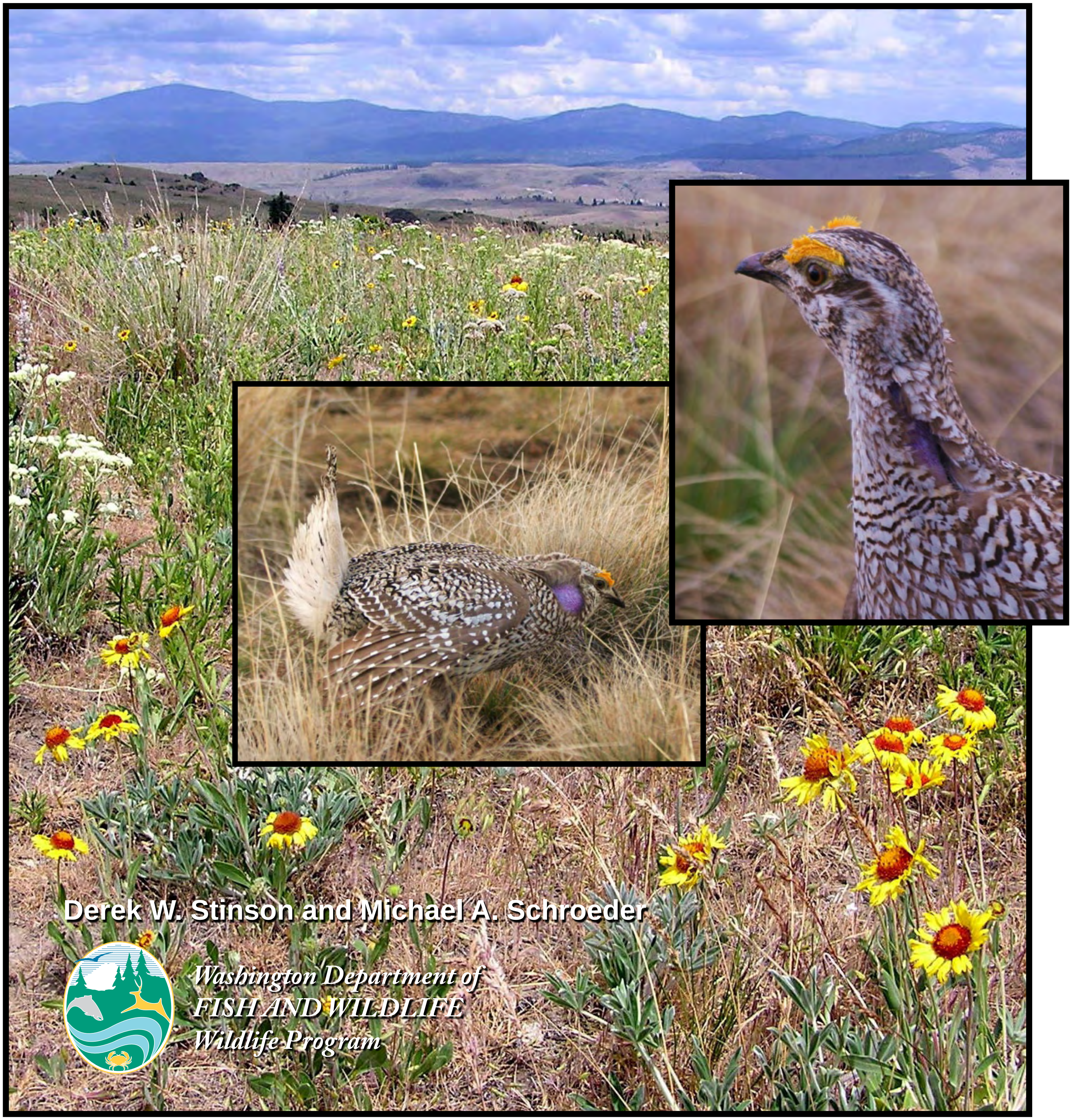
STATE OF WASHINGTON July 2012

Columbian Sharp-tailed Grouse Recovery Plan



Derek W. Stinson and Michael A. 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 A). 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 is the Washington State Recovery Plan for the Columbian Sharp-tailed Grouse. It summarizes the historical and current distribution and abundance of sharp-tailed 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, potential reintroduction of sharptails into vacant habitat, and initiating research and cooperative programs. Target population objectives and other criteria for reclassification are identified.

As part of the State's listing and recovery procedures, the draft recovery plan was reviewed by researchers and technical staff from state, tribal, and federal agencies, and regional experts. This review was followed by a 90-day public comment period. Responses to the public comments are included in Appendix E. All comments received were considered in preparation of the final recovery plan. For additional information about sharp-tailed grouse or other state-listed species, check our web site, or contact us by e-mail at: wildthing@dfw.wa.gov, or by mail to:

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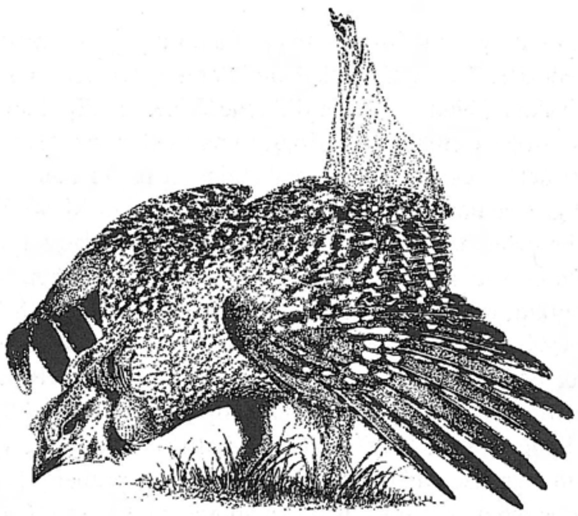
WASHINGTON STATE RECOVERY PLAN FOR THE COLUMBIAN SHARP-TAILED GROUSE



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7/17/2012
Date

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Recovery activities have benefitted from the involvement of a multi-agency work group with participation by Bureau of Land Management, the Colville Confederated Tribes, Spokane Audubon, Washington State University, Yakama Nation, Coeur d'Alene Tribe, and Spokane Tribe. The Fish and Wildlife Department of the Colville Confederated Tribes, in particular, has been an important partner in sharp-tailed grouse recovery activities for many years, and their interest and involvement is much appreciated. Translocation of grouse has benefitted from cooperation of Idaho Fish and Game, Utah Department of Wildlife, and the Fish and Wildlife Branch, Ministry of Water, Land, and Air Protection, British Columbia. Sharp-tailed grouse, and other wildlife species in Washington, have benefitted from the Conservation Reserve Program, which has been vastly improved through the efforts of Don Larsen, and undoubtedly others. Grouse habitat on WDFW lands has improved through the efforts of dedicated staff, in particular, Marc Hallet, Mike Finch, Jim Olson, Juli Anderson, Dan Peterson, and others. Washington grouse recovery efforts have also been assisted by dedicated volunteers, particularly Kim Thorburn (WDFW's 2010 Volunteer of the Year), and many others. The interest and cooperation of many landowners that host sharp-tailed grouse and allow us access to their property for lek counts, locating radio-collared birds, and various other activities, is much appreciated. Foster Creek, Lincoln County, and other conservation districts in recent years have helped facilitate the protection and restoration of riparian habitat, fence marking, and other habitat improvements.

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EXECUTIVE SUMMARY

The Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) is the rarest of six described subspecies of sharp-tailed grouse, a close relative of prairie-chickens. The subspecies' historical range extended from southern British Columbia, south along the eastern slope of the Cascade and Sierra Nevada mountain ranges to northeastern California, and east to Colorado and Utah. Only small portions of this area still support populations. The sharp-tailed grouse was listed as a State Threatened species by the Washington Fish and Wildlife Commission in 1998. This plan updates information in the 1998 status report, identifies population recovery objectives, and outlines activities needed to recover a viable population of sharp-tailed grouse in Washington.

Columbian sharp-tailed grouse were the most abundant and important game bird in eastern Washington during the 1800's. However, numbers declined dramatically with the conversion of large areas of Palouse prairie, the Klickitat region, and arable shrub-steppe to cropland. By the 1920's, sharp-tailed grouse were extirpated from significant portions of their historical range in Washington. Their decline continued with the degradation of habitat that came with drying of moist meadows, the elimination of woody riparian vegetation, heavy livestock grazing of native bunchgrasses, and general agricultural intensification. Hunting seasons for sharp-tailed grouse were shortened and bag limits were steadily reduced beginning in 1897. The season was closed statewide from 1933–1953, but short seasons were opened from 1954–1987.

The loss of active leks (dancing grounds where males conduct courtship displays) over time is indicative of the trend in reduced population and range, and increased isolation of populations of Columbian sharp-tailed grouse in the state. Of the 136 leks documented between 1960 and 2011, 92 (68%) are currently vacant. Twenty-eight vacant leks are in portions of the historical range that are no longer occupied, whereas the remaining 64 vacant leks reflect declines in density within occupied portions of the historical range. The overall population declined almost continually from 1970 to 2001, with annual changes in attendance at leks suggesting a 74% decline during this period.

The current distribution of Columbian sharp-tailed grouse covers approximately 2,173 km^2, only 2.8% of their historical range in Washington. Sharp-tailed grouse persist in seven scattered populations in Lincoln County, northern Douglas County, the Colville Indian Reservation, and valleys and foothills east and west of the Okanogan River in Okanogan County. Declines of some remnant populations have continued in recent years due to continued degradation of habitat, isolation, and possible declining genetic health. At least one subpopulation (in the Horse Springs Coulee area) appears to have gone extinct since 2000. The statewide population estimate dipped to a low of 472 in 2001. The estimate increased to 902 in 2011, probably in response to translocations and habitat restoration.

Shortages of nesting, brood rearing, and wintering habitats are important factors limiting population recovery. Good sharp-tailed grouse habitat contains a mix of perennial bunchgrasses, forbs, and a few shrubs, along with patches of key species of deciduous shrubs for wintering. Historically, the highest densities of sharp-tailed grouse were likely in mesic grassland and steppe types where annual precipitation averaged at least 11 inches. Much of the remaining steppe vegetation in Washington is in areas that were not converted to cropland due to shallow soils or steep slopes, factors that negatively affect productivity for sharp-tailed grouse.

Grassland cover types are preferred during spring and summer in Washington, with shrub, riparian, and bitterbrush habitats used primarily as escape cover. Leks are often on knolls or ridge tops with short vegeta-

tion and good visibility, and females generally select nest sites <3 km from the lek. The quality of nesting and brood-rearing habitat depends on height and density of vegetation. Residual native grasses and forbs conceal the nest and provide shelter for the brood during spring and early summer. Optimal nesting habitat has residual vegetation averaging at least 25 cm in height. Females often raise broods within 1 km of their nests in habitat containing a diverse cover of shrubs, forbs, and bunchgrasses, where insects are abundant. In late summer and fall, broods often move to riparian areas offering green vegetation, berries, and shade.

