CHAPTER III

Indicators for Conservation and Maintenance of Plant and Animal Resources on Rangelands

INTRODUCTION

Within the Sustainable Rangeland Roundtable (SRR), a group identified, developed, and adopted standardized indicators that would characterize the conservation and maintenance of plant and animal resources, one of the five criteria for assessing sustainable rangelands. The development of these 10 indicators is a reflection of the expert opinions of rangeland scientists, rangeland management agency personnel, non-governmental organization representatives, practitioners, and other interested stakeholders. Associated concepts and ideas have evolved from lively discussions at the SRR workshops as well as electronic correspondence between meetings. These indicators are not inclusive, but provide a suite of variables, that when complemented with indicators from the four other criteria, produce a viable system to monitor, at the national level, the biophysical, social, and economic characteristics indicating trends of sustainability on rangelands.

PLANT AND ANIMAL INDICATORS

Plant and animal resources are an important component of rangeland ecosystems. The 10 indicators identified here reflect multiple factors relevant to the conservation and maintenance of plant and animal resources, from location and area of rangeland to detailed information on population dynamics of species of concern (Table 3-1). The development of these indicators built upon previous work in the refereed literature and work such as the Criteria and Indicators of the Montreal Process (Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests, 1995), and The H. John Heinz III Center report on *The State of the Nation's Ecosystems: Measuring the Lands, Waters, and Living Resources of the United States* (The H. John Heinz III Center 2002).

Criterion 1 from the Montreal Process, conservation of forest biological diversity, includes indicators of forest type area, fragmentation, status of species at risk, and population dynamics of representative species. Similarly national-level indicators proposed for grasslands and shrublands by The Heinz Center included extent of land area in rangelands (The H. John Heinz III Center 2002). These indicators are identified here as important factors related to plants and animals on rangelands. West (1993) identified components of biodiversity such as landscape, community, population, and genetics. These components are reflected in our indicators associated with fragmentation, plant communities, presence of species and communities of concern, and population levels of representative species. Genetic diversity of rangeland plants has been little studied with few exceptions for some shrubs and grasses; thus, no indicator was identified here. Another Criterion from the Montreal Process, Criterion 3 Maintenance of forest ecosystem health and vitality, includes forest area affected by processes beyond the range of historic variation, impacted by air pollutants, or with diminished biological processes. This criterion has a narrower definition of health than is commonly discussed in the range science literature. The term "rangeland health" has been defined as "the degree to which the integrity of the soil and the ecological processes of rangeland ecosystems are sustained" (National Research Council 1994), and has often been characterized with multiple indicators of ecosystem structure and function (Pellant et al. 2000). Within the Plants and Animal Criterion, ecosystem processes, such as the natural disturbance of fire and the human-induced disturbance of invasive species, are proposed as indicators (Table 3-1). Riparian systems are maintained by disturbance so this functions as another measure of disturbance on rangeland systems. The Heinz Center also proposed national-level indicators for grasslands and shrublands such as the integrity of natural fire regimes, extent and condition of riparian systems, fragmentation, the area of infestation, and presence/absence of invasive and non-native species of concern (The H. John Heinz III Center 2002). Within the SRR, indicators for additional concepts related to rangeland health and biodiversity have been identified under two other criteria: (1) Maintenance of Productive Capacity and Conservation, and (2) Maintenance of Soil and Water Resources on Rangelands. When taken together, these three criteria of the SRR and their associated indicators reflect rangeland health and biodiversity concepts.

Indicators follow Table 3-1.

Table 3-1. Indicators for conservation and maintenance of plant and animal resources on rangelands.

Indicator	What the indicator describes
1. Extent of land area in rangeland	Over several measurements, changes in the total amount of land that fits the definition of rangeland.
2. Rangeland area by plant community	Changes in the area of vegetation types on rangeland.
3. Number and extent of wetlands	Changes in wetland abundance.
4. Fragmentation of rangeland and rangeland vegetation communities	Changes in spatial patterns on rangeland and on vegetation community types.
5. Density of roads and human structures	Change in intensity of human uses.
6. Integrity in natural fire regimes on rangeland	Changes in characteristics associated with the natural disturbance of fire, such as fire frequency, intensity, and extent.
7. Extent and condition of riparian systems	Condition of riparian vegetation and watershed health.
8. Area of infestation and presence/absence of invasive and non-native plant species of concern	Displacement of native plants and habitat.
9. Presence and status of species and communities of concern	Changes in species and communities that are threatened, endangered, or of concern for some identified reason.
10. Population status and geographic range of rangeland-dependent species	Finer scale information, such as population levels and current geographic range, on select plant and animal species.

EXTENT OF LAND AREA IN RANGELAND

Description of the Indicator

This indicator quantifies (1) the amount of the total area of land defined as rangelands for a given time period, (2) the amount of other land cover types that change to rangeland for a given period, and (3) the amount of rangeland that converts to another land cover type, e.g., urban or industrial land cover within the same time period. The extent of this indicator will either be within a region of the United States, e.g., the state of Florida, or for the entire United States and associated territories. The extent of land area in rangeland is important because it provides the spatial and temporal framework and spatial extent from which all other indicators will be considered.

Analysis of this indicator requires a nationally accepted definition for rangeland that can be physically mapped and distinguished from other land cover types, particularly the forest cover type. Many definitions for rangeland have been developed; commonly rangeland is defined as land with a specific vegetation and climate (Shiftlet 1994, Heady and Child 1994, National Rangeland Management Workshop Group [Australia] 1994, Friedl et al. 2000) in which the vegetation is predominately grasses, grass-like plants, forbs, or shrubs; includes such plant communities as natural grasslands, savannas, shrublands, deserts, tundra, alpine ecosystems, marshes, and meadows; and may include introduced species such as crested wheatgrass. Some definitions stipulate that rangeland is managed as a natural ecosystem. Variation in definitions is widespread. For example, savanna, a plant community with variable amounts of grasses, shrubs, and trees, can be viewed as a transition between rangeland and forest. The distinction as to whether a “savanna” is rangeland or forest is often based on an arbitrary designation of the threshold height difference between shrubs and trees and the density of trees (trees per area). Attributes of land use have also been used to define rangeland, such as lands unsuitable for crops or timber due to rockiness, salinity, steepness, and seasonal flooding (Friedl et al. 2000). A land-use is defined as “the purpose to which land is put by humans” (e.g., protected areas, forestry for timber products, pastures, or human settlements, Dale et al. 2000). A land-cover is defined as the ecological state and physical appearance of the land surface (e.g., closed forests, open forests, grasslands [Dale et al. 2000]).

The SRR recommends a land cover definition as follows: rangelands are areas dominated by self-propagating vegetation comprised predominantly of grasses, grass-likes, forbs, shrubs, and dispersed trees. Ecological classifications, including vegetation, soil, and ecophysical classifications, have the purpose of delineating common areas and common management units (McMahon et al. 2001). The main assumption is that landscape heterogeneity can be delineated into homogenous patches, sites, units, or landscape elements that have similar physical and biological characteristics and that these homogenous units will have a common response to disturbance or management. For this indicator, the ecological classification provides the framework for identifying rangeland vegetation across the landscape.

Both the ecological classification and the areal estimation method (ground based inventory, remote sensing methods) will affect the estimate of rangeland area (Turner et al. 2001, Konarska et al. 2002). Further discussion on the choices and implications of the available classification systems is found under Rangeland Area by Plant Community. This section will focus on methods for detecting land area and change in land area.

The most consistent and most commonly used assessment of rangeland area and change in that area has been the Natural Resource Conservation Service (NRCS) National Resources Inventory (NRI) of non-federal lands, collected since the 1970s (Nusser and Goebel 1997). Of interest here are the reported changes in rangeland area between the five-year periodic inventories (USDA Soil Conservation Service 1987; USDA Natural Resource Conservation Service 1995, 1996; Mitchell 2000, p 19, Table 26; and USDA Forest Service 2001). For example, the 3 percent net loss of non-Federal rangeland nationwide between 1982 and 1997 was associated with the largest loss of rangelands going to cropland (USDA Forest Service 2001, Table 2).

Information has been compiled about the area of all rangeland in the United States and in various regions of the United States; however, the methods used to estimate land area and detect change have varied. On federal lands, no periodic inventory of rangelands is available. Further, the extent of federal rangelands has not been consistently determined across agencies and over time (Mitchell 2000). A consistent methodology assessing the area of rangeland and the temporal change in area could be implemented across all U.S. lands, offering a repeatable method to track rangeland area. The SRR proposes also that current technology may be available to offer the opportunity to assess rangeland areal extent and change in a spatial context.

Importance: What does it measure and why is it important to sustainability?

Analysis of this indicator over time would quantify if total rangeland area were increasing, decreasing, or static and to what type of land cover rangeland had converted to and what types of land cover had become rangeland.

Rangelands are important for sustainability because of the ecosystem services they provide including (from Daily et al. 1997):

- purification of air and water
- generation and preservation of soils and renewal of their fertility
- detoxification and decomposition of wastes
- pollination of crops and natural vegetation
- dispersal of seeds
- cycling and movement of nutrients
- control of the vast majority of potential agricultural pests
- maintenance of biodiversity
- partial stabilization of climate
- moderation of weather extremes and their impacts
- provision of aesthetic beauty and intellectual stimulation that lift the human spirit.

Rangelands are an important source of marketable goods, including animals whose parts or products are consumed (as meat, milk, wool, and leather) and to a lesser extent, those used for labor (horses, mules, etc.). Rangelands are important as habitat for most domestic animals such as cattle, goats, sheep, and horses, as well as the original source for many crops, such as wheat, barley, rye, oats, and other grasses (Sala and Paruelo 1997). In a wide variety of rangeland habitats, people hunt game animals such as waterfowl, deer, moose, elk, fox, boar and other wild pigs, and rabbits. In many places, hunting is an economically and culturally important sport. Nearly 84 percent of the mammals and 74 percent of the bird species within the United States (inhabitants or common migrants) use rangeland habitats (Flather et al. 1999). Rangelands are an important source of non-marketable goods and services such as bird-watching, ecosystem services such as clean water, and spiritual and esthetic values. Rangelands also offer diverse recreational experiences from mountain bike riding in the desert Southwest to bird watching along the migratory flyways. The loss of the land cover defined as rangeland would have ecological, economic, and social implications.

Geographic Variation: Is the indicator meaningful in different regions?

This indicator is meaningful in different geographic regions. Rangeland area has been reported globally, regionally, at the state level, and within counties in the United States. Shriner and Street (2000) reported that nonforest terrestrial ecosystems make up the single largest type of land surface cover (>51 percent) in North America—here they include non-tidal wetlands, grasslands, deserts, savannas, and improved pastures. The World Resources Institute (WRI) estimated that North America had 913 million hectares of rangeland in 1986 (WRI 1986, Friedl et al. 2000). Mitchell (2000) reported that privately owned rangeland accounted for 399 million acres of the total US land base in 1992, based on the NRCS NRI. At the regional scale, rangelands can be an even greater percentage of the land surface cover; however, estimates of the proportion of rangelands varies with the way they are defined and sampled making comparisons across regions difficult.

Scale: Is the indicator meaningful at different spatial and temporal scales?

This indicator is meaningful at different spatial and temporal scales, if consideration is given to the sensitivity to scale that exists in the current methods. The definition of plant communities and the implementation of those definitions in the field are sensitive to spatial scale. Along the temporal scale, modern changes in the regional and national extent of rangelands are superimposed over geological changes in the last 25,000 years (Jackson and Overpeck 2000). Rangelands are highly variable landscapes with an ever-changing mosaic of plant communities within plant communities, driven by abiotic and biotic forces as well as by human use. For different reasons, the variability of the rangeland landscape challenges ground-based point inventories and remote sensing methods to consistently measure spatial and temporal changes over time.

Ground based inventories estimate the amount of land area (in any classification) using a point-based sampling system; an extensive number of sample points where each point represents a certain amount of land area. To capture the heterogeneity of rangeland vegetation, field-based inventories require comprehensive environmental and vegetation attribute data, stratification, and appropriate sample sizes per attribute and the associated person hours to produce statistically acceptable results. The number of samples needed in field-based inventories is typically determined by the desired variation in the estimate. In the 1992 NRI, 800,000 sample points were needed in order to obtain the objective of a coefficient of variation of less than 10 percent for any estimate of surface area within a particular resource condition (or for other variables such as erosion rates) on areas that constitute at least 10 percent of the surface area within the ecophysical classification of Major Land Resource Area (MLRA) (Nusser and Goebel 1997). Major Land Resource Areas (MLRA, USDA SCS Soil Survey Staff 1981) are geographic areas, usually several thousand acres in extent, that are characterized by a particular pattern of soils, climate, water resources, land uses, and type of land use, and that are nested within Land Resource Areas. This classification system is based on the assumption that landscapes are hierarchically structured discrete entities that can be mapped at different spatial scales. A number of federal agencies, including the NRCS, USDA Forest Service, Environmental Protection Agency (EPA), and the Multi-Resolution Land Characteristics Consortium (MRLC), use or have developed eco-physical or eco-regional maps that use this hierarchical concept (Bailey 1983, Omernick 1987, Hargrove and Hoffman 1999). Ecoregions have been delineated using expert opinion or using quantitative procedures, such as Hargrove and Hoffman (1999). In the 1992 NRI, the MLRA classification was the geographical framework within which the sampling objective was specified and determined. The 1997 NRI data also assigns each sample point to Bailey's Ecoregion so that data can be aggregated by ecoregion (domain, division, province) or subregion (section).

In remote sensing methods, scale issues arise from the pixel size of the remotely sensed imagery. As pixel sizes increases the estimates of rangeland area have the potential for increasing bias due to boundary and inclusion effects. For example, Konarska et al. (2002) found that estimates for the valuation of ecosystem services differed between standardized thematic maps derived from the 1-km x 1-km International Geosphere Biosphere Programme (IGBP) dataset and the finer resolution (30-m pixels) National Land Cover Dataset (NLCD). While issues of uncertainty arise because of omission and commission errors in land cover maps created from remotely sensed imagery, these can be addressed through error checking an a reliability score assigned to the classification (Richards and Furby 2002).

Recent advances in technologies offer opportunities to quantify and map the total area of rangelands and change in that area for a given time period. With an increase in spatial scale from an individual ranch paddock (pasture) to regional and national-scales, the costs of field-based methodologies (after initial startup) are more expensive when compared to aerial photographic and satellite remote sensing-based analyses that may come to the same conclusions while measuring the same or surrogate vegetation parameters (Pickup 1989, Wessman et al. 1996). And, though the argument is often made for qualitative rapid field assessments, results can be questionable (e.g., Rasmussen et al. 1999). Tueller (1989), West et al. (1994), and Washington-Allen (1995) have discussed the limitations of field-based datasets and recommended expanded research on the use of GIS and remote sensing technologies for use in rangelands. It is likely that the future land inventories would use a combination of remotely sensed information in a Geographic Information System (GIS), and ground-based information. In the GIS system, either raster (pixels) or polygon (vector based data) would be used to estimate the land area (in any classification). For raster data, pixel size would influence the estimation of rangeland. The smaller the pixel size, the smaller the land unit identified as rangeland could be inventoried. A probabilistic based accuracy assessment of the land cover maps will be needed to calculate unbiased estimates of the area of rangeland (Stehman 2001, Zhu et al. 2000) as simple pixel counts will be biased due to omission and commission errors. However, these measures of accuracy will not provide spatially explicit maps of the uncertainty in the land cover map.

Data

The available data for this indicator is best described by B) Some data set(s) exist at the regional-national level, but methods and procedures are not standardized at the regional-national level. The data sets that currently exist for this indicator, though not descriptive of the entire US are based on inventory or monitoring systems that were designed at the national level. The implementation of these systems has not been national; for example the NRI focuses only on the non-federal sample points in a system that covers the entire US.

At least three sources of extant data could be evaluated for this indicator: the USGS/USEPA 1992 National Land Cover Data Set (remote sensing method), MODIS Global Land Cover Product (remote sensing method), and the NRCS NRI (ground survey point sample on non-federal lands).

The most commonly used assessment of change in total rangeland area is the NRCS National Resources Inventory data. This periodic survey was designed to assess conditions and trends for soil, water, and related natural resources on non-federal lands in the United States (Nusser and Goebel 1997). The sampling and analysis procedures have evolved over time, now reflect the use of remote sensing information as well as ground-based inventories, and have enhanced estimation techniques for missing values and weighting procedures that incorporate controls from other data sources and from previous surveys (Nusser and Goebel 1997). The NRI detects change over time through repeated visits to the permanent points within the inventory. The Forest Service also conducts inventories of public and private land, primarily focusing on forestland attributes. In 1995, an inter-agency demonstration project was conducted to investigate the feasibility of integrating the sample units and ecological measures (Nusser and Goebel 1997). Such comparisons explore the utility of various inventories and allow consideration of a holistic approach to consistently sampling all of rangeland in the US.

A partnership of six federal agencies called the Multi-Resolution Land Characteristics Consortium (MRLCC) was formed in 1992 to reduce the cost to any one agency of the purchase of Landsat satellite data (Vogelmann et al. 2001, http://landcover.usgs.gov/nationallandcover.html). A number of land cover maps were produced from the MRLCC data including the 1992 National Land Cover Data (NLCD). The NLCD was developed from Landsat imagery from the early 1990s by the United States Geological Survey's (USGS) Land Cover Characterization Program (LCCP) (http://landcover.usgs.gov/) (Loveland et al. 2000). A second NLCD is being produced using more recent, 1999 and later, Landsat imagery. The same classification scheme, with refinement in 2001, has been used for both data sets. Consequently, the 1992 NLCD has 21 land use/land cover classes and the 2001 map will have 18. The 1992 map has three to four (including wetlands) classes that could be considered rangelands and the 2001 map has four to five classes. These datasets can be used to compare the change in rangeland cover between 1992 and 2001. Within the LCCP is the Land Cover Trends Project (http://landcover.usgs.gov/landcovertrends.html), which is a joint EPA and USGS program that uses the concept of ecoregions as a geographic framework to document the rates, causes, and consequences of land use and land cover change from 1972 to 2000 within the conterminous United States (Loveland et al. 2002). This program uses a probability based sample design and manual interpretation of Landsat Thematic Mapper imagery to calculate estimates of land cover trends.

Defries et al. (1998) began development of a remote sensing-based data set that could detect changes in land cover overtime using the International Geosphere-Biosphere Programme (IGBP) definition of land cover types. This concept has been extended to the Moderate Resolution Imaging Spectroradiometer (MODIS, Zhan et al. 2000, Reeves et al. 2001), which has been functional since July of 2000. MODIS views earth every one to two days and has a spectral resolution of 36 bands from the visible to the far-infra-red spectrum. MODIS has three pixel resolutions at 250 m, 500 m, and 1000 m. MODIS generates land cover characteristics, ecosystem variables, and radiation budget variables. Ecosystem characteristics include vegetation indices, biophysical variables of structure, e.g., the leaf area index (LAI) and energy absorption and carbon sequestration, i.e., the fraction of photosynthetically absorbed radiation (fPAR), vegetation net primary production (NPP), evapotranspiration, and surface resistance.

