Soil Quality Information Sheet

Pastureland Soil Quality—Introduction

USDA Natural Resources Conservation Service **July 2003**

What is pastureland?

Pastureland supports introduced or domestic native forage species and is used primarily for livestock production. It receives periodic renovation and/or cultural treatments, such as tillage, applications of fertilizer, mowing, and weed control. Permanent pastureland is in areas where the present operator has no desire to change the land use or rotate crops in the field. Some areas of pastureland are irrigated. Some may have trees growing on them as part of a secondary, silvicultural enterprise. Others are open savannas or partially cleared forests where introduced forage species have naturalized and supplanted all, or nearly all, of the native herbaceous plants.

What is pastureland condition?

Pastureland condition is the status of the plant community and the soil in a pasture in relation to its highest possible condition under "ideal" management. The land user selects and establishes the desired plant community unless a preexisting one is acceptable or can be developed from the existing site. The desired plant community should be selected on the basis of the adaptability to the existing soils and climate at the site. Livestock production goals and livestock forage preferences should also be considered.

Where "ideal" pastureland management is applied, grazing pressure and agronomic inputs are managed in a manner that keeps the desired plant community reasonably stable at the species proportions desired for the livestock type and class. Over time, permanent pastures tend to naturalize. Other unintended plants invade and become part of the plant community. Some of these are acceptable forage species; others are not. Shifts in plant species composition, if allowed to proceed without intervention, usually result in a plant community that does not meet the goals of the land user. This plant community often produces lower quality forage than the established pasture plant community, sometimes yields less forage, and may not respond as well to agronomic inputs.

What is soil?

Soil is a dynamic resource that supports plants. It consists of mineral particles of different sizes (sand, silt, and clay), organic matter, air, water, and numerous species of living organisms. Soil has biological, chemical, and physical properties, some of which change in response to how the soil is managed.

What is soil quality?

Soil quality is the capacity of a specific kind of soil to function within natural or managed ecosystem boundaries, sustain plant and animal productivity, maintain or enhance the quality of water and air, and support human health and habitation. Soil quality reflects changes in the capacity of soil to function in response to management within a particular environmental setting.

What does soil quality affect on pastureland?

- Plant production, reproduction, and mortality
- Erosion
- Vegetation composition
- Water availability and water quality
- Wildlife habitat
- Carbon sequestration
- Livestock health and production

How are soil quality and pastureland condition related?

Pastureland condition and soil quality are interdependent. Pastureland condition is characterized by the functioning of both the soil and the plant communities. The capacity of the soil to function affects ecological processes, including the capture, storage, and redistribution of water; the growth of plants; and the cycling of plant nutrients. For example, increased surface compaction caused by excessive or untimely livestock traffic decreases the infiltration capacity of the soil and thus the amount of water available to plants. As the

availability of water decreases, plant production declines. Some plant species may disappear, and less desirable species may increase in abundance. Where livestock traffic is very heavy and prolonged, bare areas become evident. In contrast, vigorous, rapidly growing plants increase the inputs of organic matter into the soil and thus improve water infiltration and the subsequent availability of water to plants, and they reduce the potential for erosion by providing a vegetative cover, which reduces the impact of raindrops and minimizes subsequent soil movement. Changes in vegetation may precede or follow changes in soil properties and processes. Significant shifts in vegetation generally are associated with changes in soil properties and processes and/or the redistribution of soil resources across the landscape. In some cases, such as accelerated erosion resulting in a change in the soil profile, this shift may be irreversible. In others, recovery is possible with changes in grazing management.

Why is soil quality important?

Changes in soil quality that occur as a result of agronomic and grazing management affect:

- the amount of water from rainfall and snowmelt that is available for plant growth;
- surface runoff and the potential for erosion;
- the availability of nutrients for plant growth;
- seed germination, seedling establishment, vegetative reproduction, root growth, forage production; and
- the ability of the soil to filter and protect water and air.

How are soil quality indicators integrated into pastureland assessments and monitoring?

Changes in pasture condition are evaluated on the basis of soil and vegetation indicators. Evaluations made through assessment and monitoring provide information about the functional status of soil and pastureland. Soil quality indicators are properties that change in response to management, climate, or both and reflect the current functional status. Functions include maintaining soil and site stability; distributing, storing, and supplying water and plant nutrients; and maintaining a healthy plant community.

