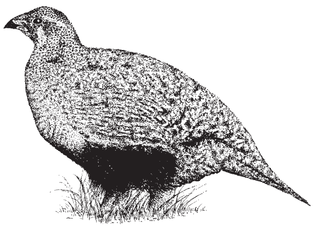
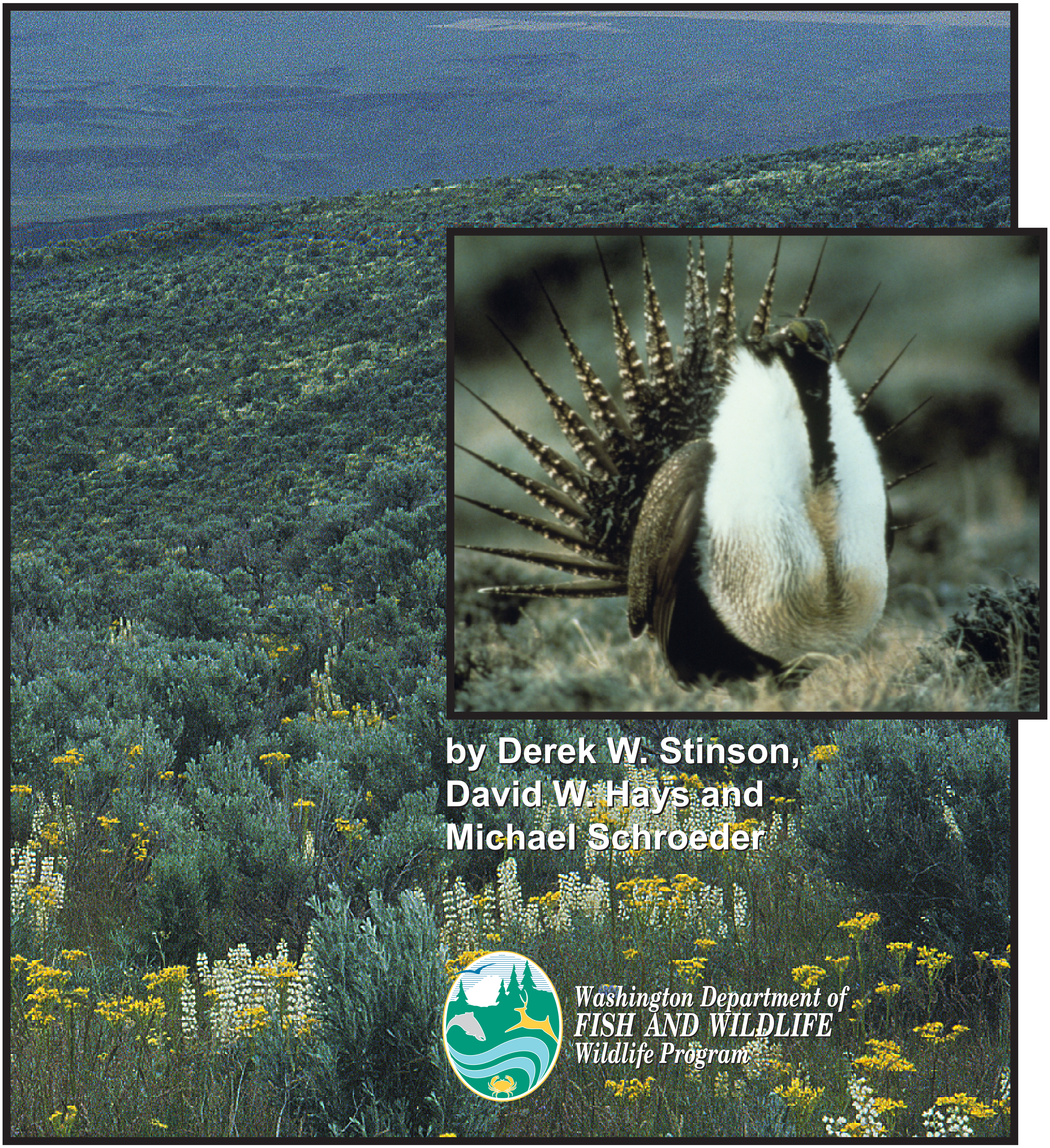
STATE OF WASHINGTON — May 2004

Greater Sage-Grouse Recovery Plan





by Derek W. Stinson, David W. Hays and Michael Schroeder

Washington Department of FISH AND WILDLIFE
Wildlife Program

In 1990, the Washington Wildlife Commission adopted procedures for listing and de-listing species as endangered, threatened, or sensitive and for writing recovery and management plans for listed species (WAC 232-12-297, Appendix B). The procedures, developed by a group of citizens, interest groups, and state and federal agencies, require preparation of recovery plans for species listed as threatened or endangered.

Recovery, as defined by the U.S. Fish and Wildlife Service, is "the process by which the decline of an endangered or threatened species is arrested or reversed, and threats to its survival are neutralized, so that its long-term survival in nature can be ensured."

This document summarizes the historic and current distribution and abundance of sage-grouse in Washington and describes factors affecting the population and its habitat. It prescribes strategies to recover the species, such as protecting the population and existing habitat, evaluating and restoring habitat, reintroducing birds into vacant habitat, and initiating research and cooperative programs. Target population objectives and other criteria for reclassification are identified.

The draft state recovery plan for the sage-grouse was reviewed by researchers and representatives from state and federal agencies, regional experts, and non-governmental organizations. This review was followed by a 90-day public comment period. All comments received were considered in preparation of the final recovery plan. For additional information about sage-grouse or other state listed species, check our web site (http://wdfw.wa.gov/wildlife.htm), or contact:

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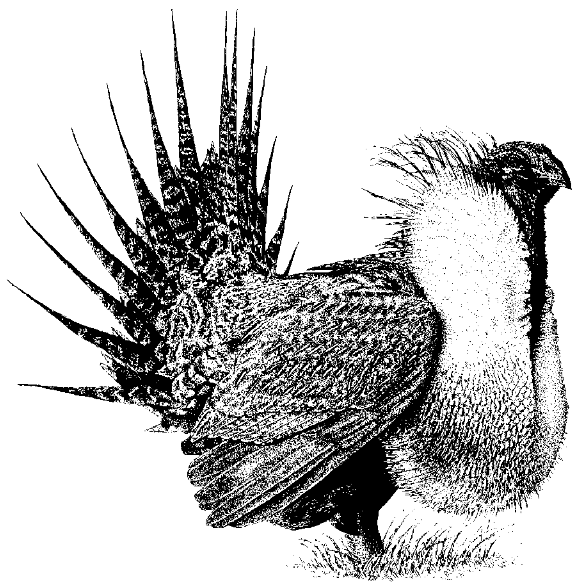
Washington State Recovery Plan for the Greater Sage-Grouse



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May 2004

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ACKNOWLEDGEMENTS

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Jerry Benson, WDFW retired; Heidi Newsome, USFWS; Rocky Ross, Pete Lopushinski, Dan Peterson, Paul Wik, and Greg Fitzgerald of WDFW; and Colin Leingang and Brian Knapp at Yakima Training Center provided information about restoration work, ongoing management activities, reports, or otherwise assisted with the draft. John Talmadge and John Jacobson patiently developed maps and analyzed spatial data. Darrell Pruett created the black and white cover illustrations. Diane Mitchell and others at the Washington State Library provided invaluable assistance in obtaining published literature.

The Washington Sage-Grouse Working Group has contributed to sage-grouse conservation in Washington by developing an HSI model, revising management unit maps, and reviewing the first draft of the recovery plan. Formerly called the *South-Central Washington Sage Grouse Enhancement Committee*, the group was formed in 1998 to work on sage-grouse conservation, with primary focus on the population on the Yakima Training Center, and efforts to expand into other areas such as the Hanford and Yakama Reservation. The recovery plan has broadened the interest of the group to statewide sage-grouse conservation. The group, now called the Washington Sage-Grouse Working Group, is being expanded to include representation by landowner and agricultural groups to reflect the greater importance of private lands. The committee included the individuals listed below.

Washington Sage-Grouse Working Group

Brent Billingsley, WDNR	Margaret Pounds, Yakima Training Center
Larry Cadwell, U.S. Dept of Energy	Deb Salstrom, SEE Botanical
Rich Easterly, SEE Botanical	Mike Schroeder, WDFW
Rob Fimbel, Washington State Parks	Andy Stepniewski, Yakima Audubon
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Steve Kruger, Yakima Training Center	Todd Thompson, BLM
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Mike Livingston, WDFW	Chuck Warner, The Nature Conservancy
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Doug Pineo, N. American Grouse Partnership	

EXECUTIVE SUMMARY

The sage-grouse was listed as a threatened species by the state of Washington in 1998. In May 2001, the Washington population of the sage-grouse also became a Candidate for listing under the federal Endangered Species Act when the U.S. Fish and Wildlife Service (USFWS) found that listing as Threatened was warranted but precluded by higher priority listing activities. This Recovery Plan summarizes the state of knowledge of sage-grouse in Washington and outlines strategies to increase their population size and distribution in order to ensure the existence of a viable population of the species in the state.

The sage-grouse has been declining in Washington and many parts of its range in North America. The reduction in sage-grouse numbers and distribution in Washington is primarily attributed to loss of habitat through conversion to cropland and degradation of habitat by historic overgrazing and the invasion by cheatgrass and noxious weeds. Sage-grouse occur on about 8% of their historical range in the state. The population is estimated to have declined 62% from 1970 to 2003. Local extirpations have been noted as recently as the 1980's. The statewide breeding population of sage-grouse in Washington in 2003 was estimated to be 1,011 birds. This estimate is based on leks counts of males, and probably is an underestimate.

A breeding population of about 624 sage-grouse is located in Douglas and Grant Counties where a large amount of agricultural lands are enrolled in the Conservation Reserve Program (CRP) and shrub-steppe remnants exist where rocky soil and rugged terrain have precluded agricultural conversion. The other population of about 387 birds is located in Kittitas and Yakima counties in contiguous shrub-steppe that has been maintained on the Yakima Training Center (YTC), a U.S. Army training facility. Neither of the 2 isolated grouse populations is large enough for long-term viability. A recent investigation indicated reduced genetic diversity in both the YTC and Douglas-Grant populations. The polygamous mating system and fluctuations of sage-grouse populations over time reduce the effective population size and increase the number of grouse needed for a population to be viable.

Major threats to the Washington populations include fires and continued conversion of shrub-steppe to cropland or development; additional factors affecting sage-grouse include the impacts of military training and past and ongoing grazing practices. The Douglas-Grant County population is dependent on voluntary enrollment of private lands in CRP, a program that may not always be funded by Congress. Maintenance of the YTC population requires frequent rehabilitation of damage to vegetation caused by military training. Wind energy developments may pose a threat to recovery if sage-grouse avoid nesting and brood rearing within 1 mile of wind turbines, as has been predicted for prairie-chickens. One wind energy project that was recently denied a permit by Benton County, might have effectively eliminated 43 mi^2 of recovery area from use by breeding sage-grouse; a second proposal may affect suitability of habitat in an important corridor between the 2 existing populations. Remaining habitat has been degraded by fragmentation, historic overgrazing, fires, and the invasion by cheatgrass, medusahead, and other exotic weeds. Disease is a potential new threat to the population. In August 2003, West Nile Virus killed sage-grouse in Wyoming, Montana, and Alberta. The implications of the added source of mortality for more robust populations are not yet known, but the disease may pose a serious threat to Washington's small populations.

The small size and continued threats to the 2 populations suggest that the long-term persistence of sage-grouse in Washington will depend on protecting and enhancing suitable shrub-steppe habitat, re-establishing additional populations, and expanding existing populations outside the current occupied areas. The minimum viable population for sage-grouse in Washington is estimated at 3,200 birds. The recovery objective to down-list the sage-grouse from Threatened to Sensitive status is an average breeding season population of

at least 3,200 birds for a period of 10 years, with active lek complexes in 6 or more Sage-grouse Management Units. The recovery plan outlines strategies to increase population numbers and distribution. A study is underway to evaluate the feasibility of re-establishing a sage-grouse population on the Yakama Reservation through reintroductions. A project to translocate additional birds into the YTC population to reduce genetic deterioration is also underway; 25 sage-grouse hens were trapped in Nevada and transported to Washington and released on the YTC in March 2004.

Sage-grouse recovery will require protecting remaining shrub-steppe habitat from fires, harmful grazing, conversion, and development. Some areas of degraded shrub-steppe will need to be restored in order to support nesting sage-grouse. The structure of older CRP fields increasingly resembles shrub-steppe and provides important habitat, but CRP does not guarantee long-term protection. New programs in the 2002 Farm Bill may benefit sage-grouse by providing funding for habitat improvements, protection, and the acquisition of perpetual conservation easements. Washington Department of Fish and Wildlife (WDFW), the Bureau of Land Management (BLM), and The Nature Conservancy have recently acquired lands where shrub-steppe will be protected or restored, but restoration may take a long period of time. The success of sage-grouse recovery, however, may depend on cooperative efforts by private landowners, tribes, and agencies that manage public lands in recovery areas or influence agricultural practices on private lands. These agencies include the U.S. Army, WDFW, BLM, USFWS, U.S. Department of Energy, Washington Department of Natural Resources, Washington State Parks, and USDA Natural Resources Conservation Service. A multi-party 5-year action plan for sage-grouse that will outline more specific actions and responsibilities may be completed by the Washington Sage-grouse Working Group in 2004.

Maintaining sage-grouse in Washington will depend on protecting remaining habitat, restoring degraded habitat and re-establishing populations outside their current range. Sage-grouse recovery in Washington will take a sustained cooperative effort by many agencies and individuals for a long period of time. Successful recovery of sage-grouse will result in benefits to many other shrub-steppe species that have also declined dramatically in the state.

PART ONE: BACKGROUND

INTRODUCTION

The greater sage-grouse (*Centrocercus urophasianus*) has experienced widespread declines and has been eliminated from many locations, particularly along the outer perimeter of its historical range. Washington historically hosted a population that perhaps numbered in the tens of thousands, but with the conversion of habitat to cropland, the state's population has dwindled to two small populations. The sage-grouse hunting season was closed in 1988, and in 1991 the species was added to the list of candidates for possible listing as sensitive, threatened, or endangered in the state. The sage-grouse was added to the state list of threatened species in 1998 after the release of a status report that summarized all information available about the status of its population, its habitat, and other factors potentially affecting the population. This plan updates the information in the 1998 status report, identifies population recovery objectives, and outlines activities needed to recover a viable population of sage-grouse in Washington.

TAXONOMY

Greater sage-grouse belong to the family Phasianidae (pheasant-like birds) and subfamily Tetraoninae (A.O.U. 1998). Two subspecies of greater sage-grouse have been traditionally recognized: the western sage grouse (*Centrocercus urophasianus phaios* Aldrich), which occurs in eastern Washington and central and southeastern Oregon; and the eastern sage grouse (*C. u. urophasianus* Bonaparte) which inhabits the remainder of the species' range. A recent investigation, however, detected no apparent genetic difference between these two subspecies (Benedict et al. 2003). The Gunnison sage-grouse (*C. minimus*) that occurs in southwest Colorado and southeast Utah was recently recognized as a separate species by the American Ornithologist's Union. It is smaller with longer tail feathers, and differ in several other traits from *C. urophasianus*, which was given the official common name of greater sage-grouse (Young 2000, AOU 2000).

Common colloquial names of sage-grouse include sage hen, sage fowl, spine-tail grouse, fool hen, cock of the plains, spiney-tailed pheasant, sage cock, and sage chicken (Coues 1893, Girard 1937, Patterson 1952, Jewett et al. 1953, Johnsgard 1973). The genus name *Centrocercus* means 'spiny-tailed'.

DESCRIPTION

The greater sage-grouse is the largest North American grouse species. Adult males range in size from 66 to 76 cm (26 – 30 in) and in the breeding season weigh between 2.5 and 3.2 kg (5.5 – 7.0 lb); adult females range in size from 48 to 58 cm (19 – 23 in) and weigh between 1.3 and 1.7 kg (2.9 – 3.7 lb) (Schroeder et al. 1999). Adults have a variegated pattern of brownish gray, buff and black on the upperparts, a black belly, and white underwing coverts and a long pointed tail. Males are larger and more colorful than females, with a black throat and bib and white breast. The white breast feathers conceal 2 large yellowish-green balloon-like gular sacs which are inflated during mating displays. Females are more cryptically colored with grayish-white upper throats and the white tips of the under tail coverts that extend part way down to the feather rachis (Pyrah 1963). The blue grouse (*Dendrogapus obscurus*) is distinguished from female sage-grouse by its smaller size, rounded tail and the lack of a black belly. The larger size, dark belly, overall grayer color, longer tail, and absence of white outer-tail feathers distinguish sage-grouse from the sharp-tailed grouse *(Tympanuchus phasianellus)*, a co-inhabitant of portions of sage-grouse range in Washington.

GEOGRAPHICAL DISTRIBUTION

North America. Sage-grouse occur only in western North America. Historically, greater sage-grouse were distributed throughout much of the western United States in 13 states and along the southern border of three western Canadian provinces (Patterson 1952, Braun 1993) (Fig. 1). Gunnison sage-grouse were found in southwestern Colorado, southeastern Utah, northern New Mexico and in western Oklahoma and Kansas (Young et al. 2000). Sage-grouse range followed the distribution of sagebrush (*Artemisia* spp.) north to British Columbia, south to Arizona, east into Nebraska, and west to California (Aldrich 1963, Guiquet 1970). Lewis and Clark first reported sage-grouse at the head of the Missouri River and on the plains of the Columbia Basin.

Currently, greater sage-grouse occur in 11 states and 2 provinces ranging from southeastern Alberta and southwestern Saskatchewan, south to northwestern Colorado, and west to eastern California and central Oregon and Washington. Within this area, sage-grouse occur in southern Idaho, northern Nevada, Utah, Wyoming, central and eastern Montana, and extreme western North and South Dakota (Schroeder et al. 1999). Greater sage-grouse have been extirpated from Arizona, Nebraska, and British Columbia (Braun 1998); Gunnison sage-grouse have been extirpated from New Mexico, Kansas, and Oklahoma (Young et al. 2000).

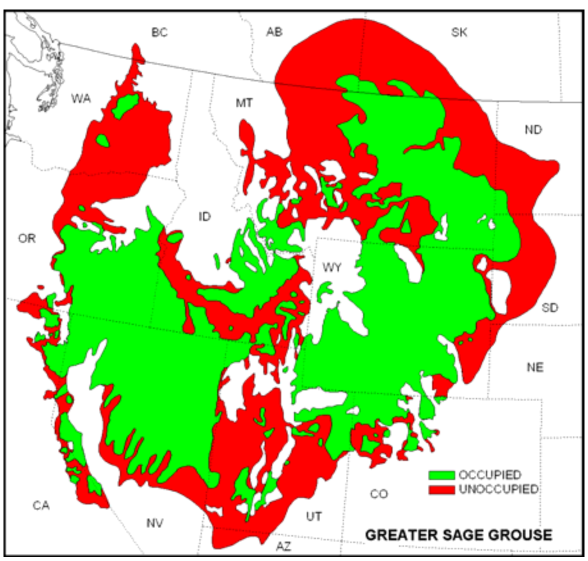

Figure 1. Historical and currently occupied range of the greater sage-grouse.

Oregon. Sage-grouse were distributed throughout central and eastern Oregon, except for Wallowa County, in sagebrush dominated areas until the early 1900s (Gabrielson and Jewett 1940). By 1920, sage-grouse populations had decreased and were considered scarce except for areas in southeastern Oregon (Gabrielson and Jewett 1940, Meyers 1946). Sage-grouse distribution in Oregon declined by approximately 50% from 1900 to 1940 (Crawford and Lutz 1985). By 1955, the northern parts of the state, including Jefferson, Wasco, Sherman, Morrow, and Umatilla counties, and sizeable portions of Lake County in south-central and Grant County in northeastern Oregon were devoid of sage-grouse (Fig. 1; Masson and Mace 1962, Drut 1994). Further declines in distribution and abundance likely continued to the mid-1980s (Crawford and Lutz 1985). In 1992, there were estimated to be 28,000 - 66,000 breeding birds in Oregon (Willis et al. 1993).

Washington. The estimated historical distribution of sage-grouse in Washington spanned 57,741 km^2 (Fig. 2). Sage-grouse inhabited the shrub-steppe and meadow steppe of the Columbia Basin region of eastern Washington. There are now 2 relatively isolated sage-grouse populations remaining in Washington. Their total range has been reduced about 92% to 4,683 km^2 (Schroeder et al. 2000). One population is found in Douglas and Grant counties, predominantly on private land. The other population is found on the Yakima Training Center (YTC), a U.S. Army training facility in Kittitas and Yakima counties. Both populations are isolated from one another, as well as surrounding populations in Idaho and Oregon.

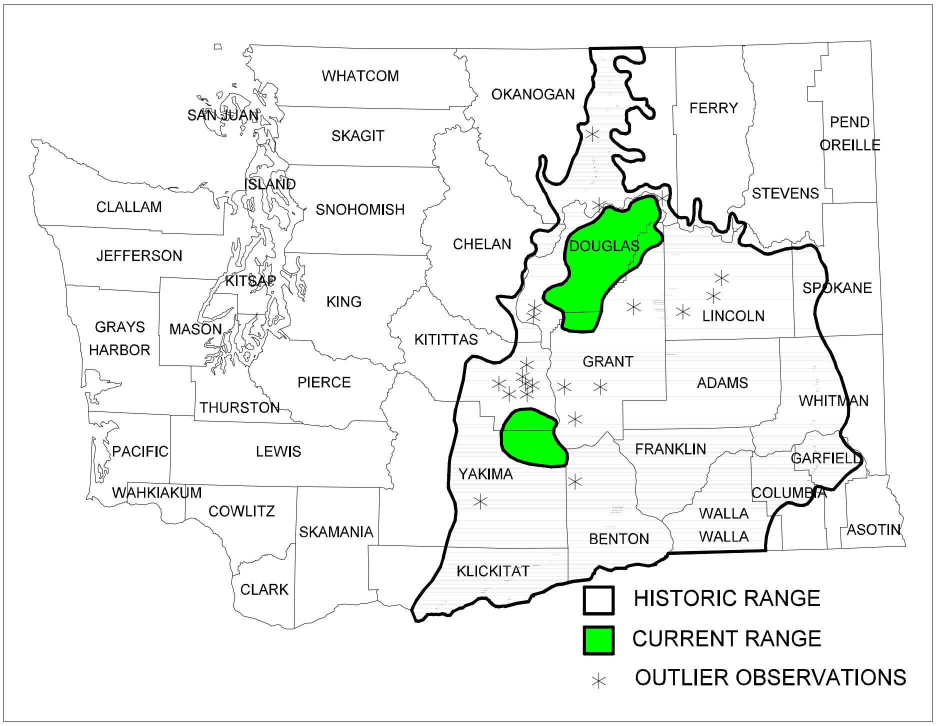

Figure 2. Historical and current sage-grouse range in Washington (from Schroeder et al. 2000).

NATURAL HISTORY

Behavior

The spring courtship display of males is the most conspicuous behavior of sage-grouse. Male and female sage-grouse gather in the spring for displaying and mating at specific locations, called "leks." At the beginning of the breeding season, male sage-grouse establish small territories on the lek. Adult males occupying territories near the center of the lek are usually more successful at mating (Davis 1978). Adult males typically establish and occupy territories before yearlings and dominate breeding activities. Males perform the spring strutting display to proclaim and defend a territory and attract females for copulation (Johnsgard 1973). The ability to attract females and copulate is determined through display and aggressive behavior by males (Hartzler and Jenni 1988). Males stand on their territory with tail feathers fanned, wings drooped, neck feathers ruffled, and the esophogeal air sacs inflated (Johnsgard 1973). The white-tipped tail feathers contrast sharply with natural colors in the shrub-steppe environment; the tail attracts females and serves as a warning to males (Hjorth 1970). Ruffled neck feathers, inflated air sacs, and enlarged eye combs likely serve the same function (Hjorth 1970). To begin the display a male stands erect, fans his tail, lowers his folded wings, and steps forward. The back is gradually raised, the white feathers above the eyes (filoplumes) are erected, and the air sacs exposed. Next, the air sacs are pushed outward and the male jerks upwards. The display peaks when males pull their heads into the neck feathers and emit loud distinctive plop sounds produced in conjunction with expansion of their air sacs. The sequence is then repeated with slight variations and more steps.

During most of the year, sage-grouse segregate into flocks according to sex. Broodless hens gather in flocks in early summer and remain separate from hens with broods (Gregg et al. 1993). Where sage-grouse are migratory, they may congregate in late summer and early fall in flocks of both sexes in preparation for movement to wintering grounds (Patterson 1952). Similar aggregations may occur in late winter or early spring before movement to breeding areas (Patterson 1952). However, not all sage-grouse populations undergo these seasonal movements (Connelly et al. 1988).

Reproduction

Chronology. The mating season generally begins at about the same time each year, but can vary depending on weather and vegetative conditions. In Douglas and Grant counties, most birds return to breeding areas in late February or March (Schroeder 1994), and Pedersen (1982) recorded the highest number of male and female sage-grouse on leks from mid-March to mid-April. On the YTC, males return to the vicinity of leks in February and females return in March (M. Livingston, pers. comm.), and the annual peak of male attendance has ranged from 7 March to 25 April (U.S. Army 2002). Mating begins after males and females congregate on a lek. Hens form clusters near a few centrally-located, dominant males (Hartzler and Jenni 1988); These dominant males participate in most of the mating (Eng and Schladweiler 1972). Males spend early morning and late evening at leks and remain nearby the rest of the day (Batterson and Morse 1948, Wallestad and Schladweiler 1974). After mating, males spend the summer alone or in small flocks. In Washington, males begin to leave leks in late April and early May and move to summer habitat (Pedersen 1982, Cadwell et al. 1994). Average date of nest initiation was 22 April (range: 1 Apr - 26 May) for 182 nesting attempts in northcentral Washington, 1992-1996 (Schroeder 1997). First nests were generally initiated in April, and renestings after predation or other failure were initiated in May. Yearlings nested an average of 9.4 days later than adult females. The mean duration of incubation for 66 successful nests was 26.8 days (range: 25-28)(Schroeder 1997).

Fidelity to breeding areas. Most specific lek sites are traditional with some occasional shifting of locations, but the sites may be used for many years. Bird point arrowheads suggest that leks that occur at natural openings in the vegetation, such as the beds of drying playa lakes may be used for hundreds or perhaps even thousands of years (Dalke et al. 1963). Leks on the YTC have changed considerably; of 9 leks monitored in 1991, only one was still active in 1998, and other new leks were discovered (Livingston 1998). Most male sage-grouse return to the same lek or lek complex each spring (Schlatterer 1960, Jarvis 1974, Braun and Beck 1976, Wiley 1978). In Montana, almost all males returned to the same lek regardless of their success at mating (Hartzler and Jenni 1988). Male sage-grouse in Washington demonstrate strong fidelity to leks. All 43 males in Pederson's (1982) study remained at the same leks throughout the breeding season. During 1992-1998, only 1 of 19 radio-tagged adult males visited more than 1 lek, but 4 of 9 yearlings visited 2 leks (Schroeder and Robb 2003). All 4 males monitored by Schroeder (1994) during consecutive breeding seasons attended the same lek.

A male may choose a lek based on the number of females likely to visit (Bradbury et al. 1989b). Some young adult males that have not been able to secure a position at established, relatively permanent 'core' leks may attend temporary 'satellite' leks or may establish new leks (Gates 1985). Clusters of shifting lek locations and core and satellite leks can be grouped into identifiable 'lek complexes.' Specific lek sites within a complex are usually < 3 km from one another. Lek complexes are usually spatially separated from adjacent complexes by ≥ 6 km. Fluctuations in annual counts of sage-grouse among adjacent leks and observations of birds moving among leks in the same area indicate some shifting of use among the leks of a complex. Leks can become obsolete because of habitat changes or disintegration of local populations.

Females generally return to the same nesting area (Schroeder et al. 1999), and probably visit the same lek or leks each year. The general pattern in Douglas County seemed to be that females typically visited the same lek within a single nesting cycle, with occasional visits to other leks prior to renesting; 24 of 78 (30.8%) females visited ≥2 leks, and 8 visited ≥3 leks; there was no difference between adult and yearling females (Schroeder and Robb 2003). The likelihood of observing a female at >1 lek increased with the number of observations, but the proportion appeared to level-off at 40-50% of females with ≥ 5 observations (Schroeder and Robb 2003).

Nests were an average of 1.6 km from the previous year's nest for successful females and 5.2 km for unsuccessful females. Most distances between consecutive nests were < 3 km, but some females moved >20 km. One female in Washington nested 32.9 km from her previous season's nest, and again moved 32.4 km to nest in the 3rd year, returning to the vicinity of the first year's nest (Schroeder and Robb 2003); another female made a similar round trip of 19 km. Another Washington female moved 27 km between a first nest and a renest (Schroeder and Robb 2003). In Idaho and Montana, the nest was typically 500-700 m from the previous year's nest bush (Berry and Eng 1985, Fischer et al. 1993), but some longer distances between nests have been noted (J. Connelly, pers. comm.). The greater distances moved between nests in Washington may be related to fragmentation of the habitat in Douglas County, where only 44% remains in native shrub-steppe, and much of this consists of small patches (Schroeder and Robb 2003). The mean inter-lek distance in the study was about 6.9 km during the 1960 - 1999 period, but from 1992- 1998, the mean inter-lek distance for the 12 remaining leks was 10.2 km.

Nesting. After mating, females devote most of their time to building nests, laying eggs, incubation, and raising chicks; males do not assist in these activities (Rasmussen and Griner 1938, Patterson 1952, Harrison 1978). Females build nests within 7 - 10 days of mating (Autenrieth 1981, Call and Maser 1985). Nests are typically located 2 to 6 km (1-4 mi) from leks (Gill 1965, Martin 1970, Jarvis 1974, Wallestad and Pyrah 1974, Petersen 1980, Pedersen 1982, Berry and Eng 1985, Eberhardt and Hofmann 1991, Wakkinen et al. 1992, Fischer et al. 1993). In Washington, nests were <1 to 19 km (0.62-12 mi) from leks on the YTC (Cadwell et al. 1994). In Douglas County, the first nests of 82 females (n = 204 nests) averaged 7.3 km from the lek of capture, and 5.1 km from the nearest lek (Schroeder 2001). Nest placement likely depends on habitat quality and not distance to the lek (Wakkinen et al. 1992). In California, hens chose nest sites before they chose a lek, they traveled farther from winter grounds to select a nest site than to select a lek, and after mating, they nested on the chosen site rather than nesting near the lek (Bradbury et al. 1989b).

The average clutch size for greater sage-grouse from 10 studies was 7.5 eggs (range 6.6-9.1 eggs; Schroeder 2000b), with both the lowest and the highest means reported from Washington (Sveum 1995, Schroeder 1997) (Table 1). Wallestad and Pyrah (1974) reported that clutch size was higher for adult than yearling females in Montana (2.1 egg difference) and Peterson (1980) reported a 0.6 egg difference. Wakkinen (1990) and Schroeder (1997) did not detect a difference in clutch size by hen age. Re-nests may have a smaller clutch than first nests, as observed in Washington (0.9 fewer eggs; Schroeder 1997), Alberta (2.6 fewer; Aldridge 2000), and Colorado (0.2 fewer; Petersen 1980). Annual variation in clutch size suggests that differences in habitat conditions due to weather and management may affect the nutritional state of hens and ultimately clutch sizes. The level of protein in the diet affects clutch size and chick viability in captive ruffed grouse (*Bonasa umbellus*; Beckerton and Middleton 1982) and willow ptarmigan (*Lagopus lagopus*; Hanssen et al. 1982). For sage-grouse, Barnett and Crawford (1994) reported decreases in forbs eaten and nutrient content of the diet when precipitation was 40% below normal in Oregon. They reported a corresponding decline in sage-grouse productivity as measured by chicks/hen and average brood size, but did not have data on clutch size. Aldridge and Brigham (2001) did not think that clutch size was affected by the flush of new growth in Alberta because egg-laying began prior to spring plant growth. The proportion of eggs hatching in successful nests averaged 94.3% (range 85.5%-98.1%) in 8 studies. About half of the eggs that do not hatch are infertile (56.4%: Patterson 1952; 42.9 %: Petersen 1980; 68.2%: Schroeder 1997). Low hatchability (≈70%) in greater prairie chickens has been linked to reduced genetic heterogeneity in a small population (Bouzat et al. 1998, Westemeier et al. 1998).

Nesting and reproductive success. The percent of hens that nest, has varied from 67.9-100%. However, data on folicular development suggest that the actual rate may exceed 90%, and lower rates may result from some nests being lost to predators before being detected by researchers (Schroeder 2000b). The percent of hens that renest after losing the first clutch also varies widely (Table 1). Adult hens were more likely to renest than yearlings in both Washington studies (47.4% vs 0 %: Sveum 1995; 87.9% vs. 81.8%: Schroeder 1997). Hens will occasionally renest twice (Appendix F *in* Sveum 1995, Schroeder 1997). Schroeder (1997) reported that renesting accounted for 38% of grouse productivity for 1992-96 in northcentral Washington.

Table 1. Mean greater sage-grouse productivity in Washington and other states (modified from Schroeder et al. 1999 and Schroeder 2000b).

Location	Reference	Clutch size (n)	Nest likelihood % (n)[a]	Re-nest likelihood % (n)[b]	Nest success % (n)[c]	Annual reproductive success % (n)[d]	Hatched chicks/ female
Washington	Sveum (1995)	6.6 (38)	80 (95)	41 (44)	41 (93)	40 (95)	2.49 (95)
Washington	Livingston & Nyland (2002)	6.2 (19)	95 (22)	11 (18)	25 (20)	28 (18)	1.63 (18)
Washington	Schroeder (1997)	9.1 (55)	100 (129)	87(69)	37 (188)	61 (111)	5.34 (111)
Alberta	Aldridge (2000), Aldridge & Brigham (2001)	7.8 (28)	100 (22)	36 (12)	46 (26)	55(22)	3.92 (22)
Colorado	Petersen (1980)	7.0 (29)		38 (16[f])	45 (31[f])	47 (30	2.79 (30)
Idaho	Wakkinen (1990), Connelly et al. (1993)	6.7 (30)	69 (242)	15 (79)	52 (166)	48 (52)	3.08 (52)
Idaho	Wik (2002)	6.5 (18)	95-100 (39)	20 (10)	45 (38)	45 (38)	
Montana	Wallestad & Pyrah (1974)	8.2 (22)	71 (31)		70 (20[f])	70 (20[f])	5.41 (20)
Oregon	Gregg 1991, Gregg et al. (1994)		78 (119)	9 (75)	15 (124)	15 (119)	
Oregon	Hanf et al. (1994)		68 (28)	7 (14)	30 (20)	21 (28)	

[a] The % of hens that nest in a season.
[b] The % of hens that renest after losing the first nest.
[c] The % of nests that hatch ≥1 egg.
[d] The % of hens that hatch ≥1 egg.
[e] Sample size reduced from thesis due to the elimination of 4 nests abandoned because of investigator and 1 hen that was captured immediately prior to renesting.
[f] Sample size lower than publication because 2 females died after entanglement with radio harness.

Sage-grouse nest success (% of nests with at least 1 egg that hatches) ranges from 15 to 86% and averaged 47.4% for 14 studies (Schroeder et al. 1999). In Washington, Schroeder (1997) reported overall nest success of 37%, but 87% of females renested following nest failure, so overall reproductive success was 61% (Schroeder 1997). Sveum (1995) reported reproductive success of 40% on the YTC. Annual reproductive success averaged 44.6% for 8 studies of greater sage-grouse (Schroeder 2000b). Wallestad and Pyrah (1974) and Autenrieth (1981) reported greater productivity in adult females than yearlings, but Connelly et al. (1993) found no difference in nest success or re-nesting success among age classes.

Brood-rearing. After hatching, chicks wait until they are dry, then leave the nest. Sage-grouse hens attempt to raise one brood in a season (Girard 1937). The precocial chicks feed themselves, but hens spend considerable time keeping chicks warm and guarding them for the first 4 to 5 weeks (Patterson 1952). Chicks remain with hens until late summer or early fall and then congregate with other sage-grouse in winter flocks. Brood size depends on nest success and chick survival. Average brood size was 4.6 chicks/hen in Washington (Pedersen 1982), 2.3 to 4 chicks/hen in Nevada (Zunino 1987), and 6.1 chicks/hen in Wyoming (Girard 1937). Wik (2002) reported brood success of 0.43 and 0.66 chicks/hen for flush counts at 7 weeks in 2000 and 2001 in southwest Idaho. Connelly et al. (2000b) reported that production of about ≥2.25 juveniles/hen to the fall may be necessary for populations to remain stable or increase. In Washington, Schroeder (1997) observed broods with 3.8 chicks/hen 45 - 75 days after eggs hatched, but this estimate of brood size may be low because some chicks leave broods within 60 days after hatching (Dunn and Braun 1986). Recruitment of chicks to 1 August on the YTC was low (24 chicks from 45 successful nests), and Sveum et al. (1998a) suggested that quality brood rearing habitat may be a strong limiting factor for the population.

