

# The Development of Landscape-Scale Ecological Units and Their Application to the Greater Huachuca Mountains Fire Planning Process

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**Abstract**—The multi-partner Greater Huachuca Mountains fire planning effort involves over 500,000 acres of public and private lands. This large area supports distinct landscapes that have evolved with fire. Utilizing GIS as a tool, the United States Forest Service (USFS), General Ecosystem Survey (GES), and Natural Resources Conservation Service (NRCS) State Soil Geographic Database (STATSGO) maps were refined using digital elevation model derived data, geology maps, existing vegetation maps, and expert knowledge. The resulting seamless map coverage will help define and characterize fire management units. It stratifies the planning area into distinct units suitable for modeling landscape-scale historical fire regimes and determining current condition classes.

## Introduction

Landscape-scale ecological units, such as landtype associations (LTAs), have been mapped and used successfully to address numerous resource concerns. A recent conference held in Madison, Wisconsin, was devoted to their development and use in natural resource management, planning, and research (Smith 2002). A number of States, mostly in the Eastern United States, have or are in the process of developing seamless LTA coverages. A good example is the state of Missouri (Nigh 2002). These products have proven to be an excellent context for interpreting historical vegetation and fire regimes relative to current conditions.

LTAs represent the landscape level of a scale-dependent hierarchy described in the National Hierarchical Framework of Ecological Units (Cleland 1997). Within southeastern Arizona, LTAs are nested within subsections comprised of large mountain ranges, mountain range complexes, and valleys. They reflect local influences of geologic materials, geomorphic processes, and climatic characteristics that are expressed as distinct topographic, soil, and vegetation patterns.

Landscape-scale ecological units were mapped to provide an ecological context for the Greater Huachuca Mountains fire planning process. These units were derived by applying expert knowledge, spatial modeling techniques, and field validation. Spatial data layers used include USFS General Ecosystem Survey (GES), NRCS State Soil Geographic Database (STATSGO) maps, digital elevation model derived data, geology and current vegetation maps. A geographic information system was used to define spatial relationships between the various spatial coverages and to create digital elevation model

derived information, such as shaded hillside relief, aspect maps and the elevation ranges and means for the units. They constitute an interim product developed by applying the mapping concepts used to formulate LTAs. Additional refinement and characterization, as well as additional peer review, is needed for these units to meet LTA standards.

In addition to providing benefits to the fire planning process, these units may serve as a valuable prototype for the future development of LTAs in southeastern Arizona and Sonora, Mexico. LTAs and similar map products also provide landscape-scale context to: (i) evaluate and address natural resource conservation issues, (ii) assess and monitor the status of key ecological processes such as fire regimes and ecological patterns, (iii) stratify landscapes for monitoring and inventory purposes, (iv) facilitate improved communication and collaboration among land managers and partners, and (v) help define feasible ranges of desired conditions to be achieved through collaborative planning and land management. In the Northern Region of the U.S. Forest Service, landtype associations are being used to develop landscape character descriptions and to map scenic attractiveness for the their Scenery Management System (personal communication with Larry Blocker, Regional Landscape Architect, Missoula, MT).

## The Units and Their Application to the Fire Planning Process

Interim landscape-scale units were developed to provide an ecological context for the Greater Huachuca Mountains (GHM) fire planning process. The GHM Fire Management Group involves a number of land managers, including Arizona

State Parks, Arizona State Lands, Audubon Research Ranch, Coronado National Forest, Coronado National Memorial, Fort Huachuca, The Nature Conservancy, the San Pedro Riparian National Conservation Area (Bureau of Land Management), and private ranches. A separate paper in these proceedings (Gebow and Lambert) describes the current progress of this planning effort.

