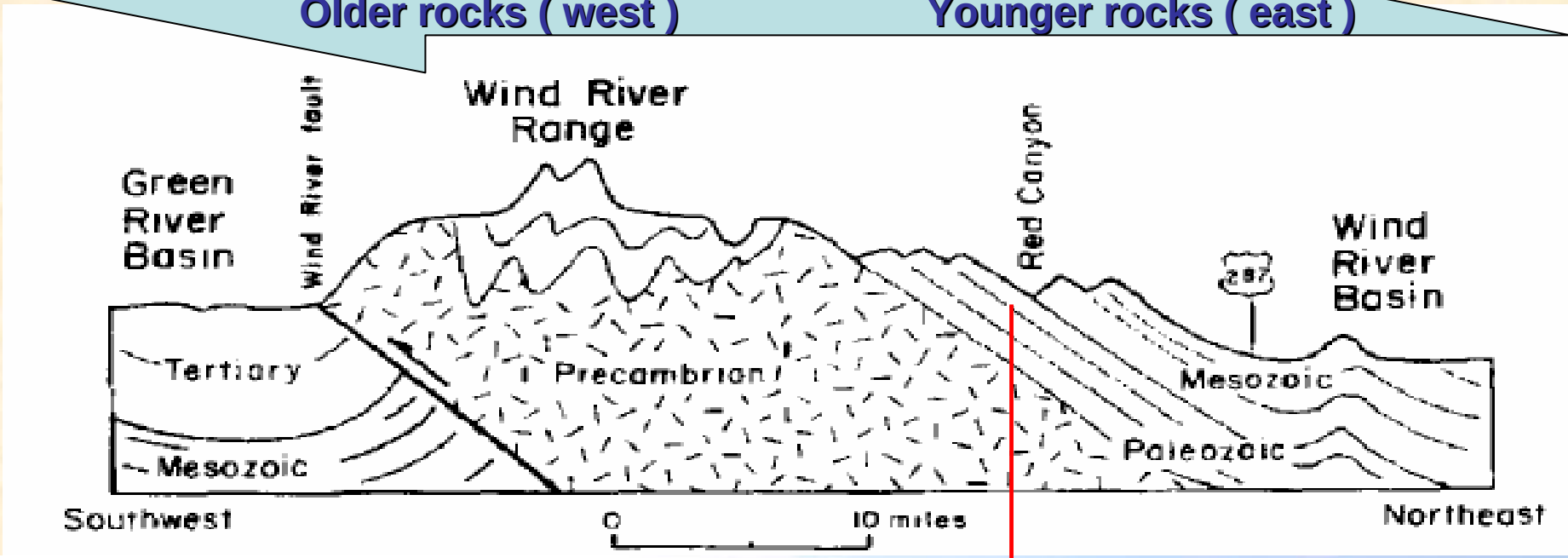
Mollisols, Alfisols, Inceptisols

Sagebrush steppe, coniferous forests

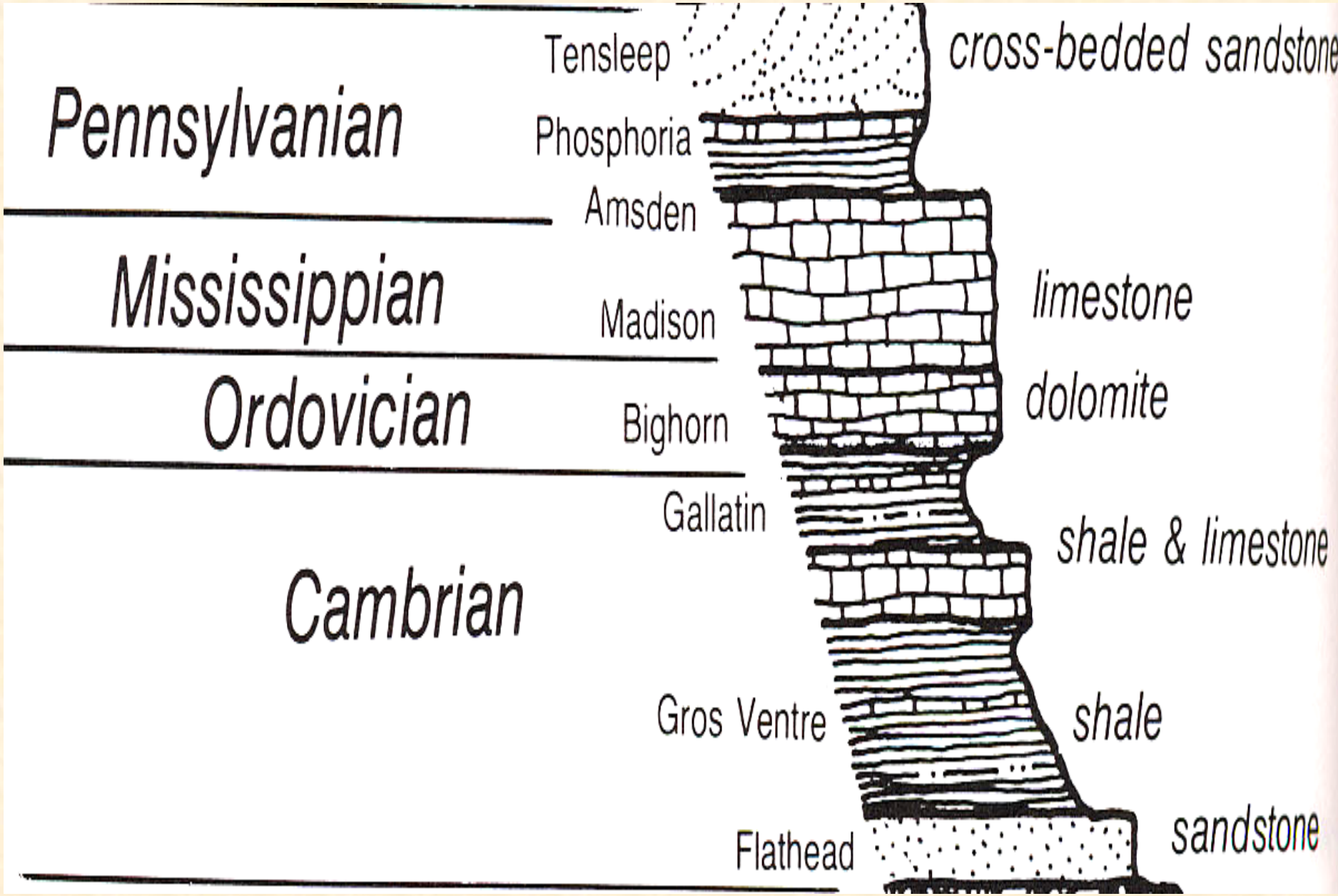
Background Geology

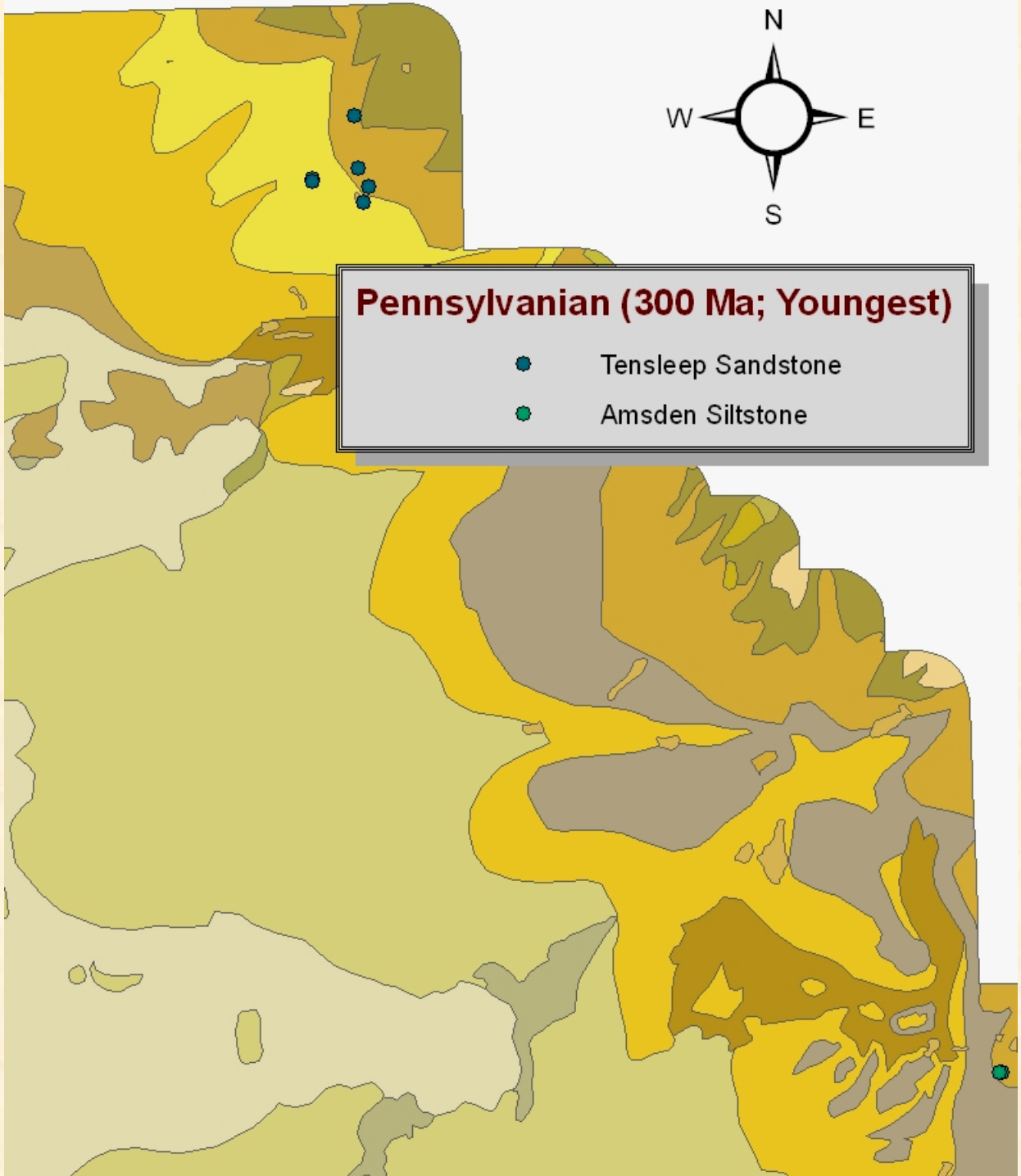
- All 3 major rock types are represented in the Winds
  - Igneous
    - granite, granodiorite
  - Metamorphic
    - gneiss and schist
  - Sedimentary
    - limestone/dolomite, sandstone, shale, siltstone

