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# GAP ANALYSIS OF THE VEGETATION OF THE INTERMOUNTAIN SEMI-DESERT ECOREGION

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Abstract.--A conservation gap analysis was conducted for the Intermountain Semi-Desert ecoregion to assess the representation of land-cover types within areas managed primarily for biodiversity objectives. Mapped distributions of plant communities were summarized by land-management status categories. The total amount of land permanently protected in the ecoregion is <4%, and most types that are characteristic of the region have <10%. Of 48 land-cover types, 20 were found to be particularly vulnerable to potential loss or degradation because of low level of representation in biodiversity management areas and the impact of expected land-use activities. Gap analysis data and findings will be useful in providing a regional perspective in project impact assessment and future conservation planning within this ecoregion.

*Key words: gap analysis, land cover, land management, conservation assessment, National Vegetation Classification System, alliance.*

In recognition of the alarming but largely unmeasured conversion and degradation of native habitat, many conservation biologists have recommended protecting representative samples of all natural ecological communities as a goal for preserving biological diversity (e.g., Shelford 1926, Committee on the Study of Plant and Animal Communities 1950-51, Austin and Margules 1986, Shafer 1990, Scott et al. 1993). Underlying this "coarse-filter" approach is the assumption that protecting ecosystems or habitats will simultaneously confer protection on most plant and animal species (Noss 1987, Franklin 1993, Orians 1993). While this approach sounds straightforward in principle, a lack of comprehensive and consistent data on the extent, location, and management of ecological communities makes it quite challenging to implement. Fundamental questions have often been beyond our capacity to answer with any confidence; for example, How well are community types represented in areas specially managed for the preservation of biodiversity?

Scott et al. (1993) outlined a "gap analysis" methodology to identify the underrepresented plant communities, or gaps, in the representation of biological diversity in areas managed primarily for long-term maintenance of native wildlife populations and natural ecosystems. This approach uses medium-scale mapping of land cover and land management as the only practical solution for assessing the conservation status of biodiversity across ecological regions covering hundreds of thousands of square kilometers. Originating as a pilot study in Idaho (Scott et al. 1993, Caicco et al. 1995), gap analysis has been expanded into a national Gap Analysis Program (GAP) coordinated by the Biological Resources Division of the U.S. Geological Survey (formerly the National Biological Service). Initial published results have focused on analyses at the state level for Idaho (Caicco et al. 1995), Utah (Edwards et al. 1995), and Wyoming (Merrill et al. 1996). Since its inception, however, GAP has aimed to provide a national conservation assessment based on ecological rather than political planning regions (Scott et al. 1993).

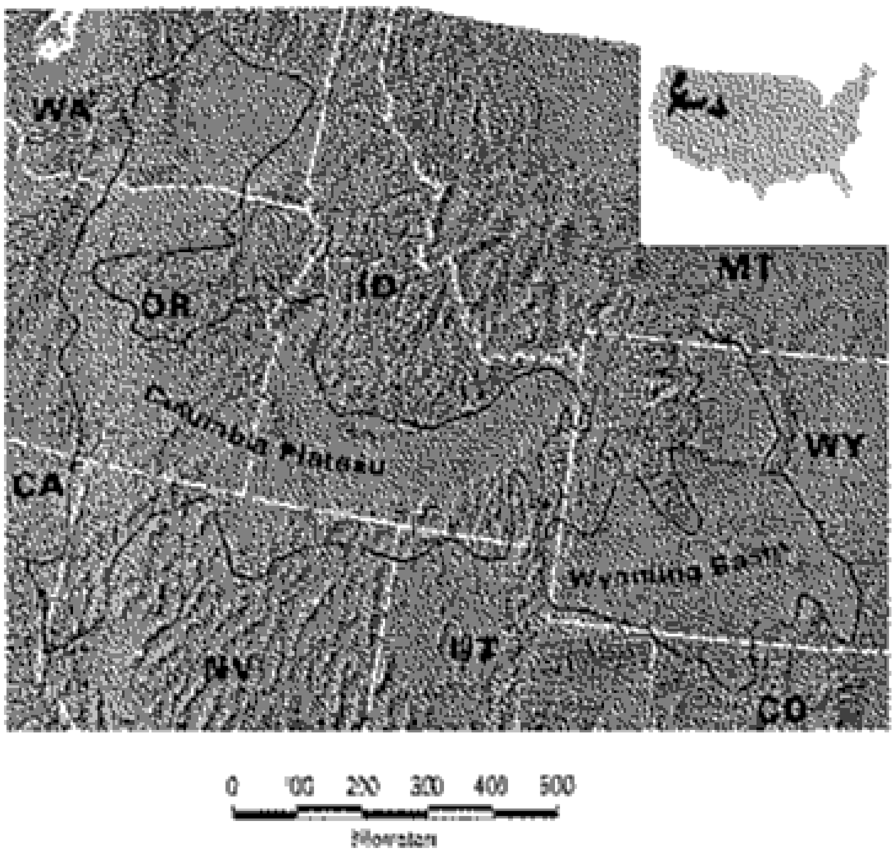
The objective of this paper is to report the results of the nation's first multistate gap analysis of plant communities of the Intermountain Semi-Desert (ISD) ecoregion (Fig. 1) as currently delineated in the U.S. Forest Service's ECOMAP program (ECOMAP 1993, Bailey 1995). Ownership and management status of land-cover types within the ISD ecoregion (and 2 subregions) are summarized, poorly represented types are identified, and the highest conservation priorities are identified. Secondarily, we discuss some ecological and cartographic issues of this approach to regional conservation assessment. Technical aspects of regional mapping will be treated in Stoms et al. (in press). Although gap analysis as defined by Scott et al. (1993) typically includes vertebrate species distributions, here we report only plant community types.

This ecoregion was selected for the prototype regional gap analysis for both practical and conservation reasons. From a practical standpoint, the ISD ecoregion was among the first for which the requisite land-cover and land-management mapping were completed by individual state-level GAP projects. Additionally, the area provides a suitable testing ground for demonstrating whether GAP can overcome technical challenges associated with regional mapping that have concerned some program reviewers (Zube 1994, DellaSala et al. 1996). Very little land in the ISD ecoregion has been designated for maintenance of biodiversity, while potentially conflicting land uses such as grazing and cultivation are extensive. Enough undeveloped habitat remains, however, for proactive conservation action to be effective. Thus, the ISD ecoregion makes a representative case study that could be applied to other regions throughout the western U.S. Planning for conservation and ecosystem management within this ecoregion is underway by The Nature Conservancy (Sandy Andelman personal communication), Oregon Biodiversity Project (Vickerman 1996), and Interior Columbia Basin Ecosystem Management Project (a joint effort by the U.S. Forest Service and Bureau of Land Management; Quigley et al. 1996). BLM is considering wilderness proposals in Wyoming (Merrill et al. 1996). Proposals for new wilderness areas in Idaho (Merrill et al. 1995) and Wyoming (Merrill et al. 1996) and for new national parks (Wright et al. 1994, Wright and Scott 1996) are being discussed. A regional gap analysis can add valuable information for all of these planning programs.

## Intermountain Semi-Desert Ecoregion

The U.S. Forest Service's National Hierarchical Framework of Ecological Units (ECOMAP 1993) was adopted for this ecoregional gap analysis. This division of regional units is widely used both by federal agencies and The Nature Conservancy (The Nature Conservancy Ecoregional Working Group 1996) as the basis for resource assessments. The framework subdivides the Earth's surface into successively smaller, more homogeneous land units. The highest level, called the *domain,* is associated with broad climatic regimes and gross physiography. Domains are split into *divisions* based on vegetational affinities. *Provinces* are subdivisions of a division corresponding to continental weather patterns, soil orders, and potential natural vegetation. Domains, divisions, and provinces are all categorized at the ecoregional level in the framework. Provinces can be progressively subdivided into *subregions, landscapes,* and ultimately *land units* at the project planning level. The ISD ecoregion used in this gap analysis is a province in the ECOMAP hierarchy.