Maturation. Sage-grouse chicks begin to lose their down soon after hatching and are fully feathered in about a month. They are considered juveniles when 10 weeks old (Connelly et al. 2003b). Juveniles become independent 10 to 12 weeks after hatching. Juveniles weigh the same as adults after 6 or 7 months (Patterson 1952). Broods break up by late August and early September, when juveniles join adult sage-grouse in flocks. Sage-grouse are called yearlings during their first breeding season until they complete their second summer molt (i.e., 10-17 months old; Connelly et al. 2003b). Yearling males become sexually mature in April or May following their first winter. Although they display on leks, they seldom mate and devote less time and energy to courtship activities than adults (Dalke et al. 1963, Patterson 1950, Wiley 1974). Female sage-grouse are sexually mature their first fall and nest the following spring (Patterson 1952).

Sex Ratios. Sex ratios are typically determined from information supplied by hunters or wing samples taken from harvested birds. Male to female sex ratios of 1:1 for all sage-grouse (Girard 1937), and 1:1.2 and 1:2.3 for juvenile sage-grouse (Patterson 1952) were reported in Wyoming. In Colorado, Rogers (1964) reported a sex ratio of 1:1.5 for all sage-grouse, and Braun (1984), reported a ratio of 1:1.1 for juveniles, 1:1.6 for yearlings, and 1:2.6 for adults. Because of their conspicuousness during breeding, more adult males may be killed by predators than females. This may result in adult sex ratios that are skewed towards females as compared with more even sex ratios for chicks and juveniles.

Longevity, Survival, and Mortality

Greater sage-grouse can survive at least 9 years in the wild (Zablan 1993), and may be able to live 14 or 15 years as reported in blue grouse and white-tailed ptarmigan (Zwickel et al. 1992, Braun et al. 1993). In Washington, the annual survival rate for adult males was 56.9% (n = 29) and 72.5% for adult females (n = 88)(Table 2). Survival data suggest that 6 – 32% of one-year old birds live to the age of 5, when survival of breeding age birds is 50 – 75% (Schroeder 2000b). In a population with 75% annual survival of females, 10% of the females live 8 years or more.

Table 2. Survival estimates for greater sage-grouse.

Location / Sex/age class	Survival (%)	Sample size and method	Reference
Washington			
Males (annual)	56.9	29 radio-marked	Schroeder (2000b)
Females (annual)	72.5	88 radio-marked	" "
Juveniles (up to 50 days)	33.4	515 hatchlings	Schroeder (1997)
Alberta			
Males (annual)	31	59 radio-marked	Aldridge (2000)
Juveniles (up to 50 days)	18	88 hatchlings	Aldridge & Brigham (2001)
Colorado			
Adult males (annual)	36.8	1,935 banded	Zablan (1993), Zablan et al. (2003)
Yearling males (annual)	63.5	1,892 banded	" "
Females (annual)	59.2	1,800 banded	" "
Yearling females (annual)	77.7	915 banded	" "
Idaho			
Males (annual)	60	76 radio-marked	Connelly et al. (1994)
Females (annual)	75	262 radio-marked	" "
Males (1999/2000)	54	14 radio-marked	Wik (2002)
Males (2000/2001)	61	17 radio-marked	" "
Ad. Females (1999/2000)	58	21 radio-marked	" "
Ad. Females (2000/2001)	42	38 radio-marked	" "
Yearling females (1999/2000)	22	16 radio-marked	" "
Yearling females (2000/2001)	55	18 radio-marked	" "
Montana			
Juveniles (through autumn)	43.1	Brood observations	Wallestad (1975)
Oregon			
Juveniles (up to 28 days)	39	155 chicks; 62 radio- marked	Crawford and Gregg (2001)
Wyoming			
Males (annual)	58.5	451 banded	June (1963)
Females (annual)	66.9	527 banded	" "
Juveniles (summer-spring)	26.5	2,196 banded	" "

Juvenile survival. Brood sizes decline 18-68% through the summer as predators eliminate unwary chicks (Schroeder et al. 1999). In north-central Washington, the survival rate for juveniles up to 50 days was 33.4% (n = 515) (Schroeder 2000b). Based on 2,196 banded chicks, survival to autumn was 38% in Wyoming (June 1963). In Oregon, 61 of 155 chicks (39%) survived to 28 days; some early mortalities were not due to predation, and the cause was undetermined (Crawford and Gregg 2001). Aldridge and Brigham (2001) estimated survival to 50 days at about 18% in a declining population. Juvenile survival may be correlated with habitat condition, and has the potential to dramatically affect populations (Schroeder and Baydack 2001).

Hunting. In the past, sage-grouse were managed like other small game (e.g. ring-necked pheasants (*Phasianus colchicus*), California quail (*Callipepla californica*), and cottontails (*Sylvilagus* spp.)) that are able to compensate for high mortality rates with high rates of reproduction (Edminster 1954, Wallestad 1975). Allen (1954:43) summarized the thinking about species with high annual turnover:

> "Our populations of small animals operate under a 1-year plan of decimation and replacement; and Nature habitually maintains a wide margin of overproduction. She kills off a huge surplus of animals whether we take our harvest or not."

Hunting mortality of up to 30% of the fall sage-grouse population was usually assumed to be compensatory (Autenrieth et al. 1982); that is, the animals harvested would have died of natural causes during the winter anyway, so that hunting did not add to the rate of mortality (Wallestad 1975). Birds that succumbed to predation or other non-hunting mortality were viewed by many as being wasted (Allen 1954, Yocum 1956). Crawford (1982) examined 20 years of data for Oregon, but did not find a correlation between harvest level and spring breeding population. Braun and Beck (1985) analyzed banded birds, harvest, and lek counts and concluded that the harvest rate of 7-11% in Colorado had no measurable affect on sage-grouse densities in spring. They suggested that 20–25% of the fall population could be removed without hunting mortality becoming additive to non-hunting mortality. More recently, the decline in sage-grouse has caused some to question the assumptions of compensatory mortality (Schroeder et al. 1999, Reese 2001). Sage-grouse do not fit the 'high productivity-short life span' life history model well, and most populations do not regularly produce large annual 'surpluses' of young. They have relatively low reproductive rates (clutch size of 6.6 – 9 eggs vs. 12 – 16 for California quail), relatively long lives, relatively low annual recruitment rates (Connelly et al. 2000a), and low winter mortality (Ilhi et al. 1973, Connelly et al. 1994, Wik 2002). From 1978-1998, hunting was responsible for 42% of known causes of mortality of radio-tagged females and 15% of males in Idaho (Connelly et al. 2000a). Connelly et al. (2000a) concluded that for adult hens, "hunting losses are likely additive to winter mortality and may result in lower breeding populations." They speculated that females were probably more susceptible to harvest because they often aggregate with juveniles at or near moist areas, whereas males are more dispersed (Connelly et al. 2000a). Wik (2002) made similar observations in southwestern Idaho; hunters focused their efforts at moist sites and irrigated cropland where most marked females and juveniles were located July-September. The mean percentage of marked birds killed was 5.3% for males, 5.9% for adult females and 18.1% for yearling females. Wing barrel data for the area indicated that 2.1–3.8 times more females were harvested that males, in part because many males were located in less accessible areas (Wik 2002). Johnson and Braun (1999) modeled population viablity for the North Park, Colorado sage-grouse population and concluded that hunting mortality can be additive to other sources of mortality.

Little experimental research on the effects of hunting on sage-grouse has been done, and Schroeder et al. (1999) cautioned that it may be very difficult to detect the adverse impacts of harvest because they may be small, cumulative, annually variable, area specific, and confounded by variability of productivity and habitat conditions.

Connelly et al. (2003a) reported on the response of sage-grouse populations to season closure vs. 2 levels of exploitation in lowland and mountain valley habitats in southern Idaho. Based on the average number of males/lek and percent change between 1995/96 and 2001/02, lowland populations without hunting increased by 82%, while areas with limited and moderate harvest increased 6% and 15% respectively. Areas with no hunting had greater increases than hunted areas; for 2 populations in similar lowland habitat separated by a large lava flow, the non-hunted population increased at a rate 5 times that of the population with moderate hunting. Populations in more productive mountain areas increased, despite moderate bag limits (2 birds/day, 23 day season). Their data supported the ideas that hunting mortality can be additive to overwinter mortality and that a population's response to exploitation may depend on habitat quality (Connelly et al. 2003a).

Predation. In grouse species, predation typically accounts for about 85% of reported non-hunting mortalities and 79% of nest failures (Bergerud 1988:615,684). Slater (2003) reported nest predation rates of 63% and 67% for 2 study areas in Wyoming, and mammals were responsible for most (89% and 100%) of the predation. Recent studies suggest that predation on young sage-grouse chicks can be high and affect populations (Aldridge and Brigham 2001, Crawford and Gregg 2001, Schroeder and Baydack 2001). Predation was the most common cause of death for radio-marked sage-grouse in a hunted population in Idaho, accounting for 83% of mortalities for males and 52% for females (Connelly et al. 2000a). Mammalian and avian predation accounted for 24% of deaths (12 of 51) of marked birds in southwest Idaho, and hunters killed >22%; cause of death was undetermined for 49% (Wik 2002). Predation on adult males is probably most frequent when they are attending leks and most frequent on females during incubation and brood rearing (Patterson 1952, Schroeder et al. 1999). Predation during winter may depend in part on the availability of alternative prey for predators, such as cottontail rabbits and jackrabbits (*Lepus* spp.).

Habitat quality, specifically the amount and type of vegetation available to conceal nests, ultimately affects the number of nests destroyed by predators (Gregg et al. 1994). In general, the territoriality of some predators prevents them from increasing markedly in response to grouse abundance (Bergerud 1988). However, the predation rate may depend on the density of predators supported by the habitat. Ritchie et al. (1994) studied predation of artificial nests in untreated Wyoming big sagebrush habitat and areas that had been chained and seeded 25 years previously. Mammal predators accounted for 37 of 43 depredated nests. Predation rates were higher in untreated areas, apparently because treatment reduced the abundance of lagomorphs and mammalian predators. Vegetation characteristics measured at the transect scale accounted for 86% of the variance in nest predation, but only 12% when measured at the nest site scale. Nest cover is apparently more important in protecting nests from visually hunting predators, like corvids, than badgers, coyotes, and other mammals which rely more on scent while hunting (Ritchie et al. 1994).

Known predators of adult sage-grouse include golden eagles (*Aquila chrysaetos*), ferruginous (*Buteo regalis*), red-tailed (*B. jamaicensis*), Swainson's (*B. swainsoni*), and Cooper's hawks (*Accipiter cooperii*), gyrfalcons (*Falco rusticolus*), northern goshawks (*A. gentilis*), coyotes (*Canis latrans*), red foxes (*Vulpes vulpes*), and bobcats (*Lynx rufus*) (Schroeder et al. 1999). In Montana, ground predators were seen less frequently than aerial predators but killed more grouse (Hartzler 1974). Slater (2003) reported that badgers were the most important predator on nests in his Wyoming study areas. Schroeder (1994) found that ravens (*Corvus corax*), coyotes, badgers (*Taxidea taxus*), and small mammals preyed on sage-grouse eggs and were primarily responsible for nest failure in north-central Washington. Other nest predators included elk (*Cervus elaphus*), weasels (*Mustela* spp.), American crows (*Corvus brachyrynchos*), and magpies (*Pica pica*) (Schroeder et al. 1999). On the YTC, coyotes, ravens, Townsend's ground squirrels (*Spermophilous townsendii nancyae*), badgers, and an unidentified avian predator were probably responsible for instances of sage-grouse predation (Eberhardt and Hofmann 1991, Sveum 1995). Additional predators of chicks include kestrels (*Falco sparverius*), merlins (*F.columbarius*), harriers (*Circus cyaneus*) (Schroeder and Baydack 2001).

Weather. Weather influences nesting success and survival of young chicks (Rasmussen and Griner 1938, Crawford 1960, Schlatterer 1960, Gill 1966, Rothenmaier 1979). Sveum et al. (1998a) reported that precipitation seemed to affect brood survival on the YTC, because brood success was 10% in a dry year vs. 50% in a wetter year. They speculated that dry conditions required greater brood movements for foraging resulting in greater exposure to predation. However, in Montana, Wallestad and Watts (1972) found no correlations between productivity of sage-grouse and rainfall or temperature. Weather affected nest success in Idaho (Dalke et al. 1963, Autenreith 1981), but its impact depended on the availability of forbs and insects for broods immediately following hatch (Autenrieth 1981). In Colorado, Gill (1966) reported good sage-grouse production when mean average temperature in spring exceeded 45° F and total precipitation was ≥5 cm (2 in). In Wyoming, Patterson (1952) found no nest failure resulting from low temperatures or snow but chicks apparently died from several consecutive days of cold rain, sleet, and snow accompanied by low temperatures. It appears adult sage-grouse endure the winter reasonably well, provided wintering habitat contains adequate amounts of suitable sagebrush (Patterson 1952). The effect of annual weather variations on habitat condition and plant and insect foods may explain the population fluctuations exhibited by sage-grouse.

Disease and parasites. Local populations may occasionally be affected by parasites or disease. Batterson and Morse (1948) mention accounts of a crash of sage-grouse populations in Oregon in 1919-1920 when dead and dying grouse were "very prevalent throughout the preferred portions of their range." Schroeder et al. (1999) list the various parasites that infect sage-grouse. Coccidiosis is the most commonly reported disease (Grover 1944, Honess 1947, 1968, Thorne 1969).

In late summer 2003, West Nile Virus (WNV) caused mortalities of sage-grouse in other western states, with at least 27 sage-grouse found dead, though WNV could be confirmed in only 18 (Naugle and Walker 2004). The dead grouse included 19 birds in northeastern Wyoming. At least 9 of 15 radio-marked birds died of the virus in Campbell County where artificial ponds constructed for coal bed methane extraction may have elevated local mosquito populations and increased the incidence of the virus. WNV mortalities did not occur in southwestern Wyoming where >100 sage-grouse were radio-tagged. Deaths from WNV have also been recorded in Alberta (5 known cases) and Montana (3 cases). Several other marked grouse were found dead in Montana, but there were no remains that could be tested (R. Matchett, pers. comm.).

Fluctuations in sage-grouse populations are not known to be related to parasite infection rates. Parasitic infections are known to cause significant cyclic fluctuations with a period of 4 - 8 years in most red grouse (*Lagopus lagopus scoticus*) populations. Population crashes are associated with low reproduction caused by widespread serious infection in females with a caecal roundworm *Trichostrongylus tenuis*. Hudson et al. (1998) demonstrated that treatment of 20% of a population for the parasitic nematode prevented the cyclic population crashes and prevented the population cycles. Boyce (1990) reported that male sage-grouse infected by avian malaria (*Plasmodium pediocetii*) or lice (*Lagopoecus gibsoni* or *Goniodes centrocerci*) have lower reproductive success than uninfected males. Gibson (1990) found no evidence that individual variation in male courtship display and mating success were linked to variation in infection by a blood parasite (*Haemoproteus* spp.).

Sage-grouse can host *Heterakis gallinae*, a caecal worm that is widespread in chickens and also infects other grouse, quail, pheasants, turkeys, and chukar (Mississippi State University 1997, Beyer and Moritz 2000). This parasite is of concern because it serves as the host for the protozoan flagellate *Histomonas meleagris* which causes histomoniasis, or blackhead disease (Svedarsky and Van Amburg 1996). Blackhead is an acute or chronic disease that produces lesions in the caeca and liver. Chickens are resistant to the disease, but their droppings can transmit the disease to turkeys and gamebirds which can have high rates of mortality in captive flocks. It may have been an important factor in the decline and extinction of the heath hen (*Tympanuchus cupido cupido*), an eastern subspecies of greater prairie chicken (Gross 1930:36). Most blackhead transmission is due to ingesting infected caecal worm eggs, which may remain infective in the soil for at least 3 years. Transmission may also occur by earthworms (Mississippi State University 1997). Areas where poultry have been raised may remain contaminated for a long period of time.

Insecticides. Pesticides may also directly kill sage-grouse. Blus et al. (1989) found organophosphorus insecticides (dimethoate or methamidophos) directly responsible for the death of sage-grouse occupying or being near sprayed alfalfa or potato fields in southeastern Idaho.

Roads. Sage-grouse, particularly juveniles, are susceptible to being killed by vehicles on roads. Dalke et al. (1963) reported that grouse were killed each year on a road that was used as a lek. Rogers (1964:52) reported that sage-grouse broods seem to have "an affinity for" dirt or gravel roads. Connelly et al. (2000a) reported that vehicles accounted for 4% of mortalities of 77 radio-marked females in Idaho. Wallestad (1975:43) reported that mortalities from vehicle collisions were more frequent than collisions with wires and fences. He notes that roadkills were quite common in Montana during dry summers when sage-grouse concentrated to feed on green vegetation along highway ditches.

Wires and fences. Sage-grouse are occasionally killed by colliding with utility lines or fences. A barbed wire fence in winter habitat killed at least 36 sage-grouse the first winter after the fence was installed (Call and Maser 1985). Fences located in swales or on ridgelines may be a greater hazard where birds come on them unexpectedly (Call and Maser 1985). Utility wires are also known to cause mortality (Borell 1939). Collisions with powerlines accounted for 2% of male and 0.9% of overall mortalities of radio-marked sage-grouse in Idaho (Connelly et al. 2000a).

Population fluctuations

Sage-grouse populations seem to fluctuate. The somewhat regular nature of these fluctuations have led some researchers to hypothesize the existence of regular cycles with peaks occurring every 8-12 years (Rich 1985). This phenomenon would be similar to the 10-year cycle described for snowshoe hares and their predators in boreal regions (Keith and Windberg 1978, Hodges 2000). Rich (1985) summarized evidence for a 10-year cycle in sage-grouse using data from Idaho, Utah, and Nevada. A similar cyclic pattern seems to be evident for the last 30 years in total lek count data for Washington (Fig. 3). No likely causal mechanism for these cycles in sage-grouse populations has been identified. Population cycles of red grouse in Britain seem to be caused by an interaction with a parasite (Hudson et al.1998).

Food, Nutrition, and Energetics

Sagebrush, grasses, forbs, and insects comprise the annual diet of sage-grouse. Sagebrush comprises 60 to 80% of the yearly diet of adult sage-grouse (Patterson 1952, Wallestad et al. 1975, Rasmussen and Griner 1938, Remington and Braun 1985), and as much as 95 to 100% of the winter diet (Roberson 1984). Forbs appear to be important to nesting hens in the pre-laying period. Barnett and Crawford (1994) reported that forbs contributed 20-50% of the diet of pre-laying hens in southeastern Oregon, with hawksbeard (*Crepis* spp.), desert parsley (*Lomatium* spp.), long-leaf phlox (*Phlox longifolia*), mountain-dandelion (*Agoseris* spp.), everlasting (*Antennaria* spp.), clover (*Trifolium* spp.), milk-vetches (*Astragalus* spp), and buckwheat (*Eriogonum* spp.) among the most important forbs. Forage species used by adult sage-grouse in Montana included dandelions (*Taraxacum officinale*), common salsify (*Tragopogon dubius*), prairie pepperweed (*Lepidium densiflorum)*, prickly lettuce (*Lactuca serriola*), alfalfa (*Medicago sativa*), curlcup gumweed (*Grindelia squarrosa*), fringed sagewort (*Artemisia frigida*), yarrow (*Achillia millefolium*), white clover (*Trifolium repens*), sweet clover (*Melilotus officinalis*), western wormwood (*Artemisia ludoviciana*), silver sage (*Artemisia cana*), and asters (*Aster* spp.). Grasshoppers, ants, and beetles were also eaten (Wallestad et al. 1975). Eberhardt and Hofmann (1991) reported sagebrush constituted >90% of the diet during fall, winter, and much of the spring on the YTC, although they used analysis of fecal pellets which probably biases the data toward sagebrush. In June and July, sage-grouse also ate rabbitbrush and forbs, but sagebrush was still 43-68% of their diet.

Insects, particularly grasshoppers, beetles, and ants, make up ≥50% of the diet during the first and second weeks of life (Rasmussen and Griner 1938, Patterson 1952, Klebenow and Gray 1968, Peterson 1970, Schroeder et al. 1999). Johnson and Boyce (1990) found chicks <3 weeks old required insects for survival and chicks >3 weeks old had reduced growth rates when insects were removed from the diet. The availabilities of forbs and insects are important post-hatch limiting factors (Autenrieth 1981), especially in highly fluctuating sage-grouse populations (usually those found in the xeric 18 to 25 cm [7-10 in] precipitation zone). Forbs may constitute ≥50% of the diet of juveniles up to 11 weeks of age (Rasmussen and Griner 1938, Klebenow and Gray 1968, Peterson 1970). In Oregon, forbs and invertebrates composed 80% of the dietary mass of chicks in one area with high grouse productivity, but only 36% in a less productive area where sagebrush composed 65% of the dietary mass (Drut et al. 1994b). The food habits of juvenile sage-grouse in central Montana were composed of 75% forbs (flowers and leaves of dandelions, 25%; common salsify, 15%; and pepperweed, prickly lettuce, alfalfa, curlcup gumweed, and fringed sagewort, 30%) and a declining percentage of insects from one week of age (60%) to 12 weeks of age (12%) (Peterson 1970). Big sagebrush did not become the major component of the diet of juvenile birds until they reached the age of 11 weeks and then they primarily used sagebrush plants that were 6–18 inches (15.2–45.7 cm) high (Peterson 1970).

In fall, sage-grouse shift back to a sagebrush dominated diet (Girard 1937; Griner 1939 and Bean 1941, cited in Roberson 1984; Dargan et al. 1942; Patterson 1952; Trueblood 1954; Nelson 1955; Klebenow and Gray 1968; Savage 1969; Martin 1970; Peterson 1970; Oakleaf 1971; Wallestad et al. 1975; Autenrieth 1980). Remington and Braun (1985) observed sage-grouse in winter selecting sagebrush varieties with the highest protein levels (Wyoming big sagebrush Artemisia tridentata wyomingensis, vs. mountain big sagebrush *A. t. vaseyana* or Alkali sagebrush *A. longiloba*) possibly because protein is a readily digestible source of energy.

Home Range, Dispersal and Seasonal Movements

Home range. Greater sage-grouse have large home ranges in comparison to other grouse species (Bergerud 1988). Within home ranges, sage-grouse move daily between feeding, breeding, and roosting sites (Wallestad 1971). The quality of habitat likely affects home range size. Mean home ranges at Hart Mountain, Oregon were 8 km² and 1 km² in the early and late brood period, respectively, but were 21 km² and 51 km² at Jackass Creek, an area with lower forb cover, fewer terrestrial invertebrates, and lower precipitation (Drut et al. 1994a). Mating, nesting, brood rearing, loafing, roosting, and foraging occur within 3 km (2 mi) of a lek in some areas (Wallestad and Pyrah 1974, Wallestad 1975, Autenrieth 1981), and at distances >3 km in other areas (Connelly et al. 1988, Wakkinen et al. 1992, Schroeder 1994). In Washington, home range estimates of sage-grouse from the YTC were much higher than from Douglas County (Table 3) (Pedersen 1982, Eberhardt and Hofman 1991). Eberhardt and Hofman (1991) attributed the large home ranges they reported for sage-grouse on the YTC to repeated disturbance. However, their study differed from Pedersen's study in seasons, the number of relocations, and number of females followed. Maximum distances moved from leks ranged from 4 to 36 km (2-22 mi) in Washington (Pedersen 1982, Eberhardt and Hofmann 1991, Cadwell et al. 1994, Schroeder 1994).

Density. Sage-grouse density varies with habitat availability and quality, and demographic factors. A compilation from the 13 states and provinces with sage-grouse had average counts of 16 to 32

Table 3. Estimates of seasonal home ranges of greater sage-grouse in Washington.

Season	Home range (km^2)	Sex/age[a]	*n*	Study area	References
Spring	4	M/Ad	13	Douglas County	Pedersen (1982)
	6	M/Y	1	Douglas County	" "
	29	C	25	YTC	Eberhardt and Hofmann (1991)
Spring-summer	5	F/Ad	1	Douglas County	Pedersen (1982)
Summer	8	M/Ad	14	Douglas County	" "
	26	C	25	YTC	Eberhardt and Hofmann (1991)
	2	M/Y	1	Douglas County	Pedersen (1982)
Fall	44	C	25	YTC	Eberhardt and Hofmann (1991)
Winter	0.28	M/Ad	3	Douglas County	Pedersen (1982)
	2	F/Ad	1	Douglas County	" "

[a] M = male, F = female, Ad = adult, Y = yearling, C = combined.

males/lek from 1988 to 1990 (Braun 1991). In Wyoming, Patterson (1952) reported an average of one lek/15 km^2 (6 mi^2) with a density of 5 males/km^2 (13 males/mi^2). Overall grouse densities are estimated based on lek counts of males and average male:female ratios (1:1.5 or 1:1.6) (Schroeder et al. 1999). Edminster (1954) analyzed Patterson's data to estimate 12 to 19 grouse/km^2 (30-50 grouse/mi^2) or 1 grouse/5-8 ha (13-21 ac). In Colorado, Rogers (1964) estimated a fall density of 12 to 19 grouse/km^2 (30-50 grouse/mi^2) in areas containing the best sage-grouse habitat. Fall density in areas of marginal habitat ranged from 0.4 to 12 grouse/km^2 (1-30 grouse/mi^2) (Rogers 1964).

Dispersal. Natal dispersal distance, or the distance between site of hatching to the site of first breeding, has important implications for connectivity of populations, genetics, and conservation. There are few data available on natal dispersal in sage-grouse. Median natal dispersal was 8.8 km for 12 females and 7.4 km for 12 males in Colorado (Dunn and Braun 1985). Most (58.3%) birds returned to the proximity of the lek closest to their initial capture site. Some juveniles may disperse relatively long distances outward from their natal site. In widespread and interconnected populations dispersal by juvenile birds out of a population would be balanced by immigration of other juveniles. As populations become fragmented and isolated, birds that emigrate may never find another population and constitute a net loss to the population (Schroeder 2000b).

Seasonal movements. Seasonal movements may be influenced by topography, vegetative cover, abnormally dry spring or summer conditions, winter weather, and availability of winter food (Beck 1975, Fischer et al. 1996a, Schroeder et al. 1999). In southeastern Idaho, sage-grouse moved each summer to agricultural fields along traditional migration routes or to foothills with riparian areas and meadows present (Wakkinen 1990, Fischer et al. 1996a). The majority of females began migration when the moisture content of vegetation declined to ≤60% water (Fischer et al. 1996a). Females also initiated migration earlier in dry years, but some did not migrate in a wet year. In Douglas County, most sage-grouse of both sexes migrated between breeding areas and winter areas which were more or less distinct (Schroeder 1994). The sage-grouse in Douglas County are more migratory than birds on the YTC, possibly because the winter range is not used for nesting due to its general lack of herbaceous vegetation. Adult sage-grouse often return to specific wintering areas.

Sage-grouse occupying sagebrush communities at low elevation may not migrate (Wallestad 1975), whereas those inhabiting mountain valleys or areas with distinct elevation gradients are typically migratory (Dalke et al. 1960, Connelly et al. 1988). Migratory sage-grouse generally move >16 km (Berry and Eng 1985). Migrations of 80 to 160 km between wintering areas and leks (Pyrah 1954, Dalke et al. 1963,) and 81 km from leks to winter range (Connelly and Markham 1983) have been reported, but shorter distances are more common (Bradbury et al. 1989a). On the YTC in Washington, males moved to summer habitat that averaged 12.6 km from leks, while females ranged 6-7 km from the lek of capture (Cadwell et al. 1994). Males shifted back toward the leks during the fall and winter. Migratory movements in north-central Washington are comparable in distance, and clearly follow major intact shrub-steppe corridors (Schroeder, in prep.). Sveum et al. (1998a) suggested that non-migratory populations, like the YTC population, may be more affected by drought when broods are less able to find forb-rich sites than are more migratory birds.

HABITAT REQUIREMENTS

Greater sage-grouse inhabit shrub-steppe and meadow steppe, and as their name implies they are closely associated with sagebrush. Shrub-steppe is a descriptive term for plant communities consisting of one or more layers of perennial grass with a conspicuous, but discontinuous, layer of shrubs above (Daubenmire 1970). Forest vegetation is generally absent. Elevations range from 30.5 −1,220 m (100 to 4,000 ft). Mean monthly temperatures range from −4.7° C (23.5° F) in January in Ellensburg to 24.2°C (75.6°) in July at Kenniwick. Average January minimum is −9.3°C (15.3°F) at Ellensburg and average July maximum is 33.3°C (91.9°F) at Kennewick. Average annual precipitation is 19 cm (7.5 in) at Kennewick and 23 cm (9.1 in) at Ellensburg (Franklin and Dyrness 1973). Average precipitation ranges from 12 cm (4.7 in) at the Columbia River to 55 cm (21.6 in) where steppe transitions to forest at the northeast part of the Columbia Basin (Daubenmire 1970, Rickard et al. 1988). Shrub-steppe communities in Washington typically contain bunchgrasses, shrubs such as big sagebrush, three-tipped sagebrush (*A. tripartita*), and bitterbrush (*Purshia tridentata*), and a variety of forbs. Meadow steppe communities are dense at ground level, supporting many grasses and forbs with broad leaves, and have few shrubs. Meadow steppe is barely dry enough to exclude trees and generally has meadow characteristics (Franklin and Dyrness 1973, Daubenmire 1970). Sage-grouse populations are found in areas of the *Artemisia tridentata* - *Agropyron spicatum* and the *Artemisia tripartita* - *Festuca idahoensis* vegetative units described by Daubenmire (1970).

Sage-grouse have adapted to seasonal use of altered habitats (e.g., alfalfa fields), but that use generally depends on the proximity to native steppe habitat (Schroeder et al. 1999). Low rolling hills and adjacent valleys provide the best topography for sage-grouse (Call and Maser 1985). Sage-grouse prefer slopes <30% (Call and Maser 1985). In Colorado, they preferred south-facing slopes year round (Rogers 1964). On the YTC, habitat that contained successful nests was more likely to be on northeast aspects than on south or southwest aspects (Cadwell et al. 1997). Habitat consists of sagebrush/bunchgrass stands having medium to high canopy cover (10-35%) of sagebrush in a variety of height classes (Table 4) and a diverse grass and forb understory (Peterson 1970, Wallestad 1971, Eng and Schladweiler 1972). In Washington, sage-grouse on the YTC were found at elevations of 500 to 900 m (1,650 to 2,970 ft) and on slopes <16° (Cadwell et al. 1997).

Spring

Leks. Leks are the focal point of the breeding season

Table 4. Vegetation characteristics typical of productive greater sage-grouse habitats (modified from Connelly et al. 2000b).

	Breeding		Brood-rearing		Winter[a]	
	Height (cm)	Canopy (%)	Height (cm)	Canopy (%)	Height (cm)	Canopy (%)
Sagebrush	30-80[b]	15-25	40-80	10-25	25-35	10-30
Grass-forb	>18[c]	>25[d]	variable	>15	--	–

[a] Above snow
[b] For more mesic sites, the height is 40-80 cm.
[c] Measured as droop height; the highest naturally growing portion of the plant.
[d] For arid sites, the canopy is ≥15%.

and range in size from 0.04 to 40 ha (0.1-99 ac) (Scott 1942, Call 1979, Call and Maser 1985). Leks are often near nesting habitat and between areas used in winter and summer (Wallestad 1975, Klebenow 1985, Connelly et al. 1988). They are found in gravel pits, burned areas, cultivated fields, air strips, abandoned homesteads, roads, bare ridges, grassy swales, natural and irrigated meadows devoid of grass, knolls, small buttes, openings in sagebrush stands, dry-lake beds, and areas denuded of vegetation by livestock (Roberson 1984, Call and Maser 1985, Schroeder et al. 1999). Given the diverse habitats where leks are placed, lek habitat availability is likely not a limiting factor for sage-grouse.

Most leks contain a central area that is barren and a surrounding area containing shrubs (Klebenow 1985, Ellis et al. 1989, Klott and Lindzey 1989). However, in Washington, some active leks are devoid of surrounding shrubs (Schroeder 1994). Most active leks on the YTC are on lithosol soils surrounded by a cover of stiff sagebrush (*Artemisia rigida*) and are a few acres in size (M. Livingston, pers. comm.). Visibility is important on a lek and is necessary for sighting predators and for females to observe displaying males (Gill 1965, Wiley 1973).

Shrubs surrounding leks are used extensively by sage-grouse. Males use shrubs ≤1 km (0.6 mi) from a lek for foraging, loafing, and shelter (Rothenmaier 1979, Emmons and Braun 1984, Autenrieth 1981, Roberson 1984). Males select shrub stands 18 to 38 cm (7-15 in) high (Call and Maser 1985, Rothenmaier 1979) with a canopy coverage of 20 to 50% (Wallestad and Schladweiler 1974, Autenrieth 1981, Ellis et al. 1989). *Nesting habitat.* After mating, sage-grouse hens leave the lek to nest. Most hens build nests under shrubs (Jarvis 1974, Wallestad and Pyrah 1974, Roberson 1984), specifically in areas with medium to high shrub cover and residual grass (dry grass from the previous growing season) (Schoenberg 1982, Gregg 1991, Sime 1991). However, females occasionally nest in grassland (Sveum 1995), cultivated fields that contain abundant insects for chicks after hatching (Autenrieth 1981), or in idle cropland, such as land enrolled in the Conservation Reserve Program (CRP) (Schroeder 1994). Sage-grouse may require a balance of shrubs and grasses for greatest nest success (Sveum 1995). Shrubs located in nesting habitat act as an umbrella, which helps shield the nest from weather and predators and increases nest success (Autenrieth 1981, Connelly et al. 1991, Gregg et al. 1994). In Washington, big sagebrush/bunchgrass is the predominant habitat selected for nesting (Schroeder 1994, Sveum 1995). Livingston and Nyland (2002) reported that females on the YTC preferred nesting under big sagebrush and selected big sagebrush-three-tipped sagebrush cover types. In other states, additional species used for nesting include rabbitbrush (*Chrysothamnus* sp.), bitterbrush, three-tipped sagebrush, silver sagebrush (*A. cana*), and mountain big sagebrush (Gregg 1991, Sime 1991, Gregg et al. 1994).

Tall, dense vegetation provides visual, scent, and physical barriers between predators and the nests of ground-nesting birds (Redmond et al. 1982; Sugden and Beyersbergen 1986, 1987; Crabtree et al. 1989;

Sveum 1995). The presence of grass, especially tall grass, and forbs interspersed with sagebrush increases nest success (Autenrieth 1981, Wakkinen 1990, Gregg 1991, Sveum 1995, Wik 2002). Grass may increase nest success by hiding the nest from ground predators and forming a microclimate that is warmer than the air above (Autenrieth 1981:20). Areas with successful nests on the YTC were characterized by a more even mixture of grass and shrubs in contrast to areas where unsuccessful nests occurred (Cadwell et al. 1997). In Oregon, a study of both real sage-grouse nests and artificial nests found that nests placed in tall grass (>15 cm [6 in])and medium high shrubs (40-80 cm [16-32 in]) had the least predation (Crawford and DeLong 1993). Another artificial nest study suggested that the type and density of predators may affect the degree to which nest cover reduces nest predation; habitat with reduced density and height of sagebrush in Utah actually had lower predation apparently because it was poorer habitat for rabbits and mammalian predators (Ritchie et al. 1994). A separate study in Oregon also found that sage-grouse nests placed in medium high shrubs had the least predation (Gregg et al. 1994). Non-depredated nests had higher grass canopy coverage (18% vs. 5%) and higher shrub coverage (41% vs. 29%) than depredated nests within 1 m (3 ft) of the nest (Gregg et al. 1994). In southwest Idaho, hens selected areas with greater grass cover and taller residual grass (33 vs. 12 cm) than at random sites, and there was a weak difference in residual grass height (39 vs. 29 cm; $P = 0.058$) between successful and unsuccessful nests (Wik 2002). Table 5 summarizes characteristics of sage-grouse nest sites in the region. Both sagebrush and tall grasses are important at nest sites (Sveum 1995). In Washington, most females nested in areas with medium to very high canopy coverage of sagebrush and grass (20% and 51%, respectively) (Schroeder 1994). Grass cover within 10 - 30 cm may be critical because sagebrush, which tends to be taller in Washington than in other study areas, does not provide the needed low cover.

Table 5. Vegetation cover characteristics at greater sage-grouse nests in Washington, Oregon and Idaho.

	Sagebrush		Grass			
State	Nest shrub height (cm)[a]	Cover[b] %	Height (cm)	Cover %	Number of nests (n)	Reference
Washington	124[c]	20	108[c]	51	78	Schroeder (1995)[d]
	59	51	-	34	35	Sveum et al. (1998b) [e]
	63	59		44	58	Sveum et al. (1998b)[e]
	76	59	30	16	20	Livingston & Nyland (2002)[e]
Oregon	-	44	22	15	20	Hanf et al. (1994) [e]
Idaho	57-80	23-38	-	-	307	Autenrieth (1981)[f]
	72	29	20	7	71	Connelly et al. (1994); pre-burn[g]
	59	40	16[g]	30	67	Connelly et al. (1994); post-burn[e]

[a] Mean height of nest bush.
[b] Mean canopy coverage of the sagebrush surrounding the nest
[c] tallest within 5.6 m radius plot
[d] plot size was 5.6 m radius centered at nest
[e] 1 m^2 plot, except as noted.
[f] 3.6 m radius plot
[g] 20 m plot radius

Brood-rearing habitat. Early brood rearing generally occurs in upland sagebrush areas near nest sites, ideally with abundant and diverse forbs and insects (Drut et al. 1994b, Sveum et al. 1998a, Connelly et al. 2000b). Broods are found in a variety of habitats during summer including sagebrush, wet meadows, cropland, and irrigated fields adjacent to sagebrush (Connelly et al. 2000b). Brood rearing areas in Idaho had more abundant forbs, ants, and beetles than unused sites (Fischer et al. 1996b, Apa 1998). When sagebrush habitats dry out, grouse may move to moister areas with succulent forbs. On the YTC, broods in big sagebrush/bunchgrass selectively used sites with more total forbs (25% cover) and food forbs (8%) than randomly available (8% and 2%, respectively) (Sveum et al. 1998a). Late brood-rearing sites had 19-27% forb cover on Hart Mountain in Oregon, and Drut et al. (1994a) suggested that 12-14% forb cover may be the minimum needed for brood habitat in Oregon. Toward the end of the brood-rearing period, brood use in Oregon shifted toward lakebeds and meadows which had the highest availability of forbs (Drut et al. 1994a).