How are soil quality indicators used on pastureland?

Assessment.—Soil quality indicators are used to increase the value and accuracy of pastureland assessments and trends. Assessments help to identify pastured areas where problems occur and areas of special interest. Land managers can use this information and other inventory and monitoring data to make management decisions, which, in turn, affect soil quality. When assessments or comparisons are made, the desired plant community is the standard. For the soils associated with a given forage suitability group, the properties that change in response to management or climate are used as indicators.

Monitoring.—Tracking trends in the functional status of the soil and the plant community helps to determine the success of the management practices or the need for additional management changes or adjustments. Regular measurement of soil quality at the same location can detect changes over seasons or years and provide early warning of future problems.

How do I get more information?

For additional information, refer to pastureland soil quality information sheet 2, “Indicators for Assessment and Monitoring."

Pasture condition indicators.—Descriptions of the following qualitative assessment indicators are available in the “Guide to Pasture Condition Scoring” and the “Pasture Condition Score Sheet” at http://www.glti.nrcs.usda.gov.

Percent desirable plants	Plant cover
Plant residue	Plant diversity
Plant vigor	Livestock concentration areas
Uniformity of use	Erosion
Percent legume	Soil compaction

Soil quality and rangeland soil quality information sheets.—The following fact sheets include information about additional soil quality indicators that can be used on pastureland. Download the sheets from http://soils.usda.gov/sqi.

Aggregate stability	Compaction
Infiltration	Organic matter
Physical and biological crusts	Soil biota
Soil pH	Salinization
Water erosion	Wind erosion

Other fact sheets are also available.

(Prepared by the Soil Quality Institute, Grazing Lands Technology Institute, National Soil Survey Center, Natural Resources Conservation Service, USDA and Agricultural Research Service, USDA)

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Indicators for Assessment and Monitoring

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What are indicators?

Indicators are key soil or plant community characteristics that are measurable and are sensitive to change in management practices or the environment. Trends in condition can be interpreted from regularly measured indicators that provide clues about the response of the system to management. Environmental factors, such as time since the last rainfall, can affect some indicators and should be considered when the effects of management are interpreted.

What indicators are used on pastureland?

Soil properties.—Physical, biological, and chemical soil properties are included. Some physical properties, such as bulk density and soil strength, reflect limitations to root growth, seedling emergence, and water infiltration. Chemical properties, including plant nutrients, organic matter, cation-exchange capacity, base saturation, and pH, directly affect plant production and the ability of the plants to provide soil cover. Soil organisms, such as earthworms, are also soil properties. Some of these are beneficial organisms, but some are harmful, including insect larvae and nematodes that can reduce or destroy forage stands or infect livestock. Organic matter in the soil and the aggregate stability of the soil reflect a combination of physical, biological, and chemical processes.

Soil surface features. —Pedestals, exposed plant roots, rills, gullies, wind scours, terracettes, penetration resistance, stoniness, and soil or plant residue movement and deposition (debris dams or windrows after major storms) reflect such processes as runoff and erosion. These indicators are commonly assessed qualitatively.

Vegetative features.—Such features as plant cover, desirable species, plant residue, plant vigor, and species diversity are indicators that reflect the makeup and vegetation cycling of the current plant community.

Management factors.—Visibly evident features, such as uniformity of plant removal, excessive use areas, adaptation of the pastureland species, plant stress resulting from insects or disease, and currently modified soil fertility and pH, help to determine the effects of management on the site. Often, these are the primary causes for changes in soil quality.

Environmental conditions.—The level of physiological stress exhibited by the plants results partly from the weather and other environmental conditions of the site at the time of the assessment.

Spatial patterns and variability.— Landscape position, erosion, and deposition affect the distribution and cycling of water and nutrients in pastured soils. Nutrient distribution is affected by the kinds, amounts, and spatial distribution of living plants and decaying residue on the soil. As the distribution of soil organic matter and animal waste becomes less uniform because of poor grazing or traffic distribution, resource availability decreases in some patches and increases in others.

Table 1.—Pasture condition indicators.
From "Guide to Pasture Condition Scoring" and the "National Range & Pasture Handbook," available at www.glti.nrcs.usda.gov. Additional soil quality indicators are described in Soil Quality Information Sheets, available at http://soils.usda.gov/sqi.