Land cover characteristics include fire anomalies, land cover, cover conversion, and continuous fields of vegetation. The MODIS Land Group (MODLAND) has developed algorithms for generating and validating quarterly land cover and land cover change products (Justice et al. 2002). The Land Cover maps are 1-km pixel resolution and are provided on a quarterly basis since July 2000. The Land Cover data set has 17 cover types, five of which can be considered rangeland: grassland, woody dry savanna and savanna, and closed and open shrubland. A portion of another one of the 17 cover types, Cropland/natural vegetation mosaics, will also contain an unknown proportion of rangeland. This cover type might be common in the Great Plains and could result in an underestimate of the area of rangeland (Friedl et al. 2002). With additional data and testing, the quality of the MODIS land cover product will improve (Friedl et al. 2002)

A comparison of areal estimates of rangeland from USGS/USEPA 1992 National Land Cover Data Set (Landsat imagery with 0.09 ha spatial resolution), MODIS Global Land Cover Product (100 ha spatial resolution), and NRI (ground survey point sample on non-federal lands) would be informative. The NLCD and MODIS data sets have the advantage of providing a map product that is needed for other SRR criteria and indicators. However, the maps will likely have omission and commission errors, and accuracy assessment of the products will be needed to calculate unbiased estimates of the area of rangeland. The accuracy assessment will not provide spatially explicit maps of the errors in the land cover maps. The MODIS product has the advantage that daily images are composited on a 16-day cycle, and multiple 16-day composites are used to construct the land cover maps. A disadvantage is the relatively coarse 100 ha spatial resolution. The NLCD has a much finer spatial resolution, 0.09 ha, but is constructed using only three images for a location on a roughly decade scale. The NRI estimates of the area of rangeland should be unbiased but are only available for non-federal lands (Appendix 3-1). The NRI estimates do not offer the opportunity to map rangelands area or change. This type of comparison would identify the most efficient method to assess land area change in rangeland. Other indicators may require a different approach; Thematic Mapper (TM) imagery may be better for calculating rangeland fragmentation than a map from MODIS imagery, however the resolution of TM data is not sufficient to inventory many of the small wetlands in the Northern Great Plains.

Clarity: Do stakeholders understand the indicator and the indicator unit?

Total area of rangeland and changes in the total area of rangeland would likely be one of the more easily understood and accepted indicators by the general public (O'Malley and Wing 2000). The possibility of mapping rangeland area and change would enhance the understanding by the general public.

RANGELAND AREA BY PLANT COMMUNITY

Description of the Indicator

This indicator describes rangeland plant communities in the United States and their abundance (area covered by each community and change in this area through time). The indicator has a classification component—how we name and describe the plant community—and an inventory component—what plant communities exist and what area they cover. With repeated inventories, the change in area and type of these communities will be available.

Plant communities are loosely assembled collections of plant species (Mueller-Dombois and Ellenberg 1974). The species composition of a plant community also identifies physical structure (e.g., grass, shrub, etc.), functional groups (e.g., nitrogen fixers, etc.), and habitat availability for rangeland plants and animals, including a number of rare, threatened and endangered species. Presence of a plant community can also serve as a loose proxy for environmental characteristics, disturbances, and ecosystem processes.

Description and classification of plant communities is challenging because the distribution of plant species is influenced by many factors operating at a number of scales. Classification systems are artificial constructs developed to simplify the variability of vegetation; therefore numerous ways to classify vegetation have been developed. Vegetation can be described in terms of potential vegetation (that which would become established if all successional sequences were completed without disturbance under the present climate and environmental conditions) (Tuxen 1956 in Mueller-Dumbois and Ellenberg 1974)—or existing vegetation (that can be observed on the site at the present time). Vegetation can be described in terms of physiognomy (structure, growth form, and external appearance of the dominant or characteristic plants) and floristics (the species composition). Vegetation classification systems are often hierarchal, combining physiognomic and floristic schemes.

Numerous strategies for classifying vegetation have been developed over the last century (for historical reviews see Mueller-Dombois and Ellenberg 1974, Shimwell 1971, Whittaker 1962, 1973, ESA Vegetation Classification Panel 2002). The Society for Range Management identified 154 rangeland plant communities for the Nation (excluding Hawaii, Alaska, and the Northeast United States) in a non-hierarchal classification system of existing vegetation (Shiflet 1994). The National Vegetation Classification System (NVCS) is a hierarchal classification system for existing vegetation that has evolved from the UNESCO vegetation classification system (UNESCO 1973) and Driscoll et al. (1984). It serves as a first approximation of a Federal government standard for classifying terrestrial vegetation for the Nation (FGDC 1997). The Ecological Site is a single level classification system for rangelands developed by the National Resources Conservation Service (NRCS) and used by the Bureau of Land Management. This system represents an evolution of the range site classification developed by the Soil Conservation Service (SCS) (National Range and Pasture Handbook 1997).

Under the NVCS, the alliance is the first level where floristics are described (the upper levels are physiognomically-based). The alliance is defined as a physiognomically uniform group of associations sharing one or more diagnostic species found in the upper most stratum of the vegetation (Grossman et al. 1998, ESA Panel on Vegetation Classification 2002, FGDC 1997). The association is a recurring plant community with a characteristic range in species composition, specific diagnostic (dominant, differential, indicator, or character) species, and a defined range in habitat conditions and physiognomy (ESA Vegetation Classification Panel 2002). To date, 4,852 associations have been described in the United States (NatureServe, February 2003, www.natureserve.org/explorer/summary.htm).

Ecological Sites are defined by NRCS at a relatively fine spatial scale (roughly equivalent to the association level of the NVCS) useful for local, on-the-ground land management (see also Allen-Diaz and Bartolome, 1998, Creque et al. 1999). As defined in Peacock (2002), an Ecological Site is the product of all environmental factors responsible for its development and has characteristic soils (parent material, climate, landscape position), hydrology (infiltration, runoff), plant community (kind and amount), herbivory (kind, amount, season of use), and disturbance regime (such as season and frequency of fire) (Ecological Site Information System, http://plants.usda.gov/esis). The Ecological Site Description System (http://ironwood.itc.nrcs.usda.gov/scripts/ndISAPI.dll/esd/pgWelcome) provides the capability to produce automated Ecological Site descriptions from its database (inventory data collected on thousands of plots over the past 40 years). Inventory data collected on rangeland plots include the total annual production of all plant species of a plant community as well as the composition of individual plant species comprising the plant community. This system is the official repository for all data associated with the development of forestland and rangeland Ecological Site descriptions by the NRCS.

Other federal agencies (Forest Service, Fish and Wildlife Service, Department of Defense, National Park Service, U.S. Geological Survey, etc.) and non-governmental organizations (The Nature Conservancy, NatureServe) use other systems for land and plant community classification. For example, the California Native Plant Society fostered the development of *A Manual of California Vegetation*, a classification system where vegetation series are defined by their dominant and/or characteristic plant species in the highest strata (Sawyer and Keeler-Wolf 1995). A web-based manual is available http://davisherb.ucdavis.edu/cnpsActiveServer/index.html.

For this indicator to be useful, a nationally accepted procedure for defining vegetation is needed, as well as consensus as to what qualifies as "rangeland vegetation." In addition to the indicator's need for a standard rangeland vegetation classification system, the indicator requires an inventory of the abundance of the rangeland plant communities. To conduct an inventory of rangeland plant communities, observers (ground crews or analysts of remotely sensed imagery) are required to accurately identify the rangeland vegetation at a location. This is the real test of the classification system. The classification system must be exhaustive (all plant communities must be described) and the description of the communities must include criteria that the observer can use to unambiguously identify the rangeland plant community at a location. Because vegetation classification systems are artificial constructs, even ground observers often find it difficult to identify the boundaries of plant communities. Stohlgren et al. (1998) observed that most vegetation studies have focused on describing perceived homogenous communities although heterogeneous areas, ecotones, and the cumulative area of rare habitats may dominate many rangelands. Air photo interpretation involves drawing boundaries around areas that the human classifier perceives as being homogenous. Skilled photo interpreters use texture, shape, size, pattern and context in addition to tone and color to identify objects. The problem can be even more difficult when remotely sensed imagery is used because accurate discrimination of rangeland plant communities requires the communities to have different spectral reflectance characteristics (see also discussion under Extent of Land Area in Rangeland). The challenge is to recognize the strengths of all approaches and use the best combination of them.

It is also important to consider the existing vegetation in context of plant communities that could potentially occur on a site due to its climate and environmental conditions. Knowing the suite of plant communities possible, given the climate and physical characteristics of a site, can help place the existing vegetation in a historical and environmental framework. Ecological Site Descriptions being developed by the NRCS and the Agricultural Research Service can provide such a context. The plant community component of an Ecological Site description describes the ecological dynamics and the various plant communities comprising the vegetation states of the site with emphasis on the potential natural vegetation and climax communities (http://plants.usda.gov/esis). A number of potential vegetation states may be expected for the climate and environmental conditions of a site. The processes that cause a shift from one state to another are called transition pathways (Ecological Site Information System, http://plants.usda.gov/esis/). Additionally, rapid, qualitative assessment methods for indicators of rangeland health have been developed which include methods for defining the extent to which the structural and functional characteristics of the plant community deviate from those described in the Ecological Site Description for that site (Pellant et al. 2000). A possible future metric may be the percent of rangeland sites on which the existing vegetation has departed from the range of potential plant communities associated with the climate and environmental conditions.

Information has been compiled about the types of plant communities on rangelands. However, few classification systems have been implemented at the national scale or regionally to describe the area associated with the communities. A consistent classification system could be implemented across the United States within the context of an inventory system sampling all of rangelands. Technology is available to perform an inventory and monitoring program for rangeland plant communities and to enhance these direct measurements with a probability-based sample design on a national scale. The integration of the remotely-sensed methods with abiotic data, geographic information systems technologies, and ground sampling in a probability based sampling design offer improved opportunities to capitalize on the strengths of each approach. The current technology may be available to offer the opportunity to describe the plant communities spatially across the United States and track temporal changes in the area of plant communities.

Importance

The varieties of rangeland vegetation reflect the variety of benefits and values of rangelands. The extent of these communities indicates the current capability of rangeland to produce these benefits and values for society. Changes in certain plant communities could have implications to the sustainability of these benefits and values—changes in resource outputs, ecosystem services, non-market values, and habitats for plant and animal species produced from these communities. Examples of endangered or critically endangered rangeland ecosystems include native shrubs and grassland steppe in Oregon and Washington; in the Pacific Coast region, Palouse prairie; and tallgrass prairie throughout the United States (Flather et al. 1999 summarized Noss et al. 1995). Eastern grasslands have been extensively converted to other land cover types. Some of these identified rangeland communities have unique characteristics, such as the limestone red cedar glades in Tennessee or the alkali sink scrub habitats in California.

Changes in communities may suggest changes to underlying environmental factors (such as climate and nutrient availability) or changes in ecosystem functioning. Flather and Sieg (2000) report that the simplest measure of ecosystem diversity is the amount of each rangeland plant community that occurs nationally. They state that the maintenance of sufficient area of each rangeland community is necessary to sustain the complex of ecosystem components and associated processes necessary to support the suite of species dependent on this complex. Maintaining ecosystem components and processes is also critical for ensuring the sustainability of rangelands.

Geographic Variation

While different plant communities will occur in different regions, if communities are classified and named using the same protocols and methodology, the indicator is useful in and across different regions.

Scale

If a standard definition of rangeland plant communities is nationally accepted, the indicator of area of plant community is meaningful at different geographic scales such as nation, region, watershed, or within a hierarchical classification such as Bailey’s Ecoregion (Bailey 1983). It will be necessary to define the spatial scale and hierarchal level in the classification system that the indicator data will be collected—the field implementation of the definition is influenced by spatial scale. Estimations of areal extent of plant communities through either ground-based inventories or remotely sensed techniques are sensitive, for differing reasons to the spatial scale of the application (see discussion in Extent of Land Area in Rangeland). As technology advances, we may be able to improve our ability to determine plant communities more efficiently, less costly, and at greater spatial resolution.

Discrimination of the taxonomic composition of rangeland vegetation using satellite data has proved quite elusive and it is possible, but unlikely, that newer sensors of high spectral and spatial resolution will dramatically improve the capability to determine botanical composition (Graetz 1990). Far greater promise is offered by the process of context modeling whereby the taxonomy of vegetation is inferred from remotely sensed physiognomic and structural vegetation maps in conjunction with other landscape variables such as soil type and elevation within a geographic information system.

This indicator would be sensitive to changes over time, providing a consistent definition of vegetation is used and the same spatial scale is measured. The working group initially conceived a seral stage component to this indicator where the temporal changes within a plant community would be monitored. But the difficulties of defining successional stage within a rangeland plant community, also noted by Flather and Sieg (2000), were sufficient to drop further discussion. The extent of rangeland area by plant community may be broad enough to monitor seral stage dynamics, as different seral stages are characterized by different mixes of species. Flather and Sieg (2000) suggested that “If sufficient area of each rangeland community is not maintained, these ecosystems are less likely to have the mix of successional stages necessary to support various species, may become more vulnerable to fragmentation effects, and may be more susceptible to invasion by exotic species, or may be predisposed to catastrophic loss from fire or drought.”

Data

The data available for this indicator can be categorized in terms of the classification component and the inventory component. For the classification component, the data availability is categorized as both **B** – Standardized methods and procedures for data collecting and reporting exist at the regional-national level, but useable data set(s) do not exist at the regional-national level, and **C** – Some data set(s) exist at the regional-national level, but methods and procedures are not standardized at the regional-national level. For the inventory component, the data availability is categorized as **B** – Standardized methods and procedures for data collecting and reporting exist at the regional-national level, but useable data set(s) do not exist at the regional-national level, and **C** – Some data set(s) exist at the regional-national level, but methods and procedures are not standardized at the regional-national level.

Information on the area of rangeland vegetation at the national scale is limited. Differences in definitions and approaches exist among federal agencies, non-governmental organizations, and vegetation scientists. The lack of a complete national soils inventory could be another limiting factor.

The U.S. Geological Survey’s (USGS) National GAP Analysis Program is the first attempt to map existing vegetation of the Nation using floristically defined classes and a common vegetation classification system. State GAP projects attempt to map existing vegetation at the alliance level of the NVCS using Thematic Mapper imagery and ancillary data with a per-class accuracy of 80 percent or greater. The USGS/ National Park Service (NPS) Vegetation Mapping Program is using manual interpretation of aerial photography to map the vegetation of National Parks at the association level of the NVCS with a minimum mapping unit of 0.5 hectares and classification accuracy goal of 80 percent for each map class. A review of rangeland vegetation descriptions in the legends of the GAP and of the NPS vegetation maps and the accuracy assessments of these maps reveal these goals are difficult to achieve for rangeland plant communities even, as is the case with NPS, with the use of manual interpretation of aerial photography.

While the Ecological Site classification offers the classification component of this indicator, there has been no attempt to map Ecological Sites at the national level. Some watershed planning efforts in some locations have mapped Ecological Sites. Soil is the basis for determining, correlating, and differentiating Ecological Sites. Soils with like properties that produce and support a characteristic native plant community, and that respond similarly to management, are grouped into the same Ecological Site. Soils maps at the national scales include the State General Soil Maps (STATSGO) data set (http://www.ftw.nrcs.usda.gov/stat_data.html) and at regional scales, the detailed soil survey data for GIS (SURGO) data set (http://www.ftw.nrcs.usda.gov/ssur_data.html). The difficulty in mapping Ecological Sites using the current soils maps is that the soils maps are Order three maps where a soil map unit may include several soil series within one unit. Soil associations may include two dominant soils and soil complexes may include three or more. Each soil series will generally (with a few rare exceptions) have one Ecological Site, but an Ecological Site may have several associated soil series. Therefore, a soil map will not be a one-to-one conversion to Ecological Sites. For example, for the 3,272 range sites associated with the 20 Great Plains, Southern and Western States, the SCS identified 24,295 range site-soils combinations, a ratio, on average, of one range site with more than seven soil types (Joyce et al. 1986). Scaling of this fine scale concept to regional and national spatial scales involves recognizing spatial scale changes in climatic, edaphic, and other physical regimes that constrain distinctly larger ecological units (Bailey 1983) and there is a question as to whether a bottom-up rescaling of ecological sites will correspond to the boundaries within a hierarchical classification system, such as MLRAs.

The NVCS provides a standard framework and nationally-consistent classification approach for natural, semi-natural, planted, and cultivated plant communities (FGDC 1997), but this system has not been field implemented at a wide scale. The objective is to be able to classify all areas with 1 percent or more of the surface area covered with live vegetation. The NVCS recognizes that distinction of vegetation is sensitive to scale; therefore, the classification system is hierarchical, combining floristics (vegetation) at the lower levels with physiognomy (life form, cover, structure, leaf type) at the higher levels. The NVCS is based on existing vegetation—what is there—at the optimal time during the growth season, rather than potential natural vegetation. According to Federal Geographic Data Committee (FGDC 1997), the classification is the result of modifications to the vegetation classification standard compiled and refined for conservation planning and resource management at The Nature Conservancy. The upper physiognomic levels of the NVCS hierarchy are based on factors that are generally discernible from aerial photography or fine spatial resolution satellite imagery. The floristic levels of the classification hierarchy are based on field plot data concerning the composition, structure, and cover of the vegetation. The NVCS is being used by The Nature Conservancy, NatureServe, the joint U.S. Geological Survey-National Park Service Mapping Program, the Gap Analysis Program, and programs within the Forest Service.

The original list of plant communities (associations and alliances) published by The Nature Conservancy, in conjunction with the Natural Heritage Network (Anderson et al. 1998), provided a comprehensive compilation of literature and field observations for each community. This list, now maintained by NatureServe, serves as a first approximation of plant communities under the International Classification of Ecological Communities (www.natureserve.org). The Ecological Society of America (ESA) Vegetation Classification Panel (www.esa.org/vegweb/) is working with

NatureServe (including members of The Nature Conservancy's science staff that helped develop the original NVCS) and the FGDC Vegetation Subcommittee (representing the Federal community) to further develop the floristic levels of the NVCS. This collaboration has yielded standards proposed by the ESA Vegetation Classification Panel for quantitatively designating associations and alliances under the NVCS (ESA Vegetation Classification Panel 2002). Developing and revising these plant communities under the NVCS will be a peer-reviewed process.

Consistent data management protocols are also needed for maintaining a national vegetation classification. The ESA Vegetation Classification Panel is developing a VegBank plot database (www.vegbank.org) to store, preserve, and distribute vegetation plot data that meet recognized minimum standards. These plot data will be used to develop peer-reviewed plant communities which will also need to be stored, preserved, and distributed. Such a classification database will likely be maintained by NatureServe (ESA Vegetation Classification Panel 2002) and could be built on the existing ecological communities component of the existing NatureServe Explorer.

Standardization may be challenging, but several attempts, including SRR, to get a larger community consensus are ongoing. Efforts to develop standardized methods for designating plant communities include efforts related to the National Vegetation Classification (e.g., the Gap Analysis Program, the USGS/NPS Vegetation Mapping Program, NatureServe, the FGDC Vegetation Classification Standards, and the ESA Vegetation Classification Panel) and efforts related to the ecological site descriptions being developed by NRCS. Protocols for designating plant communities are being developed under each of these programs. The value of an indicator of rangeland community type will depend upon the vegetation science community and the range management community collaborating to develop a standardized method to designate rangeland vegetation.

Clarity

Understanding by the general public is questionable, but many stakeholders probably have at least a vague conceptual understanding of rangeland plant communities. The SRR definition for rangeland offers a land cover approach; however agreement is needed on operational definitions for rangeland plant communities. As professional organizations and federal agencies come to agreement on definitions and approaches to designating rangeland vegetation, understanding and acceptance should increase.

The FGDC (www.fgdc.gov) can assist in the process to reach consensus on the definitions and establish a Federal standard. The FGDC has senior representatives of the departments and is chaired by the Deputy Secretary of the Interior. It has the mandate and an established procedure for extensive collaboration in setting standards, including a Federal Register notice, and its mission stresses cooperation with organizations from state, local and tribal governments, the academic community, and the private sector. A group has been formed to work on developing operational definitions for rangelands and forests (http://www.pwrc.usgs.gov/brd/Definitions.htm). The following organizations are participating: Sustainable Rangelands Roundtable, Roundtable on Sustainable Forests, FGDC Sustainable Forest Data Working Group, FGDC Vegetation Subcommittee, FGDC Sample Inventory and Monitoring of Natural Resources and the Environment Working Group, Bureau of Land Management, Forest Service, Natural Resources Conservation Service, US Geological Survey, Society for Range Management, Society of American Foresters, and NatureServe.

NUMBER AND EXTENT OF WETLANDS

Description of the Indicator

The indicator relates to abundance of wetlands in the rangeland landscape. Wetlands for this indicator include depression (e.g., prairie potholes and playas) and slope wetlands but do not include riverine or floodplain wetlands that are covered under Riparian Condition. Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification, wetlands must have one or more of the following three attributes: (1) at least periodically the land supports predominately hydrophytes, (2) the substrate is predominately undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin et al. 1979).