The initial step in the mapping process was to identify and compile relevant data that might be useful in developing a seamless coverage for the half million acre planning area. Such data included spatial layers critical to defining landscape unit mapping criteria and boundary placement. Of equal importance was local knowledge and data related to current vegetation structure and composition, fuel conditions and trends, fire occurrence and behavior, historical fire regimes, and erosion events. To no one's surprise we encountered relevant spatial coverages of varying scales, vintage, and reliability. Simply overlaying this assemblage of data layers would have provided a relatively meaningless map with confusing polygons and "slivers." We elected instead to assess the individual coverages and attempt to understand how the layers related to each other; in other words, we tried to determine linkages between layers and, if they seemed in conflict, identify the nature and cause of the discrepancy. For example, differences in mapping scale and delineation criteria were often problematic on the surface but could be addressed more effectively once they were recognized and understood. GIS was also used to construct and characterize the units. Unit formulation was an interactive process utilizing existing data layers, expert input, field validation, and feedback from the fire planning group. The units were delineated to represent land areas that were relatively consistent in terms of geologic material, landform, and vegetation patterns. The USFS General Ecosystem Survey and NRCS STATSGO mapping on other ownerships, mapped at a scale of 1:250,000, provided us with an excellent preliminary base map. The mapping units were described utilizing existing data, such as soil survey information, GIS generated data, local knowledge, and field observations.

Twelve interim landscape scale ecological units are currently mapped, and have been individually field validated, in the planning area. Several more may be established following additional refinement. They are named based on their assumed historical vegetation and landform(s).

Table 1 list the units and illustrates how they relate to fire regime and condition classes on a landscape basis. "Historical" vegetation assumptions and fire regime condition classes in table 1 are estimated for the landscapes of each interim ecological unit based on local knowledge and expert opinion.

Figure 1 displays the interim ecological units in relation to the local topography and roads. Detailed narrative map unit descriptions are being developed that more fully describe their characteristics and fire management implications.

In addition to providing a basic ecological template for the fire planning effort, the interim units provide an effective stratification for estimating natural (historical) fire regimes on a landscape level. Natural fire regimes are based on fire frequency and amount of replacement required following fire (Hann 2001). These units and their landform components, in combination with awareness of broader climatic influences,

provide logical strata for a landscape-scale assessment and context for finer scale documentation of fire regime condition classes. They can be used to develop finer resolution maps of potential natural vegetation groups (PNVGs) and can form the basis for finer resolution VDDT (vegetation dynamics development tool) models of PNVG and current condition maps. Such information is useful for determining local fire management strategies, project priorities, and funding needs. An opportunity exists to further validate our assumptions by studying similar units in neighboring Sonora, Mexico, where higher elevation systems show less departure from historical fire regimes due to less fire suppression and grazing.

These landscape-scale ecological units vary in terms of other characteristics important to fire management including landscape accessibility, soil and watershed characteristics, and species richness and diversity.

