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U.S. DEPARTMENT OF AGRICULTURE

Range and Pasture
Technical Note No. 190-RP-4
Determining Indicators of Pasture Health

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Introduction

Pasturelands are an important land use in all US states and territories. Non-federal pastureland comprises about 6%, or 121 million acres in the contiguous 48 US states (USDA Natural Resources Conservation Service, 2018). Pasturelands provide many benefits such as forage for livestock, wildlife food and habitat, watersheds, and recycling carbon.

What specifically are pasturelands? There are several definitions for pasture but in essence, all definitions agree that pasture is a land use type having vegetation cover comprised primarily of introduced or domesticated native forage species and is primarily used for livestock grazing (Forage and Grazing Terminology Committee, 1991; SRM, 1999; USDA NRCS, 2023). Pastures may receive periodic renovation and cultural treatments such as fertilization, weed control, reseeding, tillage and mowing, and may also be irrigated (SRM, 1999; Holechek, et al., 2010; USDA NRCS, 2023). Pasture vegetation can consist of single species or mixtures of grasses, legumes, other forbs, shrubs (USDA NRCS, 2023). Many of the common pasture forage species are now naturalized and are vital components of pasture-based grazing systems (USDA NRCS, 2022).

Pastureland has a close connection to cropland as many pastures were once cultivated and subsequently converted to pasture plant species for a variety of reasons e.g., slope restraints, erosion history, low or reduced crop productivity, economics of cropping, and need for livestock forage. Cropland and pastureland soils originally were prairie grasslands, rangeland, or forested lands and are now recognizably different in their converted state. Expectations about their functionality, especially in manipulated agricultural settings and response to management must be uniquely considered (Brown & Herrick, 2016; Spaeth, 2022). Converted or altered states that represent many of these pasturelands are now depicted in ecological site descriptions and State and Transition Models.

Pastureland Assessment

Field assessments on range and pastureland are integral steps in USDA-NRCS conservation planning and in National Resource Inventory (NRI) Field Studies (USDA NRCS, 2022). Land assessments for both range and pastureland continue to evolve and are important tools to translate land condition, health, and the functionality of ecological processes.

The premise associated with Interpreting Indicators of Rangeland Health (IIRH)and Determining Indicators of Pasture Health (DIPH) is that many unique site-specific effects and environmental relationships exist in grazing land ecosystems, and these methodologies provide a means of detecting changes in ecological attributes relative to a site's ecological potential. Toledo et. al. (2016) compared the concepts of Pasture Condition Scoring (PCS) and IIRH and stated that there is a “need for an improved grazing land assessment tool that merges the relevant elements of both rangeland and pastureland assessment methods, while taking into account

the differing ecosystem attributes and management objectives of the grazing lands where these methods are usually applied." Having a similar standardized grazing land assessment protocols based on ecological and land management principles would also ultimately improve national-level assessments (NRI) and would provide a valuable and efficient tool for assessing and managing grazing lands.

In 2001, the USDA-NRCS Grazinglands Technology Institute developed Pasture Condition Scoring (PCS) (USDA NRCS, 2001) for the purposes of 1) providing "a framework for planning and assessing management at a site" (Toledo, et al., 2016); 2) evaluating current plant productivity and the stability of soil, and water resources on pastureland; and 3) assisting in identifying future conservation treatment needs required to maintain or improve pasture conditions (Cosgrove, et al., 2001).

Two pastureland assessment tools were developed to reduce inconsistencies and bias of indicators associated with the 2001 PCS. These two assessment tools are available from NRCS and provide a "quick assessment" of current conditions and management. Both tools are qualitative but can also be semi-quantitative, meaning that there are some quantitative indicators that can be taken to support and supplement the assessments.

(1) Revised **Pasture Condition Scoring Tool** (USDA NRCS, 2020) provides the visual evaluation of 10 indicators, which rate pasture vegetation and soils. The revisions included incorporating quantitative measures which reduce rating subjectivity (Herrick, et al., 2005). Each indicator or factor has five possible ratings, ranging from lowest (poorest) condition (1) to highest (best) condition (5). The indicators are tallied into an overall score (50) for the pasture unit or utilized as individual scores and compared with the other nine indicators. Indicators receiving the lowest scores can be targeted for corrective action.

(2) **Determining Indicators of Pasture Health (DIPH)** is a detailed assessment tool and includes a matrix of indicators that can be used to determine the preponderance of evidence for four separate pastureland ecosystem attributes: biotic integrity, soil/site stability, hydrologic function, and livestock management quality factor. DIPH is a similar methodology to IIRH V5 (Pellant, et al., 2020), but has additional indicators that are only relevant to pastureland systems (Table 1).

Determining Indicators of Pasture Health

Determining Indicators of Pasture Health (DIPH) includes a matrix of 22 indicators that can be used to determine the health rating for four separate pastureland ecosystem attributes: biotic integrity, soil/site stability, hydrologic function, and livestock management quality factor. The 22 indicators are used to rate the attributes based on the preponderance of evidence approach. The biotic integrity, soil/site stability, and hydrologic function are evaluated in both IIRH and DIPH, which standardizes indicators across grazing lands, and provides information about how well ecological processes – such as the water cycle, energy flow, and nutrient cycling – are

functioning at a site regardless of grazing land type. The three ecosystem attributes (soil and site stability, hydrologic function, and biotic integrity) are determined from specific indicators (some indicators are used in the assessment of one or more of the three attributes) (Table 2).

Attribute definitions:

(1) Soil/Site Stability (SSS)—The capacity of an area to limit redistribution and loss of soil resources (including nutrients and organic matter) by wind and water (Pellant, et al., 2020).

(2) Hydrologic Function (HF)—The capacity of an area to capture, store, and safely release water from rainfall, run-on, and snowmelt (where relevant), to resist a reduction in this capacity, and to recover this capacity when a reduction does occur (Pellant, et al., 2020).

(3) Biotic Integrity (BI)—The capacity of the biotic community to support ecological processes within the normal range of variability expected for the site, to resist a loss in the capacity to support these processes, and to recover this capacity when losses do occur. The biotic community includes plants, animals, and microorganisms occurring both above and below ground (Pellant, et al., 2020).

(4) Livestock Management Quality Factor (LMQF) — The capacity of an area to support a sustainable livestock grazing operation. This attribute incorporates elements of grazing management and the suitability of the current plant community for livestock production (Toledo, et al., 2016).

Various soil and plant variables may be different across the continuum of pasturelands in the U.S. Some pasture environments can sustain high species diversity and many different adapted forage species (including legumes) and soil biota such as earthworms, etc., while some pasture systems are limited by various environmental constraints. For example, a wide variety of cool season grasses and legumes may be grown and maintained successfully in humid cold temperate climates in New England, whereas a semiarid subtropical climate in Louisiana may only support a maximum diversity of two warm season pasture grasses (Bermuda grass and Bahia grass), with no inherent introduced long-term sustainability of legumes (which act as annuals). Therefore, rating these indicators should be evaluated with the ecological constraints associated with the ecological site.

The Natural Resources Conservation Service (NRCS) classifies rangelands and forestlands into ecological sites for scientific study, evaluation, monitoring, planning activities, and management. Other land uses such as pastureland, cropland, and agroforestry are being incorporated into the state-and-transition model framework as converted or altered states for improved conservation planning (Figure 1). Ecological sites can provide a reference for understanding soil capabilities and a guide for planning and achieving a realistic approach to soil health. NRCS is actively involved in developing ecological site descriptions in coordination with other USDA agencies and the Department of Interior, Universities, and other partners (USDA NRCS, 2022).

Ecological site descriptions can provide valuable information about environmental parameters and reference conditions for specific indicators related to adaptability of certain forage species, legumes, invasive plants, as well as hydrology and erosion properties such as drainage, flooding, water flow paths, and propensity for rills, gullies, and erosion. The DIPH methodology is centric to the dynamics of the ecological site (ES) but can be used as a “stand-alone tool” similar to Describing Indicators of Rangeland Health (Lepak, et al., 2024).

Ecological site descriptions may contain one or several interconnected State and Transition Models (STM) depending on land use (range, forest, pasture, crop, agro-forestry) (Briske, et al., 2005; Karl & Herrick, 2010; Bestelmeyer, et al., 2017) . Figure 2 is an example of an STM which incorporates various land uses. In this example, a forest state (1) may be converted into cropland (2), pasture (3), or tree farm (4) states. Ecological site descriptions can be valuable documents that provide reference information related to climate-soils-plants-hydrology-management interactions. DIPH is a stand-alone tool when ecological site information is not available.

Table 1. Comparison of Interpreting Indicators of Rangeland Health and Determining Indicators of Pasture Health indicators. SSS=Soil and Site Stability, HF=Hydrologic Function, BI=Biotic Integrity, LMQF=Livestock Management Quality Factor.

Interpreting Indicators of Rangeland Health V 5	Assessment	Interpreting Indicators of Pastureland Health	Assessment
1. Rills	SSS, HF	1. Erosion (sheet and rill)	SSS, HF
2. Gullies	SSS, HF	2. Erosion (gullies)	SSS, HF
3. Water-flow Patterns	SSS, HF	5. Water-flow Patterns	SSS, HF
4. Pedestals and terracettes	SSS, HF	7. Pedestals and terracettes	
5. Bare ground	SSS, HF	6. Bare ground %	SSS, HF
6. Wind-scoured, or deposition areas	SSS	3. Wind-scoured, or deposition areas	SSS
		4. Erosion (shoreline) if present	SSS, HF
7. Litter movement (wind or water)	SSS	8. Litter movement (wind or water)	SSS, HF
8. Soil surface resistance to erosion	SSS, HF, BI		SSS, HF
		12. Live plant foliar cover (hydrologic and erosion benefits	SSS, HF
9. Soil surface loss and degradation	SSS, HF, BI	10. Soil surface loss or degradation	SSS, HF, BI
10. Effects of plant community composition and distribution on infiltration and runoff	HF	9. Effects of plant community composition and distribution on infiltration and runoff	HF
11. Compaction layer	SSS, HF, BI	11. Compaction layer	SSS, HF, BI
12. Functional/structural groups	BI		
		13. Forage plant diversity	BI, LMQF
		14. Percent desirable forage plants (for identified livestock class)	LMQF
13. Dead or dying plants or plant parts	BI	18. Dead or dying plants or plant parts	BI
14. Litter cover and depth	HF, BI	19. Litter cover and depth	HF, BI
15. Annual production	BI	16. Potential production	BI, LMQF
16. Invasive plants	BI	15. Invasive plants	BI
17. Vigor with an emphasis on reproductive capability of perennial plants	BI	17. Plant vigor with an emphasis on reproductive capability of perennial plants	BI
		20. Percent non-toxic legumes (based on adaptability with Ecol. Site or what is expected stand and longevity for the site.	BI, LMQF
		21. Uniformity of use	HF, BI, LMQF
		22. Grazing and utilization	BI, SSS, HF, LMQF

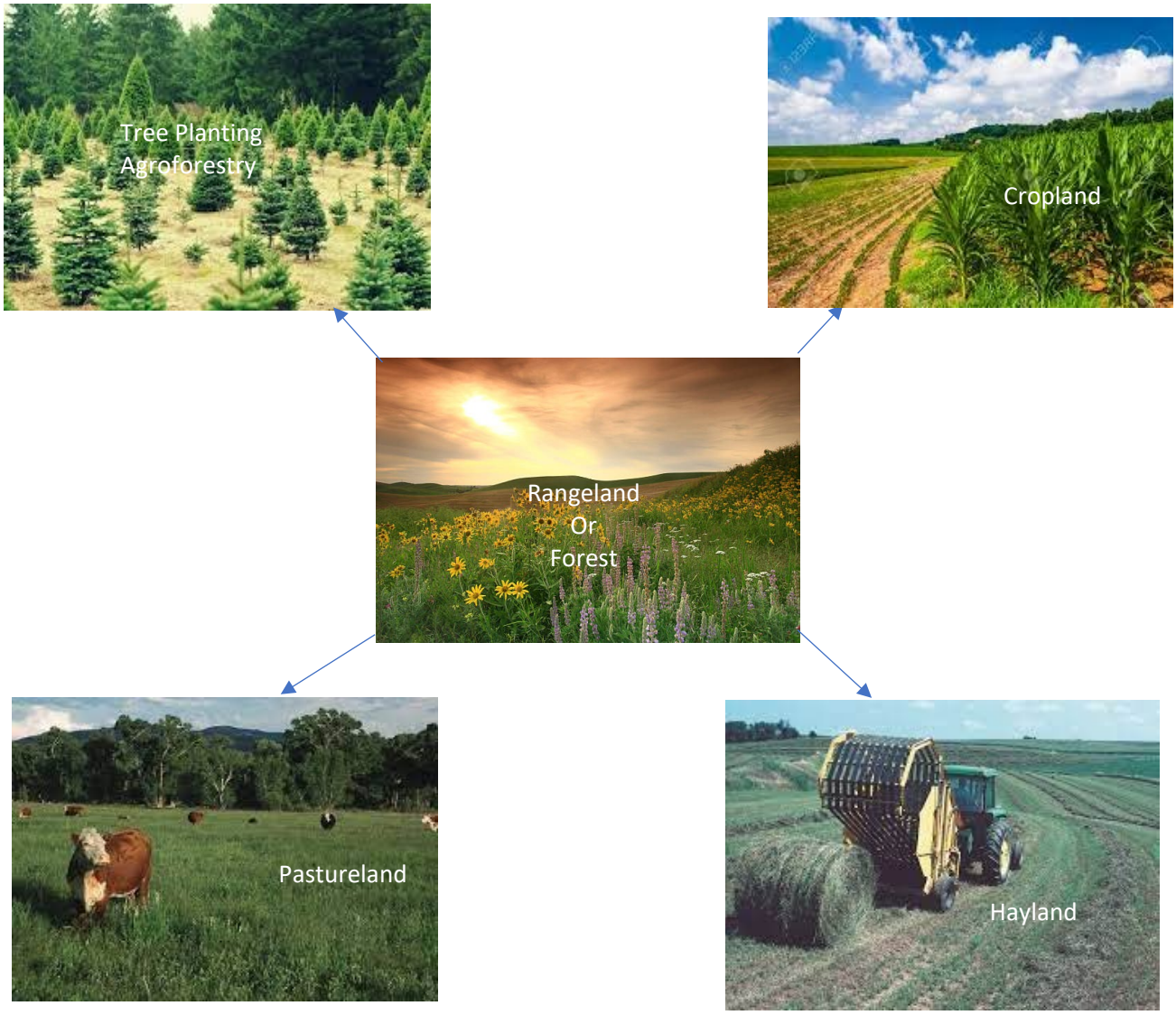

Figure 1 Concept example of a rangeland state and transition model identifying several alternative or converted land uses (altered states) within an Ecological Site.