Importance

The indicator measures the numbers and total area of wetlands within all or portions of the rangeland system. The metric may be either (a) numbers of individually identifiable wetlands and acreage per a particular region, or the entire rangeland region, or (b) numbers and percent of landscape occupied by wetlands. Most wetlands occurring on rangelands will fall into the Riverine, Lacustrine (subsystem Littoral), or Palustrine systems. They can be further described by class and subclass as well as by modifier for Dominance type (vegetation), water regime, water chemistry, and soil (order or suborder as well as hydric criteria). Within the Cowardin et al. classification system, riverine systems are distinguished from riparian areas—the riverine system is bounded by the channel or stream bank while riparian areas typically begin at the stream bank. Within this Criterion, riparian condition and extent are treated as a separate indicator (see discussion under Riparian Condition).

The importance of wetlands to rangeland sustainability is that wetlands are a unique feature of rangelands functioning through interaction with adjacent uplands and other wetlands. Maintenance of biodiversity in rangeland wetland systems requires connection among many wetlands as well as linkages to neighboring uplands. Reduction of wetland areas, often a consequence of hydrological or land use changes, reduces the potential for sustaining the diverse assemblage of rangeland organisms that depend on wetlands for all or part of their life cycles. Wetlands also offer feeding sites for migratory waterfowl and other species, a connection that may be used for evaluating functionality of wetlands. Wetlands may function as buffers or filters of runoff helping maintain water quality in aquatic systems.

Geographic Variation

The indicator of wetland abundance can be determined at a local, state or regional scale. The presence of wetlands is connected directly to availability of hydrogeomorphic characteristics of the regional landscape. For example, prairie pothole wetlands, depressional wetlands, are primarily in the region of the Dakotas; vernal pool wetlands, also depressional, occur within portions of California (and other areas in the United States); playas; mineral soil flats are in the arid Southwest; and coastal wetlands, estuarine fringe wetlands, are along low oceanic coast lines. Recognition of these regional and hydrogeomorphic differences can be included in presentation of the indicator.

A wetland indicator can also be developed relative to different climatic regimes that often are associated with different regions of the country's rangelands. If response to changing climate is important, wetlands may be more sensitive to changes in many hydrological components of climate than most indicators. The month of the inventory will be important factor so that the sampling can be placed in the context of the seasonal distribution of precipitation as it normally occurs and in the context of the natural variability of the climate.

Changes in wetlands area will be associated with the regional hydrogeomorphic characteristics and the regional climate. For example, wetland area in the Southwest and in the southern Great Plains will be closely tied to changes in water flow (groundwater depletion, water diversion) whereas in other regions, such as the Northern Great Plains, hydrologic variability will strongly influence changes in wetland areas. Regional differences in wetland area can be described using this indicator.

Scale

The spatial scale of wetlands ranges from tens of meters to several kilometers. If wetland delineation is done on an individual basis, the data can be scaled up to any spatial scale desired; whereas, wetland identification done by satellite on a regional basis may not be able to be scaled down to a local level (see discussion in Extent of Land Area of Rangeland on spatial scale and remotely-sensed methods). Changes in wetland numbers and areas can occur in decadal or smaller time frames, sufficiently so for measurements to demonstrate changes within reasonable time frames for management purposes.

Data

The data for this indicator are best represented by **A –** Methods and procedures exist for data collecting and reporting and data sets of useable quality exist at the regional-national level. The data set being developed by the USFWS under its National Wetland Inventory Program (NWI) (http://wetlands.fws.gov/) may be the most comprehensive and applicable to the Sustainable Rangeland project.

In 1982, the NWI produced their first estimate of the status of the Nation's wetlands and wetland losses, and in 1990 and 2000 produced the updates. Future national updates are scheduled for 2010, and 2020 (http://wetlands.fws.gov/overview.htm). For each plot, aerial imagery is interpreted and annotated in accordance with procedures published by the Fish and Wildlife Service. The results are compared with previous era imagery and any changes recorded. The differences between the data sets are analyzed and a statistical estimate of the change is produced. One hundred percent coverage for wetland mapping by the Fish and Wildlife Service does not exist, but the mapping continues and eventually all rangeland areas will be covered. It is unknown whether remapping will occur on a regular basis to allow comparisons for changing wetland coverage. To date NWI, maintained by the National Wetland Inventory Center, has mapped 90 percent of the lower 48 states, and 34 percent of Alaska. About 44 percent of the lower 48 states and 13 percent of Alaska are digitized. Examples of the protocols used are presented in Tiner et al. (2002).

Baseline, or reference conditions, published in "Status and Trends of Wetlands in the Conterminous United States 1986-1997" (USFWS) may be useful for future evaluation of wetland changes. This publication is a result of the Emergency Wetlands Resources Act of 1986, which requires the Fish and Wildlife Service to conduct status and trend studies of the Nation's wetlands, and report the results to Congress each decade. The report provides the most recent and comprehensive estimates of the current status and trends of wetlands in the conterminous 48 United States on public and private lands. A major finding is that the Nation's estimated wetlands loss rate has declined by 80 percent from the previous decade.

The National Resources Inventory (http://www.nrcs.usda.gov/technical/NRI/) of NRCS also inventories wetlands using a statistically based sample of land use and natural resource conditions and trends on U.S. nonfederal lands. Analyses of the inventory results over time provide data on land use, soil erosion and soil quality, water quality, wetlands, and other issues regarding the conservation and use of natural resources (http://www.nrcs.usda.gov/technical/land/). Maps, imagery, and data resources from the NRI can be found at these web sites:

- Data Resources (http://www.nrcs.usda.gov/technical/dataresources/): Links to NRCS base map coverages, status maps, the National Resources Inventory (NRI) database, and databases on soil, water and climate, plants for conservation, and other subjects. This site is a node of the National Spatial Data Infrastructure.

- Geospatial Data Gateway (http://www.lighthouse.nrcs.usda.gov/gateway/ gatewayhome.html): Provides One Stop Shopping for natural resources or environmental data at anytime, from anywhere, to anyone. Choose area of interest, browse and select data from catalog, customize format, and download it or have it shipped on CD.

- Imagery: Aerial Photography (http://www.apfo.usda.gov/);
  Orthoimagery (http://www.ftw.nrcs.usda.gov/ortho.html); and
  Satellite Imagery (http://mapping.usgs.gov/www/ndop/).

Although the NRI coverage does not include federal lands, the data may be sufficiently focused on those lands where land use change is most likely to allow interpretation of wetland change. Within the NRI, wetlands are presents as an attribute that may occur on all other land cover/use categories, therefore the data can be queried by land cover/use (e.g. rangeland) for wetland estimates by any category. Each NRI sample point has multiple attributes (soil map unit component, soil descriptions, land cover/use, wetland type, etc.) associated with them for many kinds of analyses. Additionally state, administrative region, ecoregion, and other geographically defined areas of interest can be used to summarize data within the NRI. An additional advantage is that since 1997 the NRI has gone to an annualized inventory providing for annual reports beginning in about 2005. The NRCS has made maps of the area of non-federal wetlands in 1992 and 1997 available on the web (http://www.nrcs.usda.gov/technical/land/wetlands.html). Figure 3-1 (next page) displays wetlands located on non-federal rangelands in 1992, mapped by NRCS. The dot density map includes all types of wetlands as defined in the Cowardin system. Each dot represents 1,000 acres of wetlands. Dots were aggregated by and placed randomly within each eight-digit hydrologic unit. Flather et al. (1999) analyzed wetland trends from 1982 to 1992 using the NRI data and found a similar decline (70 percent) in the rate of wetland loss between the mid-1970s and mid-1980s. During the 1982-1992 period, the primary cause of wetland conversion on non-federal lands was urban development.

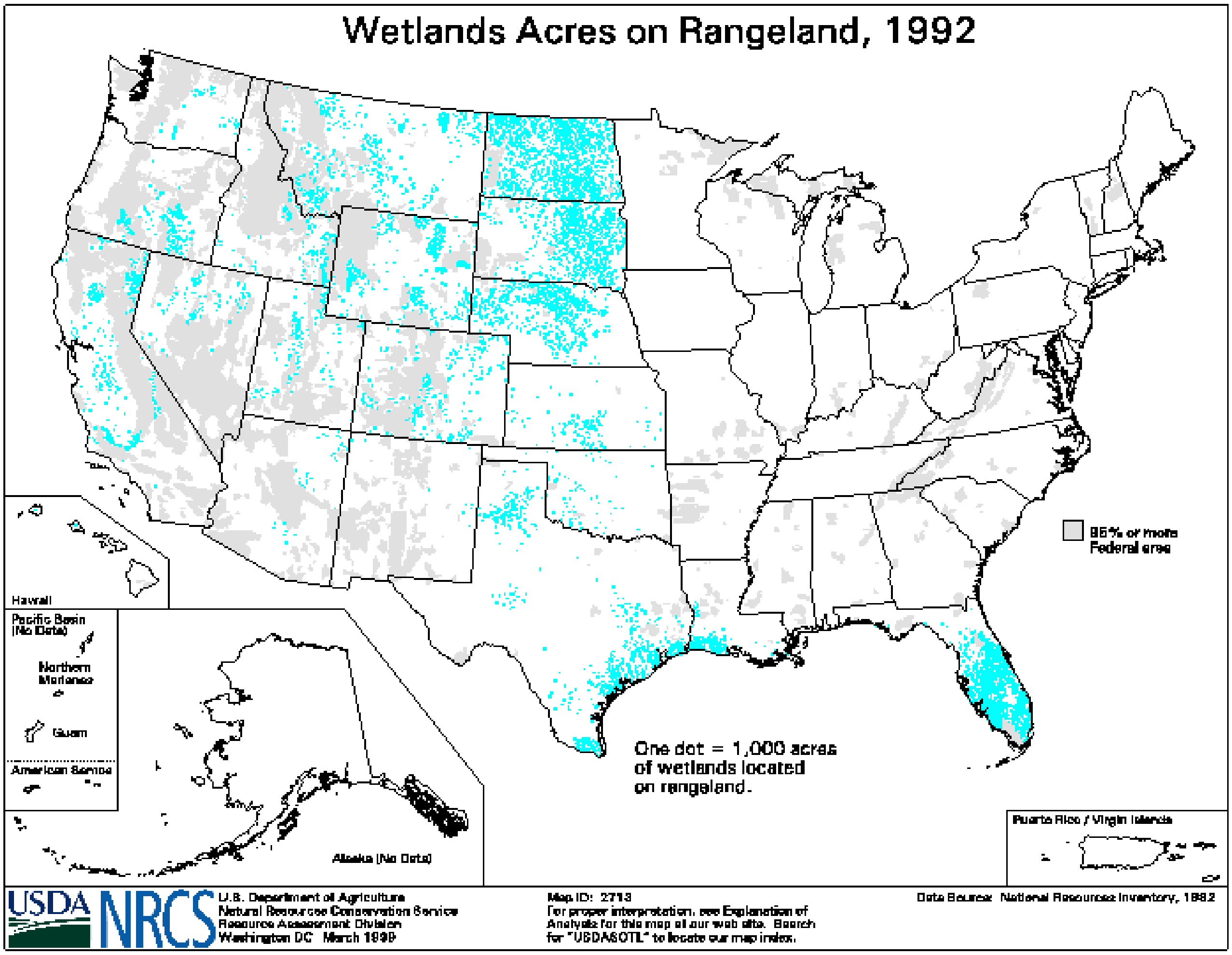

Figure 3-1. Wetlands located on non-federal rangelands in 1992. Light gray is federal land.

The indicator can be adequately monitored with existing remote sensing capabilities (see National Wetland Inventory above). These monitoring data are repeatable and can be collected over time to present a picture of changing abundance of wetlands in the rangeland landscape. If NWI was to be repeated periodically and compared with NRI data, a more complete picture of changing wetland abundance may emerge. Appendix 3-2 using FGDC criteria demonstrate how wetland changes can be documented over time. The probability-based sampling design allows the calculation of errors associated with each measurement in time. Accuracy of NWI is based on how much of the area is ground-truthed (for example, for a forested area see, Kudray and Gale 2000). Tiner (1997) points out that wetlands can be missed for various reasons because remote sensing is the primary tool for wetland identification, thus wetlands with similar spectral signatures might not be identified as separate from the surrounding vegetation.

The Federal Geographic Data Committee (FGDC) has passed standards for classification of Wetlands and Deepwater Habitats of the United States (http://www.fgdc.gov/standards/status/sub3_4.html). It has evaluated changes in wetlands and deep waters in the United States (Appendix 3-2). Specific objectives of these standards are to:

a. provide a nationally consistent definition of wetlands and deepwater habitats for mapping and inventory purposes;
b. describe ecological units that have certain homogeneous natural attributes;
c. arrange those units in a system that will aid decisions about resource management;
d. furnish units for inventory and mapping;
e. ensure that data from widely differing regions of the country are collected and can be interpreted similarly; and,
f. move toward a system that allows communication about wetlands and their features in a National context. Doing so enhances the ability of all agencies and individuals to interpolate and extrapolate wetland resource data, wetland loss and gain data, and restoration efforts in the same semantic and ecological context.

This standard provides specific ecological and hydrological information for the identification, classification, and mapping of wetlands in the United States and its territories. Adoption of the FGDC standard will not change the current status of National Wetlands Inventory maps produced by the U.S. Fish and Wildlife Service.

NatureServe Explorer (www.natureserve.org) provides users with the ability to search for wetland communities within other plant communities.

Clarity

Stakeholders understand what wetlands are and that wetlands in the rangeland landscape have been greatly reduced in the 20th century. Consequently, an indicator that simply presents the number and total area of wetland for selected spatial scales (e.g., regions or states) will be understandable to stakeholders and the public. Data from the Fish and Wildlife Service National Wetland Inventory and from the NRCS National Resources Inventory are also readily available to stakeholders and the public over the Internet.

FRAGMENTATION OF RANGELAND AND RANGELAND PLANT COMMUNITIES

Description of the Indicator

The indicator, fragmentation of rangeland and rangeland plant communities, is defined as the breaking up of a habitat or cover type across a landscape (Turner et al. 2001). A cover type is a category within a classification scheme defined by the user that distinguishes among the different habitats, ecosystems, or vegetation types on a landscape (Turner et al. 2001, see also discussion under Area of Rangeland by Plant Community). Each cover type can be considered a patch type (Pickett and Cadenasso 1995). The designation of a patch is a subjective exercise (McGarigal and Marks 1995). A patch is usually a discrete scale-dependent entity of interest that is used to categorize landscape heterogeneity (Pickett and Cadenasso 1995). Landscapes are characteristically a mosaic of heterogeneous patches and this is true of rangelands (Tueller 1973, Senft et al. 1987, Urban et al. 1987, Belsky 1989, Coughenour 1991, Archer and Smeins 1991, Friedl 1994, Wessman et al. 1996). For our purposes, a patch or cover type has both regional and national spatial extents delineated both by total rangeland area (Extent of Land Area in Rangeland) and rangeland plant communities (Area of Rangeland by Plant Community), respectively.

Importance

This indicator is important because it measures the size of contiguous areas, spatial organization, and community type dispersion within the ecosystem, which are important rangeland descriptors, in terms of grazing use, habitat and niche, and ecosystem services. Tall grass prairie in the eastern Great Plains is one example of a highly fragmented rangeland ecosystem. Tall grass prairie had spanned 14 states and covered 57 million hectares. Today less than 10 percent of the original tallgrass prairie remains (Noss et al. 1995). The public has expressed the importance of ecosystem loss and extinction in the laws formulated (The Endangered Species Act), public displays (The Tall Grass Prairie example within the National Zoo, Washington, D.C.), and the establishment of public lands (National Park Service National Grasslands) and private conservation reserves (The Nature Conservancy's Tall Grass Prairie Preserve in Northern Oklahoma).

The fragmentation of tall grass prairie is probably due to disturbance factors such as land use changes such as cropland conversion and urbanization, which have resulted in the breaking up of tallgrass prairie into many patches of smaller size. The reduction of patch size can lead to an increase in the distance between tallgrass prairie patches in a homogenous or heterogeneous manner across the landscape. In order to quantify this fragmentation, metrics are needed that would identify the kinds of patches (e.g., cover type), measure the size and number of patches, and the distance between patches. Additional metrics would be required to measure changes in the shape of patches as this has been found important for supporting both amount of edge and corridors required by individual species (Forman and Godron 1986).

Fragmentation is an interruptive process affecting the sustainability of rangeland ecosystems. Fragmentation of community types is particularly critical for wildlife and some plant populations; sufficient habitat and niche size is required to sustain breeding, rearing, feeding, and shelter needs. Fragmentation studies have a long history in forested ecosystems (Romme 1982, Spies et al. 1994, McGarigal and Marks 1995, Turner et al. 2001). In these studies, the nature of how forested ecosystems are fragmented and the impact of that fragmentation on plant and animal species and ecosystem function have been determined (Romme and Knight 1982, Homer et al. 1993). Similar work has been conducted on rangelands (De Pietri 1995, de Soyza et al. 2000, Wu et al. 2000, Washington-Allen 2003). Flather and Sieg (2000) described the need to refine the use of remotely sensed satellite imagery to quantify rangeland fragmentation and in the process identify the specific agents of fragmentation, such as intensive land uses, roads, concentrations of exotic species, etc.

Geographic Variation

The indicator would be meaningful in different regions. The changes in this indicator are nested within the total rangeland area of a region (Extent of Land Area in Rangeland) and within plant communities in the region (Area of Rangeland by Plant Community). The extensive geographic extent may or may not change with loss or extinction of patches if the plant community shifts to another rangeland plant community. For example, ecological responses to abiotic or biotic changes at the local spatial scale, such as a shift to another plant community due to plant invasions, may not be apparent at the landscape scale where the total rangeland areal extent may not have been altered. However, at the local scale, fragmentation may have occurred. Thus, it is meaningful to speak of fragmentation of total rangeland area of a region, and also fragmentation of particular plant communities.

Scale

Fragmentation has the capability of capturing spatial heterogeneity at varying spatial and temporal scales because it can be viewed hierarchically (Pickett and Cadenasso 1995).

Data

The data currently available for this indicator are best represented by **C** – Some data set(s) exist at the regional-national level, but methods and procedures are not standardized at the regional-national level. Jones et al. (1997) discuss the availability of data sets for the analysis of fragmentation at a regional scale, i.e., the Mid-Atlantic region of the United States. The data sources included federal agency repositories such as USGS (satellite imagery, digital elevation models, GAP analysis map data layers of land ownership, vegetation, and species distribution, the NLCD), USEPA, USDA, and US Census Bureau. Rangeland and rangeland community data sets identified in Extent of Land Area in Rangeland and Area of Rangeland by Plant Community could be used to calculate fragmentation matrices for rangelands.

A suite of metrics have been developed that directly and indirectly measure fragmentation (Turner 1989, Turner et al. 2001, Washington-Allen 2003). These metrics were developed to analyze categorical digital maps that are inputs to a Geographic Information System (GIS). The digital maps are in either of two data formats (raster or vector) and are usually input to a spatial analysis program such as FRAGSTATS (McGarigal and Marks 1995). A raster data set is usually a grid where each cell in the grid is a pixel that denotes the grain of the image. Satellite images are usually raster data sets. Each raster cell has a nominal or ordinal value. Vector data sets have three basic elements: nodes (points), arcs, and polygons. These elements are used to delineate and represent different map objects, e.g., an arc may represent streams and a polygon a lake. Both data types are inter-changeable, i.e., they can be converted between formats but each has different advantages.

Appendix 3-3 lists a few indicators that have been used to measure fragmentation. Mean nearest neighbor (MNN) is the distance (in meters) to the edge of the nearest neighboring patch of the same type. Nearest neighbor standard deviation (NNSD) is a measure of patch dispersion (McGarigal and Marks 1995). A small NNSD relative to the mean implies a homogenous response of patches across landscapes, whereas a large NNSD relative to the mean indicates a more heterogeneous response of patches (McGarigal and Marks 1995). NP is a count of either the total number of patches within a landscape or the total number of patches for each class type. Mean patch size is the mean of the area of all the patches within a landscape or for a class. Contagion measures the probability that two randomly chosen adjacent raster cells belong to different classes. IJI (Interspersion and Juxtaposition) is a measure of interspersion that is somewhat different from contagion, because it measures individual patch types whereas contagion measures individual pixels. IJI measures the juxtaposition of a focal patch type from all other types at the landscape and individual class type scales. IJI ranges from 0 to 100 percent with low values indicating low interspersion and high values indicating high interspersion or even distribution throughout a landscape (McGarigal and Marks 1995).

