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Understanding Ecological Sites

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Introduction

Today, land managers are challenged with synthesizing an overwhelming amount of scientific information concerning soils, hydrology, ecology, management, etc. Discrete and arbitrary land ownership boundaries with differences in regulations (or lack of regulations) will often dictate the management goals and objectives for our rangelands (Table 1). Adding to this complexity, natural systems seldom have distinct boundaries with respect to either space or time; therefore, managing landscapes have a certain amount of variability and uncertainty.

Ecological sites are a conceptual landscape classification system used to interpret potential across the landscape. The fundamental assumption of ecological sites is that landscapes can be grouped with sufficient precision to increase the probability of success of site-specific predictions, decisions, and management actions (USDA-NRCS, 2011). Ecological sites incorporate abiotic and biotic environmental factors such as climate, soils and landform, hydrology, vegetation, and natural disturbance regimes that together define the site. Each ecological site is identified, differentiated, and described based on the relationships among these environmental factors and how they influence plant community composition and other environmental processes.

Ecological site concepts are important to understand because they can influence the success or failure of a management action or affect the types of ecosystem services or benefits that are provided by a land area (Bestelmeyer and Brown, 2010). Any inventory, monitoring, analysis and assessment of rangeland monitoring data require the knowledge of these individual ecological sites and their interrelationships to one another on the landscape (USDA-NRCS, 2008).

Table 1. Approximate percent of land ownership in Arizona.

Private	18
Federal	42
State	13
Tribal	27

Classifying the Landscape

Classification systems are used in almost everything. One of the most notable systems is the Linnaean system for classifying living things: Kingdom, Phylum, Class, Order, Family, Genus and Species. The hierarchal Linnaean system not only conveys information about a particular species, but also information about its closest relatives. The Natural Resource Conservation Service (NRCS) has a similar hierarchal system for classifying landscapes (Figure 1).

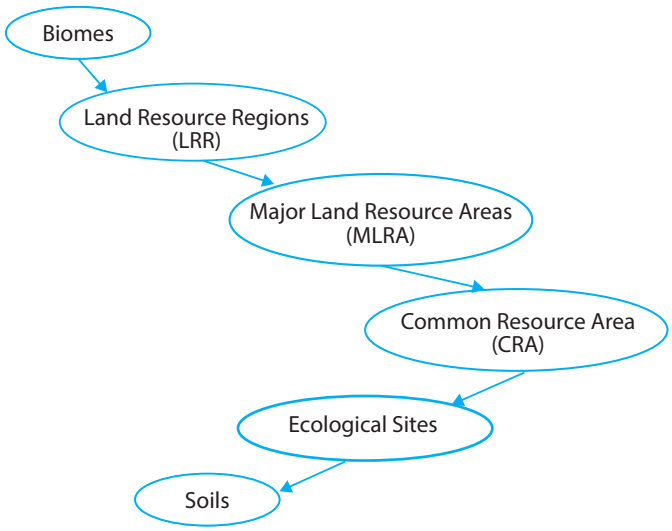

Figure 1. USDA NRCS Landscape Classification Categories

Biomes are large naturally occurring communities of flora and fauna occupying a major habitat. Some examples of major biomes include the desert, grasslands, forests, and tundra. Climate and geography determine what type of biome can exist in an area (Figure 2). Each biome consists of many different ecosystems where plant and animal communities have adapted to smaller differences in climate, geographic features and soils within the biome.

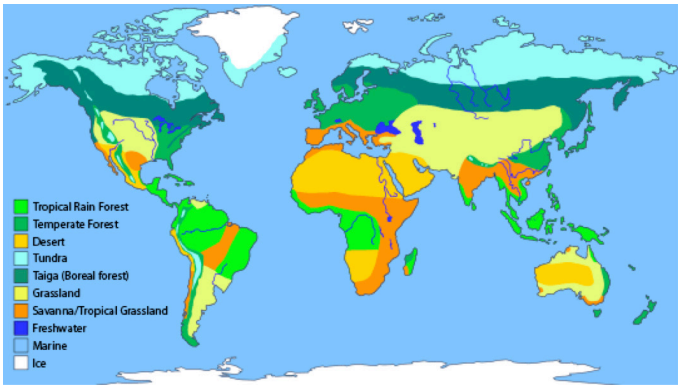

Figure 2. Biomes of the World. Used with permission from https://askabiologist.asu.edu/explore/biomes

Next on the landscape classification hierarchy are Land Resource Regions (LRRs). The NRCS delineates LRRs based on broad agricultural market regions. Many of these agricultural areas are remarkably similar to major geographic ranges such as the Basin and Range region of the southwest. LRRs are further classified into Major Land Resource Areas (MLRAs) and Common Resource Area (CRAs).

