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Fred B. Samson

Fritz L. Knopf

Clinton W. McCarthy

Barry R. Noon

Wayne R. Ostile

See next page for additional authors

Authors
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Abstract Broad-scale information in concert with conservation of individual species must be used to develop conservation priorities and a more integrated ecosystem protection strategy. In 1999 the United States Forest Service initiated an approach for the 1.2×10^6 ha of national grasslands in the Northern Great Plains to fulfill the requirement to maintain viable populations of all native and desirable introduced vertebrate and plant species. The challenge was threefold: 1) develop basic building blocks in the conservation planning approach, 2) apply the approach to national grasslands, and 3) overcome differences that may exist in agency-specific legal and policy requirements. Key assessment components in the approach included a bioregional assessment, coarse-filter analysis, and fine-filter analysis aimed at species considered at-risk. A science team of agency, conservation organization, and university personnel was established to develop the guidelines and standards and other formal procedures for implementation of conservation strategies. Conservation strategies included coarse-filter recommendations to restore the tallgrass, mixed, and shortgrass prairies to conditions that approximate historical ecological processes and landscape patterns, and fine-filter recommendations to address viability needs of individual and multiple species of native animals and plants. Results include a cost-effective approach to conservation planning and recommendations for addressing population viability and biodiversity concerns on national grasslands in the Northern Great Plains.

Key words Biological diversity, conservation planning, ecological processes, grasslands, management, population viability, prairie

Recent years have seen development of large-scale conservation plans that feature population viability assessments for individual at-risk species such as the northern spotted owl (*Strix occidentalis*) (Noon and McKelvey 1996), California spotted owl (Verner et al. 1992), and grizzly bear (*Ursus*

Address for Fred B. Samson and Susan M. Rinehart: United States Forest Service, 200 East Broadway, Missoula, MT 59812, USA; e-mail for Samson: FSamson@fs.fed.us. Address for Fritz L. Knopf: United States Geological Service Biological Resources Division, 2150-C Center Avenue, Fort Collins, CO 80525, USA. Address for Clinton W. McCarthy: United States Forest Service, 324 25th Street, Ogden, UT 84401, USA. Address for Barry R. Noon: Fishery and Wildlife Biology, College of Natural Resources, Colorado State University, Fort Collins, CO 80523, USA. Address for Wayne R. Ostlie: The Nature Conservancy, 2060 Broadway, Suite 230, Boulder, CO 80302, USA. Address for Scott Larson: United States Fish and Wildlife Service, 420 South Garfield, Suite 40, Pierre, SD 57501, USA. Address for Glenn E. Plumb: National Park Service, Badlands National Park, P.O. Box 6, Route 240, Interior, SD 57750, USA; present address, Yellowstone National Park, P.O. Box 168, Yellowstone, WY, 82190, USA. Address for Gregory L. Schenbeck: United States Forest Service, 125 North Main Street, Chadron, NE 69337, USA. Address for Daniel N. Svingen: United States Forest Service, 240 West Century Ave., Bismarck, ND, 58503, USA. Address for Timothy W. Byer: United States Forest Service, 2250 East Richards Street, Douglas, WY 82633, USA.

arctos) (Mattson and Craighead 1994). In a few cases, the large-scale plans have sought to consider viability of all or most of the native animals and plants in the planning area—for example, the Tongass Land and Resource Management Plan (United States Department of Agriculture 1997) and the Interior Columbia River Basin Ecosystem Management Project (United States Department of Agriculture and United States Department of Interior 2000). All such planning efforts were long in development and extremely costly. The inadequacy of traditional approaches to planning on federal lands is clear (General Accounting Office 1997). There is need for large-scale planning approaches that are affordable, practical, and defensible in addressing objectives for species viability and biodiversity conservation.

This paper describes a large-scale approach to conservation planning for the national grasslands in the Northern Great Plains. Our approach for this task was to engage scientists from a variety of organizations in an exercise to apply the best available information, conservation planning concepts, and analysis methods. The purpose was to develop conservation guidelines having a moderate to high likelihood of sustaining biodiversity on the national grasslands in the Northern Great Plains.

Status of Great Plains grasslands

The Great Plains grassland region of the United States encompasses all or part of 16 states, covering approximately 4.1×10^8 ha east of the Rocky Mountains and west of Ohio, from the Canadian border into Texas. The main bodies of grassland are the tallgrass prairie that once extended from Minnesota south into Texas and east from Ohio across Iowa, the mixed prairie that reached from eastern North Dakota south to Texas, and the shortgrass prairie that extended from western Texas and New Mexico north into eastern Montana and from the Rocky Mountains east into Nebraska and Kansas. Before the arrival of European settlers, the vegetation consisted of vast open expanses of native perennial grasses and forbs (Weaver 1954). Many large and small animals evolved on the North American grasslands (Van Valkenburgh and Janis 1993). As early as 1830, homesteading in Ohio and Indiana began to forever alter the extent of native grasslands. Recent surveys suggested area declines as high as 99.9% in the tallgrass prairie, 46.4% in the mixed prairie, and 21.1% in the shortgrass prairie (Samson and Knopf 1994). On a global basis, the tallgrass prairie is "critically endangered" (Rickletts et al. 1999:72). In the Northern Great Plains, the shortgrass prairie in eastern Wyoming and the mixed prairie in North and South Dakota and Nebraska are considered endangered.

Public grasslands, which comprise 1.2×10^6 ha of the total Northern Great Plains area of 7.8×10^7 ha, are important for the conservation of biological diversity in the United States (Scott et al. 2001). Of grasslands in public ownership, 71% are national grasslands managed by the United States Forest Service. The national grasslands were largely homestead lands reacquired in the 1930s by the federal government to conserve and restore soil productivity. Many of these lands were converted to nonnative species in an effort to protect soils from wind and water erosion.

The Forest Service is required to maintain well-distributed habitat to maintain viable populations of all native and desirable introduced vertebrate (Code of Federal Regulations 219.19 [1982]) and vascular plant species (United States Department of Agriculture Regulation 9400 [1983]) within a planning area. In 1999 the Forest Service began a formal effort to improve compliance with the viability requirement in revised land and resource management plans for the Northern Great Plains.

Conservation planning approach

The Forest Service began its conservation planning approach by formally establishing a science team. The team's charge was to develop a large-scale approach to address species viability issues on national grasslands in the Northern Great Plains; apply to the planning task all relevant information available from conservation organizations, natural resource agencies, academia, research institutions, and individual experts; and clarify the responsibilities and roles of federal resource management agencies. The science team included members from the United States Fish and Wildlife Service, National Park Service, Forest Service (National Forest System and Research Branch), United States Geological Survey (Biological Resources Division), Colorado State University, and The Nature Conservancy, a nongovernmental organization. Criteria used to select members included quality of relevant experience, peer-reviewed publications, and acceptance by peers. The science team was supported by specialists including wildlife biologists, resource planners, plant ecologists, and geographical information specialists.

