Ecological Site Descriptions: Developmental Considerations for Woodlands and Forests

By Lyn Townsend

An ecological site description (ESD) conveys important interpretive and management information about the dynamic behavior of a related set of forest overstory and understory biological communities. Ecological sites and their descriptions provide a consistent framework for stratifying and describing soil, vegetation, and abiotic features; delineating units that share similar capabilities to respond to management activities or disturbance processes; and estimating ecosystem services that can be expected from particular soil/vegetation combinations.

ESDs are intricately tied to the extent, history, and use of the forests and woodlands that they describe. The fundamental assumption underlying ecological sites is that soils, climate, and geomorphology can be correlated with sufficient precision to provide a site-specific basis for successful ecological predictions and management decisions. A systematic knowledge of how management and disturbance processes interact with abiotic and biotic factors is critical to understanding ecological processes and relationships. A state-and-transition model (STM) within each ESD is a diagram displaying those relationships that applies to a correlated grouping of soil series components mapped as part of the National Cooperative Soil Survey.

Extent, Ownership, and Use of Forests and Implications for ESD Development

Forests and woodlands occupy about 30% of the world's land surface.[1] They provide a biodiverse cover that maintains water quality and quantity, sequesters carbon, and provides habitat for terrestrial wildlife and riparian habitat supporting fish and aquatic organisms, as well as providing wood fiber for lumber and energy generation, recreational and aesthetic opportunities, and other ecosystem services.

On the North American continent when the first European immigrants arrived around 1630, the total area of forest land was estimated at just over 1 billion acres or about 46% of the total land area.[2,3] The percentage declined steadily as settlement expanded and today is about 72% of the area that was forested in 1630. About 300 million acres of forest land have been converted to agricultural and other uses. Between 1850 and 1910, American farmers cleared more forest than the total amount cleared in the previous 250 years of settlement.[4] Since 1950, US forests have had a slight net increase in acreage, but this varies by region: North, +6%; South, −0.3%; Rocky Mountains, +7%; Pacific Southwest, −9%; and Pacific Northwest, −3%.[5]

Not included with estimates of forest increases are changes in some US woodlands such as the juniper–piñon type. For example, since 1860 in the interior West, areas of juniper–piñon have increased from 125% to 625%. The increase is due to infill into shrub-steppe communities historically featuring relatively open low-density stands of trees and expansion of juniper and piñon into sagebrush-steppe communities that previously did not support trees. The role of fire, use of domestic livestock grazing, and shifts in climate all play a part in the increase.[6]

Smith et al.[5] state,

> *More than half of the Nation's forest land is in private ownership. In 2007, 423 million acres—56 percent of the total—were owned by private individuals, Native Americans, or corporate entities. Of the Nation's forests, 44 percent are in public ownership. The Forest Service, U.S. Department of Agriculture, administers the largest segment of public forest land—147 million acres or 45 percent of the total public forest land.*

There are an estimated 10 million private family-forest owners (noncorporate) who own 264 million acres (35%) of US forest land. Ninety-two percent of family-forest owners make the management decisions for their forest land themselves. Most own their land for greater than 10 years with about 22% holding the land for less than 10 years. (On a related note, the turnover rate for public forest decision-makers may range from 6.5 years to 9.9 years, if the rate is similar to government workers overall.[7])

The reasons for owning land by family-forest owners are quite varied and include aesthetics, passing on to heirs, privacy, and nature protection, to name a few. Timber and firewood production as reasons for ownership were only identified by about 10% of the owners.[8]

ESD development for forests and woodlands in the United States is growing in practice for several reasons: 1) forest and woodland will remain an important land cover and may continue to increase in extent; 2) the content of ESDs encompasses the needs of family-forest owners, most of whom make their own management decisions; 3) the tenure of private and public decision-makers indicates that ESDs are one of the products needed for an ever-changing group, requiring a lasting information source for decision support.

Existing Status of Forest–Woodland ESDs

In 2008, about 7,000 ecological sites had been identified nationally. Many of these had ESDs and most were correlated to rangeland soil series. About 600 of these were correlated to forest and woodland soil series. ESDs available to the public were only a fraction of the 7,000 sites—about 1,600 rangeland sites and 100 forest sites. ESDs for public use are available in the Ecological Site Information System (ESIS) at http://esis.sc.egov.usda.gov/ESIS/.