MLRAs often include the dominant physical and climate characteristics of the area and are important in statewide agriculture planning. CRAs are sub-units of MLRAs and are typically distinguished by resource concerns, soil groups, hydrologic units, resource use, topography, other landscape features, and human considerations affecting use and treatment needs (USDA-NRCS, 2006). The MLRAs and associated CRAs for Arizona can be seen in Figure 3. Finally, the landscape classification system delineates between ecological sites and soils. These are the genus and species of our landscape classification system.

Ecological Sites

An ecological site is defined as a kind of land with specific physical characteristics which differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its response to management actions and natural disturbances (Task Group, 1998). Ecological sites divide the landscape into manageable units that provide a standard reference for land management, research and monitoring (Karl and Herrick, 2010).

A fundamental concept of ecological sites is their direct linkage to soil types, specifically the soil map unit components of the National Cooperative Soil Survey. Ecological sites can be accurately delineated even when displaying a variety

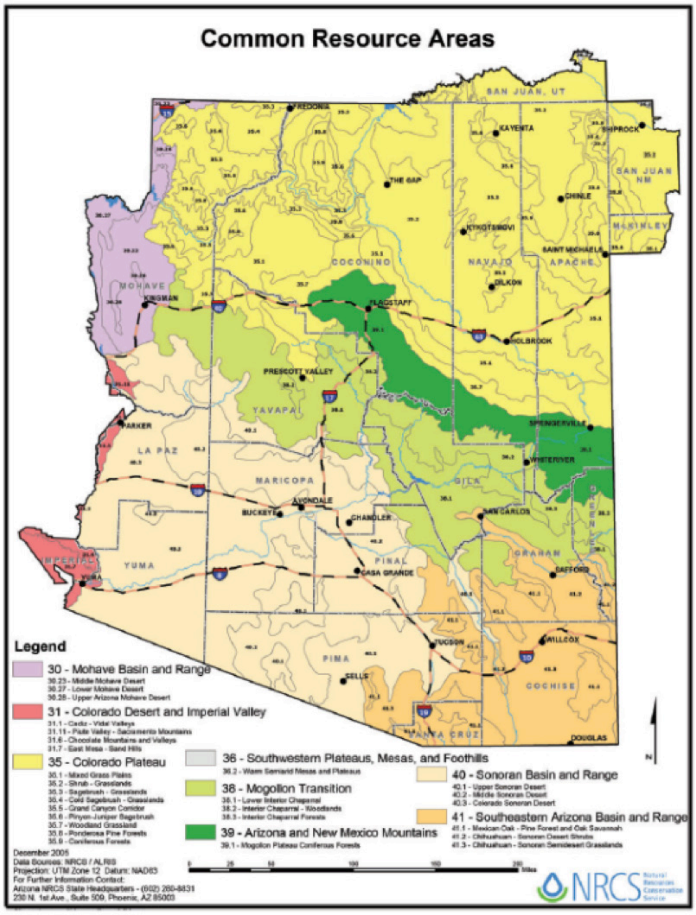

Figure 3. Arizona Major Land Resource Areas (MLRA) and Common Resource Areas. USDA-NRCS, 2006. Major Land Resource Area (MLRA)

of vegetation communities resulting from past and current disturbances (Photos 1, 2, and 3). Vegetation communities can offer a clue as to what ecological site occurs in an area, but sites can only be definitively delineated through the link of soil map unit components (USDA-NRCS, 2016).

The sites shown in Photos 1, 2, and 3 have different vegetation composition but they all reside on a "Loamy Upland 41-3, 12-16" PZ" ecological site. By knowing the location, precipitation zone (PZ), and working with the classification system through an ecological site dichotomous key, ecological sites can be identified.

Location alone can narrow the search down to MLRA. Photos 1 , 2, and 3 are located in southeast Arizona. Using Figure 3 and knowing the location of photos 1, 2, and 3, puts the site in the Southeastern Arizona Basin and Range MLRA 41. Photo 1 averages approximately 16 inches of precipitation annually, which conservatively puts it in the 12-16" PZ where the Chihuahuan – Sonoran Semidesert Grasslands CRA 41-3 is found.