Clarity

The public has been informed of the general subjects of habitat loss, and species extinction, and has an indirect knowledge of fragmentation and its relationship to biodiversity. The popular literature is replete with articles and books on the fragmentation of tropical forests and biodiversity. The public is more likely to associate the concept of fragmentation with respect to forested habitat (e.g., Jones et al. 1997) and the consequences of timber harvesting and land use change on forested habitat. The use of many easily calculated metrics could confuse the sense of fragmentation, thus it will be important to use metrics of fragmentation where they convey additional ecological information about underlying processes.

INTENSITY OF HUMAN USES ON RANGELANDS

Description of the Indicator

This indicator provides a surrogate measure of intensive human uses of rangelands through the use of road density measures and housing densities. Many intensive uses of rangeland are often not represented in land cover maps because of their small individual spatial extents. Examples of these types of land uses of rangelands include low-density rural housing developments, powerlines, off-road-vehicle (ORV) uses, mines, oil and gas wells, and their associated transportation infrastructure. Although these activities have small individual spatial extents, their ecological impacts at both local and landscape scales and their cumulative impacts can be significant (Theobald et al. 1997, Forman and Alexander 1998).

Importance

The processes of land use change are reasonably well understood and flow predictably from population growth, household formation and economic development (Heimlich and Anderson 2001). Pressures on the interface between rural and urban landscapes are expected to increase from both rural and urban populations (Brown et al. 1997). New technology lowers the cost of communication and transportation resulting in higher land prices farther out into rural areas. As access to urban centers through communication and transportation technology increases, the development value of rural land exceeds the value for agricultural purposes. To adapt to rising land values and increasing contact with new residents, traditional rangeland users may change their operations to fit an urbanizing environment, which may include selling properties for development purposes, or discontinuing their activity.

The potential ecological impacts of intensive human uses of rangeland include loss and fragmentation of rangelands and open space (Theobald et al. 1997), reduced primary and secondary productivity and biodiversity (Forman and Alexander 1998), increased soil disturbance and susceptibility to wind and water erosion (Iverson et al. 1981), disruption of material flows and ecological processes in the landscape, e.g., groundwater flow, fire spread, (Forman and Alexander 1998), and enhanced opportunities for successful establishment of invasive plants and animals. The ecological impacts of intensive human uses of rangelands extend beyond the footprints of the land uses and vary with the spatial location and pattern of the intensive land uses.

This indicator uses digital road and housing data available in the geographic vector model format to calculate measures of the density and spatial pattern of roads and housing units. Road density (km/km^2) is an overall index that averages patterns over an area. Road effects vary with road width and type, traffic density, location and spatial pattern (Forman and Alexander 1998). Because digital road data are spatially explicit, a "roadedness" image can be constructed which incorporates these factors (Davis et al. 1996; Stoms 2000). A "roadedness" image is constructed by buffering road arcs with a buffer width related to the class of road, e.g., a freeway is given a greater buffer width than an unimproved soil road. Digital housing data are available for the nation in census block groups and blocks that are subdivisions of the familiar census tract (Theobald 2001). Although these data are available at relatively fine spatial grain for the nation, the location of individual houses is not spatially explicit. A housing unit density can be calculated for each polygon (block group and blocks) in the census data. To interpret the "roadedness" and the housing density images in the context of rangelands requires a spatially explicit map of rangelands or rangeland types (see Extent of Land Area in Rangeland).

Geographic Variation

Intensive human uses of rangelands are ubiquitous and, thus, the indicator is meaningful in all geographic areas.

Scale

To interpret the "roadedness" and the housing density images in the context of rangelands requires a spatially explicit map of rangelands or rangeland types. These maps, discussed under Extent of Land Area in Rangeland and Area of Rangeland by Plant Community, are needs identified in several indicators within the Conservation of Plant and Animal Resources Criterion Group, and likely other Criterion Groups of the SRR. The "roadedness" image could be intersected with the rangeland map and the amount of roads in rangeland or rangeland types calculated and the data aggregated by watersheds, counties or other analysis units. Interpretation of the housing density image is more difficult because of the data is non-spatially explicit and may not allow a determination if the housing units occur within land designated as rangeland. The proportion of rangeland or rangeland types in different housing density classes, e.g., urban, suburban, exurban, and rural could be tabulated and aggregated by counties (Theobald et al. 2001). Provided road and housing unit data are updated to reflect changes with time, the indicator could be used to examine the trend in intensive human land uses of rangelands.

Data

The data currently available for this indicator are best described by A) Methods and procedures for data collecting and reporting; and data sets of useable quality exist at the regional-national level.

Methods and procedures for data collecting and reporting, and data sets of useable quality for roads and housing units exist at the regional-national scale (Davis et al. 1996; Stoms 2000; Theobald 2001; U.S. Census Bureau 2002). The Census Bureau TIGER (Topologically Integrated Geographic Encoding and Referencing) database is the most current source of national data for roads and housing units. The U.S. Geological Survey 1:100,000 scale Digital Line Graphs were the initial source used to create most of the transportation lines in the TIGER database. Most of the 1:100,000 scale DLGs were constructed in the 1980s and have not been updated. The Census Bureau uses various internal and external procedures to update the TIGER database. There are issues with the completeness and location accuracy of the updated TIGER database (U.S. Census Bureau 2002). In preparation for the 2010 census, the Census Bureau and the U.S. Geological Survey have initiated discussions about the construction of spatially explicit road and structural data with 5 m positional accuracy. If road omissions in the TIGER database are identified as a serious problem, additional road data might be acquired from state department of transportation offices, federal agencies, e.g., Forest Service, and local governments. However, the work required to prepare the road data for analysis would increase substantially. The road data do not provide information about off-road vehicle use on rangelands.

Clarity

Roads and houses are common objects familiar to everyone and thus stakeholders should easily understand the indicator.

INTEGRITY OF NATURAL FIRE REGIMES ACROSS U.S. RANGELANDS

Description of Indicator

This indicator, integrity of natural fire regimes, spatially and temporally quantifies acres of rangeland burned annually. Analysis of this indicator requires a nationally accepted standard for reporting fire statistics. Burned acres would be identified annually both by location and season. This is necessary because frequency, intensity, seasonality, and type of fire depend on weather and climate in addition to the ecosystem structure and composition (Dale et al.2001). Areas of both natural and prescribed (i.e., set) fires would be tracked.

Importance

Fire is a key ecological driver in many rangeland ecosystems, facilitating nutrient cycling, promoting recruitment of the native grasses and forbs, and limiting encroachment of woody species. The dynamics of fire in rangeland ecosystems historically varied across the United States in terms of how frequent the fires were, the season that fires occurred, and the intensity and severity of the fires. In the desert grasslands of southwestern United States, the highly variable rainfall coupled with a lack of fine fuels may have limited fire (Archer 1994). Regional climatic conditions such as the periodic meso-scale phenomena of El Nino-Southern Oscillation have been correlated with fire occurrence in the more mesic southwestern ecosystems (Swetnam and Betancourt 1990). Across the Central Great Plains, periodic fire was important for maintaining ecosystem structure and function (Engle and Bidwell 2001), with pre-European human management of fire to attract larger grazers and the herbivory of large grazers an important component in the landscape dynamics (Biondini et al. 1999). Fire return intervals may have varied from 7 to 30 years across the Great Plains (Perryman and Laycock 2000, Wright and Bailey 1982).

For many rangeland ecosystems, the introduction of domestic grazers, and invasive species, conversion of rangeland to cropland, fire suppression, and fragmentation of the landscape has altered significantly the natural fire regimes as well as landscape composition and structure (Natural Research Council 1994, McPherson and Weltzin 2000, Rueth et al. 2002). Domestic livestock graze a majority of both private and public rangelands in North America, altering the seasonal patterns of fine fuels (live and dead biomass) availability, as well as species composition on the landscape. In many Southwestern ecosystems with a history of frequent fire, fine fuel (grasses and forbs) removal by livestock, and the increase in bare ground resulted in a greatly extended fire-free interval (see for example, Savage and Swetnam 1990, Madany and West 1983). In Texas, the combination of factors---reduced grass cover, fewer fires, a reduction in available moisture in the topsoil and a change in rainfall patterns over the past 100 to 200 years--resulted in a shifting from a savannah with only scattered trees to a subtropical thorny woodland (Archer 1989). Throughout much of the Intermountain west, fire return intervals have decreased as a result of the livestock-facilitated invasion of cheatgrass. Because native sage-steppe species do not survive the frequent fires facilitated by cheatgrass, and do not disperse effectively, the system moves toward a cheatgrass monoculture devoid of biodiversity value or economic value (West and Young in Barbour and Billings 2000). Indeed, the large majority of the West's arid rangelands have fire regimes that are significantly altered from their natural patterns (Schmidt et al. 2002).

Because fire is such a dramatic disturbance, changes in the frequency or intensity of fire results in significant changes in nutrient cycling, species richness, ecological integrity, carbon stocks, and local weather. Monitoring the integrity of these fire regimes promises to significantly inform evaluations of rangeland health.

Geographic Variation

The areal extent of fire in rangeland ecosystems would be meaningful in different regions. Understanding the implications of changes in the area of rangeland annually burned will also require an understanding of the role of fire in these ecosystems. This role of fire would vary in rangeland ecosystems across the United States.

Scale

The areal extent of rangeland burned is applicable across spatial and temporal scales. Changes in the fire regime result from both natural (e.g. climate) and anthropogenic sources (e.g. grazing management, fire suppression). As a result, measures of changes in the fire regime are reflective of important ecological changes at multiple scales ranging from sites to regions. These changes must be interpreted with respect to the plant community being described.

Data

The data currently available on acres burned are best represented by **C** – Some data set(s) exist at the regional-national level, but methods and procedures are not standardized at the regional-national level. However, precise location and season of fires are best represented by **D –** Conceptually feasible or initially promising, but no regional-national methods, procedures, or data sets currently exist. National-level data are (i.e., C) currently available for fire occurrence for 1986-1996 and for departure from the historical fire regime (Schmidt et al.2002, see also http://www.fs.fed.us/fire/fuelman). However, these data were not the result of a national-reporting effort institutionalized within the federal government. Rather, these data represent a one-time coarse scale assessment and mapping effort funded by the Forest Service and Bureau of Land Management where data from several federal agencies and state agencies were compiled to produce a geographic information database. Two layers of interest are: (1) Fire occurrence data for each of the 11 years between 1986 and 1996, a spatial layer and database of federal and non-federal fire occurrences and (2) Fire Regime Current Condition Class, a spatial layer depicting the degree of departure from historical fire regimes possibly resulting in alternations of key ecosystem components. Schmidt et al.(2002) note that there are several potential problems with the fire occurrence data set, such as missing records, duplicate fires where the same fire may have been reported on federal and on non-federal lands, approximate locations of fires where county was the finest spatial identifier, and unreported fires. The most appropriate use of such an occurrence data set, according to the authors, is in illustrating trends in fire occurrence. A national standardized reporting method is needed for all jurisdictions so that fire reporting at the national level can be dependable and consistent. The Fire Regime Current Condition Class has had several recent refinements that have improved the validity of the information for rangelands. This information needs to continue to be improved and assessed at regular intervals in the future.

Within the database are vegetation layers (Kuchler vegetation type as well as current vegetation types), so acres of fires within rangeland types could be assessed and mapped using such a system. Schmidt et al. (2002) report the summary of land areas within the different Fire Regime Current Condition Classes for all cover types except agriculture, barren, water, and urban/development/agriculture lands (Appendix 3-4). Across the historical fire regimes, only 48 percent of the land area is in condition class 1, where fire regimes are within a historical range, and the risk of losing key ecosystem components is low. The historical fire regime II is typically associated with grasslands, and 57 percent of this fire regime is in Condition Class 1. Schmidt et al. (2002) ascribed fire exclusion, housing and agricultural development, livestock grazing, logging, and invasion of exotic species as the primary causes of departures for Fire Regime I and 2. Those areas identified as in Condition Classes 2 and 3 within Fire regimes I and 2 are at risk of catastrophic fire with the consequent risks of loss of native plant and animal habitats, air quality and water quality impacts from wildland fire, reduced commodity outputs, and risks to human health (Schmidt et al. 2002). The most recent version of the Fire Regime Condition Class information also provides fire interval information that may also be useful for this assessment.

Other methods of establishing acres burned annually are being developed. For example, using data from the Moderate Resolution Imaging Spectroradiometer (MODIS) project (http://modis.gsfc.nasa.gov) on NASA's TERRA satellite, scientists at the Goddard Space Flight Center are mapping fire activity worldwide (http://modis.gsfc.nasa.gov/). These data are available since February 2000, can be summarized at a variety of geographic scales, and can be used to explore frequency and extent of fires. An interagency research project, called LANDFIRE, is to provide the spatial data and predictive models needed by land and fire managers to prioritize, evaluate, plan, complete, and monitor fuel treatment and restoration projects. Currently the MODIS data are being evaluated as part of this LANDFIRE (www.landfire.gov) program. The LANDFIRE products can be broken into three main groups: (1) maps that characterize vegetation and fire regimes, (2) maps that characterize fuel conditions, and (3) maps and models used to evaluate ecosystem status and fire hazard and potential status. This project is evaluating data currently collected on ecosystem status and fire regimes to compare with models of natural fire regimes so that areas and ecosystem types in which the fire regime is beyond its historical norms can be identified (see: http://www.fs.fed.us/fire/fuelman/curcond2000/maps/frcc2000.pdf). This determination of the fire regime status is important as the data from Schmidt et al. (2002) is based on the best available information, including expert opinion.

Clarity

Total acres burned and fire frequencies are concepts readily understood by the general public. The importance of other measures, for example seasonality, severity, and intensity, are less well understood. Much more public education is needed to advance the concept of natural fire regimes.

EXTENT AND CONDITION OF RIPARIAN SYSTEMS

Description of the Indicator

The indicator is the extent and condition of the riparian plant community along rivers and streams in the rangeland region.

Importance

The indicator will measure the "status or condition" of riparian vegetation on a linear basis measured in kilometers for 1^{st} to 4^{th} order streams within the rangeland regions of the USA. The status or condition may be evaluated on a quantitative basis using a numeric value (e.g., a number similar to IBI … Index of Biotic Integrity, or HGM…a hydrogeomorphic index), or a qualitative evaluation with a descriptor such as "fair condition" (e.g., PFC—Proper Functioning Condition). No indicator similar to IBI has been developed, although several riparian researcher teams are working on such an index which should be ecologically based and include geomorphic, hydrologic and biotic parameters. HGM is a complex index and has been applied to riparian areas only on a case-by-case basis. PFC is used by several agencies to evaluate riparian and stream bank conditions (Pritchard et al. 1993, et al. 1994), By necessity, the method depends on subjective evaluation by different personnel and is primarily based on physical parameters which may limit its applicability on a national comparative basis; perhaps, a quantitative index of condition built upon the concepts of PFC with more ecological parameters could become an indicator acceptable to most resource managers. When developed, the resulting indicator will be X number of miles (or km) of riparian community in a region with an index score of Y, or an indicator rating using several classes.

Riparian ecosystems respond to the "funnel effect" of changes in the associated, upstream watershed. They also function as buffers between the upland and stream, help maintain water quality, and control flood magnitudes. Riparian ecosystems are used as habitat by a high percentage of animals for all or some portion of their life cycle. Consequently, sustainability of a watershed and all its components can be evaluated, in part, through the condition of the riparian ecosystems within that watershed.

Geographic Variation

Riparian systems occur wherever there are streams and rivers. These systems tend to be linear, that is, following the course of the river, and are formed and maintained by similar processes throughout their range. Consequently, an indicator metric or indices developed for one region within the rangeland areas of the United States will be applicable to other regions.

Scale

Riparian systems can be related to watersheds, which can be aggregated within larger hydrological units. Measurements of riparian condition can be applied locally or aggregated and evaluated on a larger scale such as a particular national forest, unit of BLM, or region. The indicator relates to a system that is linear and characterized by disturbance (e.g., flooding). The temporal scale of riparian disturbance and resilience is normally within decades and this is commensurate with the linear extent of the system, which is tens to hundreds of miles (or kilometers).

Data

The data currently available for this indicator are best represented by C **C** – Some data set(s) exist at the regional-national level, but methods and procedures are not standardized at the regional-national level. Several protocols exist that may be used on a local basis (e.g., HGM developed by USACE, see Brinson 1993, Smith 1993, and Smith et al. 1995) and some are generally used by several resource management agencies. The subjective nature of these data (e.g., PFC used by BLM and USFS) would likely result in inconsistencies when aggregated across the local implementations to a regional or national level.

Clarity

The importance of riparian systems is becoming more visible to concerned stakeholders as local decisions on development and agricultural intrusion into riparian buffer strips are often brought before city, county and state planning entities. These areas also are widely used by the public for recreational purposes and the public recognizes their importance in maintaining the quality of rivers.

AREA OF INFESTATION AND PRESENCE/ABSENCE OF INVASIVE AND NON-NATIVE PLANT SPECIES OF CONCERN

Description of the Indicator

Invasions of non-indigenous species can threaten native biodiversity, ecosystem functions, animal and plant health and human economies (Carey 2003). Plant invasions are a serious threat to natural and managed ecosystems, and the number of species involved and extent of existing invasions renders the problem almost intractable with the likelihood of the problem worsening in the future (Hobbs and Humphries 1995). The optimal solution regarding invasive and non-native species is to prevent the introduction of the species or exotic organisms into the ecosystem. However, in many rangeland situations, this option has already been lost and activities have to be developed to monitor the exotic organisms and attempt to minimize their impacts on other systems while trying to manage those systems that have already had invasion take place. The proposed indicator is designed to track the area of infestation and presence/absence of invasive or non-native species on rangelands over time; thus providing information for land manager in developing strategies to address the problems.

Invasive species are defined in Executive Order 13112 signed by then President William J. Clinton (http://www.invasivespecies.gov, 1999). The Executive Order defined "alien species" as a term that "means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species that is not native to that ecosystem." The term "invasive species" was defined as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health."

Invasive species typically have high reproductive rates, fast growth rates, and dispersal mechanisms that allow for swift movement across landscapes. Other non-native plant species, not officially defined as noxious or invasive, can also share some of these traits and can alter the functioning of rangeland ecosystems in ways similar to invasives. Hence, non-native species of concern are included in this indicator to be used at the discretion of those monitoring the rangeland systems. Their inclusion provides the opportunity to monitor them through the indicator and to measure potential impacts they may be having on native rangeland systems. The implementation of this indicator requires that stakeholders define what species are to be monitored for their region, outside those federally designated species, that are of concern in rangeland systems.

The indicator measures the area of infestation (acres/hectares) of identified invasive plant species to track their progress within the rangeland landscape over time. The areas of infestation can be inventoried or monitored at the county level and be scaled up to the state, regional and national level. In association with the monitoring of area of infestation, one could also develop a database that determines presence/absence of an invasive or non-native species at both the state and county levels. This tracking allows for efficient mapping to track movement of identified species. Ultimately, the indicator can be used by policy makers and managers to monitor changes in the abundance and distribution of invasive or non-native species and make determinations on management actions needed to manage the species in question.