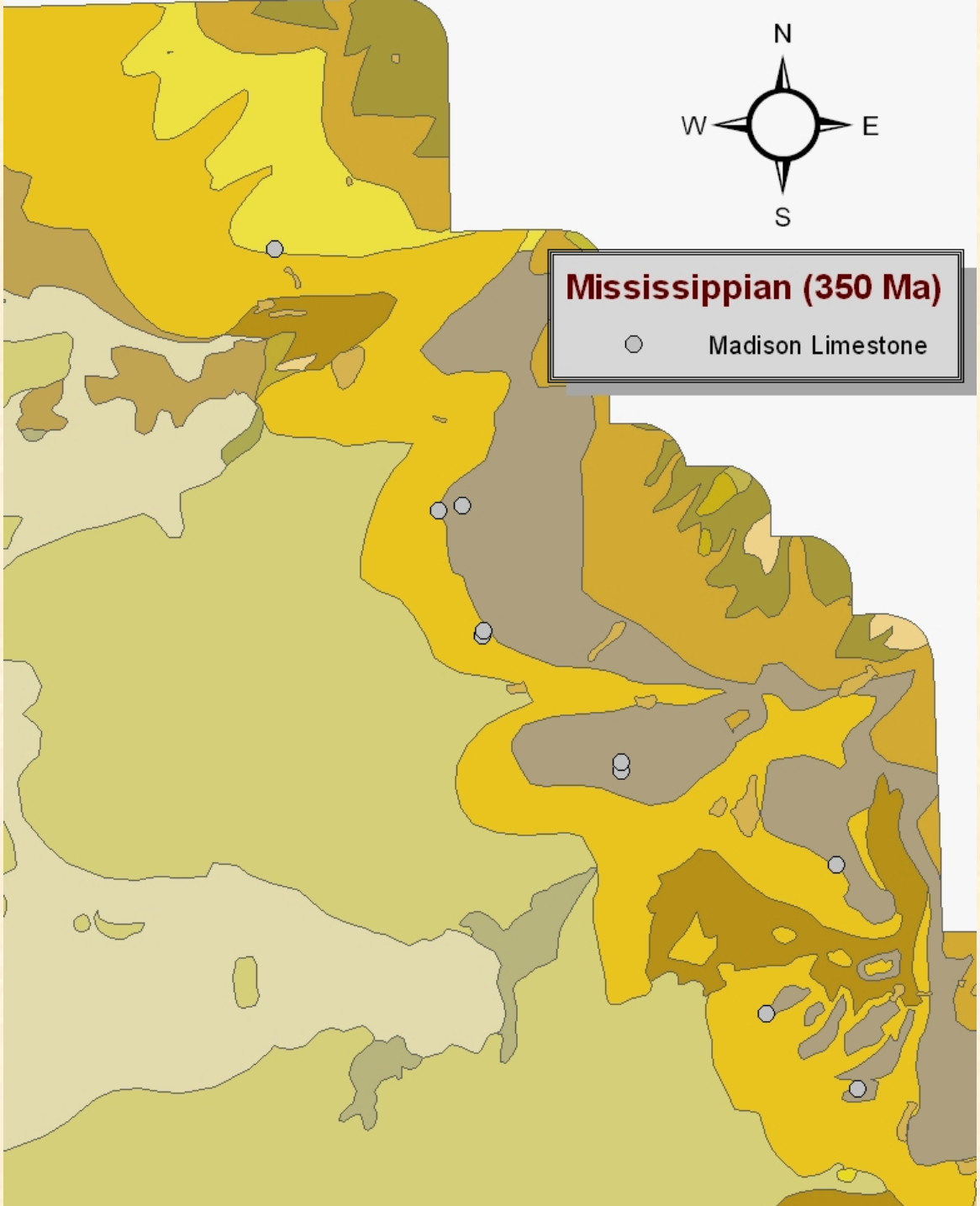
Older rocks (west) Younger rocks (east)