Five steps comprised the science team's approach to conservation planning: 1) conduct a bioregional assessment to estimate the distribution and abundance of native grassland in private ownership and on the national grasslands, 2) conduct a coarse-filter analysis to identify areas of each major vegetation type sufficient to sustain native biological diversity, 3) develop, through a fine-filter analysis, conservation strategies for individual or multispecies groupings aimed at restoring or maintaining viable populations, 4) present management actions to achieve coarse-filter and fine-filter conservation recommendations, and 5) deal with uncertainty and risk through effective and efficient monitoring.

Step 1—Bioregional assessment

The ecoregion and province provide the common framework in large-scale conservation planning (Rickletts et al. 1999). The Northern Great Plains occurs within 3 provinces: the Great Plains Steppe, the Great Plains-Palouse Dry Steppe, and the Prairie Parkland (Bailey 1996). Delineated on the basis of broad climate differences, these provinces correspond to the tallgrass prairie, mixed prairie, and shortgrass prairie (Table 1). Provinces may be further divided into sections based on geologic and climatic variation (Kuchler 1964). The section level relates most directly to the 8 isolated national grasslands and other major grassland bodies in the Northern Great Plains (Figure 1).

Table 1. Summary of the bioregional assessment: percent decline from historic levels of tallgrass, mixed, and shortgrass prairies by ecological section; and, percent and area (ha) of each section remaining on national grasslands managed by the United States Forest Service, 1998.

Ecological Section prairie type	% decline	National grassland	% area (ha)
Red River tallgrass prairie	89.2	Sheyenne	10.8 (2.3×10^4)
Northeastern Glaciated Plains mixed prairie	92.8	Sheyenne	0.6 (5.0×10^3)
North-Central Great Plains mixed prairie	95.5	Fort Pierre	0.4 (4.6×10^4)
Northwestern Great Plains mixed prairie	50.4	Little Missouri	4.1 (4.1×10^5)
		Cedar Creek and Grand River	0.7 (6.5×10^4)
		Buffalo Gap	2.6 (2.4×10^5)
		Oglala	0.4 (3.8×10^4)
Powder River shortgrass prairie	75.0	Thunder Basin	7.5 (2.2×10^5)

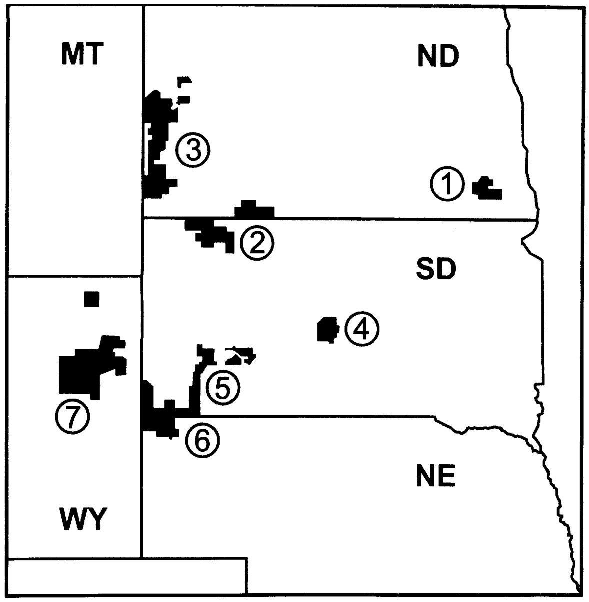

Figure 1. Map of the United States Forest Service national grasslands in the Northern Great Pains, including Sheyenne (1), Grand River/Cedar River (2), Little Missouri (3), Ft. Pierre (4), Buffalo Gap (5), Oglala (6), and Thunder Basin (7).

The Red River Section consisted of bluestem (*Andropogon* spp.) tallgrass prairie and northern flood plain forest. The Northeastern Glaciated Plains Section was the transition zone between the tallgrass prairie to the east and mixed prairie to the west. The North-Central Great Plains Section was level to gently rolling plains and potholes; vegetation consisted of wheatgrass (*Agropyron* spp.)-bluestem-needlegrass (*Artistida* spp.) prairie. The Northwestern Great Plains Section was an area of cool-season mixed prairie grass species, gently sloping to open plains, isolated buttes and badlands in the west, and occasional stands of conifers. The Powder River Basin Section was shortgrass prairie and shrub-steppe.

The University of Nebraska-Lincoln Center for Advanced Land Management Information Technology provided estimates of existing vegetation and current land-use patterns for the bioregional assessment and coarse-filter analysis. Data were based on 1×10^2 ha Advanced Very High Resolution Radiometer (AVHRR) imagery merged with vector coverages for the 5 sections in the bioregional assessment. Because national grassland boundaries were used to estimate land cover, some private, state, or other federal ownership may have been included in the administrative units summaries.

Information sources included the scientific literature, government reports (Baird 1857), nongovernmental organization reports (e.g., The Nature Conservancy 2000), and historical sources such as journals kept by Lewis and Clark (Lewis 1961) and railroad (Henry 1858) and border surveys (Coues 1878) conducted by the Smithsonian Institution. These sources provided information on historic geographic variation in the extent and structure of dominant vegetation types, temporal and spatial pattern of important ecological processes such as herbivory and fire, and species at risk and the factors that threaten them. Historic was considered to be before 1770 and, with caution, from 1770 to 1840 (Higgens 1986).

The bioregional assessment made the following assumptions: 1) larger areas of native habitat are better for species conservation than smaller areas of native habitat; 2) a habitat type common at the section level, if regionally rare, was highly important to species conservation at larger scales; and 3) native habitats that were rare across the Northern Great Plains were important for conservation strategies on public lands.

Historic and current vegetation patterns were evaluated using AVHRR imagery to estimate how much of remaining prairie habitats occur on the national grasslands. Extensive conversion of native prairie and shrubland to other uses has occurred across the Northern Great Plains (Table 1). Only 10.8% of tallgrass prairie within the Red River Section remains, all within the 2.3×10^4-ha Sheyenne National Grassland. The Sheyenne National Grassland and Fort Pierre National Grassland retain small percentages (0.6% and 0.4%, respectively) of mixed prairie. Both are important to conserving mixed prairie in the Northern Glaciated Plains and North-Central Great Plains Sections, where conversion to other land uses has been extensive (92.8% and 95.5%, respectively). More mixed prairie remains (49.6%) in 2 administrative units of the Northwestern Great Plains: the Little Missouri National Grasslands (4.1×10^5 ha) and the Buffalo Gap National Grassland (2.4×10^5 ha). Both areas are important to conservation of mixed prairie. Only the Thunder Basin National Grassland retains shortgrass prairie.