**Fig. 1. Shaded relief image of the Intermountain Semi-Desert ecoregion and the 2 subregions, Columbia Plateau and Wyoming Basin.**




The ISD ecoregion encompasses approximately 412,000 km$^2$ in portions of Washington, Oregon, Idaho, Nevada, California, Utah, Wyoming, Colorado, and Montana (Fig. 1). Two geographically disjunct subregions make up the larger ecoregion, the Columbia Plateau in the west and the Wyoming Basin in the east. The ISD boundary corresponds closely to the limits of Küchler's (1970) sagebrush steppe potential natural vegetation type. The ISD ecoregion southern boundary grades into the Intermountain Semi-Desert and Desert Province, which tends to be warmer, drier, and with greater topographic relief than the ISD ecoregion. The Cascade and Sierra Nevada ranges bound the ecoregion on the west and the northern Rocky Mountains on the north and east.

The combination of soils and climate generates a characteristic vegetation often called "sagebrush steppe" (Küchler 1970), dominated by *Artemisia* spp. or *Atriplex confertifolia* (shad-scale) with short bunchgrasses (e.g., *Festuca* spp., *Pseudoroegneria* spp.). The rainshadow effect produced by the Cascade-Sierra Nevada ranges favors shrub cover and limits tree cover to higher elevations (mostly conifers and aspen), narrow riparian corridors, or sparse pinyon or juniper woodland. In low-lying alkaline areas formed in Pleistocene lake beds and subject to periodic flooding, sagebrush is replaced by saltbush (*Atriplex*) and greasewood (*Sarcobatus*) communities. Shrub species are replaced by perennial grasses where deeper soils occur. Most relatively level land with adequate water supplies has been converted to agriculture (West 1988). Nonnative annual grasses, especially cheatgrass (*Bromus tectorum*), have invaded the region since the 1870s, successfully converting native steppe communities to exotic grassland (West 1988) and dramatically affecting ecological processes of this vegetation type. Despite the relatively homogeneous appearance of sagebrush steppe, the ecoregion is floristically complex. For instance, there are 8 species or subspecies of *Artemisia* that dominate various plant communities. Three juniper and 2 pinyon species occur in different portions of the ecoregion.

**Methods for a Regional Gap Analysis**

The first critical issue in mapping land cover is selecting a classification system that is ecologically defensible and yet feasible for mapping at a regional scale with remote sensing and limited field information. The alliance level of the proposed National Vegetation Classification System (NVCS; Federal Geographic Data Committee 1996) was selected as the most appropriate schema. Derived from the UNESCO system (UNESCO 1973, Driscoll et al. 1984), this hierarchical scheme begins with structural and broad ecological properties at higher levels, adding floristic divisions at lower levels. Alliances are named by their dominant canopy species within structural classes based on life-form and canopy closure. Proposed NVCS standards define closed tree canopy (i.e., forest) as tree cover of 60-100%, open tree canopy or woodland with 25-60% tree cover, shrubland classes with >25% shrub cover and <25% tree cover, and herbaceous classes with <25% shrub or tree cover. An example of an alliance in the ISD ecoregion would be the *Pinus ponderosa* alliance within the rounded-crowned temperate or subpolar needle-leaved evergreen open canopy tree formation. Because the same dominant species also occurs within a closed canopy tree formation, there are 2 *P. ponderosa* alliances distinguished by canopy closure. For simplicity, we use the terms *forest* and *woodland* in the text in place of the closed and open canopy terminology when referring to land-cover classes.

Land cover was originally mapped independently for each of the states in the ISD ecoregion (Kagan and Caicco 1992, Caicco et al. 1995, Davis et al. 1995, Driese et al. 1997, Homer et al. 1997, Cassidy in press). Although most state GAP projects used 1990 (2 yr) satellite imagery from the Landsat Thematic Mapper (TM) sensor, combined with field inventories and existing maps of vegetation in compiling their land-cover data, they differed in methods and products. Maps for Idaho (Caicco et al. 1995) and Oregon (Kagan and Caicco 1992) used photointerpretation techniques with older, lower-resolution Multispectral Scanner (MSS) images and had larger minimum mapping units than the other states. In contrast, land-cover mapping in Nevada and Utah was done with digital image processing of TM image mosaics (Homer et al. 1997). This approach generally achieved greater spatial resolution at some expense in classification detail. The other state projects fall somewhere in between these methods, using manual photointerpretation of higher resolution TM data (e.g., Davis et al. 1995, Driese et al. 1997, Cassidy in press). Few maps have been validated with a formal accuracy assessment (except see Caicco et al. 1995, Edwards et al. 1995).

For this ecoregional analysis, a regional land-cover map was required but with greater spatial and thematic consistency than was contained in the collection of state-level maps. Therefore an innovative technique was developed to utilize the state GAP maps as training data and then reclassify satellite data into a common set of NVCS cover types. First, all land-cover classes in the state GAP maps were converted to alliances as prescribed by the NVCS. In some cases it was necessary to aggregate to a higher level where dominant species could not be distinguished in related alliances (e.g., deciduous riparian forest types). Pixels of multi-temporal satellite imagery from the NOAA Advanced Very High Resolution Radiometer were then assigned to these cover types using a maximum likelihood classifier. Some cover types that were either rare or occur in small patches were not classified with the 1-km2 satellite data but were retained from the original maps. Thus, the final map had a consistent spatial resolution (1-km2 or 100-ha pixel size) across the entire ISD ecoregion while retaining the best floristic information from the original maps (Stoms et al. in press).

Although a comprehensive map accuracy assessment of the regional land-cover map has not been undertaken, the map was compared to a set of randomly distributed 1-$km^2$ field plots compiled nationwide by the U.S. Forest Service (Zhu et al. 1996). Seventy-eight of these plots occur within the ISD ecoregion. This small sample size is insufficient for a statistical per-class assessment but adequate for a preliminary indication of the strengths and weaknesses of the land-cover map. Each plot record listed dominant tree and/or shrub species and their relative canopy cover, total absolute tree cover in classes similar to the NVCS definitions of open and closed canopy, presence of grasses (identified as annuals or perennials), and presence of agriculture. Based on species composition and cover, each plot was assigned to one (or in some cases to a set) of the cover types in the regional land-cover map.

Maps of land-stewardship and land-management status were also compiled for individual state gap analysis projects, usually by digitizing BLM Surface Management Status maps. Maps of special managed areas were compiled from a wide variety of sources (see Caicco et al. 1995 and Davis et al. 1995 for details). These maps were combined to create a regional map. GAP uses a scale of 1-4 to denote relative degree of maintenance of biodiversity for each tract of land. A status of 1 denotes the highest, most permanent level of maintenance, and 4 represents the lowest level of biodiversity management as evidenced by legal and institutional factors. Each tract of land is assigned to 1 of the 4 status levels as defined by Scott et al. (1993):

**Status 1:** An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a natural state within which disturbance events (of natural type, frequency, and intensity) are allowed to proceed without interference or are mimicked through management. Included are Research Natural Areas, many wilderness areas, national parks and monuments, and Nature Conservancy preserves.

**Status 2:** An area having permanent protection from conversion of natural land cover and a mandated management plan in operation to maintain a primarily natural state, but which may receive use or management practices that degrade the quality of existing natural communities. Most National Wildlife Refuges, Areas of Critical Environmental Concern, and some state parks are included in this category.

**Status 3:** An area having permanent protection from conversion of natural land cover for the majority of the area, but subject to extractive uses of either a broad, low-intensity type or localized intense type. It also confers protection to federally listed endangered and threatened species throughout the area. Undesignated public lands managed by the U.S. Forest Service or the BLM are examples of this status category.

**Status 4:** Lack of legally enforced easement or mandate to prevent conversion of natural habitat types to anthropogenic habitat types. Allows for intensive use throughout the tract. Also includes those tracts for which sufficient information to establish a higher status is not available. Privately owned lands (except for private conservation group reserves), most Department of Defense tracts, and state school lands are included in this category.

Intersecting the land-stewardship and management map with the distribution of land-cover classes results in tables that summarize the area and percent of total mapped distribution of each class in different land-stewardship and management categories. The percentage and acreages of cover types in each management status category and managed by each steward were quantified (Caicco et al. 1995).