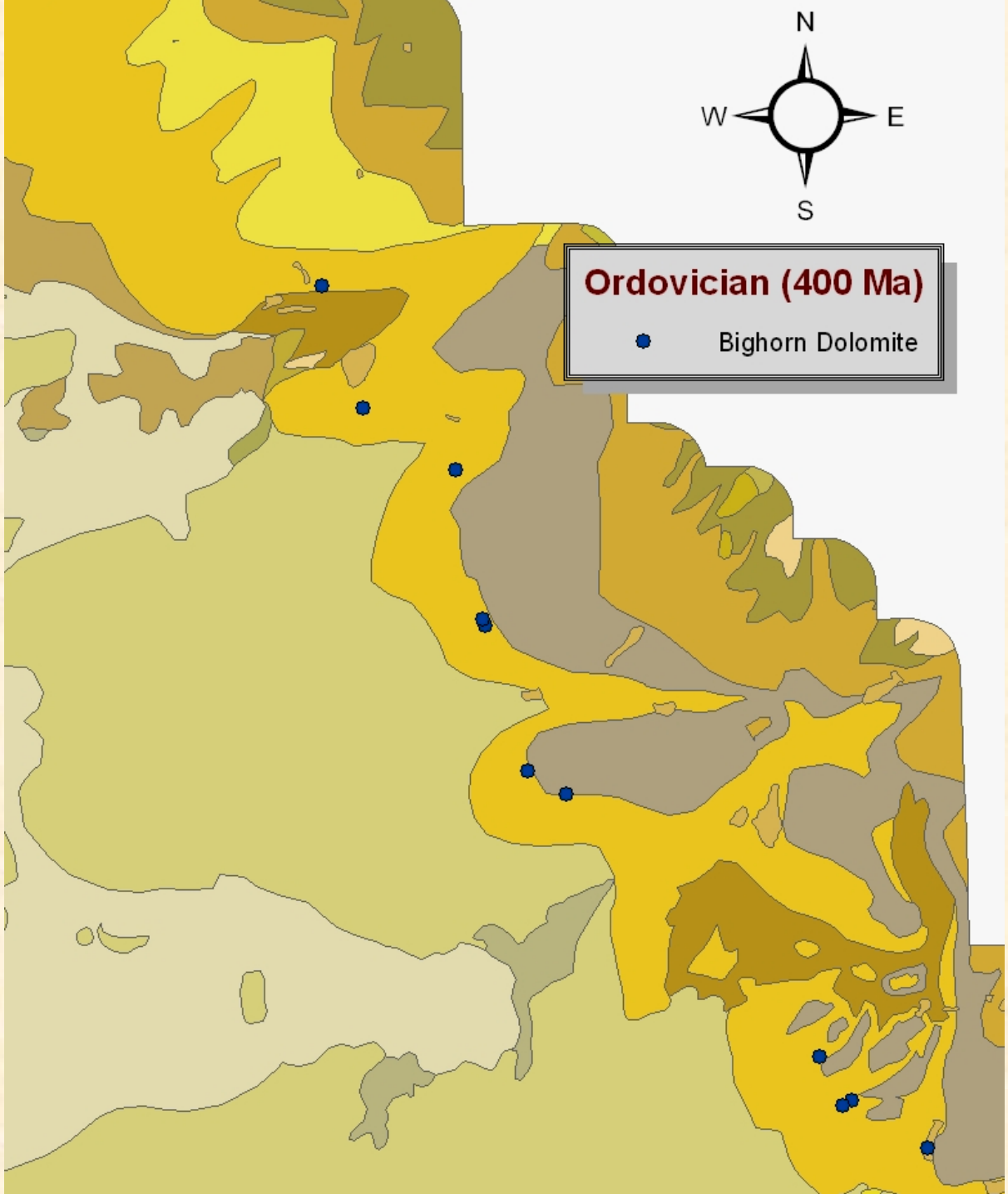


Sedimentary Formations of Eastern Slope

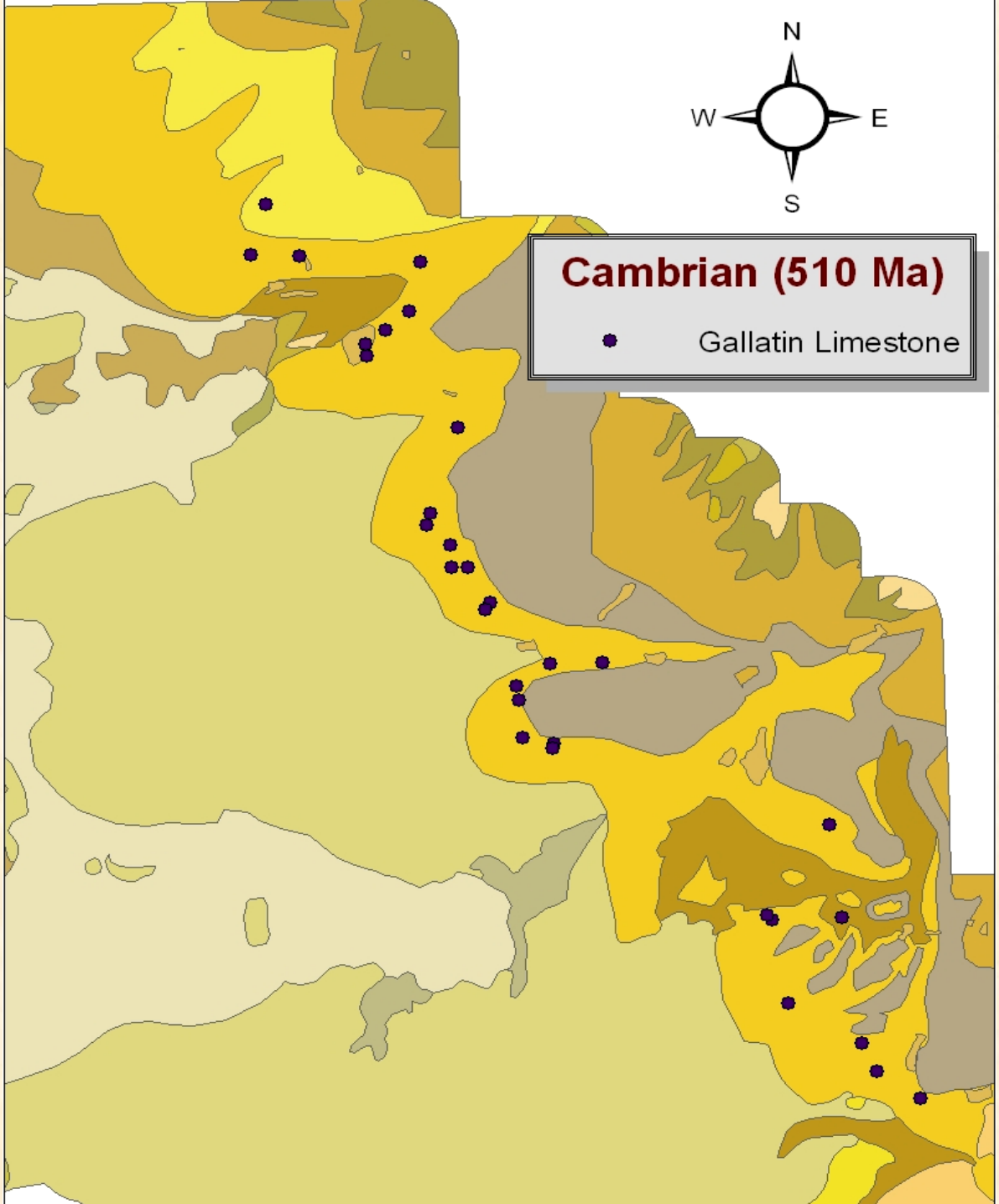



N
W
E
S
Pennsylvanian (300 Ma; Youngest)
Tensleep Sandstone
Amsden Siltstone

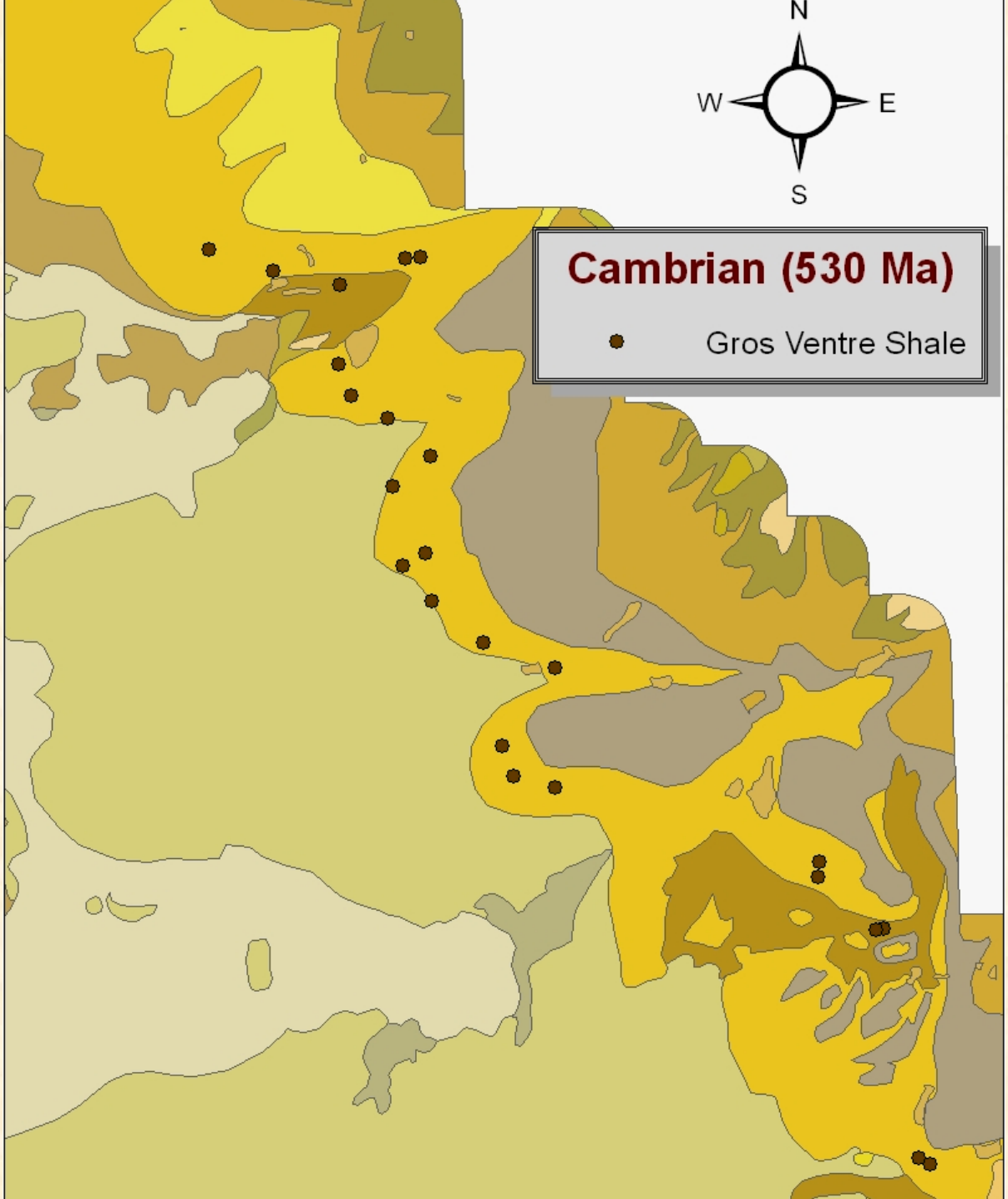

N
W
E
S
Mississippian (350 Ma)
Madison Limestone


N
W
E
S
Ordovician (400 Ma)
Bighorn Dolomite

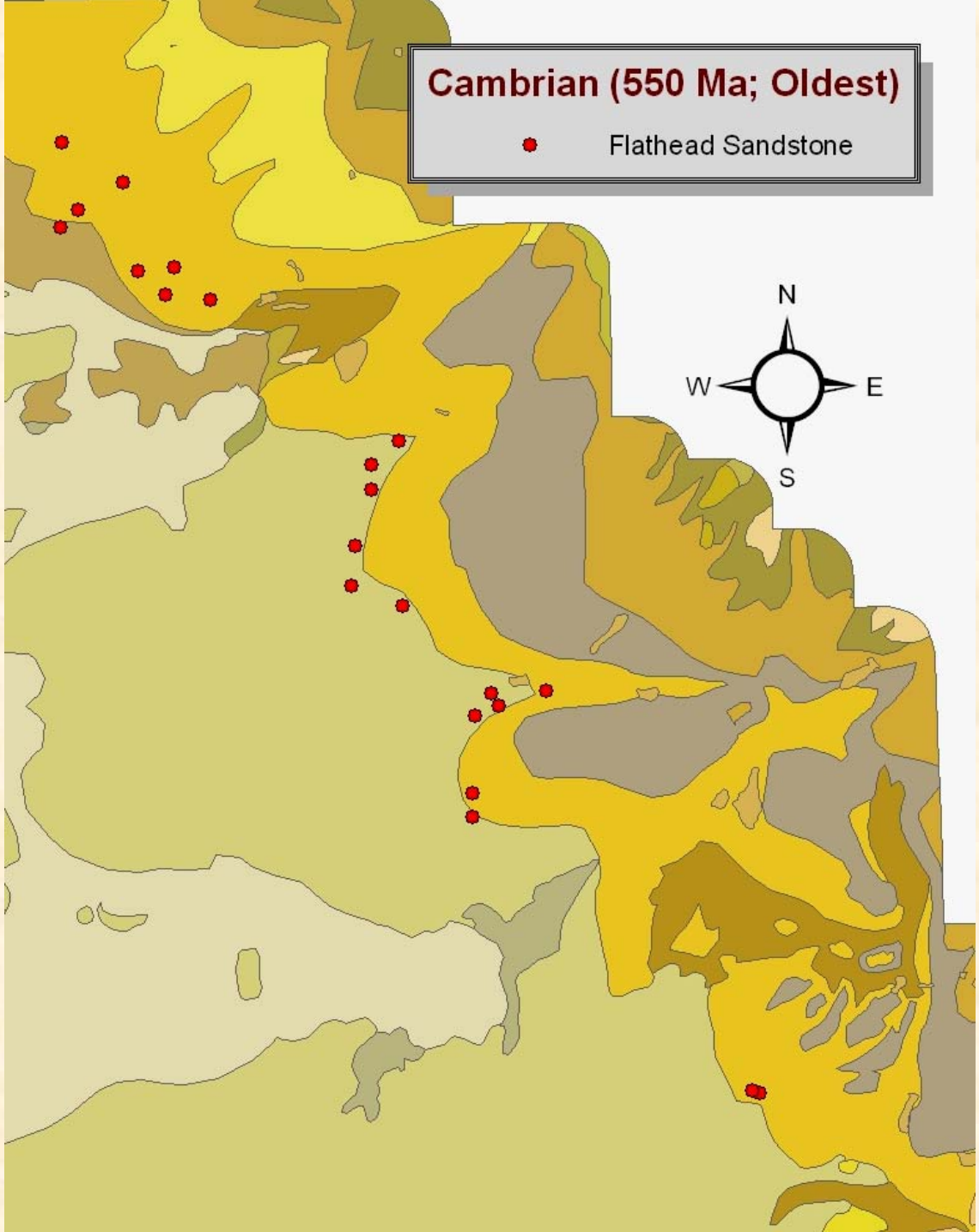
Bighorn Dolomite Soil Profile Under Mixed Calcareous Colluviu


N
W
E
S
Cambrian (510 Ma)
Gallatin Limestone

Gallatin Limestone near contact with Gros Ventre Shale

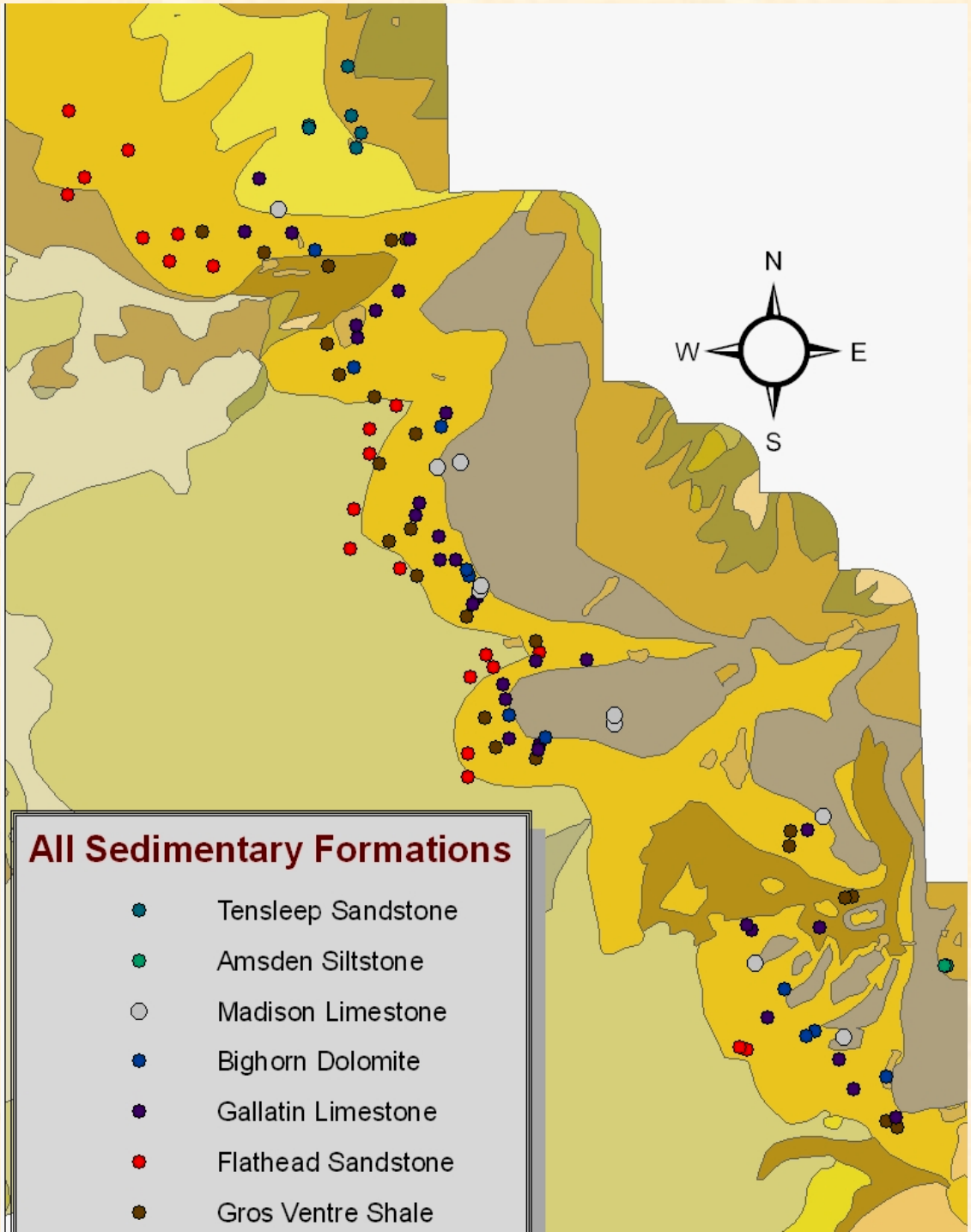

N
W
E
S
Cambrian (530 Ma)
Gros Ventre Shale

Gros Ventre Shale Slope with Gallatin and Bighorn Outcrops Above


Cambrian (550 Ma; Oldest)
Flathead Sandstone
N
W
E
S

Cambrian Flathead Sandstone

Clay and sand-rich weathering profile of Flathead Sandstone


N
W
E
S
All Sedimentary Formations
Tensleep Sandstone
Amsden Siltstone
Madison Limestone
Bighorn Dolomite
Gallatin Limestone
Flathead Sandstone
Gros Ventre Shale

Habitat Types of the Sedimentary Formations

Forested

- Douglas Fir (*Pseudotsuga menziesii*)
- Limber Pine (*Pinus flexilus*)
- Lodgepole Pine (*Pinus contorta*)
- Subalpine Fir (*Abies lasiocarpa*)
- Aspen (*Populus tremuloides*)

Habitat Types of the Sedimentary Formations

Non-Forested

– **Sagebrush**

- **Mountain Big Sage (*Artemisia tridentata*)**
- **Three-tipped Sage (*Artemisia tripartita*)**

– **Grasses**

- **Bluebunch wheatgrass (*Elymus spicata)***
- **Idaho Fescue (*Festuca idahoensis*)**
- **Prairie Junegrass (*Koeleria macrantha*)**

