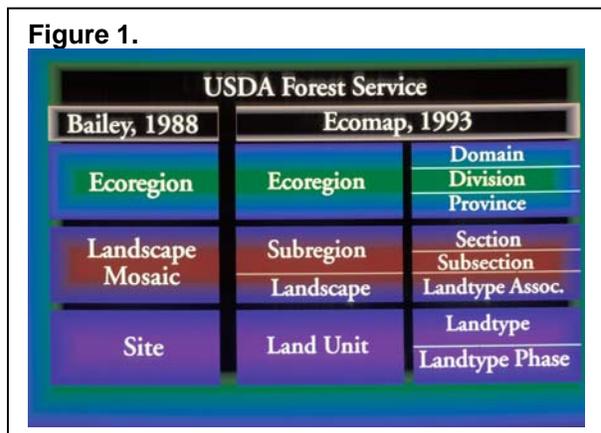


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Changing Ecoregional Map Boundaries

The Forest Service has developed a mapping framework to help managers better understand the hierarchical order of the ecosystems they manage (Figure 1). This framework is called the National Hierarchical Framework of Ecological Units (Ecomap 1993, Cleland et al. 1997). The Agency officially adopted this framework (a.k.a. Ecomap) to provide a framework on which National Forest planning and assessment could be built. Broad-scale ecoregions (domain, division, and province) and subregions (section only) have been mapped and described for the whole country (Bailey 1995, Bailey et al. 1994, McNab and Avers 1994). North American ecoregions have also been mapped (Bailey 1998). More detailed subdivisions—referred to as land type associations and land types—have been developed for most National Forests—to assist with forest-level analysis and planning.



An Ecomap team¹ has been working to complete the hierarchy by identifying subsections. The process used in identifying subsections was a “layering approach” in which coincidences in equivalently generalized factor maps were sought to suggest boundaries. Some have proposed to use subsections to “refine” the boundaries of coarser-scale ecological units (ecoregions and subregions). In this paper, I present my evaluation of this idea and give recommendations.

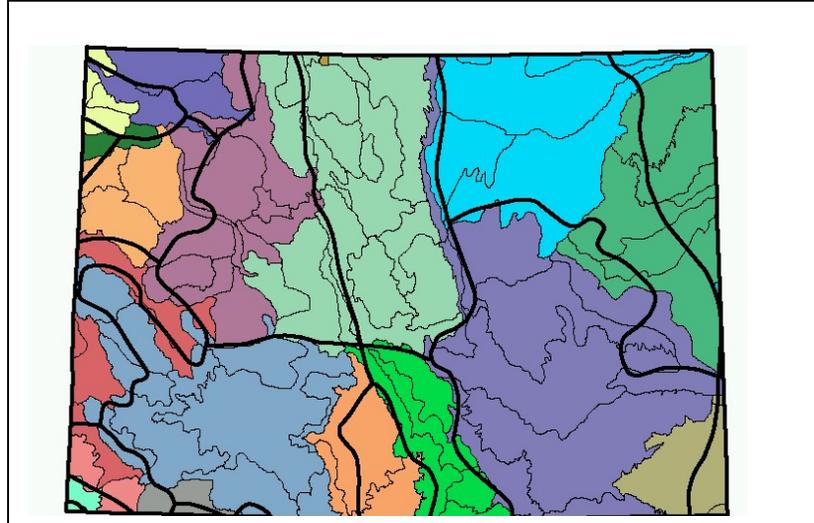
Issues

The Ecomap framework is a nested system of ecosystem units with larger systems broken into smaller subsystems based on more specific criteria. Thus, modification of any given level has the potential of affecting the boundaries of systems both above and those below the level in question. This could result in significant differences from the 1994 published map (Figure 2). There are large bodies of satisfied users in many agencies and programs that use the 1994 published maps and descriptions, especially at the ecoregion level. Thousands of maps and accompanying descriptions have been distributed. Digital versions reside in many databases, both inside and outside the Forest Service. Ecoregion

¹ Dave Cleland, Jim Keys, Jerry Freeouf, Bob Bailey, Greg Nowacki, Randy Davis, Connie Carpenter, Henry McNab

names appear is a large body of published literature. Modifications of published maps, descriptions, and names can potentially incur huge cost for revision and can disrupt management and analysis programs upon which they are based.

Figure 2. The Colorado portion of the subregion (section) map of United States: 1994 map, heavy lines; proposed revisions to sections (colors), subsections (thin lines). Note that colors and thin lines do not coincide with heavy lines.



Furthermore, the bottom-up refinement of coarser-scale ecological units overlooks a very important principle of ecosystem mapping. Because subsystems can be understood only within the context of the whole, a classification of ecosystems begins with the largest units and successively subdivides them. Aggregating subsections to modify sections, and, thereby, all the higher levels of the hierarchy (province, division, and domain) defeat the purpose from which ecosystem patterns were defined.