Recent calculations were made to estimate the remaining number of forest ecological sites. Based on the number of sites for geographic areas considered to be largely complete in terms of both ESD development and mapping of soils, a reasonable ratio of four soil series per ecological site was established. This ratio, applied to US land, soils, and ownership data, indicates a need of about 4,500 forest–woodland sites. Of these forest–woodland sites, about 3,200 would be needed to describe ecological and management dynamics on nonfederal forests and woodlands.

Although the remaining work seems daunting for generating the needed forest–woodland ecological site descriptions, development could be accomplished over a 5-year period (including time for initial training and start-up) with the workload distributed between US states. An "average" state would need to develop about 20 forest–woodland ecological sites per year (including training and startup) for the 5-year period. At the end of 5 years, ESDs with valuable ecological data, STMs, and interpretations would be available to forest and woodland decision-makers with an estimated population of over 10 million.

Challenges in Developing Forest and Woodland ESDs

The fundamental issues associated with completing ESDs on forests and woodlands have roots in both technical and managerial aspects.

Differences Between Forest and Rangeland Ecological Sites

Concepts of short- and long-term succession and correlation of communities to an ecological site work similarly on forestland and rangeland. Physiographic, edaphic, and climatic parameters define the local makeup of communities and influence the responses to disturbance and management. Two major differences between forest and rangeland sites involve 1) the effects of shade-producing upper forest/tree canopies, and 2) generally higher levels of precipitation on forest land that mask the effects of soil texture and depth on community composition and production. The first difference limits understory species (including regenerating trees) to those tolerant of shade typical of forest communities as they progress from young seedlings and saplings to mature trees that in some geographic areas exceed 100–200 feet in height. Of course, a profusion of species can populate a disturbed area that results after a severe forest wildfire or clear-cut harvest. It may take decades for the understory composition to equilibrate with the developing overstory canopy after such disturbances. The second difference, higher levels of precipitation, allows a greater range of soil textures and depths to produce essentially the same composition and production of communities in an ecological site. At the highest precipitation levels, even dramatic differences in aspect can have little to no effect.

Availability of Expertise

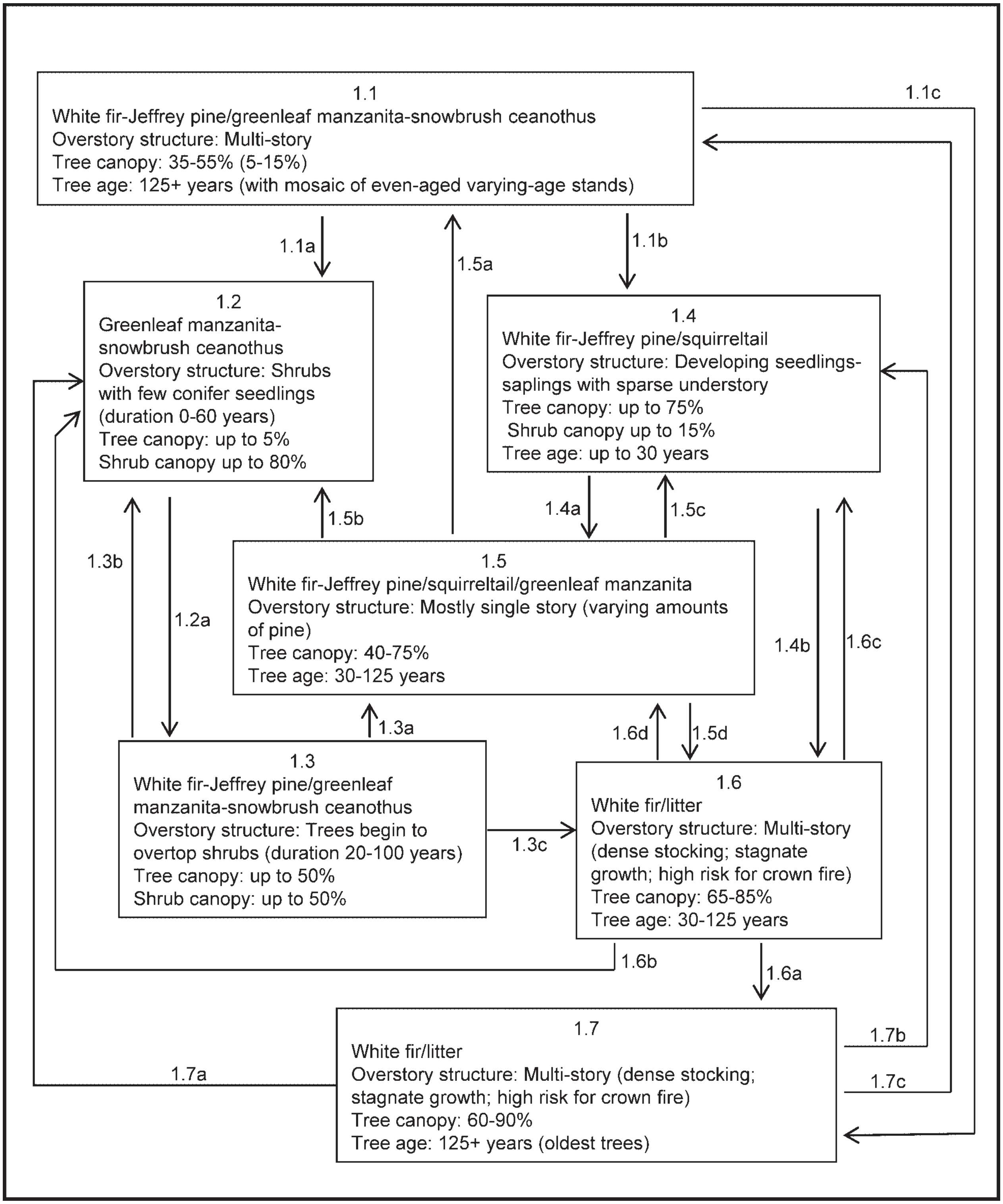
Ecologists with local expertise are ideally suited to the early stages of ESD development. When ecologists are not available, a variety of specialists are typically employed: botanists, foresters, and other disciplines that possess formal ecology training such as range conservationists, soil scientists, and biologists. Other specialists integral to ESD development in middle and later stages are biologists, silviculturists, forest entomologists and pathologists, and soil scientists.