## Results

### Land Cover and Alliances

Forty-eight land-cover classes were mapped for the region (Table 1), including 2 cultural land-use types, 5 nonvegetated or sparsely vegetated types, 16 formations or undifferentiated groups of related alliances, and 25 alliances. Formations tend to be relatively scarce types that occur in small patches or as linear features. For instance, the seasonally/temporarily flooded cold-deciduous forest formation consists of alliances dominated by *Populus tremuloides, P. fremontii, P. balsamifera, P. angustifolia,* or other riparian tree species. At the regional scale it was not feasible to discriminate between them. Species of pinyon and juniper have overlapping range (except *Juniperus occidentalis,* which has a distinct geographic range), and so were grouped into 3 more general classes. Similarly, 2 *Cercocarpus* classes (*C. ledifolius* and *C. montanus*) that occur in the ecoregion could not be distinguished in the land-cover mapping. Mixes of canopy species with no clear dominants were also mapped at the formation level. This aggregation occurred for cover classes such as mountain brush in the temperate cold-deciduous shrub formation, mixed salt desert shrub primarily composed of various *Atriplex* species, and grassland types. Grasses were divided into dry (e.g., *Pseudoroegneria* and *Poa* spp.) and moist (e.g., *Festuca* spp.) perennial bunchgrass, an annual grassland (primarily the exotic *Bromus tectorum*), and artificial seedings of *Agropyron cristatum* or *Poa pratensis*. One alliance is defined by a subspecies--mountain big sagebrush (*Artemisia tridentata* ssp. *vasey- ana*), where it could be mapped separately from other *A. tridentata* subspecies.

Three land-use or land-cover types account for 57% of the region--*Artemisia tridentata* (29%), agriculture (17%), and *A. tridentata/A. arbuscula* (11%). Other significant types include *Juniperus occidentalis* (4%), *A. tridentata* ssp. *vaseyana* (6%), mixed salt desert shrub (6%), and annual grassland (5%). Seventeen types had mapped distributions of <1000 km<sup>2</sup> each (or 0.25% of the regional area).

The land-cover map and Forest Service field plots showed general agreement. Thirty-one (40%) of the plots were completely consistent with the land-cover map in both structural and floristic attributes. Another 17 (22%) plots were at least partially consistent, such as where the same species were recorded but percent canopy cover in the plot would assign them to a different formation type than the map did. The largest discrepancies tended to be between grassland and sparse shrub cover, in part because it is difficult with satellite data to discriminate accurately the 25% shrub cover threshold on a continuous gradient from grass to shrub. Several state maps had a sagebrush-steppe class that was always assigned to an *Artemisia tridentata* alliance at the regional level, even though in some cases the shrub cover might be <25%. Another 15 (19%) of the plots that disagreed with the map were located within 1 pixel's width (1 km) of a landscape with the correct type according to the plot, which could be attributed to a combination of map registration error, mixed pixels at ecotones, and more generally to the fuzziness of transitions between alliances. Absolutely wrong labels, according to the plots, were assigned to 13 (17%) samples. We emphasize that this comparison is only indicative of the strengths and weaknesses of the land-cover map but, due to the small sample size, conveys no statistical significance about its accuracy.

**Land Stewardship and Management Status**

Sixty percent of the land in the ISD ecoregion is publicly owned (Table 2). The steward with the greatest holdings is the Bureau of Land Management (45.4% of the total land area). The U.S. Forest Service and state governments control slightly more than 4% each. Tribal lands account for 2.8% of the region, while the U.S. Fish and Wildlife Service, Department of Energy, Department of Defense, Bureau of Reclamation, National Park Service, and county or regional governments make up the remainder of public lands in descending order of area. Private lands, including a very small proportion of nongovernmental organization holdings, constitute nearly 40%.

Greater than 96% of the ecoregion is managed such that extractive resource uses are permitted and biodiversity conservation is not a primary objective (status 3 and 4, Table 2). Only 0.9% (3648 $km^2$) is designated to be maintained in its natural state by formal designation (status 1), with an additional 2.8% (11,288 $km^2$) managed as status 2 lands (Fig. 2). The Bureau of Land Management, U.S. Fish and Wildlife Service, Department of Energy, and state lands constitute the major stewards of this protected land. This regional pattern of small proportions of status 1 and 2 with approximately equal amounts of status 3 and 4 is repeated in both subregions (Table 3). The Wyoming Basin has slightly more public land but less formally protected land than the Columbia Plateau subregion.

If the status 1 and 2 managed areas are examined without regard to steward or site name but are simply aggregated into disjunct spatial units, there are 809 separate sites with a median size of just 252 ha (mean size of 1886 ha). Of these, 228 are <100 ha in size, and another 399 are between 100 and 500 ha. Despite the large number of small sites (78% of the total number), they account for only 7% of the area of all status 1 and 2 lands. Only 26 sites are >10,000 ha, but represent >70% of protected area. Five managed areas are each >50,000 ha--Sheldon National Antelope Range (>220,000 ha) in northwestern Nevada, Idaho National Environmental Engineering Lab, Hart Mountain National Antelope Range in Oregon, Owyhee River Bighorn Sheep Habitat Area of Critical Environmental Concern (ACEC) managed by the Bureau of Land Management in Idaho, and Malheur National Wildlife Refuge/ Steens Mountain ACEC complex in Oregon.

**Gap Analysis of Land-cover Classes**

The profile of management status for each land-cover type for the ISD ecoregion is shown in Table 1. This table can be summarized by categorizing the percentage of total area of each type within status 1 and 2 managed areas. Categories include types not represented in any status 1 or 2 managed area, types with <1%, 1-10%, 10-20%, 20-50%, and >50%. The number of land-cover types in each category for the region and for each subregion is shown in Table 4. Despite the low level of representation across most types, the representation is an unbiased sample of the communities of the ISD ecoregion (chi square = 52.57, 43 df, $P$ = 0.849). That is, the pattern of representation across types is not significantly different than if sites had been selected with the intention of achieving equal representation for all cover types.

Types with no representation in status 1 and 2 managed areas.--Only 2 natural land-cover types are completely unrepresented within the ISD ecoregion according to the regional maps: *Pinus jeffreyi* and alpine tundra. Similarly, several cover types are not represented in status 1 and 2 lands within 1 of the 2 subregions, even though they are represented within the ecoregion as a whole. These unrepresented types in the Columbia Plateau include the *Pinus ponderosa* forest and *P. contorta* woodland alliances. In the Wyoming Basin unrepresented types are pinyon-juniper woodland, mountain brush, *Cercocarpus ledifolius* or *C. montanus*, and *Purshia tridentata.*

Types with <1% in status 1 and 2.--Seven alliances or cover types have minimal representation (<1% of their mapped extent) within the ISD ecoregion. These include *Pinus ponderosa-Pseudotsuga menziesii* forest, pinyon woodland, *Purshia tridentata*, *Quercus gambelii, Artemisia rigida, Atriplex gardneri,* and seasonally/temporarily flooded sand flats (alkali playa). Minimally represented types in one of the subregions, in addition to those listed for the ISD ecoregion, are *Pseudotsuga menziesii* woodland and *A. nova* in the Columbia Plateau and *Pinus flexilis* or *P. albicaulis* woodland and dry perennial grassland in the Wyoming Basin subregion.