Importance

Invading non-indigenous species in the United States cause major environmental damages and losses adding up to more than $138 billion per year (Pimentel et al. 1999). There are approximately 50,000 foreign species in the United States and the number is increasing; and about 42 percent of the species on the Threatened and Endangered species lists are at risk primarily because of non-indigenous species (Pimentel et al. 1999). Invasive plant species make up approximately 10 percent of the 50,000 non-indigenous species problems in the United States that have escaped into natural systems (Morse et al. 1995). Non-indigenous, "weedy," species are spreading and invading approximately 700,000 ha/yr of the U.S. wildlife habitat (Babbitt 1998). The 700,000 ha/yr of habitat refers only to wildlife habitat that is being lost. The total area of infestation due to invasive plants is much higher. According to the US Department of Interior, Bureau of Land Management (USDI BLM 1996), current rates of infestation on rangelands are increasing at approximately 14 percent per year. At this rate, it was estimated that 33 million acres would be infested with on-indigenous plant species in the year 2000. It is estimated that 100 million acres of land are moderately to heavily infested with non-native grasses such as cheatgrass, red brome and medusahead (Westbrooks 1998).

One example of an invasive plant that is having significant impacts on natural ecosystems is purple loosestrife (*Lythrum salicaria*). Purple loosestrife, introduced in the early 19th century as an ornamental plant (Malecki et al. 1993), is spreading at a rate of 115,000 ha/yr and is changing the basic structure of most of the wetlands it has invaded (Thompson et al. 1987). This plant alone is able to reduce critical species impacting 44 native plants and endangered wildlife species that rely upon the native plants for survival (Gaudet and Keddy 1988). Loosestrife now occurs in 48 states and costs $45 million per year in control costs and forage losses (ATTRA 1997). Other examples such as non-native grasses have altered historical fire regimes in the Great Basin and at Hawaii Volcanoes National Park (Mack and D'Antonio 1998). Salt cedar (*Tamarix chinensis, T. parviflora*, and *T. ramosissima*) was introduced as an ornamental in the early 1800s and has spread into nearly every riparian community of the desert Southwest. The dense stands of salt cedar, as well as the release of salt accumulation in its tissues makes the site unsuitable for native species (Westbrooks 1998). Invasive species can also result in economic impacts, on rangeland economic value, and enterprise net returns (Masters and Sheley 2001).

"Healthy ecosystems" are often viewed to be highly diverse with a multitude of plant and animal species present (i.e., high biodiversity). A system can have a high biological diversity, but lack biological integrity if a number of exotic species make up a large proportion of the diversity (Karr and Dudley 1981). Ecosystem health can be deemed as a condition of the normality in the linked processes and functions that constitute ecosystems (Rapport 1995), and defined in terms of vigor, resilience, and organization (Mageau et al. 1995). However, ecosystem health and biological integrity are highly related because a sure way to maintain ecosystem health is to maintain biological integrity (Karr 1995), but the opposite is not necessarily true. In this case, inclusion of multiple or even a single exotic species can influence the ecosystem functions and processes to the point that biological integrity can be lost from its previous state and ecosystem health can be diminished.

Geographic Variation

The proposed indicator is meaningful throughout all regions of rangeland systems and could be integrated across regions to provide a national level metric with standardized monitoring programs developed. There are many variations that could be used to standardize the metric and perhaps one most easily implemented would be based upon the taxonomic relationships of the invasive or non-native plants. In such a manner, the species can be tracked based upon their taxonomic relationships where similar plant species are being compared across the multiple scales. For example, those plant species in the Poaceae can be tracked together to determine problems associated with invasive or non-native grasses both locally and at the regional and national scale. This arrangement can eliminate the comparison of "apples to oranges" where different lifeforms of plants with different strategies are not being compared. Placing the plants into taxonomic criteria allows for a strategy to be developed and implemented managing for the various problem classifications (grasses, forbs, shrubs, trees, etc.).

Scale

The indicator can be scaled from the local, county level up through the state, region and national levels of reporting. How each species is classified can be integrated into the scale up for a national level reporting system. County level monitoring would, most likely, be used (and is being used) to develop a national database. The use of area as a monitoring metric allows for the quantification across counties, states and throughout the nation. Presence/Absence is a measurement that could be used based upon the gathered data to develop mapping and to track the plants at county and state levels. The presence/absence designation is not designed to implicate an area as "invaded" if only one or two plants are in a county. Instead, the presence/absence portion of the indicator is designed to monitor where problems may increase as presence of an identified invasive or non-native species is noted.

Data

The data currently available for this indicator are best represented by **C** – Some data set(s) exist at the regional-national level, but methods and procedures are not standardized at the regional-national level. At this time, there are a multitude of invasive species data systems; however, most of these only represent a listing of the species with several providing actual distribution information at various scales (see Appendix 3-5). The proposed metric would require an effort be put forward to develop a national framework of data collection (for example, FIA and NRI) or at least national data standards and consistent species in databases that could be aggregated up from some common local level, such as county. At this time, an effort to standardize collection and analysis of invasive species information is being developed. According to Rita Beard (pers. comm.) from the U.S. Forest Service, a multi-agency task force is developing a scale-sensitive standardized monitoring system that is planned for implementation within the next five years. To date, work has been accomplished on the development with a proposal of a standardized mapping procedure included for each entry into a national level data system (North American Weed Management Association 2002). Also, a National Early Warning and Rapid Response System for Invasive Plants in the United States has been proposed (Federal Interagency Committee for the Management of Noxious and Exotic Weeds 2002).

The University of Montana has developed the INVADERS database, which is a comprehensive database of exotic plant names and weed distribution records for six states in the Pacific Northwest (http://invader.dbs.umt.edu). Within this database, the spatial and temporal spread of weeds can be displayed using information on the historical distribution of the species. The database also contains a listing of all noxious weed species in the United States. The design structure of this database is such that it could be expanded to cover additional areas in the United States. Weed managers are invited to cooperate

For the purpose of this indicator, the working group does not intend to develop a threshold value of area of infestation within an ecosystem. This will require local stakeholders to develop the levels to be monitored. The value of the indicator would be in the periodic re-sampling of the metric to develop trend data showing spread or decline of invasive or non-native species. The metric should be established to be repeatable, reliable and accurate over time.

Clarity

Through a multitude of educational efforts, the impacts of invasive plant species and particular non-native species that are likely to become invasive are becoming increasingly understood by the public. However, it will be necessary to continue educational activities to increase awareness and provide further understanding. The indicator itself is fairly straightforward and should be understood by the general public.

NUMBER AND DISTRIBUTION OF SPECIES AND COMMUNITIES OF CONCERN

Description of the Indicator

This indicator measures the numbers and geographic ranges of rare or "at-risk" species that occupy rangeland habitats for a significant portion of their life cycle, as well as the presence and extent of rangeland plant communities of concern. Trends in the number of at-risk species and communities help identify potential loss of historical and natural rangeland ecological functioning and loss of associated values and benefits. This indicator is analogous to the "canary in the coal mine" as a warning of ecosystem stress.

This indicator is related to Rangeland Area by Plant Community. Rare and at-risk communities will be identified in that indicator, but are included in this indicator because of the legal and biological importance of rarity and threatened status.

Importance

This indicator measures the number and geographic ranges of at-risk species and plant communities. Species of concern include those identified by the Nature Conservancy at the G1, G2 or G3 level, species listed under the Endangered Species Act or identified as candidates for listing, or species otherwise identified as being at risk, e.g., IUCN categories. Communities include those identified as G1, G2, or G3 by the Nature Conservancy, as well as those identified by other organizations such as the World Wildlife Fund (1999).

There are several metrics that could be used to describe the indicator. For species, metrics include the number of species, the number of populations per species, the abundance (number of individuals) per population, and the geographic range. For communities, metrics include the presence and number of at-risk communities, the number of stands of each community, the size of the stands, and the geographic range of the community.

The concept of at-risk communities is less well defined in the ecological literature compared with at-risk species. Plant community is defined in the indicator, Rangeland Area by Plant Community. At a coarse scale the Nature Conservancy community-level measure of rarity (G1-G5) can be used, as it is well defined and widely applied. Areal extent (e.g., hectares or km^2) is also relatively easy to determine. The status of particular stands is more difficult to determine. Loss of native species, spread of exotics, and changes of ecosystem-level attributes such as nutrient cycling or pollination function could be used, but are not currently well defined or standardized.

An increasing number of at-risk species or communities, or a decline in their ranges, generally indicates regional or landscape-level ecosystem instability or degradation, and the potential loss of critical components to maintain ecosystem function. The number of at-risk species or communities in a region is not as responsive an indicator as some other indicators because a species or community is probably in serious trouble before it becomes recognized or listed as threatened. It should be viewed more as a trailing rather than a leading indicator of ecosystem stress. Population demography or community-level functional attributes are more responsive measures, but are more difficult to obtain than simple counts of species and communities.

Geographic Variation

Measures of the numbers of at-risk species and plant communities can be easily aggregated and compared among areas. However, as larger areas and more complex biomes are likely to have more species and communities, including rare and at-risk species, the numbers of at-risk species and communities should be considered relative to the total number of rangeland species and communities. In order for comparisons to be meaningful, the metrics used to describe conservation status should be uniform across taxonomic groups and between regions. Metrics and assessment tools developed by the U.S. Fish and Wildlife Service, The Nature Conservancy, NatureServe, World Wildlife Fund, and the IUCN are recommended as they are widely used and are applicable to U.S. rangelands.

Scale

The distribution of at-risk species and communities at the landscape level is generally patchy. However, the data can be easily aggregated from the local (county) and regional (state) levels to the national level. Trends in the number of species, populations, or local vegetation stands, and trends in their distributions (geographic range) over time, can also be aggregated. The basic metrics are population and community locations and either abundance or areal extent. These metrics are generally scale-independent. This indicator will also be comparable over time, if the criteria and assessment methods do not change.

Data

The data for this indicator are best characterized as **A** – Methods and procedures exist for data collecting and reporting and data sets of useable quality exist at the regional-national level. There are extensive data available on at-risk vertebrate and vascular plant species and many plant communities at the local, state, ecoregional and national levels. Most federally listed species will have either recovery plans or other documents that indicate status and distribution (http://endangered.fws.gov). Other at-risk species and community data are available through state-level heritage programs, the Nature Conservancy, and NatureServe (http://www.natureserve.org). These programs include data on both population locations and often species and community status. However, data are scarcer for some vertebrate groups, such as fish, small mammals and reptiles, than they are for large mammals and birds. Generally, much less is known about other taxonomic groups, such as lichens, bryophytes, invertebrates, fungi, algae and bacteria. Identifying and describing rare plant communities is at an earlier stage of development than for species. However, the Nature Conservancy, NatureServe and World Wildlife Fund have attempted designations of rare communities. Some states also have relatively detailed community classifications and status. For example, the California Native Plant Society has published a list of plant communities at the alliance level, and includes information on their status within the state (Sawyer and Keeler-Wolf 1995)

Although subjective judgment is often used in determining rarity, there are guidelines and extensive research available that can make these indicators both repeatable and reliable. Vascular plants and vertebrate animals have received closer scrutiny than other species, and charismatic species sometimes receive special emphasis, increasing the bias and decreasing the accuracy of the indicator. However, the numbers and ranges of at-risk species and communities remains valid despite these concerns because they measure the potential loss of critical rangeland components.

Clarity

The concept of threatened and endangered species and communities is easily understood, and it forcefully communicates threats to rangeland sustainability. Almost everyone is familiar with endangered species through news reports. The concept of rare plant communities is understood in a very general sense by the public, e.g., loss of tropical rainforests, but a more detailed understanding is not widespread.

POPULATION STATUS AND GEOGRAPHIC RANGE OF RANGELAND-DEPENDENT SPECIES

Description of the Indicator

This indicator measures the population levels (abundance) and the current geographic ranges of rangeland-dependent plant and animal species, monitored across their known range. Species should be dependent on rangelands for most if not all of their life cycle, i.e., permanent residents. One cannot generally use the population level or range of one species to reliably infer traits about another species; so single species are not always useful as representatives of other species or communities. However, it is not possible to monitor the population levels and ranges of all species of animals, plants and microorganisms, so some species must be selected for monitoring. If the selected species include keystone species and those that are sensitive to particular threats, such as overgrazing, irreversible soil erosion, or fire, and if the species are diverse with respect to their taxonomy, habitats, trophic levels, ranges, and life strategies, the indicator will have a higher likelihood of detecting trends in range ecosystems.

Importance

This indicator measures population levels (abundance) of rangeland-dependent species and the geographic area of their current ranges. This indicator combines elements of the Montreal Process (forest) indicators 6, 8, and 9 (Working Group on Criteria and Indicators for the Conservation and Sustainable Management of Temperate and Boreal Forests 1995). To a certain extent, it also measures genetic diversity in rangelands (but for an alternative view see Flather and Sieg 2000). A reduction in the geographic range of a species often results in the loss of subspecies and locally adapted populations. It is a leading indicator of ecosystem stress and will respond to impacts before the indicator measuring the number of at-risk species. Stressed species likely will exhibit the stress through reduced population sizes, reduced geographic range or both, which will be detected by this indicator.

Rangeland-dependent species include widespread common plants and animals such as *Artemisia tridentata* or Greater sage Grouse, or species from particular kinds of rangeland, such as *Carnegiea gigantea* in the Sonoran Desert. Species may be categorized as umbrella, keystone, or guild indicator species (Landres et al. 1988; National Research Council 1986). The species thus categorized can indicate one of three factors, levels of contaminants in an ecosystem, changes in other species in the same guild, or changes in habitat quality that affects other species as well. An alternative to the use of particular species is to use community-level or ecosystem processes such as trophic relationships or species diversity as indicators of ecosystem function (Launer and Murphy 1994; Williams and Gaston 1994). The selection of the kinds of species or community-level attributes to measure is problematic for a variety of reasons (Landres et al. 1988). In the case of either species or ecosystem functions, ecological theory does not have the ability to precisely define the nature or quantity of species or community responses needed to maintain all the native elements of a regional biota or landscape.

At the species level, two terms are widely used, indicator species and umbrella (keystone) species. Indicator species are those that are representative of a particular ecological guild, trophic level, or ecosystem function. Indicator species do not necessarily have direct interactions or causal relationships with the species or groups they are supposed to represent. Umbrella or keystone species are over-arching species that need to exist in a community for a variety of other species to be present and persist as well. Implied in this are more direct causal linkages between an umbrella species and other species. For example, the presence of breeding woodpeckers in forested communities, through their propensity for cavity excavation, allows the presence of a wide variety of secondary cavity-nesting species. Another well-known indicator is the prairie dog, which is a keystone species because of their abundance and colonial and burrowing instincts. Many other rangeland species are dependent on the existence of the prairie dog colonies, such as black-footed ferret, burrowing owl, and various plants, raptors and reptiles. More recently, Lambeck (1997) introduced the term focal species, defined as a multiple-species umbrella. He provides a conceptual model for selecting focal species. Although his emphasis was on rare and declining species in fragmented habitats, the method is also applicable to more common species.

Landres et al. (1988) point out the many pitfalls in using guild indicator species, suggesting that the method should be abandoned. If a species is to be used as an indicator of habitat change or quality, it must have a demonstrated relationship with the habitat attributes of interest. Because of the complex and multiple causality in natural ecosystems, it may prove difficult, if not impossible, to find a species that can be used to indicate habitat quality for any other species or group. Because of these problems, this indicator focuses on types other than guild indicator species, and includes both “typical” representative rangeland-dependent species, and umbrella species that are critical for maintaining subsets of a regional rangeland biota. Recognizing that we cannot monitor all species, some species selection is necessary. Careful selection of species can increase the likelihood of detecting threats to sustainability, but we cannot claim that the selected species are indicator or representative species.

Geographic Variation

Because of the wide diversity of vegetation in the term “rangeland,” any regionally restricted rangeland species is not useful as an indicator outside the regional level (e.g., ecoregion or province). This makes it difficult to compare groups of species across various regions and at the national level, but trends in range and abundance can be compared in the abstract across regions and at the national level. For example, is there a widespread decrease in rangeland species or are the decreases occurring primarily in particular areas or with particular types of species? The numbers of species can be aggregated from the local to the regional level.

Scale

The distribution of species and communities at the landscape level is often patchy. However, the data can be easily aggregated from the local (county) to regional (bioregion, state) levels, although less easily to the national level. Changes in species' population sizes over time, and changes in the distribution (geographic range) of a species' populations over time, can also be aggregated. This indicator will be more meaningful if species trends can be extrapolated into the past to measure the loss of populations and contraction of geographic range over time up to the present. The basic metrics are population locations and overall status for representative species, repeated over space and time. This indicator will be comparable over time if the criteria and assessment methods do not change.

The number and geographic range of species in a region is a more responsive indicator than the number of at-risk species or communities as such species, if carefully selected, will give early warning of ecosystem degradation. If a wide enough variety of species from different trophic levels and taxonomic groups are included, there is a greater probability of detecting early changes in communities and ecosystems that could lead to loss of function and sustainability.

Data

The data for this indicator are best characterized for some vertebrate and vascular plant species as **A** – Methods and procedures for data collecting and reporting; and data sets of useable quality exist at the regional-national level, and for many other species as **C** – Some data set(s) exist at the regional-national level, but methods and procedures are not standardized at the regional-national level.

Data are available for a wide variety of vertebrate and vascular plant species that could be selected as representative or umbrella species. The data are primarily in the form of either local focused research or as annual or other temporal counts of species abundance, such as the Breeding Bird Survey of the U.S. Geological Survey (Sauer et al. 2002), the Christmas Bird Count of the Audubon Society (http://www.audubon.org/bird/cbc/bb.html), North American Waterfowl Breeding Survey (http://www.mp2-pwrc.usgs.gov/bbs/), Great Plains Flora Association county-level distributional data (Great Plains Flora Association 1977), and others. Less is known about other groups, including invertebrates, reptiles, small mammals, bryophytes, fungi, algae and bacteria. Lichens are well known to respond to air pollution, and extensive research on their uses as indicators is available. Much of the available species-specific data are from local research sites that may or may not be applicable at a coarser scale, such as the regional level. Because of this local site-specific nature of much of the data, it will be necessary although difficult to synthesize the available research and aggregate it above the local site.

Some characteristic and widespread plant species may be identified and tracked using remote imaging and mapping. For example, extent and density of big sagebrush is easily mapped using satellite and aerial photography methods. Other widespread and common rangeland plant species can also feasibly be monitored this way. However, this type of data cannot be collected for other taxonomic groups.

Species are typically characteristic of a particular climatic region; hence they are extremely useful at the regional level. There are many different classifications of regional vegetation that data could be aggregated upwards to, including but not limited to those developed by Brown et al. (1980), McLaughlin (1989) or Bailey (1995). However, the data cannot be easily aggregated beyond the regional level, as species-level comparisons are largely invalid across biome or ecoregional boundaries. However, patterns of similar species-groups (e.g., neotropical migrant birds) can be compared across regions.

Clarity

Most people readily understand the concepts of population size, trends in abundance, and changes in geographic ranges of species. Rangeland-dependent as a concept may be less well understood by the general public, except for a few large game or threatened species like the black-footed ferret, primarily because the public tends to lack the detailed ecological background needed to evaluate the concept.

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APPENDIX 3-1. Changes in land cover/use between 1982 and 1997 (data per 1,000 acres) (Summary Report, 1997 National Resources Inventory, Revised December 2000).

	Land cover/use in 1997 per 1,000 acres								
Private land cover/use in 1982	**Cropland**	**CRP land**	**Pasture land**	**Rangeland**	**Forest land**	**Other rural land**	**Developed land**	**Water areas & federal land**	**1982 total**
Cropland	350,265.3	30,412.1	19,269.4	3,659.2	5,606.5	3,158.9	7,097.5	1,485.1	420,954.0
Pasture land	15,347.0	1,329.6	92,088.3	2,567.9	14,091.4	1,619.0	4,230.0	732.8	132,006.0
Rangeland	6,967.5	728.5	3,037.2	394,617.4	3,021.6	1,702.7	3,281.3	3,383.2	416,739.4
Forest land	2,037.1	128.8	4,168.2	2,098.8	380,343.3	1,754.8	10,279.2	2,528.0	403,338.2
Other rural land	1,386.8	93.1	1,013.6	719.1	2,767.7	42,713.3	726.9	227.8	49,648.3
Developed land	196.7	1.2	78.6	110.8	227.0	12.0	72,618.7	0.8	73,245.8
Water areas & federal land	797.5	2.7	336.6	2,204.0	897.7	180.8	18.1	443,760.6	448,198.0
1997 total	376,997.9	32,696.0	119,991.9	405,977.2	406,955.2	51,141.5	98,251.7	452,118.3	1,944,129.7

Notes: 1982 land cover/use totals are listed in the right hand vertical column, titled “1982 total.” 1997 land cover/use totals are listed in the bottom horizontal row, titled "1997 total." The number at the intersection of rows and columns with the same land cover/use designation represents acres that did not change from 1982 to 1997. Reading to the right or left of this number are the acres that were lost to another cover/use by 1997. Reading up or down from this number are the acres that were gained from another cover/use by 1997. This table is Table 5 from http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/table5.html.