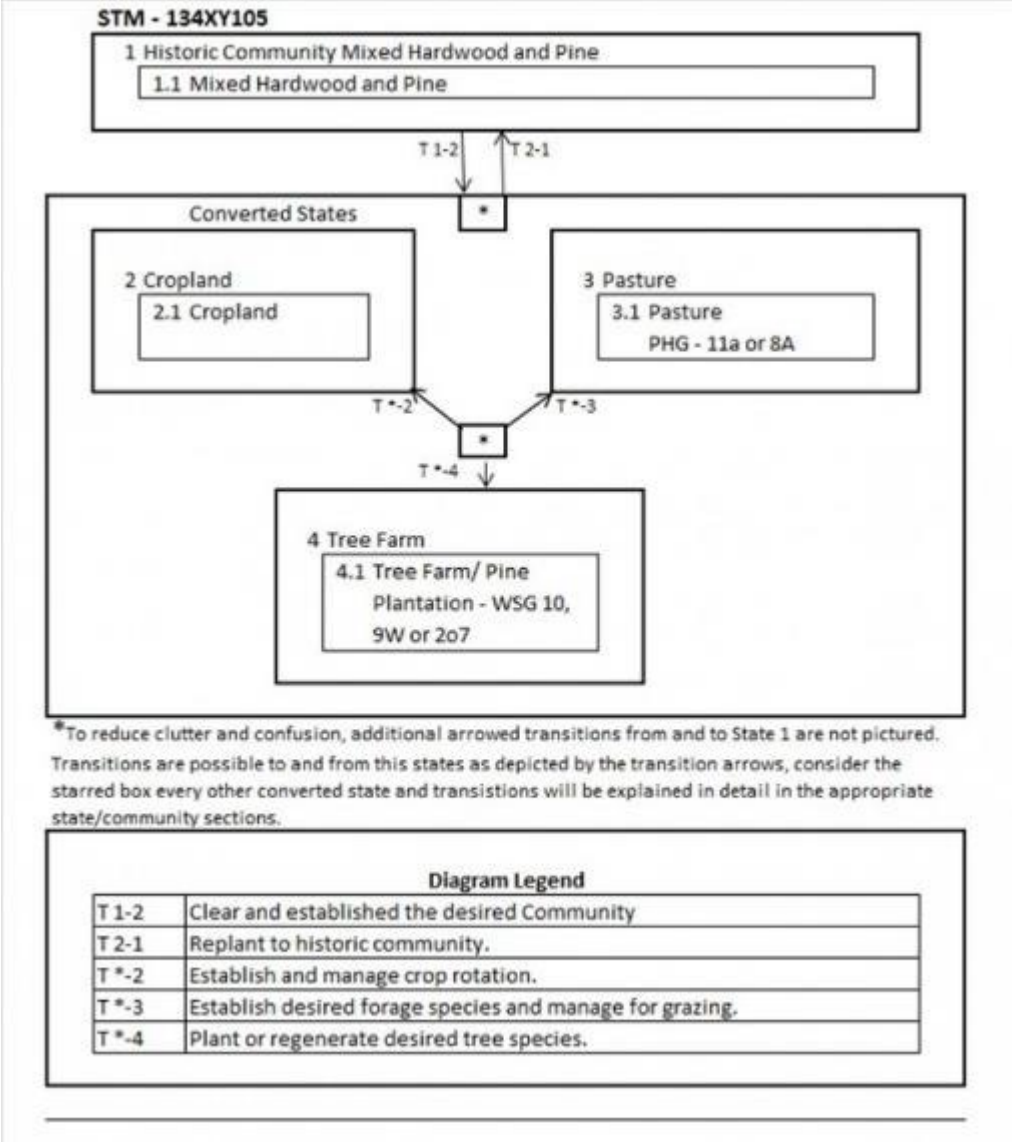

Figure 2 State & Transition model for F134XY105MS Southern Rolling Plains Loess Fragipan Upland, Community 3.1 Pasture or Grassland: This phase is characterized by a monoculture of or mixture of Forage species planted or allowed to establish from naturalized species, managed for forage production or as herbaceous ground cover. This Site fits into multiple Pasture Suitability Groups: 11a in MS or 8A in LA. • 11a - Upland, moderately deep, medium textured soils, Moderately well and somewhat poorly drained • 8 - Upland, deep, medium-textured soil • A – soils having few limitations for the growth of the commonly grown plants except for slope. From these bullet descriptions of the Groups this site would generally be described as a Moderately Deep to Deep, Moderately Well to somewhat poorly drained, Medium textured soils on Uplands. It has limiting factors including a possibility of a root limiting layer. All soils need nitrogen fertilization for production when grasses are grown alone. It is not practical to apply high rates of fertilizer due to the wetness limitation potential of the site. To prevent extreme acidity in the subsoil when high rates of acidifying nitrogen is used, the surface soil should not be allowed to become more acid than 5.0 pH and lime should be applied at more frequent intervals.

Determining Indicators of Pasture Health in the Field

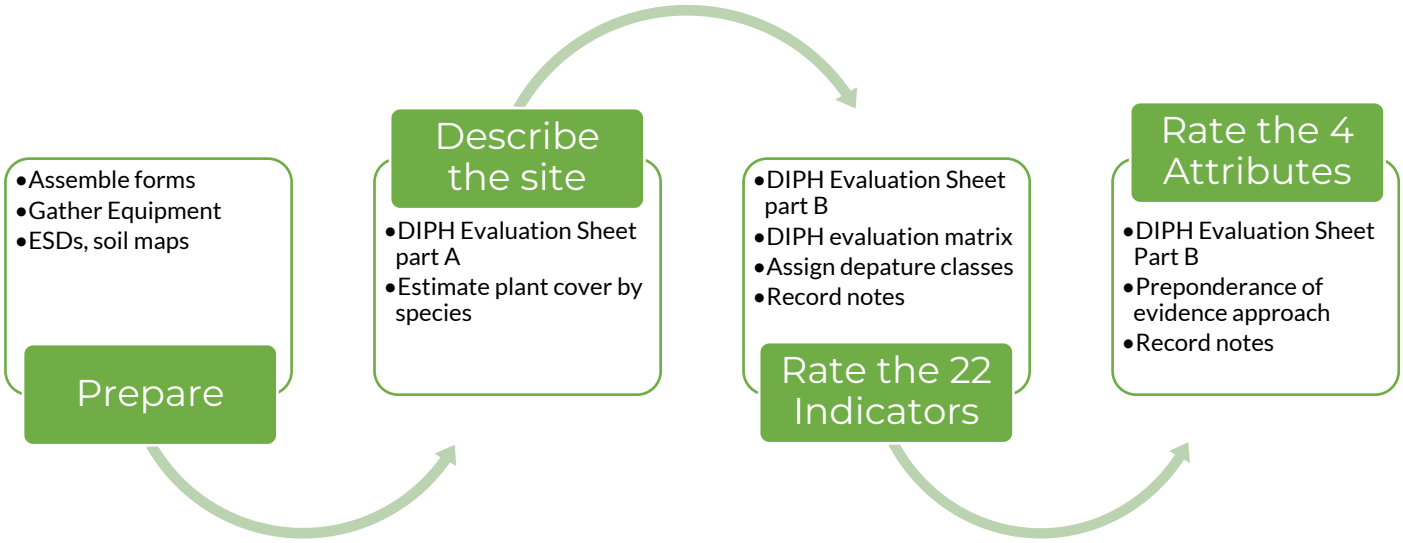

Figure 3 Flow chart showing steps to completing a DIPH assessment in the field.

Prepare

Having the proper knowledge and training before conducting assessments using DIPH is highly advisable.

To begin the DIPH protocol, assemble field forms as shown in Table 2, Table 3, and Table 4, then follow the steps below.

Determining Indicators of Pasture Health Evaluation Sheet Part A (appendix) is used to collect basic information about the site.

Table 24 Evaluation matrix used to rate the 22 indicators and five departure categories of pasture health.

Determining Indicators of Pasture Health Evaluation Sheet Part B, page 1 of 2 (appendix) is used to record notes about the individual DIPH indicators.

Determining Indicators of Pasture Health Evaluation Sheet Part B, page 2 of 2 (appendix) is used for determination of preponderance of evidence of the indicators.

Field Equipment Checklist

- ✓ DIPH Technical Reference
- ✓ DIPH evaluation matrix and data sheets
- ✓ LPI data sheet
- ✓ Measuring tape and pin
- ✓ Aerial imagery of site
- ✓ Shovel or soil borer
- ✓ Penetrometer
- ✓ Grazing stick or yard stick
- ✓ GPS
- ✓ Soil Web or printed soils description
- ✓ Ecological Site Description
- ✓ Grass clipping equipment
- ✓ Plant Identification Aids
- ✓ Maps, weather data, etc.

Step 1: Describe the site

Complete site evaluation sheet part A (appendix). Estimate plants based on ocular estimates (foliar cover classes) or conduct a line point sample--50-100 points; (Pellant, et al., 2020; USDA NRCS, 2022).

Step 2: Rate the 22 indicators

DIPH is conducted in the field, and each indicator is evaluated based on the scale in the matrix. This table includes five generic descriptors for each indicator, which reflect the range of departure from expected conditions for the site: none to slight, slight to moderate, moderate, moderate to extreme, and extreme to total. Since many ecological sites have not developed pasture state narratives to establish reference conditions for pasture stands, the DIPH evaluation matrix is used with generic descriptors.

Step 3: Rate the 4 attributes

The 22 indicators are rated individually to determine the attribute ratings and recorded on the Determining Indicators of Pasture Health Evaluation Sheet Part B (appendix). Make notes to support attribute ratings. See section on Interpreting the Indicator Ratings – the 4 Attributes.

Indicators of Pasture Health

1. Erosion (sheet and rill)

Photo 5 Rill erosion on a hillslope. Photo credit: Antonio Jordán, University of Seville, Sevilla, Spain

Soil loss caused by water drop impact, drip splash from water dropping off plant leaves and stems onto bare soil, and a thin sheet of runoff water flowing across the soil surface. Sheet and rill erosion increase as cover decreases. Evidence of sheet erosion appears as small debris dams of plant residue that build up at obstructions or span between obstructions. Some soil aggregates or worm castings may also be washed into the debris' dams (USDA NRCS, 2022; USDA NRCS, 2020).

Rills are associated with water erosion. Rills are small channels usually a few centimeters deep formed by runoff. Interrill erosion includes soil loss by raindrop splash and erosion from shallow overland flow (sheet). Rills are not always discernable in the long-term, but can appear in denuded pastures after heavy rainstorm events.

Observe and record: Consider number of rills, width, depth, length and where they occur: exposed areas or vegetated.

Relevance to DIPH: SSS-transport and movement of soil, soil redistribution and loss on-site; HF-rapid loss of water, reduced infiltration, and water storage on-site

Table 2 Generic descriptors of the five departure categories in the evaluation matrix for Erosion (sheet and rill)

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
1. Erosion (sheet and rill)	Numerous and frequent throughout. Nearly all rills are wide, deep and long. Occur in exposed and vegetated areas.	Moderate in number at frequent intervals. Many rills are wide, deep, and long. Occur in exposed areas and in some adjacent vegetated areas.	Moderate in number at infrequent intervals. Moderate rill width, depth, and length. Occur mostly in exposed areas, and steeper slopes.	Scarce and scattered. Minimal rill width, depth, and length. Occur in exposed areas, and steeper slopes.	Current or past formation of rills – none.

2. Erosion (gullies)

Gullies are deeper than rills and are erosion channels caused by concentrated overland flow, usually from runoff between two adjacent slopes (natural drainage) after rainstorm event. Gullies normally follow natural drainage channels but are not considered “streams”.

Difference between rills and a gully: rills are less than 1 ft (30 cm) wide and 2 ft (61 cm) deep, and gullies exceed these limits (Selby, 1993). It is important to rate an observed erosional feature as either a gully or a rill.

Because of the magnitude to which a single gully can affect an evaluation area, gullies are assessed by the observing the severity of erosion in individual gullies. The occurrence of deeper, wider, or more actively eroding gullies indicates accelerated soil erosion and water loss.

Observe and Record: Determine the numbers of gullies in an evaluation area (if there are more than one) and assessing the severity of erosion in individual gullies. Signs of active erosion (e.g., incised sides along a gully or headcuts) are indicative of a current erosional problem, while a healing gully is characterized by rounded banks, perennial vegetation growing in the bottom and on the sides (Anderson, 1974), and a reduction in gully depth (Martin & Morton, 1993).

Relevance to DIPH: SSS-soil loss erosion, landscape degradation; HF-accelerated runoff and transport of water offsite, and water table affects.

Table 3 Generic descriptors of the five departure categories in the evaluation matrix for Erosion (gullies)

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
2. Erosion (gullies)	Sporadic or no vegetation on gully banks and bottom. Numerous nick points. Significant active bank and bottom erosion, including downcutting. Substantial depth and width. Active headcuts may be present.	Intermittent vegetation on gully banks and bottom. Nick points common. Moderate active bank and bottom erosion, including downcutting. Significant width and depth. Active headcuts may be present.	Occasional vegetation on gully banks and bottom. Occasional nickpoints or slight downcutting. Moderate depth and width. Active headcuts absent.	Vegetation on most gully banks and bottom. Few nickpoints or minimal downcutting. Minimal gully depth and width. Headcuts absent.	None

Photo 6 Gully erosion progression from 2011 (left) to 2017 (right) in a Mississippi pasture. Photo credit: Google Earth

Photo 7 A large headcut at the beginning of a long gully in a pasture in Mississippi. Photo Credit: Shane Green, NRCS

3. Erosion, Wind-Scoured, or Depositional Areas

This indicator includes soil loss, movement, and deposition from wind erosion. It is highly correlated with major site deterioration and desertification. Windblown particles cause abrasion damage to plants and may leave exposed roots or buried plants. Changes in soil surface dynamics will result. An area of wind-scour has had surface soil "scoured" off by the wind.

Observe and record: Frequency, size and connectivity of scours and deposition areas.

Relevance to DIPH: SSS-soil erosion and deposition, change in soil surface dynamics, buried plants.

Table 4 Generic descriptors of the five departure categories in the evaluation matrix for Erosion, Wind-Scoured, or Depositional Areas

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
3. Erosion, Wind-Scoured or Depositional Areas	Extensive. Wind blowouts/scours usually connected. Large soil depositions around obstructions.	Common. Wind scours frequently connected. Moderate soil depositions around obstructions.	Occasionally present. Wind scours infrequently connected. Minor soil deposition around obstructions.	Infrequent and few. Wind scours rarely connected. Trace amounts of soil deposition around obstructions.	None or as expected in reference ESD

Photo 8 Wind erosion in a pasture in Hawaii. Photo credit: Carolyn Auweloa, NRCS, 2016

4. Erosion (streambank or shoreline)

Streambank erosion is a naturally occurring process, but the rate of degradation is often increased by human activities such as changes in land use, grazing or urbanization. Streambank erosion is caused by activities both at the watershed (large-scale) as well as at the stream or reach scale (small-scale). Streambank erosion occurs when the forces of water (hydraulic) and gravity (geologic) are greater than the ability of the streambanks to remain stable, resulting in failure. A hydraulic failure occurs when the flowing water from the stream directly hits the streambank, while a geologic failure occurs when an overhanging bank collapses or sloughs off due to gravity. At the stream reach scale, streambank erosion is increased largely by activities that impact riparian vegetation, soil stability, and channel sinuosity.