In Washington, critical winter habitats are riparian areas with deciduous trees and shrubs that provide cover, berries, seeds, buds, and catkins when the ground is snow-covered. The most important trees and shrubs include water birch, serviceberry, chokecherry, rose, hawthorn, snowberry, cottonwood, and aspen. Some areas with suitable nesting and brood-rearing habitat may remain unused because the areas lack adequate winter habitat.

Declining quality of steppe habitats in eastern Washington is probably a significant factor in the decline of sharp-tailed grouse. In addition to the direct loss of Palouse prairie and steppe habitats by conversion to cropland, sharp-tailed grouse habitat has been lost and degraded through: 1) the destruction of deciduous riparian vegetation needed for winter food and cover; 2) overgrazing by cattle, sheep, and horses; 3) loss of riparian vegetation and seasonally wet meadows due to alteration of hydrology by agriculture; 4) invasion by exotic grasses, forbs, and conifers; 5) fragmentation of native habitat into small, isolated patches; 6) degradation of shrub-steppe habitat by wildfires in Wyoming big sage areas and removal of sagebrush; and 7) increased presence of fences, and powerlines. The most productive areas of steppe habitat for sharp-tailed grouse occurred on sites with deep soils and have been converted to agriculture. Although considerable steppe vegetation remains on shallow soils of the channeled scablands, these areas have generally been degraded by a long history of livestock grazing, and may not be as productive for grouse if they produce fewer forbs and insects than deeper soil areas.

Management for sharp-tailed grouse in Washington is difficult because much of the landscape, including lands between the existing populations, is privately owned cropland, orchards, or rangeland. The U.S. Department of Agriculture's Conservation Reserve Program (CRP) is currently the main financial incentive for private landowners to provide sharp-tailed grouse habitat in Washington and in other states. However, many CRP fields enrolled in the 1980s–90s were seeded to crested wheatgrass, smooth brome, or other exotic grasses, and provide little habitat value to sharp-tailed grouse compared to native grassland or more diverse CRP lands enrolled later. Older CRP fields need to be reseeded with native seed mixes whenever possible. State Acres for Wildlife Enhancement (SAFE), a new initiative under the CRP program, may boost grouse populations; 63,000 ac were allocated in 2010 for sage-grouse and sharp-tailed grouse habitat in northern Douglas County. CRP enrollment is voluntary, re-enrollment is affected by commodity prices, and the program is dependent on re-authorization in the federal Farm Bill every five years. Current sharp-tailed grouse populations would be adversely affected if CRP lands supporting grouse were placed back into grain production.

CRP and restoration efforts on WDFW wildlife areas have shown that farmland can be restored to usable condition for sharp-tailed grouse, and strategically located cropland could be the focus of acquisition efforts. However, funding acquisition of cropland can be difficult because grant programs such as the Washington Wildlife and Recreation Program give higher priority to funding proposals for areas with intact native vegetation.

The goal of the Columbian sharp-tailed grouse recovery program is to restore and maintain healthy self-sustaining populations in a significant portion of the historical range in the state. The species will be considered for down-listing from State Threatened status to Sensitive status when Washington has at least one population averaging >2,000 birds for a 10-year period, and when the statewide population averages >3,200 birds for a 10-year period. Meeting recovery objectives will require improvements in habitat availability and quality, increases in population numbers and expansion of occupied areas. Reaching these recovery goals may require establishing a significant population in a portion of the historical range with deep soil and average annual precipitation exceeding 13 inches. Maintaining the genetic health of sharp-tailed grouse populations may require periodic translocations between populations if habitat connections cannot be re-established.

Restoring sufficient habitat is an important recovery need and will require a sustained effort involving many partners. Sharp-tailed grouse often move up to 20 km across multiple ownerships to meet their year-round habitat needs. Cooperation is needed among private landowners, public agencies, tribes, and non-governmental organizations to facilitate recovery.

Habitat enhancement in occupied areas and, where possible, re-establishment of habitat connections between occupied areas are essential for recovery. Prescribed burns may be useful for improving habitat in the more mesic steppe communities where conifers or other woody vegetation have invaded. Prescribed fire is not recommended in dry Wyoming big sagebrush shrub-steppe.

The remaining populations in Washington are small, isolated from one another, and will not persist unless they increase in size. Habitat restoration and enhancement and population augmentation using birds from other states are ongoing and have prevented extirpation of one subpopulation in Okanogan County. Areas with the greatest potential to support reintroduced sharp-tailed grouse populations need to be identified for reintroductions and prioritized based on environmental factors, existing land cover, and land ownership, to help focus habitat restoration efforts.

INTRODUCTION

The Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) has experienced widespread declines and has been eliminated from many portions of its historical range. Washington once had tens of thousands of birds, but their numbers have dwindled to <1,000 birds with the conversion of grassland and shrub habitat to cropland. Sharp-tailed grouse were last hunted in Washington in 1987. The sharp-tailed grouse was added to the state list of threatened species in 1998. This plan updates the information in the 1998 status report (Hays et al. 1998), identifies population recovery objectives, and outlines activities needed to recover a viable population of sharp-tailed grouse in Washington.

Sharp-tailed grouse are culturally significant to Native Americans in eastern Washington, the Great Plains, the Great Lakes states, and Canada (Connelly et al. 1998). They are the subject of many legends and inspired 'chicken dances' that remain an important tradition at annual powwows. The Colville Confederated Tribes have long been a partner with Washington Department of Fish and Wildlife (WDFW) in efforts to restore sharp-tailed grouse populations in north-central Washington. Additional tribal partners, including the Spokanes, Coeur d'Alenes, and Yakamas have conducted evaluations of the potential for habitat on their reservations to support reintroduced populations of sharptails.

This recovery plan is organized in two parts. The first part reviews the biology of sharp-tailed grouse, the status of populations and habitat in Washington, and factors affecting their populations. The second part presents recovery objectives, explains the rationale behind them, and outlines recovery strategies and tasks needed to attain the objectives.

TAXONOMY

Sharp-tailed grouse belong to the order Galliformes, family Phasianidae (pheasant-like birds), and subfamily Tetraoninae (grouse). The species was originally described as *Tetrao Phasianellus* in 1758 by Linnaeus, but was later placed in the monotypic genus *Pedioecetes* by Baird in 1858 (American Ornithologists' Union 1998, Connelly et al. 1998). *Pedioecetes* was later synonymized with *Tympanuchus*, recognizing the similarities between sharp-tailed grouse and prairie-chickens (Hudson et al. 1966, Short 1967, American Ornithologists' Union 1983). The ancestors of sage-grouse (*Centrocercus* spp.), ptarmigans (*Lagopus* spp.), sharp-tailed grouse, and prairie-chickens may have been forest-dwelling species, and of these groups, *Tympanuchus* diverged from forest-dwelling forms most recently (Drovetski et al. 2006). Genetic differences between sharp-tailed grouse and prairie-chickens are small suggesting recent speciation, possibly during the late Pleistocene (Ellsworth et al. 1994, 1995, Johnson et al. 2003). Sharp-tailed grouse lack the elongated neck feathers of prairie-chickens, but have elongated central tail feathers (Connelly et al. 1998); male sharp-tailed grouse also have violet air sacs instead of the orange or yellow of prairie-chickens. Hybrids of matings between sharp-tailed grouse and greater prairie chickens (*T. cupido*), dusky grouse (*Dendrogapus obscurus*), or greater sage-grouse (*C. urophasianus*) have been reported (Cockrum 1952, Eng 1971). Three sharp-tailed grouse x greater sage-grouse hybrids were observed on a sage-grouse lek in Colorado in 2002 (Hoffman and Thomas 2007). Aldridge et al. (2001) noted that of nine reported observations of hybridization between sharp-tailed grouse and greater sage-grouse, five occurred in Canada in the previous 13 years; they expressed concern for the genetic health of the small and declining greater sage-grouse populations in Canada if hybridization was becoming more common.

The sharp-tailed grouse in Washington are Columbian sharp-tailed grouse (*T. p. columbianus*). The Columbian subspecies was first described by Lewis and Clark in 1805 (Bent 1963). In 1815, Ord classified the species, *Phasianus columbianus*, as the Columbian pheasant, because of its resemblance to pheasants. There are five other extant subspecies of sharp-tailed grouse: *T. p. phasianellus* (northern sharp-tailed grouse); *T. p. kennicotti* (northwestern sharp-tailed grouse); *T. p. caurus* (Alaskan sharp-tailed grouse); *T. p. campestris* (prairie sharp-tailed grouse); and *T. p. jamesi* (plains sharp-tailed grouse) (Johnsgard 1973). The New Mexico sharp-tailed grouse (*T. p. hueyi*) was found only in a portion of northeastern New Mexico and went extinct in 1952 (Dickerman and Hubbard 1994). Spaulding et al. (2006) suggest that applying the name Columbian sharp-tailed grouse only to birds west of the Rocky Mountains would restrict it to birds with a common evolutionary origin, and that sharp-tailed grouse in western Colorado should perhaps be considered part of the plains subspecies (*T. p. jamesi*). However, the western Colorado birds are much more similar to *T. p. columbianus* in terms of habitat, size, and plumage, than to *jamesi*, which are found at lower elevation in eastern Colorado (R. Hoffman, pers. comm.), suggesting additional analysis is needed. Warheit and Dean (2009) indicated that the birds in western Montana are molecularly more similar to plains sharp-tailed grouse than to birds in Idaho and Utah, and the Continental Divide did not appear to have been a barrier to historical gene flow. They suggested that whether Columbians are a monopyletic group (i.e. all from the same ancestral stock) needs to be further examined.

The subspecies endemic to Washington was named "Columbian," because Lewis and Clark mentioned its abundance on the "plains" of the Columbia River. Other common colloquial names used for sharp-tailed grouse include "sharptails," "prairie chicken" (more accurately applied to *T. pallidicinctus* and *T. cupido*), "fire grouse," and "pin-tailed grouse" (Hart et al. 1950, Evans 1968:1).

DESCRIPTION

The tail of the sharp-tailed grouse is wedge-shaped, with the two middle tail feathers extending beyond the other tail feathers about 5 cm (2 in), creating the characteristic sharp tail. Sharp-tailed grouse are generally cryptically colored. The upperparts are heavily barred with dark brown, blackish, and buff; underparts are pale with dark brown V-shaped markings, and the undertail coverts are white (Connelly et al. 1998). The white underparts are conspicuous when sharp-tailed grouse fly. The crown feathers are somewhat elongated and form a slight crest when erected. The legs of sharp-tailed grouse are feathered (Connelly et al. 1998), which is characteristic of all grouse.