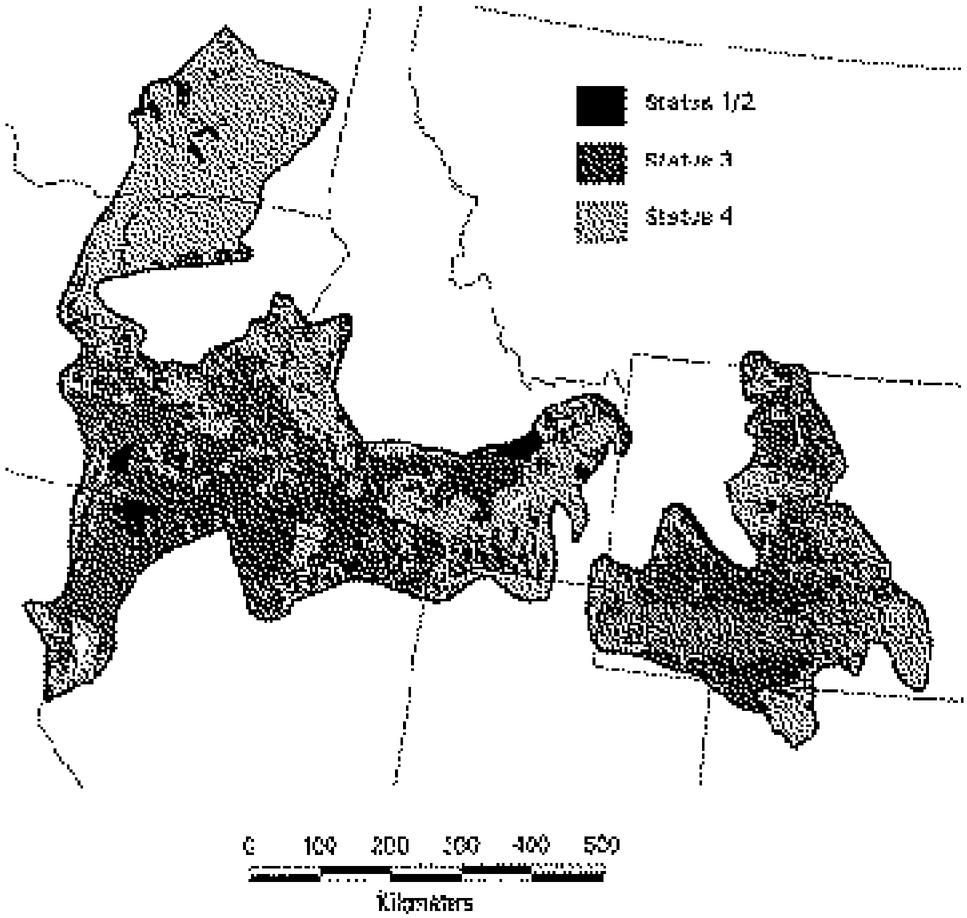
Types with 1<10% in status 1 and 2.--Twenty-six types are in this category, including the most widespread ones such as the various *Juniperus* and *Artemisia tridentata* types, *Sarcobatus vermiculatus* and mixed salt desert shrub, dry grassland, and annual grassland. The *Artemisia tridentata-A. arbuscula* shrubland type has proportions by status level that are nearly identical to the region as a whole (Fig. 3).

Types with 10-20% in status 1 and 2.--Five alliances or cover types have this level of representation in the ecoregion. These types are the *Pinus contorta* forest alliance, seasonally/temporarily flooded cold-deciduous (i.e., riparian) forest, pinyon-juniper woodland, *Artemisia cana* shrubland, and seasonally/temporarily flooded cold-deciduous shrubland.

Types with 20-50% in status 1 and 2.--Four types are in this category--the *Pinus contorta* woodland alliance, non-tidal or subpolar hydromorphic rooted vegetation (i.e., marsh and wetland), wet or dry alpine or subalpine meadows, and sparsely vegetated sand dunes. In addition to these types, the seasonally/temporarily flooded cold-deciduous forest and shrubland types have this level of representation in the Columbia Plateau subregion. The *P. contorta* forest alliance is similarly represented in the Wyoming Basin.

Types with >50% in status 1 and 2.--There are no types in this category in the ecoregion. Only the *Pinus flexilis* or *P. albicaulis* woodland type has 67% representation in the Columbia Plateau subregion, while the Wyoming Basin has none.

**Fig. 2. Land-management status of the Intermountain Semi-Desert ecoregion (levels are defined in the text).**

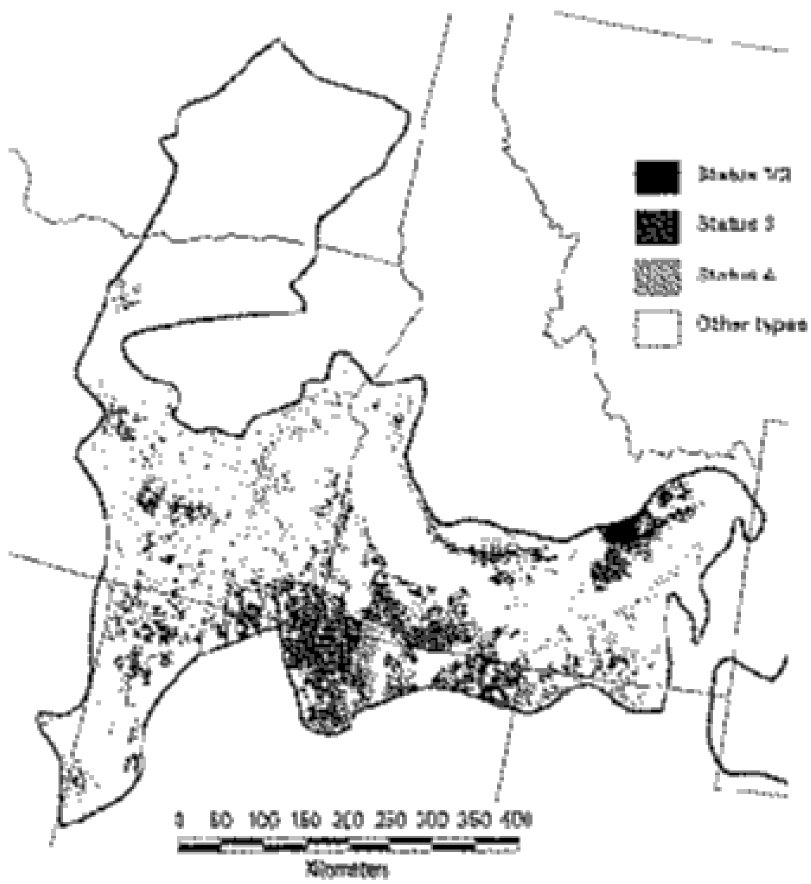



**Discussion**

**Limitations of Regional Gap Analysis**

Gap analysis at the state or regional scale is subject to limitations pertaining to its basic assumptions and those related to technological limitations and ecological realities of mapping a specific study area. We address both forms here. Gap analysis is defined as an expanded coarse-filter approach to conservation (Scott et al. 1993). It provides a baseline assessment of the distribution and management of biodiversity elements at a given point in time. As such, it attempts to characterize the variability of biodiversity across large geographic regions with moderately low-resolution map information. This rapid assessment requires the use of satellite remote sensing data, supplemented with a modest amount of field observation and any existing land-cover maps. Some plant com- munities frequently occur in patches below the 100-ha minimum mapping unit of the current mapping phase of gap analysis and conse- quently may be omitted from or underestimated in the regional analysis. Their omission highlights the need for complementary fine-filter assessments at more local scales to investigate a more complete range of biodiversity in a region. As a baseline assessment, gap analysis provides little or no information on current conditions or past trends in the community. Where changes in disturbance regime such as the increase in fire frequency have caused a conversion from sagebrush to dense annual grasses, the land-cover map depicts the current grassland type, but the loss of the original cover type is undocumented. Impacts from grazing or other activities that change the quality of the cover type but not its classification are not portrayed.

**Fig. 3. Land-management status of the *Artemisia tridentata-A. arbuscula* shrubland type in the Intermountain Semi-Desert ecoregion (levels are defined in the text).**




A similar limitation of gap analysis is its underlying assumption that land-management status is determined by the intentions expressed by the steward in formal designations or agency mission statements, not the actual or permitted land uses on specific tracts which tend to be more difficult to ascertain. For example, public lands may be inaccessible or otherwise not suitable for intensive resources uses and be de facto wilderness areas. GAP normally assigns these lands to status 3, however, because digital map information on site-specific management is not widely available and future use is uncertain. Most lands under stewardship of the Department of Defense are categorized as status 4 (except for such dedicated sites as Research Natural Areas) because there is no permanent protection offered for biodiversity. Management may change with the needs of the national defense or with reassignments of base commanders. Some tracts of Department of Defense lands, however, are relatively undisturbed compared to some other public lands. As regional-scale data on land uses and other threats to biodiversity become more widely available in electronic form in the future, the vulnerability of communities could be more directly assessed than by using land-management classes as a surrogate for threats. In the meantime, this is the best approximation.