During mid-day, broods on the YTC were observed loafing and dust-bathing under large sagebrush in big sagebrush/bunchgrass. Mid-day locations had greater shrub cover, shrub height, and vertical cover than morning or afternoon locations. In a dry year, broods on the YTC remained in big sagebrush/bunchgrass cover types, but in a wetter year, they spent more time foraging in grasslands, particularly in the afternoon (Sveum et al. 1998a). Sveum et al. (1998a) suggested that brood rearing habitat may be a strong limiting factor for the YTC population because alternative high quality brood rearing habitat, such as meadows, lake beds, or broad forb-rich drainages, was not available.

Summer and Fall

During summer in Washington, Pedersen (1982) observed sage-grouse moving from sagebrush communities to fallow fields with wet areas that contained annual forbs. Sage-grouse on the YTC did not frequent springs, nor did they prefer major streams and associated riparian areas for water and food (Cadwell et al. 1994). Sage-grouse broods used both big sagebrush-bunchgrass and grasslands of bunchgrasses and rabbitbrush where that sagebrush had been eliminated by fires on the YTC (Sveum 1995). In Oregon, sage-grouse were generally observed feeding on forbs near playas, water holes, and meadows in summer (Willis et al. 1993). Males and broodless hens used a greater diversity of cover types than hens with broods in Oregon (Wallestad and Schladweiler 1974, Gregg et al. 1993).

Fall habitat use reflects the transition from a diet rich in forbs to one composed almost entirely of sagebrush. Grouse in Idaho move slowly from summer to winter habitat from August to December, with most birds abandoning summer areas by early October (Connelly and Markham 1983).

Winter Habitat

Sage-grouse are relatively well adapted to survive winter conditions and in good habitat gain weight during winter (Patterson 1952). Sagebrush constitutes nearly 100% of the winter diet. The height and canopy coverage of sagebrush are important, particularly when snow depth exceeds 30 cm (12 in) (Autenrieth 1981, Hupp and Braun 1989, Willis 1991). Deep snow limits food availability and may prevent a flock from using a site in winter. Winter habitat is often the most limited seasonal habitat because sagebrush tall enough to protrude above snow is limited (Patterson 1952, Eng and Schladweiler 1972, Beck 1977, Connelly et al. 2000b). Most studies report grouse using areas with >20% canopy coverage of sagebrush (Table 6). Beck (1977) reported that grouse foraged in the tallest sagebrush with the highest canopy cover. Robertson (1991) reported that sage-grouse selected areas having taller and denser stands of sagebrush than randomly available. Sites with taller sagebrush offered some protection from the wind. The percent canopy cover of Wyoming big sagebrush was the most important variable; grouse selected sites with 8-12% coverage regardless of snow depth.

Table 6. Sagebrush characteristics in winter sage-grouse use areas (modified from Connelly et al. 2000b).

State	Canopy coverage (%) of sagebrush above snow	Shrub height (cm) above snow	Reference
Colorado	-	24-36 (males), 20-30 (hens)	Beck (1977)
Colorado	37 (males), 43(hens)	34(males), 26 (hens)	Schoenberg (1982)
Idaho	26 (males), 25 (hens)	29 (males), 26 (hens)	Connelly (1982)
Idaho	15 (total shrub 20)	46	Robertson (1991)
Montana	27	25	Eng & Schladweiler (1972)
Montana	>20		Wallestad (1975)
Oregon	12-17		Hanf et al. (1994)

Wyoming big sage was more important than three-tip sage during winter on the Big Desert in Idaho possibly because it is taller. Robertson (1991:56) recommended managers in southeastern Idaho, "strive for at least 10% canopy coverage of big sagebrush (with exposed height of at least 30 cm in years of moderate snowfall) in order to attain a total shrub canopy coverage of 20% on areas used in winter." Remington and Braun (1985) found Wyoming big sagebrush the preferred winter food in Colorado, but Welch et al. (1991) found captive grouse preferred mountain big sagebrush over Wyoming big sagebrush.

In Douglas and Grant counties, sage-grouse were observed feeding on steep (>15%) south-facing slopes and roosting on gradual slopes (15%) and ridgetops during winter (M. Schroeder, pers. obs). On the YTC, males used areas with more grass and less shrub cover in winter when compared with nest sites (Cadwell et al. 1997). The best wintering sites are often located at the lowest elevations (Rogers 1964) in areas having flat or gentle slopes with <15% gradient (Jarvis 1974, Beck 1977, Autenrieth 1981). Winter sites typically face south or west, possibly because less snow accumulates than on north or east aspects (Beck 1977, Autenrieth 1981, Hupp and Braun 1989). Drainage basins with abundant sagebrush (Pedersen 1982, Schoenberg 1982, Hupp and Braun 1989), or dry areas that may be unsuitable other times of the year, are often used during winter.

POPULATION STATUS

Connelly and Braun (1997) estimated declines of 17- 47% in breeding populations of sage-grouse since 1985 for states with sufficient data. The population in Washington has been in overall decline since 1970. The historical population of sage-grouse in Washington, past harvest, and declines are discussed in greater detail in the Washington State Status Report for the Sage Grouse (Hays et al. 1998). The decline and current status of greater sage-grouse are briefly summarized below.

The Decline of Sage-grouse in Washington

Meriwether Lewis reported sage-grouse "in great abundance" in 1806 in areas of present-day Benton and Klickitat counties (Zwickel and Schroeder 2003) and they were particularly abundant at the mouth of the Snake River (Coues 1893). Historical reports describe large numbers of sage-grouse throughout their range (Escalante 1776, Coues 1893, Huntington 1897, Burnett 1905, Wilhelm 1970). Sage-grouse populations declined throughout North America from 1900 to 1940 (Patterson 1952, Jewett et al. 1953). Sage-grouse numbers in Washington declined from the late 1800s to the early 1900s because of habitat conversion, overgrazing, and weak hunting regulations (Yocom 1956). Sage-grouse historically ranged from the Columbia River in Klickitat County, north to Oroville, west to the foothills of the Cascades, and east to the Spokane River (Fig. 2). As early as 1860, sage-grouse had declined and were rarely seen in some areas that formerly contained numerous birds. In 1897, the hunting season for sage-grouse extended from 15 August - 1 December, with a bag limit of 10 birds/day. By the early 1900s, sage-grouse had been extirpated from Spokane, Columbia, and Walla Walla counties and perhaps other counties that historically contained small populations. In 1922, the sage-grouse season was closed in all counties except Benton and Franklin counties, where the season was limited to 2-6 September with a daily bag of 3 birds. The season was closed in all counties in 1923 and remained closed statewide until 1950. Sage-grouse numbers increased in some areas with the change from horse-drawn to mechanized farming, and protection from hunting. Sage-grouse were apparently abundant enough to be causing damage to alfalfa and potatoes in the Badger Pocket area of Kittitas County where hunting resumed in 1950 (Yocum 1956). The recovery was temporary, however, as more and more shrub-steppe was converted to agriculture within the Columbia Basin Irrigation Project.

Declines and local extirpations of sage-grouse continued through the 1980s. The population declined an average of -0.76% /year from 1970-2003. Schroeder et al. (2000) estimated a decline of 77% between 1960 and 1999, but indicated that the estimate would be closer to 95% if an additional 16 leks for which there was no early count data were assumed to have been of average size in 1960 and were included in the estimate. The breeding population in Lincoln County was essentially eliminated by 1985 because of habitat alteration. The Badger Pocket area, southeast of Ellensburg in Kittitas County, historically supported large numbers of sage-grouse, but they were extirpated by 1987 due to conversion of shrub-steppe to cropland in the 1970's and 1980's. The sage-grouse population on the Fitzner and Eberhardt Arid Lands Ecology Reserve (ALE) unit of Hanford Reach National Monument (formerly part of the Department of Energy's Hanford site) in Benton County was evidently extirpated, probably due to catastrophic fires in 1981 and 1984. No sage-grouse populations have been found there in recent surveys, although individual birds are sighted on rare occasions. In the 20th century, the range of sage-grouse in Washington has declined by approximately 92%.

While habitat loss was probably the most important factor in the elimination of sage-grouse from most of their range in Washington, over-harvest may have exacerbated the impacts of habitat fragmentation and accelerated local extirpations. Recent management guidelines state that where sage-grouse populations are hunted, harvest rates should be 10% or less of the estimated fall population (Connelly et al. 2000b), although this recommendation was not based on research experiments. An accurate accounting of historical harvests is impossible. Harvests may have been over-estimated by up to 100% because estimates were based on surveys of $\leq$10% of hunters (Pedersen 1982). There is also uncertainty in the estimates of historical population sizes (Schroeder et al. 2000). Fall populations may have been significantly higher, perhaps 30% higher than spring populations, assuming reproductive success of 50%, production of 4 chicks per successful hen, and 25% chick survival to fall (Schroeder 2000b). Nonetheless, past harvest rates in Washington greatly exceeded 10% of the estimated spring population in some years. For example, in 1954, an estimated 2,700 birds were killed in Kittitas County, when the statewide breeding population may have been around 9,000 birds; 3,300 hunters killed an estimated 2,065 birds in 1970 when the total spring population may have been only about 3,800 birds (Hays et al. 1998). Excessive harvest occurred in part because it was assumed that hunting mortality of less than 30% of the population was compensatory (Autenrieth et al. 1982). Also, harvest was assumed to be more or less self-limiting by what Leopold (1933) called the "law of diminishing returns," meaning that hunters would stop hunting when game became scarce.

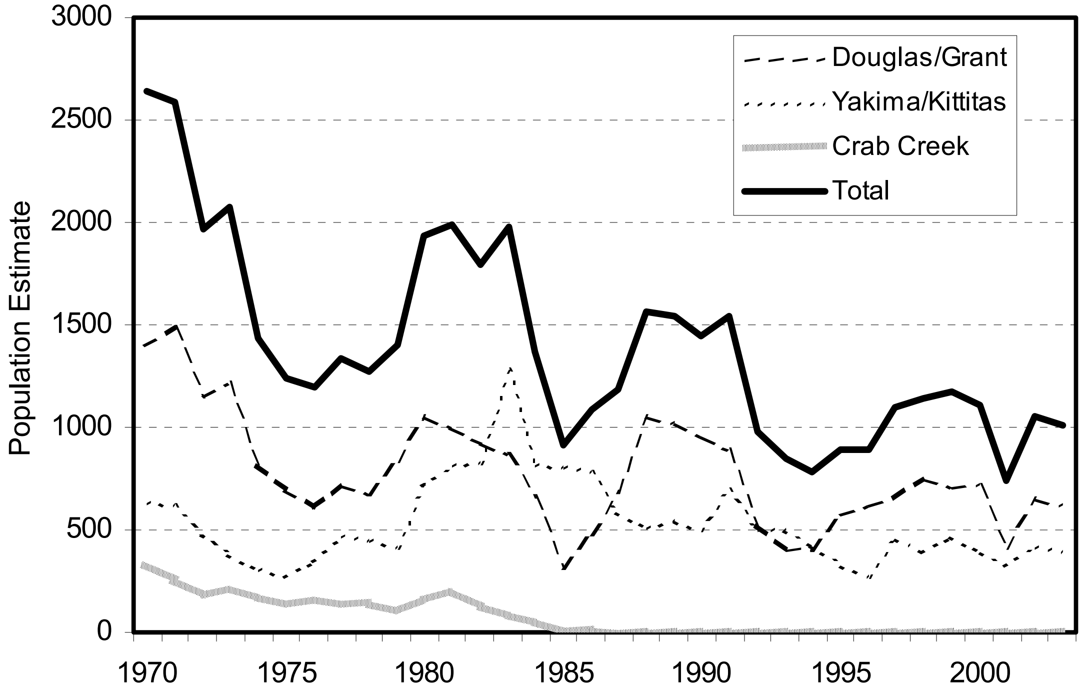

Figure 3. Estimated breeding population of greater sage-grouse in Washington, 1970–2003.

Despite statewide closure of the season in 1988, the sage-grouse population stayed at low levels or continued to decline (Fig. 3), probably due to the dramatic reduction in habitat, deterioration and fragmentation of the remaining habitat, and isolation and small size of the remaining populations.

Current Status

Sage-grouse have survived in Washington largely because portions of the land in Douglas County are poorly suited to agriculture, and in part because U.S. Army ownership of the YTC prevented agricultural conversion and most other development. The statewide breeding population of sage-grouse in Washington in 2003 was conservatively estimated to be approximately 1,011 birds in two populations: about 624 birds in the Douglas-Grant counties population and 387 birds in Kittitas-Yakima counties population on the YTC (Fig. 4). These populations are separated by about 50-60 km. The statewide breeding population declined from about 1,080 birds in 2000 to 730 birds in 2001, but seemed to rebound to 1,059 birds in 2002 (Schroeder, unpubl.data). These figures are probably underestimates. The Yakima-Kittitas population estimate ranged from 166-421 birds during 1989-2002 and averaged 306 birds (U.S. Army 2002). Although the Yakima-Kittitas population has fluctuated over the years, the average estimate is higher for the most recent 7 year period (326 for 1996-2002; 285 for 1989-95). The average annual percent change (+6.84%) indicates a slight increase overall since 1989 (U.S. Army 2002).

Based on occasional sightings, a few scattered sage-grouse may occur on the periphery of the current range but are not believed to play a significant role in the dynamics of the populations. Most of the lek complexes (49 of 68; 72.1%) that were active at least 1 year from 1960 - 2001, are now vacant (Fig. 4). Just over half (26 leks) of these vacant leks are outside the current range, while the remainder (23)

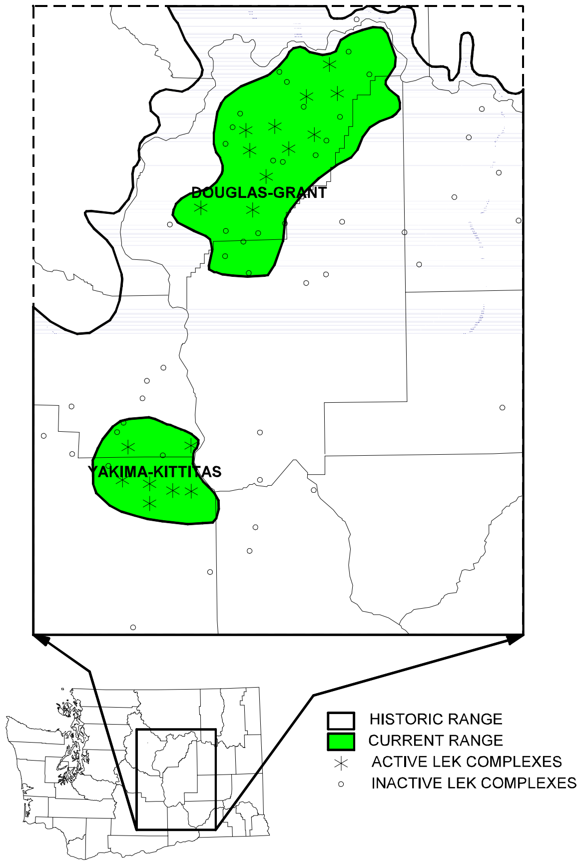

Figure 4. Distribution of active and inactive lek complexes within current and historical sage-grouse range in Washington. Inactive leks are those known to be active ≥1 year since 1960.

reflect a decline in grouse density within the current range (Schroeder et al. 2001).

The two remaining populations in Washington are too small to be considered viable, so the persistence of sage-grouse in Washington is likely to depend on recovery efforts. Small populations are affected by loss of genetic variability, inbreeding, and predation pressure, and are at risk from random events such as extreme weather or fires. The effective population size of sage-grouse populations is smaller than the number of individuals because a small portion of the adult males do most of the breeding. This means that genetically and demographically, these populations are more similar to populations of a smaller size. Sage-grouse numbers are somewhat cyclic, putting small populations at greater risk. Populations of a few thousand individuals may be needed for long term viability (i.e., 100 years).

Population estimation based on lek counts. The population estimate is based on lek counts, which are commonly used as an index of population trends, but their use to derive a population estimate has not been experimentally validated (Connelly et al. 2003b). Lek count-derived estimates have no confidence interval or other measure of precision and may typically underestimate the population. Walsh (2002) reported that an adjusted lek count procedure yielded a population estimate that was >40% lower (1,089 birds vs. 1,843 birds) than Bowden's Estimator, an intensive mark-recapture technique. The reliability of annual lek count-based estimates of breeding population depends on the assumptions that all leks are known and surveyed, all males were counted on leks, and an assumed sex ratio of 1:1.6. Sex ratios and male attendance may vary somewhat annually, and finding all active leks requires frequent surveys, so these assumptions may be regularly violated to some degree. Lek count protocols are designed to maximize the number of males counted without double counting birds that may move between leks. It is likely that most but not all males are counted on leks. Dunn and Braun (1985) reported 43% (SD = 26, range 3-96%) daily attendance by 52 males, with older males attending more regularly than yearling males. Walsh (2002) reported an average daily attendance rate of 42% (SE = 0.225, range 7.1-85.7%) for adult males, and 19.2% (SE = 0.140, range 0-38.5%) for yearling males. High lek counts from the peak of attendance are typically used for trend and population estimation, and counts from previous years help determine when that annual peak occurs. Emmons and Braun (1984) reported that of 33 radio-marked males monitored during 2 years, 90% of juveniles and 94% of adults attended leks during the peak of male attendance, although they used telemetry, and not all males were actually observed on the leks.

The 1 male:1.6 females sex ratio assumption is based on the literature (Girard 1937, Patterson 1952, Rogers 1964, Braun 1984) and sex specific survival data (Schroeder, unpubl. data). The sex ratio may change somewhat year to year, however, if conditions affect mortality of male and female juveniles differently (Swenson 1986). Swenson (1986) reported lower numbers of juvenile males than females killed by hunters, and attributed this to higher male chick mortality during spring and summer resulting from the greater nutritional needs imposed by the larger size of males. He did not consider differential vulnerability by sex during harvest, as reported by Connelly et al. (2000a).

Although population estimates based on lek counts contain significant uncertainty, other methods would entail the high cost and risks inherent in capturing and marking a significant portion of the population. Additional research is needed to determine if lek counts can be calibrated using mark-resighting or sightability techniques to derive better population estimates.

HABITAT STATUS

Past

> "At the present time nearly all the perennial grasses have been destroyed" Cotton (1904)

Before the arrival of early settlers, the shrub-steppe region of eastern Washington consisted of large tracts of native sagebrush and bunchgrass vegetation (Daubenmire 1970, Vale 1975). Occasional and patchy wild fires created a landscape mosaic of young and old sagebrush interspersed with grassland, wet meadows, and other shrub communities. Sagebrush coverage generally ranged from 5 to 26%, and coverage of perennial bunchgrasses ranged from 69 to 100% on undisturbed sites (Daubenmire 1970). Many species of forb and a biotic crust composed of mosses and lichens carpeted the space between taller plants so that little bare ground was exposed (Crawford and Kagan 2001). The most common shrubs were big sagebrush, three-tip sagebrush, stiff sagebrush and antelope bitterbrush; native bunchgrasses included bluebunch wheatgrass (*Pseudoroegneria spicata*), Idaho fescue (*Festuca idahoensis*), bottlebrush squirreltail (*Elymus elymoides*), Thurber needlegrass (*Stipa thurberiana*), basin wildrye (*Leymus cinereus*), and needle and thread (*Stipa comata*). Shorter grasses and sedges included threadleaf sedge (*Carex filifolia*) and Sandberg bluegrass (*Poa sandbergii*) (Crawford and Kagan 2001). Common perennial forbs included yarrow (*Achillea millifolium*), fleabanes (*Erigeron* spp.), buckwheats (*Eriogonum* spp.), lupines (*Lupinus* spp.), biscuitroots (*Lomatium* spp.) phlox (*Phlox* spp.), and milkvetches (*Astragalus* spp.) (Dobler et al. 1996, Crawford and Kagan 2001).

Shrub-steppe vegetation and large ungulates. In contrast to the prairies east of the Rocky Mountains, which sustained great herds of bison (*Bison bison*), the shrub-steppe plants and animals of eastern Washington do not seem to be adapted to the presence of large herds of large ungulates. This conclusion is based on the form and life history of native bunchgrasses, the fragility of biotic crusts, and the relatively low number of historic and archaeological records of bison (Mack and Thompson 1982, Van Vuren 1987, Belnap et al. 2001, Lyman and Wolverton 2002). Mack and Thompson (1982) also noted that while 34 species of *Onthophagus*, a nearly worldwide genus of dung beetle, occur east of the Rocky Mountains, none are native to intermountain shrub-steppe. During recent millennia elk (*Cervus elaphus*) were present at least seasonally along rivers. Their abundance waned with increasing aridity about 6,700 years ago (McCorquodale 1985). Lyman and Wolverton (2002) stated that at no time during the last 10,000 years were bison or elk as abundant in southeastern Washington as they were east of the Rockies when Lewis and Clarke arrived in the region. Burkhardt (1996) pointed out that the Columbia Basin was inhabited by a suite of large herbivores for the 2.5 million years of the Pleistocene. However, the intervening 7,000-10,000 years is sufficient time for plants to adapt to a relaxed grazing regime (Mack and Thompson 1982). Grass populations with different grazing histories can exhibit morphologic and genetic differences in <50 years (Painter et al. 1989). The observations of vegetation responses to livestock management over the last 150 years would seem to be more pertinent that speculations about prehistoric grazing regimes.

Native grasses and forbs in shrub-steppe do not seem to be adapted to intensive grazing by ungulates (Mack and Thompson 1982). Perennial bunchgrasses in the Columbia Basin grow rapidly in the spring to set seed before summer drying. Heavy spring grazing can prevent the plants from reproducing and can eventually eliminate the native bunchgrasses (Mack and Thompson 1982). Grazing by large herds of livestock after 1850 had a profound effect on the shrub-steppe ecosystem, greatly reducing the understory species of grasses and palatable forbs (Daubenmire 1940, Daubenmire and Colwell 1942, Ellison 1960, Galbraith and Anderson 1971, Tisdale and Hironaka 1981, Mack and Thompson 1982, Elmore and Kaufman 1994, Fleischner 1994). Shear (*in* Mack 1981) reported in 1901 that "bunchgrasses have been practically exterminated over large areas and their places occupied more or less by weedy annual plants, especially the soft chess" (*Bromus mollis*). Some of the most palatable bunchgrasses, such as Idaho fescue, may have declined in abundance, while less palatable species, like Sandberg bluegrass, probably increased in abundance (Rickard 1985; J.Benson, pers. comm.). Affected areas were then invaded by various aggressive, less-palatable species, especially introduced cheatgrass (*Bromus tectorum*) (Pickford 1932, Stewart and Hull 1949). Lowered water tables in meadow areas and erosion also resulted (Cottam and Stewart 1940, West 1983). By the 1930's, federal range personnel estimated that 84% of the sagebrush-grass region in the United States was severely depleted (USDA 1936).

Heavily grazed sites may have an understory of introduced annual grasses, like cheatgrass and crested wheatgrass (*Agropyron cristatum*), little forb cover, and little or no moss and lichen cover (Crawford and Kagan 2001). Many sites that have had repeated or intense disturbance are dominated by cheatgrass. Additional weed species that have invaded are medusahead (*Taeniatherium caput-medusa ssp. asperum*), rush skeletonweed (*Chrondilla juncea*), yellow starthistle (*Centaurea solstitialis*), and knapweeds (*Centaurea* spp.). The normal fire return interval for Washington shrub-steppe communities is uncertain, but was likely 50-125 years in Wyoming big sagebrush types, the most widespread communities (Scharf 2002, Wambolt et al. 2002). Fires result in the promotion of cheatgrass (Whisenant 1990, Peters and Bunting 1994), and cheatgrass also facilitates fire by providing a highly combustible, continuous fuel blanket, resulting in more intense and frequent fires that can eliminate sagebrush. Crawford and Kagan (2001) summarized: "alteration of fire regimes, fragmentation, livestock grazing, and the addition of >800 exotic plant species have changed the character of shrub-steppe habitat." More than half of the shrub-steppe community types in the Pacific Northwest are listed as imperiled or critically imperiled in the National Vegetation Classification published by The Nature Conservancy (Anderson et al. 1998).

Agricultural expansion, overgrazing, and sagebrush control through burning, mechanical removal, and herbicides severely degraded sage-grouse habitat. The combination of agricultural expansion and horses used in farming operations caused the most serious damage and deterioration to eastern Washington's shrub-steppe in the late 1800s and early 1900s (Harris and Chaney 1984). The Homestead Act of 1862 led to the proliferation of small farms in eastern Washington between 1863 and 1910 (Harris and Chaney 1984), and burning and plowing of shrub-steppe for agriculture became widespread (Yocom 1956). Nearly all of the conversion of shrub-steppe habitat to dryland farming occurred prior to 1940. After 1950, habitat was converted to irrigated farming as a result of large-scale reclamation projects associated with construction of the Columbia and Snake River dams.

Present

An estimated 7.4 million acres of steppe vegetation types remain in Washington (Jacobson and Snyder 2000). This is about 50% of the estimated 15 million ac of steppe habitats that existed in eastern

Table 7. Existing cover type[a] on lands in current and historical sage-grouse range in Washington (Schroeder et al. 2000).

Portion of Sage-grouse range	Proportion of area dominated by cover type (%)				Total area (km^2)
	Steppe habitats[b]	Cropland	CRP	Other	
Current sage-grouse range	57.0	26.6	13.0	3.4	4,683
Douglas-Grant County population	44.3	35.1	16.7	3.9	3,529
Yakima/Kittitas (YTC) population	95.6	0.5	1.9	1.9	1,154
Historical sage-grouse range[c]	43.5	41.5	6.1	8.9	57,741

[a] Based on 1993 Thematic Mapper Landsat data (Jacobson and Snyder 2000); current CRP percent would be higher and cropland lower for Douglas-Grant County.
[b] Includes shrub-steppe, meadow-steppe, and steppe habitats described by Daubenmire (1970).
[c] Cover types now present on the total area once occupied by sage-grouse in Washington.

Washington before European settlement. Most of the shrub-steppe lost was converted to cropland, but smaller amounts have been lost to roads, residential and commercial development, or inundation by reservoirs (Table 7). Within the historical sage-grouse range in Washington, approximately 25,117 km^2 (6,203,982 acres, 44%) of steppe habitats remain. Sage-grouse habitat is a subset of this remaining acreage, and factors affecting suitability include the type and percentage of shrub cover, elevation, slope, soil type, size of shrub-steppe patch, and habitat quality. Concurrently, there has been a 90-92% reduction in the distribution of sage-grouse. Swenson et al. (1987) also observed a disproportionate decline (73%) in sage-grouse when 16% of their Montana study area was converted to grain production.

Much of the most productive shrub-steppe with deep soil has been converted to agriculture, and what remains has steeper slopes, and/or has shallow rocky soil (Vander Haegen et al. 2000). Nearly all of it has been degraded to some degree; the worst is in poor condition and dominated by cheatgrass (Vale 1975, Mack 1981, Mack 1986, Dwire et al. 1999). More than 42% of the land classified as shrub-steppe has <10% shrub cover, either due to fires or because it is a grass-steppe vegetation type (Jacobson and Snyder 2000), and is generally not suitable for sage-grouse. Even where shrub-steppe with >10% shrub cover remains, often the understory of bunchgrasses and forbs has been degraded by historical overgrazing so that it is unsuitable for sage-grouse breeding and may only be suitable for wintering.

Three of the largest blocks of remaining shrub-steppe occur on the U.S. Army's YTC in Yakima and Kittitas counties, on and around the Hanford Department of Energy site in Benton County, and the Yakama Reservation (Dobler et al. 1996). The population in Douglas-Grant counties is supported by a mix of shrub-steppe remnants, CRP, and croplands.

Yakima Training Center. The YTC is a 327,242 ac facility used for military training exercises where 241,000 ac are still vegetated with sagebrush communities and of which about 145,000 ac can potentially support the big sagebrush/bluebunch wheatgrass habitat type (Livingston 1998, ENRD-YTC 2002). Based on radio telemetry relocations, sage-grouse occupy about 124,000 ac (38%) of the YTC (Livingston and Nyland 2002). The YTC was grazed from 1960-1995. The grazing program was initiated to reduce fuel and fire risk, but damaged sage-grouse habitat, increased the area dominated by cheatgrass and weeds, and did not seem to reduce fire frequency (Livingston 1998, M. Pounds, pers. comm.). Most of the 200 springs on the YTC were capped and diverted to cattle troughs, and perennial and ephemeral creeks were grazed, degrading summer brood habitat for sage-grouse. Grazing was eliminated in 1995, in part to mitigate the increased impacts associated with mechanized training units. The bunchgrass understory and riparian vegetation is showing signs of recovery from grazing, but habitat damage from tracked vehicles requires an ongoing restoration program (Livingston 1998). The northern portion of the YTC (65,000 ac) was acquired in 1991. It was formerly a combination of private and BLM lands that were managed for grazing and ORV recreational use. The area still has a sagebrush overstory, but the bunchgrass and understory forbs are degraded. Some areas of the YTC are infested with knapweeds (*Centaurea diffusa*, *C. maculosa*, and *C. repens*) that displace native vegetation, degrading habitat (Livingston 1998). The knapweeds are controlled with herbicides, which do not affect sagebrush, but also kill understory forbs. About 25,000 ac have been treated for knapweeds since 1994 (M. Pounds, pers. comm.). Cheatgrass and sandberg bluegrass/ cheatgrass communities are dominant on about 4,300 ac or 1.3 % of the YTC (ENRD-YTC 2002).

Hanford. Another large parcel of shrub-steppe is located on lands that are, or were formerly, part of the Department of Energy's (DOE) Hanford site in Benton and Grant counties. The area includes the Hanford site (Central Hanford), and the recently established Hanford Reach National Monument, which encompasses the Arid Lands Ecology (ALE) Reserve, Saddle Mountain National Wildlife Refuge, and the former Wahluke Wildlife Area. These areas provide a block of about 378,000 ac of steppe vegetation types. Fires in the 1980s and 2000 dramatically decreased the abundance of sagebrush in the area and likely contributed to the loss of breeding sage-grouse in Benton County.

Yakama Reservation. Roughly 400,000 ac of shrub-steppe vegetation remains on the Yakama Reservation in Yakima County (M. Livingston, pers. comm.), including a large block of about 250,000 ac. Of the 400,000 ac of shrub-steppe, roughly one-third of the area is in excellent condition with moderate sagebrush canopy cover and an understory of native bunchgrasses and forbs (B. Jamison, pers. comm.). Another one-third could provide wintering habitat for sage-grouse, but use during the breeding season would be limited. The remaining one-third is in poor condition and would be of little value to sage-grouse. Habitat degradation is due primarily to wildfires and historical overgrazing that have reduced or eliminated sagebrush and facilitated invasion by exotic annual grasses (B. Jamison, pers. comm.). Feral horses have probably had an impact on the condition of shrub-steppe on the reservation. A study is underway to determine the feasibility of re-introducing sage-grouse onto the reservation based on the quality, quantity, and distribution of shrub-steppe habitat.

Douglas-Grant Counties. The Douglas-Grant grouse population is supported almost entirely on private lands. The best remaining patches of habitat are relatively small parcels of 'scablands' with shallow soil and/or steep terrain, generally unsuited to cultivation. Some over-grazed lands that do not support nesting, probably due to a sparse herbaceous understory, are used for wintering habitat. A substantial amount of rangeland in Douglas County is no longer grazed because it has become increasingly difficult over the last 30 years for small cattle operations to remain profitable (J. Benson, pers. comm.). The federal CRP program removes land from crop production and establishes perennial vegetation. The grouse population has benefitted from CRP in Douglas and Garnt Counties, where 757 km^2 of cropland has been re-vegetated with seed mixes that include native grasses and sagebrush (Schroeder et al. 2000; B. Dudek, pers. comm.).

Because CRP establishes relatively permanent cover, it provides more year-round security to wildlife than land under cultivation. Sage-grouse likely use CRP fields because the cover is contiguous and can provide good nesting habitat which is usually not subject to livestock grazing. The quality of a CRP field for grouse habitat depends on the type of vegetation planted and the length of time the field has been in the CRP. Sage-grouse will use higher quality CRP fields that contain sagebrush and native grasses. CRP fields contained 40% of about 60 nests found in Douglas County from 1992 to 1996, and these nests were as successful as ones built in other cover. The CRP fields that appear to be most important are those near islands of shrub-steppe (Schroeder 1994). These patches of shrub-steppe are typically privately owned land with poor suitability for agricultural conversion.

Sage-grouse Management Units

Recovery and management of sage-grouse populations requires a realistic assessment of the habitat and population potential for the species within respective regions of Washington. Because these regions differ in may ways, it is useful to delineate the separate regions to aid future management directions. Areas within the historical range of sage-grouse in Washington that still contain significant concentrations of shrub-steppe and have potential for contributing to recovery were outlined by the Washington Sage-grouse Working Group, an interagency technical group. Fourteen management units were delineated within this area based on current occupancy, land ownership, location, topography, habitat quantity, condition, and potential (Fig. 6). These units are not the only areas with potential for use by sage-grouse. The intent of the Management Units map is not to restrict restoration activities, but to focus recovery efforts in those areas most likely to contribute to reaching recovery objectives. Recent observations of individual sage-grouse east of Omak and east of Sprague were outside of these Management Units. If sage-grouse consistently use additional areas, the management unit maps may be revised in the future. The units range in size from 325 to 2,424 km^2 and total 16,478 km^2 (Table 8). The proportion of steppe vegetation cover in these units ranges from 42 to 95% (average = 71%). However, only about half of the steppe vegetation (37% of the total area) has shrub cover >10% which is necessary for productive sage-grouse habitat (Connelly et al. 2000b). The portion of the historic distribution of sage-grouse in Washington where sage-grouse are extirpated consists of 42.3% shrub-steppe, 42.8% cropland, 5.5% CRP, and 9.4% other habitats (Schroeder et al. 2000).

Public lands are more likely to still support steppe vegetation. Eight of the management units are mostly state, federal, or tribal government lands (Table 9). The YTC unit is >95% military training facility, the Hanford Unit is >96% public, and Toppenish Ridge and Bridgeport Point are essentially 100% tribal lands. The remaining 6 units range from 57 % to 85% private land, and along with Bridgeport Point, have a significant area (>4%) enrolled in CRP (Table 8). These areas are characterized by a close configuration of shrub-steppe habitat (either remnant shrub-steppe or rangeland) and unirrigated cropland. The Washington State Parks and Recreation Commission owns 3 relatively small, but strategically located properties. The Ginkgo State Park and Wanapum Recreation Area, which straddle Interstate 90 on the Colockum and YTC units, are important locations for their potential to allow birds to move between the Douglas-Grant and YTC populations. Sun Lakes-Dry Falls State Park is located in a corridor connecting the Dry Falls and Moses Coulee units at the south end of Banks Lake.

Currently occupied areas. Mansfield Plateau, Moses Coulee, and YTC are the only management units known to be occupied by resident breeding populations of sage-grouse. They also illustrate the dramatic variation between management units. YTC has the largest portion of shrub-steppe (95%) of any unit, while Moses Coulee and Mansfield Plateau have only about 52%. The presence of sage-grouse on the YTC easily can be explained by the abundance of shrub-steppe, some of which is in very good condition. In contrast, sage-grouse in the two Douglas-Grant County units appear to have benefitted from a unique configuration of 52%shrub-steppe, 10-16% CRP, and 29-37% cropland.