Males have a pink to pale violet 'air sac' (cervical apterium) on each side of the neck, though they are not as obvious as those of male sage-grouse. The air sacs and yellow combs above the eyes are enlarged during breeding display. Females lack air sacs, but do have yellow combs, though they are not as conspicuous as in males. Adult male and female sharp-tailed grouse are nearly identical in plumage, except that females have crosswise bars

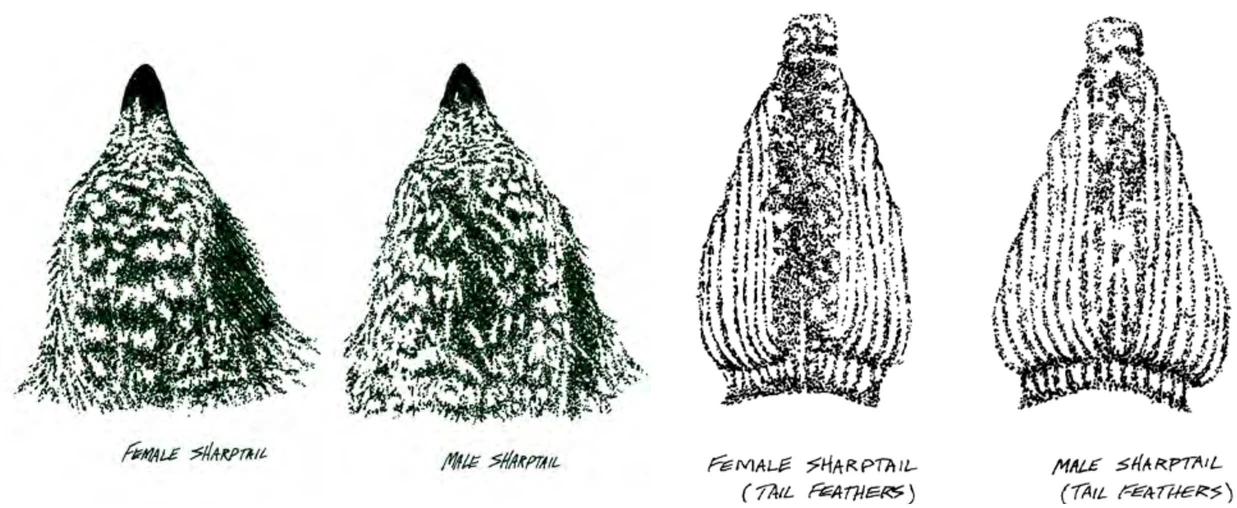

Figure 1. Feather differences used to distinguish male and female sharp-tailed grouse (illustration by Darrell Pruett, after Henderson et al. 1967).

on the two middle tail feathers (Fig. 1), whereas males have longitudinal bars (Edminster 1954, Henderson et al. 1967). Females also have alternating buff and dark-brown crosswise bars on top of the head, whereas males have dark-brown crosswise bars edged in buff (Henderson et al. 1967). Feathers from the top of the head are black with a buff or tan edge in males and have bold black and buff horizontal bands in females (Northern Prairie Wildlife Research Center 2006). Sharp-tailed grouse are lighter brown than greater sage-grouse or dusky grouse (Hjorth 1970). Sharp-tailed grouse have short feathers above their air sacs, whereas sage-grouse and ruffed grouse (*Bonasa umbellus*) have elongated feathers (Hjorth 1970). In the spring, juveniles can often be distinguished in the hand from adults by the worn ninth and tenth primaries; adults have gone through a molt and these primaries show little wear (Fig. 2).

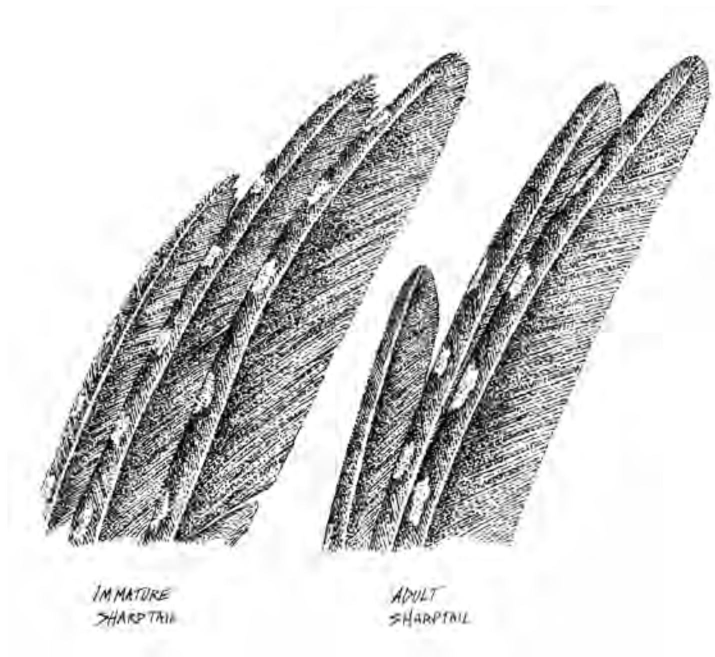

Figure 2. Outer primaries of juvenile (left) showing wear not usually evident in adults (right) (illustrated by Darrell Pruett).

Columbian sharp-tailed grouse have upperparts that are ruddy brown, with a buffy throat with moderate to heavy spotting, and bold V-shaped markings on the underparts that are narrower and darker than in other subspecies (Dickerman and Hubbard 1994, Connelly et al. 1998). Columbians have the shortest wings of all the sharp-tailed grouse subspecies (Connelly et al. 1998).

Adult sharp-tailed grouse average 41–47 cm (16–18.5 in) in total length (Connelly et al. 1998). Sharp-tailed grouse body mass is generally highest in late winter and it declines through the summer and fall (Giesen 1992, Collins 2004). Males are heavier than females by about 10% within each age class and season (Table 1). Adult males also have greater body mass than yearling males in spring (Giesen 1992). Compared to other grouse species in Washington, sharp-tailed grouse are similar in size and weight to ruffed grouse (Rusch et al. 2000), are much smaller than adult sage-grouse (male = 2,800 g, females = 1,500 g; Schroeder et al. 1999) and are somewhat smaller than sooty grouse (*Dendragapus fuliginosus*; males ≈ 1,273 g, females ≈ 839 g; Zwickel 1992).

Table 1. Mean weight of Columbian sharp-tailed grouse in Washington (M. Schroeder, unpubl. data).

Sex/age class		*n*	Weight (g)	Range	SD
Males	Adult	130	755	671–909	44
	Yearling	80	710	606–812	37
Females	Adult	34	691	591–790	45
	Yearling	19	641	569–705	36

GEOGRAPHICAL DISTRIBUTION

North America

Sharp-tailed grouse have occupied the western and northern United States and Canada since at least the late Pleistocene Epoch, no later than 23,000 years ago (Snyder 1935, American Ornithologists' Union 1957, Spaulding et al. 2006). *T. phasianellus* bones dated to the late Pleistocene have been recovered from Oregon, Nevada, Texas, Tennessee, Virginia, and Pennsylvania (Lundelius et al. 1983, *in* Spaulding et al. 2006). The historical range of sharp-tailed grouse encompassed 6 Canadian provinces, 2 territories, and 21 states (Aldrich 1963, Johnsgard 1973). Sharp-tailed grouse have declined in western North America since the late 19th century (Hart et al. 1950, Miller and Graul 1980, Kessler and Bosch 1982), and have disappeared from 8 of the 21 states they formerly occupied (Johnsgard 1973, Miller and Graul 1980).

Figure 3. Historical and current range of the Columbian sharp-tailed grouse.

The Columbian subspecies ranged from central British Columbia south across eastern Washington, Oregon, Idaho, and northwestern Montana, south into northern California and Nevada, and east into Utah, western Wyoming and western Colorado (Fig. 3; Aldrich and Duvall 1955, Aldrich 1963, Miller and Graul 1980). The subspecific identity of sharptails in the Rocky Mountains is currently unsettled and requires additional analysis (Spaulding et al. 2006, Warheit and Dean 2009, R. Hoffman, pers. comm.). Currently, Columbian sharp-tailed grouse occupy <10% of their historical range in Idaho, Utah, Wyoming, and Washington; approximately 15% in Colorado, and 78% in British Columbia (Bart 2000, Leupin 2003). They were extirpated from California, Montana, Oregon, and Nevada. They were recently reintroduced to Nevada and Oregon, but the outcomes of these projects are uncertain.

Washington

"The Grouse or Prarie hen is peculiarly the inhabitant of the Grait Plains of Columbia they do not differ from those of the upper portion of the Missouri…"

Meriwether Lewis, 1 March 1806
(Zwickel and Schroeder 2003).

Historically, Columbian sharp-tailed grouse were widely distributed in eastern Washington in all the nonforested areas (Fig. 4; >75,000 km^2 area; Schroeder et al. 2000). Sharp-tailed grouse inhabited most of the prairies in the Columbia Plateau and the stream valleys emptying into the Columbia River (Dawson and Bowles 1909, Darwin 1918, Yocom 1952, Schroeder et al. 2000). They were more abundant in grassland (steppe and meadow steppe; Daubenmire 1970), and less abundant in sagebrush communities. In 1836, John K. Townsend reported that sharp-tailed grouse were "occasionally seen in this vicinity," of Fort Vancouver in present-day Clark County, about 129 km (80 miles) west of The Dalles, and suggested they were probably "only a straggler here," because they were considered rare by the local Native Americans, some of whom seemed to be unfamiliar with the bird (Jobanek and Marshall 1992:9).