Extensive stream reaches should be assessed with the Stream Visual Assessment Protocol (USDA NRCS, 2009) or Proper Functioning Condition (USDI BLM, 2017) tools.

Observe and record: Bank sloughing, trampling, vertical cutbanks, and the proportion of vegetated: eroded banks.

Relevance to DIPH: SSS and HF

Photo 9 Streambank erosion in South Dakota. Photo credit NRCS South Dakota.

Table 5 Generic descriptors of the five departure categories in the evaluation matrix for Erosion (streambank and shoreline)

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
4. Erosion (streambank or shoreline)	Banks bare, major vertical down cutting, major sloughing, little or no bank vegetation. Hydrology of riparian system severely altered.	More than half the expected bank vegetation absent, veg. trampled, sloughing and vert. banks active erosion. Hydrology of riparian system highly altered.	About half the bank vegetation trampled; active sloughing and downcutting. Hydrology of riparian system moderately altered.	Some indication of trampled bank vegetation, active sloughing downcutting, or vertical slopes are minimal. Hydrology of riparian system slightly altered.	Bank vegetation intact, minimal trampling or sloughing.

5. Water Flow Patterns

Water flow patterns on the landscape have inherent path(s) of moving water across the soil surface during periods of rainfall. This waterflow is sometimes referred to as sheet flow or overland flow.

Water flow patterns follow the natural microtopography of the landscape. These patterns are generally evidenced by litter, soil or gravel redistribution, or pedestalling of vegetation or stones that break or divert the flow of water.

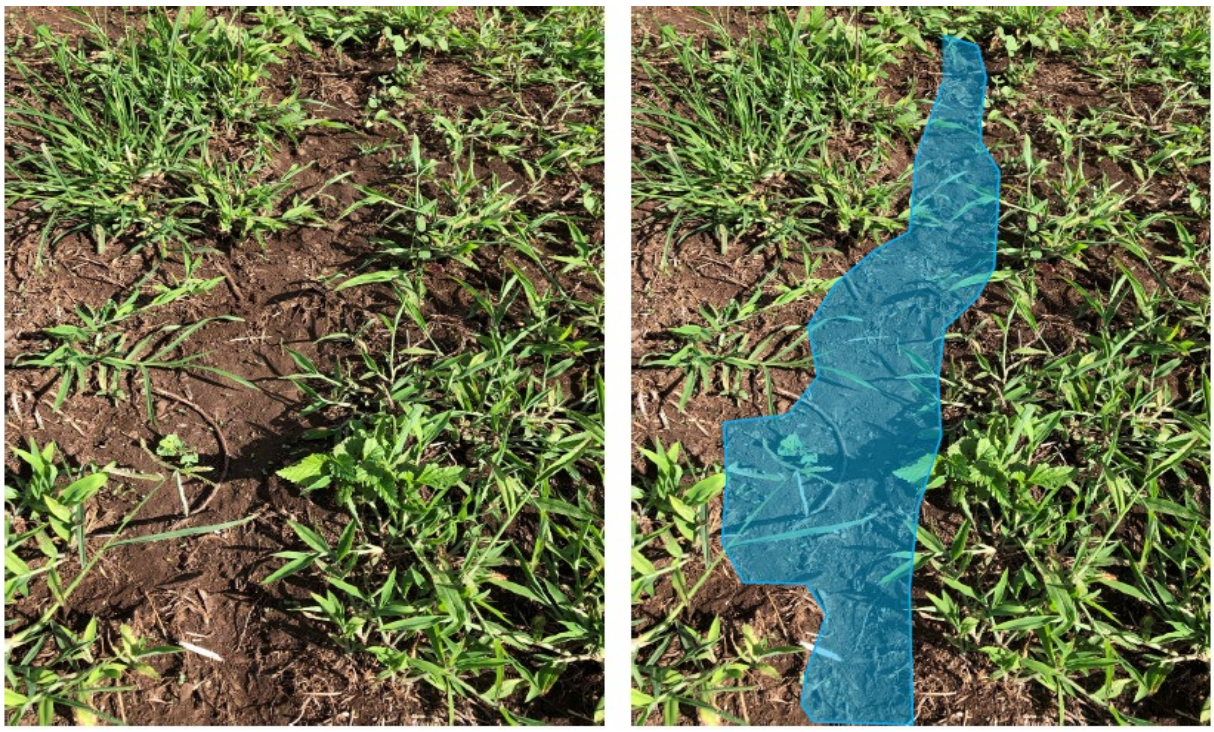

Photo 10 Water flow pattern in a pasture in Maui. Most water flow patterns are subtle and difficult to observe where cover is high. Photo credit: Carolyn Auweloa, NRCS 2021

Length, width, and number of water flow patterns are influenced by the number and kinds of obstructions to water flow provided by basal intercepts of living or dead plants, persistent litter, or rocks. They may be continuous or appear and disappear as the slope, perennial plant density, and microtopography change. Soils with inherently low infiltration capacity may have a large number of natural water flow patterns. Generally, as slope increases and ground cover decreases, water flow patterns increase.

Observe and record: Length, width, frequency and connectivity of water flow patterns.

Relevance to DIPH: SSS-associated with inter-rill erosion, sediment transport; HF-accelerated water loss and erosion, increased length, and number of water flow paths associated with reduced infiltration and water storage on-site.

Table 6 Generic descriptors of the five departure categories in the evaluation matrix for Water Flow Patterns

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
5. Water Flow Patterns	Extensive. Long and wide. Erosional or depositional areas widespread. Usually connected.	More numerous and widespread. Longer and wider than expected. Erosional or depositional areas common. Occasionally connected.	Lengths and widths slightly to moderately higher than expected. Minor to moderate erosional or depositional areas. Infrequently connected.	Length and width nearly match expected. Some minor erosional or depositional areas. Rarely connected.	Natural, well vegetated, or as described in ESD

6. Bare Ground (%)

Photo 11 Bare ground patches commonly occur in high traffic areas of the pasture. Photo credit: Greg Brann.

Bare ground is exposed mineral soil that is susceptible to raindrop splash erosion and exacerbates accelerated overland flow. Bare ground in the context of raindrop impact is associated with a lack of plant foliar cover, litter, rock, or basal plant crowns covering the soil surface.

A bare ground patch is an area where bare ground is concentrated. They may include some ground cover (individual plant, litter, rock) within their perimeter but there is proportionally much more bare soil than ground surface cover. Some bare ground patches may be part of the natural range of variability associated with the ecological site, e.g., disturbances like ant mounds and rodent burrows.

Observe and record: Increases in overall bare ground AND increases in the size and connectivity of bare ground patches as compared to expectations and for the appropriate reference state, if available.

Relevance to DIPH: SSS and HF are directly impacted by bare ground, as infiltration rate and capacity decrease, and runoff and subsequently erosion increase.

Table 7 Generic descriptors of the five departure categories in the evaluation matrix for Bare Ground (%)

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
6. Bare Ground (%)	Substantially higher than expected. Bare ground patches are large and frequently connected.	Much higher than expected. Major bare ground patches throughout stand, large and occasionally connected.	Moderately higher than expected. Bare ground patches are moderate in size and sporadically connected.	Slightly higher than expected. Bare ground patches are small and rarely connected.	Amount and size of bare areas match that expected for the site. Else, no bare ground in stand.

7. Pedestals and Terracettes

Photo 12 Terracettes of litter and soil accumulated from overland flow. Photo credit: Greg Brann.

Pedestals can form with the movement of soil by water or wind around the base of plants or from around rocks or persistent litter clumps and have the appearance of being elevated above the soil surface. Roots may also be exposed and is a significant sign of active erosion. Loss of soil around plant bases affect hydrologic function as infiltration is reduced and runoff and erosion are increased. Frost heaving, considered a non-erosional process, can create features that are similar in appearance to erosional pedestals. Distinguish between the two processes as separate processes associated with the ecological site.

Terracettes are “benches” of soil deposition (may include incorporated litter or gravel) behind or between obstacles (persistent litter, rocks, or plant bases) caused by water (not wind) movement. Terracettes caused by livestock or wildlife paths or trails on hillsides are not considered erosional terracettes; they are assessed using other indicators; they can affect erosion by concentrating water flow (1, 2, 5), changing infiltration (9) or soil compaction (11) (Pellant, et al., 2020).

Observe and record: Extent (number) of pedestals and terracettes, exposed roots.

Relevance to DIPH: SSS pedestals are directly related to soil movement by wind and water. Loss of soil around plant bases is also associated with changes in HF as infiltration is reduced, and runoff and erosion are increased.

Table 8 Generic descriptors of the five departure categories in the evaluation matrix for Pedestals and Terracettes

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
7. Pedestals and Terracettes	Pedestals extensive; roots frequently exposed. Terracettes, if present, are widespread.	Pedestals widespread; roots commonly exposed. Terracettes, if present, are common.	Pedestals common; roots occasionally exposed. Terracettes, if present, are uncommon.	Pedestals uncommon; roots rarely exposed. Terracettes scarce.	None Terracettes, none

8. Litter Movement (wind or water)

Photo 13 Accumulations of litter from feeding hay are not assessed as litter movement unless they have been moved, accumulated, or dispersed by wind or water. Photo credit: Greg Brann

“Litter” includes plant litter, mulch, crop residues, compost material, etc. Visual indications of litter movement can include accumulation of litter lodged against obstructions or patches void of litter that was removed. Distance of litter movement is associated with active erosional processes and nutrient redistribution.

When trying to determine the distance litter may have moved, it may be easier to look for litter from plants that are not dominant on the site, as their litter will be more recognizable and proximity to source more measurable.

Observe and record: Size classes and distance of litter movement and number of accumulations around obstructions or in depressions.

Relevance to DIPH: SSS and HF-correlated with accelerated runoff and erosion, and sediment transport. Secondary effects-associated nutrient loss.

Table 9 Generic descriptors of the five departure categories in the evaluation matrix for Litter Movement (wind or water)

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
8. Litter Movement (wind or water)	Extreme movement of all size classes (including large). Significant accumulations around obstructions or in depressions.	Moderate to extreme movement of small to moderate size classes. Moderate accumulations around obstructions or in depressions.	Moderate movement of mostly small size classes. Small accumulations around obstructions or in depressions.	Slight movement of small size classes. Minimal or no accumulations around obstructions or in depressions.	None or as described in ESD

9. Effects of Plant Community Composition and Distribution on Infiltration and Runoff

Variables that affect site hydrology include: above-and below-ground plant morphology, total production, production of individual plant species, total canopy cover, canopy cover of individual plant species, plant architecture, sod-forming growth form, bunchgrass growth form, and interspace areas. Infiltration is usually highest under trees and shrubs and decreases progressively in the following order: bunchgrass, sodgrass, and bare ground (Thurow, et al., 1986). Individual plant species also have a profound effect on hydrology and erosion dynamics; i.e., different grasses, forbs, and shrubs (USDA NRCS, 2022; Spaeth, et al., 1996; Spaeth, et al., 1996). Field studies have documented infiltration capacity with individual species composition. Bunchgrasses are associated with higher infiltration capacity than sodgrass species (Mazarak & Conrad, 1959; Dee, et al., 1966; Aase & Wight, 1973; Spaeth, et al., 1996; Pierson, et al., 2002; USDA NRCS, 2022) Plant growth form can have a dramatic effect on infiltration. (Pearse & Wooley) compared bare plots with fibrous and tap-rooted species. Compared to the bare plots, the fibrous-rooted plant was associated with a 127 percent increase in infiltration, whereas tap-rooted species was associated with a 51 percent increase.

Photo 14 At the U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS) scientists excavate eastern gamagrass roots for study at the Big Flats Plant Materials Center in NY. (L to R USDA NRCS agronomist Paul Salon, USDA Agricultural Research Service (ARS) technician Richard Lychalk, Bureau of Sugar Experiment Station, Queensland, Australia research scientist Jason Bull, and USDA ARS plant geneticist Rich Zobel). Photo credit: https://flic.kr/p/e56Jb4 USDA, March 5, 2013.

Observe and record: When evaluating this indicator, we want to compare the current plant community with the potential naturalized community –not the historic plant community or a plant community with a different disturbance regime. How does the naturalized species composition of the site affect the hydrology (infiltration and runoff), compared to its potential?

Relevance to DIPH: HF.

Table 10 Generic descriptors of the five departure categories in the evaluation matrix for Effects of Plant Community Composition and Distribution on Infiltration and Runoff

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
9, Effects of Plant Community Composition and Distribution on Infiltration and Runoff * Assume that decreased infiltration causes a corresponding increase in runoff. Indicator 9 is correlated with Indicator 10	Changes in plant community (functional/structural groups) composition or distribution are associated with severe reduction in infiltration and a significant increase in runoff.	Changes in plant community (functional/structural groups) composition or distribution are associated with significantly or greatly decreased infiltration and a large increase in runoff.	Changes in plant community (functional/structural groups) composition or distribution are associated with moderate reduction in infiltration and a moderate increase in runoff	Community (functional/structural groups) composition or plant distribution are associated with moderate reduction in infiltration and slight to moderate increase in runoff.	Infiltration and runoff are as expected for pasture state in S&T model. Plant composition and corresponding soil physical properties are not impeding infiltration

10. Soil Surface Loss or Degradation

Photo 15 A soil pit or vertical slice of the soil surface horizon will allow the opportunity to observe soil characteristics that may indicate loss or degradation, such as color, structure, or compaction. This photo shows a very crumbly granular structure in the surface horizon. Photo credit: Greg Brann

Indications include loss of thickness of surface soil horizon, loss of organic matter, changes in soil color, surface textural, and structural changes. Soil surface loss or degradation is an indicator of long-term change in pasture health and often persists after vegetation has recovered. If the degree of surface loss

and degradation are significant, the ramifications on all three attributes are permanent (Weltz & Spaeth, 2012). Depending on inherent soil texture by horizon, subsurface layers commonly exhibit less infiltration capacity and loss of the soil pores and porosity (Spaeth, et al., 1996).

Photo 16 Erosion is a natural process, but with continuous or compounding disturbances, can accelerate beyond natural levels. The surface contains the most fertile and biologically active portion of the pasture's soil. It is the interface for water infiltration, nutrient cycling, and plant growth and reproduction. Accelerated soil losses, disturbance, or degradation can have enduring effects, depending on the system's resilience. Photo credit: NRCS

Observe and record: On sites where the loss is not obvious, a soil pit can be compared to the soil description to help determine how much soil loss or degradation may have occurred.

Relevance to DIPH: SSS-significant impact on all three attributes. Indication of past or current erosion, loss of organic matter, and decline in overall soil function; HF-significant effects, common reductions of infiltration and water holding capacity, increases in runoff and erosion, which have concomitant effects on biotic integrity and plant growth and production; BI-impact on the function of living organisms due to loss of organic matter.