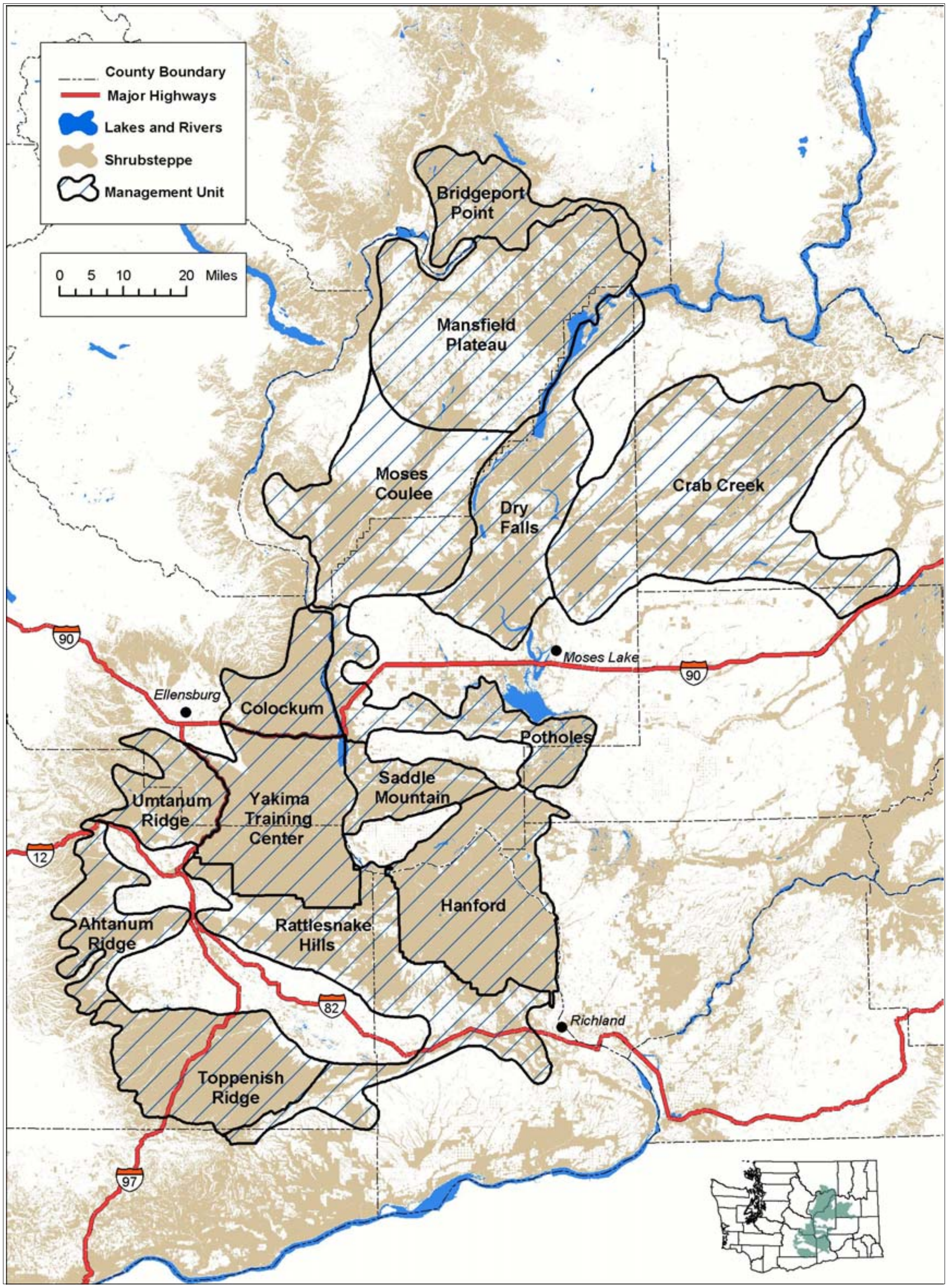

Figure 5. Shrub-steppe cover types and 14 Sage-Grouse Management Units in Washington.

Table 8. Area and cover types[a] (%) in 14 Sage-Grouse Management Units in eastern Washington.

Management Unit	Area (km^2)	Steppe vegetation types[b] (%) >10% shrub cover	<10% shrub cover	Total steppe (%)	CRP[c] (%)	Cropland (%)	Other[d] (%)
Ahtanum Ridge	605	27.4	42.9	70.3	0.6	23.3	5.9
Bridgeport Point	325	0.2	55.2	55.4	7.4	8.8	28.5
Colockum	561	78.3	10.5	88.7	0.00	4.2	7.1
Crab Creek	2,084	33.0	47.5	80.5	14.9	2.5	2.1
Dry Falls	1,242	37.8	43.1	80.8	4.3	1.6	13.3
Hanford	1,662	34.8	57.3	92.0	<0.1	2.0	6.0
Mansfield Plateau[e]	2,424	25.3	27.7	53.0	16.2	28.9	1.9
Moses Coulee[e]	1,811	32.3	19.8	52.0	9.9	37.0	1.0
Potholes	763	20.1	32.5	52.6	4.2	32.8	10.5
Rattlesnake Hills	1,420	31.3	11.1	42.4	9.5	45.2	2.9
Saddle Mountains	462	49.5	33.2	88.7	0.00	10.8	6.5
Toppenish Ridge	1,284	49.6	42.0	91.6	0.1	4.5	3.7
Umtanum Ridge	457	52.3	25.8	78.2	1.0	11.8	9.0
Yakima Training Center[e]	1,375	62.5	32.6	95.1	0.00	0.3	4.7
Total	16,478	37.0	34.4	71.4	6.9	16.5	5.1

[a] Based on 1993 Thematic Mapper Landsat data (Jacobson and Snyder 2000).
[b] Includes shrub-steppe, meadow-steppe, and steppe habitats described by Daubenmire (1970).
[c] CRP refers to the federal Conservation Reserve Program lands in place at the time of the habitat assessment in 1993 (Jacobson and Snyder 2000).
[d] Other includes forest/shrub, dunes, barren ground, snow, open water, wetlands, and urban development.
[e] Currently occupied by breeding sage-grouse (shaded).

The highly fragmented nature of the landscape has meant that the remaining shrub-steppe exists in relatively small patches of good quality. The relatively high precipitation in the Douglas-Grant units means the vegetation recovers more quickly from disturbance.

Potential expansion and reintroduction areas. Bridgeport Point, Dry Falls, Rattlesnake Hills, Saddle Mountains, and Umtanum Ridge are all adjacent to currently occupied units, whereas, the Hanford unit is < 10 miles from the YTC. All of these areas have had recent or anecdotal observations of sage-grouse (Schroeder et al. 2000). The fact that all remain unoccupied, despite their proximity to currently occupied units (Figs. 3, 5) indicates that sage-grouse may be poor colonizers or these areas may suffer problems with regard to critical limiting factors, or both. For example, initial assessments indicate that breeding habitat of sufficient quality is a consistent limiting factor on these areas. Recovery may also be inhibited by long-term declines in the vigor of existing populations; declining productivity in current populations may reduce opportunities for recruitment to new areas (Schroeder et al. 2000).

Table 9. Land ownership and predominant land use types in 14 Sage-Grouse Management Units.

Management Unit	Land ownership (%)[a]										Land use[b]
	Private	Tribal	DOD	DOE	DNR	BLM	WDFW	BOR	FWS	WSP	
Ahtanum Ridge	23.4	66.5	0.0	0.0	5.0	0.5	4.5	0.0	0.0	0.1	r
Bridgeport Point	0.8	99.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	p,ss,crp
Colockum	36.0	0.0	0.0	0.0	21.9	3.9	35.2	0.0	0.0	3.1	r
Crab Creek	78.6	0.0	0.0	0.0	6.8	9.8	3.7	1.1	0.0	0.0	r, p,ss,crp
Dry Falls	70.7	0.0	0.0	0.0	11.0	2.0	2.7	9.6	1.9	1.9	r,p,ss,crp
Hanford	3.5	0.0	0.0	77.1	0.3	15.2	0.8	2.8	0.2	0.0	g
Mansfield Plat.	83.9	0.0	0.3	0.0	12.4	1.6	1.3	0.3	0.0	0.0	r,ss,crp
Moses Coulee	84.9	0.0	0.0	0.0	4.0	9.6	0.9	0.4	0.1	0.0	r,ss,crp
Potholes	56.9	0.0	0.0	0.0	4.7	0.7	7.8	19.8	10.1	0.0	r,ss
Rattlesnake Hills	80.5	0.0	0.0	0.0	9.8	8.9	0.7	0.0	0.0	0.0	r,ss
Saddle Mts	44.5	0.0	0.0	0.0	5.3	21.3	11.9	11.9	5.1	0.0	r,p
Toppenish Ridge	0.1	99.8	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	r
Umtanum Ridge	26.7	0.0	0.0	0.0	18.2	10.3	44.7	0.0	0.0	0.1	r,p
Yakima Tr. Ctr.	2.8	0.0	95.9	0.0	0.2	0.1	0.0	0.0	0.0	0.9	g
Percent of total area	51.2	12.2	8.1	7.8	6.6	6.1	4.4	2.5	0.8	0.3	

[a] Land ownership categories include private, tribal, DOD (U.S. Department of Defense), DOE (U.S. Department of Energy), DNR (Washington Department of Natural Resources), BLM (U.S. Bureau of Land Management), WDFW (Washington Department of Fish and Wildlife), BOR (U.S. Bureau of Reclamation), FWS (U.S. Fish and Wildlife Service), and WSP (Washington State Parks).
[b] The most prevalent land use types: r = public rangeland; p = private rangeland; ss = remnant shrub-steppe; crp = Conservation Reserve Program; g = government reservation or U. S. Army training facility.

Based on proximity and the amount of shrub-steppe present, areas with the highest potential to become occupied (i.e., support nesting birds) in the near future appear to be the Beezley Hills in the Moses Coulee unit, the Boylston Mountains on the YTC, and the Rattlesnake Hills unit. There are occasional sightings of sage-grouse in the Boylston Mountains, but breeding has not been reported (M. Pounds, pers. comm.).

Ahtanum Ridge, Crab Creek, and Toppenish Ridge are isolated from units currently occupied by sage-grouse, but parts of these units may have potential to support sage-grouse. Establishment of viable populations may require a dramatic expansion of current distributions and/or deliberate translocations of birds into the unit after needed habitat improvements. These sites seem to have been occupied until relatively recently (Crab Creek was the most recent) (Schroeder et al. 2000). Consequently, there may be realistic potential to re-establish populations in these units.

Corridors and connections. The Colockum, Potholes, and Rattlesnake Hills management units appear to have significant potential as corridors, aside from any potential as habitat for resident populations of sage-grouse. The Colockum and Potholes units have potential to link the current Douglas-Grant and YTC populations of sage-grouse. This linkage would be particularly important in maintaining the long-term genetic health of sage-grouse in Washington. Unfortunately, both of these units have severe limiting factors such as quality of winter and breeding habitat. The Colockum Unit, which contains substantial portions of WDFW and DNR lands, appears to offer the best potential to connect the Moses Coulee and YTC units. However, it is handicapped by relatively rugged terrain, much of which may be unsuitable for sage-grouse. In contrast, the Potholes Reservoir has suitable topography but has numerous deficiencies in habitat and is an imperfect corridor between northern and southern populations. The Columbia River may inhibit movements of birds into the Potholes unit from currently occupied areas. Interstate 90 may inhibit north-south movements to some extent. Although full grown sage-grouse can easily fly over the highway corridor, it is uncertain if they will readily do so. The northeastern portion of the Rattlesnake Hills unit, particularly Umtanum Ridge, may provide an important movement corridor between the YTC and Hanford units. Sightings of sage-grouse on the Hanford unit since 1998 may result from birds moving out of the YTC (L. Cadwell, pers. comm.).

Habitat Limitations. Several factors limit sage-grouse populations or prevent habitat from being re-occupied. These include the quality of habitat present, the quantity of breeding and wintering habitat, isolation from occupied habitat, and the general health of existing sage-grouse populations. The quantity and quality of breeding habitat limits the expansion and recovery of sage-grouse in all management units. Some units, including Colockum, Umtanum Ridge, Bridgeport Point, Rattlesnake Hills, Saddle Mountains, Potholes Reservoir, and Hanford may currently have insufficient quality or quantity of breeding habitat and will require restoration to support breeding populations.

Sage-grouse are absent from many areas in Washington that contain limited amounts of winter and breeding habitat in adequate condition. Habitat patches are too small and too isolated from other patches to support a population that can persist for very long. There may also be unoccupied areas in Washington that contain an adequate quantity of breeding and winter habitat but lack sage-grouse simply due to isolation from source populations. This may include the Toppenish Ridge unit which is currrently being analyzed for its capability to support a population. The lack of habitat corridors is becoming a more critical problem every year as occupied habitat becomes more fragmented and isolated. Although the lack of winter habitat is not believed to be a significant factor in the declines of sage-grouse in currently occupied areas, the lack of sagebrush in some areas may reduce the opportunities for population recovery. Management units lacking or with a low amount of wintering habitat include Bridgeport Point, Colockum, Crab Creek, Hanford, Potholes Reservoir, Saddle Mountains, and Umtanum Ridge.

CONSERVATION STATUS

Legal Status

Sage-grouse were listed as threatened by the Washington Fish and Wildlife Commission in 1998 after becoming a state Candidate species in 1991 (Hays et al. 1998). Sage-grouse are classified as a game species in Washington and were formerly hunted. The hunting season was closed in 1988. Sage-grouse are designated a priority species and their habitat designated a priority habitat by the WDFW Priority Habitats and Species (PHS) program. Sage-grouse are not protected under the federal Migratory Bird Treaty Act and jurisdiction has been the responsibility of states.

In response to a petition to list the Washington population of sage-grouse under the U.S. Endangered Species Act, the U.S. Fish and Wildlife Service determined in May 2001 that listing the

Washington population was warranted but precluded by higher priority listing activities (USFWS 2001). Pursuant to this finding, the Washington population of sage-grouse became a federal Candidate species with a listing priority number of 9 on a scale of 1-12. The population is expected to be listed as Threatened under the Endangered Species Act at some point in the future, unless recovery efforts demonstrate significant positive results.

MANAGEMENT ACTIVITIES IN WASHINGTON

Population Monitoring, Protection and Recovery

The WDFW has conducted counts of sage-grouse to assess population status and trends since the 1950's. More intensive surveys were initiated in 1971 because of a recognized decline in the sage-grouse population. The WDFW conducts lek counts and surveys for new leks each spring. Lek counts are generally conducted during the peak period of activity from 1 March - 30 April. Each lek is counted at least 4 times, with counts separated by 7 or more days. Searches for new leks are conducted by listening at points along roads and sometimes by aerial searches (Connelly et al. 2003b). On the YTC, leks are surveyed and counted more intensely and lek attendance has been monitored annually since 1989. Lek counts and searches for new leks are conducted by the Environment and Natural Resources Division, Public Works, YTC. Around 1 February, lek surveys begin using vehicle routes with listening/observation stops every half mile (Livingston 1998). Aerial searches are occasionally used for inaccessible areas on the YTC. Targeted survey areas are searched for active leks at least once before the peak of lek attendance and each YTC zone is surveyed at least once per season. Active leks are checked once per week until male attendance increases substantially, when leks counts begin and all leks are counted on single days. Lek counts are conducted 2 times per week until male attendance drops dramatically, usually the last week of April, when count frequency drops to once per week. Livingston (1998) reported additional protocol details.

Winter surveys are conducted by the U.S. Bureau of Land Management (BLM) in cooperation with WDFW on BLM lands in Lincoln County. The reliability and feasibility of winter surveys in other areas are being determined as part of a current WDFW research project.

Sage-grouse receive protection on the YTC during the breeding season through lek buffers and seasonal training restrictions. Active leks both inside and outside of sage-grouse protection areas have a 1 km buffer excluding all training and aircraft below 300 ft from 2400- 0900 hrs from 1 March - 15 May, or as soon as the leks become active in spring (Livingston 1998). In addition, sage-grouse protection areas are off limits to training, except at existing ranges and on designated roads to those ranges, during nesting and early brood rearing (1 March - 15 June). Outside of this closed period, the sage-grouse protection areas are generally only used every 18-24 months for brigade-level exercises (Livingston 1998, M.Pounds, pers. comm.). The YTC is the only area in Washington where sage-grouse are officially protected from disturbance during the breeding and brood-rearing period.

For small populations, protection may not be sufficient to insure their persistence because inbreeding may result in loss of productivity or vigor. A recent genetic analysis funded in part by the YTC, WDFW, and the National Fish and Wildlife Foundation suggested that sage-grouse populations in Washington have abnormally low genetic diversity compared to sage-grouse elsewhere and would likely benefit from translocating additional birds from outside the state. This research was the impetus for a cooperative translocation project involving WDFW, YTC, and the Yakama Nation. With the cooperation of the Nevada Division of Wildlife, 25 sage-grouse hens were captured in Nevada and transported and released onto the YTC in March 2004. These birds will be monitored by telemetry to determine if they survive and reproduce, and genetic samples will be taken in future years to see if the translocation succeeded in improving the genetic health of the population or if an additional translocation is needed. A similar translocation will be done to benefit the Douglas-Grant population.

Habitat Acquisition

During the last decade, resource agencies or conservation organizations have acquired >120,000 ac in the sage-grouse recovery area. Some acquisitions were primarily focused on other species or were for multiple management objectives. The BLM and WDFW have been acquiring shrub-steppe lands in Washington. The BLM 1985 Spokane Resource Management Plan (RMP), the Record of Decision of 1987, and the RMP Amendment directed that the management efficiency of BLM public lands in eastern Washington be enhanced through a land tenure adjustment program (BLM 1985, BLM 1987, BLM 1992). The mechanism established to accomplish this goal was the consolidation of public land ownership through the exchange of isolated parcels of public lands, which were identified as difficult and uneconomic to manage, for other lands that met the specified goals for the management areas identified in the Plan (T. Thompson, pers. comm.). The 1992 Amendment provided additional guidance regarding the Spokane District Land Tenure Adjustment program. The management plan describes that "The highest land tenure adjustment priority would be placed on consolidation of public lands through land exchanges and purchases into, between and within the ten management areas identified in this RMP Amendment." Further RMP guidance directs that:

"Exchanges would be accomplished to acquire specific tracts that: provide greater expanses of uninterrupted high value wildlife habitats, possess recreational values that can be better managed and/or developed in public ownership, provide legal access to other public lands, qualify as an ACEC (Area of Critical Environmental Concern), have high scenic values, enhance the value/manageability of other public land, or possess other resource values of public interest that would be devalued or lost if retained in private ownership."

In an effort to meet the goals of protecting important wildlife habitat, providing public access, and promoting the efficient management of public lands, over 70,000 acres of important riparian and shrub-steppe habitat was acquired in Lincoln, Spokane, Whitman, Douglas, Grant and Yakima Counties. The majority of this acreage was acquired in the Upper Crab Creek and Moses Coulee Sage-grouse Management Units.

The WDFW has been acquiring and restoring habitat for sage-grouse and other shrub-steppe species in eastern Washington with funding from the Bonneville Power Administration (BPA) and the Washington Wildlife and Recreation Program. BPA is obligated to mitigate for habitat and wildlife, including sage-grouse, that are impacted by the construction and operation of federal dams on the Columbia River. The following criteria have been used to prioritize acquisition areas for sage-grouse:

- Areas of high-quality shrub-steppe currently occupied by sage-grouse
- Overlapping leks and winter-use areas on remaining shrub-steppe
- Key wintering areas
- Shrub-steppe ≤8 km (5 mi) from active leks
- Areas supporting many shrub-steppe obligates including sage-grouse
- Historic use areas and travel corridors

Sites recently acquired primarily for the conservation of pygmy rabbits (*Brachylagus idahoensis*) have provided habitat for sage-grouse in the Moses Coulee Sage-grouse Management Unit, including 4,000 ac on the Sagebrush Flat Wildlife Area and 2,000 ac at Chester Butte Wildlife Area. Lands acquired primarily for the conservation of sharp-tailed grouse that may provide sage-grouse habitat in the Crab Creek sage-grouse unit include 20,000 ac at the Swanson Lakes Wildlife Area.

The Nature Conservancy (TNC) has acquired 25,000 ac in the Moses Coulee sage-grouse unit, including >4,500 ac in the Beezeley Hills and 3,500 ac in Moses Coulee, where management will probably be compatible with sage-grouse recovery.

They also secured conservation easements on 2,800 ac and hoped to purchase an additional 9,000 ac in 2003. Lands acquired by WDFW and BLM, and the TNC reserves in southern Douglas and southwest Grant County should help facilitate sage-grouse conservation in the area.

Habitat Protection and Restoration

Yakima Training Center. The YTC has an active program for the protection and restoration of sage-grouse habitat, including revegetation of impacted areas, lek monitoring, briefings for military trainers, evaluation of training impact on habitat, and coordination meetings (Livingston 1998). Sage-grouse occupy about 124,000 ac on the YTC (Livingston and Nyland 2002). Sage-grouse protection areas include 44,320 acres, or 13.5% of the YTC (YTC-ENRD 2002). The majority of active leks and nest sites are in the Lmumma Creek and Selah Creek watersheds and have been identified as sage-grouse protection areas. Conservation strategies include seasonal restrictions on military training and other activities in core sage-grouse areas. Livestock grazing was largely eliminated in 1995, with the exception of brief trail-through by sheep. Bivouacking (i.e., camping) and digging are not permitted in sage-grouse protection areas (Livingston 1998). Maneuver training can occur in the sage-grouse protection areas every 18-24 months, but not during the 1 March- 15 June breeding period. 10,000 ac of riparian and other sensitive areas are off-limits to vehicle travel; protection of these sites also protects some valuable sage-grouse habitat (YTC-ENRD 2002). Remote sensing is used to detect and map areas of non-compliance (Livingston 1998); ongoing violations have been quickly corrected by contact with unit commanders. The YTC also has a Wildland Fire Management Plan to reduce the frequency of fires and facilitate fire suppression and conducts prescribed burning at firing ranges to reduce risks of wildfires. A Fire Risk Assessment is used to evaluate risks of fires due to training activities. The YTC also maintains >240 mi of fire breaks and 300 mi of road that help limit firespread and facilitate suppression (YTC-ENRD 2002).

The YTC has been restoring sagebrush and native grass and forbs. This includes planting sagebrush seedlings both inside and outside of the sage-grouse protection areas (Livingston 1998). The YTC plants up to 300,000 sagebrush seedlings annually with survival rates averaging 60%. A native seed mix including five grass and two forb species is planted annually depending on training levels.

USFWS and Department of Energy. Restoration is being conducted on the Arid Lands Ecology Reserve (ALE) now managed by the USFWS as part of the Hanford Reach National Monument. In 1998, 200 ac were planted with 75,000 sagebrush, and in 1999, 170 ac were planted with 51,000 sagebrush. However, most of these plants were destroyed in the Hanford Fire in June/July 2000 that burned 163,884 ac, including 75,000 ac on the ALE. Post-fire restoration included planting 265 ac (79,570 sagebrush) in 2000, 500 ac (173,347 sagebrush) in 2001, and 1,600 ac (700,000 sagebrush) in 2002 (H. Newsome, pers. comm.). In 2002, 10,000 ac were seeded with 200,000 lbs of native grass mix, with much smaller areas seeded in 2000, 2001, and 2003. Plans for 2003 were to plant 130 ac (53,200 sagebrush). Restoration work through 2003 will have covered only about 3.2% of the burn on ALE, and indicates the magnitude of the task of restoration after large fires. Since the 2000 fire, the Monument has improved its firefighting capabilities with more staff and equipment, the establishment of firebreaks along roads, and the development of agreements with neighboring fire districts. In addition to the ALE, 60,000 ac of the Central Hanford (Department of Energy) lands burned. Only 820 ac were planted with native vegetation in fall 2000, primarily to protect employees and facilities from blowing sand.

WDFW. WDFW Wildlife Areas that contain high quality shrub-steppe can potentially be used for sage-grouse reintroduction or augmentation projects in the future. Lands purchased by the WDFW in Douglas and Lincoln counties that are designated Wildlife Areas are being enhanced for sage-grouse, specifically through grass and forb seeding and planting of shrubs. The Hanford Fire of 2000 included the 3,633 ac Rattlesnake Slope Unit of the Sunnyside Wildlife Area. Restoration included seeding a mixture of native grasses, forbs, and sagebrush on 1,000 ac of the Unit in fall 2000. Results indicate fair to good establishment of sagebrush, yarrow, and thickspike wheatgrass, and demonstrated that seeding of sagebrush can be successful. This may be the only feasible method for immediate restoration after extensive fires (D. Larsen, pers. comm.). On the Colockum Wildlife Area, 1,397 ac of cropland have been enrolled in CRP and seeded with a mix that includes bunchgrasses and sagebrush. The seeded sagebrush is doing well (P. Lopushinski, pers. comm.). Problems encountered include weeds (mustards, cheatgrass, and jointed goatgrass (*Aegilops cylindrica*)), and damage to plantings from concentrations of elk.

Restoration work in Douglas County has included planting 100 ac on the Sagebrush Flat Wildlife Area to a shrub/grass mix in 1994; in 2002, sagebrush cover was 5-10% and 30" tall, but sheep fescue was crowding out more desirable species. In 1998, 230 ac were enrolled in CRP and seeded with a mix. Sagebrush cover was 10-20% and 5-10" in 2002. On the Chester Butte Wildlife Area, 171 ac were enrolled in CRP and seeded in 1998, and as of 2002 sagebrush coverage was 35-40% and 5-10" tall. Plans for 2003-2004 include reseeding 150 ac of former CRP and cropland on the West Foster Creek Unit with a mix of sagebrush, bluebunch wheatgrass, Idaho fescue, Sandberg bluegrass, Great Basin wild rye, and several forbs, using regional ecotypes if available (D. Peterson, pers. comm.). Fire breaks were also put in on Sagebrush Flats.

In 2002, WDFW revised the grazing policy for its lands. The policy requires that new grazing leases be consistent with the recently published Priority Habitat and Species (PHS) management recommendations (Schroeder et al. 2003). State law (*Ecosystem Standards for State-owned Agricultural and Grazing Land*, RCW 79.01.295) requires the WDFW and WDNR to develop goals to preserve, protect, and perpetuate fish and wildlife on state land used for agriculture, rangeland, or woodland used for grazing. Some WDFW lands are not fenced, so cattle from adjacent private lands are not excluded. Unless funds become available for fencing, livestock grazing on these lands cannot be closely managed.

Yakama Nation. Recent restoration efforts on the Yakama Reservation are in response to the Mule-Dry fire of August 2000. This has included reseeding bulldozer trails. Some cheatgrass control and native grass restoration is tentatively scheduled for 2003 depending on funding (M. Livingston, pers. comm.).

Washington State Parks. State Parks completed a detailed assessment of the vegetation in the Ginkgo State Park and Wanapum Recreation Area to assist with sage-grouse conservation planning using the protocols used on the YTC. Grazing has been at least temporarily suspended in the Ginkgo-Wanapum parks until a comprehensive planning effort has been completed. These parks are strategically located in the area connecting the YTC and Moses Coulee units. WDFW and State Parks are exploring ways to restore the riparian habitat in the Hell's Kitchen area of Rocky Coulee near Vantage.

BLM. In August of 1997, the Bureau adopted new standards and for rangeland health (BLM 1997). These *Standards for Rangeland Health and Guidelines for Livestock Grazing Management for Public Lands in Oregon and Washington* were developed in consultation with Resource Advisory Councils, Provincial Advisory Committees, tribes and other interested parties. The objectives of the Rangeland Health Standards and Guides are: to promote healthy sustainable rangeland ecosystems, to accelerate restoration and improvement of public rangelands to properly functioning conditions; and to provide for sustainable industry and communities dependent upon healthy rangelands. Although the focus of these standards is on domestic livestock grazing on BLM lands, on-the-ground decisions must consider the effects and impacts of all uses (T. Thompson, pers. comm.). More recently, specific guidelines for sage-grouse have been developed

(Barrett et al. 2000).

Shrub-steppe restoration efforts have been focused on recently acquired former agricultural lands, including over 1,200 acres in Lincoln County (Crab Creek Management Unit) and 100 acres in Douglas County (Moses Coulee Management Unit).

Conservation Reserve Program. New CRP enrollments are using a seed mix that includes sagebrush, which has produced encouraging results when properly used (D. Larsen, pers. comm.). This could eventually result in the partial restoration of all the 1.3 million acres of CRP in Washington.

Research

WDFW initiated sage-grouse research on the Douglas-Grant population in 1992. This work and related research activities have generated reports on sage-grouse population status (Hays et al. 1998, Schroeder et al. 2000), reproduction (Schroeder 1997), dispersion of nests relative to leks (Schroeder 2001), breeding area fidelity (Schroeder and Robb 2003), and nest predation in fragmented habitat (Vander Haegen et al. 2002). Review papers authored or co-authored by WDFW staff addressed sage grouse in general (Schroeder et al. 1999), predation (Schroeder and Baydeck 2001), population dynamics (Schroeder 2000b), and management (Connelly et al. 2000b, Crawford et al. 2004). Recent research initiatives include an investigation of wildlife use of CRP lands in Lincoln, Grant, Douglas, and Adams counties. The results of this research will be useful for restoration of shrub-steppe habitat.

Past research efforts on the YTC have focused on identifying and modeling sage grouse habitat use patterns (Eberhardt and Hofmann 1991, Cadwell et al. 1994, Cadwell et al. 1997). Sveum (1995) examined sage-grouse nesting and brooding habitat selection on the YTC (Sveum 1995, Sveum et al. 1998a, 1998b). The Battelle Pacific Northwest National Laboratory studied sage-grouse on the YTC beginning in 1989. Research projects included the development of a habitat model that integrates habitat suitability with potential training impacts (Livingston 1998). The model incorporates habitat data (Cadwell et al. 1997) with the magnitude, location, frequency, and season of training activities. Research objectives include determining the habitat required to maintain 200 sage-grouse on the YTC (Livingston 1998). A comprehensive vegetation survey mapped plant communities was completed in 1999 (YTC-ENRD 2002). A sage-grouse telemetry study was conducted in 1999-2000 (Livingston and Nyland 2002). Habitat restoration includes management experiments to evaluate and update planting and monitoring protocols as necessary.

The Yakama Nation mapped habitat on the Yakama Reservation, which will be used to evaluate the feasibility of re-establishing sage-grouse on the Reservation and in identifying habitat restoration needs. Current work will incorporate maps of habitat capability with a population model similar to that reported by Edelmann et al. (1998). The final report is scheduled to be completed in spring 2004 (B. Jamison, pers. comm.).

A recent genetic analysis funded in part by the YTC, WDFW, and the National Fish and Wildlife Foundation suggests that the sage-grouse population on the YTC has abnormally low genetic diversity compared to sage-grouse elsewhere and would likely benefit from translocating additional birds from outside the YTC. This research led to the translocation project that released 25 sage-grouse hens from Nevada onto the YTC in March 2004.

Additional research activities have included the development of a standardized survey protocol and a Habitat Suitability Index model (HSI). The HSI model provides an index that can be used for mapping habitat, refining habitat objectives, evaluating land acquisition, and assessing the potential for sage-grouse reintroductions.

Interagency Coordination and Partnerships

National sage-grouse conservation planning. Increased conservation concern for sage-grouse has generated a range-wide increase in activity. In 2000, a memorandum of understanding was signed by the Western Association of Fish and Wildlife Agencies, the U.S. Forest Service, BLM, and USFWS, establishing a Sage-Grouse Conservation Planning Framework Team. This team, consisting of representatives from state and federal agencies, provides coordination for sage-grouse and sagebrush conservation efforts. The team has been involved in coordinating a range-wide genetic study and is currently preparing a conservation assessment.

Conservation planning in Washington. A conservation agreement was developed in 1992 between the USFWS, the U.S. Army, and WDFW for the protection of sage-grouse and their habitat on the YTC. The agreement was in effect from 1992-99, but was not renewed in part due to the recognition that a more comprehensive, multi-agency conservation stategy was needed. This document, which was developed with input from multiple agencies, provides a broad outline and objectives for recovery activities. The Washington Sage-Grouse Working Group plans to develop a more specific 5-year action plan in 2004.

Significant partnerships include the Army/YTC and the Yakama Nation. They have cooperated on habitat mapping on the Yakima Reservation as part of an effort to re-establish a population there (YTC-ENRD 2002).

WDFW and TNC cooperated in acquisition of shrub-steppe habitat at two Grant County locations. WDFW was able to secure grants through USFWS for acquisition and the property is owned and managed by TNC.

The WDFW coordinates with federal and other state agencies on habitat management and enhancement. Some public lands owned by the BOR, BLM, and USFWS are managed by the WDFW. Mike Schroeder, a WDFW research scientist, has been active in national sage-grouse conservation committees and co-authored the most recent management guidelines for the Western States Sage and Columbian Sharp-tailed Grouse Technical Committee (Connelly et al. 2000b). The WDFW currently works with the USDA (through the Natural Resources Conservation Service and the Consolidated Farm Service Agency) on reducing the effect of brush control on sage-grouse and other wildlife.

BLM Sage-Grouse Habitat Conservation Strategy. The BLM recently issued a Draft Sage-Grouse Habitat Conservation Strategy, which outlines actions needed for conserving sage-grouse habitat on BLM-managed lands (available at: www.blm.gov/nhp/spotlight/sage-grouse/). The BLM manages about half of the sage-grouse habitat remaining in the United States (BLM 2003). The draft strategy will act as a framework for establishing state-level conservation strategies that will be completed and approved by January 2005. The national strategy directs state-level strategies to complement state- and local-level conservation actions, and generally directs an increased level of coordination and cooperation for sage-grouse habitat conservation. State-level strategies will have measurable accomplishments and progress will be reported annually. The adequacy of the strategy will be measured by a USFWS policy that provides guidance for evaluating existing conservation measures when making listing decisions (U. S. Fish and Wildlife Service 2003a).

Foster Creek Conservation District HCP. Numerous agencies, organizations, and landowners are involved in the development of a Habitat Conservation Plan (HCP) in Douglas County. Participants include WDFW, USFWS, TNC, DNR, BLM, BOR, the Audubon Society, Douglas County Public Utilities District, and private landowners. A draft environmental impact statement for the HCP was expected be completed in late 2003.

Coordinated Resource Management. WDFW was among 12 signatory agencies and organizations of the memorandum of understanding that established the Coordinated Resource Management (CRM) process for addressing management issues where mixed ownerships, or public/private management concerns. CRM is a collaborative process to achieve consensus solutions and could prove useful in reaching agreements on management of grazing and other issues in sage-grouse management areas.

Washington Sage-Grouse Working Group. The South-Central Washington Sage Grouse Enhancement Committee was formed in 1998 to work on sage-grouse conservation, with primary focus on the southern population and efforts to expand it from the YTC into other areas such as Hanford and the Yakama Reservation. The group coordinated mapping of habitat, standardized survey protocols, developed an Habitat Suitability Index (HSI) model, and provided review and comment for the sage-grouse recovery plan and recovery area map. During preparation of the WDFW recovery plan interest began to develop for a working group for sage-grouse with a statewide focus. The group, now called the Washington Sage-grouse Working Group, is being expanded to include representation by landowner and agricultural groups to reflect the greater importance of private lands. The Group plans to initiate work on a 5-year action plan in 2004.

FACTORS AFFECTING CONTINUED EXISTENCE

The primary threat to remaining sage-grouse populations is habitat loss and degradation resulting from large-scale fires; the potential reduction of lands in CRP; and conversion of shrub-steppe to cropland on DNR state-owned lands to produce income for state trust funds. The two remaining sage-grouse populations at the YTC and in Douglas and Grant counties are too small to be considered secure. Fire prevention and management of training activities are critical to maintaining sage-grouse at the YTC and continuation of the CRP and protection of remnant patches of native habitat are critical for sage-grouse in Douglas County. Additional causes of habitat degradation, besides fire, include overgrazing, encroachment by noxious weeds, and herbicides. Loss of habitat is also occurring by removal of vegetation by county road crews. Genetic data suggest the two populations are isolated from each other and losing genetic diversity. Both populations have many leks with low numbers of males. Small reductions in habitat quality may have significant effects on the continued use of leks. Without continued and expanded conservation effort to address the remaining threats, the sage-grouse population in Washington is likely to continue to decline.

Population Size and Isolation

> " Isolated relict populations, such as greater prairie chickens in Illinois, cannot be conserved indefinitely with inadequate habitat and small size." Westemeier et al. (1998)

Population isolation is a potentially significant factor influencing the continued existence of sage-grouse in Washington. Grouse populations naturally fluctuate due to environmental conditions. This natural variability put smaller populations at greater risk of extirpation. The potential for compounded effects of habitat change are great when populations have dropped to low levels. For example, dispersal by juvenile sage-grouse is typically advantageous in widespread and connected populations. However, it may become detrimental in isolated populations if dispersing juveniles are a net loss to the population and there is no compensating immigration. Both the YTC and Douglas-Grant sage-grouse subpopulations have fluctuated to estimated lows of 100-150 females during the 1990's. Many authors indicate that long-term survival (greater than 100 years) of isolated populations may require many more individuals (Lande and Barrowclough 1987, Dawson et al. 1987, Grumbine 1990).

Genetic health. Although chance events, such as fires or extreme weather, may be the biggest current threat to the Washington populations, the isolation of small populations will likely result in a loss of genetic quality (Lacy 1987) that may require the introduction of individuals to counteract loss of fitness. Inbreeding depression has contributed to declines and extinctions of several species in the wild (Brook et al. 2002). Inbreeding has been reported to affect male fitness in black grouse (*Tetroa tetrix*) (Högland et al. 2002). Genetic health (represented by adequate genetic heterogeneity) may be an important issue in both populations of sage-grouse in Washington, particularly on the YTC. Benedict et al. (2003), after a range-wide analysis of greater sage-grouse populations, reported that the two Washington populations exhibited the lowest genetic diversity, probably as a result of recent population declines. The YTC population was represented by only 1 common haplotype and the Douglas-Grant population contained only 3, compared to an average of 6.4 haplotypes for all populations (Benedict et al. 2003). Lack of genetic vigor may reduce the viability of a population and its ability to expand into adjacent management units. Benedict et al. (2003) indicated that management strategies should address the probable loss of genetic variation caused by this bottleneck. Bellinger et al. (2003) reported the loss of genetic variation in greater prairie chickens (*Tympanuchus cupido pinnatus*) following a population bottleneck in Wisconsin. Westemeier et al. (1998) and Bouzat et al. (1998) reported the reduced heterogeneity and fertility in a declining, remnant population of greater prairie chickens in Illinois. Fertility, hatching rate, and the population size of the Illinois population increased following augmentation with birds from large healthy populations (Westemeier et al. 1998).