By the 1950's, sharp-tailed grouse were mostly

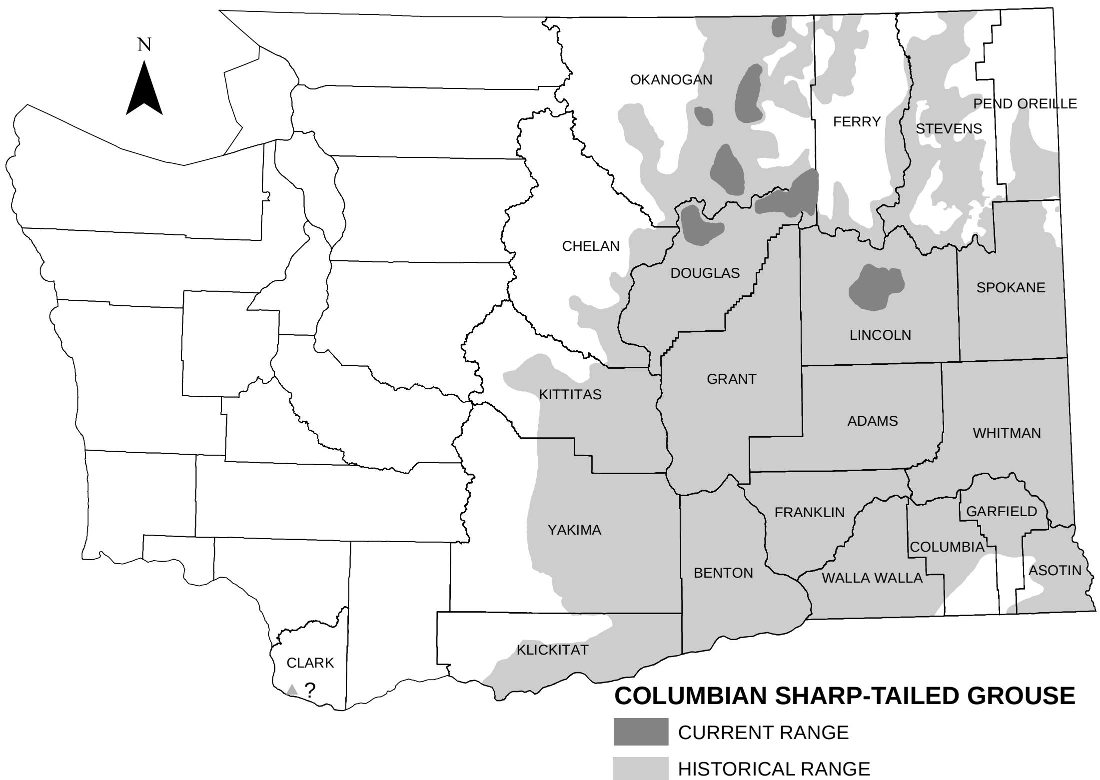

Figure 4. Historical and current range of Columbian sharp-tailed grouse in Washington; ? = 1836 record by Townsend (modified from Schroeder et al. 2000).

restricted to Lincoln, northern Grant, Douglas, and Okanogan counties (Yocom 1952, Buss and Dziedzic 1955), with scattered sightings from Adams, Asotin, Klickitat, Spokane, Stevens, and Whitman counties (Yocom 1952, Weber and Larrison 1977). The current range of Columbian sharp-tailed grouse in Washington consists of seven isolated areas in Douglas, Lincoln, and Okanogan counties (Fig. 4). Sightings of sharp-tailed grouse were reported in Asotin County in the mid-1980s, but these may have been birds dispersing from Idaho following a translocation conducted by the Idaho Department of Fish and Game. Sharp-tailed grouse found outside Douglas, Lincoln, and Okanogan Counties are likely transient birds that periodically occupy patches of remaining shrub/meadow steppe. Sharp-tails currently inhabit only about 2.8% of the estimated 79,865 km^2 historical range in Washington (Schroeder et al. 2000).

NATURAL HISTORY

General Behaviors

Sharp-tailed grouse usually walk, but fly to escape threats or to reach foraging perches in trees. They may move long distances when disturbed (Hart et al. 1950). Sharp-tailed grouse typically fly 2 to 15 m (5–50 ft) above the ground, flapping their wings for approximately 30 to 50 m (98–164 ft) and then alternating between gliding and short bursts of wing beats. Average flight speed is about 30 to 35 mph (48–56 km), but they can attain speeds up to 46 mph (74 km) (Hart et al. 1950). Sharp-tailed grouse often fly 0.4–0.8 km, (¼–½ mi) but flights of 3.2 –4.8 km (2–3 miles) are not unusual (Hart et al. 1950). When flushed, sharp-tailed grouse issue a series of rapid calls that Lumsden (1965) described as "*tuckle…tuckle…tuckle*" or "*tuk…tuk …tuk*" (or *whucker-whucker-whucker*, Connelly et al. 1998); he characterized this as an alarm call because it is sometimes uttered from the top of a tree when they are approached. Variations of "cluck" or clucking calls are used as contact calls by feeding birds and by the female during brood-rearing (Kermott and Oring 1975, Connelly et al. 1998).

Sharp-tailed grouse typically forage in the early morning, when not attending leks, and again in the late afternoon, and spend the middle part of the day loafing (Connelly et al. 1998, Conover and Borgo 2009).

Flocks spend time during the day at favored spots to which they return frequently (Hamerstrom and Hamerstrom 1951); and as night approaches, they move to a different location to roost, though the habitat may be very similar to the open grass-forb habitat of their daylight loafing sites (Gratson 1988, Conover and Borgo 2009). In fall and winter, they roost in shrubs or trees more often (Gratson 1988, Connelly et al. 1998).

Seasonal aggregations. Sharp-tailed grouse are usually found singly or in small groups during the summer. During summer in North Dakota, Kermott (1982) had great difficulty finding and flushing male sharp-tailed grouse, which hid in the grass. From fall until spring, they aggregate into larger flocks. Sharp-tailed grouse may gather in flocks to share information, search for food, and guard against predators while foraging (Gratson 1988). Habitat, the availability of cereal crops, or snow depth may influence the size of flocks (Hart et al. 1950, Gratson 1988, Meints 1991, Weddell et al. 1991b). Meints (1991) observed concentrations of >200 sharp-tailed grouse foraging in grain fields in Idaho. Lord (1866 *in* Hammerstrom and Hammerstrom 1951) reported that west of the Canadian Rockies flocks aggregate, "about the middle of September and on into October …until they gradually accumulate into hundreds…." In Washington, Weddell et al. (1991b) found larger flocks in riparian areas (up to 19 birds) than in uplands (7 birds). J. Olson (pers. comm.) recently observed a flock of 38 at the WDFW Scotch Creek Wildlife Area. Historically, larger flocks may have been common in Washington; a flock estimated at 250 birds was reported in McLaughlin Canyon in Okanogan County in 1954 (Weddell et al. 1991b). In Idaho, Marks and Marks (1987a) reported winter flock size up to 32 birds; 80% were within 2 km (1.2 mi) of leks. Meints (1991) observed winter flocks of 5–22 birds. Leupin (2003) reported winter flocks of 7–72 birds in British Columbia. In Utah, large sharp-tailed grouse flocks disbanded in winter but formed again in spring, usually near leks, after snow receded (Marshall and Jensen 1937, Hart et al. 1950). Gratson (1988:182) reported that flock size of prairie sharp-tailed grouse in Wisconsin declined when availability of ground foods decreased and when snow depth exceeded 18 cm (7 in) and birds began using snow burrows.

Snow burrows. Many grouse species, including sharp-tailed grouse, use snow burrows for roosting during periods of deeper snow. Snow burrows allow sharp-tailed grouse to roost in relative safety from predators and conserve energy by adding insulation and reducing exposure to wind (Evans and Moen 1975). Sharp-tails in Washington used snow burrows when there was >28 cm (11 in) of uncrusted snow (McDonald 1998). Burrows averaged 73 cm (n = 16, range 28–180 cm; 29, 11–70 in) in length. Marks and Marks (1987a) reported that burrows used by sharp-tailed grouse in Idaho were up to 1 m long and radiated from the entrance in random directions. They suggested it would be difficult for a mammalian predator to isolate the location of a grouse and capture it before the bird escaped. When flushed, sharp-tailed grouse will burst out of the snow creating an exit hole away from the entrance. In Wisconsin, snow burrows were used both at night and during the day; night burrows averaged 2.4 m long (7.9 ft, n = 57), and day burrows averaged 1.4 m (4.6 ft, n = 101) (Gratson 1988: 180–181). During midwinter, birds remained in their burrows through the night, left them to feed in the morning, then made new burrows and remained in them until leaving to forage again the following morning.

Territorial and Mating Behaviors

Male sharp-tailed grouse gather on communal dancing grounds called 'leks' where they engage in specialized behavioral displays to attract females in hopes of mating. Leks are also characteristic of mating behavior in sage-grouse and prairie chickens. In lek mating systems, females mate with established territorial males at a lek, the male territory contains no resources needed by the female, and males do not contribute to parental care (Bradbury and Gibson 1983). All North American grouse species, except ptarmigan, are polygynous, that is, they do not form stable pair bonds and a male may mate with many females.

Sharp-tailed grouse lek sites are typically small in area (0.01–0.1 ha, or up to 0.25 ac) on open elevated knolls or ridges with good visibility. Leks may shift location over time, or cease to exist as populations decline or vegetation changes, but many persist in the same location for many years. Although most leks have only one location, one lek in eastern Washington moved on an annual or biannual basis among >10 locations (Schroeder 2006). Movement of lek locations appears to be more common with smaller leks.

At the beginning of the breeding season, male sharp-tailed grouse establish small territories on a lek. The mating season generally begins about the same time each year depending on snow conditions, food and habitat availability (Oedekoven 1985, Giesen 1987). In Colorado, males returned to the breeding range in mid- to late March, and females began arriving in early April (Collins 2004). In Wyoming, most females appeared on leks when snow covered <10% of the area (Oedekoven 1985). Males congregate at leks before dawn to perform courtship displays. Kermott (1982) was able to predict the arrival of males by measuring the intensity of incident light in the eastern sky with a light meter. Courtship display occurs both in the morning and early evening. Displaying begins about 45–60 min before sunrise (Marshall and Jensen 1937, Kermott 1982), but local sunrise is affected by topography. The morning display period on the lek is variable, but typically lasts 2–4 hours; an overcast sky tends to prolong the display period (Kermott 1982). Early in the season, before females begin visiting leks, morning display periods in Manitoba averaged 107 $\pm$ 6.4 min; after females began visiting, the display period increased to 252.8 $\pm$ 4.9 min (Caldwell 1976). Weather, particularly heavy or steady precipitation, or disturbance by predators or humans at a lek, cause sharp-tailed grouse to temporarily stop displaying and mating, or leave the lek (Marshall and Jensen 1937, Hart et al. 1950, Rogers 1969, Farrar 1975, Caldwell 1976, Baydack and Hein 1987). Rain at night that continues into morning often prevents the morning display session (Kermott 1982). Males return in the evening and display during the 1–3 hours before dark. The dawn and dusk display schedule may be an adaptation to avoid diurnal predators and conditions that reduce sound transmission (i.e. wind and thermal turbulence; Sparling 1983).

Leks may contain 2–40 males (Connelly et al. 1998), but 8–12 males is more typical. Caldwell (1976) suggested that the spacing of nests or male territorial aggression may impose an upper limit of 30–35 birds on a lek; however, one lek in Washington contained 58 birds in 2009, although some of these birds were females (J. Olson, pers. comm.). Males typically lose weight during this period because they spend less time foraging during the lekking season (Caldwell 1976).