Table 11 Generic descriptors of the five departure categories in the evaluation matrix for Soil Surface Loss or Degradation

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
10. Soil Surface Loss or Degradation	Soil surface horizon very thin to absent throughout. Soil surface structure similar to or more degraded than subsurface. No distinguishable difference between surface and subsurface organic matter content.	Severe soil loss or degradation throughout. Minor differences in soil organic matter content and structure between surface and subsurface layers.	Moderate soil loss or degradation in plant interspaces with some degradation beneath plant canopies. Soil organic matter content is markedly reduced.	Slight soil loss or soil structure shows slight signs of degradation, especially in plant interspaces. Minor change in soil organic matter content.	No apparent soil loss or degradation (Reference ESD narrative)

11. Compaction Layer

Soil compaction is a result of soil disturbance due to past or current repeated compaction from farm machinery and other vehicles (Webb, et al., 1983; Thurow, et al., 1988), livestock trampling (Willatt & Pullar, 1984; Warren, et al., 1986; Chanasyk & Naeth, 1995), foot traffic (Cole, 1986), brush removal, seeding equipment, and raindrop impact with loss or absence of plant or litter cover (Wood & Blackburn, 1981; Thurow, et al., 1986; Thurow, et al., 1988; Blackburn, et al., 1992; Spaeth, et al., 1996). Compaction layers restrict water infiltrability and percolation (Willatt & Pullar, 1984; Thurow, et al., 1988), plant growth (Wallace, 1987), and nutrient cycling (Hassink, et al., 1993), which can have a negative effect on plant composition and production. Moist soils are more easily compacted than dry or saturated soil (Hillel, 2003). Compaction layers known as “plow pans” can occur at the bottom of a tillage layer and are commonly permanent in agricultural fields. Plow pans can restrict root development of plants, which also affect production capacity and resilience to drought.

Observe and record: Assess the frequency and distribution of compaction and thickness, depth and density of compacted layer.

Relevance to DIPH: Affects all three soil health attributes (SSS, HF, and BI) due to changes in hydrologic cycle, including reduced infiltration and water storage, increased runoff, soil erosion, and sedimentation. Compaction can significantly restrict root development and penetration.

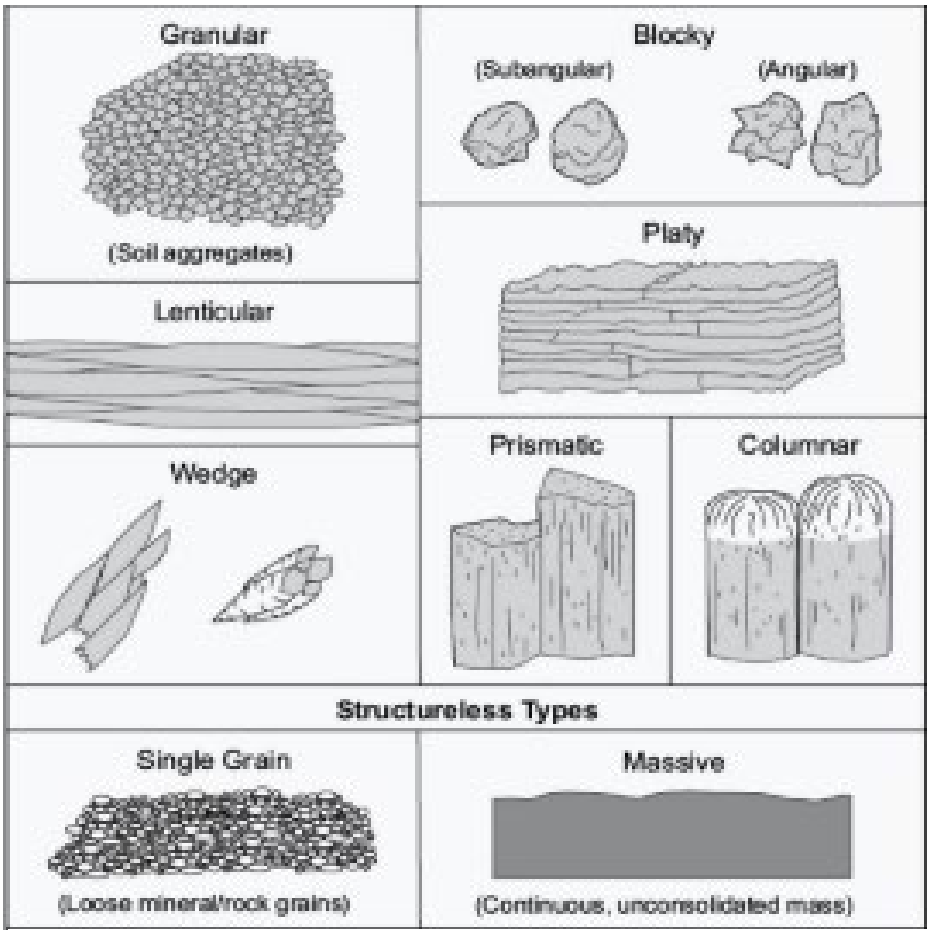

Figure 4 Soil structure types (USDA NRCS, 2012). Platy structure is commonly associated with soil compaction.

Table 12 Generic descriptors of the five departure categories in the evaluation matrix for Compaction Layer.

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
11. Compaction Layer	Extensive or strongly developed (thickness and density); may severely restrict root penetration and infiltrability.	Widespread or moderately to strongly developed (thickness and density); may greatly restrict root penetration and infiltrability.	Moderately widespread or moderately developed (thickness and density); may moderately restrict root penetration and infiltrability.	Not widespread or weakly developed (thickness and density); may weakly restrict root penetration and infiltrability.	No apparent compaction.

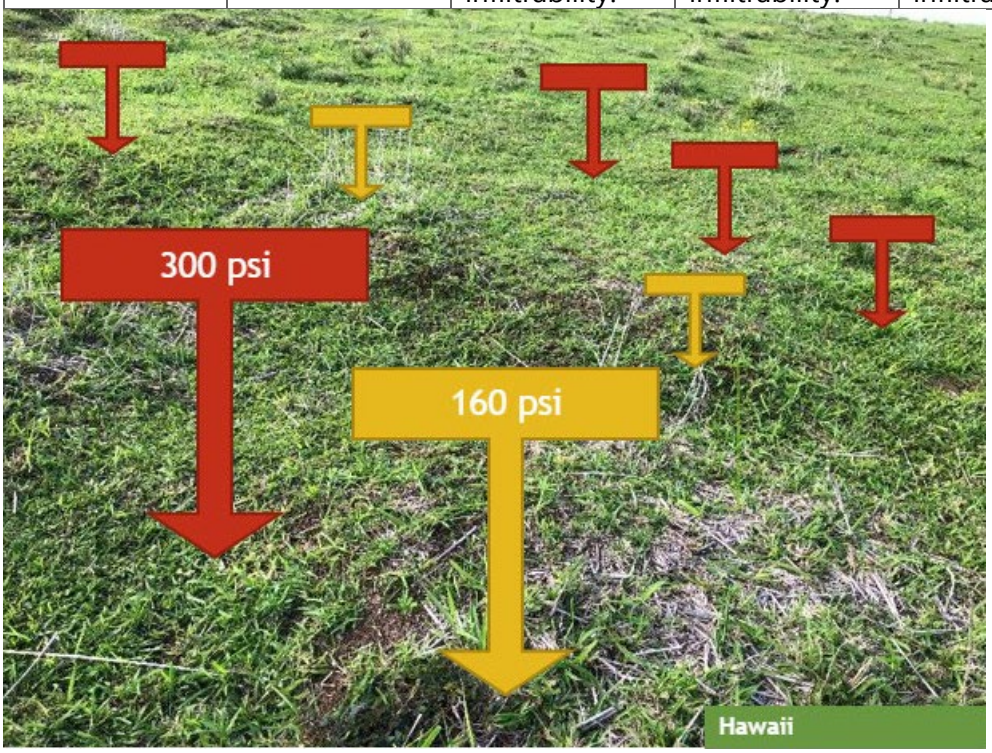

Photo 17 Patterns of differences in penetrometer readings between grass clumps and plant interspaces caused by long-term overgrazing under wet conditions. Photo credit: Carolyn Auweloa, NRCS, 2021

Photo 18 Management induced soil compaction resulting in decreased rooting depth that reduces plant growth, animal habitat, and soil biological activity. Photo credit: https://flic.kr/p/2nwRgLU by Blaine Brakke, USDA NRCS South Dakota, June 7, 2012

12. Live Plant Foliar Cover (hydrologic and erosion benefits)

Research has demonstrated a significant correlation between vegetative cover and kinds of vegetation with soil erosion, infiltration, and runoff (Pearse & Wooley, 1936; Osborn, 1950; Mazarak & Conrad, 1959; Dee, et al., 1966; Rauzi, et al., 1968; Blackburn & Skau, 1974; Blackburn , 1975; Hanson & Lewis, 1978; Wood & Blackburn, 1981; Blackburn, 1984) (Swanson & Buckhouse, 1984; Blackburn, et al., 1986; Snyman & Van Rensburg, 1986; Johnson & Gordon, 1988; Thurow, et al., 1988; Thurow, 1991; Holechek, et al., 1989; Wilcox & Wood, 1989; Wood & Wood, 1988; Blackburn, et al., 1992) (Blackburn, et al., 1990; Spaeth, et al., 1996; Spaeth, et al., 1996; Pierson, et al., 2002).

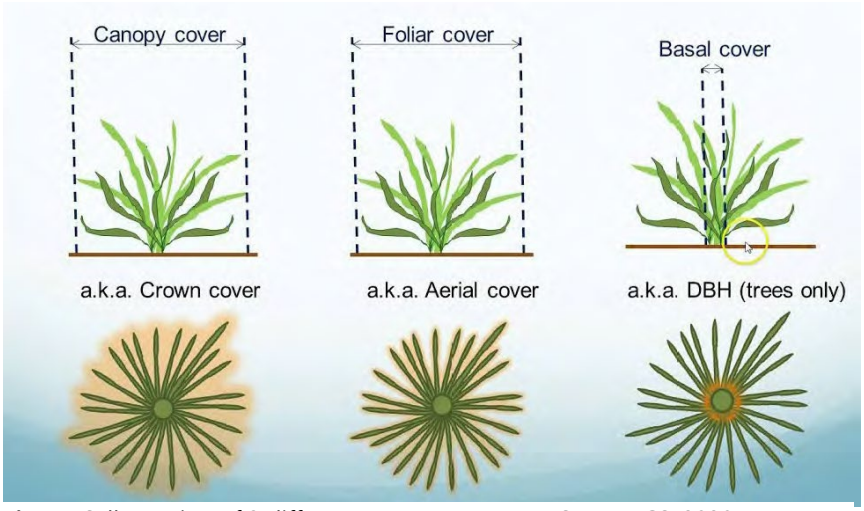

Figure 6 Illustration of 3 different cover concepts. (USDA NRCS, 2020)

Plant cover on grazing lands can be viewed in several ways, such as canopy cover, foliar cover, and basal cover (Figure 5). Canopy cover is an abstract view of the plant canopy as an estimate of the area occupied by the plant (the whole area) but ignores gaps or holes viewed from a vertical projection. Canopy cover can also be viewed as the vertical projection of the outer perimeter or edges of the plant. Foliar cover is more specific, the vertical projection of exposed leaf area covering soil. If a pin were lowered through the plant canopy, foliar cover is recorded where the pin intercepts a plant part. Foliar cover does not include gaps or openings in the plant canopy. Basal plant cover is related to the crown of the plant, the proportion of the plant at ground level or extends into the soil. Plant canopy cover occupies an outline of the projected area. Foliar cover is specific to a plant part that would intercept a raindrop. Basal cover occupies the least area as a plant crown at the ground surface.

As plant cover declines, infiltration decreases (Holechek, et al., 1989). Each plant soil complex exhibits a characteristic infiltration pattern (Gifford, 2021) Hydrologic processes such as infiltration are not constant from one soil complex to another. Soil physical and chemical attributes, plant/life growth forms, and storm dynamics can significantly change hydrologic dynamics among different ecological sites and within an ecological site. Most studies indicate that cover of 50 to 75 percent plant foliar and ground cover is probably sufficient (Gifford, 1985; Thurow, 1991; Spaeth, et al., 2022; Wood & Blackburn, 1981; Weltz, et al., 1998; Pierson, et al., 2011; Pierson & Williams, 2016; Cadaret, et al., 2016) to prevent degradation from accelerated soil erosion processes.

Observe and record: Live plant foliar cover is not species specific. Whether they are desirable species or not, measure percent live cover on the site and assess. Do not include dead-standing material or litter. Don't forget to look up and include tree cover.

Relevance to DIPH: SSS HF.

Table 13 Generic descriptors of the five departure categories in the evaluation matrix for Live Plant Foliar Cover (hydrologic and erosion benefits)

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
12. Live Plant Foliar Cover (hydrologic and erosion benefits)	Less than 40% live foliar cover. Remaining is either dead standing material or bare ground.	40–60% live foliar cover. Remaining is either dead standing material or bare ground.	60–75% live foliar cover. Remaining is either dead standing material or bare ground.	75–95% live foliar cover. Remaining is either dead standing material or bare ground.	More than 95% live foliar cover. Remaining is either dead standing material or bare ground.

13. Forage Plant Diversity

Plant species diversity refers to the number of plant species (richness) and their relative abundance (evenness in composition). One important point associated with this indicator: "diversity is not simply a numbers game" (Sanderson, et al., 2004). From an environmental perspective, the proportional abundance of plant species (composition), their unique attributes, and their spatial distribution across the landscape are critical features in pasturelands (Sanderson, et al., 2004).

Photo 20 A diverse pasture plant community including a variety of species and functional groups. Photo credit: Greg Brann.

Two situations are important regarding species diversity in pasturelands. First, many grazing lands are highly heterogeneous with varying soils, climate, and landscape features. Individual pastures may need to fulfill multiple functions for producers (animal production, resource protection, wildlife enhancement, including pollinators). Therefore, greater plant diversity may be the most beneficial course of action. Secondly, pasture management strives to maintain productivity, be energy efficient, achieve low cost, and provide adequate nutritive value to meet animal production goals. Management also minimizes stresses such as defoliation, drought, or weed invasion. Fulfilling these requirements and functions often requires growing many forage species together and "will entail a multi-scale approach with different forages and combinations of forage species distributed across a farm, according to site suitability and goals of the producer" (Sanderson, et al., 2007). Pastures consisting of mixtures of several forage species in some instances can improve forage yield and reduce weed invasion.

However, in highly productive soils and stable environments (low risk of erosion), where productivity is the main goal, a highly diverse system may not be appropriate. This indicator allows for judgment in establishing and maintaining diversity based on environmental conditions or its diversity of forage species, in accordance with landowner objectives.