Fire and Sage-Grouse

Wyoming big sagebrush, the dominant shrub in most shrub-steppe communities in eastern Washington, is fire intolerant, so the abundance of sagebrush reported by early European explorers in the region suggests that fire was infrequent probably because vegetation was relatively sparse and discontinuous (Tisdale and Hironaka 1981). Sagebrush-bunchgrass communities do not sustain a fire as well as sagebrush-cheatgrass does. Charcoal deposits in lake sediments from a study area in northern Douglas and southern Okanogan counties indicate that between 500 and 1,500 years ago fires occurred on average every 148 years (range 94-232 years; Scharf 2002). This return interval is more consistent with natural ignition sources rather than aboriginal burning. The charcoal deposits of the more recent 500 years were much reduced, perhaps indicating a reduction in fire size (Scharf 2002). These data are somewhat consistent with typical 50-100 year estimates of return interval for shrub-steppe regions (Whisenant 1990, Wambolt et al. 2002). Natural fire return intervals in shrub-steppe vary widely depending on precipitation. Areas with higher precipitation regenerate plants and shrubs that can act as fuel for the next fire more quickly (Tisdale and Hironaka 1981), although the window of time when conditions are dry enough to burn is more brief (Welch and Criddle 2003). Drier areas likely often exceeded 100 years between fires, while more productive areas may have had a shorter fire return interval. Welch and Criddle (2003) presented evidence that estimates of 20-30 years for fire return intervals in mountain big sagebrush are too low, and that the natural interval may be 50 years or more. Shrub die-off from voles, insects, disease, and winter kill may also be responsible for some shrub turnover (Wallace and Nelson 1990, Miller et al. 1994).

Grazing, crust disturbance, and range fires since European settlement have resulted in the domination of several million acres of the sagebrush-grass region by cheatgrass (Tisdale and Hironaka 1981). Cheatgrass is highly flammable and forms a continuous carpet of fine-textured fuel, and its presence has greatly increased the incidence of wildfire in the sagebrush-grass region (Whisenant 1990, Billings 1994, Moseley et al. 1999). Big sagebrush only re-colonizes burned areas by seed. Thus it may require 30 years or more may be required to regain pre-burn densities if a seed source is in the general vicinity, (Harniss and Murray 1973). Wildfires have converted large tracts of sagebrush in some areas to cheatgrass monocultures that are unsuitable as sage-grouse habitat (Drut 1994). Burning may also facilitate invasion by noxious weeds which may out-compete native grasses and forbs.

Nelle et al. (2000) examined vegetation cover and forb and invertebrate abundance on 20 different-aged burns and wildfires in mountain big sagebrush on the Upper Snake River Plain in southeastern Idaho. They found no apparent benefits for sage-grouse from the burning of nesting and brood-rearing habitat. They further concluded that burning had long-term negative impacts on nesting habitat because sagebrush required >20 years for canopy cover to become sufficient for nesting. Data from the oldest burns suggested that 36 years may allow sufficient recovery for sage-grouse nesting to resume. Pyle and Crawford (1996) reported that prescribed burns of plots with >35% cover of mountain big sagebrush and bitterbrush resulted in increased production of some forbs (Cichorieae) that are important food of sage-grouse chicks, but noted that further investigation of optimal interspersion with sagebrush cover is needed to determine the utility of burns to enhance brood-rearing habitat. Wambolt et al. (2001) also examined different-aged burns on mountain and Wyoming big sagebrush sites in Montana and found that big sagebrush burns up to 32 years old had not recovered to the density of surrounding unburned portions of study sites. They also noted that the decrease in sagebrush from burning did not result in the generally anticipated increase of herbaceous species. Fischer et al. (1996b) and Connelly et al. (2000c) studied a prescribed burn in Wyoming big sagebrush-three-tip sagebrush nesting and early brood rearing habitat and observed no increase in forbs or use by grouse, and a decrease in ants. That study found a more rapid decline in breeding age grouse in a burned area than in a control. Connelly et al. (2000c) urged managers to refrain from burning in low precipitation (<26 cm) sagebrush areas and indicated that their study did not support the use of fire to enhance brood rearing habitat. Byrne (2002) investigated burns and habitat use in southeast Oregon and reported that unburned areas were generally selected and burned areas were generally avoided by female sage-grouse during the breeding season. When burned areas were used they were typically ≥20 year old burns. All nests (n = 5) in ≤20 year-old burns failed, but nest success in ≥20 year-old burns did not differ from success in unburned areas. Byrne (2002) found some use of ≤20 year-old burns in mountain big sagebrush types which recover more quickly than drier types, but no use of burns ≤20 years old in other cover types. Burns in Wyoming big sagebrush appeared to have no value to female sage-grouse. Wambolt et al. (2002) reviewed the impact of fire on big sagebrush ecosystems and noted recovery usually takes several decades. They concluded that there was "no empirical evidence supporting the notion that fire has positive effects on sage-grouse over the short or long term." In contrast, Slater (2003) reported that burns were not avoided by nesting hens in Wyoming big and mountain big sagebrush in southwestern Wyoming and there was no apparent long-term negative impact. Slater's (2003) study area contained 2 recent prescribed burns (1 and 5 years old) and 2 wildfire burns (12 and 25 years old) that averaged about 20% total shrub cover. He observed that although the burns did not seem to improve brood rearing habitat based on forb or grass cover or insect abundance, the openings and edges created by the burns were attractive to brood-rearing females. Observations of females and males in spring and summer indicated that feeding and loafing birds were rarely found >60 m from an burned/unburned edge. Slater (2003) speculated that the greater visibility within burns may facilitate foraging for insects and forbs.

The invasion by cheatgrass, which is accelerated with fire and increases fire frequency, requires that fire prevention receive greater emphasis in management of shrub-steppe. Where a healthy community of native bunchgrasses and forbs are present, it will survive, and only the sagebrush component may need to be restored. Burned areas where cheatgrass is a significant component, however, may need immediate restoration if a community of sagebrush and native perennials is to be maintained on the site. The alternative may be an annual grassland of cheatgrass and perhaps eventual succession to medusahead which is unpalatable to livestock and has little value to wildlife (Hironaka 1994). Green-stripping has been used by BLM in Idaho to limit the size of fires (Pellant 1990). Green-stripping involves strategic placement of 30-400 ft-wide strips of fire-resistent vegetation on fire-prone landscapes (Pellant 1994). Monsen (1994b) lists several species with desirable attributes for use in green-stripping. Green-strips may need to be clipped or grazed to reduce fuel. Ideally, some green strips could be removed after recovery of the adjacent shrub-steppe (Monsen 1994b).

Fires in Washington. Large fires have the potential to devastate the core habitats of existing or re-established populations of sage-grouse and remain a major threat. The large fire "Hanford Fire," in June/July 2000 burned over 160,000 ac across multiple jurisdictions. The burn included >75,000 ac on the ALE unit of Hanford Reach National Monument, managed by the USFWS, 60,000 ac on the Central Hanford managed by the U.S. Department of Energy, >20,000 ac of private lands, >3,500 ac of WDFW lands, and about 1,000 ac of BLM land. The extirpation of sage-grouse from the Hanford Reservation may have been precipitated by large fires in the 1980s. One fire in 1984 burned >200,000 ac, including most of the ALE Reserve. During August 2000, the Mule Dry fire burned 70,000 ac, including 40,000 ac on the Yakama Reservation.

Fire is a constant threat on the YTC, particularly when training activities occur during the driest months of May to October. Most fires begin in the Artillary Impact Area or on firing ranges. Between 1987-2000, fires burned >75,000 ac, not including the 12,685 ac impact area where prescribed burns and wildfires occur periodically. A wildfire in August 1996 burned >48,200 ac on the YTC and portions of the Hanford site (YTC-ENRD 2002). Some areas used by sage-grouse were burned, but critical cover near leks and nesting habitat managed for sage-grouse were spared. The YTC has a comprehensive Wildland Fire Management Plan to minimize the risk and to suppress wildfires as quickly as possible, and fire management improvements have contributed to a decline in the ignition and spread of fires since 1996 (YTC-ENRD 2002).

The YTC may be better prepared for fighting fires than other agencies or jurisdictions in Washington and the risk of large fires may be less or no greater than for other areas with extensive shrub-steppe. The ability of agencies and landowners to reduce risk and suppress fires may ultimately determine the success of sage-grouse recovery efforts.

Biotic Soil Crusts and Disturbance

Shrubs, bunchgrasses, and forbs in shrub-steppe occur as patches, separated by what may appear to be bare ground. There is virtually no bare ground on undisturbed sites however, even in the driest parts of Washington steppe (Daubenmire 1970). Areas not occupied by the bases of vascular plants support a mosaic of cyanobacteria (formerly called blue-green algae), green algae, lichens, mosses, microfungi, and bacteria (Belnap et al. 2001). Biotic crusts, also called cryptogamic, cryptobiotic, microbiotic, or biological soil crusts, are found in arid and semi-arid environments throughout the world. Biotic crusts should not be confused with physical soil crusts caused by compaction or raindrop impact on unprotected soils. Physical soil crusts reduce water infiltration and increase soil erosion (Belnap et al. 2001:7). Wyoming big sagebrush community types support high bio-crust cover except where soil surfaces are greatly disturbed or current vegetation is in an early successional stage. In the Columbia Basin, the dominant crust components are tall mosses and green algae (Belnap et al. 2001). Ponzetti et al. (2000) reported that biotic crusts of the Horse Heaven Hills included a total of 58 species of lichens and 11 bryophytes (10 mosses and 1 liverwort) (McIntosh 2003); 35 species could be reliably identified in the field. They reported that, though the species composition differed with soil type and topographic position (e.g., ridges, warm slopes, cool draws, etc.), all areas had the potential to develop 100% cover by crustal organisms in spaces between vascular plants, except in disturbed and weedy areas. McIntosh (2003) identified 54 lichen taxa and 24 bryophyte species associated with soil crusts on the Hanford Reach National Monument.

Ecological significance of biotic crusts. Biotic crusts reduce wind and water erosion by binding soil particles together, thereby increasing the size of soil aggregates (Belnap et al. 2001). The rough surface creates a still-air layer above the surface that protects the soil from wind erosion and facilitates soil accretion. Well developed crusts with lichens and mosses resist wind erosion 2-130 times better than uncrusted soils (Belnap et al. 2001). The rolling surface crust type in the Columbia Basin impedes overland water flow and increases water infiltration. In addition to reducing wind and water erosion, biotic crusts fix atmospheric nitrogen and function as living mulch by retaining soil moisture, contributing soil organic matter, and discouraging annual weed growth (Belnap et al. 2001). Crusts can inhibit germination of cheatgrass and other exotic plants. Seedling establishment of native forbs and grasses, which often have self-burial mechanisms, is either not inhibited or is increased by crusts (Anderson et al. 1982, Harper and Pendleton 1993, Belnap et al. 2001). Observations on the ALE Reserve indicate that crevices bordering biotic crust polygons function as collection sites for seeds (Boudell et al. 2002). Crusts can trap blowing material and may create nutrient-rich microsites enhancing germination and growth of vascular plants, which in turn reduce erosion and increase soil development. Crusts also tend to be darker and absorb more energy than bare soil. The warmer temperature of crusted soil can support higher rates of photosynthesis, nitrogen fixation, and seedling germination and growth, an advantage since when the crust has been wet and is actively growing, the environmental temperature is often low.

Cyanobacteria and cyanolichens can be an important source of fixed nitrogen for plants and soils (Belnap et al. 2001). Crustal organisms lack a waxy epidermis and tend to leak nutrients into the soil, which are readily taken up by surrounding plants. Plants growing in bio-crusted soil show higher concentrations of various nutrients than plants in adjacent uncrusted soil. In one study, leaf tissue nitrogen was 9% higher in the shrub *Coleogyne*, 31% higher in the perrenial forb *Streptanthella*, and 13% higher in the annual grass *Festuca* (*Vulpia*) in crusted vs. adjacent uncrusted soil (Belnap 1995, Belnap & Harper 1995, Belnap et al. 2001). The dry weight of *Festuca* plants was twice that of plants in uncrusted soil. Shallow-rooted plants or seedlings of deep-rooted plants grown in well developed cyanobacteria-rich crust often contain more protein, phosphorus, potassium, calcium, sodium, magnesium and iron than those grown without it (Harper and Pendleton 1993). Herbivores, such as sage-grouse, probably benefit directly from the enhanced nutrient status of plants grown in healthy biologically-crusted soils. Fertilization experiments have demonstrated that sage-grouse will shift foraging activity to fertilized sites in Wyoming big sagebrush communities (Myers 1992).

Disturbance. Biotic crusts are sensitive to disturbance and crust components are good indicators of past land use. McIntosh (2003) reported that disturbance appeared to be the most important factor in seral stage development of crusts on the Hanford Reach National Monument. Ponzetti et al. (2000) reported that biotic crust cover and species richness in the Horse Heaven Hills, Benton County, was inversely related to disturbance, which is consistent with studies elsewhere. Over 30 studies on 4 continents indicate that livestock grazing, vehicles, and human trampling dramatically reduce lichen/moss cover and species richness of crusts (Belnap et al. 2001). Disturbance generally results in a greatly simplified crust community and loss of biomass and surface cover. After severe disturbance results in bare soil, the crust recovers very slowly. Intensity and type of disturbance, along with time since disturbance, influence the species composition of crusts. The presence and abundance of early or late successional crust organisms provides information about a site's disturbance history. Dominance by large filamentous cyanobacteria is generally indicative of severe, new, or frequent disturbance. Cyanobacteria, the most resistant to disturbance, are highly mobile and can re-colonize disturbed surfaces rapidly, but more complex organisms are more sensitive. When disturbance is less severe, less frequent, or some time has elapsed, crusts are generally in some mid-successional state, with some lichens and mosses present. Algae made up 80% of the total biotic cover on grazed sites in Utah (Anderson et al. 1982). Crust development increases stability of soil aggregates, which improves the environment for additional crust organisms. As soil stability increases, communities of cyanobacteria, lichens, and mosses become more widespread.

Mechanical disturbance by vehicles, foot traffic, mountain bikes, or raking immediately reduces nitrogen input from crusts (25-40% on silty soils, 76-89% on sandy soils) and can result in large decreases in soil nitrogen through a combination of reduced input and elevated losses (Belnap et al. 2001). Species changes affect nitrogen inputs, because cyanolichens (such as *Collema*) fix 10 times the nitrogen that an equivalent soil surface area of cyanobacteria. Heavy grazing can reduce nitrogen fixation by 95% in sandy soils (Jeffries et al 1992). On an arid Utah study area, Evans and Belnap (1999) showed nitrogen fixation in an area without grazing for 25 years was still 2.5 times less than an adjacent never-grazed area due to reduction in *Collema* cover. They found 42% less soil nitrogen and 34% less plant tissue nitrogen on a site grazed 30 years prior, as compared to an adjacent ungrazed area. Both field and greenhouse experiments have shown that cyanobacteria and cyanolichens enhance growth and essential element uptake by associated plants. Evidence also suggests that herbivores benefit from the enhanced mineral content of forage plants growing in well-developed cyanobacterial crusts (Harper and Pendleton 1993). It is likely that damage to biotic crust has affected sage-grouse directly through the nutritive quality of sagebrush and forbs and indirectly through the alteration of the vascular plant community. The condition of biotic crusts, however, has received no attention in sage-grouse research and literature (e.g., Beck and Mitchell 2000).

Crust recovery. Crusts in different communities recover at different rates. Large filamentous cyanobacteria can recover from disturbance relatively quickly followed by smaller cyanobacteria and green algaes. Lichens and mosses require a stable soil surface. Recovery is much faster when the crust is crushed in place by vehicles, foot traffic, or livestock than when the crust is removed (Belnap et al. 2001). Vehicle tracks generally have longer recovery times than foot traffic or other disturbances that do not churn the soil or make continuous tracks. Vehicles often turn the soil over and bury crustal organisms, while trampling tends to only compress the surface. Size and shape of disturbed areas are important because re-colonization comes mostly from adjacent less disturbed sites. Impacts vary seasonally depending on soil type; on silty soils early wet season use by livestock may have less impact than late wet season-spring use. Disturbance in the dry season is usually more destructive (except on clay), because crust organisms are brittle and not able to recover until wet (Belnap et al. 2001).

For sites in the northern Great Basin with 350 mm annual precipitation, recovery is estimated to take 20 years for gelatinous lichens, 25 years for early colonizing lichens and mosses, 60 years for mid-successional species, and 125 years for late colonizing species (Belnap et al. 2001:59). Anderson et al. (1982) reported substantial recovery of algae and other cryptogams 14-18 years after cessation of grazing in Utah exclosures, but new lichen species were still colonizing after 40 years of protection. After 38 years, the grazed community outside the exclosure had only 4% as much biotic cover as within the exclosure. Kaltenecker et al. (1999) reported substantial recovery of crust in an exclosure after 8 years on a Wyoming big sagebrush site in Idaho. Belnap (1993) cautioned, however, that assessment of recovery visually often greatly underestimates the time for total recovery. Johansen et al. (1993) reported that algae and cyanobacteria on the ALE Reserve in Benton County probably recover to pre-fire condition in 2-5 years. Johansen et al. (1993) suggested that the acidic soil may have facilitated more rapid recovery than alkali soils that are present in most of the Great Basin. Ponzetti et al. (2000) reported that some areas in the Horse Heaven Hills with well developed crust were known to have burned within the previous 20 years. Recovery of crustal components from other forms of disturbance has received little study in Washington. If crust recovery from severe trampling takes decades in Washington, as in Great Basin communities with similar levels of precipitation, it may be difficult, given historical grazing in Washington, to find sites that have a fully developed crust and the associated fertility that was generally typical before the introduction of cattle and horses. Crust recovery may be aided, however, by a greater frequency of overcast days in eastern Washington. This results in higher relative humidity and a higher precipitation/evaporation ratio for the frostless season compared to southern Idaho (Daubenmire 1940). The rate of crust recovery may vary dramatically from site to site within Washington depending on the soil type and aspect, with north slopes of fine soils recovering more quickly than south slopes with sandy soil.

Effect of cheatgrass on crusts. Heavy invasion by exotic annuals, like cheatgrass, results in replacement of perennial moss/lichen communities with a few species of annual mosses and cyanobacteria (Belnap et al. 2001). Invasive annual grasses can create a monoculture of densely spaced plants and homogenize litter distribution, thus decreasing crust cover and species richness. The increases in plant and litter density in interspaces previously occupied by crust affect moisture infiltration, which may further facilitate changes because less moisture is available for perennial plants (Belnap et al. 2001). Moisture is retained under the litter layer for long periods while temperatures are warm, and lichens may then become parasitized by ubiquitous molds (Belnap et al. 2001). Ponzetti et al. (2000) reported that biotic crust integrity and cover was inversely related to cover by cheatgrass in the Horse Heaven Hills.

Fire and crusts. Biotic crusts provide little fuel to carry a fire between shrubs and grass bunches, so fires are slowed and lower in intensity. Unburned patches of plants and crust are sources of seeds and spores for reestablishment in burned areas. Crusts are generally killed by hot ground fires, resulting in loss of biomass and visible cover (Belnap et al. 2001). Large fires are more frequent in areas invaded by cheatgrass and other annual weeds, and they preclude re-colonization or succession of crustal organisms (Belnap et al. 2001:49). Frequent fires will prevent the recovery of lichens and mosses, leaving only a few species of cyanobacteria. The degree of crust damage and recovery depends on pre-fire vegetation, fuel distribution, and fire intensity and frequency (Belnap et al. 2001). Johansen et al. (1993) observed that immediately following fire the crust, though blackened and dead, was still in place and helped protect the soil during the critical post-fire period when vascular vegetation was absent and soil was vulnerable to wind and water erosion. The burned crust broke down over the subsequent 6-8 months, and by that time vascular plants were visibly recovering. Ponzetti et al. (2000) reported that a burn in 1998 in the Horse Heaven Hills resulted in only partial mortality of the biotic crust.

Livestock Grazing

Livestock grazing has been suggested as a potential factor in both historical (Edminster 1954) and recent declines in sage-grouse numbers throughout their range (Connelly and Braun 1997, Braun 1998, Pedersen et al. 2003). An earlier range-wide decline coincided with the maximum livestock use of range resources between 1900 and 1915 (Patterson 1952). Yocom (1956) believed overgrazing during the era when cattle, sheep, and horses were much more abundant in Washington may have had a depressive effect on sage-grouse populations, but noted that the plowing and burning of shrub-steppe had a greater effect. The historical decline of sage-grouse from 1870-1930 also occurred during the period when hunting regulations were becoming established. Today, the main apparent difference between shrub-steppe where sage-grouse still exist in Washington and where they do not is the amount of herbaceous cover and the presence of sagebrush. Despite the pervasive influence of livestock grazing in sage-grouse range, there have been no experimental studies of the impact on sage-grouse populations. Bock et al. (1993) noted the lack of large representative tracts of ungrazed rangeland makes it nearly impossible to conduct definitive experiments to determine the consequences of livestock grazing. Nevertheless there have been many studies of how grazing affects vegetation.

In general, heavy grazing in sagebrush steppe decreases perennial forbs and grasses, often increases the dominance of introduced annuals, and may increase the dominance of unpalatable woody species (Miller et al. 1994, Anderson and Inouye 2002). The herbaceous plants of sagebrush communities are sensitive to defoliation in the late-spring and early summer, when heavy grazing reduces their vigor and coverage (Crawford et al. 2004). The conventional wisdom in range management suggests that since most herbaceous species are more palatable than sagebrush, livestock grazing eliminated understory grasses, while the shrubs flourished and cover of sagebrush became unusually dense (Vale 1975, Tisdale and Hironaka 1981). However, Welch and Criddle (2003) suggest that the assumption that heavy grazing increases sagebrush density and that Wyoming big sagebrush does not naturally exceed 10% canopy cover (20% for mountain big sagebrush), is based on weak scientific evidence. They refute these ideas based on several exclosure studies reporting inconsistent relationships between sagebrush density and grazing, the selection by several sagebrush obligate species of areas with 20-50% sagebrush canopy cover, and sagebrush densities in undisturbed areas (Welch and Criddle 2003). They concluded that grazing may or may not increase big sagebrush cover.

Beck and Mitchell (2000) reviewed the effects of grazing on sage-grouse habitat. They found that little was known about the direct impacts on sage-grouse, but more was known about indirect effects. Direct negative effects included deterioration of wet meadow hydrology and destruction of sagebrush in wintering habitat by sheep. Positive effects included an increase in growth or availability of forbs in dense grassy meadows. Several studies indicate that sage-grouse select meadows grazed by cattle over ungrazed meadows in early spring (Miller and Eddleman 2000). In Nevada, sage-grouse selected grazed areas in meadows where plants remained green longer in late summer because grazing had delayed plant fruiting and senescence and increased the abundance of succulent leaves (Evans 1986). However, heavy grazing of meadows can shorten the growing season through dessication and result in the loss of food plants (Miller and Eddleman 2000). Development of springs for stock has often resulted in the elimination of the mesic vegetation and concentrated stock use in important brood habitat. Vegetation at mesic sites, such as streams, springs, seeps, and wet meadows provide critical summer brood habitat for sage-grouse and these areas are often hard hit by livestock, particularly cattle (Savage 1969, Oakleaf 1971, Autenrieth et al. 1982, Belsky et al. 1999, Beck and Mitchell 2000). Horses are less likely than cattle to concentrate on mesic sites and may range up to 5 miles from water. However, being non-ruminants, horses use forage less efficiently than cattle and consume much more per animal than cattle and therefore have the potential for significantly impacting both upland and riparian shrub-steppe habitats (Beever and Brussard 2000). Low elevation exclosures at springs and meadows in Nevada had notably greater plant species richness, percent cover, and abundance of grasses and shrubs than horse-grazed springs; exclosures at higher elevations exhibited maximum vegetation heights 2.8 times greater than vegetation grazed by horses and 4.5 times greater than vegetation grazed by horses and cattle (Beever and Brussard 2000). Cattle are the most common livestock affecting sage-grouse habitat in Washington, but sheep and horses have affected shrub-steppe habitat quality in some areas.

Indirect impacts of livestock grazing include spraying, burning, and mechanical treatments of sagebrush, seeding of crested wheatgrass to increase livestock forage and an increase in alien weeds (Beck and Mitchell 2000). Somewhere between 2 - 4.8 million ha of sagebrush habitats were altered by sagebrush control activities by 1975 (Beck and Mitchell 2000). Existing studies indicate that the most immediate impact of grazing is reduction of grass cover at sage-grouse nest sites, which can result in high rates of nest predation (Hockett 2002). For example, in an Oregon study only 18 of 124 nests found in 3 years were successful, and successful nests had taller grass cover (Gregg et al. 1994). Grazing of tall grasses to

<18 cm (7 in) decreased their value for nest concealment (Gregg et al. 1994). An artificial nest study by DeLong et al. (1995) supported the importance of tall grass and medium shrub cover for reducing predation rates. Sveum et al. (1998b) concluded that sagebrush communities with abundant herbaceous cover were best able to conceal nests, and that increasing native bunchgrasses and forbs would improve concealment and food in sagebrush cover types. In addition to possible impacts during the nesting period, grazing may affect sage-grouse during their brood phase. Livestock grazing during drought generally reduced grasshopper populations in southern Idaho rangeland (Fielding and Brusven 1995), and grasshoppers are an important food of growing chicks. Trampling impacts to the biotic crust, so readily overlooked, may affect the ability of native vascular plants to sustain and recover from disturbance (Belnap et al. 2001). As Anderson et al. (1982) stated, "prolonged grazing during seasons of low precipitation, high temperature and persistent wind is almost certain to destroy even well-developed biotic crusts."

The impacts and merits of livestock grazing in arid and semi-arid western ranges has been much reviewed and debated from various perspectives (Fleischner 1994, Vavra et al. 1994, Belsky et al. 1999, Donahue 1999, Jones 2000, Curtin 2002). One key consideration, sometimes overlooked in the discussions (Knight 2002), is that native shrub-steppe vegetation in the Columbia Basin, characterized by an understory of bunchgrasses and a biotic crust, reflects a recent evolutionary history without large numbers of large herbivores (Mack and Thompson 1982, Daubenmire 1970). Though rare episodes of severe damage by jackrabbits, rodents, and grasshoppers may have occurred, and bison, elk and bighorn sheep were at least seasonally or locally present, grazing by large ungulates seems to have played little part in the evolution of shrub-steppe organisms in Washington prior to the arrival of early settlers. In a worldwide review of the effects of grazing by large herbivores, Milchunas and Lauenroth (1993) concluded that an evolutionary history that included grazers in the local environment is the most important factor in determining negative impacts of grazing on an ecosystem. This suggests that the impact of livestock grazing in the Columbia Basin would be different than in other regions.

Crawford et al. (2004) concluded that light or moderate livestock grazing in mid to late summer, fall, or winter is generally compatible with maintenance of perennial grasses and forbs in sagebrush habitat. In an earlier review, Miller et al. (1994) concluded based on the limited data, that light to moderate grazing can be compatible with a return to good condition if the site has not been pushed into a degraded steady state by past overgrazing. The recovery of native grasses and shrubs from past overgrazing may not occur, however, where more than light grazing by livestock and wildlife (>30-35% use) continues (Holechek et al. 1999). Range management plans often consider 50% use of forage as moderate stocking. Moderate grazing "allows the palatable species to maintain themselves but usually does not permit them to improve in herbage producing ability." In a review, Holechek et al. (1999) concluded that research consistently shows that moderate grazing involves about 35-45% use of forage, whereas light grazing averaged 32%, though they lacked data from intermountain sagebrush communities. A more recent paper, advises that "a 25% harvest coefficient is a sound idea for most western rangelands" (Galt et al. 2000). Pedersen et al. (2003) reported that simulations suggest that a 50% utilization of available forage by sheep combined with a moderate fire regime (5% of the spring area burned every 25 years) would lead to sage-grouse extirpation. Higher utilization rates (>35%) may be compatible with vegetation recovery if grazing occurs in the early spring, but ceases while there is still sufficient soil moisture for the grass to recover and set seed (E. Bracken, pers. comm.). However, this may not be compatible with the need for residual grass >7" desired in sage-grouse nesting areas. Crawford et al. (2004) cautioned that management should not be based on utilization guidelines and that vegetation monitoring is critical to sound management.

Light early spring, and/or fall or winter grazing by smaller ungulates, such as sheep or goats, may be more consistent than cattle grazing with the recent evolutionary history of vegetation and biotic crust in the Columbia Basin (Mack and Thompson 1982, Belnap et al. 2001, Lyman and Wolverton 2002; see also Habitat Status: Past, p. 23). However, sheep may compete directly with sage-grouse for forbs, whereas under light to moderate grazing there is little potential for direct competition from cattle, which eat mostly grass (Miller and Eddleman 2000, Pedersen et al. 2003). Herds of sheep or goats are also likely to be much more dense than native ungulates were historically and are capable of serious damage. Laycock (1967) reported that heavy spring grazing in three-tipped sagebrush by sheep caused rapid deterioration of range. Sagebrush production increased 85%, production of grasses and forbs decreased 50%, and some forbs decreased >85%. Heavy grazing by sheep only in late fall allowed the site to remain in good condition from 1924-1949. Further experimentation found that late fall grazing reduced the density of sagebrush, but maintained a healthy understory. Grasses and forbs were not damaged because they are dormant in late fall. The production of desirable forage species increased 30% while sagebrush decreased 20%. The amount of annual browsing on sagebrush was determined by snow cover which was often present during the latter half of the fall grazing period. Laycock (1967) and Bork et al. (1998) suggested fall sheep grazing as an alternative to other means of controlling three-tip sagebrush on ranges with an intact understory of perennials. However, Pedersen et al. (2003) noted that the live shrub cover in fall-grazed plots reported in Bork et al. (1998) was not significantly different than in exclosed plots. Pedersen et al. (2003) suggested that reduction of sagebrush canopy cover with fall grazing needs further investigation. Clipping experiments suggest that reduced sage-brush cover in fall-grazed pastures results from competition from healthy grasses and forbs rather than fall livestock browsing of sagebrush (Wright 1970).

Cessation of livestock grazing would not necessarily result in recovery of vegetation and subsequent benefit to sage-grouse. Laycock (1994) reviewed studies that showed that once a site has a reduced understory and sagebrush dominates, the site may remain in that condition for a very long time. He indicated that simple relaxation or removal of grazing often is not sufficient to move a site out of that new stable state (Laycock 1991, 1994, West 1999). Observations of this type are consistent with the 'state and transition' theoretical model for rangelands that involves multiple successional steady states (Westoby et al. 1989, Pieper 1994). This model is an alternative to the Clementsian model of a climax community with a single successional pathway that predicts recovery of climax vegetation with the removal of stressors, such as grazing. Pieper (1994) concluded that the traditional model fits "some ranges well, others not so well, and still others barely at all." West and Yorks (2002) reviewed data from grazed and ungrazed portions of a 20-year old burn and concluded that neither the Clementsian model nor the state and transition model described the vegetation responses observed. Miller et al. (1994) stated that "our understanding of the long-term effects of light to moderate grazing on plant composition and ecosystem processes in the Intermountain Sagebrush Region has progressed little since the turn of the century."

In contrast to the observations of Laycock (1994), Anderson and Inouye (2001) present information on the steady recovery of native vegetation over 45 years on the Idaho National Engineering Laboratory (INEL). The INEL had been heavily grazed and went through a prolonged drought during the 1930s-40s. When grazing ceased in 1950, the site had combined shrub and perennial grass cover of 18%, was heavily dominated by sagebrush, and the perennial grass component was only 0.5%. Precipitation improved in 1957 and by 1965 total shrub cover had increased to 25%, and by 1975 perennial grass cover had increased 13-fold. Richness of shrubs, perennial grasses, and forbs steadily increased from 1950-1995. Cheatgrass and other exotic plants were rare in plots until 1975, and the authors did not know how vegetation dynamics would have differed if cheatgrass had been abundant in 1950 (Anderson and Inouye 2001). The trend in the sage-grouse population on the INEL during that period of vegetation recovery is not known (J. Connelly, pers. comm.). There is little data prior to the mid-1970s and since then the population has fluctuated in response to wildfires and droughts.

Livestock grazing is compatible with sage-grouse where the habitat characteristics needed for breeding and wintering can be consistently maintained (Connelly et al. 2000b; see grazing sections in Wambolt et al. 2002, Rowland and Wisdom 2002, and Crawford et al. 2004). Whether this is possible on any particular site probably depends on many factors including the grazing history of the site, site condition, precipitation zone, livestock involved, the season, intensity, frequency and duration of grazing. Livestock grazing does not occur on the Hanford sage-grouse management unit and was discontinued on the YTC in 1995. Many other areas in Washington, though currently lightly or moderately grazed, have little perennial grass or forb cover, a legacy of past over-grazing. Nesting sage-grouse in Douglas County seem to avoid these areas (M. Schroeder in prep.). Hockett (2002) provides useful recommendations for grazing in sage-grouse habitats, and suggests developing strategies that will protect sage-grouse spring, summer, and fall habitat from the cumulative effects of grazing during droughts.

Elk

Concentrations of wintering elk have negatively affected some areas in sage-grouse management units that are potential corridors for grouse movement (Fig. 6). Past livestock grazing and annual concentrations of elk on winter feeding areas on some WDFW wildlife areas has resulted in patches of degraded shrub-steppe. These lands were purchased largely to provide elk winter range and to reduce elk damage to private lands. It is not known if the degraded areas are large enough to seriously inhibit grouse movement. Elk are restricted from moving to lower elevation areas by fencing to prevent damage to agricultural fields and orchards that now occupy what was historical winter range. This creates concentrations of elk that graze and trample the vegetation on wildlife areas in fall and winter, and necessitates feeding of elk in large numbers at several sites each winter. Approximately 4,500 elk wintered on the Colockum, Quilomene, and Whiskey Dick wildlife areas in 2001 (WDFW 2001). These sites encompass portions of the Colockum sage-grouse management unit which may provide a corridor for grouse movements between the YTC and Douglas-Grant populations. The condition of the vegetation varies widely on different portions of the Colockum Wildlife Area. For example, the vegetation is seriously degraded on the West Bar area west of the Columbia River, which was heavily grazed historically and now hosts 2,000 elk each winter. Seeding projects have been attempted there, but high elk use prevents seedling establishment. In contrast, the Tarpiscan Creek drainage has a healthy and diverse shrub-steppe community (J. Benson, pers. comm.)

The Umtanum and Ahtanum Ridge units may eventually be used by sage-grouse as seasonal habitat and movement corridors between the YTC and the Toppenish Ridge unit, however, the habitat has not been formally evaluated for suitability to sage-grouse. The Yakima elk herd, which numbers about 10,000 animals, winters in large numbers in these units on the Oak Creek and Wenas wildlife areas and is fed at several feeding stations each winter. A large portion of the Umtanum Ridge sage-grouse management unit west of the Yakima River is on the Wenas Wildlife Area and is considered critical elk winter range (WDFW 2002). Elk movements are restricted by over 100 miles of A portion of the Yakima elk herd occurs in the Hanford and Rattlesnake Hills Sage-grouse Management Units. A small number of elk, probably from the Yakima elk herd, colonized the area in 1972. Since the ALE and Central Hanford is closed to hunting, the herd grew relatively unimpeded from about 8 animals to an estimated 838 in 1999 (Tsukamoto 2000). Among the concerns raised about the number of animals was

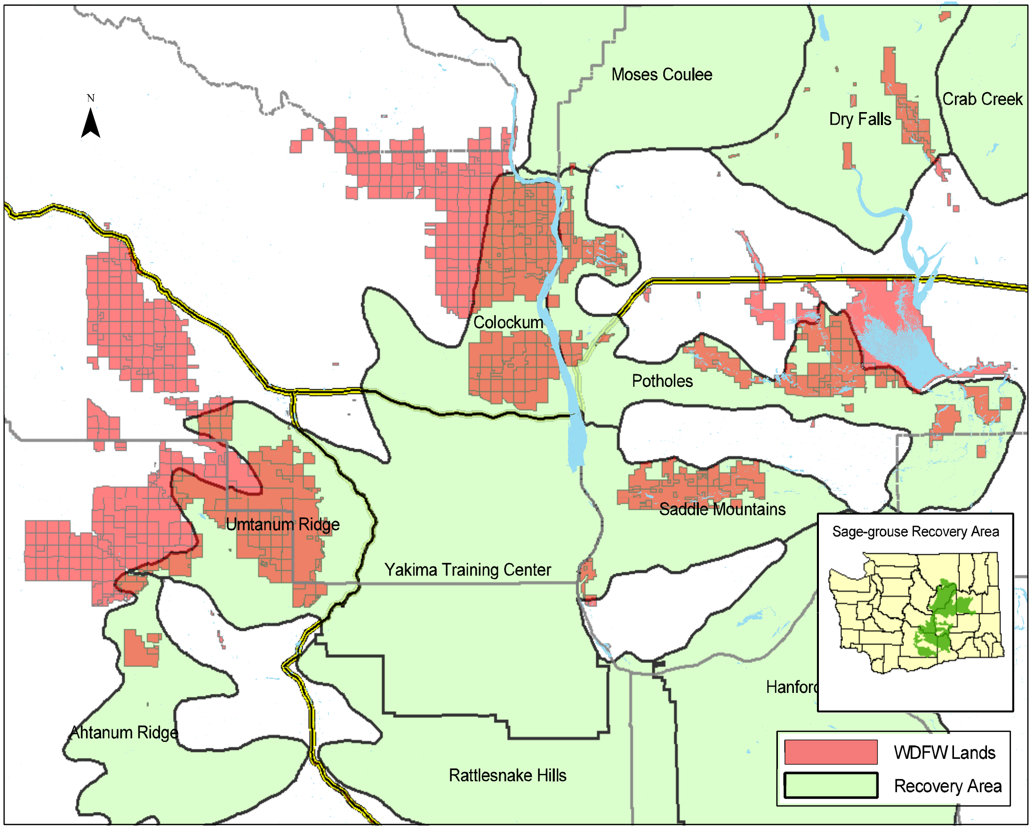

Figure 6. WDFW lands and sage-grouse management units that are potential corridors between populations.

that the herd would eventually damage shrub-steppe vegetation on the ALE Reserve. The herd was reduced to about 439 in 2001 through relocations and liberalized hunting on adjacent lands. The 2000 fire that affected 164,000 acs forced elk to forage off the ALE, where they were vulnerable to hunting, and resulted in a record harvest of 253 that year (Washington Dept. Fish and Wildlife 2002). The population goal for the herd set by WDFW and USFWS is to keep the herd at around 300-400 animals. A controlled hunt on the ALE may be needed to keep the herd from increasing and damaging vegetation and agricultural crops on adjacent lands. McIntosh (2003) noted that elk have impacted soil crust on the Hanford unit, particularly in remaining patches of Wyoming big sagebrush on the ALE where elk have concentrated since the 2000 fire.