To test the validity of this assumption, we compared the GAP land-status map with a map of categories of impact of permitted land uses on natural ecological processes compiled for the Interior Columbia Basin assessment area (Quigley et al. 1996). For the geographic area of overlap, there was very close correspondence between the status classifications based on designation and those based on permitted uses (Table 5). GAP status levels 1 and 2 areas were primarily managed for maintaining natural ecological processes. Only 3% of these lands allowed intensive uses. Over 80% of status 3 lands managed by the BLM and the USFS were being managed for a variety of ecological and human needs, most often with high levels of activity and vegetation manipulation. Roughly 15% of the area in status level 3 was also being managed for natural ecological processes and conservation of representative or rare biodiversity elements. Thus, 16,000 km<sup>2</sup> of undesignated public land is managed in ways compatible with designated GAP status 1 and 2. The premise of GAP, however, is that without the assurance of formal designation, the protection offered in current management plans cannot be considered long term. Such areas currently managed for low-intensity uses could, however, be designated with only minor economic impacts. It should be noted that the Interior Columbia Basin assessment area does not cover the entire ISD ecoregion, and management category data were compiled for only BLM and USFS lands. The findings of this comparison of management classifications cannot necessarily be extended to private or to other public lands.

Despite general consensus among ecologists and conservation planners that conservation assessments should be conducted over ecologically and biogeographically meaningful regions, there has been no universally accepted system for mapping ecoregions suitable for all purposes. We chose the ECOMAP mapping of regions (Bailey 1995) because it is in wide use throughout the Forest Service for ecosystem management and forms the basis for regional planning by other groups (The Nature Conservancy Ecoregional Working Group 1996). It is not clear how different our biological assessment might have been if a different regionalization had been selected. In general, cover types in the 2 subregions had similar management status, suggesting that relatively minor boundary adjustments would probably have little effect on the identification of conservation gaps. Where atypical plant communities are present only near the boundary of the region, we have not highlighted them as high conservation priority. No matter what ecoregion

scheme one chooses, the distribution of some communities will span more than a single region. There may be biologically important variation within such communities that is reflected by ecoregional boundaries. If one's goal is to capture the full range of biological variation of a type within special management areas, it may be prudent to assess its status across its entire range. One such approach is to assess representation by latitudinal, longitudinal, and elevational variables which have been found to vary with biotic composition and ecological processes (Mike Scott personal communication).

The land-cover map of the ISD ecoregion contains several limitations in classification that affect the findings of this analysis to an unknown degree. Aside from those related to the omission of fine-grain patches of communities, the greatest source of uncertainty relates to canopy closure in assigning vegetation to formations. Source maps were not consistent in how (or whether) forest and woodland were discriminated. Consequently, identification of tree-dominated formations in the NVCS hierarchy is probably less reliable than dominant canopy species information. Tree-dominated cover types, however, are minor components of the vegetation of the ecoregion and occur primarily at the margins. The accuracy of the separation of grassland from shrubland along the continuous gradient of increasing shrub density is also uncertain in the land-cover map. The greatest uncertainty between alliances occurs among various sagebrush species and subspecies, which were not always distinguished in the source maps. To some extent these were identified in the regional land-cover map with elevation data. The final point to emphasize is that some cover types could not be meaningfully assigned to an alliance, such as where the vegetation has no clear dominant species. As an example, mountain brush is an aggregate class representing a mixture of deciduous shrub species. No species dominates this type and the mix of dominant species varies between locations, so no alliance named for a dominant species was practical. In other cases the difficulty lies with the NVCS schema. Where individual alliances are all rare and closely related (e.g., seasonally/temporarily flooded cold-deciduous forest), it was necessary to aggregate to the formation level. Thus, the quantitative findings should be considered as preliminary indications of potential gaps in the coarse-filter representation of plant communities.

**Management Implications of the Gap Analysis**

With these limitations in mind, we draw on other published literature to interpret the raw numbers provided by the analysis. On the basis of level of representation in status 1 and 2 areas, the degree to which land-cover types are characteristic of the ISD ecoregion, and the extent of historic loss or degradation of habitat or modification of disturbance regime, we have tentatively categorized land-cover types by relative priority for conservation attention. Higher-priority categories are listed in Table 6. States in which more than 20% of the mapped distribution occurs, and stewards who manage at least this amount, are also shown in Table 6 to alert principal stakeholders of planning and management responsibilities.

Highest priority types have minimal biodiversity protection and are vulnerable to expected land-use activities; their extent and management status may be crudely estimated at the scale of regional mapping. Seasonally/ temporarily flooded cold-deciduous forest and shrubland types generally occur in narrow linear strips adjacent to rivers and streams, while marshes and meadows tend to be quite small. These patterns make them difficult to map comprehensively. Further, they contain many different alliances consisting of a variety of dominant species, and so the status of individual riparian alliances is unknown. Riparian types depend on flood scouring for germination, which has frequently been prevented by dams (Noss et al. 1995). Thus, simply allocating nature reserves without other management actions aimed at maintaining ecological processes will not preserve them. Further, these 4 types are sensitive to disturbance and valuable for wildlife habitat. Native perennial bunchgrasses are poorly represented in status 1 or 2 lands (both types at <5%) and have been substantially modified by introduced annual grasses or converted to agriculture. Three-fourths of Küchler's fescue/wheatgrass (*Festuca*/ *Pseudoroegneria* spp.) potential natural vegetation type in eastern Washington has been converted to other land uses while the wheatgrass/bluegrass (*Pseudoroegneria*/*Poa* spp.) type has lost 31% of its presettlement extent (Klopatek et al. 1979). Both perennial grassland types are predominantly on privately owned lands (dry = 77%, moist = 89%). It will take a combination of preservation and active management to maintain adequate representation of the bunchgrass types. Sparsely vegetated sand dunes may also be underestimated because dunes beneath sparse vegetation cover are difficult to recognize in satellite images. Management must protect dune-forming processes to preserve the dune community and should also recognize that many plants are endemic to specific dunes. Despite a moderately high level of representation in status 1 and 2 areas, this cover type needs a fine-filter investigation to ensure protection of the individual plant species it represents. BLM wilderness study areas in Wyoming could substantially increase the proportion of status 1 for this type (Merrill et al. 1996).

Second priority includes types where their current biodiversity protection is minimal, types are characteristic of the ecoregion, and they are vulnerable to expected land-use activities. Klopatek et al. (1979) reported a 15% loss of sagebrush steppe to other land uses, largely agriculture. Locally, the impact on sagebrush steppe has been much more severe, such as a substantial conversion of big sagebrush habitat in the Snake River plain (Noss et al. 1995). Only 1% of the sagebrush steppe has been unaffected by livestock grazing, with 30% being heavily grazed (West 1996). The major impact of grazing has been a decrease in perennial bunchgrasses with a corresponding increase in woody shrub cover. The introduction of *Bromus tectorum* has increased fire frequency in many locations to the extent that annual grasses have totally supplanted sagebrush (West 1988). Because of the selective grazing pressure on palatable species, even lightly grazed areas cannot be fully restored to a pristine condition (West 1996). Public agencies have responded to the removal of native herbs through heavy grazing by seeding large areas with introduced *Agropyron cristatum* (crested wheatgrass). Restoring these degraded or seeded sagebrush steppe sites would be extremely expensive and possibly beyond our current understanding (West 1996). The *Artemisia tripartita* and *Purshia tridentata* alliances are noteworthy because they both have 70% of their mapped distributions on private lands. In contrast, 2/3 of the *A. nova* type occurs on public lands. The actual management status of *A. rigida* (stiff sagebrush) dwarf shrubland, with 61% in status 4, is only an estimate. It was not mapped in Idaho where it is known to occur on small patches of specific soils that were below the resolution of the original Idaho land-cover map (Caicco et al. 1995).

The xeric cover types, including mixed salt desert shrub, *Atriplex gardneri* (which was mapped only in the Wyoming Basin subregion but does occur in the Columbia Plateau), *Sarcobatus vermiculatus*, and seasonally/temporarily flooded sand flats, are also in the second-priority category. These types tend to be arranged in distinct gradients of moisture and alkalinity in valley bottoms, with strong competitive sorting of species. Stutz (1978) proposes that rapid evolutionary divergence and hybridization within the *Atriplex* genus may be occurring in different valleys in Wyoming, Nevada, and Utah. If true, this would argue for protection of many replicates in this ecoregion and in the Intermountain Semi-Desert and Desert ecoregion to the south to nurture this evolutionary process. Currently, <2% of the mixed salt desert shrub type is in status 1 or 2 lands. The seasonally/temporarily flooded sand flats, or alkali playa, type is even less well represented at 0.2%. The *A. gardneri* and *S. vermiculatus* alliances have 1% and 6%

representation, respectively, but are not highly vulnerable to grazing impacts because of the defense mechanisms of their dominant species. Over 80% of the *A. gardneri* type was mapped on public lands, primarily under the jurisdiction of the BLM. Formally designating the BLM wilderness study areas in the state of Wyoming, however, would contribute very little additional protection for these 4 desert types (Merrill et al. 1996).