Pasture management involving increased plant species diversity should not simply rely on mixing and planting as many forage species as possible. The goal should be to include species that provide stable protection against erosion and meet the needs of livestock and the farming or ranching operation.

Observe and record: Assess plant species diversity and composition by dry weight considering site potential, environmental conditions and needs and producer objectives and livestock class.

Relevance to DIPH: BI, LMQF.

Table 14 Generic descriptors of the five departure categories in the evaluation matrix for Forage Plant Diversity

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
13. Forage Plant Diversity Note: Legumes' adaptability based on what is expected for site in ESD.	Diversity severely lacking in comparison with site potential or with management objectives.	Low diversity in comparison with site potential or plant diversity not in accordance with management objectives.	Moderate diversity in comparison with site potential or plant diversity is not optimum with management objectives.	Diversity slightly decreased in comparison with site potential or plant diversity is somewhat lacking with management objectives.	High diversity of desirable forage plants in stand or plant diversity in full accordance with management objectives.

14. Percent Desirable Forage Plants (for identified livestock class)

Desirable plants are those that are palatable, productive, and nutritious. Secondary traits may also include species that have strong resilience to grazing (plants that readily tiller, location of meristematic tissue and growing points), are long-lived, and have extensive root systems to aid in erosion protection. Many forage species meet these criteria, but some forage plants are associated with anti-quality characteristics (Launchbaugh, 2001). For example, alkaloids can have large effects on forage quality, even when present in small quantities (Barnes, et al., 2003); tremorgens in perennial ryegrass can result in ryegrass staggers; indole alkaloids in reed canarygrass (*Phalaris arundinacea*); endophytic fungus, pyrorolizidine and ergopeptine alkaloids in tall fescue (fescue foot, fat necrosis, and or fescue toxicosis/summer syndrome); prussic acid poisoning in sorghum, sudangrass, johnsongrass (*Sorghum halepense*); cyanide poisoning (cyanogenic glycosides) in white clover; glucosinolates and S-methyl cysteine sulfoxide in brassica forages; magnesium deficiencies in spring forage grasses causing grass tetany; and pasture bloat from alfalfa, red clover, white clover, and other clovers, vetches, and grazed out wheat pastures.

Photo 21 This pasture contains a high percentage of forage plants that are desirable for cattle. Photo credit: Greg Brann.

As when using Pasture Condition Scoring (USDA NRCS, 2020), refer to your state or regional desirable plant list, and ideally, by grazing livestock type (cattle, sheep, goats) for scoring this indicator. Desirable species will depend upon geographic region and livestock type.

The most desirable species may be grazed first and close to the ground in poorly managed systems and therefore, may decline in prevalence. Meanwhile, other less-palatable species that can avoid grazing impacts may increase. These less-desirable species can eventually displace the desirable ones since they are grazed less, if at all. This replacement is important to this indicator and should not be overlooked when the desirability score is low.

Observe and record: The percent species that are desirable (for the identified livestock class) forage plants by dry-matter weight.

Relevance to DIPH: LMQF

Photo 23 The type of livestock will determine which plants are considered as desirable. Photo credit: David Toledo

Table 15 Generic descriptors of the five departure categories in the evaluation matrix for Percent Desirable Forage Plants (for identified livestock class)

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
14. Percent Desirable Forage Plants (for identified livestock class)	Desirable forage species <20% dry weight.	Desirable forage species 20–40% dry weight.	Desirable forage species 40–60% dry weight.	Desirable forage species 60–80% dry weight.	Desirable forage species exceed 80% dry weight.

15. Invasive Plants

Invasive plants are an important aspect of biotic integrity in perennial pasture systems. Invasive plants are plants that can be native or exotic non-native plants that have the potential to become a dominant or codominant species on the site, if their establishment and growth is not actively controlled by management interventions. Managing invasive plants before they are dominant or codominant is the key to sustained pasture production and health, especially rhizomatous species, shrubs, and trees. Certain invasive plants may or may not be classified as noxious as designated in federal, state, or county lists. Once invasive species become dominant or codominant on the site, they dominate ecological processes such as energy and nutrient cycles, and often create feedbacks, which sustain their dominance.

Observe and record: Note the distribution and amount of invasive species that may dominate a sites ecological processes and inhibit sustained pasture production and health.

Relevance to DIPH: Invasive plants specifically affect HF, BI, and LMQF. If invasive plants are associated with shifts in plant life forms – such as tall grasses, mid grasses, short grasses, forbs, shrubs, half shrubs, and trees – this compositional change on a site greatly influences infiltration and runoff dynamics (HF). Infiltration is usually highest under trees and shrubs and decreases progressively in the following order: bunchgrass, sodgrass, and bare ground (Thurow, et al., 1986). Invasive plants often significantly impact BI, namely plant composition, species diversity, community dynamics, and the processes associated with the energy and nutrient cycles. As biotic integrity degrades on pastureland, less preferable vegetation subsists, which has a direct impact on LMQF.

Photo 24 Invasive plant species Canada Thistle in Western SD. This invasive species is spread via vehicles, humans, or animals. Once this weed is on the site, it spreads by seeds or rhizomes and will take over a pasture or meadow. It lowers the plant community diversity and degrades wildlife habitat. Biocontrol insects are available to use on Canada Thistle. Photo credit: https://flic.kr/p/2khBML9 South Dakota NRCS. July 7, 2020.

Table 16 Generic descriptors of the five departure categories in the evaluation matrix for Invasive Plants

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
15. Invasive Plants	Invasive species dominate the site.	Invasive species common throughout the site.	Invasive species scattered throughout the site.	Invasive species present in infrequent disturbed areas within the site.	Invasive species rare, except in very infrequently disturbed areas.

16. Production

Photo 25 NRCS Supervisory District Conservationist Ann Fischer prepares to clip forage samples of ungrazed pasture on Hayden Ranch, Fallon County, Montana. Photo credit: https://flic.kr/p/2kfqW6k USDA NRCS Montana, June 2020

Production is the result of energy captured by plants through the process of photosynthesis and subject to fluctuations in climate and local weather conditions. Annual production is the net quantity of aboveground vascular plant material produced annually. Standing dead vegetation (produced in previous years) or live tissue (woody stems) not produced in the current year as annual production are not included in annual production. Standing dead vegetation can be included in the production estimate, if grown during the current year. Production directly correlates with the ecological process of energy flow. In plant ecosystems, annual production is the most important variable that represents how resources are partitioned (Whittaker, 1975).

Relevance to DIPH: Directly related to BI and LMQF

Observe and record: Estimate production using a method prescribed by the NRCS state grazing specialist or found in the National Range and Pasture Handbook.

Table 17 Generic descriptors of the five departure categories in the evaluation matrix for Production

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
16. Production	Less than 20% of potential production. Considering recent weather conditions	21–40% of potential production. Considering recent weather conditions	41–60% of potential production. Considering recent weather conditions	61–80% of potential production. Considering recent weather conditions	Production >80% of potential. Considering recent weather conditions

17. Plant Vigor with an Emphasis on Reproductive Capability of Perennials

Plant vigor relates to the robustness of individual plant species in the population and is commonly represented by the size of the plant and its parts in relation to the plant's age and the local environment in which it is growing (SRM, 1999).

Reproductive capability is dependent on plant health and the ability to reproduce, given the constraints of climate and herbivory. Reproductive potential is associated with inflorescence (e.g., seed stalks) and flower production, which are the basic measures of reproductive potential for sexually reproducing plants and clonal production (e.g., tillers, rhizomes, or stolons) for vegetatively reproducing plants.

Photo 26 This fence line contrast shows differences in plant vigor that result from fertility differences. Photo credit: Greg Brann.

Color is an indicator of plant vigor. Drought, insect damage, or prolonged (continuous) heavy usage can cause yellowing. Low fertility or poor growing conditions (e.g., saturated soils) can be indicated by pale green plants. Dark green spots under dung or urine patches contrasted with the rest of the pasture indicate low nitrogen. Frost-damaged can change color. Generally, color is a visual indicator of mineral deficiencies or excesses.

Observe and record: Plant color, recovery from grazing, sward density, and reproductive plant parts on desirable plants as described in the matrix. Do not rate invasive species or undesirables under this indicator.

Table 18 Generic descriptors of the five departure categories in the evaluation matrix for Plant Vigor with an Emphasis on Reproductive Capability of Perennials

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
17. Plant Vigor with an Emphasis on Reproductive Capability of Perennials	Plant reproduction or recovery after use is extremely reduced. Pale, yellow or brown, or severely stunted plants.	Plant reproduction or recovery after use is greatly reduced. Yellowish green forage, or moderately or slightly stunted plants.	Plant reproduction or recovery after use is moderately reduced. Adequate recovery. Yellowish and dark green areas due to manure and urine patches.	Plant reproduction or recovery is slightly-to-moderately reduced after use. Good recovery. Light green and dark green plants present	Plant reproduction or recovery is what is expected for the site. Rapid recovery. All healthy green plants.

Relevance to DIPH: Plant vigor and reproductive capability are key elements associated with BI. When environmental conditions are favorable, new plant recruitment occurs to balance plant mortality. Plant community composition and resiliency of plant species are dependent on their ability to reproduce (Svejcar, et al., 2014).

18. Dead or Dying Plants or Plant Parts

Photo 28 At the end of each growing season, annual plants are expected to die and perennial plants are expected to go into dormancy. Photo credit: https://flic.kr/p/2iCwzHb Maryland NRCS, March 6,

Plant mortality and senescence of leaves, stems, branches, and roots are a natural phenomenon in all perennial plant communities. However, the proportion of dead or dying plants or plant parts varies considerably with various levels of disturbance over time. Dying plant parts are natural for perennial plants. Some perennial bunchgrasses tend to age as a ring with a dead center, and many live shrubs will have dead branches. Dead or dying plant parts are greatly influenced by the natural disturbance regime. The key point for this indicator is to determine departure according to the normal range of variability.

Observe and record: Note any signs of mortality and the functional groups affected (bunch grasses, forbs, woody species, etc.)

Relevance to DIPH: This indicator is an important factor of BI. If existing plants are either dead or dying, the integrity of the plant stand declines, and undesirable plants (e.g., weeds or invasive plants) may increase (Svejcar, et al., 2014; Pyke, 1995).

Table 19 Generic descriptors of the five departure categories in the evaluation matrix for Dead or Dying Plants or Plant Parts

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
18. Dead or Dying Plants or Plant Parts	Extensive mortality, dying plants, or plant parts concentrated in one or more functional groups.	Widespread mortality, dying plants, or plant parts concentrated in one or more functional groups.	Moderate mortality, dying plants, or plant parts concentrated in one or more functional groups.	Occasional mortality, dying plants, or plant parts concentrated in one or more functional groups.	No apparent mortality, dying plants, plant, or plant parts.

19. Litter Cover and Depth

Litter is dead recognizable plant material that are detached from the plant, including leaves, stems, and branches. Plant stems and seed heads that are dormant or dead but still attached to the plant are considered a dead plant part, not litter (sometimes referred to as “standing dead”). Unrecognizable plant material that is partially decomposed and smaller than 2mm is not litter but is considered duff or particulate organic matter (POM) (USDA NRCS, 2011). The longevity of litter on a site is highly dependent upon current moisture and temperature. Decomposing material (above and below ground) is the primary source of soil organic material for mineralization of organic matter. The potential amount of litter is proportional to the productivity of the ecological site, the plant community, the composition of the litter (e.g. amount of lignified material), as well as weather conditions with more litter accumulation after wet years and less accumulation after dry years.

Excessively high amounts of litter or “thatch” can interfere and slow down new tiller growth and tie up nitrogen. This can be resolved with a shorter rest period, increased diversity (especially legumes), and increased stock density.

Observe and record: Note amount and depth of litter either increased or decreased compared to site potential and recent weather.

Relevance to DIPH: HF, BI.

Photo 29 Part the sward to observe the amount of litter that is accumulated at the soil surface. Photo credit: Greg Brann

Table 20 Generic descriptors of the five departure categories in the evaluation matrix for Litter Cover and Depth

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
19. Litter Cover and Depth	Accumulation of litter cover and depth, and decomposition extremely out of balance with current weather conditions.	Accumulation of litter cover and depth, and decomposition moderately-to-extremely out of balance with current weather conditions.	Accumulation of litter cover and depth, and decomposition moderately out of balance with current weather conditions.	Accumulation of litter cover and depth, and decomposition slightly out of balance with current weather conditions.	Accumulation of litter cover and depth, and decomposition as expected for the site, and with current weather conditions.

20. Percentage Legumes

This indicator considers the proportion of legume present in a forage stand (by weight) during the growing season. Legumes can vary considerably, depending upon growing conditions, timing and intensity of grazing, and agronomic inputs.

Forage legumes in pastures have unique advantages and disadvantages for ruminant production. In comparison with grasses or cereals, the main advantages are 1) “low reliance on fertilizer nitrogen (N) inputs, 2) high voluntary intake and animal production when feed supply is non-limiting, and (3) high protein content. The main disadvantages of forage legumes are generally 1) lower persistence than

grass stands under grazing, 2) high risk of livestock bloat, and 3) difficulty to conserve as silage or hay. In comparison to grass or legume monocultures, grass and legume mixtures have particular advantages, such as more balanced feeding values, increased resource use efficiency, and increased herbage production" (Phelan, et al., 2015). Unfertilized legume-grass mixtures in pasture tend to have fewer negative environmental impacts from nutrient losses in runoff compared to grass or cereal-based pastures supplemented with N fertilizer. From an economic perspective, incorporating forage legumes with other non-legume forages can reduce N fertilizer costs.

Establishing and maintaining forage legumes in pastures vary throughout the U.S. Some soils and climates are not conducive to establishment and maintenance of legume species in the stand, and the Ecological Site pasture state narrative (when available) should discuss this dynamic in detail. If legumes are not particularly adapted to a certain region, climate, or soils, this indicator can be eliminated from the assessment.

Photo 34 Legumes at 6% by dry weight (approx. 10% visual wet) (USDA NRCS, 2020)

Photo 34 Legumes at 15% by dry weight (approx. 30% visual wet) (USDA NRCS, 2020)

Photo 34 Legumes at 27% by dry weight (approx. 50% visual wet). (USDA NRCS. 2020)

Although forage legumes are good sources of dietary protein – and in some cases, energy – the risk of bloat cannot be underestimated and can be a major limitation to their use. Management and available supplements can reduce risk, but some producers do not want the risk. The loss of a valuable animal can upset the economic advantages associated with legumes in the pasture.

The recommended percentage of legumes based on dry herbage weight varies in the literature (30-60 percent). Planning legume mixtures in pastures should be done carefully with the producer, and risks and liabilities should be discussed. The percent legumes indicator is based on a more conservative approach of 30-35 percent.

Producers should understand the advantages and disadvantages of using legumes in pasture systems. Therefore, this indicator contains two approaches: 1) legumes as part of the pasture management plan; and 2) legume use in accordance with management objectives.