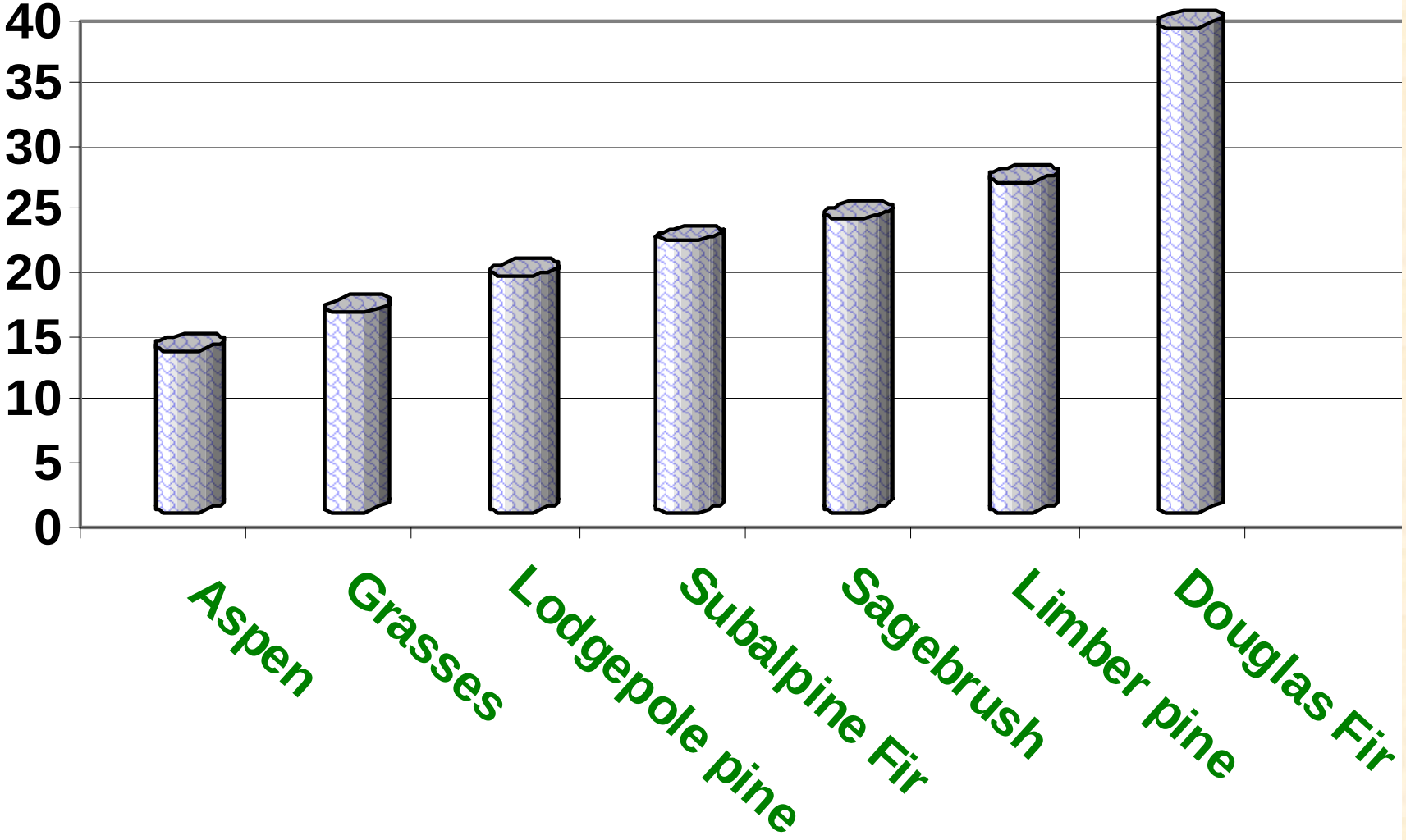
Examining Variability Within and Between Habitat Types

I. Range of Site Characteristics

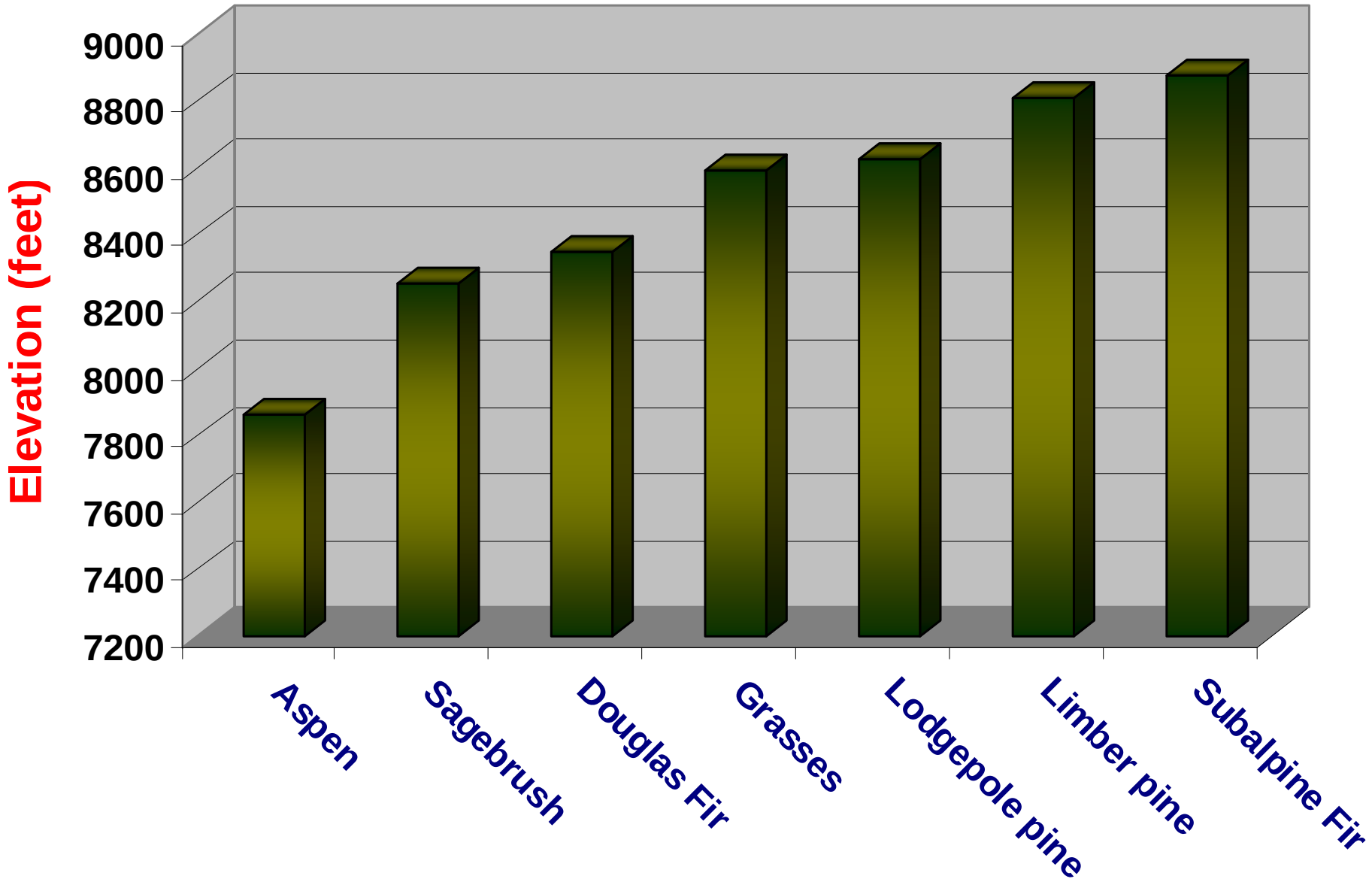
II. Variability Within Douglas Fir Habitat Type