Military Training on the Yakima Training Center

The survival of sage-grouse in Kittitas and Yakima counties for the foreseeable future depends on the maintenance of shrub-steppe habitat on the YTC and elsewhere. This requires management of military activities in critical areas, and the prevention and successful suppression of fires. Maintaining sage-grouse habitat where mechanized training exercises occur is difficult, but a goal of Army Regulation 200-3 is the systematic conservation of biodiversity on Army lands within the context of the training mission (Livingston 1998). Sagebrush levels on the YTC are low when compared to studies from other states, and the destruction of sagebrush on the training center likely affects the sage-grouse population (Eberhardt and Hofmann 1991, Cadwell et al. 1996). A Candidate review by USFWS concluded that military training on the YTC did not pose an immediate threat to the population based on the implementation of the Army's conservation measures and the level of training activity (USFWS 2002).

The most obvious impact of training is the damage to sagebrush cover. An exercise conducted in October 1995 damaged approximately 14% of the big sagebrush occurring in the primary sage-grouse habitat, and probably had negative impacts on the sage-grouse population (Cadwell et al. 1996). The combined impacts of exercises in 1995 and 1996 resulted in shrub cover being lost on 11% of the affected area (Stephan et al. 1996). The spread of noxious weeds by vehicles is also a problem that requires ongoing attention. In addition to damage to vegetation, troop and vehicle activity on the training center may be responsible for large home ranges (Eberhardt and Hofmann 1991) and the shifting of leks to new locations over the last 15 years. At least 2 leks are located on roads, and if protection measures are not followed and leks are repeatedly disturbed they may be abandoned (Livingston 1998). Disturbance of females may lead to nest or brood abandonment. Eberhardt and Hofmann (1991) reported that a radio-tagged female abandoned a nest, apparently in response to troop and vehicle movements.

Training restrictions and restoration of vegetation reduce impacts in sage-grouse protection areas; however, of the area that has the potential to support big sagebrush/bluebunch wheatgrass habitat in the 6 watersheds where grouse nest, 36% is outside of sage-grouse protection areas (Livingston 1998). During 1999-2000, 48% of telemetry relocations of sage-grouse on the YTC were outside of the sage-grouse protection areas (Livingston and Nyland 2002). Two new lek complexes are also outside the protection areas (U.S. Army 2002). The YTC's Western Sage Grouse Management Plan's population objective is to maintain a sage-grouse population of at least 200, which was the 10 year average (Livingston 1998). It is unknown how many birds could be maintained on the YTC; an isolated population of 200 may not persist indefinitely. Connecting the YTC population to populations outside the YTC is necessary for their long-term persistence. The Army has been actively working to maintain the YTC population since 1989; however, the continued success of maintaining sage-grouse on the YTC despite impacts of military training and the risk of large fires, is uncertain. Additional populations of sage-grouse will be needed in the state so that, if a large fire does occur on the YTC, the state-wide sage-grouse population will not be reduced by 200-300 overnight.

Wind Energy Projects

There are currently 15 proposals for wind energy projects in Washington. Two projects are within the sage-grouse recovery area. The Maiden Wind Farm proposes to construct up to 549 wind turbines on private lands in the Rattlesnake Hills sage-grouse management unit near the southern boundary of the Hanford unit and extending 6 miles west of the unit's western boundary (BPA 2002b). The Bonneville Power Administration has issued a final environmental impact statement (EIS)(BPA 2002b) for the project, although it is currently on hold, and may be stopped over concerns about potential impacts to research facilities in the area that are extremely sensitive to vibrations. In considering impacts of wind farms on wildlife, most of the focus has been on collision impacts to flying birds and bats (Erickson et al. 2002). For sage-grouse, an important issue that has received little attention is the potential for habitat loss and fragmentation due to behavioral avoidance of towers. Interim guidance provided by the USFWS states, "Avoid placing turbines in habitat known to be occupied by prairie grouse...In known habitat, avoid placing turbines within 5 miles of known leks..." (U.S. Fish and Wildlife Service 2003b). The Maiden Wind Farm EIS (BPA 2002b:65) states that, "Should the sage grouse population increase in the vicinity, there is no reason to believe they would be excluded from inhabiting the shrub steppe habitat on the site after the project is in place." However, sage-grouse and other prairie grouse are reported to avoid areas with tall structures even where anti-perching devices prevent raptors from using the tower or pole as a hunting perch (Manes et al. 2002). In California, sage-grouse abandoned leks within 1.4 mi of new powerlines and lek attendance was reduced up to 3 mi away (Rodgers 2003; F. Hall, pers. comm.). This avoidance may be an instinctive response to tall structures that reduces the bird's vulnerability to avian predators. In radio-telemetry studies, prairie chickens avoided suitable habitat within ½ mi of residences, well-traveled roads, and compressor stations, and none of the 200 marked birds nested or were ever located within 1 mi of a coal-fired generating station (Robel 2002). Robel (2002, R. Robel, pers.comm.) predicts that prairie-chickens will not nest or rear broods within at least 1 mile of wind turbines which will render otherwise suitable habitat unusable. If this holds true for sage-grouse, the Maiden project may render 43 mi^2 of sage-grouse recovery area, including 5 mi^2 of shrub-steppe on the ALE unit of the Hanford Reach National Monument, unusable for breeding. The EIS outlines a plan to mitigate for only 414 ac of native habitat permanently or temporarily impacted by the project at a ratio of 3:1 (BPA 2002a). The Maiden project location is also problematic to sage-grouse recovery because it has the potential to inhibit movements of birds between the YTC, the Hanford unit, and the Toppenish Ridge unit, where a study is evaluating the feasibility of reintroduction of sage-grouse. If sage-grouse will not breed near wind towers, then the likelihood of expansion of populations into the other units from the YTC is reduced.

The second wind project located within the Recovery Area is the Wild Horse project, which proposes to erect 100 turbines near Whiskey Dick Mountain east of Ellensburg in the Colockum Sage-grouse Management Unit. The Colockum is an important corridor for grouse to potentially move between the YTC and Douglas-Grant populations.

Grassland nesting passerines, waterfowl, and wading birds are also known to avoid wind turbines (Winkelman 1990, Leddy et al. 1999). It is not known if birds avoid the vicinity of turbines due to disturbance from noise, motion, or human activity, or if the area is avoided because tall structures are perceived as potential raptor perches. Noise that can disrupt mating communication may also be a factor for lekking species.

Powerlines, Fences and Roads

The concerns about behavioral avoidance of wind turbines are also true about electrical transmission lines and any other tall structures. There are no leks near major transmission lines in Douglas County or on the YTC. Leks in California and Nevada disappeared within 1.4 mi after a new transmission line was erected and lek attendance declined within 2-3 miles. Smaller distribution lines that do not have tall towers may primarily be a concern as a collision hazard. Powerlines, wire fences, and roads are all known to cause sage-grouse mortalities. All of these structures fragment and degrade sage-grouse habitat and make it more hazardous for sage-grouse to move within otherwise suitable habitat and between habitat patches.

Habitat Fragmentation

In addition to the issues of demographic and genetic isolation, habitat fragmentation creates or exacerbates other impacts to sage-grouse. This includes increased predation in habitat patches (Schroeder and Baydack 2001), increased potential for encroachment by noxious weeds, and increased impacts of herbicides and insecticides sprayed on adjacent cropland.

CRP and Habitat Security on Private Lands

Sage-grouse in Douglas County are dependent upon private lands, but agriculture is the major land use and brush control and shrub-steppe conversion continue. The federal candidate status of sage-grouse strained relations with some landowners due to fears of regulation, but benefitted many landowners applying for enrollment in the Conservation Reserve Program (CRP). The presence of sage and sharp-tailed grouse contributed to the high acceptance rate of CRP applications in Washington. Douglas County now has 33.3% of its cropland enrolled in the CRP program.

CRP has not been used for livestock grazing, and sagebrush is invading many CRP lands and creating better habitat conditions for sage-grouse. The CRP benefits sage-grouse by providing essential cover for nesting that would otherwise be unavailable. Beneficial CRP lands are those adjacent to remnant shrub-steppe patches. Many of the island patches of shrub-steppe have been maintained by private landowners for the past several decades. The principal difference between lands in Franklin County (where sage-grouse were recently extirpated) and Douglas County (where sage-grouse still occur) is the presence of remnant shrub-steppe patches in Douglas County. Both areas have significant acreages enrolled in the CRP and have similar CRP habitats.

However, reliance on CRP lands involves significant uncertainty. The acreage enrolled may be reduced significantly in the near future. CRP enrollment is usually limited to a maximum of 25% of cropland in a county. Douglas County received a waiver that allowed the enrollment of 33%. However, under the new rules, Douglas County no longer qualifies for the waiver. This means that the number of acres will be reduced by 47,000 ac to 25% of cropland in 2007 (B. Dudek, pers.comm.). This reduction is likely to impact sage-grouse.

CRP lands were opened to grazing and haying for "emergency" drought relief in 2002 by the US Department of Agriculture. This reduces payments to the landowner, thus few landowners have opted to use CRP lands for grazing and there has been little impact to date on sage-grouse in Washington. Of more long-term concern, the CRP program is funded through the Farm Bill and depends on renewal of the program by Congress in 2008. Should the CRP program not be renewed or if it were replaced with another program that did not maintain the habitat value of enrolled lands, sage-grouse would probably decline dramatically and could be extirpated in Douglas County. Additionally, landowners may choose not to re-enroll lands in CRP if there is a dramatic increase in the price of wheat.

New programs offered in the 2002 Farm Bill may in the long run become important including the Grassland Reserve Program, Wildlife Habitat Incentives Program, Environmental Quality Incentives Program, and the Conservation of Private Grazing Lands Program. For example, the Grassland Reserve Program can be used to purchase permanent easements that may provide the desired long-term security for sage-grouse populations. Information about grants is available from USDA-NRCS, and on the USDA website: www.usda.gov/programs/farmbill /2002/products.

Sagebrush Control

Fire, herbicides, and mechanical means have been used to control sagebrush in shrub-steppe habitat in an attempt to increase grass production for livestock. Welch and Criddle (2003) concluded from a review of studies that 50% of the time killing big sagebrush results in no increase in perennial grass production, and that grass production in big sagebrush stands is affected more by soils, moisture, and grazing history than by shrub cover. Between 1947 and 1981, >3,000 km^2 of sagebrush control occurred in eastern Washington (Pedersen 1982). Sagebrush control has also been done in attempts to improve sage-grouse habitat (Byrne 2002). Peterson (1995) reviewed the effects of sagebrush manipulation on vegetation and wildlife. Extensive brush control has contributed to declines in sage-grouse, and could cause further decline in the Douglas-Grant sage-grouse population or prevent recovery elsewhere. Chemical treatment of vegetation has been found to reduce wintering, breeding, nesting, and brood-rearing activities of sage-grouse (Enyeart 1956, Rogers 1964, June and Higby 1965, Kufeld 1968, Klebenow 1970, Martin 1970, Peterson 1970, Pyrah 1972, Wallestad 1975, Blus et al. 1989), although the sowing of crested wheatgrass after spraying probably increased the negative impact on grouse (Connelly et al. 2000b). Connelly et al. (2000b) stated, "In virtually all documented cases, herbicide application to blocks of sagebrush rangeland resulted in major declines in sage grouse breeding populations." Rogers (1964) reported that annual herbicide application for several years eliminated sage-grouse from a site. The herbicide 2,4-D was commonly used to reduce sagebrush, but also killed forbs and detrimentally impacted sage-grouse by altering the vegetational composition (Blaisdell and Mueggler 1956, Martin 1970, Autenrieth et al. 1982). In winter habitat, sage-grouse use declined proportionally with the amount of sagebrush killed by herbicide (Connelly et al. 2000b). Application of low amounts of tebuthiuron may be useful in thinning big sagebrush; Olson and Whitson (2002) reported an increase in native grass biomass and no loss of species using this technique. Connelly et al. (2000b) cautioned against widespread use of tebuthiuron and similar herbicides, however, until experiments demonstrate they can be used without long-term negative effects on sage-grouse.

Fire became more commonly used in the 1990s after most uses of 2,4-D on public lands were prohibited (Connelly et al. 2000b). However, fire may be as harmful as herbicides and the effects last much longer. Peterson (1995) reported that total grass cover was lower than pre-burn levels 8 years after a controlled burn, and several studies noted a decline in Idaho fescue as a result of burning. Slater (2003) observed that although burns did not appear to increase forbs, the openings and edge were attractive to grouse, particularly brood-rearing females. He suggested that controlling shrubs in strips 120 m wide by chaining or spraying might improve habitat. Connelly et al. (2000b) state that areas meeting conditions for breeding habitat (i.e., 15-25% sagebrush canopy) should not be considered for sagebrush control. However, sage-grouse nesting occurs in areas with up to 38% canopy cover of sagebrush and wintering in areas up to 43% (Connelly et al. 2000b). Never grazed islands of vegetation surrounded by lava flows and other near pristine sites have sagebrush canopy of 34 and 35%, respectively (Daubenmire 1970, Wambolt et al. 2002), so sagebrush should probably not be controlled even in areas with >25% canopy cover except where shown to be necessary to restore understory vegetation. Wambolt et al. (2002) concluded that thinning of sagebrush to reduce canopy cover may remove too much sagebrush, and in general, activities to remove sagebrush or fragment habitats into smaller pieces should be avoided. Connelly et al. (2000b) recommended protecting all remaining sagebrush habitats in areas of large-scale loss (>40%) of winter habitat. In breeding habitat, no more than 20% of an area should be treated in a 30-year period. Wambolt and Payne (1986) reported a 29% decline in Wyoming big sagebrush canopy during an 18-year study simply through cessation of livestock grazing. Laycock (1967) and Bork et al. (1998) suggested the use of late fall grazing by sheep to reduce sagebrush where its density is high, but this management strategy needs further investigation (Pedersen et al. 2003). Welch and Criddle (2003) concluded that big sagebrush is important for the entire plant community by providing protection for understory plants, storing snow, improving soil conditions, and recycling deep soil moisture and nutrients. Given the potential for reducing sagebrush too much and the negative impacts on most other shrub-steppe species, control of sagebrush probably should not occur where sage-grouse habitat improvement is an objective without careful analysis, and only after other methods have failed.

West Nile Virus

The implications of West Nile Virus for Washington sage-grouse are not yet known. It remains to be seen if West Nile Virus will have a serious impact on robust populations in other states, but the mortality rate in a Wyoming study was very high (60%) and no individuals contained antibodies that would suggest an immunity to the disease during future exposure. This suggests 100% mortality of individuals that contracted the disease. An increase in mortalities as a result of West Nile could devastate the small populations in Washington. There is no reason to believe that the virus would not kill sage-grouse in Washington, but the infection rate to be expected is unknown.

Predation

Although predation is the most important proximate cause of mortality for sage-grouse, the rate of predation is ultimately dependent on the quality of habitat (Schroeder and Baydack 2001). Habitat that provides good shrub and grass cover for nesting and wintering allows grouse to increase despite predation, but losses to predation may be greater where habitat is fragmented (Vander Haegen et al. 2002) and may be significant for small populations. Grouse have long coexisted with predators and have developed strategies to minimize predation mortality. The numbers of some predators may be lower today (e.g., badgers) than they were historically, but other predators that benefit from human-associated food may be more abundant in some locations (e.g., ravens and coyotes). Red foxes, descendents of fur farm escapees, are now present in valleys of Kittitas County, where they were not present historically (Johnson and Cassidy 1997). Grouse may come under greater pressure when populations of other prey species (e.g., jackrabbits, ground squirrels) are low. Where studies indicate that juvenile survival is a problem, management of habitat to increase juvenile survival may be critical to restoring sage-grouse populations.

Predator control programs to benefit bird populations have been locally effective at improving nest success in ducks (Greenwood and Sovada 1996) and are commonly used to benefit grouse in Europe. However, there is no information on the long term impacts of predator control on the behavior, genetics, and abundance of sage-grouse (Schroeder and Baydack 2001). Predator control can be relatively expensive, its benefits short-lived, and it can generate strong opposition. Slater (2003) compared nesting success of sage-grouse in an area with ongoing coyote control to protect sheep to success in a similar area without coyote control. He did not detect any difference in nest success or predation rates between the two areas. Coyotes did not seem to be a major nest predator and badgers appeared to be responsible for most of the nest predation in both study areas (Slater 2003). In the only experimental study of predator control for the benefit of sage grouse, Batterson and Morse (1948) reported higher nesting success in an area where ravens had been controlled. Cote and Sutherland (1997) analyzed past studies of predator control to protect birds and concluded that though predator control may reduce nest predation and increase the post-breeding population, it does not reliably increase breeding populations in subsequent seasons. Connelly et al. (2000b) concluded that nest-success rates (>40%) in most locations suggest that nest predation is not a widespread problem. They state that though expensive and often ineffective, predator control programs may provide temporary help where habitat is recovering or where seasonal habitats have been greatly reduced. They recommend that predator management be implemented only if nest success and hen survival data support the action. If corvids are identified as the dominant nest predator and nest success is < 25% (Connelly et al. 2000b), an efficient method of control to be considered is the use of the avicide DRC-1339 applied to hard-boiled eggs in artificial nests. This would only affect the birds actually depredating nests. Slater (2003) suggested that because other predators may replace a major predator that is controlled, any control program would need to include all the primary nest predators to be effective. Any predator control programs that are implemented should be evaluated for benefits to the breeding population.

Harassment and Disturbance

Potential disturbances to sage-grouse include off-road recreational vehicles, farming activities, military training, bird dog field trials, birdwatchers, photographers, falconry, and hunting. Disturbance by military training may lead to greater amount of movements by birds on the YTC. The only current recreational use focused directly on sage-grouse is viewing. Uncontrolled viewing could disrupt breeding populations and should be monitored and restricted if necessary. During the breeding season, repeated disturbance at a lek has the potential to reduce mating opportunities and cause decreased production. When humans approach the display site, grouse often flush and may or may not return again that day (Call 1979). Viewing at a distance from automobiles does not appear to disrupt courtship activity, but grouse flush when people leave cars to get a closer look. WDFW personnel do not provide lek locations, but occasionally lead tours for college classes or other groups, usually to one specific lek. The "tour lek" has not had a lot of traffic. All the Douglas County leks are on private property, but some are visible from county roads. The location of at least one lek is known by the birding community and disturbance has on occasion been a problem at that site. At the YTC, lek tours are given in accordance with strict guidelines; no reduction in lek attendance or disruption of breeding activities has been observed (M. Pounds, pers. comm.).

Insecticides and Herbicides

Insecticides applied to agricultural fields and shrub-steppe communities may be detrimental to sage-grouse. Approximately 91,000 km^2 (35,000 mi^2) of western rangelands were sprayed for grasshopper control from 1985 to 1990 (Johnson and Boyce 1990). Areas sprayed were commonly used by nesting sage-grouse. Insects such as ants, beetles, and grasshoppers are a key item in the diet of chicks (Rasmussen and Griner 1938, Patterson 1952, Klebenow and Gray 1968, Peterson 1970, Johnson and Boyce 1990), and chicks more than 3 weeks old show reduced growth rates when insects are removed from their diet (Johnson and Boyce 1990). Blus et al. (1989) reported mortalities of sage-grouse after application of organophosphorus insecticides (dimethoate and methamidophos) on fields in southeastern Idaho. Herbicides are also used to control weeds, such as knapweeds and cheatgrass. The YTC uses herbicides to control knapweeds on 24,000 ha (Livingston 1998). The herbicides do not harm sagebrush, but suppress forbs which may eliminate those areas as brood habitat. There is little information on toxicity of those herbicides (2,4,D and Picloram®) to birds (Livingston 1998).

Adequacy Of Existing Regulatory Mechanisms

Sage-grouse are protected from killing by WDFW regulations; the Fish and Wildlife Commission closed the hunting of sage-grouse in 1988. Populations have stayed at low levels or declined since then. There are no existing state or federal regulatory mechanisms to protect sage-grouse habitat on private land, though voluntary programs encourage protection. These programs include Habitat Conservation Plans (HCPs), authorized under Section 10 of the federal Endangered Species Act, and Candidate Conservation Agreements (CCAs). Enrollment in an HCP may result in improved management practices by landowners as well as the issuance of a 'take permit' for authorized activities. 'Safe Harbor' agreements may also be possible for activities that might expand sage-grouse populations into areas where they are currently absent. Shrub-steppe in historic sage-grouse range continues to be converted to cropland on both private and state-owned lands. Ecosystem Standards for State-owned Agricultural and Grazing Land, RCW 79.01.295 (HB 1309; Washington State Legislature 1993) stipulates upland plant community structural complexity, vegetative cover and plant species diversity should approximate site potential for native and non-native plants that provide comparable or greater benefits to fish and wildlife. This standard, however, does not stop conversion of DNR-owned shrub-steppe to cropland. Sage-grouse habitat could receive some protection from development impacts by counties when permits for projects are conditioned, but rural counties tend not to restrict development. Counties can also identify sage-grouse as a species of local significance under provisions of the state's Growth Management Act and regulate development impacts.

CONCLUSIONS

The sage-grouse population in Washington is small and is not expected to persist indefinitely at its current size. A breeding population of about 1,011 sage-grouse remains in Washington, with about 387 birds on the YTC and 624 birds located in Douglas and Grant Counties. These estimates are based on lek counts of males and are likely underestimates due to negative biases inherent to the technique. Nonetheless, the two populations seem to be small, isolated, and have lost genetic diversity. It is not clear if the populations have stabilized in the last few years, or if the general decline of the last 40 years is continuing. The principal factors affecting population size and health of sage-grouse in Washington are the extent, distribution, and quality of habitat. About half of the original shrub-steppe habitat in Washington has been converted to other uses, and only about half of the remaining habitat has adequate shrub cover for sage grouse. The areas converted were predominantly those with deep loam soils that typically are the most productive for both wildlife and crops. The remaining shrub-steppe is fragmented and often has shallow soil or steeper slopes, and much was seriously degraded by historical over-grazing by livestock. Habitat continues to be lost and fragmented by agricultural conversion and development. Wind farms threaten to render suitable habitat unusable for nesting by sage-grouse. The biggest immediate threat to the remaining sage-grouse in Washington is loss of sagebrush from wildfires. Wildfires kill sagebrush, and repeated fires can result in an annual grassland of cheatgrass that burns frequently and has little value to sage-grouse and other wildlife.

The emerging threat of West Nile Virus may become another important factor in the next few years by introducing an additional source of mortality. The impact of this introduced disease on sage-grouse in Washington is not yet known, but it could pose an immediate and critical threat to the populations.

Protecting sage-grouse populations from inbreeding depression and new threats like West Nile Virus requires close monitoring of the populations. Maintaining populations of sage-grouse in Washington will also depend on protecting remaining habitat, restoring degraded habitat, and re-establishing populations outside their current range.

PART TWO: RECOVERY

Greater sage-grouse will probably never be recovered in some parts of their former range in Washington. Areas where little shrub-steppe remains, private land predominates, and large amounts of CRP are not present would be very difficult and expensive to restore for sage-grouse. Aside from key sites where habitat could be restored to provide connections between populations, areas without shrub-steppe would be considered very low priority for sage-grouse recovery. Although the current populations appear to have remained relatively stable during the last decade, the long-term prospects suggest a continuation of declines (Schroeder 2000a, Schroeder et al. 2000). These dim prospects are consistent with data showing the possible negative consequences of low population size on genetic health and eventually on productivity (Bouzat et al. 1998, Westemeier et al. 1998). Sage-grouse recovery must address maintaining and increasing current populations, expanding those populations into adjacent areas, and re-establishing additional populations. The protection of remaining habitat and restoring additional habitat will be key to the success of recovery.

RECOVERY GOAL

The goal of the sage-grouse recovery program is to establish a viable population of sage-grouse in a substantial portion of the species' historic range in Washington.

RECOVERY OBJECTIVES

The sage-grouse will be considered for down-listing from State Threatened status when:

The breeding season population averages ≥3,200 birds in Washington for a 10-year period, with active lek complexes in 6 or more Management Units.

The sage-grouse will be considered for up-listing to State Endangered if:

There is a breeding season population of < 650 birds in Washington and the population continues to decline.

Rationale

Effective population size and viable populations. The goal of the recovery strategy for sage-grouse in Washington is the establishment of a viable, self-sustaining population. A 'viable' sage-grouse population relates to its size, distribution, and ability to maintain genetic heterogeneity over the long-term. It also relates to the ability of a population to withstand fluctuations in their population and recruitment associated with annual variation in weather, predation, disease, and habitat quality. Lack of genetic 'health' may be reflected in declining productivity and hence in declining population size, regardless of other factors such as habitat. There is no objective definition of what constitutes a 'viable' population, but many conservation biologists would agree that a population of a few thousand or more is desirable for long term persistence (Frankham et al. 2002). A minimum viable population is the level at which populations can maintain their genetic variability over time. Smaller populations are subject to extinction due to stochastic events or problems associated with inbreeding (Reed et al. 1986).

In order to estimate the minimum viable population size for sage-grouse in Washington, the 'effective population' size needs to be determined (Reed et al. 1986). The effective population (N_e) is the proportion of a population (N) that can be expected to pass on their genetic information from one generation to the next, or the "genetically effective population size" (Frankham et al. 2002). The N_e in sage-grouse is reduced by their uneven sex-ratio, their lek mating system in which a minority of males breed, and fluctuations in numbers across generations. In a fluctuating population, N_e is reduced below the average number of adults over time (Frankham et al. 2002). Estimates of N_e for populations with long term census data average 11% of the census population (N_e/N)(Frankham et al. 2002:240). In general, an N_e much greater than 50 (N>500) is needed to avoid inbreeding, and 500 is the minimum N_e that could be expected to maintain the species evolutionary potential (Franklin 1980, Frankel and Soulé 1981, Frankel 1983, U.S. Fish and Wildlife Service 1985, Reed et al. 1986 Frankham et al. 2002:530).

Schroeder (2000a) used data Sveum (1995), Schroeder (1997), and Sveum et al. (1998b) to estimate effective population size for sage-grouse in Washington using equations from Hill (1972), Reed et al. (1986, 1988), and Nunney and Elam (1994). Taking into consideration the fluctuations in the sage-grouse population (Vucetich and Waite 1998), the N_e/N ratio for 41 years of data was estimated at 0.156. This suggests that a breeding population of 3,200 sage-grouse would provide the needed N_e of 500 to maintain genetic diversity and be considered a minimum viable population. This estimate will probably be revised as better data becomes available on lifetime reproductive success of male sage-grouse and other demographic parameters. The accuracy of the annual estimates of breeding population and minimum viable population depends on the assumptions that all leks are known and surveyed, all males are counted on leks, and the the male to female ratio is 1:1.6.

The recovery objectives consider the statewide population as a whole and assume that the 2 current populations will become connected as recovery progresses. The amount of immigration needed to connect grouse subpopulations genetically is not known, but generally movement of 1-10 individuals per year is enough to prevent genetic isolation (Mills and Allendorf 1996); this assumes that these individuals then breed successfully and movement is not in one direction. The numerical recovery objectives could also be met if either population increased and expanded sufficiently to achieve a viable population, though concentration in too small an area increases the risk that fires pose to the statewide population. The alternative to recovery of a single population to a the minimum viable level would be to maintain genetic connectivity between the separate populations by an expensive program of translocations and genetic monitoring.

The recovery objectives focus on the estimated breeding season population. The number of males counted on leks is the parameter that has been used to estimate populations, but this method may be revised or replaced if a better method proves feasible. The 2003 breeding population estimate of 1,011 birds was based on a total of 389 males counted on leks and an assumed sex ratio of 1.0 males: 1.6 females (389 x 2.6 = 1,0117). If the number of males on leks declines below 250, we would recommend uplisting the sage-grouse to endangered. Recovery to a breeding population of 3,200 would meet the threshold of a minimum viable population, and may be feasible since sage-grouse had a distribution comparable to our management units in 1960 and were estimated to total more than 4,600 birds (Schroeder et al. 2000). Reaching this population level will not be easy given the many factors affecting sage-grouse and the need for restoration of habitat, however, it is achievable and necessary to ensure species persistence in Washington. Because current methods may underestimate the population, the increases needed to reach the recovery objective may be less than they seem.

Recovery of the population to 3,200 birds will require an increase in population density, an expansion of occupied areas, and an improvement in habitat quality. The amount of area needed to support a breeding population of 3,200 sage-grouse depends on the quality of habitat. Rogers (1964) estimated fall densities in Colorado as ranging from 0.4-19 birds/km^2. Breeding densities would be perhaps 30% lower, or 0.3 - 13.3 birds/km^2, so supporting 3,200 birds could require anywhere from 240 - 10,000 km^2 of habitat depending on habitat quality. It is unlikely we can achieve sage-grouse densities at the higher end of that range because the most fertile portions of their historical range have been converted to agriculture. The sage-grouse recovery area totals 16,437 km^2 in area. Although not all of this area could ever become suitable for reproducing sage-grouse, the area is sufficiently large to support recovery if portions of it improve dramatically in quality and are connected with habitat corridors. The improvement in habitat quality on the YTC since the cessation of grazing and maturing of CRP and restoration of recently acquired lands in Douglas and Grant counties may result in increased sage-grouse density in those areas. The currently occupied sage-grouse management units have about 2,630 km^2 of habitat (shrub-steppe with >10% shrub cover + CRP as suitable) and an average density of about 0.4 birds/km^2. Fall densities in the best habitat elsewhere have exceeded 10 birds/km^2 (Edminster 1954, Rogers 1964), but some habitat in management units is degraded and suitable only for wintering, and fragmentation probably renders some small isolated parcels unusable. If the density of birds increased 50% to 0.6 birds/km^2, this would provide an additional 524 birds for a total of 1,578.

If sage-grouse can be re-established by reintroductions and natural expansion into all current habitat in the rest of the recovery area (4,577 km^2) at a density of 0.2 birds/km^2, this would provide an additional 915 birds, for a total of 2,493. If the density of the added area were 0.4, the total would be 3,409. If there were no density increase in current range, but all habitat in the recovery area was 0.4 birds/km^2, the total would be 3,604 birds. This assumes a constant area of habitat. New areas will presumably become suitable with restoration, and there will always be areas recovering from fires. Wider distribution of sage-grouse will reduce the risk to populations from catastrophic events, such as wildfires. Once the population averages 3,200 and occupies at least 3 management units in addition to those currently occupied, the species will be evaluated for down-listing from Threatened to Sensitive. A state Sensitive species is defined as a species "...that is likely to become endangered or threatened in a significant portion of its range within the state without cooperative management or removal of threats" (WAC 232-12-297). When the sage-grouse is down-listed to Sensitive, a management plan would be prepared outlining management needs.

Management beyond recovery. The recovery objectives are intended to recover sage-grouse to the point where there is no longer uncertainty about the survival of the species in the state. Ideally, sage-grouse populations will continue to increase to the point where a limited harvest can be permitted without concern about impacts to the population, and management will continue to facilitate expansion of sage-grouse populations into their historical range outside of the Management Units. The sage-grouse is classified a game species in Washington, and after the species is de-listed from sensitive status, its management would return to the Game Division. A game management plan would be prepared that outlines additional management strategies and identifies population levels sufficient to allow harvest.

Recovery function of management units. Management efforts to date have focused on maintaining the existing populations and distributions of sage-grouse. Recovery effort will require increasing the numbers and distribution of sage-grouse in Washington. Expansion into adjacent areas, unassisted by translocations, will likely require an increase in the existing populations to supply dispersing individuals that could colonize unoccupied areas and habitat improvements within occupied and adjacent units.

Douglas County which encompasses most of the Moses Coulee and Mansfield Plateau management units is now at the maximum allowable acreage for CRP (33.3% of cropland). Much of the CRP fields have been enrolled for more than 12 years and are beginning to resemble native shrub-steppe habitat in structure. The YTC population has increased somewhat in recent years, but it is not known if this is a result of habitat improvements since the cessation of grazing (M. Pounds, pers. comm.), increased survey efforts, or some other factor. Some management units will require substantial restoration efforts in order to support breeding and wintering populations. Table 10 provides a preliminary summary of the current and predicted potential functions of the 14 management units (Fig 5).

Table 10. Current and potential functions of 14 Sage-Grouse Management Units in eastern Washington.

	Current function[a]	Potential functions			
Management unit	Breeding & winter	Reintroduction/ breeding[b]	Secondary breeding[c]	Corridor/ connectivity[d]	Seasonal use[e]
Ahtanum Ridge			✔	✔	✔
Bridgeport Point			✔		✔
Colockum		?	✔	✔	✔
Crab Creek		✔			✔
Dry Falls		?	✔	✔	✔
Hanford		✔	✔	✔	✔
Mansfield Plateau	✔				✔
Moses Coulee	✔				✔
Potholes Reservoir			✔	✔	✔
Rattlesnake Hills			✔	✔	✔
Saddle Mountains			✔	✔	✔
Toppenish Ridge		✔			✔
Umtanum Ridge			✔	✔	✔
Yakima Training Center	✔				✔

[a] Currently occupied units include core breeding and wintering areas.
[b] Potential areas for reintroduction to establish breeding populations, but habitat needs to be evaluated and may require restoration before a population can be established; **?** = units where potential for reintroduction is probably low.
[c] Areas that may support limited breeding.
[d] Primary importance is for providing habitat connections for movement corridors between breeding areas and between seasonally used areas.
[e] Areas likely to be used seasonally during winter, summer, or fall; may or may not support nesting.

Some units such as Bridgeport Point, Dry Falls, Rattlesnake Hills, Saddle Mountains, Crab Creek, and Umtanum Ridge will require coordinated efforts between public and private land managers to maintain and improve habitat. There will also be an opportunity to incorporate CRP into long-term planning in areas with abundant cropland, particularly where CRP can provide a connecting matrix between patches of shrub-steppe. Where shrub-steppe has been converted to cropland, CRP can be used to expand breeding habitat and to connect remnant patches of shrub-steppe. Parts of the Ahtanum Ridge and Toppenish Ridge units and the Wahluke Slope portion of the Hanford unit may require extensive habitat restoration efforts designed to re-establish shrub-steppe habitat, either by re-establishing the shrub or understory layers. All units need significant budgets for fire prevention and habitat restoration following wild fires.

CONSERVATION STRATEGIES AND TASKS

1. Inventory and monitor the greater sage-grouse population in Washington.

1.1 Conduct lek counts and survey for lek complexes.

1.1.1 Conduct annual lek counts.

Use established protocols to conduct lek counts, preferably on an annual basis. Current WDFW staffing levels make it difficult to complete both annual lek counts and surveys for new leks in the same year. WDFW may consider shifting to a schedule in which surveys for new leks are conducted every third year and lek counts are not done that year. Agencies and other interested parties should explore opportunities to complete lek counts annually.

1.1.2 Conduct surveys for new leks.

Finding all leks is important to maintain the consistency of trend information and population estimates. Potential habitat should be surveyed for lek complexes on a periodic basis, with surveys in the bast habitat at least every three years. Potential habitat can be defined by the quality and distribution of the habitat in relation to known populations of birds. Areas close to existing lek complexes should be searched for new, shifting, or satellite lek sites. When a known lek becomes inactive, surveys should be conducted the same year to determine if and where the lek moved. Inactive lek complexes should be surveyed once every 3 to 5 years to determine if they are still inactive. Surveys for new leks should be conducted using standardized protocols.

1.2 Coordinate data collection and maintenance.

WDFW will maintain a centralized database for sage-grouse survey and observational information collected by agencies, groups, and interested parties including WDFW, the YTC, the Yakama Nation, The Nature Conservancy, the Bureau of Land Management, the U.S. Fish and Wildlife Service, U.S. Department of Energy, and Washington DNR.