MLRA and CRA are important because a site can have different potential with similar precipitation regimes. For example, the reference vegetation community for the 41-3,

Photo 1. Loamy Upland 41-3, 12-16" PZ dominated by a blue grama vegetation community.

Photo 2. Loamy Upland 41-3, 12-16" PZ dominated by a Lehmann lovegrass vegetation community.

Photo 3. Loamy Upland 41-3, 12-16" PZ dominated by a mesquite/annual vegetation community.

12-16" PZ Loamy Upland in the Southeastern Arizona Basin and Range MLRA is dominated by a variety of warm season perennial grasses. Comparatively, in the Colorado Plateau MLRA Pinyon-Juniper-Sagebrush CRA 35-6, 13-17" PZ Loamy Upland is a forestland site (described below). The reference vegetation community for this site is dominated by juniper, sagebrush and blue grama. The seasonal distribution of precipitation and the temperature regimes differ significantly between these two MLRAs and result in very different vegetation communities.

As stated above, ecological sites are linked to soils. Soil properties such as parent material, soil horizon depth, texture, etc. will determine the ecological site. NRCS provides dichotomous keys listing and describing these soil properties that can guide you to the appropriate ecological site (Figure 4).

MLRA-LRU 41-1, 16"-20" P.Z, ECOLOGICAL SITE KEY*

I. Flooded (bottom position, flooded from the valley-side or over-bank)

A. Soils with a water table available to plant community
  1. Soils with a perennial high water-table (3-15 ft.)
    a) Soils sandy and with redox features – Sandy Bottom, woodland (F041XA113AZ)
    b) Soils loamy to clayey with redox features - Loamy Bottom Cienega (R041XA119AZ)
  2. Soils with seasonal (summer) water table (3-15 ft.) – Loamy Bottom (R041XA114AZ)

B. Soils without a water table available to plant community
  1. Soils sandy - Sandy Wash, woodland (F041XA112AZ)
  2. Soils sandy loam to clay loam - Loamy Swale (R041XA115AZ)

II. Not Flooded (upland position, receives only precipitation)

A. Gently sloping terrain (slopes predominantly <15%)
  1. Soils Shallow (≤20" depth)
    a) Soils calcareous - Limy Upland (R041XA105AZ)
    b) Soils non-calcareous - Shallow Upland (R041XA117AZ)
  2. Soils moderately deep to deep (>20" depth)
    a) Soils calcareous - Loamy Upland, Limy (R041XA116AZ)
    b) Soils non-calcareous in upper 10 inches
      (1) Soils without an argillic horizon - Deep Sandy Loam Upland (R041XA127AZ)
      (2) Soils with an argillic horizon
        (a) Soils with sandy loam surface 4 in. or thicker - Sandy Loam Upland (R041XA110AZ)
        (b) Soils with sandy loam surface <4 in. or loam surface - Loamy Upland (R041XA108AZ)
        (c) Soils with clay loam surface (not vertic) - Clay Loam Upland (R041XA109AZ)
        (d) Soils with a clayey surface (vertic) - Clayey Upland (R041XA126AZ)

B. Steeply sloping terrain (slopes predominantly ≥15%)
  1. Soils shallow (≤20" depth)
    a) Soils calcareous - Limestone Hills (R041XA103AZ)
    b) Soils non-calcareous
      (1) Soils over granite, schist, gneiss, rhyolite (acid igneous) - Shallow Hills (R041XA102AZ)
      (2) Soils over basalt, andesite, welded tuff (basic igneous) - Volcanic Hills (R041XA111AZ)
  2. Soils moderately deep and deep (>20" depth)
    a) Soils calcareous throughout - Limy Slopes (R041XA104AZ)
    b) Soils non calcareous in the upper 10 inches
      (1) Surface & subsurf.soils are loamy (course textured) - Loamy Slopes (R041XA107AZ)
      (2) Surface loamy or clayey, clayey subsurface (fine particle size) - Clayey Slopes (R041XA118AZ)

Figure 4. Example of a NRCS dichotomous key for MLRA 41-1.

Ecological Site Descriptions

Ecological site descriptions (ESDs) are a guide for providing detailed information on a specific ecological site. ESDs provide information describing the interrelationships among soils, vegetation and land management. The guides can assess the current condition of resources and aid in management expectations to help determine appropriate management goals. The NRCS presents ESD information in four major categories.

The first category describes the site characteristics; it identifies the site and describes the physiographic, climate, soil and water features associated with the site. Physical factors include soils, climate, hydrology, geology and physiographic features such as elevation, slope, etc.