The bioregional analysis identified the following key areas: the Sheyenne National Grassland as a special area for tallgrass prairie conservation, the Little Missouri National Grassland and Buffalo Gap National Grassland as having sufficient area and extent of native vegetation to support a diversity of native plant and animal species, and geographically rare areas having specific environmental characteristics or ability to contribute in other ways to conservation of native plant and animal communities (e.g., the Sheyenne National Grassland's component of mixed prairie in the Northeastern Glaciated Plains Section; the shortgrass prairie of the Fort Pierre National Grassland and Thunder Basin National Grassland; and the Cedar Creek National Grassland, Grand River National Grassland, and Oglala National Grassland).

Step 2—Coarse-filter analysis

A coarse-filter strategy seeks to protect or restore sufficient areas of each vegetation type within a region to sustain native biological diversity (Soule and Terborg 1999). Coarse-filter analysis measures changes in the distribution of habitats within the plan area, determines whether the frequency and extent of major ecological processes (e.g., fire, herbivory) have changed, identifies human-caused disturbances and impacts, and provides a basis for conservation strategies to maintain and restore landscapes. The purpose is to conserve dominant vegetation types and seral-stage communities on the assumption that a representative array of communities will contain the vast majority of native species (Haufler et al. 1996).

Historically, bison (*Bison bison*) were keystone species in tallgrass prairie ecosystems. Bison grazing, in conjunction with fire, influenced plant community composition and production of important prairie plants (Knapp et al. 1999). Bison moved nomadically in response to vegetation changes associated with rainfall and fire (Malainey and Sherriff 1996), thereby maintaining a mosaic of vegetation composition and structure. Such behavior provided a natural "rest" for large patches of prairie. These patterns are consistent with spatial heterogeneity models that suggest stability in plant–herbivore interactions (Irby et al. 2002).

Historically, the mixed prairie may have occurred as a relatively narrow transition zone between the tallgrass and shortgrass prairie (Bessey 1893), extending south from eastern North Dakota into eastern Kansas (Blakeslee 1996). Species composition in mixed prairie is affected by grazing (Biondini and Llewellyn 1996), and herbivoryinduced shifts in composition are documented (Anderson and Briske 1995). The historic combination of grazing and fire most likely created a mosaic similar to that in the tallgrass prairie. Early explorers and naturalists described spatial and year-to-year variation in the height of mixed prairie. For example, in 1805 Lewis and Clark found the prairie "much parched with frequent fires" (Lewis 1961:26) and "all around the country had been recently burnt" (Lewis 1961:66). Fremont wrote in 1845 how buffalo "scarcely left a blade of grass standing" and suggested that intense fires provided "a natural determent of other parts of their range" (White and Lewis 1967:320).

In North America, shortgrass prairie is the vegetation type most closely associated with grazing (Milchunas et al. 1998). In 1834 Maximilian described the landscape near Fort Union (western North Dakota) as "grey and dry, without diversity, covered with low plants, which afford food to numerous herds of the large heavy buffalo. Here and there are small hollows, in which there is rather more moisture, cross the prairie, and here some water-plants and grasses grow: in spring and winter there is running or stagnent water" (Maximilian 1966:195). Larocque's 1805 daily journal of travels along the Powder River in Wyoming remarked "it is amazing how very barren the ground is between this and the lesser Missouri, nothing can hardly be seen but those Corne de Racquettes (prickly pear cactus). Our horse nearly starved" (Larocque 1934:13).

The coarse-filter analysis included habitat sampling to evaluate large-scale patterns in habitat structure that related to distribution of native animal and plant communities. Between 1992 and 1998, the Forest Service evaluated grassland vegetation structure on 5 national grasslands using a modified technique of Robel et al. (1970). Proportions of vegetation cover in 3 discrete structural categories (i.e., low, moderate, and high) were determined for each national grassland (Table 2). Differences in height criteria for the 3 areas reflected their positions along an east-to-west moisture gradient.

The national grasslands today are relatively homogeneous in vegetation structure (Table 2). The low structural category (≤7.9 cm) prevails on the Grand River National Grassland, Buffalo Gap National Grassland, Little Missouri National Grassland, and Oglala National Grassland. The Ft. Pierre National Grassland was exceptional in that 2 categories, low (≤ 7.9 cm) and moderate (8.0-11.9 cm), accounted for 78.8% of the samples. The historic pattern was thought to have been about one-third each in short, moderate, and tall structure in the 3 main native grassland bodies in the Northern Great Plains. Grazing by domestic livestock may contribute to the homogeneity in the current landscape. Grazing occurs year after year on about 98% of the national grasslands in the Northern Great Plains.

Table 2. Percentage of residual visual readings by low, moderate, and high structural classes obtained by vegetation sampling 1992–1998 on mixed prairie national grasslands in the Northern Great Plains.

	Structural class		
National grassland	Low (%)	Moderate (%)	High (%)
Ft. Pierre[a]	32.3	46.4	16.3
Grand River[b]	45.7	23.4	9.3
Buffalo Gap[b]	52.8	23.8	24.0
Little Missouri[b]	92.3	7.7	2.1
Oglala[b]	90.0	8.3	1.7

[a] Visual obstruction reading categories: low (<7.9 cm), moderate (8.0–11.9 cm), and high (>12.0 cm). N = 16,648, 16,836, 17,103, 16,803, and 16,782 in 1992, 1993, 1994, 1995, and 1996, respectively.

[b] Visual obstruction reading categories: low (<7.3 cm), moderate (7.4–9.9 cm), and high (>10.0 cm). Based on percent of (12 m) transects. Year (number of transects) were: Grand River National Grassland 1995 (54), 1996 (37), and 1997(63); Buffalo Gap National Grassland 1995 (136), 1996 (126), and 1997 (41); Little Missouri National Grassland 1996 (221), 1997 (230), and 1998 (207); and, Oglala National Grassland 1994 (28), 1995 (28), and 1996 (28).

The science team reviewed the frequency, extent, and effects of fires that occurred between 1978 and 1999 on the national grasslands in the Northern Great Plains. Fire is relatively rare today, averaging 2 fires (and 8 ha) per year in the Sheyenne National Grassland; 7 fires (457 ha) per year in the Little Missouri National Grassland, Cedar River National Grassland, and Grand River National Grassland; 21 fires (3.4×10^3 ha) per year in the Ft. Pierre National Grassland, Buffalo Gap National Grassland, and Oglala National Grassland; and 9 fires (1.3×10^2 ha) per year on the Thunder Basin National Grassland. Use of prescribed fire on the national grasslands was initially designed to improve forage rather than to emulate historic spatial and temporal patterns.