III. Variability Between Douglas Fir and Sagebrush Habitat Types

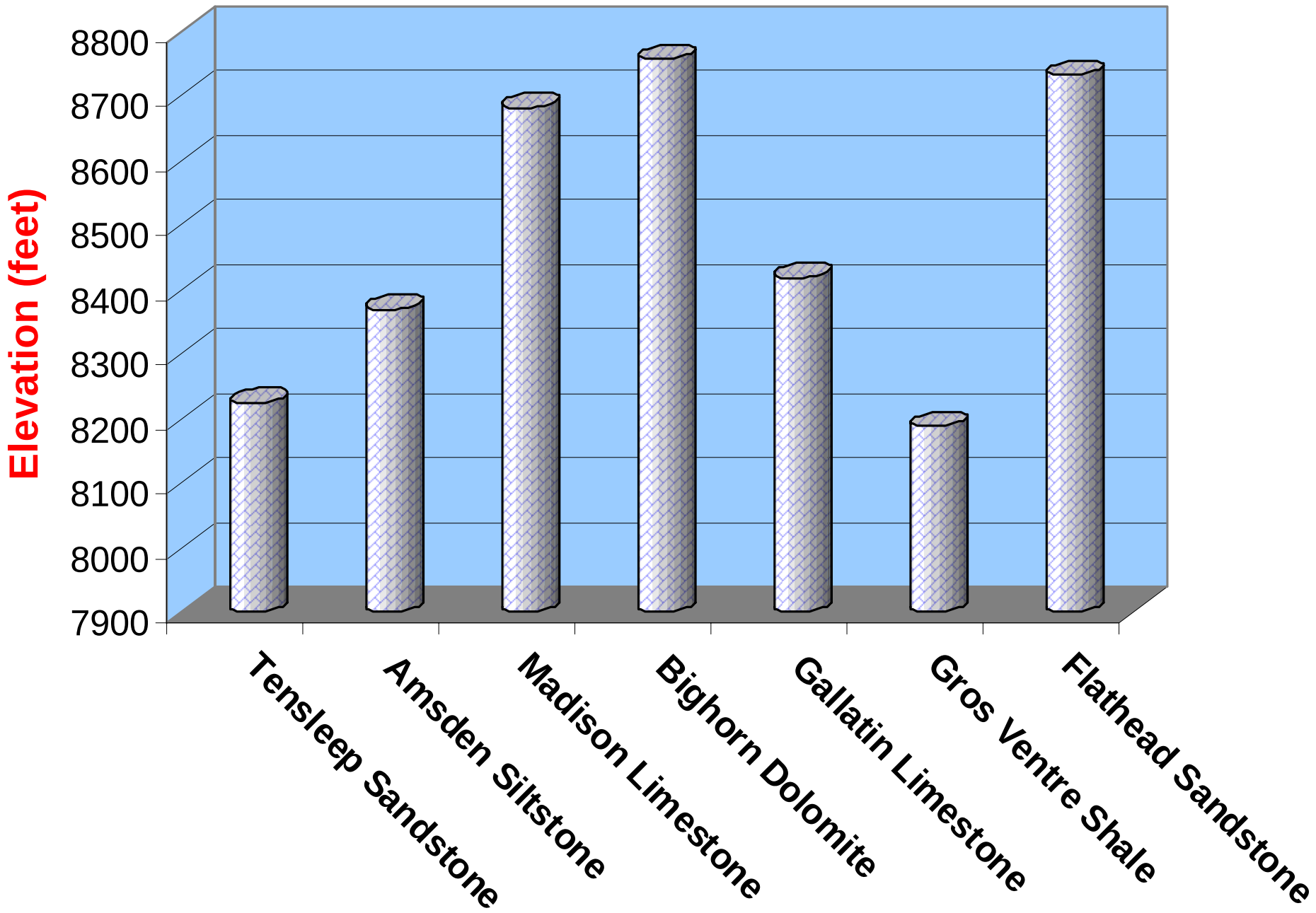
Percent Slope by Habitat Type



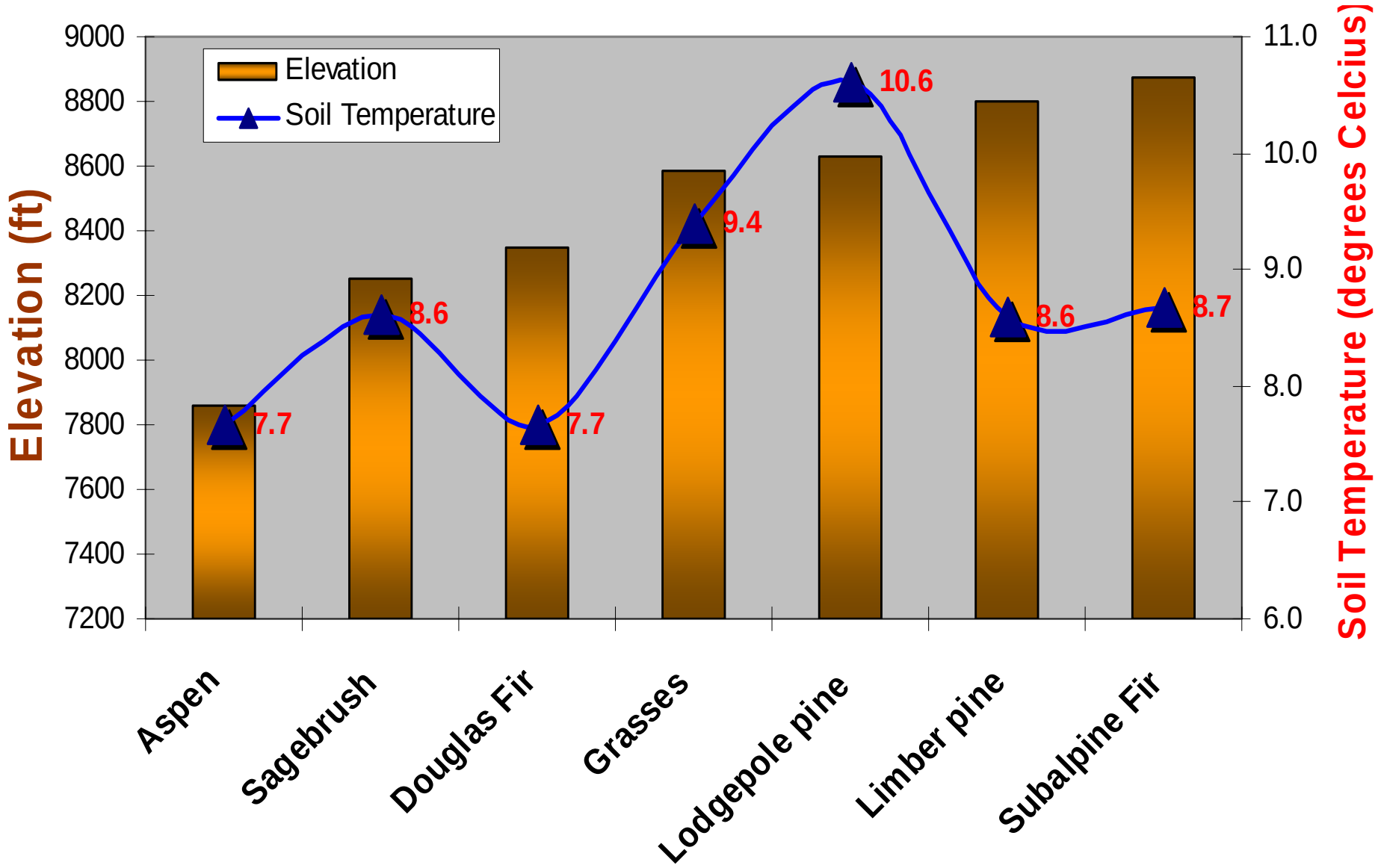
Habitat Type by Elevation

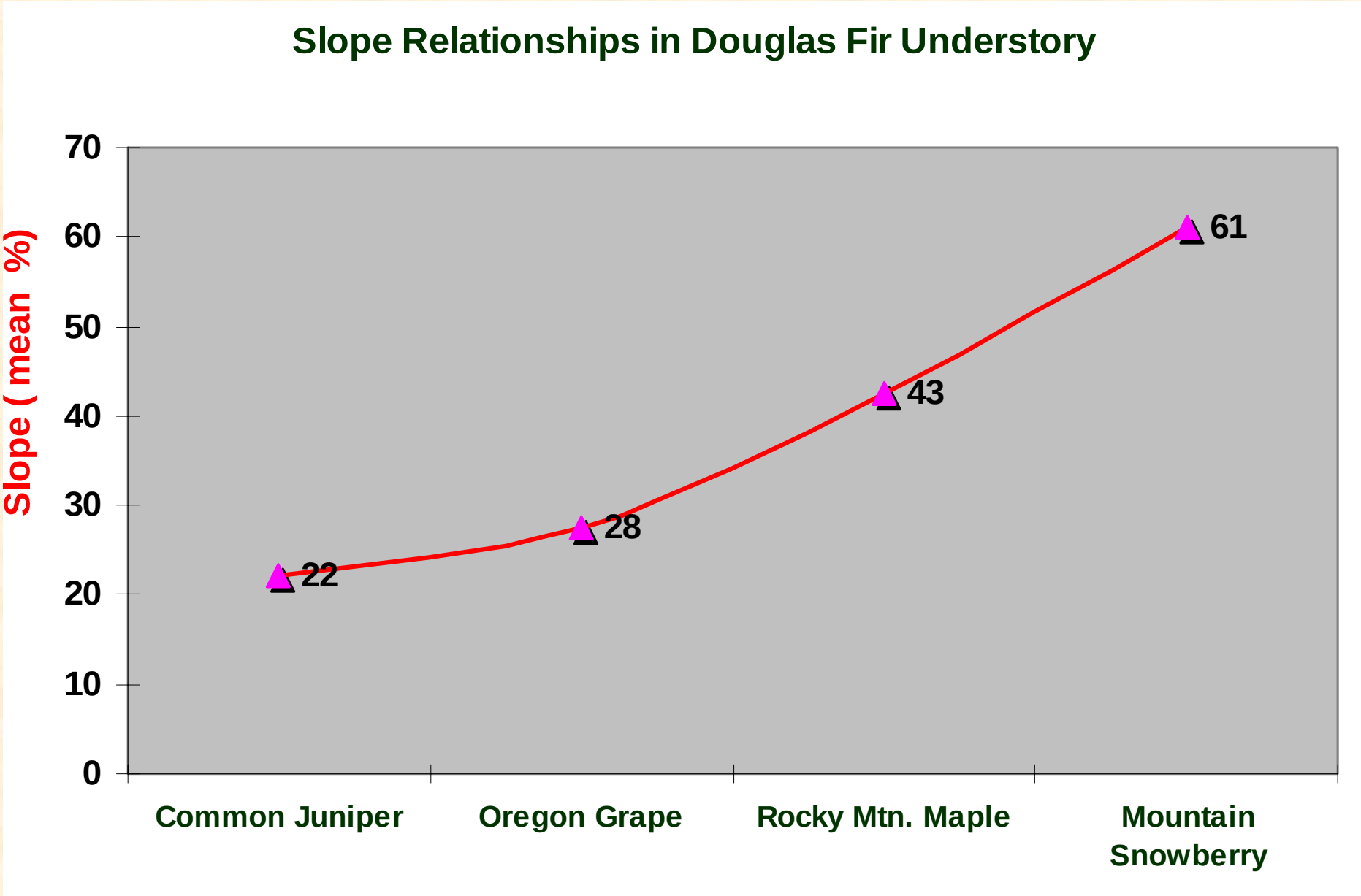


Bedrock Elevations by Age (Youngest to Oldest)