Time and Staff

Allocation of qualified staff specialists is paramount for initiation and development of ecological sites for specified geographic areas (e.g., soil survey areas, counties, project areas, USDA Forest Service districts, national parks) and, later on, the completion and publishing of ESDs. A meaningful completion of needed ESDs will require an infrastructure of full-time and part-time specialists with managerial support for a prolonged period. Specialists may be affiliated with public agencies, universities, and private and/or nonprofit organizations. The process for educating specialists must continue to include the fundamentals of ecological succession theory and, ideally, incorporation of field study and experience with ecological site development.

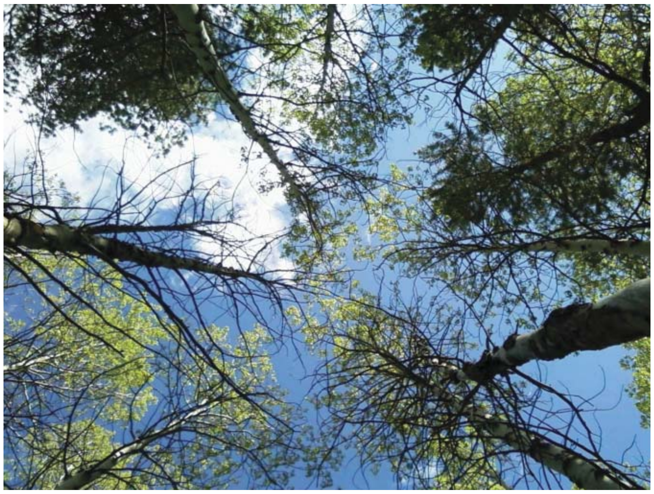
Observational vs. Research Basis

Even though various vegetation and forest measurements are taken involving statistical analysis on some measurements, ecological site development is not a research study or exercise. It is largely observational with interpretations tied to ecological principles, cited literature, and, of course, research-level documents where appropriate. In actual data collection, the Relevé technique is particularly useful when specialists are trying to quickly characterize plant cover. (Relevé is generally considered a "semiquantitative" method. It relies on ocular estimates of plant cover rather than on counts of the "hits" of a particular species along a transect line or on precise measurements of cover/biomass by planimetric or weighing techniques.[9]) Other techniques such as line or point intercepts and fixed or variable plots are appropriate to validate observational estimates.



A state-and-transition model provides a diagram of community phases and their successional pathways. It serves as a blueprint of the development of community phases that define an ecological site. Pathways (e.g., 1.1a) are explained in the ecological site description. Note that the reference community phase is designated as 1.1.

Developers of ecological site descriptions must be schooled in scientific techniques of measurement as well as in selecting representative plots and detecting response and trends of local ecological sites and community phases. Without knowledge of the representative community phase, the ecological trajectory of this community is an open-ended conjecture.