Third-priority land-cover types are those that have low representation in existing biodiversity management areas but do not appear highly vulnerable from the kinds of activities that are most probable. Also included are types which have complex, highly variable floristic composition. These types require further study to assess their conservation status in greater detail, perhaps with finer separation of alliances within the type. *Juniperus occidentalis* has doubled in areal extent, at least in Idaho and Oregon, where it has replaced sagebrush steppe communities as a result of fire suppression (Miller and Rose 1995) and reduced herbaceous fuel in the understory from heavy livestock grazing (West 1988). Given that juniper woodlands are expanding into sagebrush steppe, management concern lies more with the fire regime than necessarily increasing their representation in designated managed areas. *Populus tremuloides* forest and woodland are also dependent on periodic disturbance. Mountain brush within the ISD ecoregion is at the northern limits of its range (Caicco et al. 1995). It is perhaps one of the most complex classes in the ecoregion with a diverse mix of canopy shrubs that can vary dramatically between sites. This floristic complexity makes mountain brush a difficult class about which to draw meaningful conclusions concerning its protection status with GAP data, so it needs to be examined in greater detail. The *Cercocarpus* alliance tends to occur on steep, rocky outcrops which are not prone to development. In fact, as a fire-sensitive species, *Cercocarpus* has expanded its range since the beginning of fire suppression (Kagan and Caicco 1992). While not of the highest conservation priority, it should still receive further consideration (Merrill et al. 1996). The sparsely vegetated boulder, gravel, cobble, and talus rock is a very general class for many types of essentially bare ground. Little can be concluded about its biodiversity value except at a more site-specific scale.

Fourth priority includes types that tend to be marginal to the ISD ecoregion. These types may be of concern but are better assessed in neighboring regions or across their entire range. These types include all conifer forest and woodland types (except juniper woodlands), *Quercus garryana* woodland, *Q. gambelii* shrubland, and alpine tundra. The gap analysis projects in Idaho and Wyoming in combination provide some of that broader perspective for a few of the types marginal to the ISD ecoregion. *Pinus contorta* forest and woodland types are more characteristic of the northern Rocky Mountains where they also appear to be well represented (Caicco et al. 1995, Merrill et al. 1996). *P. flexilis* occurs mostly in the Wyoming Basin on sites unsuitable for most human land uses. Even though it is not well protected by formal land-management designations, it is not highly vulnerable and not a high conservation priority in the ecoregion (Merrill et al. 1996). The *Picea engelmannii* and/or *A. lasiocarpa* forest and woodland type is widespread throughout the mountains of Idaho and Wyoming where it is well represented (approximately 40% in each state) in status 1 and 2 lands (Caicco et al. 1995, Merrill et al. 1996).

**Conclusions**

A gap analysis was conducted for the Intermountain Semi-Desert ecoregion using data compiled from 9 states. Despite limitations in the data, our gap analysis provides the first systematic assessment across all ownerships of the management status of plant communities within a multistate region. Forty-eight land-cover types were mapped at the regional level, many of which are at the alliance level of classification. Twenty types were determined to be the highest conservation priorities, as they are especially vulnerable to future losses or degradation in the absence of formal designation or active intervention for long-term biodiversity management. Over 96% of the terrestrial environment within the region is potentially available to intensive human uses for resources, recreation, or urbanization; the proportions are similar for the Columbia Plateau and Wyoming Basin subregions. We urge that findings regarding individual vegetation types from this assessment be carefully validated by regional field investigation to better determine their true level of representation and actual vulnerability to threats before policy decisions are made and implemented.

One of the motivations for conducting gap analysis for an ecoregion rather than for political jurisdictions is to reflect more accurately the vulnerability of communities over their ranges. Findings from a sample of the community, such as a single state, could be misleading and generate inefficient conservation action. Generally, land-cover types had similar management status in the ISD ecoregion analysis as they did in the 3 gap analyses published to date for Idaho (Caicco et al. 1995), Utah (Edwards et al. 1995), and Wyoming (Merrill et al. 1996). Types with low representation within individual states were likewise poorly represented in the region. Well-represented types at the state level were mostly conifer forest types that occur in Yellowstone National Park and large wilderness areas of central Idaho, which are outside the ecoregion. Thus, even if these tree-dominated types had low representation in the ISD ecoregion, we felt they were not a high conservation priority regionally. This correspondence of state and regional findings in this particular instance is probably not typical.

Beyond the initial conservation assessment, these findings can be applied in at least 2 additional directions. First, they can provide a regional perspective when the impacts of specific land-use proposals are investigated. GAP data can quantify how rare a community type is, where else it occurs, and how well it is represented in biodiversity management areas. Second, the data from GAP can play a significant role in follow-up conservation planning efforts at a statewide or regional level (Crowe 1996, Vickerman 1996). For instance, GAP data such as shown in Figure 3 can provide the missing biodiversity dimension in discussions about alternative wilderness and national park proposals (Wright et al. 1994, Merrill et al. 1995, 1996, Wright and Scott 1996). The Nature Conservancy has already used the GAP database from the Columbia Plateau subregion as a coarse-filter to identify candidate areas to ensure adequate representation of all community types. Because GAP projects are now underway in almost every state in the nation, data to support other regional analyses and conservation planning will soon be forthcoming.

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**Table 1. Percentage of mapped area of land-cover classes by management status in the Intermountain Semi-Desert ecoregion. Formation names shown in bold italics.**

| Land-cover class ecoregion | Status1 (%) | Status 2 (%) | Status 3 (%) | Status 4 (%) | Total area (km²) | Total % |
|---|---|---|---|---|---|---|
| ***Rounded-crowned temperate or subpolar needle-leaved evergreen closed tree canopy*** | | | | | | |
| *Pinus contorta* forest | 14.1 | 4.1 | 72.9 | 8.9 | 2,726 | 0.7 |
| *Pinus ponderosa* forest | 0.0 | 3.6 | 42.4 | 54.0 | 106 | <0.1 |
| *Pinus ponderosa-Pseudotsuga menziesii* forest | 0.0 | 0.4 | 47.4 | 52.2 | 1,350 | 0.3 |
| ***Conical-crowned temperate or subpolar needle-leaved evergreen closed tree canopy*** | | | | | | |
| *Abies* species (*A. concolor, A. grandis,* or*A. Magnifica)* forest or woodland | 0.0 | 2.3 | 51.4 | 46.3 | 183 | <0.1 |
| *Picea engelmannii* and/or *Abies lasiocarpa* forest or woodland | 5.9 | 0.2 | 71.3 | 22.5 | 606 | 0.1 |
| *Pseudotsuga menziesii* forest | 1.4 | 1.2 | 63.8 | 33.5 | 3,335 | 0.8 |
| ***Montane or boreal cold-deciduous closed tree canopy*** | | | | | | |
| *Populus tremuloides* forest | 5.6 | 4.4 | 59.6 | 30.4 | 1,038 | 0 3 |
| ***Seasonally/temporarily flooded cold-deciduous closed tree canopy*** | | | | | | |
| *Populus fremontii, P. balsamifera, P. angustifolia,P. tremuloides, Salix, Alnus, Betula,* etc. | 2.5 | 11.9 | 14.1 | 71.5 | 1,053 | 0.3 |
| ***Rounded-crowned temperate or subpolar needle-leaved evergreen open tree canopy*** | | | | | | |
| Pinyon woodland (*Pinus edulis* or *P. monophylla*) | 0.0 | 0.1 | 52.6 | 47.3 | 332 | 0.1 |
| Pinyon-juniper woodland *(Pinus edulis* or*P. monophylla* with *Juniperus osteosperma* or *J. scopulorum*) | 11.1 | 0.0 | 51.1 | 37.7 | 391 | 0.1 |
| Juniper woodland (*Juniperus osteosperma* or *J. scopulorum*) | 0.2 | 3.8 | 57.1 | 38.9 | 6,728 | 1.6 |
| *Juniperus occidentalis* woodland | 1.1 | 2.0 | 51.0 | 46.0 | 17,609 | 4.3 |
| *Pinus flexilis* or *P. albicaulis* woodland | 7.2 | 0.5 | 44.6 | 47.7 | 1,141 | 0.3 |
| *Pinus contorta* woodland | 13.8 | 7.2 | 52.2 | 26.8 | 373 | 0.1 |
| *Pinus jeffreyi* forest and woodland | 0.0 | 0.0 | 68.0 | 32.0 | 181 | <0.1 |
| *Pinus ponderosa* woodland | 0.1 | 3.0 | 37.9 | 59.0 | 7,599 | 1.9 |