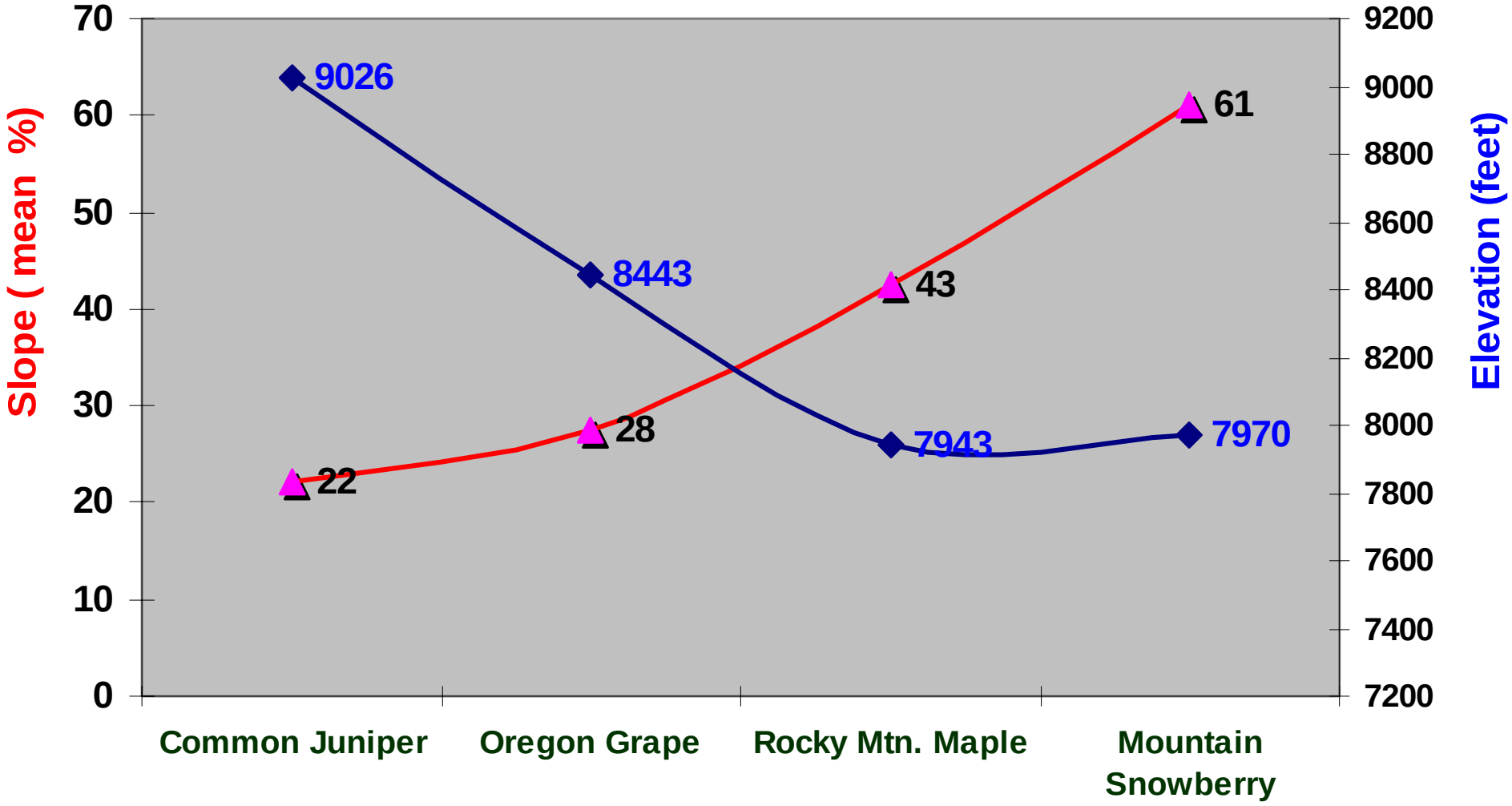


Elevation and Temperature Relationships by Habitat Type

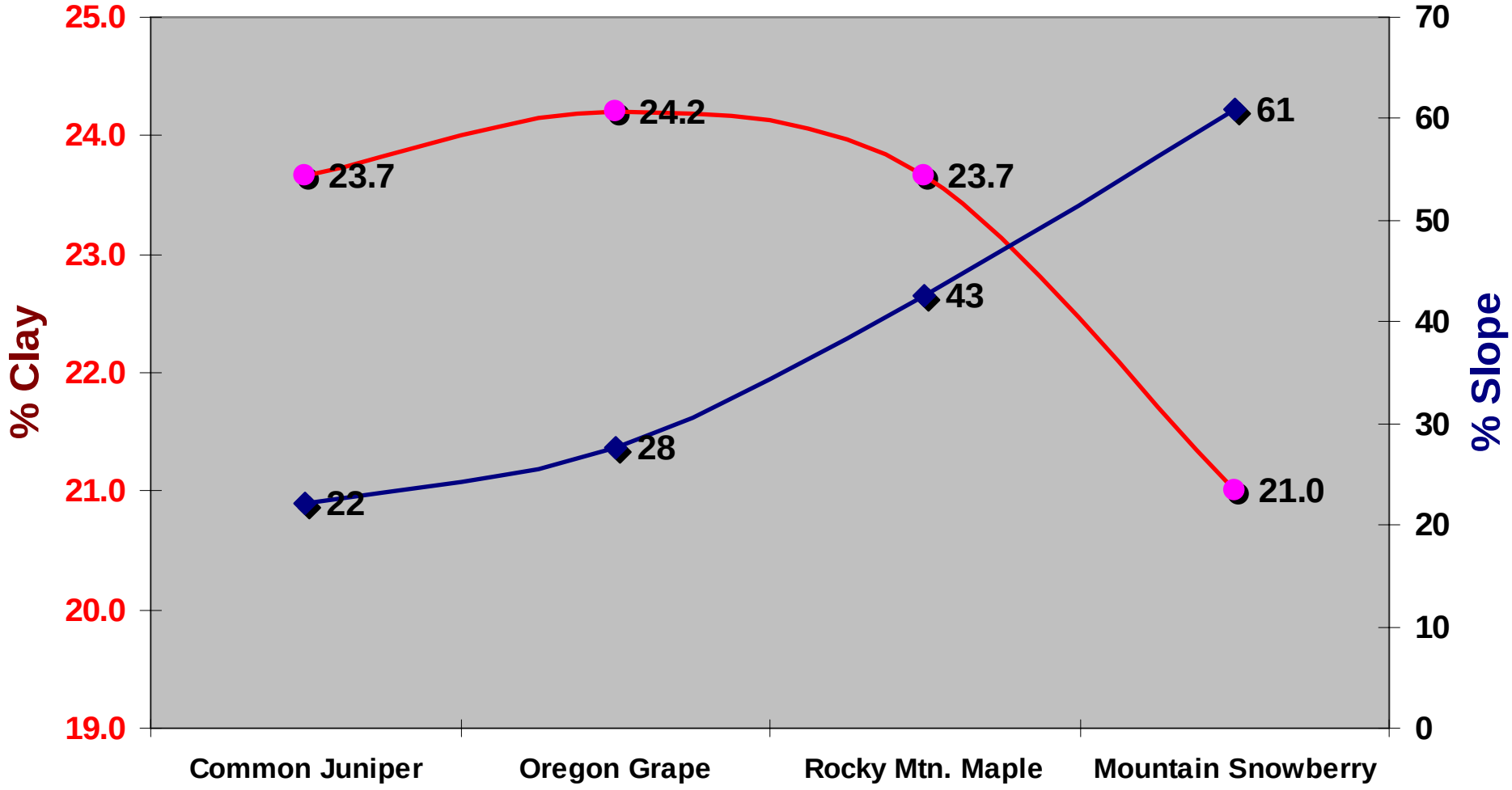



Slope Relationships in Douglas Fir Understory
Slope (mean %)
70
60
50
40
30
20
10
0
22
28
43
61
Common Juniper
Oregon Grape
Rocky Mtn. Maple
Mountain Snowberry