Quaking aspen in the western United States flourished in the "Little Ice Age" ending circa 1850. Since then, warmer temperatures exacerbated by climate change have influenced its longevity, health, and vigor with significant implications for ecological site descriptions.

Determination of the Reference Community Phase (RCP)

Soil and landscape development, along with associated normal climatic conditions and natural disturbances (e.g., occurrence of fire, wildlife use, flooding), produce predictable community phases. An important part of the STM is the identification of the community phase (usually designated as "1.1") that correlates to the RCP.

The RCP for a site in North America is typically an estimate of the historical, most successionally advanced community that existed at the time of European immigration and settlement. It is the community that best reflects the unique combination of environmental factors associated with the site. Natural disturbances, of course, were inherent in the development and maintenance of these communities, but the RCP represents the community in equilibrium with the climate, landscape, and soils under conditions of no recent natural disturbances.

Generally, depending on the type of disturbance, the time to recovery of RCP after major disturbance may have been a century or more and, after minor disturbance (e.g., low to moderate surface fire primarily affecting only the understory), may have been only a decade or two. The RCP in the **reference state** of an STM is not a fixed assemblage of species for which the proportions are the same from place to place or from year to year. The relevance of the RCP is that it provides a focal point for the creation of other states and community phases within the reference and other states of the STM. Without the RCP, the ecological trajectory is an open-ended conjecture.

Because of post-European human disturbances (e.g., widespread harvesting of old-growth forests, introduction of exotic species, use of domestic livestock, and strict control of many natural surface fires last century), determining the RCP can be extremely difficult in many US locales. Analysis of remnant old-growth forests in national parks or other reserves is helpful but may not represent the ecological potential in adjacent federal and nonfederal ownerships. Also, exotic plants and animals may have encroached into forest understories of such remnant communities while overstories remained intact. In most cases, ESD developers must derive the RCP from historical literature and records and note limitations of its accuracy in the ESD. Although estimates of overstory conditions are typically available in historical documents and pictures, understory species are usually not thoroughly described.

Climate change is another phenomenon discovered in modern times that will likely change the makeup of overstory and understory species. Some of these changes are already apparent, e.g., more drought-tolerant species in a reference state taking over as dominants in geographic areas featuring decreasing precipitation and increasing temperatures. At some point, evidence of change may be significant, requiring development of alternative states or regimes in applicable STMs (see Bestelmeyer et al., this issue). The ESD developer should explicitly note any speculations regarding community responses to climate change.

Need for Unbiased Recommendations

The range of uses of ESDs on forest land is broad and varied. One land manager may be trying to optimize wildlife habitat while another wishes to maximize wood volume for harvesting. States and transitions described within an ESD and displayed in a graphical model are typically based on a combination of observation and experimentation. They represent the consequences of time, disturbance, and ecological response. No one state or transition is deemed more desirable than another. ESD developers must use caution in the way descriptions are narrated, being sure to eliminate personal preferences and biases and remain objective.

Assumptions About Within-Site Homogeneity

Ecological site development is ideally done concurrently with the mapping and description of soils. A soil component (part of a soil map unit and classified to a soil series or phase) is correlated to a specific ecological site. Soil mapping results in delineations with about 85% of the delineated area defined by a named soil component or components. About 15% of the delineation may be unnamed or dissimilar soil inclusions. With a continuum of multiple plant and animal species along elevation, aspect, temperature, and precipitation gradients, the division between one ecological site and another is a judgment by the ecological site developer.

If the developer defines ecological sites too broadly, interpretations can become muddled when trying to sort out community dynamics. Sites defined too narrowly tend to overreach with respect to the scale and intensity of the required data and are not operationally useful. Novice developers necessarily require assistance and advice by qualified ecological site specialists—ecologists, foresters, range conservationists, soil scientists, and biologists—to gauge the proper detail and field representation of their ESDs.

Sequence of Work

Specialists need to proceed with ESD development in an efficient and organized manner. This is an overarching concern that, when addressed, can help minimize aforementioned issues. A suggested 10-step strategy for development follows, similar to that discussed in Moseley et al. (this issue).