Step 3—Fine-filter analysis

The fine-filter approach focuses on individual at-risk species to develop conservation strategies and recommended management practices aimed at restoring or maintaining viable populations (Haufler 1999). Key steps were to: 1) identify and prioritize species-at-risk, 2) determine the environmental factors that threaten these species, and 3) recommend management measures that will contribute to population viability through time.

The species selected for fine-filter analysis had undergone significant declines in abundance or distribution or were known to use highly specialized or unique habitats that have substantially changed through vegetation conversion, fragmentation, introduction of exotic species, or other factors. Three categories were established to prioritize species-at-risk: threatened, endangered, or proposed for listing (Category 1); candidates for listing by the Fish and Wildlife Service or considered globally endangered by The Nature Conservancy (2000) (Category 2); and species of concern to federal or state agencies (Category 3). Assignment of species to different risk categories was intended to reduce uncertainty and promote agreement on conservation priorities among the agencies (Samson 2002). Past experience has shown that failure to set conservation priorities may negatively affect species conservation (Mace and Lande 1990).

Resolution in the fine-filter analysis was limited by uncertainties in species-specific information and by incomplete understanding of cause–effect relationships. For some species, no information was available other than habitat relationships based on published literature or expert opinion. In such cases, conservation planning was guided by general conservation principles that were deemed relevant to species viability (e.g., Holthausen et al. 1999, Noon et al. 1999). Because life-history and ecological information was often incomplete, only qualitative analyses were possible for many species. The team's approach was similar to that proposed by Ruggiero et al. (1994), whereby analysis was focused on the interactions between habitat amount and distribution and population dynamics. These information sources were coupled with general population dynamics (Noon et al. 1999) to assess future and current viability of species-at-risk.

The fine-filter analysis focused on 17 Category 1 and Category 2 species, including both animals and plants (Table 3). Using recovery plans developed by the United States Fish and Wildlife Service, the science team adopted a conceptual framework and principal steps to recover 5 of the 17 species. Conservation principles provided the population viability framework for 11 species, and a habitat-based population viability analysis model was used for the black-tailed prairie dog (*Cynomys ludovicianus*).

Table 3. Category 1 and Category 2[a] species-at-risk[b] on national grasslands in the Northern Great Plains, by source of information used in viability analyses.

Source of viability information		
Recovery plan	Conservation principles	Population viability model
Blowout penstemon	Ute ladies' tresses	Black-tailed prairie dog
Western prairie fringed orchid	Dakota buckwheat	
American burying beetle	Smooth goosefoot	
Bald eagle	Barr's milkvetch	
Black-footed ferret	Dakota skipper	
	Powesheik skipperling	
	Ottoe skipper	
	Regal fritillary	
	Sturgeon chub	
	Mountain plover	
	Swift fox	

[a] Category 1: Listed as Threatened or Endangered or proposed for listing under the Endangered Species Act (1973); (2) Category 2: United States Fish and Wildlife Service candidate species or species considered to be globally endangered by The Nature Conservancy (2000).

[b] Scientific names not in text: blowout penstemon (*Penstemon haydenii*), western prairie fringed orchid (*Platanthera praeclara*), American burying beetle (*Nicrophorus americanus*), bald eagle (*Haliaeetus leucocephalus*), Ute ladies' tresses (*Spiranthes diluvialis*), Dakota buckwheat (*Eriogonum visheri*), smooth goosefoot (*Chenopodium subglabrum*), Barr's milkvetch (*Astragalus barrii*), Powesheik skipperling (*Oarisma powesheik*), Ottoe skipper (*Hesperia ottoe*), regal fritillary (*Spyeria idalia*), sturgeon chub (*Macrohybopsis gelida*), and swift fox (*Vulpes velox*).

Twenty-eight animal species on national grasslands were identified as Category 3 species and subsequently grouped (using qualitative information) into 7 broad habitat categories (Table 4). This grouping by habitat association allowed identification of environmental conditions and management actions presumed to similarly affect all species within a group. More complete knowledge would allow refinement of species groupings and strengthen the information base for conservation recommendations and land-management decisions.

The team examined whether environmental conditions thought to control the distribution and abundance of Category 3 animals might similarly affect Category 3 plant species (Table 5). The objective was to provide an integrated set of

Table 4. Category 3[a] animal species-at-risk by primary habitat association on national grasslands in the Northern Great Plains, 1998.

Habitat association / Common name	Scientific name
Tallgrass prairie	
Belfragi's chlorochroan bug	*Chlorochroa belfragi*
Greater prairie chicken	*Tympanuchus cupido*
Mixed prairie	
Tawny crescent butterfly	*Phyciodes batesii*
Argos skipper	*Atrytone arogos*
Upland sandpiper	*Bartramia longicauda*
Long-billed curlew	*Numenius americanus*
Sprague's pipit	*Anthus spragueii*
Baird's sparrow	*Ammodramus bairdii*
Shortgrass prairie	
Western burrowing owl	*Athene cunicularia*
Ferruginous hawk	*Buteo regalis*
Shrublands	
Greater sage grouse	*Centrocercus urophasianus*
Loggerhead shrike	*Lanius ludovicianus*
Badlands	
California bighorn sheep	*Ovis canadensis*
Fringe-tailed myotis	*Myotis thysanodes*
Conifer Communities	
Northern goshawk	*Accipiter gentilis*
Merlin	*Falco columbarius*
Black-backed woodpecker	*Picoides arcticus*
Pygmy nuthatch	*Sitta pygmaea*
Aquatic and wetland	
Flathead chub	*Platygobio gracilis*
Longnose sucker	*Catostomus catostomus*
Plains topminnow	*Fundulus sciadicus*
Northern leopard frog	*Rana pipiens*
American bittern	*Botaurus lentiginosus*
Black tern	*Chlidonias niger*
Trumpeter swan	*Cygnus buccinator*
Deciduous woodland	
Yellow-billed cuckoo	*Coccyzus americanus*
Lewis woodpecker	*Melanerpes lewis*
Fox sparrow	*Passerella iliaca*

[a] Category 3: Species of federal or state agency concern.

conservation principles that would apply to all Category 3 species. However, the 40 plant species in Category 3 were instead grouped into 8 habitat categories based on associations with broad community types, unique landforms, and special soil conditions. These categories were considered more appropriate to Category 3 plant species conservation.