Observe and record: Proportion of legumes in the plant community, by dry weight. Visual estimation of legumes cover will not correspond with actual dry weight composition (see Photo 31)

Relevance to DIPH: BI, LMQF.

Table 21 Generic descriptors of the five departure categories in the evaluation matrix for Percentage Legumes

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
20. Percentage Legumes0F0F[1]	If ES Altered Pasture State supports legumes, stands have less than 2% by weight or legume composition extremely out of balance with management objectives.	If ES Altered Pasture State supports legumes, stands have 2–5% by weight or legume composition moderately-to-extremely out of balance with management objectives.	If ES Altered Pasture State supports legumes, stands have 5–15% by weight or legume composition moderately out of balance with management objectives.	If ES Altered Pasture State supports legumes, stands have 15–30% by weight or legume composition slightly out of balance with management objectives.	If ES Altered Pasture State supports legumes, stands have 30–35% by weight or legume use in accordance with management objectives.

21. Uniformity of Use

Increasing grazing uniformity has several positive outcomes: maintenance of the forage species as a unit, manage species grazing height, minimize grazing stress on individual species, maximize animal performance and gains, and protect offsite benefits such as fisheries, wildlife habitat, and watershed resources (Bailey, 2004). Managers can increase grazing uniformity and protect sensitive areas by changing pasture attributes or by modifying animal behavior. Strategies to improve grazing distribution center around strategic water developments, salting, and fencing. Other strategies to manage distribution include fertilization, prescribed burning, shade, multi-species grazing and bale grazing.

Observe and record: Note areas of spot overgrazing or avoided areas and estimate area.

Relevance to DIPH: HF, BI, LMQF

Photo 36 The appearance of this pasture demonstrates patches where forage species are rejected while others are severely grazed. Photo credit https://flic.kr/p/2p9EQSw NRCS Utah

[1] Note: literature mentions maximum legume comp. at ≈ < 30-50 percent to minimize bloat potential (Canadian Agronomist, 2021; Forsythe, 2018; Wardynski, 2013; Montana State University , 2003; Gelley, 2018) Note: if bloating legumes dominate the stand, by weight, rating = Extreme to Total. Substantial risk to livestock with and without bloat prevention protocols.

Table 22 Generic descriptors of the five departure categories in the evaluation matrix for Uniformity of Use

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
21. Uniformity of Use	Little-grazed or ungrazed patches where forage species are rejected cover over 50% of the area. Rejected patches are generally connected. Or Uniform use due to overutilization.	Little-grazed or ungrazed patches where forage species are rejected cover 26 to 50% of the area. Patches are occasionally connected.	Little-grazed or ungrazed patches where forage species are rejected cover 10 to 25% of the area. Patches sporadically connected.	Light-grazed or ungrazed and unconnected patches where forage species are rejected are small and isolated (<10% cover). Urine and dung patches avoided.	Uniform grazing throughout pasture. Areas where forage species are rejected only present at urine and dung patches.

22. Grazing and Utilization

In developing grazing management plans, consider both grazing frequency and utilization of every pasture in the system. Due to the high variability that exists throughout pastureland in the U.S., it is difficult to suggest absolute use values as they vary, depending on local climate and growing conditions, grazing systems, and management objectives. The general “rule of thumb” regarding utilization values is around 50 percent (Figure 6), which is generally considered appropriate to maintain pasture health. Temporary heavier utilization is sometimes used in grazing systems, where rest or deferment is part of the plan; but this should not be a consistent practice. Continuous heavier stocking rates are correlated with greater compaction and degradation of soil aggregates, lower infiltration, declining soil moisture capacity, and higher erosion rates (Nelson, 2012).

Stubble heights of pasture forage species are often used as measurements of use. It is important to note that stubble heights can also vary (ranges in grazing height are common), depending on the condition of the pasture, site potential, grazing system, and management objectives.

Observe and record: Note degree of utilization in key areas and of key species that are grazed. Also consider livestock concentration areas and trails and rate accordingly.

Relevance to DIPH: SSS, HF, BI, LMQF

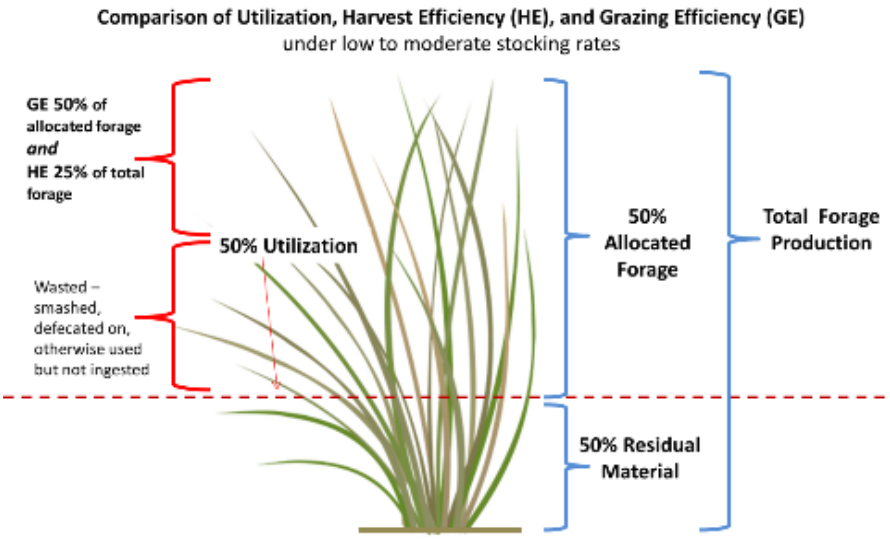

Figure 7 A graphical definition of the term "utilization" in contrast with the related terms harvest efficiency and grazing efficiency (Green & Brazee, 2012)

Photo 37 This pasture exhibits a high degree of use with very little residual forage (short stubble heights) following grazing. Photo credit Greg Brann.

Table 23 Generic descriptors of the five departure categories in the evaluation matrix for Grazing and Utilization

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
22. Grazing and Utilization Note: Utilization percentages can be temporarily adjusted in grazing rotation systems given that rest and deferment are planned.	Pasture severely overgrazed (>70% utilization), plant height continually below recommended graz. Ht. for spp. Livestock concentration areas > 10% of the pasture and can transport contaminated runoff directly into water channels unbuffered.	Pasture utilization 65–70%, plant height is continually below recommended graz. Ht. for spp. Livestock concentration areas and trails cover 5–10% of the area and drain into water channels unbuffered.	Pasture utilization 60–65%; current utilization is temporary and not representative of continual management. Isolated and unconnected livestock concentration areas and trails (<5% of area); can potentially drain into water channels unbuffered.	Pasture utilization 50–60%; plant height generally meets recommended graz. Ht. for spp. Some livestock trails and one or two small unconnected concentration areas.	Pasture utilization =<50%; plant ht. meets recommended graz.ht. for spp. No presence of livestock concentration areas or heavy use areas.

Interpreting the Indicator Ratings – the 4 Attributes

Determination of preponderance of evidence follows the same approach as used in Pellant, et al., 2020. The 22 indicators rated on Table 3 determine the overall degree of departure for each attribute on Table 4. Determining preponderance of evidence is subjective, although some of the indicators can be supported by quantitative data if available. Examine the summary matrix columns for each of the DIPH attributes and determine what departure class represents the current condition. Often the majority of indicators in a specific departure class e.g., slight to moderate may dominate the preponderance of evidence matrix; however, important key indicators such as invasive plants, erosion, percent desirable forage plants may be in different departure classes and perhaps indicate a more significant departure from reference conditions. As a result, you may have an overall preponderance of evidence that represents a cross section i.e., a mixture of determinations for some key indicators. Depending on the severity of departure of critical indicators, it is acceptable to shift the rating to higher departure class. Conclusions need to reflect current conditions and depending on the ratings of certain key indicators, they may take precedence over the overall determination.

Table 24 Evaluation matrix used to rate the 22 indicators and five departure categories of pasture health.

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
1. Erosion (sheet and rill)	Numerous and frequent throughout. Nearly all rills are wide, deep and long. Occur in exposed and vegetated areas.	Moderate in number at frequent intervals. Many rills are wide, deep, and long. Occur in exposed areas and in some adjacent vegetated areas.	Moderate in number at infrequent intervals. Moderate rill width, depth, and length. Occur mostly in exposed areas, and steeper slopes.	Scarce and scattered. Minimal rill width, depth, and length. Occur in exposed areas, and steeper slopes.	Current or past formation of rills – none.
2. Erosion (gullies)	Sporadic or no vegetation on gully banks or bottom. Numerous nick points. Significant active bank and bottom erosion, including downcutting. Substantial depth or width. Active headcuts may be present.	Intermittent vegetation on gully banks or bottom. Nick points common. Moderate active bank and bottom erosion, including downcutting. Significant width or depth. Active headcuts may be present.	Occasional vegetation on gully banks or bottom. Occasional nickpoints and slight downcutting. Moderate depth aor width. Active headcuts absent.	Vegetation on most gully banks or bottom. Few nickpoints and minimal downcutting. Minimal gully depth or width. Headcuts absent.	None
3. Erosion, Wind-Scoured or Depositional Areas	Extensive. Wind blowouts or scours usually connected. Large soil depositions around obstructions.	Common. Wind scours frequently connected. Moderate soil depositions around obstructions.	Occasionally present. Wind scours infrequently connected. Minor soil deposition around obstructions.	Infrequent and few. Wind scours rarely connected. Trace amounts of soil deposition around obstructions.	None or as expected in reference ESD
4. Erosion (streambank or shoreline)	Banks bare, major vertical down cutting, major sloughing, little or no bank vegetation. Hydrology of riparian system severely altered.	More than half the expected bank vegetation absent, veg. trampled, sloughing and vert. banks active erosion. Hydrology of riparian system highly altered.	About half the bank vegetation trampled; active sloughing and downcutting. Hydrology of riparian system moderately altered.	Some indication of trampled bank vegetation, active sloughing downcutting, or vertical slopes are minimal. Hydrology of riparian system slightly altered.	Bank vegetation intact, minimal trampling or sloughing.

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
5. Water Flow Patterns	Extensive. Long and wide. Erosional or depositional areas widespread. Usually connected.	More numerous and widespread. Longer and wider than expected. Erosional or depositional areas common. Occasionally connected.	Lengths or widths slightly to moderately higher than expected. Minor to moderate erosional or depositional areas. Infrequently connected.	Length and width nearly match expected. Some minor erosional or depositional areas. Rarely connected.	Natural, well vegetated, or as described in ESD
6. Bare Ground (%)	Substantially higher than expected. Bare ground patches are large and frequently connected.	Much higher than expected. Major bare ground patches throughout stand, large and occasionally connected.	Moderately higher than expected. Bare ground patches are moderate in size and sporadically connected.	Slightly higher than expected. Bare ground patches are small and rarely connected.	Amount and size of bare areas match that expected for the site. Else, no bare ground in stand.
7. Pedestals and Terracettes	Pedestals extensive; roots frequently exposed. Terracettes, if present, are widespread.	Pedestals widespread; roots commonly exposed. Terracettes, if present, are common.	Pedestals common; roots occasionally exposed. Terracettes, if present, are uncommon.	Pedestals uncommon; roots rarely exposed. Terracettes scarce.	None; Terracettes, none
8. Litter Movement (wind or water)	Extreme movement of all size classes (including large). Significant accumulations around obstructions or in depressions.	Moderate to extreme movement of small to moderate size classes. Moderate accumulations around obstructions or in depressions.	Moderate movement of mostly small size classes. Small accumulations around obstructions or in depressions.	Slight movement of small size classes. Minimal or no accumulations around obstructions or in depressions.	None or as described in ESD
9, Effects of Plant Community Composition and Distribution on Infiltration and Runoff. * Assume that decreased infiltration causes a corresponding increase in runoff. Indicator 9 is correlated with Indicator 10	Changes in plant community (functional/structural groups) composition and distribution are associated with severe reduction in infiltration and a significant increase in runoff.	Changes in plant community (functional/ structural groups) composition and distribution are associated with significantly or greatly decreased infiltration and a large increase in runoff.	Changes in plant community (functional/structural groups) composition and distribution are associated with moderate reduction in infiltration and a moderate increase in runoff	Community (functional/ structural groups) composition and plant distribution are associated with moderate reduction in infiltration and slight to moderate increase in runoff.	Infiltration and runoff are as expected for pasture state in S&T model. Plant composition and corresponding soil physical properties are not impeding infiltration

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
10. Soil Surface Loss or Degradation	Soil surface horizon very thin to absent throughout. Soil surface structure similar to or more degraded than subsurface. No distinguishable difference between surface and subsurface organic matter content.	Severe soil loss or degradation throughout. Minor differences in soil organic matter content and structure between surface and subsurface layers.	Moderate soil loss or degradation in plant interspaces with some degradation beneath plant canopies. Soil organic matter content is markedly reduced.	Slight soil loss or soil structure shows slight signs of degradation, especially in plant interspaces. Minor change in soil organic matter content.	No apparent soil loss or degradation (Reference ESD narrative)
11. Compaction Layer	Extensive or strongly developed (thickness and density); may severely restrict root penetration and infiltrability.	Widespread or moderately to strongly developed (thickness and density); may greatly restrict root penetration and infiltrability.	Moderately widespread or moderately developed (thickness and density); may moderately restrict root penetration and infiltrability.	Not widespread or weakly developed (thickness and density); may weakly restrict root penetration and infiltrability.	No apparent compaction.
12. Live Plant Foliar Cover (hydrologic and erosion benefits) [2]	Less than 40% live foliar cover. Remaining is either dead standing material or bare ground.	40–60% live foliar cover. Remaining is either dead standing material or bare ground.	60–75% live foliar cover. Remaining is either dead standing material or bare ground.	75–95% live foliar cover. Remaining is either dead standing material or bare ground.	More than 95% live foliar cover. Remaining is either dead standing material or bare ground.
13. Forage Plant Diversity. Note: Legumes' adaptability based on what is expected for site in ESD.	Diversity severely lacking in comparison with site potential or with management objectives.	Low diversity in comparison with site potential or plant diversity not in accordance with management objectives.	Moderate diversity in comparison with site potential or plant diversity is not optimum with management objectives.	Diversity slightly decreased in comparison with site potential or plant diversity is somewhat lacking with management objectives.	High diversity of desirable forage plants in stand or plant diversity in full accordance with management objectives.
14. Percent Desirable Forage Plants (for identified livestock class)	Desirable forage species <20% dry weight.	Desirable forage species 20–40% dry weight.	Desirable forage species 40–60% dry weight.	Desirable forage species 60–80% dry weight.	Desirable forage species exceed 80% dry weight.

[1] Note: 60 percent cover has been shown to be the breakpoint for foliar cover where soil surface is relatively protected (Gifford, 1985; Thurow, 1991; Spaeth, et al., 2022).