Another issue is the process in which subsections were identified. The key to placing map boundaries on ecological maps is an understanding of formative (genetic) process. We can only comprehend a landscape if we know how it originated or evolved. Overlaying maps that are derived independently without formative process in mind cannot discover significant ecological units. Such maps describe the nature of a place. They do little, however, to explain *why* it is so. Subsections derived through such process are of questionable value and reliance on them for refinement of higher levels in the hierarchy is also questionable.

Question

Even if one were to disregard these shortcomings, there is still a question that needs to be asked before making such modifications, which is:

Should the boundaries of systems at any given level of the hierarchy necessarily coincide with the boundary of the system at the next higher level?

Processes of Ecosystem Differentiation

To answer this question requires an understanding of the processes that operate to differentiate ecosystems at various scales. These processes are described in detail elsewhere (Bailey 1988, 1996) and include the following:

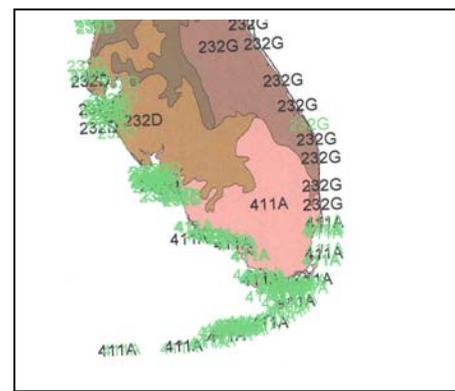
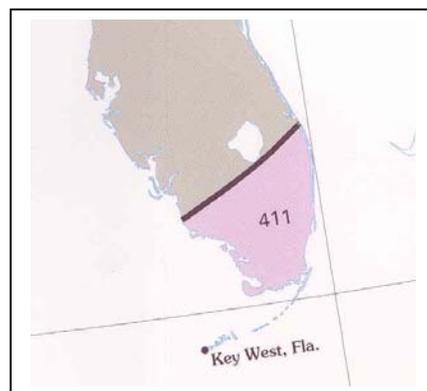
- All ecosystems are recognized by differences in climatic regime. The basic idea here is that climate, as a source of energy and moisture, acts as the primary control for the ecosystem. As this component changes, the other components change in response. The primary control over the climatic effect changes with scale. Major ecosystems are areas of essentially homogeneous macroclimate, that is, the climate that lies just above the local modifying irregularities of landform and vegetation. These areas are those that biogeographers have traditionally recognized as biomes, life zones, or formations. We call these ecosystems *ecoregions*. Three levels of macroclimatic differentiation are recognized in Ecomap: *domain*, *division*, and *province*.
- Landform is an important criterion for recognizing smaller divisions within macroecosystems. Landform (with its geologic substrate, its surface slope, and relief) modifies climatic regime at all scales within macroclimatic zones. For example, solar energy will be received and processed differently by a field of sand dunes, lacustrine plain, or an upland hummocky moraine. Thus, landform provides the best means of identifying local ecosystems. At the mesoscale, the landform and landform pattern form a natural ecological unit, called *subregion*. Three levels of landform differentiation are recognized in Ecomap: *section*, *subsection*, and *landtype association*.
- At the microscale, such patterns can be divided topographically into slope and aspect units that are relatively consistent as to soil moisture and temperature regime, and plant association; that is, the homogeneous “site.” Two levels of edaphic-topoclimatic differentiation are recognized in Ecomap: *landtype* and *landtype phase*.

Nature of Ecoregion and Subregion Boundaries

From the above, we can see that ecoregions boundaries are relatively smooth because they are controlled by the macroclimate that *lies above the modifying effects of the earth's surface* (Figure 3a). In contrast, section (and subsection) boundaries within the ecoregion can be quite irregular because they are controlled by the irregularities of the earth's surface (Figure 3b).

Figure 3.
Ecological boundaries in southern Florida:

(a) 1994 boundary of the Everglades Province (411) of the Savanna Division of the Humid Tropical Domain, (b) proposed revision of established section boundaries.



(a)

(b)

Conclusion

Subregion boundaries do not affect the placement of ecoregion boundaries, but are bounded within the ecoregion. On the published ecoregion and subregion map (Bailey et al. 1994), section boundaries were adjusted to fit the ecoregion boundary—not the other way around. If a landform cut across a province boundary, two sections were identified. This approach recognizes that landforms of similar characteristics can be found in various ecoregions but they will support different ecosystems because of the different climates. In developing the ecoregion concept, a deductive (top-down) approach was used. The upper ecoregion levels of the hierarchy were established and then physiographic units were sought that correlated with different landform-controlled patterns within the climatically determined ecoregion.

*The use of subsections to refine the upper levels of the National Hierarchy should be strongly discouraged because of the serious shortcomings identified earlier. If one were to disregard these shortcomings, “refinement” should **not** be carried out above the subregion level because the nature of the boundaries and the criteria used to identify them change between the subregion (based on landform) and ecoregion (based on macroclimate).*

Recommendations

Based on the above considerations, I recommend that

- established province boundaries should remain the same; and
- if subsection boundaries were to be used to modify the established sections, the revised section boundaries should be adjusted to fit the established province boundaries. In some cases, depending on size, revised sections may need to be subdivided in two—one in each province.

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