The second category describes the plant communities; it describes the ecological dynamics and common plant communities comprising the various vegetation states. An

ecological site may support several different plant community types at different locations or times. These plant communities may differ in species composition, life forms or other attributes. Perhaps one of the most useful tools in ESDs are State-and-Transition Models (STMs). The disturbances that cause a shift from one state to another are presented within the STM framework.

The third category includes interpretive information pertinent to the use and management of the site. This section records information about the animal community, hydrology function, recreational use, wood and other usable products, and management. Finally, the fourth category provides sources of information and data utilized in developing the site description and the relationship of the site to other sites.

Which ESD Do I Use?

Two types of Ecological Sites are recognized, Forestland sites and Rangeland sites. A Forestland is described as a site where a 25% overstory canopy dominated the Reference Plant Community (see next section for explanation). A Rangeland site is an area where the overstory tree production was not significant in the Reference Plant Community (USDA-NRCS, 2016).

A first step in deciding which ESD to use would be contacting your local NRCS representative as it is an NRCS product. Since ecological sites are directly related to soils, resources such as a soil survey or the interactive Web Soil Survey (http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm) would also be a good starting point. An Ecological Site Specialist, Range Specialist or your local Natural Resource Extension Agent are people that could help you find the correct ESD. The NRCS also provides dichotomous keys that can guide you to the proper ESD (example Figure 4). Lastly, the ecological site must be ground-truthed to verify you are using the correct ESD.

Using Ecological Site Descriptions

ESDs are a guide and should be used as such. An ecological site may support several different plant community types at different locations or times. These plant communities may differ in species composition, life forms, or other attributes. ESDs are a guide to help inform land managers of historical, current, and potential conditions on rangelands. It is important to keep in mind there can be a great deal of variation in vegetation potential within an ESD given the range in precipitation from 12-16". After all, 16" is 33% more than 12", and yet they are lumped within the same ecological site. Similarly, Photo 3 averages approximately 12" of precipitation. When using ESDs, it would be advisable to examine the suite of descriptions (CRAs) for each ecological site to determine if a wetter CRA (i.e. 16-20" PZ) or drier CRA (8-12" PZ) is a more appropriate application, particularly in transition zones or during drought conditions. Through this context, land managers can be more realistic with respect to the goals and objectives of their plan.

ESDs use a Reference Community as a baseline to describe the variability across the ecological site. The Reference Community for a site in the United States is the plant community that existed at the time of European immigration and settlement. Natural disturbances such as drought, fire, and grazing of native fauna were inherent in the development and maintenance of these plant communities. The effects of these disturbances are part of the range of characteristics of the site that contribute to fluctuations in plant community structure and composition. The Reference Community of an ecological site is not a precise assemblage of species. In all plant communities, variability is apparent in composition and productivity of individual species. Natural disturbances are accounted for as part of the range of characteristics for an individual ESD (USDA-NRCS, 2016).

Often, existing vegetation communities differ from the reference or Historic Climax Plant Community (HCPC). If the goal is to return the landscape to the HCPC, land management agencies often use a Similarity Index to measure the departure from the HCPC. The purpose for determining Similarity Index is to describe the extent and direction of changes that have taken place on a site from its original characteristics or condition. However, a more appropriate method to describe departure and direction from a HCPC is through State and Transition Models.

State and Transition Models (STMs) are conceptual theories about how plant communities change over time (Figure 5). STMs describe the dynamics of vegetation and management interactions associated with each ecological site. STMs identify different vegetation states that can exist on a site, describe the disturbances that cause vegetation change, and restoration activities needed to restore plant communities (USDA-NRCS, 2011). By using STMs managers can predict with a higher probability what changes could occur from implementing various land management decisions and strategies.

Again, using Photos 1 and 2 as an example, the two photos are the same site taken in 1988 and 1996, respectively. From the photos one can conclude the site has or is currently transitioning from a blue grama (*Bouteloua gracilis*) dominated site to a Lehmann lovegrass (*Eragrostis lehmanniana*) dominated site. From Figure 5 we can see we have or are in the transition from the HCPC stable state (blue) to an alternative state (red). Natural disturbance or management actions that transition a vegetation community from one state to another are also described (green). Transition 1a describes the process as thus: "Proximity to seed source, introduction of seeds, possibly management related to perennial grass cover." Transition 1b describes the management actions needed if the goal is to return to the HCPC. Unfortunately, in this case the management action is unknown, noting that herbicide treatments may remove perennial exotics.