## Future Implications

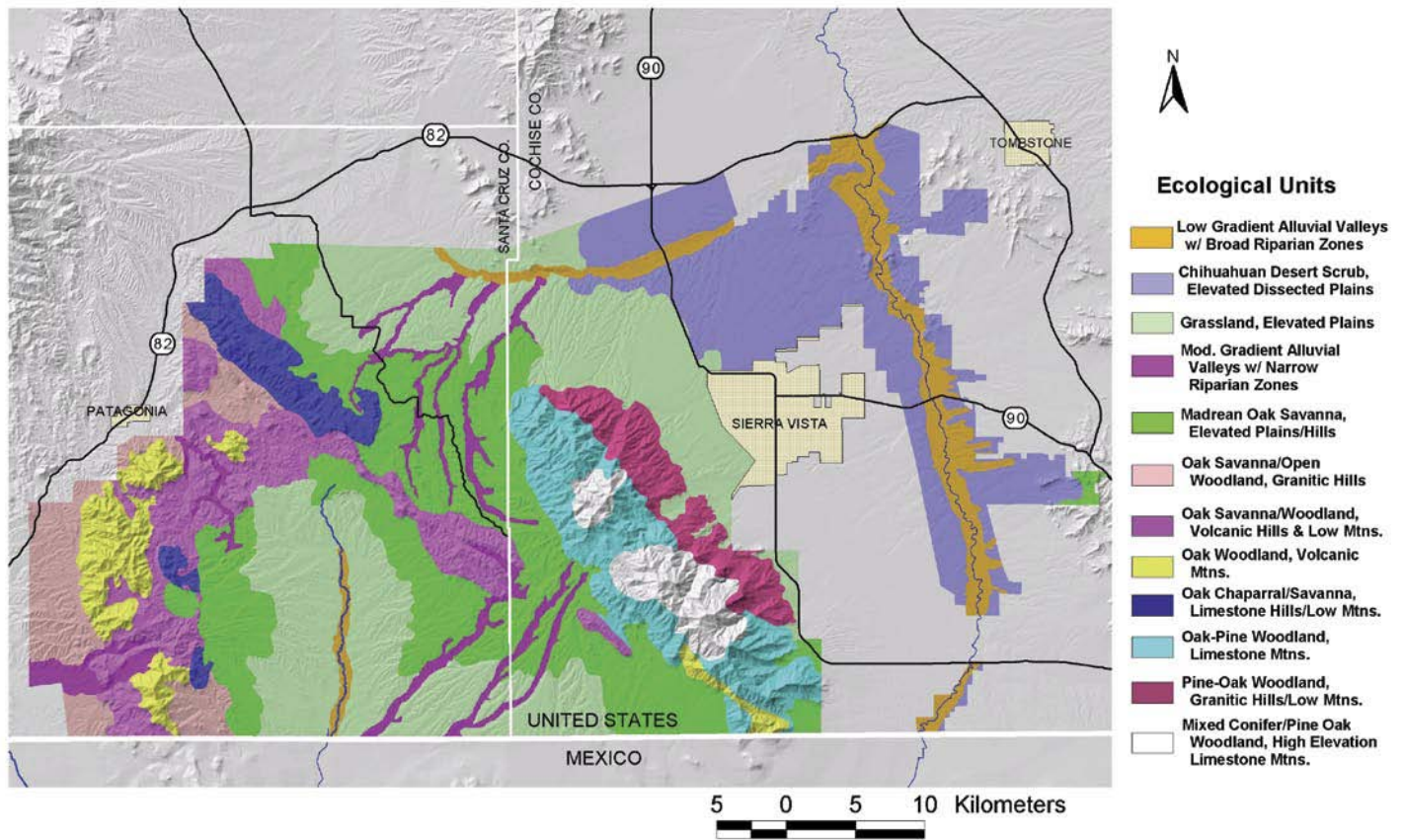
The Greater Huachuca Mountains mapping effort has given us insight into the existing spatial data available in the region and the capability of GIS analysis and modeling to define the relationships between coverages and help us integrate them. The NPS is exploring options to collaborate with a number of government and non-government partners to develop a seamless LTA coverage for southeastern Arizona. The Southern Arizona Office has an interagency agreement with Dr. David Cleland of the U.S. Forest Service Southern Research Station to develop LTAs for a proof of concept area in the Sky Islands region with involvement of local experts. This test area includes the Greater Huachuca Mountains fire planning area. The interim units developed specifically for this fire planning effort will be refined and more completely characterized as a result of Dr. Cleland's work.

## Acknowledgments

We wish to thank the Greater Huachuca Mountains Fire Management Group for their interest and input to the development of these interim ecological units. Their personal comments based on field experiences improved our characterization of the units and proved to be an excellent "reality check."