The most conspicuous displays performed on the lek territories have been described as the Flutter Jump and the Aeroplane display (Hjorth 1970; Plate 1). Male sharp-tailed grouse produce six different vocalizations associated with courtship or territorial aggression on leks, including *coo, gobble, whine*, *chatter* or *cackle*, *chilk*, *cha* and *cork* calls (Lumsden 1965, Hjorth 1970, Kermott and Oring 1975, Sparling 1983). A *cackle* vocalization by females while approaching a lek often elicits a bout of Flutter Jumps by males, in which they jump or make short flights of 3–10 m, 1–3 m in the air (Lumsden 1965). In the Aeroplane display (Hjorth 1970) or Tail-rattling (Lumsden 1965), the male moves forward, often turning or circling, rapidly stamping its feet in short steps and with its wings outstretched. Displaying males erect their tail and expose white tail undercoverts, extend their neck, inflate lavender air sacs, and erect their yellow superciliary combs. The tail is rapidly wiggled side-to-side producing a rattling and rustling sound while simultaneously the foot stomping produces a dull drumming sound. Each foot hits the ground about 10 times per second (Hjorth 1970). The wings are vibrated and the stomping and tail movements are synchronized, so that the rectrices of either side are alternately spread and closed. The dance is punctuated by occasional fanning of the tail while uttering vocaliza-

Plate 1. Territorial and courtship displays of sharp-tailed grouse: Face-off (top left) and Aeroplane posture of Dance (top right); Running Parallel (middle left); Upright Advance (middle right); Flutter Jump (bottom left and lower-middle right; male approaches female (bottom right). Photos of plains sharp-tailed grouse by Joe Higbee at Benton Lake National Wildlife Refuge in Montana.

tions (Hjorth 1970). Performance of the Aeroplane display is often highly synchronous among males, with two or more adjacent birds starting and stopping the display simultaneously, and sometimes with all the males present dancing and 'freezing' simultaneously (Hjorth 1970). The amount of dancing may increase 10 fold in the presence of females, with the Aeroplane display oriented toward the females (Hjorth 1970).

Aggressive behavior between males on leks is most visible at territorial boundaries (Hjorth 1970). Boundary encounters sometimes escalate to fights when males jump in the air and try to peck and kick each other and beat each other with their wings; pecks are aimed at the head and shoulders (Hjorth 1970, Connelly et al. 1998). Fighting rarely ends in injuries more serious than scratches, but males have been known to be mortally wounded (Connelly et al. 1998).

Female visits to the lek peak in early April in Washington (Schroeder 1994), in March in western Idaho (Marks and Marks 1987a), and in mid-May in Wyoming (Oedekoven 1985), but peaks vary year-to-year with the weather. Female visits to leks in southern British Columbia peak in mid- to late April (Leupin 2003). Females leave the lek soon after mating (Johnsgard 1973). The peak of breeding activity lasted about a week in North Dakota (Kermott 1982). There may be a second low peak in visits by re-nesting females in May or early June.

For sharp-tailed grouse, and lekking species in general, the relative importance of female choice vs. competition among males in determining mating success has been the subject of debate (Bradbury and Gibson 1983, Bergerud 1988a, Schroeder 1991, Tsuji et al. 1992, 2000, Gratson et al. 1991, Gratson 1993). Females show a marked preference for mating with males occupying central territories (Lumsden 1965, Evans 1969, Hjorth 1970, Kermott 1982). About half the females remate the same day, or a few days later (Landel 1989, Gratson et al. 1991). Tsuji (1996) suggested that females mate successfully only once, but recent evidence indicates that females often mate successfully multiple times and with more than one male (Coates 2001). Females may visit a lek 1–10 times and may attend more than one lek (Landel 1989). In Manitoba, males on two small leks (9 males) were less active and spent less time on the lek than males on two large leks (20, 30 males; Caldwell 1976); females visited small leks, but were less likely to breed there than on large leks (0 vs. 11 observed copulations).

Territorial position and dancing intensity correlates with mating success. Males with central territories were responsible for 76% of the copulations in Alberta (Rippin 1970). On a North Dakota lek, 13% of males performed 93% of observed copulations, and one male performed almost 50% (20 of 41); only one copulation during three seasons involved a peripheral male (Kermott 1982). Of 47 territorial males on four leks in Manitoba, 23 (49%) were not observed to breed, and nine (19%) did 75% of the breeding (Gratson et al. 1991).

Sexton (1979) documented off-lek copulation involving a male that was displaying singly, and reported the existence of a non-territorial segment of the population in his Alberta study area. He speculated that non-lekking males may mate with subordinate females and make an unrecognized contribution to recruitment in the population. The low number of copulations observed, even on large leks with females present suggest that off-lek copulations may be common (R. Hoffman, unpublished data).

Hens sometimes chase other females away while on the lek, but territorial behavior has not been clearly documented in females. Robel (1970) reported that dominant female greater prairie-chickens prevented, or at least delayed, subordinate females from mating on leks. Kermott (1982) observed female-female aggression on a sharp-tailed grouse lek and speculated that a dominance hierarchy may exist among females. Females have been observed calling while perched in shrubs or small trees in nesting areas, which suggests females may defend a nesting territory from other females (M. Schroeder, pers. obs.). Caldwell (1976:100) also mentioned hearing cluck calls from good nesting habitat in late May, and he suggested that it may warn other females away from her intended nesting site. Caldwell (1976) noted that all the nests discovered were ≥157 m apart. Kermott (1982) described a first stage of the mating period during which females gathered near leks and often cackled from elevated perches, but he did not associate the female vocalization with defense of nesting areas.

Display and mating decrease toward the end of May (Evans 1968, Oedekoven 1985). In late summer to early fall, males return to leks, but initially do not display. As fall mornings become chilly, attendance becomes more regular and dancing occurs and increases in intensity (Hjorth 1970). In Alberta, lek activity tapers off by early November, but males may display on warm sunny days throughout the winter (Hart et al. 1950, Evans 1968, Hjorth 1970, Oedekoven 1985). Females rarely visit leks outside the spring mating period. Kermott (1982) suggested that fall and winter displaying may allow adult males to reassert their ownership of territories with a new generation of competitors, and gives juvenile males an opportunity to acquire a peripheral territory in anticipation of the spring competition.

Reproduction

Nesting and incubation. Gratson (1988:185) observed that females had large home ranges during the period before mating and egg-laying. He suggested that females were investing time and energy in selecting suitable nest sites by moving through potential nesting habitat, and selecting potential mates by visiting multiple leks. Male sharp-tailed grouse do not assist in building nests, incubation, or raising chicks. Nests are a small depression in the ground (Fig. 5) loosely lined with dry grass, leaves, moss, and a few feathers (Hart et al. 1950, Leupin 2003). Eggs are olive to dark buff-brown and often finely speckled with spots of brown and lavender and measure about 43 x 32 mm (Hart et al. 1950, Evans 1968, Connelly et al. 1998).

In Washington, females nested an average of 1.6 km (1 mi; SD = 0.44) from a lek (Schroeder 1996). Average starting date of incubation was 8 May for all nest attempts, including renests (range 14 April–22 June; Schroeder 1996). In a study on the WDFW Swanson Lakes Wildlife Area and the Colville Reservation, initial clutch size averaged 12.2 (range 11–14, *n* = 17; McDonald 1998). Initial clutches of Columbian sharp-tailed grouse averaged 11.9 eggs in Idaho (range 10–13, *n* = 18), 10.9 eggs in Utah (range 3–17, *n* = 127), and 11.2 eggs (range 8–13, *n* = 4?) in British Columbia (Hart et al. 1950, Meints 1991, Connelly et al. 1998, Leupin 2003; Table 2). There was no difference in clutch size between adult and yearling females in Colorado (Boisvert 2002, Collins 2004). Females often renest if the initial clutch is lost to predation during laying or early in incubation. McDonald (1998) estimated that 73% of 22 females that lost their initial clutch renested; two females renested twice (Schroeder 1996). Clutch sizes of renests were slightly smaller (mean = 9.5 eggs, range 8-12 eggs, *n* = 10; McDonald 1998). Apa (1998) reported that one radio-tagged female renested after losing a brood. Gratson (1989) reported one case of intraspecific nest parasitism (a female added her clutch to a nest built by, and containing eggs, of another female) out of 120 nests in a four-year period in Manitoba. In Washington, 94.5% of 183 eggs contained a viable embryo (McDonald 1998).

The incubation period for sharp-tailed grouse usually begins after the last egg is laid. It has been

Figure 5. Successful sharp-tailed grouse nest on Swanson Lakes Wildlife Area in eastern Washington (Photo by Ben Maletzke).

Table 2. Reproductive parameters reported in Columbian sharp-tailed grouse in Washington, Idaho, Utah, and Colorado.

State/ Reference	Initial clutch size (*n*)	% Nesting effort (*n*)[a]	% Nest success[b] (*n*)	% Renest effort[c] (*n*)	% Female success[d] (*n*)	% Brood success[e]	Brood size[f] (*n*; age in days)	% Chick survival (*n*)
Washington								
Schroeder (1994)	10.4 (5)[g]	-	60 (10)	66 (3)	100 (6)	-	5.2 (3; 45–75)	54.2 (48)
McDonald (1998)	12.2 (17)	>88 (34)[h]	41 (54)	73 (22)	49 (45)	50	2.5 (22; 45)	12 (234)
Idaho								
Apa (1998)	10.4 (28)	100 (48)	51(47)	-	58 (38)	-	-	-
Meints (1991)	11.9 (19)	100 (20)	72 (25)	66 (3)	86 (21)	53 (to 28 days)	4.1 (16; 28)	
Utah								
Hart et al. (1950)	11 (127)[g]	-	37 (110)	-	-	-	4.6 (-; 28–60)	-
Colorado								
Giesen (1987)	10.8 (10)[g]	-	62 (13)	-	-	-	-	-
Boisvert (2002)	10.2 (39)	1999: 100 (29) 2000: 97 (33)	42 (71)	1999: 20(15) 2000: 28(31)	45.9 (61)	1999: 64 2000: 85	4.4 (28; 49)	1999: 49 2000: 47
Collins (2004)	10.4 (71)	2001: 100 (60) 2002: 97 (61)	63 (119)	2001: 69(13) 2002: 36(25)	71 (121)	2001: 92 (13 m[i]) 48 (29 s[i])	4.2 (22 m[i]; 49)	2001: 44.8 (125 m[i]) 13.3 (308 s[i])
						2002: 56 (18 m[i]) 53 (19 s[i])	2.7(24s[i]; 49)	2002: 19.7 (183 m[i]) 14.2 (169 s[i])

[a]Percent females that attempted to nest.
[b]Percent nests that hatch ≥1 egg
[c]Percent females that renested after surviving the loss of initial clutch.
[d]Percent females that hatch ≥1 egg.
[e]Females that rear ≥1chick to ≥45 days, or as noted.
[f]Brood counts for females that did not lose entire brood.
[g]Includes renests.
[h]Percent confirmed; female behavior suggested effort was 100%.
[i] m = reclaimed mine; s = native shrub-steppe

reported as 21–26 days (Connelly et al. 1998, Boisvert 2002), and duration may vary with environmental conditions. Females are attentive to the clutch during incubation. The female typically leaves the nest to feed for 30–45 minutes in the morning and again in the evening, but rarely wanders more than 200 m from the nest (Hart et al. 1950, Connelly et al. 1998). Females typically lose weight during incubation because foraging time is drastically curtailed (Caldwell 1976). Caldwell (1976) indicated that 5 incubating females spent 95.7 $\pm$ 1.5% of each day on the nest; two females lost about 5 grams/day. Median hatch date in Washington was May 30 (8 May+22 days, *n* = 67; Schroeder 1996). Peak of hatch occurred in early and late June in Idaho (Marks and Marks 1987a), 20 May–11 June in British Columbia (Leupin 2003), and late May to early June in Utah (Hart et al. 1950); median hatch date was 13 June (31 May–19 June) in Idaho (Apa 1998).