1.3 Estimate population size.

Sage-grouse population estimates are based on numbers of males at lek complexes. Number of males attending lek complexes should be analyzed using the highest number observed on a single day for each complex each year. This conservative technique will permit comparison with other sage-grouse populations in North America (Willis et al. 1993, Braun 1995, Connelly and Braun 1997). Total population size should be estimated by multiplying the total numbers of males at all lek complexes by 2.6. This index factor assumes all males are counted and the male:female ratio is approximately 1.0:1.6 (WDFW 1995, Hays et al. 1998, Schroeder et al. 1999).

Despite being the best method currently available to estimate sage-grouse population size, this technique suffers from a number of real and potential biases. These include: yearling males appear to visit lek complexes less frequently than adults (Emmons and Braun 1984); the number or proportion of yearlings in the population is unknown and varies annually; attendance at complexes tends to peak relatively late in the breeding season (Jenni and Hartzler 1978, Emmons and Braun 1984); the number of males not visiting complexes is unknown; and the maximum count of males on a complex tends to be positively correlated with the number of counts. The only bias which would tend to produce a higher estimate is that some males (particularly yearlings) visit more than 1 lek complex per breeding season (Emmons and Braun 1984). All count data should be retained indefinitely, regardless of whether they are high counts or not. This will permit quantifying survey variability and perhaps additional analysis when there are new techniques to deal with these biases.

1.4 Evaluate population trend.

Annual rates of population change should be estimated by comparing the maximum number of males counted at all lek complexes in consecutive years. Because sampling will occasionally be biased by effort and/or size and accessibility of lek complexes, sites not counted in consecutive years should be excluded from the sample for a given interval.

2. Protect sage-grouse populations.

2.1 Protect active sage-grouse leks from human disturbance.

Active leks are defined as any known lek active within the previous 24 months.

2.1.1 Avoid activities that interfere with sage-grouse at or near leks.

Restrict off-road vehicles, snowmobiles, camping, site visits, etc, and close roads or limit area access as necessary to protect lek areas from disturbance.

2.1.2 Avoid potentially disturbing activities such as farming, mining, and recreation near leks (~2 km) between the hours of 1800 and 0900 during February-April.

Disturbing activities are those which cause the birds to flush or alter their behavior for a substantial length of time. Persistent disturbing activities are a more serious problem; farming activities on a single day of the breeding season is not likely to be a significant problem.

2.1.3 Provide advice to regulatory agencies and private landowners to minimize disturbance from construction and development activities, particularly within 1 km of breeding habitat during February - June.

2.1.5 Treat lek locations as sensitive data.

Locational information on sage-grouse is considered sensitive under WDFW policy # 5210. Lek location information is not released by WDFW except under conditions defined in policy 5210. Land managers with sage-grouse leks should not disclose lek locations or encourage viewing at leks in order to minimize disturbance from public viewing. Agency personnel should do nothing which increases viewing disturbance. At least one lek is known to recreational observers (birders, photographers, etc) and landowners should be encouraged to limit viewing activities to long-range observation from vehicles on county roads.

2.2 Protect nesting and brood rearing areas from disturbance.

Wherever possible, prevent disturbance in sage-grouse nesting and brood rearing habitat between 1 March and 15 June, including development, blasting, military training, livestock trail use, falconry, off-road vehicle use, recreation, and training of hunting dogs

2.3 Minimize incidental mortality.

2.3.1 Enforce regulations that protect sage-grouse from harm and harassment.

2.3.2 Document incidents of illegal and accidental killing of sage-grouse and evaluate the need for remedies.

Accidental killing of sage-grouse during legal hunting of other upland bird species, falconry, and scientific research is not currently known to be a significant problem. If it is determined to be a localized problem in the future, steps should be taken such as increased hunter education or restrictions on local access during upland game seasons when sage-grouse are vulnerable. Livingston and Nyland (2002) reported that 1 female was killed by poaching out of 23 mortalities recorded on the YTC.

2.3.3 Carefully review scientific collection permits issued by WDFW that involve disturbance or handling of sage-grouse.

2.4 Reduce the collision and predation hazards posed by poles, wires, and fences.

Fences and powerlines can pose a collision hazard to grouse and provide perches for avian predators. Minimize proliferation of perch sites for raptors and corvids within occupied sage-grouse areas and where reintroductions occur. Promote removal of power lines, cables, and poles that are no longer in use. Minimize proliferation of additional corridors for power lines, towers, and fences, except where needed to exclude livestock.

2.4.1 New powerlines and utilities should use existing corridors or be located so as to minimize collision risk and damage to habitat.

2.4.2 Existing powerlines should be buried or modified with perch guards to prevent use as raptor perch sites.

Because burial of powerlines is expensive ($30,000/mi minimum), only lines which clearly pose a hazard to sage-grouse would likely be buried as funds are available.

2.4.3 Remove unneeded fences in sage-grouse use areas.

2.5 Minimize or eliminate exposure of sage-grouse to organophosphate insecticides.

Some organophosphate and carbamate insecticides are known to cause direct sage-grouse mortality. The suppression of target and nontarget insect populations may affect sage-grouse by impacting a critical food for developing chicks.

3. Enhance existing populations and re-establish additional populations.

Translocations of sage-grouse may be used to augment existing populations or to re-establish populations in historical habitat where none currently exist. Reintroduction of birds into unoccupied habitat will likely be necessary to re-establish additional populations in Washington. Eleven of the 14 sage-grouse management units are currently unoccupied by sage-grouse. Birds may be expected to re-establish in some of these units if suitable habitat is available. Other units will require reintroductions to establish populations.

Sage-grouse translocations have been conducted in at least 7 states and one Canadian province (Reese and Connelly 1997). Out of 56 attempts involving a total of > 7,000 grouse, the common features of successful attempts were: 1) reproductively active birds were captured on leks at night in March or April; 2) birds were transported rapidly and released the morning following capture; and 3) birds were released into islands of habitat surrounded by inhospitable cover types and were distant from the capture sites (Reese and Connelly 1997). Reintroductions in Washington should benefit from the experiences of these previous reintroductions in other areas.

3.1 Evaluate the feasibility of sage-grouse re-introductions.

3.1.1 Identify additional sage-grouse management units that may require reintroductions and determine habitat restoration that will be needed to support populations.

The Toppenish Ridge unit is currently being evaluated by a consultant to the Yakama Nation for the potential to support a reintroduced sage-grouse population and the habitat restoration that may be needed (M. Livingston, pers. comm.). Similar studies should be undertaken on the Ahtanum Ridge, Hanford, Crab Creek, and Dry Falls units.

3.2 Conduct reintroductions and population augmentations.

Work with other states to secure birds from source populations that are ‘healthy’ and genetically appropriate. A healthy population can be considered a population that has an annual production of young that is normally sufficient to maintain or increase the population size. Translocations from small source populations should be considered only when the potential benefits (exchange of genetic material) outweigh the risks of negatively affecting the source population. Translocations should be conducted during the early portion of the breeding season to facilitate breeding of new birds in the target area and maximize the efficiency of the effort. Reintroductions may require adding birds each year for several consecutive years to compensate for high early mortalities.

3.2.1 Develop scientifically approved protocol for sage-grouse translocations in Washington.

A protocol was developed prior to the translocation of 25 Nevada birds onto the YTC in March 2004.

3.2.2 Conduct augmentations to existing populations to maintain genetic diversity.

Due to low genetic diversity, translocation of sage-grouse from a source population outside of Washington appears to be necessary to improve the genetic health of the two existing populations in the state. It seems prudent to address this problem before signs of inbreeding or other symptoms of deteriorated genetic diversity become evident. Augmentations to improve genetics should be done from a source population that is relatively secure, genetically diverse, and genetically similar to the historical population (if brought in from outside Washington). A translocation of 25 birds from Nevada onto the YTC was done in March 2004 to improve genetic health of the population. The birds were equipped with radio transmitters and are being monitored by YTC staff. A second translocation into the Douglas-Grant population may follow in 2005.

3.2.3 Conduct reintroductions to re-establish populations in areas where sage-grouse have been extirpated and where assessments indicate that habitat is of sufficient quantity and quality to support populations.

Sage-grouse should only be reintroduced where they were present historically. The reasons for the decline and extirpation of the historical population should be identified and remedied to ensure that the reintroduced sage-grouse will not be threatened by the same factors. Ensure that habitat in the release region is available in sufficient quantity, quality, and configuration to support all sage-grouse life stages and to support a population. Release sites are likely to be locations with predominantly public land and cooperative adjacent private landowners. Re-introductions should not be conducted if sage-grouse are likely to naturally re-colonize an area without reintroduction of birds. Release sites that provide opportunities for further population expansion into additional uninhabited areas are preferred. Consult internationally recognized guidelines for introductions to ensure that no important considerations have been omitted (IUCN 1998).

3.3 Monitor and evaluate translocations.

The success or failure of re-introduction and augmentation efforts should be evaluated. Monitor movement, habitat use, productivity, survival, and size of the translocated population. This information will help determine whether additional translocations, habitat improvements, release locations, or improved translocation methodologies are necessary.

3.3.1 Evaluate the success of the planned YTC translocation to determine if genetic diversity was improved.

4. Protect sage-grouse habitat on public lands.

4.1 Within Sage-Grouse Management Units, map shrub-steppe habitat into specific categories based on features that are significant to sage-grouse, including potential habitat type (breeding, brood-rearing, winter), management history, habitat quality, and suitability for sage-grouse, and prioritize for protection.

Prioritize Sage-grouse Management Units to be mapped: occupied areas first; units with the highest potential for sage-grouse re-occupancy second. Habitat mapping has been completed for the YTC, and Ginkgo/Wanapum State Parks, and is underway for the Yakama Reservation. A Habitat Suitability Index Model for sage-grouse in Washington has been developed for evaluating habitat. Connelly et al. (2003b) outline procedures and techniques for assessment of sage-grouse habitat.

4.1.1 Prioritize habitat areas within the recovery area for protection.

4.1.2 Evaluate habitat capability of the Hanford Unit with existing vegetation maps, and assess need and feasibility of restoration.

4.1.3 Evaluate habitat connectivity and the capacity for sage-grouse movement between Sage-grouse Management Units.

Evaluate the likelihood that birds will move between the Douglas-Grant and YTC sage-grouse populations, between the YTC population and management units to the south and east, and between the Toppenish Ridge and Hanford management units.

4.1.4 Rank sage-grouse habitat areas for ecoregional conservation assessments.

4.2 Protect habitat from fire.

4.2.1 Develop and implement fire management plans on public lands to prevent catastrophic destruction of sage-grouse habitat.

The YTC and Hanford Reach National Monument have fire management plans. Plans and strategies are needed for all the Sage-grouse Management Units, and particularly for those units where reintroductions are contemplated. Large blocks of shrub-steppe on the Toppenish Ridge unit and all WDFW Wildife Areas should also have fire prevention and suppression plans. Area-specific fire plans should evaluate risks, identify responsibilities, identify priority areas for fire suppression, evaluate and map water resources if needed, and evaluate the need for firebreaks, green-stripping, and management of fuels.

4.2.3 Work with local fire managers to protect shrub-steppe important to sage-grouse.

Promote the protection of shrub-steppe from fires through communicating with local fire managers and providing informational materials. Make presentations to firefighters describing shrub-steppe habitat values and the impacts of wildfires. A brief handout for fire fighters describing the impact of fires on shrub-steppe vegetation and shrub-steppe wildlife should be developed.

4.3 Protect important sage-grouse habitat on public lands from development and agricultural conversion.

4.3.1 Work with public agencies to minimize conversion of native shrub-steppe habitat.

Work with WDNR to identify important shrub-steppe habitat for sage-grouse. Facilitate opportunities for acquisition or alternative management status of important parcels that will prevent conversion of the most important recovery areas. Recent management guidelines for migratory populations of sage-grouse recommend protecting sagebrush and the herbaceous understory in habitat within 18 km of leks for nesting habitat (Connelly et al. 2000b).

4.3.2 Provide information to regulatory agencies about the potential for sage-grouse habitat loss from wind turbines and utility towers (U.S. Fish and Wildlife Service 2003b).

Sage-grouse and other prairie grouse seem to avoid tall structures, probably as an instinctive response to avian predators. This behavioral avoidance of tall structures combined with avoidance of human disturbance may prevent sage-grouse from nesting or brood-rearing within 1 mile of wind turbines.

4.3.3 Provide technical advice to regulatory agencies to minimize the negative effects of energy and mining exploration, development, and construction activity in important sage-grouse habitats.

Permanent developments such as buildings, parking lots, gravel pits, and gravel roads, and any activity that creates continuous noise during the display season, should be no closer than 3 km from leks. Developments should address the potential for invasion by noxious weeds.

4.4 Ensure compatibility of grazing management on public lands managed for sage-grouse.

4.4.1 Where protection and restoration of sage-grouse is a major objective for public lands, manage grazing so that the habitat characteristics needed for breeding and wintering can be consistently maintained (Connelly et al. 2000b).

In general, management should be designed to increase herbaceous cover, improve the composition and diversity of native vegetation, and limit the spread of noxious weeds. This will probably require that grazing pressure be light (<35% usage), seasonally rotated, periodically deferred, and maintained at a low enough intensity to enable a rapid response to drought conditions or range fires. Where grazing capacity survey data are available, Galt et al. (2000) recommend setting stocking rates based on a 25% harvest coefficient. However, Crawford et al. (2004) cautions against using utilization guidelines; grass species vary in their ability to withstand grazing, and with drought conditions. They suggest there is no substitute for long-term vegetation monitoring. Whatever method is used to set stocking levels, the key consideration is that the habitat characteristics required for sage-grouse be maintained. Higher utilization rates (e.g., >40%) in early spring may allow regrowth and seed set of native grasses and forbs if livestock are removed before the soil dries out, but may not leave adequate residual grass for nest cover.

On degraded sites, grazing could be part of an interim phase of a long-term shrub-steppe restoration plan, such as where fall grazing by sheep is used to decrease sagebrush density (Bork et al. 1998) or to reduce fire hazard on annual grassland. Some sites degraded to an annual grassland will not recover sufficiently through grazing changes or livestock exclusion to be suitable for sage-grouse. Utilization rates on these sites may be irrelevant to grouse recovery unless, or until, the site is revegetated with native species.

Salt grounds should not be located on sites used annually by grouse. New livestock water developments should not located at sites used by grouse unless designed to improve habitat and reduce existing damage by livestock.

4.4.2 Minimize grazing damage to soil crusts.

Crusts on all soil types are least vulnerable when frozen or snow covered (Belnap et al. 2001). Rest-rotation strategies that minimize the frequency of disturbance during dry seasons and maximize periods between disturbances will reduce impacts to crust (Belnap et al. 2001).

4.4.3 Ensure that grazing leases on WDFW lands managed for sage-grouse are compatible with sage-grouse habitat needs (Connelly et al. 2000b, Schroeder et al. 2003).

Grazing use levels should be determined by "average use" throughout the entire pasture. Grazing levels should be based on predicted use during periods of drought (i.e., less than 75% of average moisture during a period of $\geq$ 6 months). Grass utilization, including livestock, feral horses, game and other influences, should not exceed 35% at the end of the growing season and throughout the dormant period. Use periodic deferral of grazing and rotational grazing in all rangeland pastures.

If it is determined through assessment, monitoring, and observation that sage-grouse habitat needs are not being met and livestock are a significant contributing factor, changes in grazing management should be made immediately to correct deficiencies. Remove grazing pressure if the area is degraded and restoration is unlikely under an altered grazing strategy, if it is increasing encroachment by noxious weeds, or where it is otherwise incompatible with use by sage-grouse.

4.4.4 Fence WDFW lands to exclude livestock when necessary to protect and restore sage-grouse habitat.

4.4.5 Evaluate the potential impact of elk wintering on WDFW lands on sage-grouse movement between populations, and identify and implement ways to minimize impacts.

4.5 Manage riparian habitats on public lands to support sage-grouse conservation.

4.5.1 Promote recovery of vegetation in riparian zones degraded by past over-grazing.

4.5.2 Avoid moderate to heavy livestock grazing, road development, and human disturbance in wet meadows.

4.6 Discourage expansion of road systems on public lands in management units.

4.6.1 Avoid adding new roads, trails, or right-of-ways.

4.6.2 Avoid improvements such as grading and widening of existing unpaved roads that receive little use.

4.6.3 Promote closures of unnecessary roads or those that are negatively impacting habitat quality.

Close roads on public lands not needed for management, or which conflict with sage-grouse conservation.

4.7 Monitor changes in sage-grouse habitat through remote sensing and mapping.

Using maps of sage-grouse habitat (described in section 4.6) and perhaps remote sensing, evaluate changes in habitat quantity, quality, and distribution over time (at intervals $\leq$ 10 years). Modify other strategies and tasks in response to changes in quantity, quality, and distribution of habitat. Connelly et al. (2003b) outline procedures for habitat assessment and monitoring.

Map distribution of basic sage-grouse habitats (shrub-steppe, cropland, Conservation Reserve Program) in eastern Washington at least every 10 years. WDFW should coordinate the collection of data with other agencies, groups, and interested parties including the YTC, the Yakama Nation, The Nature Conservancy, the Bureau of Land Management, and the Department of Natural Resources.

5. Work with landowners to protect the most important sage-grouse habitat on private land.

5.1 Acquire easements when landowners are willing to negotiate conservation agreements.

Consider conservation easements in areas where conversion or development of important sage-grouse habitat is a substantial risk. Development should not occur in acquired areas, but management options for easements may include limited farming and grazing practices where compatible with sage-grouse management. Programs in the 2002 Farm Bill provide funding for some conservation easements.

5.2 Acquire habitat where there are willing sellers and when it provides the best option to protect and/or restore critical habitats.

5.2.1 <u>Identify important parcels of sage-grouse habitat on private land that may be at risk of development or loss.</u>

Consider acquisition of lands that results in protection of key areas and/or better habitat connectivity for the region. Criteria for prioritizing of potential acquisitions include:

- Land that will increase and consolidate public and/or TNC holdings in areas having potential for sage-grouse reintroduction projects.
- Areas that provide potential corridors connecting isolated populations.
- Areas that support significant portions of an important habitat type, such as wintering habitat.
- Areas that contain habitat in relatively pristine condition.
- Areas that are at risk of an alternate land use (such as development) that would substantially impair the recovery efforts.
- Areas adjacent to existing populations.

5.2.2 <u>Work with landowners to determine if there are willing sellers of important habitats</u>.

5.2.3 <u>Use existing funding sources for potential acquisition, including the Washington Wildlife and Recreation Program (WWRP)</u>.

5.3 Provide advice to counties and regulatory agencies to increase protection of sage-grouse habitat.

Work with counties in the Columbia Basin to protect shrub-steppe habitat important to sage-grouse. Encourage recognition of shrub-steppe as important and worthy of inclusion in critical areas designations and updates of county ordinances under the state's Growth Management Act. Provide PHS management recommendations (Schroeder et al. 2003) to landowners and regulatory agencies.

6. Facilitate and promote the use of incentives, such as Farm Bill conservation programs, to benefit sage-grouse.

6.1 Assist landowners by providing information, advice, or materials for implementing incentive programs available for habitat protection and restoration.

Continue working with the Farm Service Agency and the Natural Resources Conservation Service to enroll and re-enroll landowners in CRP. Landowners that are interested should be assisted in applying for grants intended to protect natural resources, restoring habitat, and conserving wildlife on private lands. In addition to CRP, grant programs authorized in the 2002 Farm Bill include the Grassland Reserve Program, Wildlife Habitat Incentives Program, Environmental Quality Incentives Program, and the Conservation of Private Grazing Lands Program. Information about grants is available from USDA-NRCS, and on the USDA website (www.usda.gov/programs/farmbill/2002/products).

6.1.1 Identify the best local opportunities for enhancing sage-grouse habitat and assist landowners interested in incentive programs.

6.1.2 Assist with securing grants for conservation easements or habitat protection and restoration through 2002 Farm Bill programs such as CRP, Wildlife Habitat Incentives Program and Grassland Reserve Program.

6.1.3 Provide technical assistance or materials to landowners to enhance habitat value above the minimum requirements of Farm Bill conservation programs.

6.2 Provide technical advice to the Natural Resources Conservation Service and the Farm Service Agency for the implementation of Farm Bill programs (CRP, GRP, WHIP, etc.) at the local, state and national level to facilitate sage-grouse conservation in Washington and to ensure the wildlife conservation benefits intended by Congress.

6.2.1 Identify priority areas in Washington where Farm Bill programs have the greatest potential to benefit sage-grouse.

Prioritize areas within the Sage-grouse Management Units with current populations or with a high potential to support sage-grouse range expansion.

6.2.2 Provide technical advice on planting requirements and management practices to enhance or restore potential sage-grouse habitat.

6.2.3 Review and comment during rule-making at the national level to ensure that Farm Bill programs continue to benefit sage-grouse in Washington.

7. Facilitate management of agricultural and range lands that is compatible with the conservation of sage-grouse.

7.1 Promote the protection of remnant areas of native shrub-steppe.

Remnant shrub-steppe should be protected in all sage-grouse management units. Landowners sometimes consider remnant areas of shrub-steppe as 'scablands' or unusable fragments of habitat. Education should be designed to inform landowners and others of the associated wildlife-values of these fragments. Remnants of shrub-steppe are critical to maintain the presence of sage-grouse in areas like Douglas and Grant counties where a mix of cropland, CRP, and shrub-steppe exists. The shrub-steppe provides year-round food and cover for sage-grouse and sources of seed for the re-colonization of CRP by sagebrush and other native plants. Provide copies of the PHS management recommendations (Schroeder et al. 2003) to interested landowners.

7.1.1 Encourage the protection of remnant shrub-steppe by providing information about the importance of shrub-steppe remnants in the matrix of CRP and croplands.

7.1.2 Discourage burning of CRP and vegetation along the edges of farm fields and roadsides, particularly where remnant patches of shrub-steppe may be burned in the process.

7.1.3 Discourage spraying practices that result in the accidental or incidental spraying of remnant areas of shrub-steppe with insecticides and herbicides.

Incidental spraying of shrub-steppe can be due to the close proximity of remnants to croplands. It can also be exacerbated by regulations which make disposal of left-over chemicals difficult (may result in some chemicals being 'dumped' over open shrub-steppe habitat).

7.1.4 Promote removal of old fences, unused equipment, and refuse from shrub-steppe remnants.

Fence posts and farm equipment can provide perches or hiding places for sage-grouse predators and can preclude a site's use by grouse. Fences can pose a collision hazard for sage-grouse

7.2 Work with range managers interested in sage-grouse conservation to utilize range management practices that result in increased habitat value for sage-grouse.

Private rangeland accounts for a significant portion of 8 of 14 sage-grouse management units in Washington. Assist private range managers by providing information on range management practices that benefit sage-grouse as described in Connelly et al. (2000b). For mixed ownerships and leases on public lands, work collaboratively through Coordinated Resource Management (CRM) or other processes to develop management solutions.

7.2.1 Support range management practices that result in retention of residual perennial grass cover and healthy communities of native perennial grasses and the associated forb and shrub communities.

Residual grass should be retained in sufficient quantity to support soil moisture retention and improved grass vigor. Dominant perennial grasses such as bluebunch wheatgrass can provide for sage-grouse nest concealment. Sagebrush canopy cover should be maintained >15%.

7.2.2 Discourage development of additional springs and underground water wells for livestock, unless it can be shown that the result will benefit sage-grouse.

7.2.3 Discourage removal of sagebrush from known sage-grouse wintering areas and areas that provide escape cover in breeding habitat, especially within 3 km of leks.

7.2.4 Establish grass banks to provide alternative range during drought.

Grass banks are areas that are usually ungrazed, but are made available for grazing during droughts so that ranches that support sage-grouse and other shrub-steppe wildlife can avoid overgrazing their rangeland. TNC is in the process of establishing a grassbank in Douglas and Grant Counties area.

7.3 Promote agricultural practices which use fewer chemicals.

The herbicide 2,4,D kills forbs that are important sage-grouse summer foods. There is a beetle species that has been used as a biological control agent for the control of knapweeds. Some herbicides do not seem to harm grouse, but may be necessary for control of cheatgrass and other weeds, especially during restoration.

7.3.1 Discourage use of organophosphorus and carbamate insecticides in sage-grouse brood-rearing habitats.

7.3.2 Promote management strategies which minimize the potential exposure of sage-grouse to pesticides.

7.4 Promote agricultural practices which result in improved soil conservation, such as reduced tillage and stubble retention.

8. Restore degraded and burned sage-grouse habitat within Sage-Grouse Management Units.

Where extensive restoration is being done, consider fire control measures, such as establishing greenstrips along roads, to reduce future fire risk and facilitate suppression.

8.1. Identify and prioritize areas for restoration.

Habitat inventory and evaluation should precede restoration. Prioritize areas for restoration, given that many burns and degraded areas are too large to receive an immediate and complete response. High priority areas are those that contain known sage-grouse nesting habitat, are unlikely to return to a suitable condition without intervention, and have a 'realistic' potential for improvement.

8.2. Prepare contingency plans for habitat restoration to be used after wildfires.

Post-fire restoration in low precipitation zones must occur quickly within a narrow window of time before the cheatgrass recovers and the first fall season passes. Generic restoration plans should be prepared for all public ownerships within the sage-grouse recovery area. The plans should contain information on appropriate seed mixes, seed sources, equipment, and procedures for application so the plans can be implemented quickly. Plans should also identify priority areas for restoration, procedures for weed control, and a protocol for monitoring results.

8.3. Restore degraded sage-grouse habitat.

8.3.1 <u>Shrub-steppe restoration projects should use native seed sources</u>.

Restoration should use mixtures of locally adapted varieties of native grasses, forbs, sagebrush and other shrubs when available (Appendix A). Avoid seeding with non-native species whenever possible. However, some situations necessitate non-natives that can compete with weeds.

8.3.2. <u>Suppress cheatgrass and weeds</u>.

Use the best available techniques for the situation, which may include fallow procedures that reduce problems associated with noxious weeds or the selective use of herbicides to reduce the competitive advantage of noxious weeds over planted vegetation. Winter application of dilute glyphosate may be effective for suppressing cheatgrass.

8.3.3 <u>Restore bunchgrass and native forb understory to degraded areas.</u>

Many degraded areas have dense sagebrush, but lack the grass and forb community necessary to support a successfully nesting population of sage-grouse (Appendix A). Restoration efforts may need to reduce the cover of sagebrush in order to re-establish perennial grasses. Sagebrush cover should not be reduced unless it is demonstrated as necessary for restoring understory vegetation. Sagebrush should not be reduced below the 10-30% needed by breeding and wintering sage-grouse. All sagebrush control must be carefully done to avoid removing too much, and should not be done in important wintering sites. Where cattle are being removed for an extended period, they may provide the needed soil disturbance by 'walking-in' the seed of native bunchgrasses and forbs before they are removed to facilitate recovery of understory vegetation.

8.3.4 <u>Re-establish sagebrush where the shrub component has been lost.</u>

The current vegetation present on a site may determine whether to seed sagebrush or plant sagebrush seedlings. Where a perennial bunchgrass understory and biotic crust are present and healthy, planting sagebrush seedlings may be necessary. Seeding may be effective where Sandberg bluegrass predominates. For large areas, such as after wildfire, seeding is likely to be most cost-efficient method, but reseeding or follow-up planting of some local sites may be necessary.

8.3.5 Restore degraded wet meadows or vegetation at developed springs.

Mesic sites are important summer brood habitat because they provide green succulent vegetation through the summer.

8.4 Document methods, treatments, timing, and results of all restoration projects.

All restoration projects should be carefully monitored and documented in a form that can be made available to other land managers. Documentation will help evaluate levels of surface disturbance needed for sagebrush seeding, identify the best seed mixes for local use, and help other land managers benefit from previous restoration efforts and results.

9. Conduct research necessary to conserve sage-grouse populations.

9.1 Monitor the genetic health of sage-grouse populations.

Monitor the genetic health of populations to determine if, when, and where translocations are needed and to determine the effectiveness of translocations for increasing genetic diversity. Current data indicate that both sage-grouse populations in Washington have reduced genetic diversity and may benefit from translocation projects that bring in birds from outside Washington. Research and continued genetic monitoring of these populations is needed to evaluate the success of the translocations and determine if additional translocations are needed.

9.2 Evaluate and adapt population monitoring techniques.

Lek surveys provide an index to population trends, but may not provide the best data for estimating populations (Applegate 2000, Walsh 2002). Better data on lek attendance rates and sex ratios are needed if lek counts are used to derive population estimates. Research on survey and monitoring methodology is needed to determine if lek counts can be calibrated with mark-resight or sightability models to improve the accuracy and precision of population estimates. Research should also evaluate: the best methods to effectively survey lek complexes; the variability in lek counts within a year and its relevance to long-term monitoring; the relationship between productivity in one year and the coefficient of variation in lek counts in the subsequent year; and observer and other biases in lek counts. Some research could be done more effectively in other states with larger sage-grouse populations, but the YTC population, as a small discrete population, might provide an opportunity to conduct this type of research. Survey methods in Washington should be adapted as improvements are developed and proven.

9.3 Investigate the demographics and population dynamics of sage-grouse.

The specific assumptions used to develop recovery objectives for Washington's sage-grouse populations need to be tested, such as sex ratio, male genetic contribution per generation, dispersal, and other parameters that determine effective population size and population viability.

9.4 Research methods for increasing the populations of sage-grouse, such as reducing predation through manipulation of habitat features.

9.5 Determine the effectiveness of habitat management methodologies.

9.5.1 <u>Evaluate the importance of CRP lands in relation to sage-grouse abundance and distribution.</u>

9.5.2 <u>Monitor wildlife responses to restoration efforts</u>.

9.6 Research practical methods for restoring the forb component required by sage-grouse.

10. Cooperate and coordinate with other agencies and landowners in the conservation, protection, and restoration of sage-grouse in Washington.

10.1 Participate in the development of a multi-agency conservation action plan.

The development of a multi-agency 5-year action plan that identifies immediate priorities and responsibilities is planned. While the WDFW Recovery Plan provides general direction for recovery, the action plan will identify specific recovery activities for each cooperating agency, and will be updated every 5 years.

10.2 Secure funding for recovery activities.

Investigate availability of grants, cost-share agreements, and other types of funding to assist in implementation of recovery objectives. Federal, state, and non-governmental sources should be considered.

10.3 Participate in the interagency Washington Sage-grouse Working Group.

The Working Group is a partnership of federal, state, and tribal agencies with land management responsibilities and non-governmental organizations in central Washington. Its purpose is to provide a forum for exchange of information and ideas on sage-grouse conservation, and to facilitate implementation of sage-grouse recovery.

10.4 Assist with and provide technical advice for the development of the Foster Creek Conservation District Habitat Conservation Plan in Douglas County.

The Foster Creek Habitat Conservation Plan (HCP) is intended to facilitate protection of all federally listed and Candidate species within the planning area and includes measures to protect sage-grouse. HCPs are authorized under Section 10 of the federal Endangered

Species Act.

10.5 Help facilitate the exchange and dissemination of information about shrub-steppe restoration and management for sage-grouse.

10.5.1 Participate in the Washington Shrub-Steppe Working Group

The Washington Shrub-steppe Working Group was formed to promote collaboration and information exchange among agencies, organizations, and researchers working on mapping, research, restoration, and land management of Washington shrub-steppe.

10.5.2 Help facilitate exchange of information between WDFW wildlife area managers and other land managers and scientists working on shrub-steppe restoration.

Information exchange may be best done through a working group focused on shrub-steppe restoration, either as a subgroup of the Shrub-Steppe Working Group, or Sage-grouse Working Group.

11. Develop public information materials and educational programs for landowners, schools, community organizations, and conservation groups as needed.

11.1 Create and distribute updated fact sheets, management recommendations, and video or slide shows on the status and recovery needs of sage-grouse in Washington.

11.1.1 Develop educational materials.

The BLM has produced a 20-minute educational video, entitled "The Vanishing Shrub-steppe," by award-winning producer, Thomas Ager. It is available from BLM, 915 N Walla Walla, Wenatchee WA 98801-1521; 509-665-2100.

11.1.2 Priority Species (PHS) Management Recommendations for sage-grouse.

WDFW's PHS Management Recommendations for sage-grouse have recently been published and are available on the WDFW website (http://www.wa.gov/wdfw/hab/phs/vol4/sage_grouse.pdf). Management recommendations should be reviewed and updated periodically as new information becomes available.

IMPLEMENTATION RESPONSIBILITIES AND COST ESTIMATES

The outline of strategies and tasks on the following pages identifies co-managers, WDFW involvement, task priorities, and estimates of annual expenditures (Table 11). The following conventions are used:

Priority 1 First priority actions include those necessary to prevent further decline or extirpation of the species from Washington, including preventing further habitat loss or declines in habitat quality, and monitoring of the population.

Priority 2 Second priority actions are those necessary to increase the population such as reintroductions, and assessment, restoration, and acquisition of habitat.

Priority 3 All other actions necessary to meet recovery objectives, such as interagency coordination, education activities, and some research activities.

Acronyms:

BLM	USDI, Bureau of Land Management
BPA	Bonneville Power Administration
BOR	Bureau of Reclamation
DNR	Washington Department of Natural Resources
DOE	U.S. Department of Energy
FERC	Federal Energy Regulatory Administration
FSA	USDA Farm Service Agency
FWS	USDI, Fish and Wildlife Service
NRCS	USDA, Natural Resources Conservation Service
PUD	Public Utility Districts
USFS	USDA, Forest Service
WDFW	Washington Department of Fish and Wildlife
WSP	Washington State Parks
YN	Yakama Nation
YTC	Yakima Training Center
tbd	To be determined. Costs are unknown and may be impossible to determine at this time.

Table 11. Preliminary cost estimates[a] for implementation of Washington Sage-Grouse Recovery Plan.

Priority	Recovery task	Responsible agency/entity	Estimated Annual Cost	WDFW share
1	1.1 Conduct lek counts & survey for lek complexes	WDFW,YTC, BLM	35	15
1	1.2 Coordinate data collection, storage, retrieval	WDFW	5	5
1	1.3 Estimate population sizes	WDFW, YTC	2	1
1	1.4 Evaluate population trends	WDFW, YTC	2	1
1	2.1 Protect active leks from disturbance	YTC,DNR,WDFW, BLM, COUNTIES	5	1
1	2.2 Protect nesting/rearing areas from disturbance	YTC,BLM,WDFW, DNR, COUNTIES	5	1
2	2.3 Minimize incidental mortality	WDFW,YTC	2	1
2	2.4 Reduce hazards of fences, towers, and powerlines	WDFW,YTC,BLM,YN, DNR,DOE,FERC,BPA, PUDS	tbd[b]	tbd
2	2.5 Protect grouse from harmful pesticides	WDFW,DNR,BLM,YTC , NRCS, FWS	tbd	tbd
2	3.1 Evaluate locations for reintroduction	WDFW,YN,YTC,WSG WG, FWS	100	25
2	3.2 Conduct translocations/reintrodutions	WDFW,YN,FWS, YTC	32	8
2	3.3 Monitor & evaluate translocations	WDFW,YN,YTC	40	10
2	4.1 Map grouse habitat by suitability	WDFW,YTC,BLM, YN, FWS	75	20
1	4.2 Protect grouse habitat from fire	YTC,DOE,YN,WDFW, USFS, Counties DNR,BLM, FWS,WSP	75	15
1	4.3 Protect habitat on public lands from development and agricultural conversion	WDFW,DNR,BLM, DOE, FWS, FERC, BPA, YTC,WSP	100	20
1	4.4 Ensure compatibility of grazing on public lands managed for sage-grouse	WDFW,DNR,BLM,YN, YTC,WSP	50	5
1	4.5 Protect riparian habitats on public lands	WDFW,DNR,NRCS, YTC, YN,BOR,BLM,FERC,F WS,WSP	tbd	tbd

Priority	Recovery task	Responsible agency/entity	Estimated Annual Cost	WDFW share
2	4.6 Discourage expansion of county or other road systems on public lands in Management Units	DNR,WDFW,YN,YTC, BOR,FWS,WSP, COUNTIES	12	3
3	4.7 Monitor changes in sage-grouse habitat	WDFW,YTC, BLM,YN,DNR,WSP	20	4
2	5.1 Negotiate conservation easements	WDFW,YN,FWS,NRCS, FSA	tbd	tbd
2	5.2 Acquire sage-grouse habitat from willing sellers	WDFW, YN,FWS,BLM, BPA, BOR	tbd	tbd
2	5.3 Provide advice to permitting agencies to increase protection of sage-grouse habitat	WDFW,FWS,YN	20	10
2	6.1 Assist landowners with information, advice, or materials for implementing incentive programs	FSA,WDFW, NRCS,DNR	20	10
2	6.2 Affect implementation of Farm Bill programs to ensure benefit to sage-grouse	WDFW, FSA, NRCS	70	35
2	7.1 Promote the protection of remnant areas of shrub-steppe	NRCS,DNR,WDFW,YT C, YN,BLM,FWS	tbd	tbd
2	7.2 Use and promote compatible range practices	WDFW, BLM, DNR,YN,YTC, NRCS	20	2
3	7.3 Promote reduced use of chemicals	NRCS,DNR,WDFW,YT C, YN,BLM,FWS	tbd	tbd
3	7.4 Use and promote soil conservation	NRCS,DNR,WDFW,BL M,YTC,YN	tbd	tbd
2	8.1 Identify and prioritize restoration needs	YTC,YN,BLM,WDFW, DNR, DOE,FWS	8	2
2	8.2 Prepare contingency plans for post-fire habitat restoration	WDFW, USFWS, BLM, YN, WDNR, DOE, WSP, YTC	30	6
2	8.3 Restore degraded shrub-steppe habitat	YTC,YN, BLM,WDFW, DNR, DOE, FWS	tbd	tbd
2	8.4 Document methods, treatments, timing, and results of restoration projects	YTC,YN,BLM,WDFW, DNR, DOE,FWS	20	5
1	9.1 Monitor genetic health	WDFW,FWS,YTC	10	4
2	9.2 Evaluate/adapt monitoring techniques	WDFW, FWS, YTC	3	2

Priority	Recovery task	Responsible agency/entity	Estimated Annual Cost	WDFW share
2	9.3 Investigate demographics/population dynamics	WDFW,FWS, YTC	100	100
2	9.4 Investigate habitat management to increase populations	WDFW,YTC	tbd	tbd
3	9.5 Evaluate effects of habitat improvements on sage-grouse	WDFW, YTC, YN, FWS, BLM	30	5
2	9.6 Research methods for restoring forbs	WDFW, YTC, FWS, BLM	40	10
3	10.1 Participate in multi-agency conservation agreement	WDFW,FWS,YTC,YN, DNR,BLM,DOE,NRCS, WSP	40	10
1	10.2 Secure funding for recovery activities	WDFW, FWS, YTC, YN, BLM, WSP	tbd	tbd
3	10.3 Participate in sage-grouse working group	WDFW,FWS,YTC,YN, DNR,BLM,DOE,NRCS, WSP	10	3
3	10.4 Assist with Foster Creek HCP	WDFW, FWS, BLM,NRCS	10	2
3	10.5 Facilitate info exchange about restoration and habitat management	WDFW, FWS, BLM, BLM	5	1
3	11.1 Develop educational and informational materials	WDFW,FWS,BLM,TNC , YTC, WSP	5	2.5

[a] Cost figures are preliminary estimates of annual cost andWDFW share in 1000s for the first 5-year period assuming funds are available. Some tasks require continued funding, while others are one-time expenses or would be incurred for only a few years. Not all activities would be conducted simultaneously.
[b] tbd = to be determined; costs can not be estimated at this time.