## References

- Cleland, David T.; Avers, Peter E.; McNab, Henry W.; Jensen, Mark E.; Bailey, Robert G.; King, Thomas; Russell, Walter E. 1997. National hierarchical framework of ecological units. Published in *Ecosystem management: applications for sustainable forest and wildlife resources*. Yale University Press: 181-200.
- Hann, W. J.; Bunnell, D. L. 2001. Fire and land management planning and implementation across multiple scales. *International Journal of Wildland Fire*: 353-372.
- Nigh, Timothy A.; Schroeder, Walter A. 2002. Atlas of Missouri ecoregions. Missouri Department of Conservation. 212 p.
- Smith, Marie-Louise. 2002. Proceedings, land type associations conference: Development and use in natural resources management, planning and research; 2001 April 24-26; Madison, WI. Gen. Tech. Rep. NE-294. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Station. 117 p.



**Figure 1**—Interim landscape-scale ecological units of the Greater Huachuca Mountains fire planning area.

**Table 1**—Landscape-scale fire regime and condition class estimates for the interim ecological units.

| Map unit                                                                              | Current vegetation                                                                                                              | “Historical” vegetation                                                                                                                          |
|---------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| 1 Low gradient alluvial valleys with broad riparian zones                             | Riparian; sacaton with some young willow and cottonwood along Santa Cruz; galley cottonwood/willow forest along San Pedro River | Riparian: wet grass (sacaton dominated), sedges and other hydrophytic vegetation more extensive on some reaches; scattered cottonwood and willow |
| 2 Chihuahuan desert scrub and grassland mosaic on elevated and dissected plains       | Desert scrub/grass                                                                                                              | Grass                                                                                                                                            |
| 3 Grassland on elevated plains                                                        | Grass                                                                                                                           | Grass                                                                                                                                            |
| 4 Moderate gradient alluvial valleys with narrow riparian zones                       | Riparian forest or scattered trees/oak savanna                                                                                  | Riparian forest/oak savanna—more extensive wet zone on low gradient reaches                                                                      |
| 5 Madrean oak savanna on elevated plains and hills                                    | Madrean oak woodland/Madrean oak savanna                                                                                        | Madrean oak savanna                                                                                                                              |
| 6 Madrean oak savanna and open woodlands on granitic hills                            | Madrean oak woodlands                                                                                                           | Madrean oak savanna/Madrean oak open woodland (associated with rock outcrops)                                                                    |
| 7 Madrean oak open woodland and savanna on volcanic hills and low mountains           | Madrean oak woodlands                                                                                                           | Madrean oak open woodland/Madrean oak savanna                                                                                                    |
| 8 Madrean oak open woodland on volcanic mountains                                     | Madrean oak woodland                                                                                                            | Madrean oak open woodland                                                                                                                        |
| 9 Madrean chaparral and oak savanna on limestone hills and low mountains              | Madrean chaparral/oak savanna                                                                                                   | Madrean chaparral/ oak savanna                                                                                                                   |
| 10 Madrean oak-pine woodland on limestone mountains                                   | Madrean oak-pine woodland                                                                                                       | Madrean oak-pine woodland                                                                                                                        |
| 11 Madrean pine-oak woodland on granitic hills and low mountains                      | Madrean oak-pine woodland                                                                                                       | Madrean pine-oak woodland                                                                                                                        |
| 12 Mixed conifer and Madrean pine-oak woodlands on high elevation limestone mountains | Mixed conifer/Madrean oak-pine woodland                                                                                         | Mixed conifer/Madrean pine-oak woodland                                                                                                          |