Step 4—Conservation recommendations

Case example. It was difficult to succinctly

Table 5. Category 3[a] plant species-at-risk by primary habitat association on United States Forest Service National Grasslands in the Northern Great Plains , 1998.

Habitat association / Common name	Scientific name
Tallgrass prairie wetlands	
Little grape-fern	*Botrychium simplex*
Small white lady's slipper	*Cypripedium candidum*
Adder's tongue	*Ophioglossum pusillum*
Tallgrass prairie choppy	
Purple sandgrass	*Triplasis purpurea*
Sandhills	
Frostweed	*Helianthemum bicknelli*
Beach heather	*Hudsonia tomentosa*
Wahoo spindle-tree	*Euonymus atropurpureus*
Tallgrass prairie	
Northern ladyfern	*Athyrium filix-femina*
Deciduous hardwoods	
Oak fern	*Gymnocarpium dryopteris*
Leathery grape-fern	*Botrychium multifidum*
Foxtail sedge	*Carex alopecoidea*
Dogberry	*Ribes cynosbati*
Broad-leaved goldenrod	*Solidago flexicaulis*
Western rocky/scoria hills	
Golden stickleaf	*Mentzelia pumila*
Limber pine	*Pinus flexilis*
Eastern prairie boggy wetlands	
Marsh bellflower	*Campanula aparinoides*
Buckbean	*Menyanthes trifoliata*
Bog willow	*Salix pedicellaris*
Slender cottongrass	*Eriophorum gracile*
Showy lady's slipper	*Cypripedium reginae*
Labrador bedstraw	*Galium labridoricum*
Marsh fern	*Thelypteris palustres*
Spinulose woodfern	*Dryopteris carthusiana*
Marsh horsetail	*Equisetum palustris*
Delicate sedge	*Carex leptalea*
Sensitive fern	*Onoclea sensibilis*
Loesel's twayblade	*Liparis loeselii*
Shining flatsedge	*Cyperus bipartitus*
Umbrella flatsedge	*Cyperus diandrus*
Meadow horsetail	*Equisetum pratense*
Crested shield fern	*Dryopteris cristata*
Western plains riparian	
Lanceleaf cottonwood	*Populus acuminata*
Alkali sacaton	*Sporobolus airoides*
Blue lips	*Collinsia parviflora*
Buttes	
Torrey's cryptantha	*Cryptantha torreyana*
Alyssum-leaved phlox	*Phlox alyssifolia*
Hooker's townsendia	*Townsendia hookeri*
Sandy	
Sand lily	*Leucorinum montanum*
Nodding buckwheat	*Eriogonum cernuum*
Upright pinweed	*Lechea stricta*

[a] Category 3: Species of federal or state agency concern.

communicate an approach to conservation planning for population viability that encompassed a large multi-state geographic area and up to 2,000 animal and vascular plant species. A detailed case history is provided to facilitate understanding.

The mountain plover (*Charadrius montanus*) nests primarily in shortgrass prairie sites in association with historical ranges of the prairie dog (*Cynomys* spp.), bison, and pronghorn antelope (*Antilocapra americana*). Plovers avoid montane landscapes. In prairie landscapes they prefer arid, intensively grazed, or otherwise disturbed sites (Knopf 1996). The plover is especially attracted to landscapes altered by active prairie dog towns. In the northern Great Plains, where grazing intensity is less intense than before and mixed grasses are more prevalent, most plovers are found on remnant prairie dog towns (Knopf 1996).

Our bioregional assessment (step 1) identified areas of native shortgrass prairie habitat on national grasslands. The coarse-filter analysis (step 2) was deemed inadequate to address the plover's conservation needs. As explained by Hunter et al. (1988), the coarse filter does not adequately address species with very large home ranges, consistently sparse population densities, highly specialized or unique habitats, or required habitats that have undergone substantial changes. Instead, fine-filter analysis (step 3) was selected because of the plover's range-wide population declines, its use of a specialized habitat, and the substantial decline in the extent of native shortgrass prairie.

Long-term demographic data were not adequate to conduct a formal population viability analysis (Beissinger and Westphal 1998) for the mountain plover. Thus, our viability approach in the fine-filter analysis was to recommend specific management practices to provide habitat for the mountain plover on national grasslands identified in the bioregional assessment. This resulted in the following conservation recommendations (step 4) for national grasslands within the historical range of the mountain plover: 1) maintain and expand prairie dog landscapes; 2) burn extensive, flat landscapes; 3) graze domestic livestock intensively in extensive, flat areas to provide bare-ground patches preferred by plovers; 4) avoid predator introductions; and 5) recognize 28 ha as the minimum habitat area for successful brood-rearing (Knopf and Rupert 1996).

Grassland composition and structure

Results of the bioregional assessment and coarse-filter analysis portrayed the Great Plains as a vegetation continuum from tallgrass communities in the east to shortgrass communities in the west. A conservation objective shared by all national grasslands in the analysis was to achieve a distribution pattern of low, moderate, and high structural categories that more closely approximated historic patterns (Table 6). For the Sheyenne National Grassland, this meant managing for the high structure category characteristic of tallgrass prairie. The 6 national grasslands within historic mixed-prairie range would be managed primarily for moderate structure. In consideration of the transitional nature of the mixed prairie, it was further recommended to decrease the low and increase the high structural categories in these grasslands (Table 6). The Thunder Basin National Grassland would be managed for the low vegetation structure characteristic of shortgrass prairie. Both grazing and fire were recommended to move vegetation composition and structure toward the historic patterns. Recommended targets for prescribed burning were as follows: 2.0×10^3 ha per decade on the Cedar River National Grassland and Grand River National Grassland; 9.7×10^3 ha per decade on the Little Missouri National Grassland; 809 ha per decade on the Buffalo Gap National Grassland; and 202 ha per decade on the Ft. Pierre National Grassland.

Table 6. Summary of coarse-filter conservation recommendations: recommended percentage of vegetation cover to be managed in the low, moderate, and high structural categories for the national grasslands in the Northern Great Plains, 2000.

National grassland	Structural category: % low	% moderate	% high
Sheyenne[a] tallgrass	0–20	20–40	50–70
Ft. Pierre[b] mixed prairie	0–20	30–50	40–60
Little Missouri[b] mixed prairie	10–20	36–59	29–46
Grand River/Cedar Grand River[b] mixed prairie	10–20	52–72	13–33
Buffalo Gap[b] mixed prairie	11–22	44–64	23–35
Oglala[b] mixed prairie	10–20	50–70	20–30
Thunder Basin[b] shortgrass prairie	11–20	39–57	22–35

[a] Categories: low (<3.9 cm), moderate (3.9–16.5 cm), and high (>16.5 cm).

[b] Categories: low (<3.9 cm), moderate (3.9–8.4 cm), and high (>8.4 cm).