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Appendix A. Restoration of Shrub-steppe Habitat

Restoration of shrub-steppe vegetation can be difficult but will be necessary to recover and maintain sage -grouse populations. The objective of restoration is to recover or recreate the native vegetation and associated structure, function, and habitat values that existed prior to disturbance (Allen 1995). Allen (1995) states "Restoration may be more costly to implement initially, but it results in ecosystems that require less maintenance input in the long term, are more stable, and have higher species diversity." The relative success of restoration projects in shrub-steppe has been mixed depending on the precipitation zone and how badly the site is degraded. For sites that still contain sagebrush, bunchgrass and a seed bank of many natives, passive restoration that simply removes the stressors, such as livestock, may succeed in restoring a diverse shrub-steppe community (Anderson and Inouye 2001). Simple cessation of grazing however, often does not necessarily result in return to the original vegetation (Westoby et al. 1989, Laycock 1991, West 1999). For example, the Wahluke Wildlife Area, now part of the Hanford Reach National Monument, showed little recovery 30 years after cattle and horses were removed (J. Benson, pers. comm.). Often some active restoration including seeding, weeding, carefully prescribed grazing, or prescribed burning is necessary on many degraded sites (Allen 1995). Where a mix of native and alien species is present, restoration must be conducted adaptively when the vegetation responds in unexpected ways.

Except where they are critical for sage-grouse recovery, sites with no native vegetation, no residual seed bank, and serious weed infestations may not be good candidates for restoration, particularly in drier locations (Allen 1995). Drier sites are very difficult to restore because most vegetation establishment may occur during exceptionally wet years (Allen 1995). Restoring those sites would be very difficult and expensive, and the best that may be hoped for may be rehabilitation to a less weedy annual grassland (Monsen and McArthur 1995). Protecting healthy shrub-steppe appears to be the best way of keeping out cheatgrass (Anderson and Inouye 2001). Complete restoration of seriously disturbed sites has never been accomplished, and the difficulties increase the importance of protecting remaining lands with high diversity (Bunting et al. 2002:40). As Allen (1995) states, "restoration is not a substitute for conservation."

Range rehabilitation and mine reclamation. Much of the early experience with restoring shrub-steppe sites comes from rehabilitation of rangeland to improve livestock forage production and stabilize watersheds and the reclamation of mines. The use of exotic perennial grasses began in the early 20th century with the need to revegetate high elevation areas that were extremely degraded by over-grazing (Monsen and Shaw 2000). Range rehabilitation often planted monocultures of crested wheatgrass, or limited mixes that included other exotic species. These exotic grasses are generally not compatible with native communities. Their presence reduces the survival and recruitment of remnant native species and has resulted in the conversion to a community dominated by introduced species that does not provide the function, resilience, or habitat value of the native community (Monsen and Shaw 2000). In addition to wildlife habitat, the spread of weeds, especially cheatgrass has been an important issue favoring the re-establishment of the native community. Monsen and Shaw (2000) state that, "Re-establishing a community of native species appears to be the most ecologically sound means of containing weeds." Rehabilitation after wildfires is the dominant revegetation effort that occurs on public lands (Roundy et al. 1997). Although the use of native species is desired, during high fire years the demand for native seeds greatly exceeds the supply. Proven and available exotic species are often used to meet the immediate need to stabilize soils and pre-empt the occupation of the site by cheatgrass and weeds (Roundy et al. 1997).

The re-establishment of Wyoming big sagebrush during mine reclamation has proved difficult due to low seedling vigor, and its low ability to compete with herbaceaous species (Schuman et al. 1998). Sagebrush roots develop an association with arbuscular mycorrhrizal fungi, and past failures may have resulted from the absence of the fungi in disturbed and stockpiled soils (Schuman et al. 1998). The fungal association greatly enhances the drought stress tolerance of big sagebrush seedlings. Schuman et al. (1998) experimented with using stubble of Steptoe barley (*Hardeum vulgare*) and surface applied straw as mulches. Mulch increased seedling establishment the 1st year; but mulching had limited effect on density of sagebrush in test plots after 3 years.

Post-fire restoration. Under some conditions after wild fires, if cheatgrass is present the site can become dominated by it. Cheatgrass is "extremely tenacious and competitive," outgrowing competitors so that native species are unable to become established (Monsen 1994a). Cheatgrass produces an abundance of seeds that germinate at lower temperatures than perennial grasses; its roots grow 50% faster than those of bluebunch wheatgrass and can grow in temperatures as low as 3° C (Monsen 1994a). Cheatgrass increases fire frequency and after repeated fires can form a monoculture. A cheatgrass monoculture has almost no value for sage grouse and other native wildlife species. Cheatgrass is at least palatable to livestock while green in spring, though it is not reliable year to year. Medusahead rye is another fire-prone alien annual that can dominate rangelands and it is not palatable to livestock. Medusahead has the potential to replace cheatgrass through succession in the ≥11" precipitation zone (Hironaka 1994). The poor habitat value and fire-prone nature of these annual grasslands where they are in, or adjacent to, sage-grouse areas create the need to restore these sites to native vegetation. Restoration after wildfires is best done quickly, as the fire disturbance creates a brief window of opportunity to apply seed before cheatgrass and Sandberg bluegrass regenerates. Seeding that is done in the fall after the fire, and followed by herbicide in early spring has a reasonable chance of success (J. Benson, pers. comm.)

Cheatgrass and weeds. Where native herbaceous perennials and sagebrush remain abundant, cheatgrass control must use methods that will not reduce them. Where cheatgrass dominates, it must be controlled if seeding of other species is to be successful. When a site is devoid of perennials and the site is burning every few years, then effective control often requires spring tillage or burning of mature plants before seed dispersal followed by fall tillage or herbicide (Monsen 1994a, Mosely et al. 1999). Cheatgrass reproduces only from seeds. The seeds are viable for 3 years or less, so many control strategies attempt to deplete the soil seed bank (Ogg 1994). Multiple spring burns may be necessary to deplete the seed bank in cheatgrass monocultures (Allen 1995), and burning alone without revegetation is ineffective (Mosely et al. 1999). Prescribed grazing can be used to help control cheatgrass and reduce fuels and diminish the fire hazard of infested sites that threatened nearby sagebrush habitat (Mosely et al. 1999), though the usefulness of grazing to control cheatgrass is limited (Vallentine and Stevens 1994). Sheep and goats can be used as part of a program to control infestations of weedy forbs because they selectively graze on them (Olson 1999). Ogg (1994) reviewed chemical control of cheatgrass. Kennedy (1994) reviewed biological control of annual grass weeds. Wilson and McCaffrey (1999) reviewed biological control of rangeland weeds in general. They note that sometimes successful control of the dominant weed results in its replacement by another weed species. To be successful, cheatgrass control must be combined with techniques to establish perennial plants (Mosely et al. 1999). Some native species show some ability to reinvade and gain dominance of cheatgrass sites, including bottlebrush squirreltail, Sandberg bluegrass (*Poa secunda*), Thurber needlegrass (*Stipa thurberiana*), western wheatgrass (*Agropyron smithii*), and streambank wheatgrass (*A. riparian*) (Monsen 1994a). Squirreltail also shows promise for use in replacing medusahead (Hironaka 1994), though sites occupied by medusahead or rush skeletonweed are much more difficult to restore than those occupied by cheatgrass (Monsen and

McArthur 1995). Additional techniques that have been suggested include selection of the most competitive ecotypes of native species for seeding, selection for low temperature growth, and priming seeds for early germination (Monsen 1994a). Some USDA Plant Material Centers are developing methods to increase genetic diversity of plant materials to improve the long term resilience and survival of planted vegetation (Roundy et al. 1997). Bunting et al. (2002) summarizes that restoration in the Wyoming big sagebrush types usually requires 4 components, and projects that do not include all 4 usually fail. These components were: 1) fire suppression; 2) control of invasive plant competition; 3) planting of native seeds or transplants; and 4) change in livestock management to encourage plant recruitment.

Seeding and planting stock. Whether seeding or planting nursery stock is most effective or desirable depends in part on the condition of the understory on the site. The YTC has been successful with planting bare-root stock, but discontinued seeding sagebrush due to the lack of consistent success (B. Knapp, pers. comm.). The efficacy of seeding may depend on the degree of disturbance, and the existing vegetation, and the precipitation during the 9 months prior and 12-18 months after seeding. Where an understory of bunchgrass and crust cover exists, planting stock may be more effective, but on disturbed sites, CRP, and large burns, seeding is more cost efficient even if drought conditions require repeated attempts. For large projects seeding is preferable wherever feasible because it establishes much higher numbers of plants at much lower cost (J. Benson, pers. comm.). Seeding can often be done at 1/20 the cost per acre of planting stock (D. Larsen, pers. comm.). Tables 12 and 13 contain the components of a suggested seed mix for the 10"- 14" and 14" - 18" precipitation zones. Rugged terrain, however, can preclude the use of mechanical treatment, and seeding would be less successful (H. Newsome, pers.comm.). Meyer (1994) stresses the importance of matching the seed collection site with the seeding site as closely as possible. Meyer (1994) describes an alternative long term strategy for restoration is to first establish early seral species such as squirreltail which competes more effectively with exotic annuals. Once the early seral natives are established and dominate the site, big sagebrush can then be seeded along with other late-seral understory species. Meyer (1994) includes other practical suggestions for sagebrush seeding and seed handling.

Meikle (2000) suggests that the concept of direct-seeding as a one-time event is contradictory to the reproductive strategy of sagebrush, and proposed planting sagebrush in linear seed production plots. Adjacent “facilitation plots” are seeded with plants that are easier to establish and are conducive to invasion by sagebrush from the annual seed rain from seed plots. Companion vegetation for facilitation plots could include gray rabbitbrush (*Ericamerica* formerly *Chrysothamnus nauseousus*), saltbush (*Atriplex* sp.), and Sandberg bluegrass.

Restoration experience in Washington. Restoration efforts in Washington to date, have been described as ranging from “astounding success to total failure” (R. Ross, pers. comm.). In efforts that drill a seed mix below the surface, the sagebrush fails because it requires light to germinate. Problems encountered include deer eliminating planted bitterbrush, time constraints preventing effectively addressing cheatgrass, and drought (R.Ross, pers. comm.). Light to moderate soil disturbance is critical for sagebrush seed establishment and scattering sage seed on burned areas without some type of soil disturbance (harrowing, hoof action from livestock, etc.) will usually yield poor results (J. Benson, pers. comm.). WDFW seeded and harrowed 1,000 ac of the Rattlesnake Slope after the 2000 fire, with fair to good success (D. Larsen, pers. comm.). Sagebrush establishment was most successful in areas that did

Table 12. Species components of a native habitat restoration seed mix for use in the 10" to 14" precipitation zone of central Washington (J. Benson, pers. comm.).

Species Variety	Amount (lbs Pure Live Seed)
Bluebunch Wheatgrass	
Secar	1.50 lbs
Whitmar	1.00 lbs
Native	1.25 lbs
Thickspike Wheatgrass	
Schwindimar or Bannock (not Critana)	1.25 lbs
Idaho Fescue	
Native or Joseph (Joseph is a synthetic native)	1.50 lbs
Big Bluegrass	
Sherman	0.40 Lbs
Sandberg Bluegrass	
Native or Canbar (Canby type needs 14+inches)	0.50 lbs
Lupine	
Native (officinales/perennis or sericeus)	0.25 lbs
Yarrow	
White	0.20 lbs
Blue Flax	
Native or Appar (Appar is from So. Dakota)	0.20 lbs
Balsamroot	
Native *Balsamoriza sagittata*	0.12 lbs
Sagebrush	
Artemisia tridentata or/and *wyomingensis*	0.20 lbs

In addition, Great Basin Wildrye (Magnar or Native) should be seeded in draw bottoms and swales prior to the general planting at the rate of 1.5 to 2.0 lbs per acre. Also Cicer Milkvetch (non-native) is well adapted to very damp areas and quite salt tolerant. It doesn't succeed away from good moisture. Seeding rate of Cicer is about 1.0 to 1.5 lbs per acre on moist sites. Another alternative for a dry site legume is Hairy Vetch (*Vica villosa*), native to the western US but not native to this area; it has a wide variation of annual abundance dependant on seasonal moisture. This species is an excellent seed producer.

Table 13. Species components of a native habitat restoration seed mix for use in the 14" to 18" precipitation zone of central Washington (J. Benson, pers. comm.).

Species Variety	Amount (lbs Pure Live Seed)
Bluebunch Wheatgrass	
Secar	1.50 lbs
Whitmar	1.00 lbs
Native	1.25 lbs
Idaho Fescue	
Native or Joseph (Joseph is a synthetic native)	1.75 lbs
Prairie Junegrass	
Native	.35 lbs
Big Bluegrass	
Sherman	0.25 Lbs
Sandberg Bluegrass	
Native or Canbar (Canby type needs 14+inches)	0.50 lbs
Lupine	
Native (officinales/perennis or sericeus)	0.25 lbs
Yarrow	
White	0.20 lbs
Blue Flax	
Native or Appar (Appar is from So. Dakota)	0.20 lbs
Balsamroot	
Native *Balsamoriza sagittata*	0.12 lbs
Sagebrush	
Artemisia tridentata or/and *wyomingensis* (if appropriate for site)	0.20 lbs
Artemisia tripartita (used in specific sites to 16" of precipitation)	0.20 Lbs

In addition, Great Basin Wildrye (Magnar or Native) should be seeded in draw bottoms and swales prior to the general planting at the rate of 1.5 to 2.0 lbs per acre. An alternative for a dry site legume is Hairy Vetch (*Vica villosa*), native to the western US but not native to this area. Has a wide variation of annual abundance dependant on seasonal moisture. This species is an excellent seed producer.

not have dominant stands of bluebunch wheatgrass or sandberg bluegrass. As would be expected, sagebrush established most successfully in areas with sparse sandberg bluegrass and/or annuals. The YTC has an ongoing restoration program to re-establish shrub-steppe vegetation after fires and on sites that have been severely impacted by training activities (see Managment Activities: YTC, p.34). Much of the Hanford unit is in low precipitation areas and large portions burned in 1981, 1984, and 2000. Fall seeding seems to be more successful (D. Larsen, pers. comm.). The USFWS is also conducting extensive planting of seedlings grown from locally harvested seed on the Hanford Reach National Monument. Winter application of a light dose of glyphosate has worked well there for suppressing cheatgrass without affecting the native species which are dormant (H. Newsome, pers.comm.). About 1 million acres of CRP in Washington and the older fields increasingly resemble shrub-steppe (D. Larsen, pers. comm.). CRP fields increasingly are seeded with a mix including sagebrush, but some smaller projects salvaged sagebrush seedlings from the edges of winter wheat fields that are adjacent to shrub-steppe. These local seedlings seem to survive much better than some nursery stock that was from out-of-state (G. Fitzgerald, pers. comm.).

Historic overgrazing has left many areas vegetated by dense sagebrush with an understory of cheatgrass and Sandberg bluegrass. It is difficult to restore the understory without destroying the sagebrush, because seeding requires good seed/soil contact. J. Benson (pers. comm.) reports moderate success on a site in a high precipitation area where seed was broadcast 2-3 months before the cattle were to be removed, so the cattle supplied the soil disturbance. The site was then not grazed for 2-3 years, allowing re-establishment of the native grasses. WDFW plans an experiment with planting Idaho fescue plugs at Sagebrush Flats Wildlife Area. Planting plugs may be necessary on some sites where harrowing, disking, or drilling might impact declining species, such as the Washington ground squirrel. Alternative methods for restoring the understory involve eliminating the sagebrush in strips or plots and replanting a seed mix (Connelly et al. 2000b). Olson and Whitson (2002) reported successfully using low doses of tebuthurion to thin big sage-brush and increase native understory plants in Wyoming. Tebuthurion and similar herbicides could be tested experimentally in Washington for use in restoring sites with dense sagebrush and little understory (Connelly et al. 2000b).

Appendix B. Washington Administration Code 232-12-297. Section 11 addresses Recovery Plans.

WAC 232-12-297 Endangered, threatened, and sensitive wildlife species classification.

PURPOSE

1.1 The purpose of this rule is to identify and classify native wildlife species that have need of protection and/or management to ensure their survival as free-ranging populations in Washington and to define the process by which listing, management, recovery, and delisting of a species can be achieved. These rules are established to ensure that consistent procedures and criteria are followed when classifying wildlife as endangered, or the protected wildlife subcategories threatened or sensitive.

DEFINITIONS

For purposes of this rule, the following definitions apply:

2.1 "Classify" and all derivatives means to list or delist wildlife species to or from endangered, or to or from the protected wildlife subcategories threatened or sensitive.

2.2 "List" and all derivatives means to change the classification status of a wildlife species to endangered, threatened, or sensitive.

2.3 "Delist" and its derivatives means to change the classification of endangered, threatened, or sensitive species to a classification other than endangered, threatened, or sensitive.

2.4 "Endangered" means any wildlife species native to the state of Washington that is seriously threatened with extinction throughout all or a significant portion of its range within the state.

2.5 "Threatened" means any wildlife species native to the state of Washington that is likely to become an endangered species within the foreseeable future throughout a significant portion of its range within the state without cooperative management or removal of threats.

2.6 "Sensitive" means any wildlife species native to the state of Washington that is vulnerable or declining and is likely to become endangered or threatened in a significant portion of its range within the state without cooperative management or removal of threats.

2.7 "Species" means any group of animals classified as a species or subspecies as commonly accepted by the scientific community.

2.8 "Native" means any wildlife species naturally occurring in Washington for purposes of breeding, resting, or foraging, excluding introduced species not found historically in this state.

2.9 "Significant portion of its range" means that portion of a species' range likely to be essential to the long term survival of the population in Washington.

LISTING CRITERIA

3.1 The commission shall list a wildlife species as endangered, threatened, or sensitive solely on the basis of the biological status of the species being considered, based on the preponderance of scientific data available, except as noted in section 3.4.

3.2 If a species is listed as endangered or threatened under the federal Endangered Species Act, the agency will recommend to the commission that it be listed as endangered or threatened as specified in section 9.1. If listed, the agency will proceed with development of a recovery plan pursuant to section 11.1.

3.3 Species may be listed as endangered, threatened, or sensitive only when populations are in danger of failing, declining, or are vulnerable, due to factors including but not restricted to limited numbers, disease, predation, exploitation, or habitat loss or change, pursuant to section 7.1.

3.4 Where a species of the class Insecta, based on substantial evidence, is determined to present an unreasonable risk to public health, the commission may make the determination that the species need not be listed as endangered, threatened, or sensitive.

DELISTING CRITERIA

4.1 The commission shall delist a wildlife species from endangered, threatened, or sensitive solely on the basis of the biological status of the species being considered, based on the preponderance of scientific data available.

4.2 A species may be delisted from endangered, threatened, or sensitive only when populations are no longer in danger of failing, declining, are no longer vulnerable, pursuant to section 3.3, or meet recovery plan goals, and when it no longer meets the definitions in sections 2.4, 2.5, or 2.6.

INITIATION OF LISTING PROCESS

5.1 Any one of the following events may initiate the listing process.

5.1.1 The agency determines that a species population may be in danger of failing, declining, or vulnerable, pursuant to section 3.3.

5.1.2 A petition is received at the agency from an interested person. The petition should be addressed to the director. It should set forth specific evidence and scientific data which shows that the species may be failing, declining, or vulnerable, pursuant to section 3.3. Within 60 days, the agency shall either deny the petition, stating the reasons, or initiate the classification process.

5.1.3 An emergency, as defined by the Administrative Procedure Act, chapter 34.05 RCW. The listing of any species previously classified under emergency rule shall be governed by the provisions of this section.

5.1.4 The commission requests the agency review a species of concern.

5.2 Upon initiation of the listing process the agency shall publish a public notice in the Washington Register, and notify those parties who have expressed their interest to the department, announcing the initiation of the classification process and calling for scientific information relevant to the species status report under consideration pursuant to section 7.1.

INITIATION OF DELISTING PROCESS

6.1 Any one of the following events may initiate the delisting process:

6.1.1 The agency determines that a species population may no longer be in danger of failing, declining, or vulnerable, pursuant to section 3.3.

6.1.2 The agency receives a petition from an interested person. The petition should be addressed to the director. It should set forth specific evidence and scientific data which shows that the species may no longer be failing, declining, or vulnerable, pursuant to section 3.3. Within 60 days, the agency shall either deny the petition, stating the reasons, or initiate the delisting process.

6.1.3 The commission requests the agency review a species of concern.

6.2 Upon initiation of the delisting process the agency shall publish a public notice in the Washington Register, and notify those parties who have expressed their interest to the department, announcing the initiation of the delisting process and calling for scientific information relevant to the species status report under consideration pursuant to section 7.1.

SPECIES STATUS REVIEW AND AGENCY RECOMMENDATIONS

7.1 Except in an emergency under 5.1.3 above, prior to making a classification recommendation to the commission, the agency shall prepare a preliminary species status report. The report will include a review of information relevant to the species' status in Washington and address factors affecting its status, including those given under section 3.3. The status report shall be reviewed by the public and scientific community. The status report will include, but not be limited to an analysis of:

7.1.1 Historic, current, and future species population trends.

7.1.2 Natural history, including ecological relationships (e.g. food habits, home range, habitat selection patterns).

7.1.3 Historic and current habitat trends.

7.1.4 Population demographics (e.g. survival and mortality rates, reproductive success) and their relationship to long term sustainability.

7.1.5 Historic and current species management activities.

7.2 Except in an emergency under 5.1.3 above, the agency shall prepare recommendations for species classification, based upon scientific data contained in the status report. Documents shall be prepared to determine the environmental consequences of adopting the recommendations pursuant to requirements of the State Environmental Policy Act (SEPA).

7.3 For the purpose of delisting, the status report will include a review of recovery plan goals.

PUBLIC REVIEW

8.1 Except in an emergency under 5.1.3 above, prior to making a recommendation to the commission, the agency shall provide an opportunity for interested parties to submit new scientific data relevant to the status report, classification recommendation, and any SEPA findings.

8.1.1 The agency shall allow at least 90 days for public comment.

FINAL RECOMMENDATIONS AND COMMISSION ACTION

9.1 After the close of the public comment period, the agency shall complete a final status report and classification recommendation. SEPA documents will be prepared, as necessary, for the final agency recommendation for classification. The classification recommendation will be presented to the commission for action. The final species status report, agency classification recommendation, and SEPA documents will be made available to the public at least 30 days prior to the commission meeting.

9.2 Notice of the proposed commission action will be published at least 30 days prior to the commission meeting.

PERIODIC SPECIES STATUS REVIEW

10.1 The agency shall conduct a review of each endangered, threatened, or sensitive wildlife species at least every five years after the date of its listing. This review shall include an update of the species status report to determine whether the status of the species warrants its current listing status or deserves reclassification.

10.1.1 The agency shall notify any parties who have expressed their interest to the department of the periodic status review. This notice shall occur at least one year prior to end of the five year period required by section 10.1.

10.2 The status of all delisted species shall be reviewed at least once, five years following the date of delisting.

10.3 The department shall evaluate the necessity of changing the classification of the species being reviewed. The agency shall report its findings to the commission at a commission meeting. The agency shall notify the public of its findings at least 30 days prior to presenting the findings to the commission.

10.3.1 If the agency determines that new information suggests that classification of a species should be changed from its present state, the agency shall initiate classification procedures provided for in these rules starting with section 5.1.

10.3.2 If the agency determines that conditions have not changed significantly and that the classification of the species should remain unchanged, the agency shall recommend to the commission that the species being reviewed shall retain its present classification status.

10.4 Nothing in these rules shall be construed to automatically delist a species without formal commission action.

RECOVERY AND MANAGEMENT OF LISTED SPECIES

11.1 The agency shall write a recovery plan for species listed as endangered or threatened. The agency will write a management plan for species listed as sensitive. Recovery and management plans shall address the listing criteria described in sections 3.1 and 3.3, and shall include, but are not limited to:

11.1.1 Target population objectives

11.1.2 Criteria for reclassification

11.1.3 An implementation plan for reaching population objectives which will promote cooperative management and be sensitive to landowner needs and property rights. The plan will specify resources needed from and impacts to the department, other agencies (including federal, state, and local), tribes, landowners, and other interest groups. The plan shall consider various approaches to meeting recovery objectives including, but not limited to regulation, mitigation, acquisition, incentive, and compensation mechanisms.

11.1.4 Public education needs

11.1.5 A species monitoring plan, which requires periodic review to allow the incorporation of new information into the status report.

11.2 Preparation of recovery and management plans will be initiated by the agency within one year after the date of listing.

11.2.1 Recovery and management plans for species listed prior to 1990 or during the five years following the adoption of these rules shall be completed within 5 years after the date of listing or adoption of these rules, whichever comes later. Development of recovery plans for endangered species will receive higher priority than threatened or sensitive species.

11.2.2 Recovery and management plans for species listed after five years following the adoption of these rules shall be completed within three years after the date of listing.

11.2.3 The agency will publish a notice in the Washington Register and notify any parties who have expressed interest to the department of the initiation of recovery plan development.

11.2.4 If the deadlines defined in sections 11.2.1 and 11.2.2 are not met the department shall notify the public and report the reasons for missing the deadline and the strategy for completing the plan at a commission meeting. The intent of this section is to recognize current department personnel resources are limiting and that development of recovery plans for some of the species may require significant involvement by interests outside of the department, and therefore take longer to complete.

11.3 The agency shall provide an opportunity for interested public to comment on the recovery plan and any SEPA documents.

CLASSIFICATION PROCEDURES REVIEW

12.1 The agency and an ad hoc public group with members representing a broad spectrum of interests, shall meet as needed to accomplish the following:

12.1.1 Monitor the progress of the development of recovery and management plans and status reviews, highlight problems, and make recommendations to the department and other interested parties to improve the effectiveness of these processes.

12.1.2 Review these classification procedures six years after the adoption of these rules and report its findings to the commission.

AUTHORITY

13.1 The commission has the authority to classify wildlife as endangered under RCW 77.12.020. Species classified as endangered are listed under WAC 232-12-014, as amended.

13.2 Threatened and sensitive species shall be classified as subcategories of protected wildlife. The commission has the authority to classify wildlife as protected under RCW 77.12.020. Species classified as protected are listed under WAC 232-12-011, as amended.

Section	Comment and response
Habitat Status	Your conclusion that "...grazing by large ungulates seems to have played little role in the evolution of shrub-steppe organisms in Washington" is highly debatable and could be in error. There is ample evidence of large grazing animals prior to the Holocene. It is debatable whether plants evolved into new species of bunchgrasses during a period of 10,000 years. Most of our bunchgrasses also occur in the Northern Great Plains, the recent home of bison. Our experience is that these species can be grazed if the timing is planned to meet the physiological requirements of the bunchgrasses. *Our shrub-steppe grasses are much more sensitive to defoliation, particularly in spring-early summer, than are the dominant sod-forming grasses of the Great Plains. We have seen no research that would contradict the evidence enumerated by Mack and Thompson (1982) that our native shrub-steppe vegetation is not adapted to grazing by large herds of large herbivores. Vegetation assemblages are dynamic, and the Columbia Basin has undergone dramatic changes in that time period. Mack and Thompson (1982), Painter et al. (1989) and the sources therein, indicate that 10,000 years is sufficient time for plants to adapt to changed grazing regimes.*
Factors Affecting	There is no research from the Columbia Basin supporting the role of crusts in maintenance or recovery of native shrub-steppe plant communities. Belnap's research occurred in much drier environments of the Great Basin and Colorado Plateau, and current research is inadequate to draw such conclusions about the Columbia Basin. I recommend that the discussion of crusts be dropped. *The ecological functions of biotic crusts have been demonstrated repeatedly among many different arid and semi-arid ecosystems. The Columbia Basin, Great Basin and Colorado Plateau, are considered cool deserts, and all have similar winter- spring precipitation regimes, with averages of 230-635, 180-380, and 205-510 mm, respectively. Many areas in the Great Basin have very similar vegetation, with Wyoming big sagebrush being a common community type. The one difference being that there is a greater frequency of overcast days in the Columbia Basin, as is mentioned (p. 44). This may facilitate more rapid recovery of damaged crust. Biotic crusts are a common feature of Washington shrub-steppe. Local research includes Ponzetti et al. (2000) that confirmed an inverse relationship between cover of crust and cheatgrass and disturbance and crust cover and species richness. Johansen et al. (1993) and McIntosh (2003) studied crustal organisms on Hanford Reach NM and reported observations of the effect of fires and/or grazing disturbance on seral stage of crusts. Link et al. (2000) reported that 17% of the soil lichen flora (5 of 29 species) on the Hanford were capable of fixing nitrogen. Kaltenecker et al. (1999) describe the impacts of grazing on crusts in Idaho. Although more local research is needed, there is no reason to assume that much of the research on biotic crust does not apply, and there are many indications that it does apply to crusts in the Columbia Basin.*

Section	Comment and response
	No conclusive connection can be made between biological crusts and appropriate habitats for Washington sage-grouse during any part of their life cycle.
	There has been no research assessing the potential connection between healthy crusts and sage-grouse populations anywhere. Biotic crusts are a major portion of the ecosystem in which sage-grouse live, and it has been ignored in the sage-grouse literature. It would be difficult to demonstrate a direct benefit given the variability of sage-grouse populations and the many factors involved. Research elsewhere has demonstrated that healthy crust improves the nutrient content of plants. Myers (1992) showed that sage-grouse will select Wyoming big sagebrush plants that have been fertilized, and the nutritional composition of the diet of hens likely affects clutch size and resulting reproductive success (Barnett and Crawford 1994).
Factors Affecting/ Recovery	None of the literature cited that advocates light levels of livestock utilization is from research done in the Columbia Basin. In addition, the large effect of timing of grazing is not considered.
	Though Holecek et al. (1999) found no long term data for intermountain sagebrush communities, they believed that their recommendation forlight levels of livestock utilization had widespread applicability, and it seems consistent with the habitat needs of sage-grouse. We agree that timing of grazing is very important. Grazing more than lightly may be incompatible with the grass cover desired for nesting areas. Heavier grazing that occurs in early spring and stops while soil moisture still allows grass recovery may be compatible with sage-grouse in late-summer to fall and winter habitats.
Recovery	The application of site specific grazing practices to produce the desired habitat conditions will be more successful and acceptable to people whose active cooperation is needed than broad brush guidelines like 'light grazing everywhere.'
	We agree. However, conservative stocking levels and careful timing are likely needed to ensure adequate grass cover in nesting areas and recovery of native vegetation in sage-grouse management areas. Where light grazing occurs, season-long grazing may be compatible with the needs of sage-grouse.
	Contrary to statements on page 44, properly designed spring developments using float valves and/or overflow returns to the riparian area have been tremendously successful in restoration of spring-fed riparian areas. This allows managers the option of placing water in upland sites away from the spring, rather than having livestock congregate, drink from, and forage in undeveloped spring areas.
	Water developments designed to enhance sage-grouse use would be fine, though any changes to areas actually being used by grouse should be done very carefully. We have revised the language. Water should not be developed on public lands if it means areal expansion of grazing impacts; areas in sage-grouse range that have not been used by livestock due to lack of water should not receive new water developments.

Section	Comment and response
	The recommendation on page 67, “New livestock developments and salt grounds should not be located in sites traditionally used by sage-grouse” would prevent the use of good range management practices to enhance spring-fed riparian areas for sage-grouse and eliminate the use of salting to distribute livestock to areas that would not conflict with sage-grouse needs. A better recommendation would be to use properly designed spring developments to enhance mesic vegetation and salting to distribute livestock to areas that are not important sage-grouse habitat during the season that livestock grazing is occurring.
	New salt grounds should not be located in sites annually used by sage-grouse. (See previous response about water developments)
	The plan does not devote sufficient emphasis on finding innovative ways to enhance agricultural practices on private lands. The Coordinated Resource Management (CRM) process can be a very effective tool on rangelands with mixed ownerships and objectives.
	Collaborative processes like the CRM process are appropriate when issues involve mixed ownership issues or leases on state lands. We added mention of this to the Recovery Section. The plan does discuss grazing practices, brush control, and CRP and the new Farm Bill grant programs that can be used for habitat restoration or easements on private lands. The Foster Creek HCP, also mentioned in the plan, is another project that has the potential to benefit sage-grouse on private lands.
	Further analysis of each population of sage-grouse will be necessary to identify the limiting factors to recovery, for example excessive predation or wintering habitat.
	We agree. For both the populations, there are obvious habitat issues that need to be addressed and are major limiting factors both within and outside the currently occupied areas; good habitat will usually keep predation at acceptable levels.
	Recovery will require that private landowners and public land grazing lessees be able to sustain economically viable levels of grazing use; if ranchers are “kicked off” their grazing lands or required to make large reductions in levels of grazing use, the necessary cooperation from private parties may end.
	We hope that sage-grouse habitat needs are compatible with economically viable levels of grazing use, particularly since the alternative may be subdivision, or other incompatible uses that would eliminate habitat. For public lands, our highest priority is sage-grouse and other wildlife. For private lands, we hope to work cooperatively and creatively to foster conditions favorable to sage-grouse. That may involve facilitating grants for habitat improvement or fire control and prevention, discouraging incompatible development, or negotiating conservation easements.
	The Douglas County PUD is willing to discuss burial of overhead powerlines in cases where a section of line has caused >1 injury or death of sage-grouse; otherwise the cost (>$30,000/mi) would have to be paid by WDFW.
	We appreciate the willingness of the Douglas PUD to work with the Department to address this issue where sections of lines are known to cause injury or death. We note the high cost in Section 2.4.2.

Section	Comment and response
General comment	We are in full agreement with the WDFW sage-grouse recovery plan; successful recovery will depend on protecting remaining habitat, restoring degraded habitat, and re-establishing populations in other areas. Sage-grosue recovery will take a sustained effort by many agencies and individuals, but will benefit many other shrub-steppe species of conservation concern. *Thanks for your interest and support.*

Washington State Status Reports and Recovery Plans

Status Reports

2004	Killer Whale	✓
2002	Peregrine Falcon	✓
2001	Bald Eagle	✓
2000	Common Loon	✓
1999	Northern Leopard Frog	✓
1999	Olympic Mudminnow	✓
1999	Mardon Skipper	✓
1999	Lynx Update	
1998	Fisher	✓
1998	Margined Sculpin	✓
1998	Pygmy Whitefish	✓
1998	Sharp-tailed Grouse	✓
1998	Sage-grouse	✓
1997	Aleutian Canada Goose	✓
1997	Gray Whale	✓
1997	Olive Ridley Sea Turtle	✓
1997	Oregon Spotted Frog	✓
1993	Larch Mountain Salamander	
1993	Lynx	
1993	Marbled Murrelet	
1993	Oregon Silverspot Butterfly	
1993	Pygmy Rabbit	
1993	Steller Sea Lion	
1993	Western Gray Squirrel	
1993	Western Pond Turtle	

Recovery Plans

2004	Sage-grouse	✓
2003	Pygmy Rabbit: Addendum	✓
2002	Sandhill Crane	✓
2000	Sea Otter (Draft)	✓
2001	Pygmy Rabbit: Addendum	✓
2001	Lynx	✓
1999	Western Pond Turtle	✓
1996	Ferruginous Hawk	✓
1995	Pygmy Rabbit	✓
1995	Upland Sandpiper	
1995	Snowy Plover	

✓ These reports are available in pdf format on our web site:
http://wdfw.wa.gov/wlm/diversity/soc/concern.htm.
To request a hard copy of reports, send an e-mail to: wildthing@dfw.wa.gov or call 360-902-2515.