| | | | | | | |
|---|---|---|---|---|---|---|
| ***Conical-crowned temperate or subpolar needle-leaved evergreen open tree canopy*** | | | | | | |
| *Pseudotsuga menziesii* woodland | 0.9 | 0.2 | 70.6 | 28.3 | 706 | 0.2 |
| ***Cold-deciduous open tree canopy*** | | | | | | |
| *Populus tremuloides* woodland | 1.3 | 1.9 | 50.4 | 46.3 | 1,896 | 0.5 |
| *Quercus garryana* woodland | 0.0 | 3.0 | 13.7 | 83.3 | 643 | 0.2 |
| ***Microphyllous evergreen shrubland*** | | | | | | |
| *Artemisia tridentata* ssp. *vaseyana* shrubland | 0.8 | 2.6 | 50.5 | 46.0 | 24,702 | 6.0 |
| *Artemisia tridentata-A. arbuscula* shrubland | 0.6 | 4.8 | 68.7 | 26.0 | 46,047 | 11.2 |
| *Artemisia tridentata* shrubland | 1.1 | 2.9 | 63.7 | 32.3 | 117,263 | 28.6 |
| *Artemisia tripartita* shrubland | 0.0 | 1.4 | 29.4 | 69.1 | 3,494 | 0.9 |
| *Purshia tridentata* shrubland | 0.0 | 0.3 | 29.9 | 69.8 | 1,071 | 0.3 |
| ***Temperate cold-deciduous shrubland*** | | | | | | |
| *Artemisia cana* shrubland | 14.3 | 0.9 | 59.8 | 25.0 | 532 | 0.1 |
| Mountain brush shrubland | 3.5 | 1.9 | 49.3 | 45.3 | 3,339 | 0.8 |
| *Cercocarpus ledifolius* or *C. montanus* shrubland | 1.0 | 1.2 | 50.7 | 47.2 | 1,136 | 0.3 |
| *Quercus gambelii* shrubland | 0.0 | 0.1 | 17.6 | 82.2 | 379 | 0.1 |
| ***Seasonally/temporarily flooded cold-deciduous shrubland*** | 2.0 | 10.0 | 43.0 | 45.0 | 2,568 | 0.6 |
| ***Extremely xeromorphic deciduous subdesert shrubland with or without succulents*** | | | | | | |
| *Sarcobatus vermiculatus* shrubland | 0.8 | 5.2 | 51.9 | 42.1 | 5,996 | 1.5 |
| ***Facultatively deciduous extremely xeromorphic subdesert shrubland*** | | | | | | |
| Mixed salt desert shrub (*Atriplex* spp.) | 0.6 | 1.0 | 66.2 | 32.1 | 22,668 | 5.5 |
| ***Dwarf-shrubland*** | | | | | | |
| *Artemisia nova* dwarf-shrubland | 0.0 | 3.9 | 66.9 | 29.3 | 573 | 0.1 |
| *Artemisia arbuscula-A. nova* dwarf-shrubland | 0.0 | 8.4 | 76.5 | 15.1 | 1,813 | 0.4 |
| *Artemisia rigida* dwarf-shrubland | 0.3 | 0.2 | 38.2 | 61.2 | 881 | 0.2 |
| *Atriplex gardneri* dwarf-shrubland | 0.0 | 1.0 | 79.5 | 19.4 | 9,898 | 2.4 |

| | | | | | | |
|---|---|---|---|---|---|---|
| ***Temperate or subpolar perennial grassland*** | | | | | | |
| Dry grassland-*Pseudoroegneria* (*Agropyron*)-*Poa* | 0.2 | 4.3 | 18.9 | 76.5 | 21,222 | 5.2 |
| Moist grassland-*Festuca* | 0.0 | 3.1 | 7.8 | 89.1 | 1,927 | 0.5 |
| ***Temperate or subpolar perennial grassland-cultivated*** | | | | | | |
| *Agropyron cristatum* seedings, *Poa pratensis*,hayfields, and Conservation Reserve Program lands | 0.2 | 0.7 | 68.5 | 30.5 | 8,267 | 2.0 |
| ***Temperate or subpolar annual grasslands or forb vegetation*** | | | | | | |
| Annual grasses-*Bromus tectorum*, etc. | 0.7 | 0.6 | 50.5 | 48.2 | 11,522 | 2.8 |
| ***Non-tidal temperate or subpolar hydromorphic rooted vegetation*** | | | | | | |
| *(marsh and wetland)* | 0.2 | 38.0 | 7.2 | 54.6 | 518 | 0.1 |
| ***Alpine and subalpine meadows of the higher latitudes*** | | | | | | |
| Alpine tundra | 0.0 | 0.0 | 100.0 | 0.0 | 3 | <0.1 |
| Wet or dry meadow | 34.7 | 4.0 | 43.1 | 18.1 | 177 | <0.1 |
| ***Sparsely vegetated land-cover types*** | | | | | | |
| Seasonally/temporariy flooded sand flats | 0.0 | 0.2 | 73.3 | 26.5 | 2,341 | 0.6 |
| Sparsely vegetated sand dunes | 0.9 | 26.4 | 47.6 | 25.2 | 851 | 0.2 |
| Sparsely vegetated boulder, gravel, cobble, talus rock | 0.2 | 3.4 | 64.9 | 31.5 | 2,415 | 0.6 |
| ***Cultural land use types and surface water*** | | | | | | |
| Urban or human settlements and mining | | | | | 1,684 | 0.4 |
| Agriculture | | | | | 64,473 | 15.7 |
| Open water, including ponds | | | | | 2,220 | 0.5 |
| **Regional totals (including cultural land uses and surface water)** | **0.9** | **2.8** | **49.5** | **46.9** | **411,277** | |

**Table 2. Percentage of land by management status by steward in the Intermountain Semi-Desert ecoregion.**

| Steward | Status 1 (%) | Status 2 (%) | Status 3 (%) | Status 4 (%) | Area ($km^2$) | Area (%) |
|---|---|---|---|---|---|---|
| Private, including NGOs | 0.1 | 0.5 | 0.1 | 99.4 | 163,005 | 39.6 |
| County/regional government | 0.0 | 0.0 | 100.0 | 0.0 | 2 | ~0.0 |
| State government | 0.1 | 7.4 | 19.4 | 73.1 | 19,381 | 4.7 |
| Bureau of Land Management | 0.5 | 1.7 | 97.8 | 0.0 | 186,663 | 45.4 |
| National Park Service | 73.5 | 26.5 | 0.0 | 0.0 | 317 | 0.1 |
| U.S. Fish and Wildlife Service | 29.8 | 68.8 | 1.4 | 0.0 | 4,581 | 1.1 |
| U.S. Forest Service | 5.2 | 0.2 | 94.6 | 0.0 | 16,857 | 4.1 |
| Tribal lands | 0.0 | 0.0 | 0.0 | 100.0 | 11,488 | 2.8 |
| Department of Energy | 0.0 | 69.9 | 0.0 | 30.1 | 3,441 | 0.8 |
| Bureau of Reclamation | 7.7 | 2.0 | 0.0 | 90.3 | 1,160 | 0.3 |
| Military reservations/ Corps of Engineers | 0.0 | 0.2 | 0.0 | 99.8 | 2,161 | 0.5 |
| Large water bodies | -- | -- | -- | -- | 2,220 | 0.5 |
| ISD ecoregion total | 0.9 | 2.8 | 49.5 | 46.9 | 411,277 | 100 |