Nest success (% nests that hatch $\geq$1 egg) varies year-to-year probably due to weather, age structure of females, predator densities, and changes in nesting cover (McDonald 1998). In Washington, nest success averaged 43% (*n* = 67), but renesting resulted in 65% of females hatching a clutch (Schroeder 1996). Nest success was 32 % (n = 127) in Utah (Hart et al.1950), and 42% (*n* = 71) and 63% (*n* = 119) in Colorado (Boisvert 2002, Collins 2004). Nest success was 72% (18/25), and female success 86% (% females that hatch $\geq$1 egg, 18/21; Meints 1991) in southeastern Idaho. Meints (1991) noted that only half of the eggs in 2 renests hatched. Bergerud (1988b) reported that nesting success is higher for adults than yearling females in steppe grouse, so the percentage of yearlings in a population can affect recruitment. However, Apa (1998) and Collins (2004) reported that initial nest success and female success did not differ between yearlings and adult sharp-tailed grouse in their studies.

Brood rearing. Sharp-tailed grouse can raise a maximum of one brood each year. Eggs hatch over a period of a few hours and the chicks are precocial and leave the nest soon thereafter (Hillman and Jackson 1973). A newly hatched brood that is disturbed often walks about peeping, but after two days the brood will hide and remain silent. When disturbed, the female may feign injury, flopping along the ground for >50 meters to lead the intruder away, and then fly off and walk back to her brood (Hart et al. 1950). Chicks may not be able to thermoregulate on their own until over 2 weeks of age (Bergerud and Gratson 1988: 546).

Females remain with their brood all summer, often moving their brood to open areas containing succulent vegetation and insects (Hart et al. 1950, Gratson 1988). In Washington, females remained <1 km (0.6 mi) from their nest site during early spring, and 0.5 km (0.3 mi) during early summer (Schroeder 1996). Broods in Utah traveled only about 46 m (50 yd) from their hatch site by the end of their first month (Hart et al. 1950). When the chicks are able to fly only short distances, they usually walk and freeze or hide rather than fly when disturbed (Hart et al. 1950). Chicks flew up to 27 m (30 yd) at eight or nine days old (Christenson 1970), and 50 m (45.5 yd) at one month of age in North Dakota. At two months of age they attained half the mass of adults (McEwen et al. 1969) and were fairly strong fliers (Hart et al. 1950). By three months of age, the size, habits, and flight abilities of sharp-tailed grouse are well developed and juveniles are not easily distinguished from adults. In August, sharp-tailed grouse broods may join other broods in what Bergerud and Gratson (1988:585) call "gang broods" that presumably improve vigilance and avoidance of predators. The female generally leaves the brood first, before the juveniles disband in the fall (Caldwell 1976, Gratson 1988).

Adoption. Adoption has been reported in 150 bird species (Avital et al. 1998), with the most commonly reported situation being brood amalgamation. Brood amalgamation is fairly common in waterfowl, but little is known about the frequency or circumstances of adoptions in grouse. Adoption may be relatively common in Galliformes because of their precocial young and lack of territoriality in brood habitat (Wong et al. 2009). The apparently altruistic nature of adoption has generated several hypotheses about its potential adaptive advantage (Avital et al. 1998). Two hypotheses that apply to the sharp-tailed grouse female mentioned by Brown (1967a) include that unsuccessful yearling birds may adopt to get practice and improve their future chances of success, or a failed breeder might be unable to resist adopting because of high levels of hormones. Other hypotheses mentioned by Wong et al. (2009), include that chicks may seek out foster parents when they are abandoned or separated, and that parents may be unable to distinguish their own from other young, and thus are not able to avoid the costs of protecting a larger brood. Adoption could benefit the foster parents by improved predator detection, or by exposing the unrelated young to greater risk to predation at the perimeter of the brood (Wong et al. 2009); the so-called 'selfish herd' effect. The phenomenon of adoption in broods may have potential for augmenting sharp-tailed grouse populations in certain circumstances.

Brown (1967a) reported that a radio-tagged yearling sharp-tailed grouse female adopted two, 1½ week-old chicks a week after losing her near-term clutch to predation. Twenty days later she had adopted two additional younger chicks and reared this brood of four chicks for over 40 days. Maxson (1978) reported a case of two successive adoptions by female ruffed grouse with adjacent home ranges, and Keppie (1977) documented four cases in spruce grouse (*Falcipennis canadensis* a.k.a. *Canachites* spp.) in which broods were adopted after the female died. These adoptions plus the switching of broods by individual chicks totaled 4% of marked juveniles. All the spruce grouse juveniles that switched were ≥11 days old and all joined another brood in the immediate vicinity (Keppie 1977). All broods orphaned after 40 days post-hatch generally remained together without a female. Keppie (1977) also noted 10 reports in the literature in which the author suspected adoptions or brood switching; these included cases involving Attwater's prairie-chicken (*T. c. attwateri*), greater sage-grouse, ruffed grouse, sooty grouse, dusky grouse, and white-tailed ptarmigan (*Lagopus leucura*). Wong et al. (2009) reported adoption rates (% broods with adopted chicks) of 13% (n = 16) and 4% (n = 27) in white-tailed ptarmigan at two study areas, and 14% (n = 29) in rock ptarmigan (*L. mutus*). Adoption has also been reported in Merriam's wild turkey (*Meleagris gallopavo merriami*), and northern bobwhite (*Colinus virginianus*; Mills and Rumble 1991, DeMaso et al. 1997, Faircloth et al. 2005).

Chick survival and recruitment. Chick survival during the first two months after hatch is important for maintaining sharp-tailed grouse populations. Three interrelated mortality factors affect sharp-tailed grouse chicks: predation; chilling during cold wet weather; and starvation (Bergerud (1988b:610). Bergerud (1988b:609) reviewed chick mortality in 28 studies of nine species of grouse, and reported that the mean mortality rate of chicks between hatch and autumn was 44%; in 10 studies of sharp-tailed grouse, only 2 of 10 reported a chick mortality rate of >40%. In most grouse species, the period of highest chick mortality is before 2–3 weeks of age, in part because young chicks cannot fly or maintain their internal body temperature (Bergerud 1988b, Dobson et al. 1988). Chick survival was 34% (± 0.07, n = 283) to 35 days for plains sharp-tails in British Columbia (Goddard and Dawson 2009). Collins (2004) reported chick survival of 45% and 20% in mine reclamation areas, and 13% and 14% in shrub-steppe in 2001 and 2002, respectively. Chick survival in Utah was 56% from <1 month to >2 months of age (Hart et al. 1950).

Reproductive output in two Washington study areas in 1995–96 was affected most by chick survival up to 45 days post-hatch; nest depredation played a lesser, though important role (McDonald 1998). During the 2-year study, 36 radio-tagged females produced only 28 chicks to 45 days of age. Only half of the females that succeeded in hatching a clutch successfully reared at least one chick to 45 days. Chick survival was low in McDonald's study (12%), with mean brood sizes of 2.5 and 2.6 chicks, excluding females that lost their entire brood (McDonald 1998). McDonald (1998) noted that mean brood size was 1.07 and 1.63 chicks, if it included females that lost entire broods. Most studies report the average size of broods encountered during flush counts, and do not include females that lost entire broods. The failure to quantify the loss of entire broods means that chick mortality is under-represented in many estimates (Bergerud 1988b:609). Brood success (or brood survival: proportion of broods in which at least 1 chick survived brood rearing period) reported for Columbian sharp-tailed grouse ranged from 0.48 to 0.92 (Table 2). For plains sharp-tailed grouse, brood success was 0.48 (n = 21) during 2 seasons in Montana (Bousquet and Rotella 1998); 0.18 for 1 season in North Dakota (Christenson 1970), 0.32 (n = 22) during 2 seasons in southern Alberta (Roersma 2001), and 0.67 (± 0.09, *n* = 27) during 2 seasons in British Columbia (Goddard and Dawson 2009).

Boisvert (2002) reported that brood size decreased from 9.2 to 4.3 chicks during the first 49 days. Collins (2004) reported brood sizes at 49 days were 4.2 in mine reclamation and 2.7 in shrub-steppe. In Montana, Brown (1961) reported the mean brood size of one quarter-grown chicks was 7.7, but declined to 3.8 for chicks that were approximately 80% of adult size. Hart et al. (1950) reported that during a 1937–39 study in Utah, mean brood size was 8.7 (n = 150). Broods <1 month old averaged 8.5 chicks; broods 1–2 months-old dropped in size to 4.6 chicks.

Chicks produced from second nests after first nests fail, sometimes make up a large portion of the annual reproductive output of a population (McDonald 1998). Renesting is particularly important in years when early nest predation is high or inclement weather severely reduces the survival of broods from initial nests. In 1995, only 1 chick was reared to 45 days of age from 6 successful initial nests on the Colville Reservation study area, but 5 chicks were recruited from 2 renests (McDonald 1998). Half of the 28 chicks reared to 45 days were from renests. Of 15 successful initial nests, 9 (60%) failed to produce any chicks to 45 days. During 1995, 3 females had clutches hatch at the same time and rainy conditions persisted for the first week and all 3 females were depredated during that time. Survival of chicks from renests is not always higher; in Colorado, survival to 7 weeks was 21% of 707 chicks from initial nests, and 10.3% for 108 chicks from renests (Collins 2004). Survival of chicks in broods of adult females was higher than for chicks in broods of yearling females, which tend to start nesting somewhat later in the season than adults (21.7%, *n* = 677 vs. 9.3%, *n* = 108; p = 0.003; Collins 2004).