APPENDIX 3-2. Changes in wetlands and deepwater habitats between 1992 and 1997 (data per 1,000 acres).

	Classification in 1997 per 1,000 acres				
1992 classification	**Palustrine and Estuarine wetlands***	**Other aquatic habitats***	**Uplands***	**Federal land**	**1992 total**
Palustrine and Estuarine wetlands*	110,662.5	134.8	506.0	4.4	111,307.7
Other aquatic habitats*	150.3	47,182.3	93.2	0.0	47,425.8
Uplands*	343.2	485.3	1,382,364.6	215.5	1,383,408.6
Federal land	0.0	0.0	69.4	401,918.2	401,987.6
1997 total	111,156.0	47,802.4	1,383,033.2	402,138.1	1,944,129.7

*Excludes non-federal land.
This table is from http://www.nrcs.usda.gov/technical/NRI/1997/summary_report/table18.html.

APPENDIX 3-3. The landscape metrics from the spatial analysis program FRAGSTATES (McGarigal and Marks 1995) that can be used to quantify landscape fragmentation.

Metric	**Measure**
Nearest Neighbor (meter)	Distance to nearest neighbor patch edge
Nearest Neighbor Standard Deviation	Dispersion of patches
Patch Number (NP)	Number of patches in landscape or the number of patches per class
Mean Patch Size (MPS)	Mean area of patches in landscape or the mean area of patches per class
Contagion (%)	Clumping, adjacency, and dispersion of pixels
Interspersion and Juxtaposition (IJI, %)	Interspersion and adjacency of patches

APPENDIX 3-4. All ownership land summary of historical fire regimes by condition classes of all cover types except agriculture, barren, water, and urban/development/agriculture.

Historical fire regime	Condition class: Class 1 km^2 (acres)	Class 1 Row %	Class 2 km^2 (acres)	Class 2 Row %	Class 3 km^2 (acres)	Class 3 Row %	Total km^2 (total acres)	Total %
I. 0-35 years; low severity	712,901 (175,031,010)	41	708,325 (176,161,740)	41	313,600 (77,492,543)	18	1,734,828 (428,685,293)	34
II. 0-35 years; Stand replacement	779,198 (192,544,136)	57	538,965 (133,181,268)	40	41,869 (10,346,175)	3	1,360,033 (336,071,579)	27
III. 35-100+ years; mixed severity	516,553 (127,642,957)	43	454,292 (112,258,095)	38	218,542 (54,002,982)	18	1,189,387 (293,904,034)	24
IV. 35-100+ years; stand replacement	214,737 (53,062,756)	43	142,990 (35,333,666)	29	141,755 (35,028,486)	28	499,483 (123,424,908)	10
V. 200+ years; stand replacement	196,509 (48,558,333)	72	55,469 (13,706,766)	20	19,853 (4,905,719)	7	271,831 (67,170,818)	5
Total	2,419,898 (597,969,922)	Col % 48	1,900,043 (469,510,805)	Col % 38	735,621 (181,775,905)	Col % 15	5,055,562 (1,249,256,632)	

APPENDIX 3-1. Data matrix for Conservation and Maintenance of Plant and Animal Resources on Rangeland Indicators

Criterion. Conservation and Maintenance of Productive Capacity on Rangelands Indicator 1. Extent of Land Area in Rangeland		
	Data set # 1	**Data set # 2**
Response from #5 of 6-point evaluation framework (A-D)	B	B
Brief Title for Data Set:	**NRCS National Resources Inventory**	**USGS/USEPA 1992 National Land Cover Data Set**
Contact Person/Agency/Group (email, phone, address):	nri@nhq.nrcs.usda.gov	USGS/USEPA
Citation (if published):	Nusser and Goebel 1997	Loveland et al. 2000
Website (if available):	http://www.nrcs.usda.gov/technical/NRI/	http://landcover.usgs.gov
Additional information on data set:	Statistically based sample of non-federal land and natural resource conditions and trends. Analyses of the inventory results over time provide data on land use, soil erosion and soil quality, water quality, wetlands, and other issues regarding the conservation and use of natural resources. Each NRI sample point has multiple attributes (soil map unit component, soil descriptions, land cover/use, wetland type, etc.) associated with them for many kindsof analyses.	A second NLCD was produced using more recent, 1999 and later, Landsat imagery. The same classification scheme, with refinement in 2001, has been used for both data sets. Consequently, the 1992 NLCD has 21 land use/land cover classes and the 2001 map will have 18. The 1992 map has 3 to 4 (including wetlands) classes that could be considered rangelands and the 2001 map has 4 to 5 classes. These datasets can be used to compare the change in rangeland cover between 1992 and 2001.
For what years are data available and how often are data collected?	1982, 1987, 1992, 1997, 2002	1992, 2001
In what format is the data set available? (map only, data point, …)	Maps, Databases	Maps
Are data nominal, ordinal, or interval?		
What will be the approximate cost of collecting data?		
What barrier(s) prohibit access or use of data? (Restricted use, exorbitant cost, technical or legal barriers, confidential barriers, etc.?) Or are data easily accessible?	Data available through web site, although point locations are not revealed.	
What is the spatial grain of the data?		Pixel size is 0.9 ha(1 km).

Criterion. Conservation and Maintenance of Productive Capacity on Rangelands **Indicator 1. Extent of Land Area in Rangeland**		
What is the spatial extent of the data?		
At what spatial scales can these data be aggregated and reported?	State, administrative region, ecoregion, and other geographically defined areas of interest can be used to summarize data within the NRI	
What is the temporal grain of the data?	Since 1997 the NRI has gone to an annualized inventory providing for annual reports beginning in about 2005.	3 images for a location on a roughly decade scale.
What is the temporal extent of the data?	1982, 1987, 1992, 1997, 2002, and now annualized.	
At what temporal scales can these data be aggregated and reported?	Historically, every 5 years. Presently, annually.	
Quality: can data be adequately reported over time in a consistent form? (Consistent methodology.)	Yes	
Quality: how repeatable are existing data? (Include p value of differences in estimates of independent observers if available)	Highly repeatable. The NRI detects change over time through repeated visits to the permanent points within the inventory Uncertainty estimates can be calculated. See Nusser and Goebel 1997. The sampling and analysis procedures have evolved over time, now reflect the use of remote sensing information as well as ground-based inventories, and have enhanced estimation techniques for missing values and weighting procedures that incorporate controls from other data sources and from previous surveys	
Quality: how biased are the sampling methods?		
Quality: how precise are existing data? (Give standard error, if available)	In the 1992 NRI, 800,000 sample points were needed in order to obtain the objective of a coefficient of variation of less than 10% for any estimate of surface area within a particular resource condition (or for other variables such as erosion rates) on areas that constitute at least 10% of the surface area within the ecophysical classification of Major Land Resource Area (MLRA) (Nusser and Goebel 1997).	
Quality: how valid are existing data?		
Quality: how responsive are existing data?		

Criterion. Conservation and Maintenance of Productive Capacity on Rangelands Indicator 1. Extent of Land Area in Rangeland		
Quality: how much statistical power to detect change does this data set have?		
Quality: how well does this data set meet the data needs for this indicator?		
Other comments: (Include any other relevant aspects of the data set that should be included.)		

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands Indicator 1. Extent of Land Area in Rangeland	
	Data set # 3
Response from #5 of 6-point evaluation framework (A-D)	B
Brief Title for Data Set:	**MODIS**
Contact Person/Agency/Group (email, phone, address):	MODLAND
Citation (if published):	Friedl et al. 2002
Website (if available):	http://modis-land.gsfc.nasa.gov
Additional information on data set:	The Land Cover data set has 17 cover types, 5 of which can be considered rangeland, grassland, woody dry savanna and savanna, and close and open shrubland. A portion of another one of the 17 cover types, Cropland/natural vegetation mosaics, will also contain an unknown proportion of rangeland.
For what years are data available and how often are data collected?	MODIS has been operational since July 2000. MODIS views earth every 1 to 2 days and has a spectral resolution of 36 bands from the visible to the far-infra-red spectrum. MODIS generates land cover characteristics, ecosystem variables, and radiation budget variables. Ecosystem characteristics include vegetation indices: biophysical variable of structure, e.g. leaf area index, energy absorption, e.g. the fraction of photosynthetically absorbed radiation (fPAR), vegetation net primary production (NPP).
In what format is the data set available? (map only, data point, …)	Maps, Databases
Are data nominal, ordinal, or interval?	
What will be the approximate cost of collecting data?	

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 1. Extent of Land Area in Rangeland**	
What barrier(s) prohibit access or use of data? (Restricted use, exorbitant cost, technical or legal barriers, confidential barriers, etc.?) Or are data easily accessible?	
What is the spatial grain of the data?	MODIS has 3 pixel resolutions: 250 m, 500 m, and 1000m. Land Cover maps are 1-km pixel resolution.
What is the spatial extent of the data?	
At what spatial scales can these data be aggregated and reported?	
What is the temporal grain of the data?	Land cover maps provided on a quarterly basis.
What is the temporal extent of the data?	
At what temporal scales can these data be aggregated and reported?	
Quality: can data be adequately reported over time in a consistent form? (Consistent methodology.)	
Quality: how repeatable are existing data? (Include p value of differences in estimates of independent observers if available)	
Quality: how biased are the sampling methods?	
Quality: how precise are existing data? (Give standard error, if available)	
Quality: how valid are existing data?	
Quality: how responsive are existing data?	
Quality: how much statistical power to detect change does this data set have?	
Quality: how well does this data set meet the data needs for this indicator?	
Other comments: (Include any other relevant aspects of the data set that should be included.)	

Criterion. Conservation and maintenance of plant and animal resources on rangelands Indicator 2. Rangeland area by community type		
	Data set # 1	**Data set # 2**
Response from #5 of 6-point evaluation framework (A-D)	B, C	B
Brief Title for Data Set:	**Gap Analysis Program**	**USGS/NPS Mapping**
Contact Person/Agency/Group (email, phone, address):	U.S. Geological Survey Biological Resources Division Kevin Gergely Gap Analysis Program 530 S. Asbury St. Suite 1 Moscow, ID 83843 208/885-3565 gergely@uidaho.edu	US Geological Survey and National Park Service Mike Story, NPS Program Coordinator National Park Service, NRID 12795 West Alameda Pkwy Lakewood, CO 80228 (303) 969-2746 FAX: (303) 987-6704 mike_story@nps.gov Karl Brown, USGS Program Coordinator USGS Center for Biological Informatics P.O. Box 25046 Denver, CO 80225 (303) 202-4240 FAX: (303) 202-4219 karl_brown@usgs.gov
Citation (if published):		
Website (if available):	www.gap.uidaho.edu	biology.usgs.gov/npsveg/
Additional information on data set:		Cooperative effort by USGS NPS to classify, describe, and map vegetation communities in more than 250 national park units across the U.S.
For what years are data available and how often are data collected?		
In what format is the data set available? (map only, data point, …)	Maps and relational databases	Maps and relational databases
Are data nominal, ordinal, or interval?	Nominal	
What will be the approximate cost of collecting data?		
What barrier(s) prohibit access or use of data? (Restricted use, exorbitant cost, technical or legal barriers, confidential barriers, etc.?) Or are data easily accessible?		

Criterion. Conservation and maintenance of plant and animal resources on rangelands Indicator 2. Rangeland area by community type		
What is the spatial grain of the data?	Variable 1-100ha	The minimum mapping unit is 0.5 hectares.
What is the spatial extent of the data?	GAP products are produced on a state-by-state basis. State GAP products are available for most states. Products for remaining states are under development with the exception of Alaska.	
At what spatial scales can these data be aggregated and reported?	Regional, State, County, Watershed	
What is the temporal grain of the data?	State GAP projects use TM imagery from a 2-5 year period during the 1980s and 1990s	
What is the temporal extent of the data?	For most states, GAP products are available for only a single time. A second iteration of GAP data base has been begun for some states and regions (aggregations of states).	
At what temporal scales can these data be aggregated and reported?	Land cover for a single time period during the 1980s and 1990s	
Quality: can data be adequately reported over time in a consistent form? (Consistent methodology.)	Methods vary by state and state products are of variable quality. For most states, data are available for only one time period.	
Quality: how repeatable are existing data? (Include p value of differences in estimates of independent observers if available)	Variable. Accuracy and detail of land cover is dependent on availability and quality (dates in relation to important phenological events of plant communities) of TM images.	
Quality: how biased are the sampling methods?	State gap products are a census of land cover and thus this question is NA. There is an issue of the accuracy of the products. An accuracy assessment was not performed for all state GAP products. Some accuracy assessments were not based on a probability sample design and assumption-free inferences are not possible. Accuracy of some range land cover types is low (e.g., 50%)	
Quality: how precise are existing data? (Give standard error, if available)	Estimates of precision are available for states that conduct an accuracy assessment.	
Quality: how valid are existing data?	Rangeland land cover often has not been mapped at the alliance level. Thus, the detail of the data has shortcomings in terms of the indicator.	
Quality: how responsive	A time series of GAP products will allow	

Criterion. Conservation and maintenance of plant and animal resources on rangelands Indicator 2. Rangeland area by community type		
are existing data?	the analysis of trends in the amounts of rangeland plant communities.	
Quality: how much statistical power to detect change does this data set have?	Dependent upon the accuracy analysis of the land cover map.	
Quality: how well does this data set meet the data needs for this indicator?	Rangeland land cover often has not been mapped at the alliance level. Thus, the detail of the data has shortcomings in terms of this indicator.	
Other comments: (Include any other relevant aspects of the data set that should be included.)	Vegetation is mapped to the alliance level. Landcover is mapped using Landsat Thematic Mapper raw and hypercluster imagery from the Eros Data Center MRLC program. Other information sources include: existing maps and other records, air photos; air video; and ground points. State and Regional levels.	Vegetation classification based on FGDC Vegetation Classification Standard for physiognomic units and TNC's Terrestrial Vegetation Classification of the United States for floristic units when used (now spun off as NatureServe). Project results include dataset and information for each park project: Spatial Data (aerial photography, map classification, map classification description and key, spatial database of vegetation communities, hardcopy maps of vegetation communities, metadata for spatial databases, complete accuracy assessment of spatial data) and Vegetation Information (vegetation classification, dichotomous field key of vegetation classes, formal description for each vegetation class, ground photos of vegetation classes, field data in database format) Spatial databases will have a horizontal positional accuracy that meets National Map Accuracy Standards at the 1:24,000 scale. Each well defined object in the spatial database will be within 1/50 of an inch of its actual location or 40 feet (12.2 meters). Each vegetation map class will meet or exceed 80% accuracy at the 90% confidence level. The classification accuracy will be established by the program accuracy assessment protocols (link to AA protocol document).

Criterion. Conservation and maintenance of plant and animal resources on rangelands **Indicator 2. Rangeland area by community type**		
	Data set # 3	**Data set # 4**
Response from #5 of 6-point evaluation framework (A-D)	B, C	B,C
Brief Title for Data Set:	**VegBank**	**NatureServe Explorer**
Contact Person/Agency/Group (email, phone, address):	Ecological Society of America Panel on Vegetation Classification Robert K. Peet Principal Investigator Department of Biology CB#3280 University of North Carolina Chapel Hill, NC 27599-3280 919-962-6942 peet@unc.edu	Nature Serve Larry Sugarbaker Vice President and Chief Information Officer NatureServe 1101 Wilson Boulevard 15th Floor Arlington, VA 22209 TEL 703-908-1800 FAX 703-908-1917
Citation (if published):		Grossman DH, Faber-Langendoen D, Weakley AS, Anderson M, Bourgeron P, Crawford R, Goodin K, Landaal S, Metzler K, Patterson KD, Pyne M, Reid M, and Sneddon L. 1998. International classification of ecological communities: terrestrial vegetation of the United States. Volume I, The National Vegetation Classification System: development, status, and applications. The Nature Conservancy: Arlington, VA.
Website (if available):	www.vegbank.org	www.natureserve.org/explorer/
Additional information on data set:		
For what years are data available and how often are data collected?		
In what format is the data set available? (map only, data point, …)	Plot data (treated as data points) in a relational database	Data for plants, animals, and ecological communities, including exotic species
Are data nominal, ordinal, or interval?	Nominal	Nominal
What will be the approximate cost of collecting data?		
What barrier(s) prohibit access or use of data? (Restricted use, exorbitant cost, technical or legal barriers, confidential barriers, etc.?) Or are data	Some data is proprietary, much is easily accessible.	Some data is proprietary, some has restricted use, some may have a cost associated with it.

Criterion. Conservation and maintenance of plant and animal resources on rangelands **Indicator 2. Rangeland area by community type**		
easily accessible?		
What is the spatial grain of the data?	Single observation	Single observation
What is the spatial extent of the data?	National/International	National/International
At what spatial scales can these data be aggregated and reported?	National	National
What is the temporal grain of the data?	Single observation	Single observation
What is the temporal extent of the data?		
At what temporal scales can these data be aggregated and reported?		
Quality: can data be adequately reported over time in a consistent form? (Consistent methodology.)	Yes	Variable
Quality: how repeatable are existing data? (Include p value of differences in estimates of independent observers if available)		
Quality: how biased are the sampling methods?		
Quality: how precise are existing data? (Give standard error, if available)		
Quality: how valid are existing data?		
Quality: how responsive are existing data?		
Quality: how much statistical power to detect change does this data set have?		
Quality: how well does this data set meet the data needs for this indicator?		
Other comments: (Include any other relevant aspects of the data set that should be included.)	Plot databases contain site information and taxon co-occurrence data collected at the plot. Plots in the plot databases can be interpreted as representing communities that exist in community classification. Plot observations include observations of one or more plant taxa and associated attributes.	Natural communities thus far defined in the *International Classification of Ecological Communities System*, with emphasis on the continental US and Hawaii. Classification includes physiognomic and floristic levels. Ecological communities records at

Criterion. Conservation and maintenance of plant and animal resources on rangelands Indicator 2. Rangeland area by community type		
		association level. Over 3000 records which could be potentially described as rangeland vegetation communities. All currently accepted native and exotic vascular species, subspecies, varieties, hybrids, selected bryophytes and lichens.