1) Conduct literature searches applicable to the forest and woodland types in the geographic area of interest.
2) Create an ecological site expertise network by contacting state-level and local partners (these specialists become key advisors early on and essential reviewers later in the process).
3) Refine available ecological information, habitat types, or plant associations into a first approximation of ecological site names for the geographic area being studied.
4) Integrate pre-European fire regimes as necessary, alter draft site names, and review with partners.
5) Perform tentative correlation (matching) of soil components to draft site names (in collaboration with soil scientists in the early stages of soil legend development and mapping; this also provides an overview of the logistics necessary for late ecological site sampling and documentation).
6) Develop first approximations of STMs for draft ecological site names and review with partners.
7) Develop strategy for collecting field data on soil components by ecological site, state, and community phase (includes identification of appropriate national, state, and local data collection forms).
8) Collect and interpret field data and fine-tune state-and-transition diagrams.

Black Hills ponderosa pine had relatively frequent surface fires periodically eliminating the prolific regeneration of new seedlings and influencing the composition of species in the understory. Current-day management to reduce the risk of crown-type wildfires emulates the effect of historic surface fires through mechanical means.

9) Develop first drafts of complete ESDs and review with partners.
10) Refine, finalize, and publish ESDs.

Forest–Woodland ESDs Offer Added Value

Forest and woodland owners seek assistance and information about the consequences of management (prescribed burning, lack of burning, logging, site preparation, planting, thinning, road and trail building, restoration, habitat creation), biodiversity, threatened and endangered species, site index and other measures of productivity, estimated levels of carbon sequestration, and maintenance of water quality and quantity. ESDs have the capacity to address these needs and provide valuable data and information for owners to make decisions.

A new 2010 ESIS upgrade to the format and organization of forest ESDs will better characterize each vegetation state and community phase correlated to the ecological site. The upgrade covers a number of changes:

- The primary name of the ecological site will be based on physiographic and soils attributes (matching the naming convention for rangeland sites) with the biotic name being optional but recommended.
- Community phase tables will be subdivided to 1) display canopy cover, vertical structure, and other attributes for forest overstory and understory species and 2) systematically display percentage of composition by weight and foliar canopy of plant species.
- Site index and productivity estimates for overstory tree species will be specifically documented and cited. (The underlying National Register of Site Index Curves was upgraded in 2009 by the USDA Natural Resources Conservation Service.)

- Emphasis is renewed on including representative images for each community phase within an ESD.

Because many private forest and woodland owners do not regularly employ conservation planners or foresters, having written information and online resources available becomes paramount. Although a forest ESD typically contains highly technical information, most if not all landowners will be able to understand a description on some level. ESD narratives, tables, picture captions, and diagrams must be clearly defined and concisely worded. Popularized or abridged versions of ESDs with images and illustrations can help planners better communicate directly with the millions of forest and woodland owners.

References

1. Food and Agriculture Organization of the United Nations. 2006. Global Forest Resources Assessment 2005—progress towards sustainable forest management. Rome, Italy: FAO Forestry Paper No. 147. 320 p.
2. Clawson, M. 1979. Forests in the long sweep of American history. *Science* 204:1168–1174.
3. Kellogg, R. S. 1909. The timber supply of the United States. Washington, DC, USA: US Department of Agriculture, Forest Service. Forest Resource Circular No. 166. 24 p.
4. Fedkiw, J. 1989. The evolving use and management of the nation's forests, grasslands, croplands, and related resources. Fort Collins, CO, USA: US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. Gen. Tech. Rep. RM-175. 66 p.
5. Smith, W. B., P. D. Miles, C. H. Perry, and S. A. Pugh. 2009. Forest resources of the United States, 2007. Washington, DC, USA: US Department of Agriculture, Forest Service. Gen. Tech. Rep. WO-78. 336 p.
6. Miller, R. F., R. J. Tausch, E. D. McArthur, D. J. Johnson, and S. C. Sanderson. 2008. Age structure and expansion of piñon–juniper woodlands: a regional perspective in the Intermountain West. Fort Collins, CO, USA: US Department of Agriculture, Forest Service, Rocky Mountain Research Station. Res. Pap. RMRS-RP-69. 15 p.
7. US Department of Labor. 2008. Employee tenure in 2008. Washington, DC, USA: Bureau of Labor Statistics. News Release. 10 p.
8. Butler, B. J. 2008. Family forest owners of the United States, 2006. Newtown Square, PA, USA: US Department of Agriculture, Forest Service, Northern Research Station. Gen. Tech. Rep. NRS-27. 72 p.
9. California Native Plant Society. 2007. Relevé protocol. Sacramento, CA, USA: California Native Plant Society Vegetation Committee. 18 p.

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