Manzer and Hannon (2008) reported that most chick mortality (81%) occurred in the first 15 days; periods of heavy rain could result in significant mortalities, but in most years, losses due to exposure were relatively low (13%). Following 3 days of heavy rain, they found a female with her brood of 6 all dead apparently from exposure; they suggested that seasons with prolonged heavy rain during the early brood period could result in high mortality. Roersma (2001) also reported female and brood mortalities during prolonged periods of cold rain, with 3 of 8 monitored broods lost to exposure. Bousquet and Rotella (1998) reported that of 11 broods that failed to produce any chicks to 56 days of age, 10 lost all chicks in the first 3 weeks. They did not determine causes of chick mortality, but most losses corresponded with cold, wet weather. Goddard and Dawson (2009) reported 6 of 27 broods were all lost in the first 14 days. The most important variables affecting chick survival to 35 days were, in order of importance: 1) weather during days 0–7; 2) hatch date; 3) weather during 10 days pre-hatch; 4) distance moved during day 0–7; 5) female body condition; and 6) female age. Wet weather during days 0–7 negatively affected chick survival, while wet weather within the 10 days prior to hatching, positively affected survival; this may have been due to increased cover and abundance of forbs and insects, which improved food availability in the post-hatch period (Goddard and Dawson 2009).

Dry conditions can also affect chick survival and recruitment. Collins (2004) believed chick survival in shrub-steppe during his study was not adequate to sustain the population, perhaps because drought was affecting habitat condition.

Survival and Sources of Mortality

Adult survival and longevity. Most annual survival rates reported are for hunted populations of sharp-tailed grouse; rates reported in other states ranged from 17% to 42% (Connelly et al. 1998), however, hunting mortality may be at least partially additive. Robel et al. (1972) reported annual survival of 28.5% from a South Dakota study area where hunting mortality was estimated to be >20%. Estimates of survival from unhunted populations of Columbian sharp-tailed grouse in Washington and Colorado also varied widely (Table 3). Schroeder (1996) reported annual survival of 121 radio-marked birds in

Table 3. Annual survival of Columbian sharp-tailed grouse in Washington, Idaho, and Colorado.

State/location	Reference	% annual survival (*n*, sex)	Method
Washington	McDonald (1998)[a]	54.6 (19m, 19f)	Kaplan-Meier (Pollock et al. 1989)
Washington	Schroeder (1996)[a]	57.1 (74m, 47f)	Kaplan-Meier product limit
Idaho	Ulliman (1995)	86 (1992, *n* = 14)[b] 29 (1993, *n* = 14)[b]	Fate of all birds known
Colorado	Collins (2004)[b]	32.7 (2001–02, *n* = 80 f) 44.8 (2002–03, *n* = 67 f)	Kaplan-Meier, staggered entry
Colorado	Boisvert (2002)[c]	20 (40m, 45f)	Kaplan-Meier, staggered entry

[a]Non-hunted population.
[b]Over-winter survival.
[c]Hunting mortality was 2%; there was no hunting in mine reclamation.

Washington was 57% (95% CI = 45.7–68.5). For an unhunted population in Colorado, Collins (2004) reported annual survival of 32.7% in 2001–02, and 44.8% in 2002–03. Collins (2004) and Boisvert (2002) both reported no difference in survival rates of adults and yearlings, and no difference in survival rates between the sexes in mine reclamation lands. Boisvert (2002) reported annual survival of 20% in 1999 for sharp-tailed grouse in mine reclamation and lands enrolled in the Conservation Reserve Program (CRP) in Colorado. Grouse hunting occurred in the CRP habitat, but only 2% of mortality was attributed to hunting.

McDonald (1998) analyzed a subset of the Washington data from 1995-96 on the Colville Indian Reservation and Swanson Lakes Wildlife Area. He reported that survival for those years and sites pooled was 54.6 ± 0.84% (*n* = 38, 19 males, 19 females). There appeared to be a spike in mortality during nesting and brood rearing; 64% of females that died were nesting or brood-rearing (*n* = 14); 5 of 22 females were killed within 49 days of hatching a brood (McDonald 1998). Sixty-four percent of mortalities (18/28) of female sharptails released at Swanson Lakes WLA during 2005-2010 were in April-June; Schroeder et al. 2011). Manzer and Hannon (2008) reported that survival of plains sharp-tailed grouse females during the reproductive period (1 May – 13 August) was low (53 ± 0.05%; 95% CI; 44–63%, *n* = 111), and accounted for most (82%) of their annual mortality. Hagen et al. (2007b) also noted a peak in mortality of females during nesting or early brood-rearing in lesser prairie-chickens. McDonald (1998) noted that females are reluctant to abandon a brood until the chicks are able to thermoregulate on their own, making them more vulnerable to predators during the 3 weeks following hatch. Collins (2004) noted that males suffered less mortality than females during the nesting and brood-rearing period; male mortality was highest during the breeding season when they were attending leks. Boisvert (2002) noted that mortality was relatively high during the breeding and nesting period, but not during the brood rearing/summer period; she reported that survival of radio-tagged birds was highest during the summer/brood-rearing and winter periods.

The period of highest mortality for sharp-tailed grouse seems to vary with the severity of the winter. Ulliman (1995) reported that over-winter survival of sharp-tailed grouse in Idaho varied from 86% in a mild winter to 29% in a severe winter. Attwell (1977) provides an account of thousands of sharp-tailed grouse being killed when they became trapped under crusted snow in the Klickitat Valley during the severe winter of 1861–62.

Robel et al. (1972) reported that the percentage of banded plains sharp-tailed grouse recaptured in subsequent years in a South Dakota study area was 12.2, 3.5, 1.1, 0.3, and <0.1% for the first through fifth years, respectively. The maximum life span reported for sharp-tailed grouse is 7.5 years (Arnold 1988).

Predation. Predation is an important factor affecting population dynamics of prairie grouse, which are defined as sharp-tailed grouse, sage-grouse, and prairie-chickens (Schroeder and Baydack 2001). Raptors, corvids, and mammals can affect nest success, juvenile survival, and survival of breeding-age birds. Species that gather on leks to display and breed are more conspicuous to predators, and grouse may display at dawn and dusk to avoid diurnal predators, such as hawks (Hartzler 1974). Predation rate is often considered a function of habitat quality and distribution, grouse population and density, as well as predator behavior and population dynamics (Schroeder and Baydack 2001). A shortage of habitat can make it more difficult for birds to escape predators. Habitat degradation can affect visibility of nests and birds on leks, and affect the foraging and travel time to reach feeding sites. Habitat fragmentation can force birds into marginal areas and increase the density and diversity of predators (Schroeder and Baydack 2001). A higher density of birds or nests in limited habitat patches may increase the risk of detection by predators. The population dynamics of predators are often influenced by the populations of their primary prey species, which are often rodents or lagamorphs. Lower abundance of primary prey may require greater travel for predators and increase chance encounters with grouse, or cause predators to focus more on finding grouse or nests.

Determining the species responsible for predation can be difficult due to similarities in nest remains and subsequent scavenging (Lariviere 1999, Bumann and Stauffer 2002), so assignment to a specific predator species, or even taxonomic group, particularly in the older literature should be interpreted with caution. Coates et al. (2008) used video cameras at greater sage-grouse nests and reported that predation by common ravens (*Corvus corax*) and American badgers (*Taxidea taxus*) often could not be distinguished based on signs, suggesting that the predation rates attributed to various predators based on sign in earlier studies are inaccurate. They also noted that though ground squirrels and other rodents often visited nests and ate egg shells at depredated and successful nests, they depredated none, and their small gape suggested they were probably incapable of breaking sage-grouse eggs.

Predators of sharp-tailed grouse eggs include striped skunk (*Mephitis mephitis*), ground squirrels (*Spermophilus* spp.), black-billed magpies (*Pica pica*), American crow (*Corvus brachyrhynchos*), and common raven (Connelly et al. 1998). Additional predators of eggs, chicks, and adults include mink (*Mustela vison*), red fox (*Vulpes vulpes*), peregrine falcon (*Falco peregrinus*), gyrfalcon (*Falco rusticolus*), long-eared owl (*Asio otus*), rough-legged hawk (*Buteo lagopus*), and northern harrier (*Circus cyaneus*) (Connelly et al. 1998, Schroeder and Baydack 2001). Greer (2010) attributed most mortalities in a 2-year study in northern Utah to avian predation; he observed a harrier kill an adult male sharptail, and avian predators often attempted to kill sharptails while they fed in the open on waste grain. Collins (2004) noted that 6 entire clutches of sharp-tailed grouse eggs disappeared in shrub-steppe habitat. He suspected that gopher snakes (*Pituophis catenifer*) or prairie rattlesnakes (*Crotalus viridus*) were responsible, because they appeared to be much more abundant in shrub-steppe than in mine reclamation areas. Egg predation by snakes in grassland and shrub habitats may be much more frequent than previously thought (Davison and Bollinger 2000). Coates et al. (2008) noted, however, that badgers and ravens also occasionally consumed entire sage-grouse eggs, leaving no eggs or shells behind.

Boisvert (2002) attributed 74% of mortalities to predation, including 41% to mammals and 33% to raptors. Collins (2004) used radio collars with a mortality sensor and recovered most dead grouse within 24 hours; he assigned cause to 54% of 172 mortalities. He attributed 61% to mammals, 36% to birds (3% to necklace mounted radio transmitter). Radio transmitters were retrieved from the nests of a golden eagle (*Aquila chrysaetos*), great horned owl (*Bubo virginianus*), and a red-tailed hawk (*Buteo jamaicensis*). Other raptors observed at fresh kills included northern goshawk (*Accipiter gentilis*), and Cooper's hawk (*Accipiter cooperi*). Two females appeared to have been killed by bobcats (*Lynx rufus*, Collins 2004).

McDonald (1998) did not provide percentages, but noted that most nest predation appeared to be by common ravens, with coyotes the next most frequent nest predator in his Washington study. Both McDonald (1998) and Hart et al. (1950) mentioned that gulls (*Larus* spp.) may be responsible for mortalities of chicks or eggs. Marks and Marks (1987b) attributed 22 of 31 mortalities to predation, 86% to avian predators and 14% to mammals; cause of death could not be assigned for 9 birds. They observed or found evidence that predators included goshawks, a golden eagle, and a great horned owl. Meints (1991) listed 36 known mortalities of sharp-tailed grouse in a hunted population in southeastern Idaho; of these 66.6% was attributed to hunting, 19.4% to avian predators, 5.5% to mammalian predators, and 8.3% to unknown causes. Manzer and Hannon (2008), in a study of plains sharp-tailed grouse in Alberta, reported that predation was the cause of 72% of chick mortalities within 30 days post-hatch, and 96% of female mortalities during the reproductive period (1 May to 13 August). They reported that the odds of a female having a successful nest were 8 times greater in landscapes with <3 corvids/km^2 than in areas with >3 corvids/km^2 (Manzer and Hannon 2005).