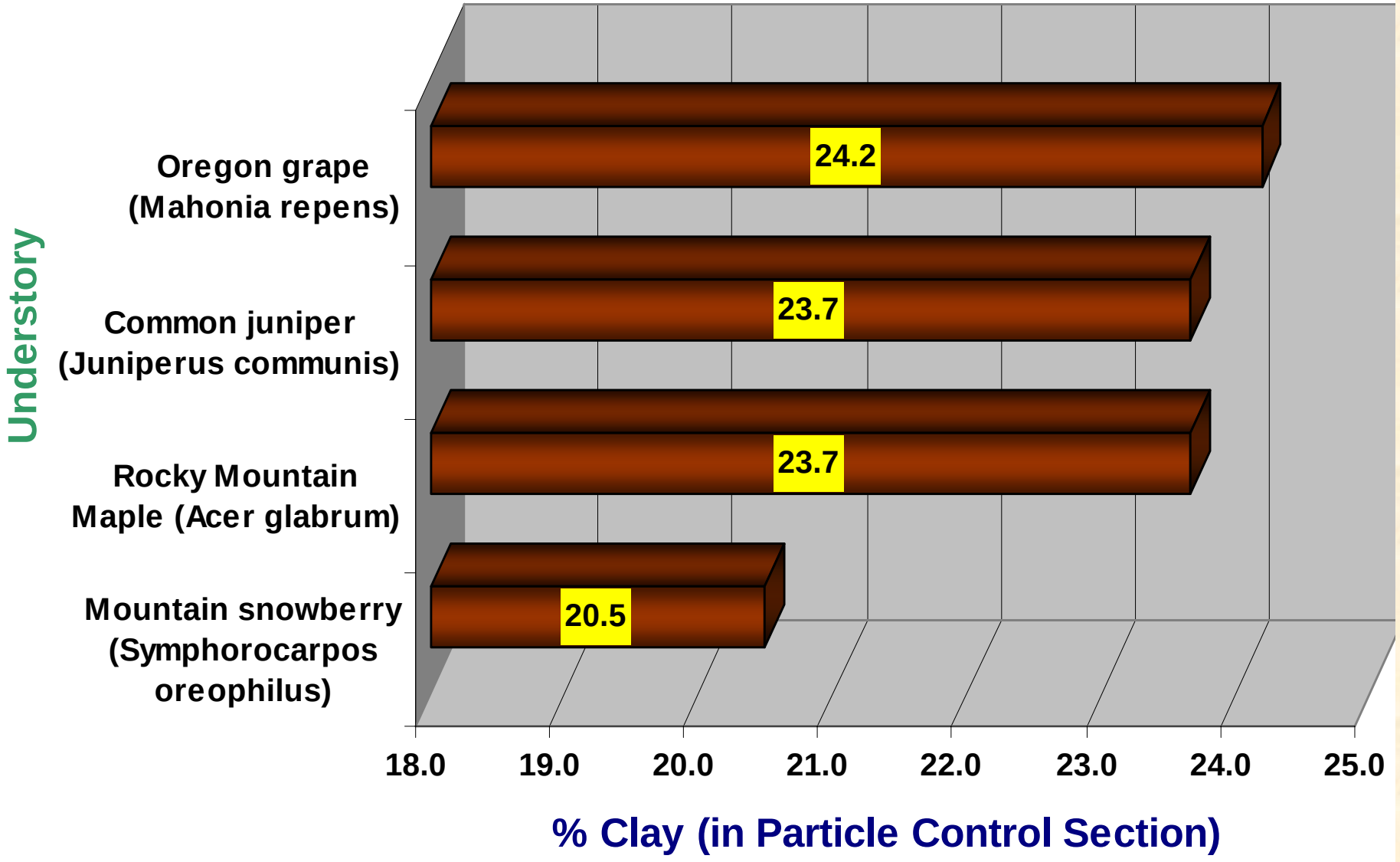
Elevational and Slope Relationships in Douglas Fir Understory



Clay and Slope Relationships by Douglas Fir Understory



Percent Clay by Douglas Fir Understory Community



Douglas Fir- Oregon Grape Clay Films

Douglas Fir – Mountain Snowberry

- Steep slopes (>55%)
- Sparse understory
- Inceptisols and weak alfisols (Inceptic Haplocryalfs)

Douglas Fir- Mountain Maple

- Rich understory
- Slopes 25 to 55%
- More clay-rich soil

Examining Variability Between Habitat Types

I. Similarities and differences between Douglas Fir and Sage communities

II. Relative importance of the soil forming factors

Gros Ventre Shale Slope with Gallatin and Bighorn Outcrops Above

Douglas Fir[1] and Sagebrush[2] Similarities

I. Mean elevation = 8346 / 8251 ft. = 95 ft of elevation difference in a range with 8000 ft. of relief

II. Mean pedon depth = 110 / 107 cm = 3 cm of difference in the soil depth sampled

III. Rock fragment percentage in particle control section = 54 / 50 % = 4 %

IV. Weighted average pH = 7.6 / 7.9 = 0.3

V. Solum parent material = calcareous colluvium (19 of 19) / (21 of 28)

Douglas Fir[1] and Sagebrush[2] Differences

I. Mean slope = 38 % / 23 %

II. Mean soil temperature = 7.7 C / 8.6 C

III. Clay percentage (family particle) = 23.0 % / 19.6 %

IV. Epipedon = Ochric (14 of 19) / Mollic (24 of 28)

V. Subsurface diagnostic properties= Argillic (14 of 19) / Calcic (19 of 28)

VI. Bedrock = Gallatin Limestone (11 of 19) / Gros Ventre Shale (18 of 28)

Explanations for Variability

I. Climate - cooler soil temperatures and higher moisture retention in Douglas Fir stands

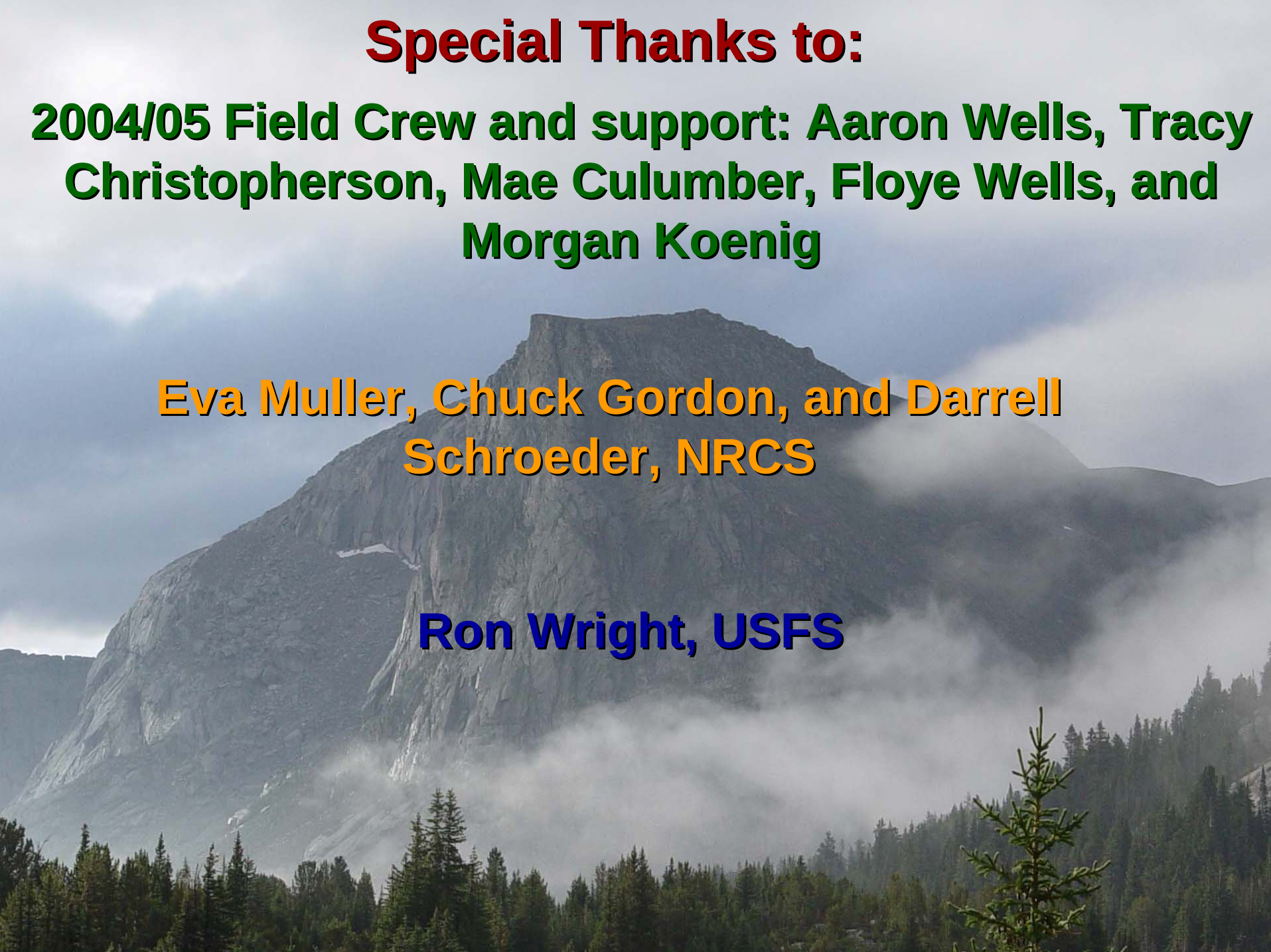
II. Organisms - Douglas fir has closed canopy, leading to cooler, moister soils

III. Relief- much steeper slope on average for Douglas Fir stands causes variability of soil properties within this habitat type

Explanations for Variability

IV. Parent Material - bedrock control of Gallatin Limestone (Douglas Fir) versus Gros Ventre Shale (Sagebrush)

V. Time - Older growth Douglas fir has longer time than to leave imprint on the soil than sagebrush



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Ron Wright, USFS

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