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands Indicator 2. Rangeland Area by Community Type			
	Data set # 5	**Data set # 6**	**Data set # 7**
Response from #5 of 6-point evaluation framework (A-D)	C	C	C
Brief Title for Data Set:	**Ecological Site Description System**	**Ecological Site Inventory System for Rangeland**	**Potential Natural Vegetation Groups, version 2000**
Contact Person/Agency/Group (email, phone, address):	Natural Resources Conservation Service George Peacock Rangeland Management Specialist Grazing Lands Technology Institute Staff (GLTI) Fort Worth, Texas Phone: 817-509-3211 Fax: 817-509-3210 gpeacock@ftw.nrcs.usda.gov gltiforum@ftw.nrcs.usda.gov	Natural Resource Conservation Service George Peacock Rangeland Management Specialist Grazing Lands Technology Institute Staff (GLTI) Fort Worth, Texas Phone: 817-509-3211 Fax: 817-509-3210 gpeacock@ftw.nrcs.usda.gov gltiforum@ftw.nrcs.usda.gov	Forest Service Fire Sciences Laboratory, Rocky Mountain Research Station Fire Effects Project 5775 Hyw 10 West Missoula, MT 59802 406-329-4800 cjohnston@fs.fed.us
Citation (if published):			
Website (if available):	plants.usda.gov/esis/	plants.usda.gov/esis/	www.fs.fed.us/fire/fuelman/pnv2000/pnvgroups_v2k.html
Additional information on data set:	Site allows the user to view approved site descriptions	The data may be viewed in a variety of standard report formats or through the use of custom queries tailored to individual needs. Data may also be downloaded for use in other applications	Arc/Info version 7.2.1

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands Indicator 2. Rangeland Area by Community Type			
For what years are data available and how often are data collected?		Inventory data collected over the past 40 years.	2000
In what format is the data set available? (map only, data point, …)		Plot: Inventory data collected on rangeland plots includes the total annual production of all plant species of a plant community, as well as the production (by weight measurement) and composition of individual plant species comprising the plant community. Inventory data collected on forestland plots includes: composition and relative abundance of the overstory and understory plant species; stand densities (basal area); and site productivity, as measured by site index. Inventories on both rangeland and forestland plots includes data relative to the physiographic features of the site (soil, slope, aspect, landform, etc.).	Map, Kuchler's PNV map was refined to match terrain using a 500 meter Digital Elevation Model, 4th Code Hydrological Units, and Ecological Subregions (Bailey's Sections). Biophysical layers were integrated with current vegetation layers to develop generalized successional pathway diagrams. Expert regional panels refined the PNV map based on the successional pathways.
Are data nominal, ordinal, or interval?			
What will be the approximate cost of collecting data?			
What barrier(s) prohibit access or use of data? (Restricted use, exorbitant cost, technical or legal barriers, confidential barriers, etc.?) Or are data easily accessible?	Data on private lands may be proprietary.	Data on private lands may be proprietary.	
What is the spatial grain of the data?			Coarse-scale developed for national-level planning

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 2. Rangeland Area by Community Type**			
What is the spatial extent of the data?			
At what spatial scales can these data be aggregated and reported?			National-level only
What is the temporal grain of the data?			
What is the temporal extent of the data?			
At what temporal scales can these data be aggregated and reported?			
Quality: can data be adequately reported over time in a consistent form? (Consistent methodology.)			
Quality: how repeatable are existing data? (Include p value of differences in estimates of independent observers if available)			
Quality: how biased are the sampling methods?			
Quality: how precise are existing data? (Give standard error, if available)			
Quality: how valid are existing data?			
Quality: how responsive are existing data?			
Quality: how much statistical power to detect change does this data set have?			
Quality: how well does this data set meet the data needs for this indicator?			

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 2. Rangeland Area by Community Type**			
Other comments: (Include any other relevant aspects of the data set that should be included.)	Data in four categories: 1) site characteristics (physiographic, climate, soil and water features) 2) plant communities (ecological dynamics and common plant communities comprising various possible vegetation states) 3) site interpretations (information pertinent to use and management of site and resources) 4) supporting information (to assess the quality of the site description and relationship to other ecological sites)	Inventory data includes total annual production of all plant species of a plant community, production (by weight measurement) and composition of individual plant species comprising that plant community. Inventories also include data relative to physiographic features of site (soil, slope, aspect, landform, etc.) Data collected using Soil-Woodland Correlation Field Data Sheet (ECS-005), Windbreak-Soil-Species Evaluation Data Sheet (ECS-004) and the Production and Composition Record for Native Grazing Lands (ECS-417)	

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 3. Number and Extent of Wetlands**		
	Data set # 1	**Data set # 2**
Response from #5 of 6-point evaluation framework (A-D)	A	A
Brief Title for Data Set:	FWS-NWI	**NRCS National Resources Inventory**
Contact Person/Agency/Group (email, phone, address):	FWS	NRCS
Citation (if published):		Nusser and Goebel 1997
Website (if available):	FWS	http://www.nrcs.usda.gov/technical/NRI/
Additional information on data set:		Statistically based sample of non-federal land and natural resource conditions and trends. Analyses of the inventory results over time provide data on land use, soil erosion and soil quality, water quality, wetlands, and other issues regarding the conservation and use of natural resources. Each NRI sample point has multiple attributes (soil map unit component, soil

		descriptions, land cover/use, wetland type, etc.) associated with them for many kinds of analyses.
For what years are data available and how often are data collected?		1982, 1987, 1992, 1997, 2002
In what format is the data set available? (map only, data point, …)	Maps	Maps, databases
Are data nominal, ordinal, or interval?		
What will be the approximate cost of collecting data?		
What barrier(s) prohibit access or use of data? (Restricted use, exorbitant cost, technical or legal barriers, confidential barriers, etc.?) Or are data easily accessible?	none	Inventory only samples non-federal private land. Data available through web site, although point locations are not revealed.
What is the spatial grain of the data?	fine	fine
What is the spatial extent of the data?	wide	National non-federal land
At what spatial scales can these data be aggregated and reported?	Local to national	State, administrative region, ecoregion, and other geographically defined areas of interest can be used to summarize data within the NRI
What is the temporal grain of the data?		From 1982 to 1997, inventory conducted every 5 years. Since 1997 the NRI has gone to an annualized inventory providing for annual reports beginning in about 2005.
What is the temporal extent of the data?		1982, 1987, 1992, 1997, 2002, and now annualized.
At what temporal scales can these data be aggregated and reported?		
Quality: can data be adequately reported over time in a consistent form? (Consistent methodology.)	Not mapped over time	Yes Highly repeatable. The NRI detects change over time through repeated visits to the permanent points within the inventory Uncertainty estimates can be calculated. See Nusser and Goebel 1997. The sampling and analysis procedures have evolved over time, now reflect the use of remote sensing information as well as ground-based inventories, and have enhanced estimation techniques for missing values and weighting procedures that incorporate controls from other data sources and from previous surveys
Quality: how repeatable are existing data? (Include p value of differences in estimates of independent observers if available)		
Quality: how biased are the sampling methods?		
Quality: how precise are existing data? (Give standard error, if available)		
Quality: how valid are existing data?		
Quality: how responsive are existing data?		
Quality: how much statistical power to detect change does this data set have?		
Quality: how well does this data set meet the		

data needs for this indicator?		
Other comments: (Include any other relevant aspects of the data set that should be included.)		Within the NRI, wetlands are present as an attribute that may occur on all other land cover/use categories, therefore the data can be queried by land cover/use (e.g. rangeland) for wetland estimates by any category. Each NRI sample point has multiple attributes (soil map unit component, soil descriptions, land cover/use, wetland type, etc.) associated with them for many kindsof analyses. Additionally state, administrative region, ecoregion, and other geographically defined areas of interest can be used to summarize data within the NRI. The NRCS has made maps of the area of non-federal wetlands in 1992 and 1997 available on the web (http://www.nrcs.usda.gov/technical/land/wetlands.html). The dot density map includes all types of wetlands as defined in the Cowardin system. Each dot represents 1,000 acres of wetlands. Dots were aggregated by and placed randomly within each 8- digit hydrologic unit, finest spatial scale for this analysis.

Indicator 4: Fragmentation of rangeland and rangeland vegetation communities
No Data Matrix

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands Indicator 5. Intensive Human Uses of Rangeland	
	Data set # 1
Response from #5 of 6-point evaluation framework (A-D)	A
Brief Title for Data Set:	**TIGER (Topologically Integrated Geographic Encoding and Referencing) database**
Contact Person/Agency/Group (email, phone, address):	
Citation (if published):	U.S. Census Bureau, 2002. UA Census 2002 TIGER/Line Files Technical Documentation. Washington, DC. 319pp.
Website (if available):	http://www.census.gov/geo/www/tiger
Additional information on data set:	
For what years are data available and how often are data collected?	1990 and 2000. Data are assembled for use in a decennial census.
In what format is the data set available? (map only, data point, …)	Digital geographic data in TIGER/Line format.
Are data nominal, ordinal, or interval?	Ordinal
What will be the approximate cost of collecting data?	Census 2000 TIGER/Line Files United States Kit ($250.00) and Urbanized Areas Census 2000 TIGER/Line Files United States Kit ($350.00) on CD-ROM provide coverage for the nation.
What barrier(s) prohibit access or use of data? (Restricted use, exorbitant cost, technical or legal barriers, confidential barriers, etc.?) Or are data easily accessible?	
What is the spatial grain of the data?	Road data were created from 1:100,000 scale maps. Housing data are available in census block groups and blocks (polygons) which are subdivisions of the census tracts used by the U.S. Census Bureau. In the 1990 TIGER/Line data set the size of census block group and blocks ranged from less than 1 sq. km to 16,000 sq. km.
What is the spatial extent of the data?	National.
At what spatial scales can these data be aggregated and reported?	Road data can be intersected with a map of rangelands and the amount of roads in rangeland or rangeland types calculated and the data aggregated by watersheds, counties or other analysis units. Interpretation of the housing density image is more difficult because of the data does not allow a determination if the housing units occur in rangeland. The proportion of rangeland or rangeland types in different housing density classes, e.g., urban, suburban, exurban, and rural could be tabulated and aggregated by counties.
What is the temporal grain of the data?	Decade
What is the temporal extent of the data?	1980 – 2000

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 5. Intensive Human Uses of Rangeland**	
At what temporal scales can these data be aggregated and reported?	Decade
Quality: can data be adequately reported over time in a consistent form? (Consistent methodology.)	Yes
Quality: how repeatable are existing data? (Include p value of differences in estimates of independent observers if available)	Very repeatable
Quality: how biased are the sampling methods?	Data are collected in a census not a sample. There are likely to be omission errors in both the road and housing density data.
Quality: how precise are existing data? (Give standard error, if available)	Data is a census not a sample. There are issues with the completeness and locational accuracy of the TIGER/Line database.
Quality: how valid are existing data?	Spatially explicit road data matches indicator needs well. The housing density data has shortcomings due to the lack of spatial explicitness.
Quality: how responsive are existing data?	Data will allow the analysis of trends in the amount of roads and housing density.
Quality: how much statistical power to detect change does this data set have?	Not applicable. This is a census not a sample.
Quality: how well does this data set meet the data needs for this indicator?	Spatial explicit road data matches the indicator needs well. The housing density data has shortcomings due to the lack of spatial explicitness. This shortcoming may be eliminated in the future. See other comments below.
Other comments: (Include any other relevant aspects of the data set that should be included.)	In preparation for the 2010 census, the Census Bureau and the U.S. Geological Survey have initiated discussions about the construction of spatially explicit road and structural data with 5 m positional accuracy. If this occurs, the housing density data could be aggregated and reported at multiple spatial scales for this indicator. Their TIGER/Line data and program will be improved through their Modernization Program for Tiger and Master Address File (http://www.census.gov/geo/mod/maftiger.html).

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 6. Integrity in natural fire regimes on rangeland**	
	Data set # 1
Response from #5 of 6-point evaluation framework (A-D)	C
Brief Title for Data Set:	Coarse-scale Spatial Data for Wildland Fire and Fuel Management
Contact Person/Agency/Group (email, phone, address):	
Citation (if published):	Schmidt et al. 2002

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 6. Integrity in natural fire regimes on rangeland**	
Website (if available):	http://www.fs.fed.us/fire/fuelman
Additional information on data set:	These data represent a one-time coarse scale assessment and mapping effort funded by the Fores tService and Bureau of Land Management where data from several federal agencies and state agencies were compiled to produce a geographic information database. Database has several layers, including two of interest here: Fire occurrence data, Fire Regime Current Condition Class.
For what years are data available and how often are data collected?	Fire occurrence data in the database is available for each of the 11 years between 1986 and 1996, a spatial layer and database of federal and nonfederal fire occurrences.
In what format is the data set available? (map only, data point, …)	Map, spatial database
Are data nominal, ordinal, or interval?	
What will be the approximate cost of collecting data?	
What barrier(s) prohibit access or use of data? (Restricted use, exorbitant cost, technical or legal barriers, confidential barriers, etc.?) Or are data easily accessible?	Data available on the web site. Schmidt et al. 2002 note that there are several potential problems with the fire occurrence data set, such as missing records, duplicate fires where the same fire may have bene reported on federal and on non-federal lands, approximate locations of fires where county was the finest spatial identified, and unreported fires.
What is the spatial grain of the data?	
What is the spatial extent of the data?	United States
At what spatial scales can these data be aggregated and reported?	
What is the temporal grain of the data?	
What is the temporal extent of the data?	
At what temporal scales can these data be aggregated and reported?	
Quality: can data be adequately reported over time in a consistent form? (Consistent methodology.)	
Quality: how repeatable are existing data? (Include p value of differences in estimates of independent observers if available)	
Quality: how biased are the sampling methods?	
Quality: how precise are existing data? (Give standard error, if available)	

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands Indicator 6. Integrity in natural fire regimes on rangeland	
Quality: how valid are existing data?	
Quality: how responsive are existing data?	
Quality: how much statistical power to detect change does this data set have?	
Quality: how well does this data set meet the data needs for this indicator?	
Other comments: (Include any other relevant aspects of the data set that should be included.)	

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands Indicator 7. Extent and Condition of Riparian Systems		
	Data set # 1	**Data set # 2**
Response from #5 of 6-point evaluation framework (A-D)		
Brief Title for Data Set:	**BLM-PFC**	**USACE-HGM**
Contact Person/Agency/Group (email, phone, address):	BLM	USACE
Citation (if published):	Pritchard et al. 1993	Brinson 1993
Website (if available):		
Additional information on data set:	No comprehensive data set. Method too qualitative for this report.	No comprehensive data set. Method to complex and detailed for this report.
For what years are data available and how often are data collected?	Variable- evaluation on a local and irregular basis	None-local only with no comparative data
In what format is the data set available? (map only, data point, …)	Data points for localized streams	Data sets only for selected stream reaches
Are data nominal, ordinal, or interval?		
What will be the approximate cost of collecting data?		
What barrier(s) prohibit access or use of data? (Restricted use, exorbitant cost, technical or legal barriers, confidential barriers, etc.?) Or are data easily accessible?	Too qualitative and lacks sufficient biological assessment.	To complex and requires extensive field work and very experienced data collector.
What is the spatial grain of the data?		
What is the spatial extent of the data?		
At what spatial scales can these data be aggregated and reported?		

What is the temporal grain of the data?		
What is the temporal extent of the data?		
At what temporal scales can these data be aggregated and reported?		
Quality: can data be adequately reported over time in a consistent form? (Consistent methodology.)		
Quality: how repeatable are existing data? (Include p value of differences in estimates of independent observers if available)		
Quality: how biased are the sampling methods?		
Quality: how precise are existing data? (Give standard error, if available)		
Quality: how valid are existing data?		
Quality: how responsive are existing data?		
Quality: how much statistical power to detect change does this data set have?		
Quality: how well does this data set meet the data needs for this indicator?		
Other comments: (Include any other relevant aspects of the data set that should be included.)		

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 8. Presence/Absence of Invasive Species**	
	Data set # 1
Response form #5 of 6-point evaluation framework (A-D)	C
Brief Title for Dataset	**PLANTS**
Contact Person/Agency/Group	USDA-NRCS
Citation	USDA-NRCS. 2002. The PLANTS database, Version 3.5. (http://plants.usda.gov) National Plant Data Center. Baton Rouge, LA. 70874-4490. USA
Website	http://plants.usda.gov
For what years are data available and how often are data collected?	Composite Listing On-going
In what format is the data set available	Map/Listing on Website
Are data nominal, ordinal or interval	Nominal

What will be the approximate cost of collecting data?	?
What barriers prohibit access of use of data?	Easily accessible on Internet for many states
What is the spatial grain of the data?	State & some county level
What is the spatial extent of data?	??
What spatial scales can these data be aggregated and reported?	State/County Presence/Absence
What is the temporal grain of the data?	Intermittent/on-going
What is the temporal extent of the data?	Intermittent/on-going
At what temporal scales can these data be aggregated and reported?	Point in time
Quality: can data be adequately reported over time in a consistent form?	Probably not
Quality: how repeatable are existing data?	Limited quality
Quality: how biased are the sampling methods	Potential bias
Quality: how precise are existing data?	Low precision
Quality: how valid are existing data?	Good
Quality: how responsive are existing data?	Limited
Quality: how much statistical power to detect change does the dataset have?	Limited
Quality: how well does the dataset meet the data needs for the indicator?	Moderate Need county level presence absence data for all states
Other Comments:	Pers. Comm. Rita Beard (USFS) said that this is the best that we have available to date.

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 8. Presence/Absence of Invasive Species**	
	Data set # 2
Response form #5 of 6-point evaluation framework (A-D)	C
Brief Title for Dataset	**Invaders Database System (National)**
Contact Person/Agency/Group	Peter Rice Division of Biological Sciences University of Montana Missoula, MT 59812 (406) 243-2671 biopmr@selway.umt.edu

Citation	http://invader.dbs.umt.edu
Website	Same
For what years are data available and how often are data collected?	Composite list
In what format is the data set available	List of state/province (Canada)
Are data nominal, ordinal or interval	Nominal
What will be the approximate cost of collecting data?	?
What barriers prohibit access of use of data?	Limited area of coverage
What is the spatial grain of the data?	State/Province
What is the spatial extent of data?	??
What spatial scales can these data be aggregated and reported?	State/Province
What is the temporal grain of the data?	Intermittent/on-going
What is the temporal extent of the data?	“”
At what temporal scales can these data be aggregated and reported?	Point in time
Quality: can data be adequately reported over time in a consistent form?	No
Quality: how repeatable are existing data?	Variable quality
Quality: how biased are the sampling methods	Potential bias
Quality: how precise are existing data?	Limited – low quality
Quality: how valid are existing data?	Good
Quality: how responsive are existing data?	Limited
Quality: how much statistical power to detect change does the dataset have?	Limited
Quality: how well does the dataset meet the data needs for the indicator?	Limited
Other Comments:	

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 8. Presence/Absence of Invasive Species**	
	Data set # 3
Response form #5 of 6-point evaluation framework (A-D)	C
Brief Title for Dataset	**Invaders Database System (NW States)**
Contact Person/Agency/Group	USDA-ARS
Citation	http://invaders.dbs.umt.edu

Website	Same
For what years are data available and how often are data collected?	Composite list
In what format is the data set available	Map & listing
Are data nominal, ordinal or interval	Nominal
What will be the approximate cost of collecting data?	?
What barriers prohibit access of use of data?	Limited to NW states (WA, ID, OR, MT, WY)
What is the spatial grain of the data?	County level
What is the spatial extent of data?	??
What spatial scales can these data be aggregated and reported?	County level
What is the temporal grain of the data?	Intermittent/on-going
What is the temporal extent of the data?	“”
At what temporal scales can these data be aggregated and reported?	Point in time
Quality: can data be adequately reported over time in a consistent form?	Possible/probably not
Quality: how repeatable are existing data?	Good
Quality: how biased are the sampling methods	Potential bias
Quality: how precise are existing data?	Moderate
Quality: how valid are existing data?	Good
Quality: how responsive are existing data?	Limited
Quality: how much statistical power to detect change does the dataset have?	Limited
Quality: how well does the dataset meet the data needs for the indicator?	Limited
Other Comments:	Pers. Comm. Rita Beard (USFS) indicated that this is good county level data for presence/absence in the 5 NW states of the US

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 8. Presence/Absence of Invasive Species**	
	Data set # 4
Response form #5 of 6-point evaluation framework (A-D)	C
Brief Title for Dataset	**Global Invasive Species Database**

Contact Person/Agency/Group	Global Invasive Species Program
Citation	Global Invasive Species Database: http://www.issg.org/database/welcome
Website	http://www.issg.org/database/welcome
For what years are data available and how often are data collected?	On-going
In what format is the data set available	Primarily Listings
Are data nominal, ordinal or interval	Nominal
What will be the approximate cost of collecting data?	??
What barriers prohibit access of use of data?	Format of data set
What is the spatial grain of the data?	Regional/state in US?
What is the spatial extent of data?	
What spatial scales can these data be aggregated and reported?	Regional
What is the temporal grain of the data?	On-going
What is the temporal extent of the data?	
At what temporal scales can these data be aggregated and reported?	Point in time
Quality: can data be adequately reported over time in a consistent form?	Possibly
Quality: how repeatable are existing data?	Good
Quality: how biased are the sampling methods	Potential bias
Quality: how precise are existing data?	Moderate
Quality: how valid are existing data?	Good
Quality: how responsive are existing data?	Limited
Quality: how much statistical power to detect change does the dataset have?	Limited
Quality: how well does the dataset meet the data needs for the indicator?	Limited
Other Comments:	