Indicators	Areas of concern			
	Soil, site stability	Site hydrology	Plant community productivity	Livestock (or wildlife) performance
Percent desirable plants	I	I	D	D
Plant cover	D	D	D	I
Plant diversity	I	I	D	I-D
Plant residue	D	D	D	D
Plant vigor	I	I	D	D
Percent legume	I	I	D	I-D
Uniformity of use	I	I	D	D
Livestock concentration areas	D	D	D	I-D
Soil compaction	D	D	I-D	I
Erosion	D	D	I-D	I
Soil fertility	I	I	D	I-D
Soil pH (reaction)	I	I	D	I
Severity of use	D	D	D	D
Site adaptation of desired forage species	D	D	D	D
Climatic stresses	I	I	D	D
Disease and insect pressure	I	I	D	I-D
Salinity and/or sodicity	I	I-D	D	I-D

D–direct impact; I–indirect impact; I-D–direct and indirect impact.

Assessment

A pasture assessment estimates or measures the functional status or condition of pastureland. The assessment must start with a consideration of the land user's desired plant community, production goals, and environmental goals. The appropriate Natural Resources Conservation Service (NRCS) forage suitability group report can help the land user to formulate a pasture plant community and production goal that will be the standard at the site. Information from this report should be supplemented, whenever possible, with updated information from local university extension forage references.

The timing of assessments depends on seasonal cycles. Some soil properties are highly variable on a daily, seasonal, or yearly basis in response to changes in both temperature and moisture. For example, the total amount of organic matter in a soil is relatively insensitive to seasonal changes. In contrast, soil compaction, which is detected by penetration-resistance tools, varies with soil moisture and temperature, which depend on recent weather conditions. In this case, there should always be a reference site, such as one along a fence line, that is free of livestock traffic to use as a comparison with in-pasture compaction measurements.

The optimum time and location for making assessments depend on the objectives. Potential objectives include:

- selection of sites for monitoring (e.g., riparian zones, heavily used areas, and areas with noxious weeds),
- gathering of inventory data used in making decisions (e.g., soil test samples and reports),
- identification of areas at risk of degradation (e.g., streambanks, shorelines, and access lanes), and
- targeting of management inputs (e.g., stocking procedures, fertilizer, water developments, and overseeding).

Careful site selection helps to ensure that the assessment sites are truly representative of the pasture. A pasture that lies on a varied landscape is best evaluated by sampling each representative landscape position and soil or by sampling only those landscape positions where obvious problems are noted. The sampling sites should be on the same soil and in the same landscape position as the area of interest. Offsite features, such as crop fields, woodlots, hedgerows, farmsteads, roads, and other areas of recent or past disturbances, can have significant impacts and should be noted. The management history of the site can aid in interpretation. For instance, the pasture stand is sparse in a recently converted row-crop area.

Monitoring

Monitoring identifies changes in the resource through the orderly collection, analysis, and interpretation of quantitative data. It must be conducted over time at permanently marked locations and include baseline data if it is to ascertain the trend of the change in the functional status of the pasture. Monitoring is often designed so that different observers can make measurements consistently. Baseline data or standards may be used to establish management goals and aid in interpretation of the monitoring results.

Site selection for monitoring depends primarily on the objectives, which include:

- evaluation and documentation of the progress toward management goals,
- detection of changes that may be an early warning of future problems or risks, and
- determination of the trend in pastureland condition (maintaining, declining, or recovering).

If the objective is to determine progress or trend, the sites that are representative of the pasture unit should be selected. If the objective is to provide an opportunity to modify management before problems occur, the sites that are most vulnerable should be selected. The detected changes must be real and must occur at a level of detection that allows land managers to recognize the problem and correct it before undesired and perhaps costly loss of soil quality occurs. Most degraded soil quality conditions can be reversed or even improved over the previous native site condition. For some conditions, such as content of organic matter, however, it may take several years or decades before the optimal level (at equilibrium) for the specific site can be restored. The monitoring plan should include the proper measurement frequency, which either limits or captures soil quality changes with time, as dictated by the specific objective, such as the need to adjust soil pH by applying lime.

For more detail about assessment and monitoring, see "Guidelines for Soil Quality Assessment in Conservation Planning" available at http://soils.usda.gov/sqi.

(Prepared by the Soil Quality Institute, Grazing Lands Technology Institute, National Soil Survey Center, Natural Resources Conservation Service, USDA; Agricultural Research Service, USDA)