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
15. Invasive Plants	Invasive species dominate the site.	Invasive species common throughout the site.	Invasive species scattered throughout the site.	Invasive species present in infrequent disturbed areas within the site.	Invasive species rare, except in very infrequently disturbed areas.
16. Production	Less than 20% of potential production. Considering recent weather conditions	21–40% of potential production. Considering recent weather conditions	41–60% of potential production. Considering recent weather conditions	61–80% of potential production. Considering recent weather conditions	Production >80% of potential. Considering recent weather conditions
17. Plant Vigor with an Emphasis on Reproductive Capability of Perennials	Plant reproduction or recovery after use is extremely reduced. Pale, yellow or brown, or severely stunted plants.	Plant reproduction or recovery after use is greatly reduced. Yellowish green forage, or moderately or slightly stunted plants.	Plant reproduction or recovery after use is moderately reduced. Adequate recovery. Yellowish and dark green areas due to manure and urine patches.	Plant reproduction or recovery is slightly-to-moderately reduced after use. Good recovery. Light green and dark green plants present	Plant reproduction or recovery is what is expected for the site. Rapid recovery. All healthy green plants.
18. Dead or Dying Plants or Plant Parts	Extensive mortality, dying plants or plant parts concentrated in one or more functional groups.	Widespread mortality, dying plants or plant parts concentrated in one or more functional groups.	Moderate mortality, dying plants or plant parts concentrated in one or more functional groups.	Occasional mortality, dying plants or plant parts concentrated in one or more functional groups.	No apparent mortality, dying plants, plant or plant parts.
19. Litter Cover and Depth	Accumulation of litter cover and depth, and decomposition extremely out of balance with current weather conditions.	Accumulation of litter cover and depth, and decomposition moderately-to-extremely out of balance with current weather conditions.	Accumulation of litter cover and depth, and decomposition moderately out of balance with current weather conditions.	Accumulation of litter cover and depth, and decomposition slightly out of balance with current weather conditions.	Accumulation of litter cover and depth, and decomposition as expected for the site, and with current weather conditions.

Indicators	Extreme-to-Total	Moderate-to-Extreme	Moderate	Slight-to-Moderate	None-to-Slight
20. Percentage Legumes [3]	If ES Altered Pasture State supports legumes, stands have less than 2% by weight or legume composition extremely out of balance with management objectives.	If ES Altered Pasture State supports legumes, stands have 2–5% by weight or legume composition moderately-to-extremely out of balance with management objectives.	If ES Altered Pasture State supports legumes, stands have 5–15% by weight or legume composition moderately out of balance with management objectives.	If ES Altered Pasture State supports legumes, stands have 15–30% by weight or legume composition slightly out of balance with management objectives.	If ES Altered Pasture State supports legumes, stands have 30–35% by weight or legume use in accordance with management objectives.
21. Uniformity of Use	Little-grazed or ungrazed patches where forage species are rejected cover over 50% of the area. Rejected patches are generally connected or uniform use due to overutilization.	Little-grazed or ungrazed patches where forage species are rejected cover 26 to 50% of the area. Patches are occasionally connected.	Little-grazed or ungrazed patches where forage species are rejected cover 10 to 25% of the area. Patches sporadically connected.	Light-grazed or ungrazed and unconnected patches where forage species are rejected are small and isolated (<10% cover). Urine and dung patches avoided.	Uniform grazing throughout pasture. Areas where forage species are rejected only present at urine and dung patches.
22. Grazing and Utilization Note: Utilization percentages can be temporarily adjusted in grazing rotation systems given that rest or deferment are planned.	Pasture severely overgrazed (>70% utilization), plant height continually below recommended graz. Ht. for spp. Livestock concentration areas > 10% of the pasture and can transport contaminated runoff directly into water channels unbuffered.	Pasture utilization 65–70%, plant height is continually below recommended graz. Ht. for spp. Livestock concentration areas and trails cover 5–10% of the area and drain into water channels unbuffered.	Pasture utilization 60–65%; current utilization is temporary and not representative of continual management. Isolated and unconnected livestock concentration areas and trails (<5% of area); can potentially drain into water channels unbuffered.	Pasture utilization 50–60%; plant height generally meets recommended graz. Ht. for spp. Some livestock trails and one or two small unconnected concentration areas.	Pasture utilization =<50%; plant ht. meets recommended graz.ht. for spp. No presence of livestock concentration areas or heavy use areas.

[3] Note: literature mentions maximum legume comp. at ≈ < 30-50 percent to minimize bloat potential (Canadian Agronomist, 2021; Forsythe, 2018; Wardynski, 2013; Montana State University , 2003; Gelley, 2018) Note: if bloating legumes dominate the stand, by weight, rating = Extreme to Total. Substantial risk to livestock with and without bloat prevention protocols.
Fields with high legume composition should be considered for hayland.

Appendix: Evaluation Sheet

Determining Indicators of Pasture Health Evaluation Sheet Part A

Evaluation Sheet ID (Landowner, Farm, ranch, etc.):		
Management Unit:		
Observer(s):	Date:	
Location		
Ecological Site ID and Code:		
Pasture State Narrative (Y/N):		
Soil Survey:	Map Unit:	Component:
Surface Soil texture:		
Position by GPS? Y/N:	Photos Taken? Y/N:	
GPS Location: Lat:	Long:	
Location Description:		
Office:	Pasture Size (ac):	
Size (ac) represented by DIPH sample:	No. samples needed:	
Criteria used to select evaluation area:		
History		
Land treatments or conservation practices applied:		
Resource Concerns:		
Stubble ht.:	Utilization %:	Haying history:
Historic Grazing Intensity (low, med, high):	Current Grazing Intensity (low, med, high):	
Grazing system:		
Land use history:		
Offiste influences on land:		
Natural Disturbances and time since (list):		
Evaluation Area description data		
Slope	Slope shape (concave, convex, linear)	
Elevation	Aspect	
Avg Annual Precipitation (in)	Precipitation range (in):	
Precip to date:	% of normal to date:	
Seasonal Climate notes:		
Dominant forage species and estimated composition:		
Supporting data		
Representative climate station:		
Foliar Cover (% composition): 0%	Ground Cover (%): 0%	
Bunchgrasses:	Bare Ground (%):	
Sod grasses:	Litter:	
Forbs:	Rock:	
Shrubs & Trees:	Biotic Crust:	
	Basal plant cover:	

Part B

DETERMINING INDICATORS OF PASTURE HEALTH EVALUATION SHEET								Page 1 of 2
Cooperator:						Conservationist:		
Evaluation Area:						Date:		
Dominant Soil:						Location:		

Departure from Expected	Code
None to Slight	N-S
Slight to Moderate	S-M
Moderate	M
Moderate to Extreme	M-E
Extreme to Total	E-T

Instructions for Evaluation Sheet:

(1) Assign indicator ratings. If indicator is not present, leave blank.
(2) In the four grids on page 2, write the indicator number in the appropriate column for each indicator that is applicable to the attribute.
(3) Assign overall rating for each attribute based on preponderance of evidence.
(4) Justify each attribute rating in writing.

	Indicators	Attribute				Rating	Notes
1	Erosion (Sheet and Rill)	SSS	HF				
2	Erosion (Gullies)	SSS	HF				
3	Erosion (Wind)	SSS	HF				
4	Erosion (Streambank) if present	SSS	HF				
5	Water-flow patterns	SSS	HF				
6	Bare Ground %	SSS	HF				
7	Pedestals and Terracettes	SSS	HF				
8	Litter movement	SSS	HF				
9	Effect on infiltration and runoff		HF				
10	Soil Surface loss or degradation	SSS	HF	BI			
11	Compaction Layer	SSS	HF	BI			
12	Plant Foliar Cover	SSS	HF				
13	Forage Plant Diversity			BI	LMQP		
14	% Desirable Forage Plants				LMQP		
15	Invasive Plants			BI	LMQP		
16	Production			BI	LMQP		
17	Plant Vigor w/ emphasis			BI			
18	Dead or Dying Plants/Parts			BI			
19	Litter cover and Depth		HF	BI			
20	% legume			BI	LMQP		
21	Uniformity of Use		HF	BI	LMQP		
22	Grazing and Utilization	SSS	HF	BI	LMQP		

Part B

DETERMINING INDICATORS OF PASTURE HEALTH EVALUATION SHEET

Soil & Site Stability (12)				
E-T	M-E	M	S-M	N-S
Overall Rating:				

Hydrologic Function (15)				
E-T	M-E	M	S-M	N-S
Overall Rating:				

Biotic Integrity (11)				
E-T	M-E	M	S-M	N-S
Overall Rating:				

Livestock Management Quality Factor (7)				
E-T	M-E	M	S-M	N-S
Overall Rating:				

Appendix: Case Study Example I (cool season plant species)

Photo 38 New England cool season pasture for case study 1.

Table 25 Determining Indicators of Pasture Health Evaluation Sheet for Case Study I Cool Season Plant Species**Photo 39** New England cool season pasture for case study 1.

General setting description

The setting for this case study depicted in Photo 34. Table 6 contains details gathered about the site during a field visit for conservation planning purposes, including a brief inventory plant species composition based on ocular estimation.

Soils

The Boothbay series consists of very deep, moderately well drained soils that formed in glaciolacustrine or glaciomarine deposits on lake plains and marine terraces. Estimated saturated hydraulic conductivity is moderately high in the surface and moderately high or moderately low in the subsoil and substratum. Slope ranges from 3 to 25 percent. Mean annual precipitation is about 1120 mm. Mean annual temperature is about 6 degrees C.

Table 26 Determining Indicators of Pasture Health Evaluation Sheet for Case Study I Cool Season Plant Species

Evaluation Sheet ID (Landowner, Farm, ranch, etc.):	Liberty Johnson				
Management Unit:	South forty				
Observer(s):	Sammy Soil		Date:	4-Jul-26	
Location					
Ecological Site ID and Code:	F143XY401 Clay				
Pasture State Narrative (Y/N):	STM model diagram but no narrative				
Soil Survey:	Lamiolle County	Map Unit:	234	Component:	Boothbay
Surface Soil texture:	Silt loam				
Position by GPS? Y/N:	Yes		Photos Taken? Y/N:	Yes	
GPS Location:	Lat:	119.324697	Long:	44.323661	
Location Description:	Across the road from the old barn by the tree where the dog was				
Office:	Franklinfield		Pasture Size (ac):	20	
Size (ac) represented by DIPH sample:	20		No. samples needed:	1	
Criteria used to select evaluation area:	Central location of the pasture, representative of the majority of				
acres in slope, aspect, grazing use, distance to water and shade					
History					
Land treatments or conservation practices applied:	Portable stockwater and fence				
Resource Concerns:	Plant community composition (inadequate diversity, lack of legumes)				
Residual (stubble) ht	5"	Utilization %:		Haying history:	none
Historic Grazing Intensity (low, med, high):	Med.		Current Grazing Intensity (low, med, high):	Med.	
Grazing system:	1 week use per paddock (~8 paddocks) during the 6 month grazing season				
Land use history:	Homesteaded in 1700's, some row crops and hay but only grazed now for decades				
Offiste influences on land:	none				
Natural Disturbances and time since (list):	none				
Evaluation Area description data					
Slope	5%		Slope shape (concave, convex, linear)	linear	
Elevation	950'		Aspect		
Avg Annual Precipitation (in)	40"		Precipitation range (in):	35-55"	
Precip to date:	19"		% of normal to date:	85%	
Seasonal Climate notes:	A cooler than normal spring has delayed intial growth and will effectively reduce				
the total production this year somewhat.					
Dominant forage species and estimated compositior	Orchardgrass 25%, Timothy 8%, Tall fescue 10%,				
Smooth brome 30%, Kentucky bluegrass 5%, Plantain 5%, Curly dock 1%, White clover 2%, Red clover 2%,					
Weedy spp. (mustard, sowthistle, bull thistle) 10%					
Supporting data					
Representative climate station	Burlington				
Foliar Cover (% composition):	98%		Ground Cover (%):	25%	
Bunchgrasses:	43%		Bare Ground (%):	2%	
Sod grasses:	15%		Litter:	20%	
Forbs:	40%		Rock:	0%	
Shrubs:	0%		Biotic Crust:	0%	
Trees:	0%		Basal plant cover:	5%	

Table 29 DIPH Evaluation Sheet for Case Study I Cool Season Plant Species, 1 of 2

DETERMINING INDICATORS OF PASTURE HEALTH EVALUATION SHEET							Page 1 of 2
Cooperator:	Liberty Johnson				Conservationist:	Sammy Soil	
Evaluation Area:	South Forty				Date:	July 4 2026	
Dominant Soil:	Boothbay				Location:	Franklinfield	
Departure from Expected	**Code**				**Instructions for Evaluation Sheet:**		
None to Slight	N-S				(1) Assign indicator ratings. If indicator is not present, rate N-S.		
Slight to Moderate	S-M				(2) In the three grids below, write the indicator number in the appropriate column for each indicator that is applicable to the attribute.		
Moderate	M				(3) Assign overall rating for each attribute based on preponderance of evidence.		
Moderate to Extreme	M-E				(4) Justify each attribute rating in writing.		
Extreme to Total	E-T						

	Indicators	Attribute				Rating	Notes
1	Erosion (Sheet and Rill)	SSS	HF			S-M	No evidence of past rills and gullies. Some rills in livestock trails and vehicle trail.
2	Erosion (Gullies)	SSS	HF			S-M	Old gullies near creek, drainageways vegetated with graminoids and stable
3	Erosion (Wind)	SSS	HF			N-S	No wind erosion observed
4	Erosion (Streambank) if present	SSS	HF				No shorelines or streambanks associated with field
5	Water-flow patterns	SSS	HF			S-M	Water flow patterns stable and vegetated
6	Bare Ground %	SSS	HF			N-S	Bare ground <2%.
7	Pedestals and Terracettes	SSS	HF			N-S	No pedestals observed in water flow channels
8	Litter movement	SSS	HF			N-S	No litter and mulch movement in water flow channels observed
9	Effect on infiltration and runoff		HF			S-M	Trend appears to be moving toward increased K. bluegrass, replacing bunchgrass, primarily orchardgrass. Sod forming species are associated with decreased infiltration
10	Soil Surface loss or degradation	SSS	HF	BI		S-M	Some surface soil and organic matter loss associated with past history of cultivation
11	Compaction Layer	SSS	HF	BI		N-S	Compaction observed, mostly along livestock trails, fencelines, gate areas
12	Plant Foliar Cover	SSS	HF			N-S	Plant foliar cover 98%, adequate for raindrops intercept & reducing overland flow
13	Forage Plant Diversity			BI	LMQF	S-M	Forage diversity declining from desirable bunchgrasses to more sod forming K. bluegrass. Increases in plantain and scattered thistles
14	% Desirable Forage Plants				LMQF	S-M	A transition is in progress shifting from bunchgrass to sodgrass. Weedy forbs such as mustards, sowthistle, prickly lettuce common and increasing in stand ≈ 10% foliar cover
15	Invasive Plants			BI	LMQF	S-M	Undesirable weedy forbs (plantain, mustards, sowthistle, prickly lettuce, bull thistle). Can be controlled by pest mgt.
16	Production			BI	LMQF	S-M	Potential annual production has decreased (≈ 30%) due to increasing composition of Kentucky bluegrass and weedy forbs
17	Plant Vigor w/ emphasis			BI		S-M	Vigor and composition of orchardgrass has diminished, and K. bluegrass gaining dominance in pasture
18	Dead or Dying Plants/Parts			BI		N-S	No evidence
19	Litter cover and Depth		HF	BI		N-S	Litter cover in bare ground areas, overall ground cover of litter is ≈ 5%
20	% legume			BI	LMQF	M	Legume composition <5%. Legumes' diversity reduced; dominant remaining legume is white clover. Area outside fence has higher legume composition and red clover.
21	Uniformity of Use		HF	BI	LMQF	N-S	Grazing distribution adequate
22	Grazing and Utilization	SSS	HF	BI	LMQF	N-S	Current pasture grazing levels are light