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 8. Presence/Absence of Invasive Species**	
	Data set # 5
Response form #5 of 6-point evaluation framework (A-D)	C
Brief Title for Dataset	**Hawaiian Ecosystems at Risk Project**

Contact Person/Agency/Group	Hawaiian Ecosystems at Risk Project P.O. Box 1272, Puunene, Hawaii 96784 webmaster@hear.org
Citation	
Website	http://www.hear.org
For what years are data available and how often are data collected?	On-going
In what format is the data set available	Listing and Mapping
Are data nominal, ordinal or interval	Nominal
What will be the approximate cost of collecting data?	??
What barriers prohibit access of use of data?	Format of data set
What is the spatial grain of the data?	By island in Hawaii
What is the spatial extent of data?	
What spatial scales can these data be aggregated and reported?	State
What is the temporal grain of the data?	On-going
What is the temporal extent of the data?	
At what temporal scales can these data be aggregated and reported?	Point in time
Quality: can data be adequately reported over time in a consistent form?	Possibly
Quality: how repeatable are existing data?	Good
Quality: how biased are the sampling methods	Potential bias
Quality: how precise are existing data?	Moderate
Quality: how valid are existing data?	Good
Quality: how responsive are existing data?	Limited
Quality: how much statistical power to detect change does the dataset have?	Limited
Quality: how well does the dataset meet the data needs for the indicator?	Limited
Other Comments:	Only limited to Hawaii, but has good distribution maps that might be used to determine area…probably not

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands Indicator 8. Presence/Absence of Invasive Species	
	Data set # 6
Response form #5 of 6-point evaluation framework (A-D)	C
Brief Title for Dataset	**CalWeed Database**
Contact Person/Agency/Group	Steve Schoenig Department of Food & Agriculture 1220 N Street, Room A-357 Sacramento, CA 95814 (916) 654-0768 sschoenig@cdfa.ca.gov
Citation	
Website	http://endeavor.edes.ucdavis.edu/weeds
For what years are data available and how often are data collected?	On-going
In what format is the data set available	Primarily Listings, perhaps some mapping for individual projects in database
Are data nominal, ordinal or interval	Nominal
What will be the approximate cost of collecting data?	??
What barriers prohibit access of use of data?	Format of data set
What is the spatial grain of the data?	State of California
What is the spatial extent of data?	
What spatial scales can these data be aggregated and reported?	State of California
What is the temporal grain of the data?	On-going
What is the temporal extent of the data?	
At what temporal scales can these data be aggregated and reported?	Point in time, repeated in some specific programs in the state
Quality: can data be adequately reported over time in a consistent form?	Possibly
Quality: how repeatable are existing data?	Good
Quality: how biased are the sampling methods	Potential bias
Quality: how precise are existing data?	Moderate
Quality: how valid are existing data?	Good
Quality: how responsive are existing data?	Limited
Quality: how much statistical power to detect change does the dataset have?	Limited
Quality: how well does the dataset meet the data needs for the indicator?	Limited
Other Comments:	Limited to CA and data set varies in information input

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands Indicator 8. Presence/Absence of Invasive Species	
	Data set # 7
Response form #5 of 6-point evaluation framework (A-D)	C
Brief Title for Dataset	**Florida Exotic Pest Plant Council**
Contact Person/Agency/Group	3915 Commonwealth Blvd. MS 710 Tallahassee, FL 32399
Citation	
Website	http://www.fleppc.org/database/data_intro.htm
For what years are data available and how often are data collected?	On-going
In what format is the data set available	Listings, county level distribution maps
Are data nominal, ordinal or interval	Nominal
What will be the approximate cost of collecting data?	
What barriers prohibit access of use of data?	Format of data set
What is the spatial grain of the data?	State of Florida
What is the spatial extent of data?	
What spatial scales can these data be aggregated and reported?	State of Florida
What is the temporal grain of the data?	On-going
What is the temporal extent of the data?	
At what temporal scales can these data be aggregated and reported?	Point in time
Quality: can data be adequately reported over time in a consistent form?	Possibly
Quality: how repeatable are existing data?	Good
Quality: how biased are the sampling methods	Potential bias
Quality: how precise are existing data?	Moderate
Quality: how valid are existing data?	Good
Quality: how responsive are existing data?	Limited
Quality: how much statistical power to detect change does the dataset have?	Limited
Quality: how well does the dataset meet the data needs for the indicator?	Limited
Other Comments:	Good distribution maps for county level presence/absence

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 8. Presence/Absence of Invasive Species**	
	Data set # 8
Response form #5 of 6-point evaluation framework (A-D)	C
Brief Title for Dataset	**Illinois Plant Information Network**
Contact Person/Agency/Group	Illinois Plant Information Network Louis Iverson 359 Main Road Delaware, OH 43015 (as best I can tell)
Citation	
Website	http://www.fs.fed.us/ne/delaware/ilpin/ilpin.html
For what years are data available and how often are data collected?	On-going
In what format is the data set available	Listings and distribution maps
Are data nominal, ordinal or interval	Nominal
What will be the approximate cost of collecting data?	
What barriers prohibit access of use of data?	Format of data set
What is the spatial grain of the data?	Regional/state in US?
What is the spatial extent of data?	
What spatial scales can these data be aggregated and reported?	Regional
What is the temporal grain of the data?	On-going
What is the temporal extent of the data?	
At what temporal scales can these data be aggregated and reported?	Point in time
Quality: can data be adequately reported over time in a consistent form?	Possibly
Quality: how repeatable are existing data?	Good
Quality: how biased are the sampling methods	Potential bias
Quality: how precise are existing data?	Moderate
Quality: how valid are existing data?	Good
Quality: how responsive are existing data?	Limited
Quality: how much statistical power to detect change does the dataset have?	Limited
Quality: how well does the dataset meet the data needs for the indicator?	Limited
Other Comments:	

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 8. Presence/Absence of Invasive Species**	
	Data set # 9
Response form #5 of 6-point evaluation framework (A-D)	C
Brief Title for Dataset	**Southwest Exotic Plant Information Clearinghouse**
Contact Person/Agency/Group	USGS Kathryn Thomas Colorado Plateau Field Station Flagstaff, AS USA
Citation	Southwest Exotic Plant Information Clearinghouse: http://usgssrv1.usgs.nau.edu/swepic/swemp/maps.html
Website	See Above
For what years are data available and how often are data collected?	On-going
In what format is the data set available	Primarily Listings
Are data nominal, ordinal or interval	Nominal
What will be the approximate cost of collecting data?	
What barriers prohibit access of use of data?	Format of data set
What is the spatial grain of the data?	Regional/state in US?
What is the spatial extent of data?	
What spatial scales can these data be aggregated and reported?	Regional
What is the temporal grain of the data?	On-going
What is the temporal extent of the data?	
At what temporal scales can these data be aggregated and reported?	Point in time
Quality: can data be adequately reported over time in a consistent form?	Possibly
Quality: how repeatable are existing data?	Good
Quality: how biased are the sampling methods	Potential bias
Quality: how precise are existing data?	Moderate
Quality: how valid are existing data?	Good
Quality: how responsive are existing data?	Limited
Quality: how much statistical power to detect change does the dataset have?	Limited
Quality: how well does the dataset meet the data needs for the indicator?	Limited
Other Comments:	

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 9. The Presence and Status of Species and Communities of Concern**	
	Data set # 1
Response from #5 of 6-point evaluation framework (A-D)	A
Brief Title for Data Set:	**NPS T&E Database**
Contact Person/Agency/Group (email, phone, address):	L. Mehrhoff (970)225-3521 C. Ogden (303) 969-2929
Citation (if published):	
Website (if available):	
Additional information on data set:	Based on four population status levels by species by park: stable, declining, increasing, unknown
For what years are data available and how often are data collected?	1998 to present Yearly
In what format is the data set available? (map only, data point, …)	Summary status of T&E's by park in Excel format: based on extensive park-level field data and maps but not listed in this database
Are data nominal, ordinal, or interval?	Nominal and ordinal
What will be the approximate cost of collecting data?	
What barrier(s) prohibit access or use of data? (Restricted use, exorbitant cost, technical or legal barriers, confidential barriers, etc.?) Or are data easily accessible?	NPS and ESA legal mandates
What is the spatial grain of the data?	Park unit
What is the spatial extent of the data?	National
At what spatial scales can these data be aggregated and reported?	Park unit, State, Regional and National
What is the temporal grain of the data?	Yearly
What is the temporal extent of the data?	1998 to present
At what temporal scales can these data be aggregated and reported?	Yearly
Quality: can data be adequately reported over time in a consistent form? (Consistent methodology.)	Some inconsistencies in data reporting by individual parks
Quality: how repeatable are existing data? (Include p value of differences in estimates of independent observers if available)	Not applicable
Quality: how biased are the sampling methods?	Park-level data variable
Quality: how precise are existing data? (Give standard error, if available)	Park-level data variable
Quality: how valid are existing data?	
Quality: how responsive are existing data?	Not very responsive
Quality: how much statistical power to detect change does this data set have?	Not applicable
Quality: how well does this data set meet the data needs for this indicator?	Fairly Well: gives status of species by park

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 9. The Presence and Status of Species and Communities of Concern**	
Other comments: (Include any other relevant aspects of the data set that should be included.)	Status is determined by a variety of methods, from intense field monitoring to "best guess", so is variable in quality

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 9. The Presence and Status of Species and Communities of Concern**		
	Data set # 2	**Data set # 3**
Response from #5 of 6-point evaluation framework (A-D)	A	A
Brief Title for Data Set:	**Endangered Species Program**	**NatureServe Explorer**
Contact Person/Agency/Group (email, phone, address):	U.S. Fish and Wildlife Service	Nature Serve Larry Sugarbaker Vice President and Chief Information Officer NatureServe 1101 Wilson Boulevard 15th Floor Arlington, VA 22209 TEL 703-908-1800 FAX 703-908-1917
Citation (if published):		Grossman et al. 1998
Website (if available):	http://endangered.fws.gov/	Http://www.natureserve.org/
Additional information on data set:		
For what years are data available and how often are data collected?	The listing history is available for each species.	
In what format is the data set available? (map only, data point, …)	Web, PDF files	Data for plants, animals,and ecological communities, including exotic species
Are data nominal, ordinal, or interval?	Ordinal	Nominal
What will be the approximate cost of collecting data?		
What barrier(s) prohibit access or use of data? (Restricted use, exorbitant cost, technical or legal barriers, confidential barriers, etc.?) Or are data easily accessible?	The listing status of each species is easily available.	The status of each species is easily available. Some data is proprietary, some has restricted use, some may have a cost associated with it.
What is the spatial grain of the data?	State	Single observation
What is the spatial extent of the data?	National	National
At what spatial scales can these data be aggregated and reported?	National and state	National and state

What is the temporal grain of the data?	Dates of listing events are provided.	Single observation
What is the temporal extent of the data?	1973 - present	
At what temporal scales can these data be aggregated and reported?	Information is available since the passage of the Endangered Species Act of 1973	
Quality: can data be adequately reported over time in a consistent form? (Consistent methodology.)	Listing may be influenced by many factors, and the level of consistency is difficult to determine.	Not Applicable
Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 9. The Presence and Status of Species and Communities of Concern**		
Quality: how repeatable are existing data? (Include p value of differences in estimates of independent observers if available)	Not applicable	Consistent methods are used, but in the end a subjective decision is made.
Quality: how biased are the sampling methods?	Not applicable	Not applicable
Quality: how precise are existing data? (Give standard error, if available)	Not applicable	Not applicable
Quality: how valid are existing data?	Because needed information is often not available, process delays and other factors, the listing status may not always reflect the true status of a species.	Assessments are based on information from the Natural Heritage Networks, but often limited data are available.
Quality: how responsive are existing data?	The information is not responsive, because a species must be in serious trouble before it is listed.	Assessments provide a snapshot of species status, which are responsive because they consider potential treats.
Quality: how much statistical power to detect change does this data set have?	Not applicable	Not applicable
Quality: how well does this data set meet the data needs for this indicator?	The data represent the current legal status of species and represents very important information for the indicator.	Probably provides the best available assessment of species' status at global, national and state level as 1 = critically imperiled, 2 = imperiled, 3 = vulnerable to extirpation or extinction, 4 = apparently secure or 5 = demonstrably widespread, abundant, and secure.
Other comments: (Include any other relevant aspects of the data set that should be included.)		Vegetation classification based on FGDC Vegetation Classification Standard for physiognomic units and TNC's Terrestrial Vegetation Classification of the United States for floristic units when used (now spun off as NatureServe).

		Project results include dataset and information for each park project: Spatial Data (aerial photography, map classification, map classification description and key, spatial database of vegetation communities, hardcopy maps of vegetation communities, metadata for spatial databases, complete accuracy assessment of spatial data) and Vegetation Information (vegetation classification, dichotomous field key of vegetation classes, formal description for each vegetation class, ground photos of vegetation classes, field data in database format) Spatial databases will have a horizontal positional accuracy that meets National Map Accuracy Standards at the 1:24,000 scale. Each well defined object in the spatial database will be within 1/50 of an inch of its actual location or 40 feet (12.2 meters). Each vegetation map class will meet or exceed 80% accuracy at the 90% confidence level. The classification accuracy will be established by the program accuracy assessment protocols (link to AA protocol document).

Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 10. The Population Status and Geographic Range of Rangeland Species**		
	Data set # 1	**Data set # 2**
Response from #5 of 6-point evaluation framework (A-D)	A	A
Brief Title for Data Set:	**North American Breeding Bird Survey (BBS)**	**Monitoring Avian Productivity And Survivorship (MAPS)**
Contact Person/Agency/Group (email, phone, address):	Keith Pardieck, Keith_Pardieck@usgs.gov, U.S. Geological Survey, Patuxent Wildlife Research Center Laurel, MD, USA 20708-4038	David DeSante, (415) 663 2052, The Institute for Bird Populations (IBP), P.O. Box 1346; Point Reyes Station, CA 94956-1346, (415) 663-1436

Citation (if published):	Bird Populations 5: 30-48	Bird Populations 5: 49-101 Http://www.birdpop.org/publications.htm
Website (if available):	http://www.mp2-pwrc.usgs.gov/bbs/	Http://www.birdpop.org/maps.htm
Additional information on data set:		
For what years are data available and how often are data collected?	Annual data, 1966 - present There are over 4000 routes.	Annual data, 1989 – present Over 500 stations
In what format is the data set available? (map only, data point, …)	Raw data, distribution and trend maps, trend estimates, custom analyses via web	Publications and arrangements with IBP.
Are data nominal, ordinal, or interval?	Interval	Internal
What will be the approximate cost of collecting data?		
What barrier(s) prohibit access or use of data? (Restricted use, exorbitant cost, technical or legal barriers, confidential barriers, etc.?) Or are data easily accessible?	Data are easily accessible and analysis tools are available, but expert knowledge is needed to effectively use the tools.	Results have been published. Access to data is only available through arrangement with IBP.
What is the spatial grain of the data?	Data are available for individual routes, but estimates are probably too variable to use below the state or physiographic region level.	Individual stations, usually located on public land.
What is the spatial extent of the data?	United States, Canada and Puerto Rico	United States
At what spatial scales can these data be aggregated and reported?	State/province, physiographic region, nation	Individual national forests, national parks, etc. that have stations, and national.
What is the temporal grain of the data?	Annual	Annual
What is the temporal extent of the data?	1966 to present	1989 to present
Criterion. Conservation and Maintenance of Plant and Animal Resources on Rangelands **Indicator 10. The Population Status and Geographic Range of Rangeland Species**		
At what temporal scales can these data be aggregated and reported?	Analyses for 1966-2000, 1966-1979 and 1980-2000 are available. Custom analysis for other years.	Annual
Quality: can data be adequately reported over time in a consistent form? (Consistent methodology.)	Consistent methodology has been used and results are routinely reported.	Consistent methodology has been used and results are routinely reported.
Quality: how repeatable are existing data? (Include p value of differences in estimates of independent	Data are repeatable. Analyses only compare routes run by the same observer to remove observer effect.	Data are repeatable. Data are adjusted for detectability, including observer differences.

observers if available)		
Quality: how biased are the sampling methods?	There are two major sources of bias. Counts are not adjusted for detectability, so any long-term change in detectability would be interpreted as a population change. Counts are made under standard conditions and observer effectiveness is monitored to minimize differences in detectability. Routes are a statistically valid, unbiased sample of rural roads, but any inference beyond the habitat near rural roads would be biased.	Estimates are model unbiased, so detectability and other measurement biases are not a problem. Sampling bias is present because stations are located on land holdings of cooperators, usually federal agencies. For logistical reasons sites are located near roads, but not on the roads.
Quality: how precise are existing data? (Give standard error, if available)	95% confidence intervals for U.S. trend estimates for a common species such as mourning doves 1966-2000 are +/- 0.25% per year. Estimates for less common species and states would be less precise. For example, that interval for the U.S. trend for sage grouse 1966-2000 is +/- 4% per year, and the Wyoming trend is +/- 6.5% per year.	For example, song sparrows 1992-1998 in the northwest had a survival standard error of 0.017. Less common species would have larger standard errors.
Quality: how valid are existing data?	The index tracks changes in the population of singing males near rural roads. Long-term chances in detectability or in the proportion of singing males would be interpreted as population changes. Populations away from roads are not tracked. Data are quality controlled and collected under standardized conditions. BBS probably can reliably detect major population changes, but detection of small changes is problematic because of these problems.	The program provides model unbiased estimates survival and the proportion on young birds, although there is sampling bias from selecting sites on the land holdings of cooperators that are close to roads. The estimates relate to fundamental demographic rates of fecundity and mortality needed to assess population status.
Quality: how responsive are existing data?	The estimates reflect changes in the breeding population and are much more responsive to population changes than indicator 9 on the presence and status of species. However, it is not as responsive as MAPS data, which estimates fecundity and mortality, allowing the detection of recruitment problems.	The data are more responsive than BBS data, because changes in of fecundity and mortality will precede changes in the breeding population.
Quality: how much statistical power to detect change does this data set		

have?		
Quality: how well does this data set meet the data needs for this indicator?	The data very well meet the needs to detect major population changes, but detections of small changes are problematic. The information is complementary to the more intensive MAPS data.	The estimates are not only leading indicators of population change, but they also provide insights into the causes of population changes. The information is complementary to the more extensive BBS data.
Other comments: (Include any other relevant aspects of the data set that should be included.)	The BBS is a long-term, large-scale, international avian monitoring program initiated in 1966 to track the status and trends of North American bird populations. The USGS Patuxent Wildlife Research Center and the Canadian Wildlife Service, National Wildlife Research Center jointly coordinate the BBS program. Each year during the height of the avian breeding season, June for most of the U.S. and Canada, participants skilled in avian identification collect bird population data along roadside survey routes. Each survey route is 24.5 miles long with stops at 0.5-mile intervals. At each stop, a 3-minute point count is conducted. During the count, every bird seen within a 0.25-mile radius or heard is recorded. Surveys start one-half hour before local sunrise and take about 5 hours to complete. Over 4100 survey routes are located across the continental U.S. and Canada. Once analyzed, BBS data provide an index of population abundance that can be used to estimate population trends and relative abundances at various geographic scales. Trend estimates for more than 420 bird species and all raw data are currently available via the BBS web site.	The Monitoring Avian Productivity and Survivorship (MAPS) Program was created by The Institute for Bird Populations in 1989 to assess and monitor the vital rates and population dynamics of over 120 species of North American landbirds in order to provide critical conservation and management information on their populations. The MAPS Program utilizes constant-effort mist netting and banding at a continent-wide network of monitoring stations staffed by both professional biologists and highly trained volunteers. MAPS is organized around research and management goals as well as monitoring goals. MAPS data are used to describe temporal and spatial patterns in the vital rates of target species, and relationships between these patterns and ecological characteristics and population trends of the target species station-specific and landscape-level habitat characteristics Spatially explicit weather variables. Information from these patterns and relationships are then used to identify the causes of population declines formulate management actions and conservation strategies to reverse declines, and maintain healthy populations evaluate the effectiveness of management actions and conservation strategies.