**Table 3. Percentage of land by management status by subregion in the Intermountain Semi-Desert ecoregion (does not include water bodies).**

| Subregion | Status 1 (%) | Status 2 (%) | Status 3 (%) | Status 4 (%) | Area (%) |
|---|---|---|---|---|---|
| Wyoming Basin | 0.6 | 1.3 | 55.3 | 42.8 | 118,942 |
| Columbia Plateau | 1.0 | 3.5 | 47.0 | 48.5 | 290,617 |
| ISD ecoregion | 0.9 | 2.8 | 49.5 | 46.9 | 409,559 |

**Table 4. The number of land-cover classes at various percentage levels of representation in existing managed areas (status level 1 and 2 combined). Does not include open water, *Agropyron cristatum* seedings, or cultural land-cover types**

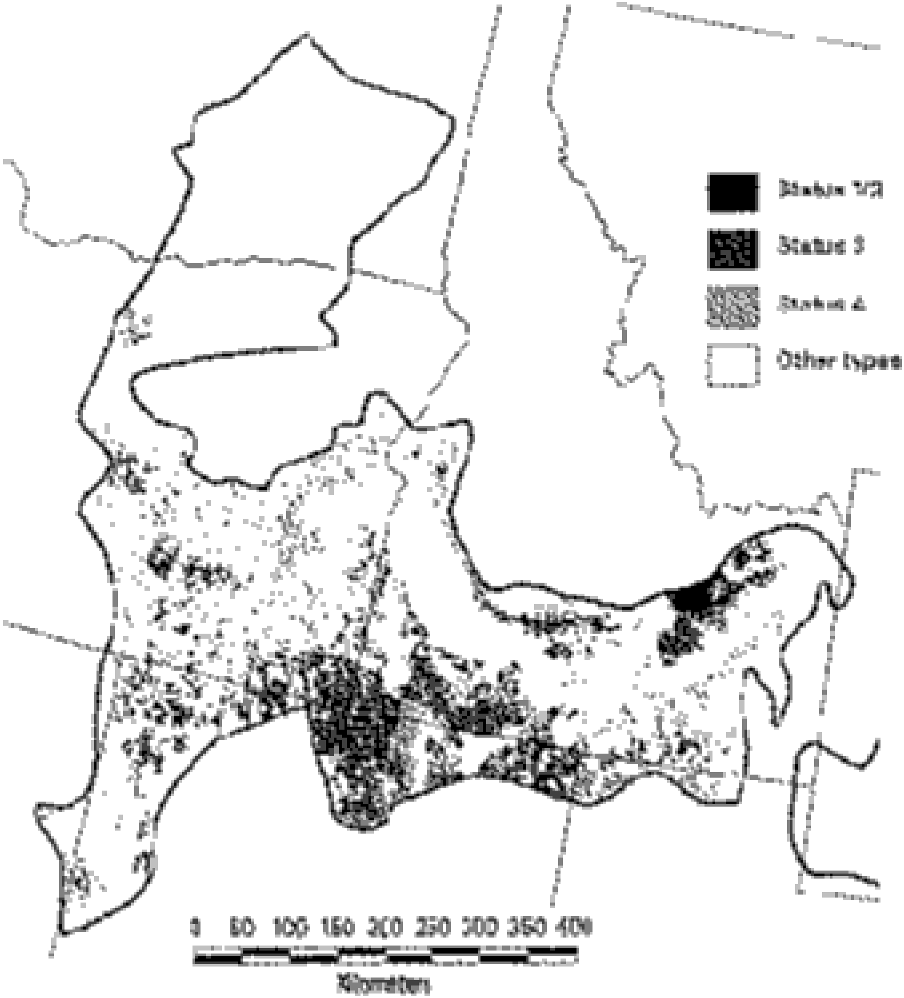
| Subregion | # not represented | # with <1% | # with 1-10% | # with 10-20% | # with 20-50% | # with >50% | Total |
|---|---|---|---|---|---|---|---|
| Wyoming Basin | 4 | 7 | 14 | 2 | 4 | 0 | 31 |
| Columbia Plateau | 4 | 7 | 20 | 5 | 5 | 1 | 42 |
| ISD ecoregion | | | | | | | |
| total | 2 | 7 | 26 | 5 | 4 | 0 | 44 |

**Table 5. Correspondence of GAP status levels based on designation with management categories from the Interior Columbia Basin Ecosystem Management Project (ICBEMP) based on actual and planned land uses on national forest and Bureau of Land Management lands. The ICBEMP categories are summarized as follows: 1 = natural ecological processes, 2 = non-intensive human uses in conservation areas, 3-4 = low-intensity human uses in balance with ecological integrity, 5-6 = vegetation manipulation for resource use, 7-8 = ecological conditions significantly altered by human activities.**

| Gap Status Level | ICBEMP management Categories 1 | 2 | 3-4 | 5-6 | 7-8 |
|---|---|---|---|---|---|
| 1 | 82.8 | 9.9 | 4.6 | 2.8 | 0.0 |
| 2 | 60.4 | 20.3 | 10.9 | 7.8 | 0.7 |
| 3 | 14.2 | 0.8 | 4.2 | 79.2 | 1.6 |

**Table 6. States where the most vulnerable land-cover classes primarily occur (>20% of the distribution of the type in status 3 and 4) and stewards most responsible for their management (>20% in status 3 and 4). States and stewards listed in descending order of extent, if more than one is listed. * indicates rare type that may be underestimated, so other states and stewards may be involved as mapping is refined**

| Land-cover class | States | Stewards |
|---|---|---|
| First-priority classes | | |
| Seasonally/temporarily flooded cold-deciduous forest | WY * | Pvt * |
| Seasonally/temporarily flooded cold-deciduous shrubland | WY, ID * | BLM, Pvt * |
| Dry grassland-*Pseudoroegneria* (*Agropyron*)-*Poa* | WA, WY, OR | Pvt |
| Moist grassland-*Festuca* | OR, WA | Pvt |
| Non-tidal temperate or subpolar hydromorphic rooted vegetation (marsh and wetland) | ID, OR, WA * | Pvt * |
| Wet or dry meadow | WY, UT * | FS, Pvt * |
| Sparsely vegetated sand dunes | WY * | BLM, Pvt * |
| | | |
| Second-priority classes | | |
| *Artemisia tridentata* ssp. *vaseyana* shrubland | ID, WY, NV | BLM, Pvt |
| *Artemisia tridentata-A. arbuscula* shrubland | ID, NV, OR | BLM, Pvt |
| *Artemisia tridentata* shrubland | WY, OR | BLM, Pvt |
| *Artemisia tripartita* shrubland | WA | Pvt, BLM |
| *Purshia tridentata* shrubland | OR | Pvt, BLM |
| *Artemisia cana* shrubland | OR | BLM, Pvt |
| *Sarcobatus vermiculatus* shrubland | WY, OR | BLM, Pvt |
| Mixed salt desert shrub (*Atriplex* spp.) | WY, NV | BLM, Pvt |
| *Artemisia nova* dwarf-shrubland | WY, OR | BLM, Pvt |
| *Artemisia arbuscula- A. nova* shrubland | ID | BLM |
| *Artemisia rigida* dwarf-shrubland | OR * | Pvt, BLM * |
| *Atriplex gardneri* dwarf-shrubland | WY | BLM |
| Seasonally/temporarily flooded sand flats | NV | BLM, Pvt |
| | | |
| Third-priority classes | | |
| Juniper woodland (*Juniperus osteosperma* or *J. scopulorum*) woodland | WY, ID | BLM, Pvt |
| *Juniperus occidentalis* woodland | OR | BLM, Pvt |
| *Populus tremuloides* forest | OR, WY, NV | BLM, FS, Pvt |
| *Populus tremuloides* woodland | WY, CO | Pvt, FS, BLM |
| Mountain brush | ID | Pvt, BLM, FS |
| *Cercocarpus ledifolius* or *C. montanus* shrubland | WY, OR | BLM, Pvt |
| Sparsely vegetated boulder, gravel, cobble, talus rock | WY | BLM, Pvt |



Status 1/2
Status 3
Status 4
Other types
0 50 100 150 200 250 300 350 400
Kilometers