Category 1 and 2 species

The science team's use of United States Fish and Wildlife recovery plans effectively shortened the time required to develop conservation plans for some Category 2 species. For example, the Black-Footed Ferret (*Mustela nigripes*) Recovery Plan (United States Fish and Wildlife Service 1988) called for establishment of ≥10 wild populations. Using results of the bioregional assessment and fine-filter analysis, the science team determined that the ferret population on the Thunder Basin National Grassland could be substantially increased because key conditions existed there, including a sufficient supply of suitable habitat and primary prey, the black-tailed prairie dog. The team also determined that a population reintroduction of the black-footed ferret to the Buffalo Gap National Grassland and the Little Missouri National Grassland would be biologically feasible.

Where recovery plans were lacking, the team's use of conservation principles within a viability analysis framework yielded species-specific management recommendations. For example, the following conservation recommendations resulted for the Dakota skipper (*Hesperia dacotae*): 1) survey for and identify potentially suitable habitats; 2) maintain and increase suitable habitats to retain characteristics; 3) prohibit use of insecticides in suitable habitats; 4) aggressively manage leafy spurge (*Euporbia esula*), an exotic plant that threatens skipper habitat; 5) inventory suitable habitats prior to prescribed burning or mowing; 6) manage adult flight and larval foraging and overwintering sites on an annual basis; 7) restore tallgrass prairie species; 8) increase the size and juxtaposition of occupied habitats to avoid isolating populations; and 9) cooperate with other agencies and private landowners to identify and manage populations on lands bordering the national grasslands.

Use of a habitat-based population viability model proved useful to develop conservation recommendations for the black-tailed prairie dog. This model assumed that: ≥10 colonies form a viable black-tailed prairie dog colony complex (Hanski 1997); the distance between 2 habitat complexes should be maximized to reduce the risk that plague, a major cause of mortality, will spread between complexes; and habitat complexes should be a mosaic of suitable and unsuitable habitat to reduce the risk of plague transmission within complexes. Multiple complexes were recommended to increase the probability of persistence and the likelihood of recolonization following a plague epizootic. Based on these considerations, the science team recommended management for multiple habitat complexes on the national grasslands to lessen the potential impact of a plague outbreak. The recommendations included 2 habitat complexes on the Little Missouri National Grassland, 2-3 on the Buffalo Gap National Grassland, 1-3 on the Grand River and Cedar River, and 2-3 on the Thunder Basin National Grassland. Multiple complexes also will facilitate recolonization of colonies hit by an outbreak, thereby making long-term persistence more likely.

Category 3 species

The team's approach for Category 3 animal and plant species was to provide conservation recommendations to each national grassland where one or more Category 3 species were known or suspected to occur. For example, national grasslands supporting the Belfragi chlorochroan bug (*Chlorochroa belfragii*) and greater prairie chicken (*Tympanuchus cupido*), both tallgrass species, were provided with recommendations to 1) provide for a high degree of heterogeneity in tallgrass prairie structure, 2) emphasize late-seral habitats, and 3) use prescribed fire to restore the natural disturbance regime. An example of conservation recommendations for Category 3 plant species associated with the Buttes habitat type (i.e., the Torrey's cryptantha [*Cryptantha torreyana*], alyssum-leafed phlox [*Phlox alyssifolia*], and Hooker's townsendia [*Townsendia hookeri*]) was to 1) restore communities associated with the unique Butte habitat, 2) reduce road densities and number of water developments, 3) restore historic (1770-1840) hydrologic regimes, and 4) limit pesticide use to avoid impacts on pollinators.

Conservation recommendations for the remaining 63 Category 3 animal and plant species are in the report, *Terrestrial assessment: a broad look at species viability on the Northern Great Plains* (Samson, F. B., United States Forest Service; F. L. Knopf, United States Geological Survey Biological Resources Division; S. Larson, United States Fish and Wildlife Service; B. R. Noon, Colorado State University; W. R. Ostlie, The Nature Conservancy; G. E. Plumb, National Park Service; and C. L. Sieg, United States Forest Service; unpublished report). General conservation recommendations for the remaining Category 3 animal species-at-risk were to 1) provide for heterogeneity of grassland structure, emphasizing low- and high-seral habitats, and prairie dog colonies on mixed prairie, 2) provide for diverse habitat structure, emphasizing low-seral habitats and prairie dog colonies on shortgrass prairie, and 3) retain and restore native habitats, reduce road densities and water developments, and restore hydrologic regimes within the context of the historic 1770-1840 landscape on the badlands. Conservation recommendations for the remaining Category 3 plant species-at-risk were to 1) emphasize natural hydrological regimes of natural wetland communities, control nonnative plant species, and use grazing to limit impacts of roads in tallgrass prairie wetland and choppy sandhill habitats; 2) emphasize native ecological processes, control nonnative plant species, and graze within the context of the historic 1770-1840 landscape in the western rocky and scoria hills; and 3) emphasize native ecological processes, control nonnative plant species, and manage for a landscape within the context of the 1770-1840 historic landscape in eastern prairie boggy wetland, western plains riparian, conifer, riverine and wetland, and deciduous woodland habitats.

Step 5—Dealing with uncertainty and risk

The science team's concluding step was to acknowledge the uncertainty associated with management recommendations for species viability and biodiversity conservation. In essence, the conservation plan was made up of management hypotheses. Testing of the plan, including prescriptions developed through coarse-filter and fine-filter analyses, requires monitoring and evaluation of effects against predicted responses. However, population monitoring of 86 species-at-risk scattered across 8 national grasslands in the Northern Great Plains is neither feasible nor affordable. Cost-effective methods do not now exist for comprehensive assessment of species status and trends (see discussion in Noon 2003). Development of efficient methods for comprehensive species monitoring is a high priority in conservation planning. It appears there is no unifying method that will allow us to successfully monitor all species including those considered to be at risk. Therefore, monitoring must both be focused and involve priority setting.

Some grassland species may have potential to serve as surrogate measures of vegetation composition and structure and native species richness (Knopf et al. 1988). Such relationships are implied in coarse-filter analysis, which essentially hypothesizes that viable species will be provided for through implementation of the coarse-filter habitat recommendations. The science team selected 4 species having potential to function as surrogates: the black-tailed prairie dog to represent the biological communities associated with prairie dog colonies and low structure grasslands; the sharp-tailed grouse (*Pedioecetes phasianellus*) and greater prairie chicken to represent high structure grasslands; and the greater sage grouse (*Centrocercus urophasianus*) to represent high structure sagebrush with diverse perennial herbs in the understory. These species were recommended for population monitoring because their distribution and abundance are known to be closely associated with the vegetation composition and structure of their respective habitats. Additional studies will be required to test the validity of the "surrogate hypothesis."