| Soils                                                                                                                                                    | Disturbance processes                            | “Historical” fire regime                                                                                           | Fire regime condition class                                                                                                                                                                                     |
|----------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------|--------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Very deep, finer textured, high organic matter, high water tables—wet soils more extensive historically on many reaches                                  | Beaver, floods, fire                             | I (0-35 years, <75% dominant overstory replaced)                                                                   | Depending on reach, class 1 (within “historical range) or 2 (moderate departure due to invasive species and soil/channel degradation)                                                                           |
| Very deep, subsurface clay, gravel and cobbles                                                                                                           | Fire, herbivory                                  | II (0-35 years, >75% upper layer replaced)                                                                         | Class 3 (high departure due to extensive soil loss and shrub increase at expense of grasses; also exotics in some areas)                                                                                        |
| Very deep, moderate amounts of gravel and cobble, clay accumulations more pronounced in absence of lime                                                  | Fire, herbivory                                  | II (0-35 years, >75% upper layer replaced)                                                                         | Class 1 in San Raphael Valley; Class 2 or 3 in Sonoita-Elgin area and east side of Huachuca Mountains depending on extent of invasive species and shrub/tree encroachment                                       |
| Very deep, generally loams and sandy loams with varying amounts of gravel and cobble                                                                     | Floods, fire, beaver (on lower gradient reaches) | I (0-35 years, <75% dominant overstory replaced)                                                                   | Depending on reach, class 1 or 2 (due to soil/channel degradation and exotic species)                                                                                                                           |
| Very deep, high gravel and cobble contents, clayey subsoils on mesas and ridge tops                                                                      | Fire, herbivory                                  | I (0-35 years, <75% dominant overstory vegetation replaced)                                                        | Mostly Class 3 (high departure due to greater tree and shrub densities and increasing prevalence of fire-intolerant species); Class 1 or moving toward Class 1 in areas of large fires (Merit and Ryan Fires)   |
| Deep, gravelly or very gravelly sandy loams and sandy clay loams dominate, ridges tend to have clayey subsoils; bedrock control with deeper soil pockets | Fire, herbivory                                  | I (0-35 years, <75% dominant overstory vegetation replaced)                                                        | Class 3 in areas east of Patagonia Mountains (high departure due to greater tree and shrub densities) and west of Patagonia Mountains due to added influence of uncharacteristic states of exotic grass species |
| Shallow, high cobble and gravel contents, sandy loam texture dominates, weakly developed                                                                 | Fire, herbivory                                  | I (0-35 years, <75% dominant overstory vegetation replaced)                                                        | Class 3 (high departure due to greater tree and shrub densities and increasing prevalence of fire-intolerant species)                                                                                           |
| Shallow, high cobble and gravel contents, sandy loam texture dominates, weakly developed, extensive rock outcrops                                        | Fire                                             | I (0-35 years, <75% dominant overstory vegetation replaced);<br>II (0-35 years, >75% dominant vegetation replaced) | Mostly Class 3 (high departure due to greater tree and shrub densities and increasing prevalence of fire-intolerant species)                                                                                    |
| Shallow and very shallow, very cobbly loams, weakly developed, rock outcrops                                                                             | Fire, herbivory                                  | II (0-35 years, >75% dominant overstory [shrub] vegetation replaced)                                               | Class 2 (moderate departure due to greater tree and shrub densities and increasing prevalence of fire-intolerant species)—trend is moderated by extremely limey soils and extensive bare ground                 |
| Shallow and very shallow, very cobbly loams, weakly developed, rock outcrops                                                                             | Fire                                             | I (0-35 years, <75% dominant overstory vegetation replacement)                                                     | Class 3 (high departure due to greater tree and shrub densities, increasing prevalence of fire intolerant species, and replacement of understory vegetation by litter and woody debris)                         |
| Moderately deep and deep, gravelly sandy loams                                                                                                           | Fire                                             | I (0-35 years, <75% dominant overstory vegetation replaced)                                                        | Class 3 (high departure due to greater tree and shrub densities, increasing prevalence of fire intolerant species, and replacement of understory vegetation by litter and woody debris)                         |
| Shallow and very shallow, very cobbly loams, weakly developed, rock outcrops                                                                             | Fire                                             | I (0-35 years, <75% dominant overstory vegetation replaced)                                                        | Class 3 (high departure due to greater tree and shrub densities, increasing prevalence of fire intolerant species, and replacement of understory vegetation by litter and woody debris)                         |