Related to STMs and plant production, it is important to know the soil stability of a site. Soil is the most important and most basic physical resource on rangelands. Avoidance of accelerated soil erosion due to land management practices should be a goal. ESDs provide information about how much and the type of ground cover each site should provide. If excessive soil is lost, the potential of the site to transition to a less desirable community is greater because it is no longer capable

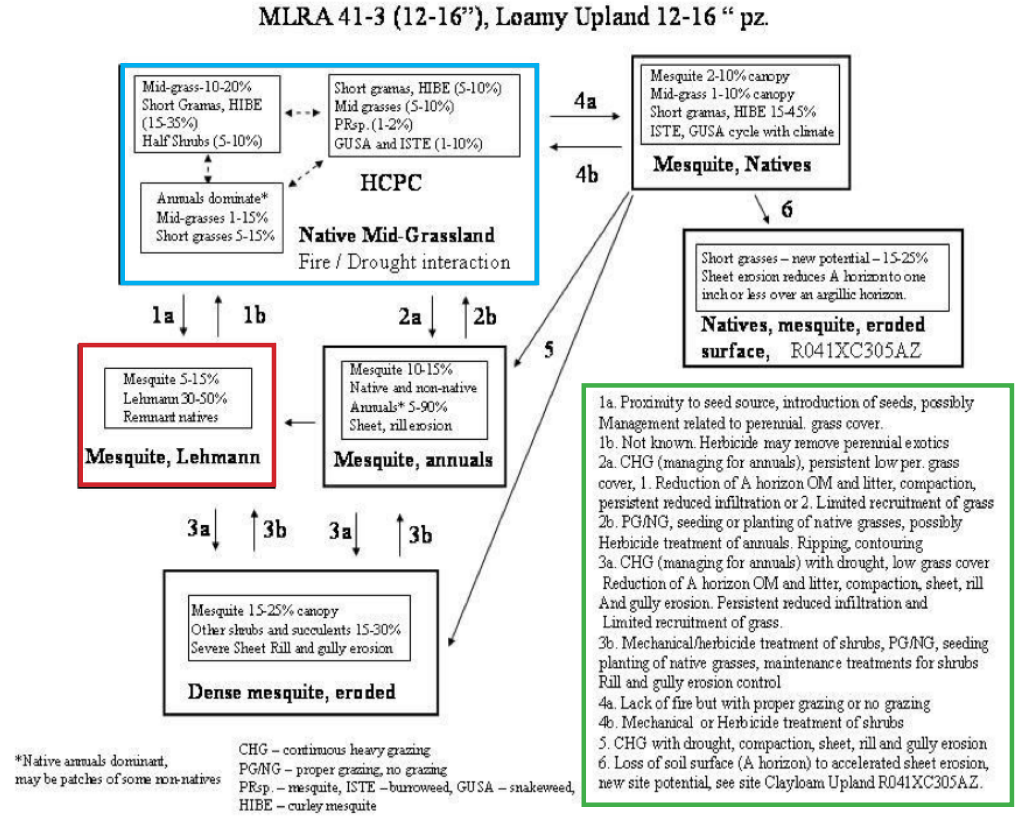

Figure 5. State and Transition Model for MLRA 31-3, 12-16" PZ, Loamy Upland

of supporting the types and amounts of plant communities it once produced. For example, if a site has more bare ground than the range listed in the ESD, the site has an elevated risk of accelerated erosion.

If a departure from the desired plant community has occurred and restoration is a land management goal, the species list described in the ESD may also be used as a starting point to develop a seed mix for rangeland rehabilitation. After a disturbance, natural or otherwise, seeding projects are often included to facilitate rehabilitation. Matching seed mixes to the species list, including proportions of seed, may increase the success of the rehabilitation effort.

Summary

Ecological sites are a land classification system. They incorporate abiotic and biotic relationships that divide the landscape into manageable units. A fundamental concept of ecological sites is their direct link to soils. It is important to remember ESDs are a guide and should be used accordingly. ESDs can be used to interpret potential across the landscape and increase the probability of successful site-specific land management decisions and actions. Other uses for ESDs include rating the landscape through a Similarity Index, evaluating the landscape for risk of accelerated erosion, and developing seed mixes for rehabilitation projects. STMs are particularly useful for evaluating what state the landscape is currently in as well as potential and management actions that can move the vegetation community into a different state

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