We found that even in the case of Category 1 and Category 2 species-at-risk, basic knowledge of occurrence patterns may be lacking because of incomplete information and inappropriate sampling methods. Documenting occurrence patterns is an essential first step to delineate candidate areas for conservation, conduct status and risk assessments of the units in which species occur, and begin the process of prioritizing the units for species-at-risk.

In the case of Category 3 animal and plant species, it is important to reduce uncertainty surrounding the factors that threaten species persistence and to emphasize those factors in monitoring (e.g., preservation and restoration of habitat, and control of human-related disturbances) (Foin et al. 1998). The monitoring strategy should invest available resources (funding, personnel) according to degree of risk. As well, monitoring should be designed to measure the effectiveness of preservation, restoration, and control efforts.

Conclusions

It is not possible to develop an affordable and practical large-scale planning approach that would rigorously assess the viability of all animal and plant species (or even the subset of all at-risk species) that occur on national grasslands in the Northern Great Plains. However, we conclude that our approach to large-scale conservation planning is scientifically defensible and provides conservation guidelines that should contribute to population viability for the majority of species. In practice, population viability analysis has tended to focus on individual species whose ecology and life history are relatively well known. The mandate of the Forest Service is much more comprehensive, however, in requiring that habitat management provide for viable populations of all native and desirable introduced vertebrate and vascular plant species. Intensive viability analyses for all species is not an option. Instead, public land managers must employ approaches that allow concentration of effort such that habitat factors affecting many species become less limiting. By considering ecological processes that sustain and renew the environment for the majority of species, managers may develop comprehensive monitoring programs that focus on few species or ecological variables (e.g., coarse-filter elements) but indicate status and trends for all the unmeasured species.

Limitations on funding and human resources significantly affect an agency's ability to plan for and achieve conservation goals. The direct cost of the conservation planning approach described here was $26,760. Moreover, membership of the science team was specifically designed to reduce the likelihood of disagreement between the United States Fish and Wildlife Service and the Forest Service about species management, particularly in issues relating to the Endangered Species Act (1973). This collaboration helped build consensus and rapid agreement between management and regulatory agencies, expedited the implementation of conservation measures, and achieved indirect cost savings.

We suggest that biodiversity conservation goals for Northern Great Plains ecosystems can be advanced by implementing the conservation guidelines emanating from the cost-effective, science-based approach described here. The approach offers a high likelihood of providing effective conservation strategies in a situation of incomplete knowledge. It represents a cost-effective use of public funds to identify appropriate strategies and specific management actions for maintaining at-risk species and overall biodiversity.

In closing, we emphasize that monitoring is an essential element of the approach, both for tracking the status of habitats and species and for testing underlying management assumptions and hypotheses. Conservation planning, plan implementation, monitoring, and adaptive feedback are all required for a comprehensive approach to promoting species recovery. If duly implemented, the approach will improve understanding of the impacts of natural and human-induced disturbances and increase the likelihood that viable populations of all native animals and plants will be maintained in the planning area.

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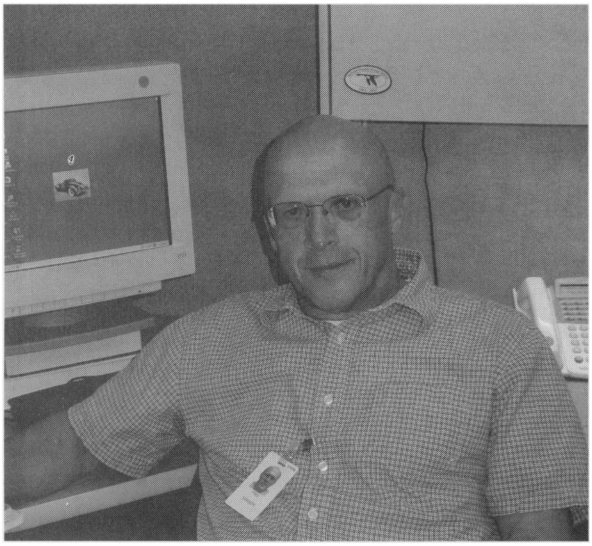
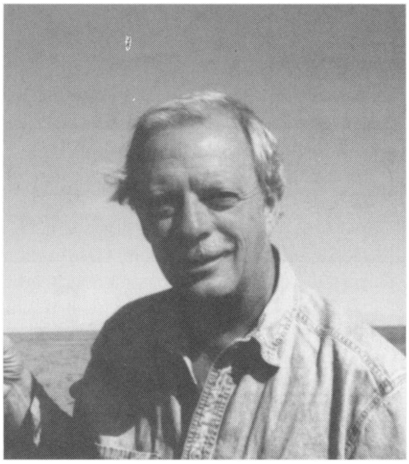
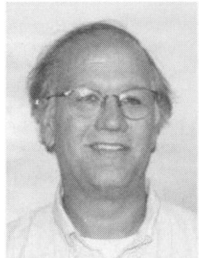
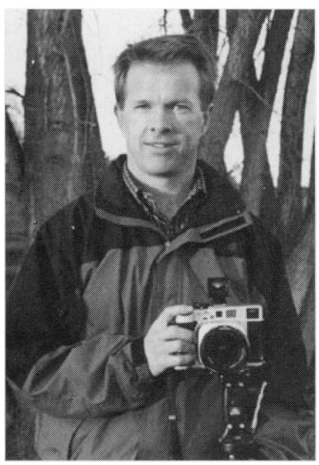