Table 32 DIPH Evaluation Sheet for Case Study I Cool Season Plant Species, 2 of 2

Soil & Site Stability (12)					Hydrologic Function (15)					Biotic Integrity (11)					Livestock Management Quality Factor (7)				
E-T	M-E	M	S-M	N-S	E-T	M-E	M	S-M	N-S	E-T	M-E	M	S-M	N-S	E-T	M-E	M	S-M	N-S
									22										
									21										
				22					19										
				12					12										
				11				10	11				17	22					
			10	8				9	8				16	21				16	
			5	7				5	7				15	19				15	
			2	6				2	6				13	18				14	22
			1	3				1	3			20	10	11			20	13	21
Overall Rating:			S-M		Overall Rating:			S-M		Overall Rating:			S-M		Overall Rating:			S-M	
Mixture of N-S and S-M. Overall rating S-M because of indicator concerns i.e., rilling in trails, past soil loss during cultivation and history of farming. Evidence of past rills and gullies but vegetated at present.					Mixture of N-S and S-M. Overall rating S-M because of past erosion (rilling, and old gullies, soil surface loss during farming history, inv. Plants) Some rilling in livestock trails and along vehicle trail.					Mixture of N-S and S-M with one moderate concern (% non-toxic legumes). Legume population is decreasing, especially red clover. Legumes' diversity reduced; dominant legume is white clover. Some Bull thistles scattered throughout, weedy spp. plantain, sow thistle, mustards, prickly lettuce. Grass comp. shifting from bunchgrasses to sodgrasses.					Salt placement by watering area. Livestock trails to watering area and along fence lines. Forage plant diversity could be improved by controlling undesirable weedy plants. Bunchgrasses are decreasing in stand, Kentucky bluegrass increasing in stand. SOM somewhat depleted from past cropping history and water erosion events.				

Summary

DIPH on this pasture showed that for the three attributes (soil and surface stability, hydrologic function, and biotic integrity), departure from expected reference conditions was none-to-slight to slight-to-moderate. Reconnaissance of the pasture clearly shows that foliar cover is high with a mixture of grasses and forb species. Litter was estimated at 20%, which provides further protection from raindrop impact and ameliorating the effect of runoff.

Total foliar cover on site is 98% and ground cover is 25%, with 2% bare ground (no foliar, no ground). Foliar cover of bunch grasses = 43%, sod forming grasses=15%, forbs=40%, and litter=20%.

Appendix: Case Study Example II (warm season plant species)

Photo 41 Southern states warm season pasture for case study II. Photo credit: Ken Spaeth, NRCS.

General Setting Description

The setting for this case study depicted in Photo 35. Table 9 contains details gathered about the site during a field visit for conservation planning purposes, including a brief inventory plant species composition based on ocular estimation. Producer recently purchased farm and wants to instigate a new management regime based on managed grazing specifications.

Soils

The Providence series consists of moderately well drained soils with a fragipan. Permeability is moderately slow. These soils formed in a mantle of silty materials, about 2 feet thick, and the underlying sandy and loamy sediments. They are nearly level to moderately steep soils in uplands and on-stream terraces of the Southern Coastal Plain (133A) and the Southern Mississippi Valley Loess (MLRA 134) Major Land Resource Areas. Slopes range from 0 to 15 percent.

Table 35 Determining Indicators of Pasture Health Evaluation Sheet for Case Study II Warm Season Plant Species

Evaluation Sheet ID (Landowner, Farm, ranch, etc.):	Owen lars				
Management Unit:	Big Pasture				
Observer(s):	Sammy Soil		Date:	4-Jul-26	
Location					
Ecological Site ID and Code:	F134XY105MS Southern Rolling Plains Loess Fragipan Upland				
Pasture State Narrative (Y/N):	Yes narrative for Community 3.1 Pasture				
Soil Survey:	Carroll County, MS	Map Unit:	PrD3	Component:	Providence
Surface Soil texture:	Silt loam				
Position by GPS? Y/N:	Yes		Photos Taken? Y/N:	Yes	
GPS Location:	Lat:	106.54332	Long:	40.43356	
Location Description:	Down from the shed in the big field where the trees are				
Office:	Carrollton		Pasture Size (ac):	35	
Size (ac) represented by DIPH sample:	35		No. samples needed:	1	
Criteria used to select evaluation area:	Central location of the pasture, representative of the majority of				
acres in slope, aspect, grazing use, distance to water and shade					
History					
Land treatments or conservation practices applied:	None				
Resource Concerns:	Invasive species, erosion				
Residual (stubble) ht	2"	Utilization %:		Haying history:	none
Historic Grazing Intensity (low, med, high):	high		Current Grazing Intensity (low, med, high):	high	
Grazing system:	Continuous				
Land use history:	Homesteaded in 1880's, grazed now for decades				
Offiste influences on land:	none				
Natural Disturbances and time since (list):	none				
Evaluation Area description data					
Slope	5%		Slope shape (concave, convex, linear)	convex	
Elevation	400'		Aspect		
Avg Annual Precipitation (in)	54"		Precipitation range (in):	50-60"	
Precip to date:	22"		% of normal to date:	100%	
Seasonal Climate notes:	Recovering from a mild drought, this year was the 21st wettest year to date				
over the past 130 years					
Dominant forage species and estimated composition:	Bermuda grass 40%, Bahia grass 15%,				
Dallis grass 2%, Foxtail 2%, Annual rye 5%, Tall fescue 2%, Curly dock 2%, Henbit 2%, Musk thistle 2%,					
Buckhorn plantain 2%, Multiflora rose 1%, Blackberry 2%, Eastern red cedar 5%,					
Supporting data					
Representative climate station	Burlington				
Foliar Cover (% composition):	82%	Ground Cover (%):	25%		
Bunchgrasses:	9%	Bare Ground (%):	18%		
Sod grasses:	57%	Litter:	20%		
Forbs:	8%	Rock:	0%		
Shrubs & Trees:	8%	Biotic Crust:	0%		
		Basal plant cover:	5%		

Table 38 DIPH Evaluation Sheet for Case Study II Warm Season Plant Species, 1 of 2

Cooperator:	Owen Lars	Conservationist:	Sammy Soil
Evaluation Area:	Big Pasture	Date:	7/4/2026
Dominant Soil:	Providence	Location:	Carrollton

Departure from Expected	Code
None to Slight	N-S
Slight to Moderate	S-M
Moderate	M
Moderate to Extreme	M-E
Extreme to Total	E-T

Instructions for Evaluation Sheet:

(1) Assign indicator ratings. If indicator is not present, rate N-S.
(2) In the three grids below, write the indicator number in the appropriate column for each indicator that is applicable to the attribute.
(3) Assign overall rating for each attribute based on preponderance of evidence.
(4) Justify each attribute rating in writing.

	Indicators	Attribute				Rating	Notes
1	Erosion (Sheet and Rill)	SSS	HF			M	Current rills and gullies active. Rills forming from livestock trails and along vehicle trail.
2	Erosion (Gullies)	SSS	HF			M	Gullies near creek, excessive upland runoff. Gullies expanding
3	Erosion (Wind)	SSS	HF			N-S	No wind erosion observed
4	Erosion (Streambank) if present	SSS	HF			M	Active sloughing and downcutting. Hydrology of riparian system moderately altered.
5	Water-flow patterns	SSS	HF			M	Lengths and/or widths moderately higher than expected. Minor to moderate erosional and depositional areas. Infrequently
6	Bare Ground %	SSS	HF			M	Bare ground 18% and excessive
7	Pedestals and Terracettes	SSS	HF			M	Plant pedestals observed in water flow channels. Terracettes forming on side slopes form livestock trailing.
8	Litter movement	SSS	HF			M	Litter and mulch movement in water flow channels observed
9	Effect on infiltration and runoff		HF			M	Trend appears to be moving toward increased undesirable weedy grasses and forbs. See foliar cover estimate table.
10	Soil Surface loss or degradation	SSS	HF	BI		M	Surface soil loss visible on side slopes.
11	Compaction Layer	SSS	HF	BI		M	Compaction observed, predominant along livestock trails, watering areas, fencelines, gate areas
12	Plant Foliar Cover	SSS	HF			M	Plant foliar cover about 82%. Plant height and cover is not adequate for interception of raindrops and reducing overland
13	Forage Plant Diversity			BI	LMQF	M	Forage diversity is declining from desirable species. Bermuda grass appears stressed from overgrazing. Weedy forbs
14	% Desirable Forage Plants				LMQF	M	A transition is in progress and shifting from desirable warm season grasses (Bermuda and Bahia grass) to weedy grasses
15	Invasive Plants			BI	LMQF	M	Undesirable weedy forbs, shrubs, and tree species (≈16%).
16	Annual Production			BI	LMQF	M-E	Potential annual production has decreased (≈ 50%) due to increasing composition of weedy grasses and forbs.
17	Plant Vigor w/ emphasis			BI		M-E	Vigor and composition of bermudagrass severely diminished.
18	Dead or Dying Plants/Parts			BI		M	Moderate mortality and/or dying plants/plant parts of desirable plants
19	Litter cover and Depth		HF	BI		M-E	Accumulation of litter cover and depth, and decomposition mod-to-extremely out of balance with phenology status
20	% non-toxic legume			BI	LMQF		Southern pasture climates not conducive to sustaining legumes
21	Uniformity of Use		HF	BI	LMQF	M	Little-grazed patches where forage species are rejected cover 26 to 50% of the area. Patches are occasionally connected.
22	Grazing and Utilization	SSS	HF	BI	LMQF	M-E	Utilization heavy ≈ 75%

Table 41 DIPH Evaluation Sheet for Case Study II Warm Season Plant Species, 2 of 2

Soil & Site Stability (12)					Hydrologic Function (15)					Biotic Integrity (11)					Livestock Management Quality Factor (7)				
E-T	M-E	M	S-M	N-S	E-T	M-E	M	S-M	N-S	E-T	M-E	M	S-M	N-S	E-T	M-E	M	S-M	N-S
							21												
							12												
		12					11												
		11					10												
		10					9												
		8					8												
		7					7					21							
		6					6					18							
		5					5				22	15					21		
		4					4				19	13					15		
		2				22	2				17	11				22	14		
	22	1		3		19	1		3		16	10				16	13		
Overall Rating:		M			Overall Rating:		M			Overall Rating:		M-E			Overall Rating:		S-M		
Predominantly M rating. Active erosion is apparent based on sheet and rill, gully, and streambank. Conduct RHEM model to evaluate current runoff and erosion and risk from design storm events.					Predominantly M rating with 2 M-E. Hydrologic function is impaired, water balance changes are significant as runoff is excessive, and evaporation of water is much higher than reference conditions. Conduct RHEM model to evaluate current runoff and erosion and risk from design storm events.					Mixture of M to M-E. Significant management changes are needed immediately to offset increase in invasive plant species. Brush management is needed as blackberry and eastern red cedar are encroaching. Primary forage species shows significant stress and overgrazing.					M to M-E. Major grazing management changes are needed to maintain site stability and productivity. Livestock performance will ultimately decline.				

Overall, the pasture has major problems with respect to SSS, HF, BI, and LMQF. Informed producer that some thresholds have been crossed for SSS, HF, and BI and complete restoration to near reference conditions is not possible. Significant changes in management can help stabilize these three DIPH assessments with managed grazing, weed and pest management applications.

Table 10 and Table 11 are examples of completed field evaluation and determination of preponderance of evidence for the three assessments.

Summary

(1) Soil and Site Stability

Some of the key erosion indicators such as sheet and rill, gully, and streambank erosion were rated at moderate departure. Rills moderate in number at infrequent intervals. Moderate rill width, depth, and length. Occur mostly in exposed areas, and steeper slopes. Bare ground is 18%, which is significantly higher compared to a reference condition of Bermuda grass composition in this climate regime. Significant soil loss has and is occurring on this field. Active gullies near creek drainage areas due to excessive runoff on upland slopes. Plant pedestals and terracettes common throughout pasture. Areas of this pasture have exceeded stable ecological thresholds. Soil loss has and is excessive, and a decreasing trend and transition to other less desirable pasture states will continue without significant changes in managed grazing.

(2) Hydrologic Function

Same indicators as above: Some of the key erosion indicators such as sheet and rill, gully, and streambank erosion are active. Rills moderate in number at infrequent intervals. Moderate rill width, depth, and length. Occur mostly in exposed areas, and steeper slopes. Water flow paths are numerous and exacerbated compared to reference conditions. Plant pedestals and terracettes common throughout pasture. Hydrologic capacity is significantly reduced due to high runoff and erosion on pasture. Available effective water is significantly reduced and is reflected by lower forage production. Compaction due to heavy grazing.

Weedy species or invasive plants are increasing in stand, which are competitive with desirable forage grasses (Bermuda grass, Bahia grass). Invasive shrub/trees are increasing in pasture (Eastern red cedar, blackberry). Brush management and pest management of undesirable weedy and invasive species is needed, as the trend of these species is increasing.

(3) Biotic Integrity

Mixture of M to M-E. Significant management changes are needed immediately to offset increase in invasive plant species. Brush management is needed as blackberry and eastern red cedar are encroaching. Primary forage species shows significant stress and overgrazing.

Weedy invasive species increasing in stand and affecting overall potential production. Due to invasive weedy species, forage production diversity, % desirable plants, and plant vigor are M to M-E departure.

Annual forage production has been compromised and has decreased from average potential (≈ 50%) due to overgrazing, erosion, changes in water balance, and invasion of weedy plant species.

DIPH on this pasture showed that for the three attributes (soil and surface stability, hydrologic function, and biotic integrity), departure from expected reference conditions was moderate to moderate-to-extreme. Reconnaissance of the pasture clearly indicates that accelerated and greater amounts of runoff are active, which has resulted in gullies in the drainage channel. From visual inspection, sheet and rill erosion is active. Water flow paths are numerous, and some are scoured with little vegetation and bare ground exposed.

(4) Livestock Management Quality Factor

Heavy grazing intensity with continuous use has resulted in patchy use patterns, decreased production, decline in desirable forage species, and encroachment by invasive plants. Management changes are necessary to reverse the trends toward these degraded conditions.

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