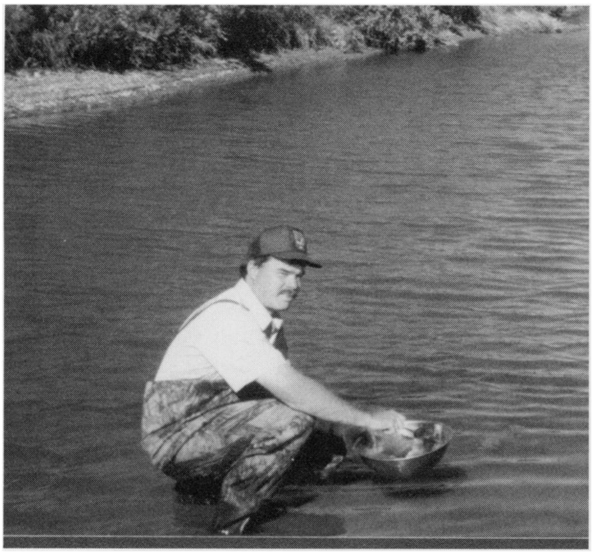
Fred B. Samson is a regional wildlife ecologist for the United States Forest Service in Missoula, Montana. He received his B.A. in business and M.S. in zoology from Indiana University and a Ph.D. in ecology from Utah State University. Fred has worked for the United States Fish and Wildlife Service, Forest Service research and management, and taught at Pennsylvania State University, State College. His primary conservation activities are large-scale planning and applied biodiversity conservation with a particular interest in the Great Plains grasslands. ***Fritz L. Knopf*** received his B.A. in biology from Hiram College and M.S. and Ph.D. in wildlife ecology from Utah State University. He is currently a senior scientist with the United States Geological Survey's Biological Resources Division, Fort Collins, Colorado; has served as project leader and branch chief of vertebrate ecology for the National Biological Survey; and has taught at Oklahoma State University. Fritz's primary research interests are in the conservation of Great Plains grasslands and declining wildlife that depend on prairie. ***Clinton W. McCarthy*** has 25 years of professional experience with the United States Forest Service in California, the Great Plains, and the Great Basin. His work in conservation has focused on the greater prairie chicken, western prairie-fringed orchid, black-tailed prairie dog, sage grouse, and the development of large-scale strategies to conserve such species. He is currently a regional wildlife ecologist for the Intermountain Region of the Forest Service. His education includes a B.S. in biology from Humboldt State University and graduate school at the University of Nevada, Reno. ***Barry R. Noon*** received a B.S. from Princeton University and a Ph.D. from the State University of New York, Albany. He has served as a supervisory research ecologist for the United States Forest Service, chief scientist for the National Biological Survey, taught at Humboldt State University, and is currently a professor of wildlife science, Colorado State University. His research interests include landscape ecology, population dynamics, conservation biology, and endangered-species management. ***Wayne R. Ostlie***'s current position is senior manager, Ecoregional Assessment Learning Center, The Nature Conservancy, in Washington, D.C. Since 1987 Wayne has held a number of positions with the Conservancy including director of science for the Great Plains Program and director of science and stewardship with the Conservancy Field Office. He received a B.A. in biology from Luther College and an M.A. in biology from the University of Kansas. His primary interest is to deliver training, peer review, tools, and methods to ecoregional practitioners worldwide. ***Susan M. Rinehart*** received a B.A. in political science from the University



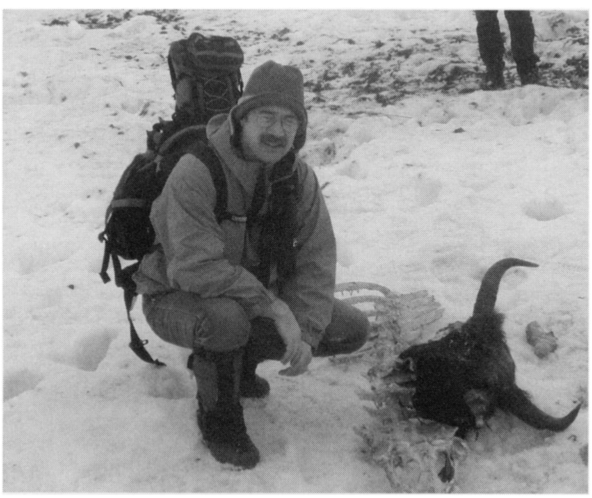




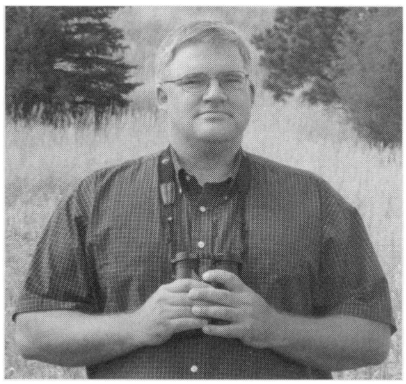
of Missouri, Columbia, a B.S. in range ecology from the University of Wyoming, and is nearing the completion of an M.S. in ecosystem management from the University of Montana. She is currently a botanist for the United States Forest Service in Missoula, Montana and has worked as both a botanist and a range conservationist for the Forest Service for the Deerlodge National Forest in Montana and the Little Missouri National Grasslands in North Dakota. Susan's primary interests are in linking science and management in the conser-



vation of rare plants. ***Scott Larson*** received a B.S. and an M.S. in wildlife management from South Dakota State University. He has worked for 17 years with the United States Fish and Wildlife Service's Ecological Services in the Northern Great Plains with a focus on endangered-species management and effects of environmental contaminants of prairie ecosystems and wildlife. He has been particularly active in the conservation and restoration of the black-footed ferret to the Northern Great Plains.



Glenn E. Plumb is supervisory wildlife biologist, Yellowstone National Park, and serves as wildlife program manager for all wildlife management, monitoring, and research activities in the Park. Prior to this, Glenn worked as a wildlife biologist for the National Park Service in the Badlands National Park and for The Nature Conservancy and the University of Wyoming. Glenn received a B.S. in forestry from the University of West Virginia, an M.S. from Texas Tech University in range management, and a Ph.D. in range ecology from the University of Wyoming. His research interests include the ecology of ungulates and carnivores. ***Gregory L. Schenbeck*** is the wildlife program manager for several national grasslands and forests in Nebraska and South Dakota and also teaches wildlife management at Chadron State College. Greg's primary interest is grassland wildlife and livestock grazing relationships. He has worked extensively with management of black-tailed prairie dogs, plains sharp-tailed grouse, and greater prairie chickens and served on the National Black-Footed Ferret Recovery Team. Prior to his Forest Service career, Greg worked for the Nebraska Game and Parks Commission and Colorado Division of Wildlife. He received his B.S. and M.S. in wildlife biology from Colorado State University and has been a certified wildlife biologist since 1979. ***Daniel N. Svingen*** received an Associate degree in wildlife biology from North Dakota State University– Bottineau, a B.S. in zoology from North Dakota State University, and an M.S. in wildlife biology from the University of Wyoming. Dan has worked for the United States Forest Service for 13 years in 9 states and prior to that for several state and federal agencies. Dan's focus is on grassland conservation and management, with an emphasis on grassland birds, and he is recognized for the development and publication of birding guides in Colorado and North Dakota. ***Timothy W. Byer*** received a B.S. in biology from the University of Wyoming and is currently a wildlife biologist on the Douglas and Thunder Basin National Grasslands in eastern Wyoming. His primary management interests include the effects of energy development on grassland wildlife, management for rare prairie species such as the black-footed ferret, and the development of partnerships between agencies and other organizations to conserve wildlife. Tim continues to serve in a leadership role for Partners in Flight and in the development of practical conservation strategies for bird species considered to be at-risk.



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