McDonald (1998) noted that predation on 3 females with young broods occurred during a long period of rain and noted other studies of ring-necked pheasants (*Phasianus colchicus)* and greater prairie-chickens that suggested a correlation between predation and precipitation, possibly due to increased olfactory detectability of birds by mammal predators in moist air. Lehman et al (2008) noted that precipitation increased the hazard of nest mortality for Merriam's turkey; they hypothesized that coyotes use olfaction to find incubating females during wet periods.

Hunting. The sharp-tailed grouse season was closed in Washington in 1988, so legal hunting is not currently a mortality factor in Washington. There have been no experimental studies of sharp-tailed grouse designed to test whether, or when, hunting mortality is additive to natural mortality. In the past 30 years, an increasing number of studies have shown that hunting mortality is often at least partially additive to natural mortality, particularly in increasing populations that are below carrying capacity. This is particularly true for sage-grouse that are longer-lived, have low over-winter mortality, and have a lower reproductive capacity than other game birds (Connelly et al. 2003, Reese et al. 2005). In 10 studies involving 8 species of grouse, Bergerud (1988c) concluded that hunting increased annual mortality by adding to rather than replacing natural mortality during winter, but may be partly compensatory to natural mortality during breeding periods when birds are spread out. Connelly (1989) noted that most of the studies cited by Bergerud (1988c) reported a harvest of >20% of the population, a level more likely to be partly additive than lightly harvested populations. The effect of hunting mortality on the breeding population may vary with population size, timing, weather, and the quality and extent of available habitat. Marks and Marks (1987a) believed sharp-tailed grouse could be over-harvested because they concentrate near leks during fall and in flocks during winter; they supported maintaining a closed season on small, isolated populations of sharp-tailed grouse.

Diseases and parasitism. Numerous parasites have been found in sharp-tailed grouse (Appendix D), but very little is known about their effect on grouse populations (Peterson 2004). Sharp-tailed grouse parasites include ticks (Acarina), chiggers (Trombidiidae), lice (Mallophaga), tapeworms (Cestoda), round worms (Nematoda), hippoboscid flies (*Ornithomyia anchineuria*), and mites (*Ornithonyssus sylviarum*) (Bernhoft 1969, Boddicker 1967, Dick 1981). Boddicker (1967) reported consistent and heavy parasite loads in sharp-tailed grouse in South Dakota; males and chicks had the highest number of parasites. Five-week old chicks were infested with ticks, chiggers, lice, tapeworms and nematodes (Hillman and Jackson 1973). Parasite levels were lowest from December to March (Hillman and Jackson 1973). Ectoparasites cause irritation and may result in reduced breeding activity in males or egg production of females (Hillman and Jackson 1973, Peterson 2004), although Tsuji et al. (2001) found no correlation between ectoparasite burdens and position on the lek in male sharp-tailed grouse in Ontario. Tsuji and DeIuliis (2003) reported no difference in nematode egg load between males on central and those on peripheral territories on leks. Boddicker (1967) believed parasites seldom caused direct mortality of sharp-tailed grouse, but could affect populations that are stressed, such as during severe weather or when food is scarce.

Brown (1967b) reported the incidence of hematozoan (*Plasmodium* sp.) infections in two populations of plains sharp-tailed grouse in eastern Montana, 1961–1966. The incidence and intensity of *Plasmodium* parasitemia was variable between study sites, years, seasons, and age and sex classes. The highest incidence was in 1965 when 36% of 180 grouse were infected; this declined to 16.8% (*n* = 285) in 1966. Incidence of infection did not seem to be related to grouse density, but survival data suggested longevity was associated with absence of latent *Plasmodium* infection. One male had a low intensity latent infection when on a central territory on the lek; after losing his central territory, a blood test indicated that the intensity of infection had increased dramatically (Brown 1967b).

The intermediate host of some nematodes and avian tapeworms include grasshoppers and isopods, species more prevalent in summer when sharp-tailed grouse are eating more animal matter. Bendell (1955) reported that helminthes parasites were prevalent in sooty grouse chicks on Vancouver Island, and seemed to be an important mortality factor affecting density and contributing to population stability. Young birds tend to eat a higher percentage of animal matter and have more tapeworms (Peterson 2004). Some haematozoans are transmitted through black flies and midges, or hippoboscid flies.

The cecal nematode ***Heterakis gallinarum*** has been documented in sharp-tailed grouse from Wisconsin and South Dakota (Peterson 2004); it is widespread in domestic chickens, and also infects other grouse, pheasants, quail, turkeys, and chukars (*Alectoris chukar*) (Mississippi State University 1997, Beyer and Moritz 2000). *H. gallinarum* can transmit the protozoan *Histomonas meleagridis*, the agent that causes histomoniasis or 'blackhead disease'. Blackhead is an acute and chronic disease that produces lesions in the caeca and liver. Domestic chickens and pheasants are relatively resistant to the disease, but their droppings can transmit the disease to game birds when cecal worm eggs, which remain infective for 3 years, are ingested; transmission may also occur through earthworms (Lund and Chute 1972, Beyer and Moritz 2000, McDougald 2005). Infected game birds can have high rates (75%) of mortality (Peterson 2004). Blackhead has not been reported in sharp-tailed grouse, but it may have been a factor in the extinction of the heath hen (*T. c. cupido*; Johnsgard 2002). Peterson (2004) questions the wisdom of perpetuating ring-necked pheasants in areas with at-risk populations of prairie grouse. (see also ***Histomoniasis***)

Coccidia, such as *Eimeria* spp. are protozoans that can cause severe anemia, weight loss and mortality, particularly in chicks; they can be a serious problem for birds in captivity, but the significance of intestinal coccidians for free-living sharp-tailed grouse is unknown (Peterson 2004).

Several micro-organisms have been reported in sharp-tailed grouse, and some can cause epizootics that result in significant mortality that could eliminate small isolated populations (Peterson 2004). Disease outbreaks could result from "spill-over" from an epizootic in migratory waterfowl or domestic poultry.

Some studies indicate that population cycles in some species of grouse may be related to parasitic infections (e.g. red grouse, *Lagopus lagopus scoticus;* Moss et al. 1996, Hudson et al. 1998,Watson et al. 1998, 2000). Peterson (2004) stated that research is needed to determine whether parasites regulate or have the potential to regulate prairie grouse populations. Batterson and Morse (1948) mentioned accounts of a crash in sage-grouse populations in Oregon when dead and dying grouse were prevalent. Population crashes were attributed to low reproduction caused by widespread serious infections in females with a cecal roundworm, *Trichostrongylus tenuis*. Northern populations of sharp-tailed grouse may exhibit cyclic fluctuations (see ***Populations cycles***), and disease is one of the factors hypothesized as a causal factor.

West Nile virus, a disease new to North America, is affecting many bird populations. It is transmitted primarily between mosquitoes and birds in a bird-to-mosquito cycle (Kilpatrick et al. 2007). After being bitten by an infectious mosquito, most birds and mammals become infected. Many die within 4–8 days, but if they survive, the antibodies confer long-lasting protection from reinfection. West Nile virus has not been reported in sharp-tailed grouse, but has been reported in greater prairie-chickens and sage-grouse (Center for Disease Control, http://www.cdc.gov/ncidod/dvbid/westnile /birdspecies.htm). Arthropod sampling in Wyoming indicated the most likely vector was the mosquito, *Culex tarsalis* (Naugle et al. 2005). The virus caused a high rate of mortality in a greater sage-grouse population in Wyoming (Naugle et al. 2004), and lab experiments confirmed that greater sage-grouse were highly susceptible to infection, and it is usually fatal (Clark et al. 2006). At study sites in Wyoming, Montana, Colorado, and California where sage-grouse were being monitored, survival of females was 10% lower at 4 sites with confirmed West Nile virus mortalities than at 8 sites with no West Nile virus detected (Naugle et al. 2005). Radio marked sage-grouse in the Powder River Basin of Wyoming experienced 25% mortality from West Nile in 2003, but the percentage dropped to 10% and 2% in the cooler summers of 2004 and 2005; mortality increased again in the warmer summer of 2006 (USGS National Health Center 2006). If West Nile virus affects sharp-tailed grouse in significant numbers, the consequences for small populations could be very serious for small populations (see also, ***West Nile virus***).

Collisions. Sharp-tailed grouse are sometimes injured or killed by flying into powerlines and fences (Aldous 1943). In Utah, Hart et al. (1950) found the bodies of 20 sharp-tailed grouse ≤91 m (100 yd) from newly erected telephone lines. Marking wires and fences with flagging or plastic markers may help minimize accidents. We have no information to suggest that accidents are currently an important source of mortality for sharp-tailed grouse in Washington, but at least one translocated greater sage-grouse was killed by a collision with a fence (M. Atamian, pers. comm.). As noted by Wolfe et al. (2007), most grouse killed or injured in collisions with fences would not be detected without intensive monitoring. Wolfe et al. (2007) reported that fences accounted for 33% of 260 mortalities for which a cause could be assigned of radio-tagged lesser prairie-chickens during a 5 year period in Oklahoma and New Mexico. The proportion of mortalities from collisions was higher in Oklahoma (42%) than in New Mexico (14%); females were three times more likely to die as a result of collisions in Oklahoma due to a much higher density of fences, powerlines and roads (Patten et al. 2005). Females seemed to be more susceptible than males, and 2 females were found dead on their nest after being injured in collisions. Additional birds were injured and unable to fly and extremely vulnerable to predation. Moss (2001) estimated that mortalities of female capercaillie (*Tetrao urogallus*) from fence collisions in Scotland were largely responsible for an 18% annual decline, and without fence deaths the female population could have increased 6% per year; he predicted the capercaillie would again be extinct in Scotland. It is unknown whether sharp-tailed grouse are as susceptible to fence collisions as sage-grouse, prairie-chickens or capercaille.

Roads can be a source of occasional mortality (Aldous 1943). Automobiles were responsible for 2 of 10 cases of mortality in a Montana study not associated with trapped birds on leks (Brown 1961). Buss (1984) recorded 18 sharp-tailed grouse killed on a Montana highway during an unusual southward movement in November 1978. He believed that many more dead birds were likely removed by scavengers.

Cultivation. Agricultural fields can be a dangerous attraction to sharp-tailed grouse. Females occasionally build nests in grain stubble or cultivated fields, but the nests are destroyed by plowing and both females and chicks are sometimes killed (Hart et al. 1950, Hillman and Jackson 1973). Historically in Washington, when summer fallow came into widespread use, the plowing and burning of stubble fields in spring destroyed many nests and likely contributed to the rapid decline of sharp-tailed grouse in agricultural areas (Dice 1918, Myers 1948, Buss and Dziedzic 1955). This remains a problem in Washington, but it's not known how widespread. A lek was discovered by a farmer in Okanogan County in 2009 while cultivating a field; the birds returned to display after the field was tilled, but it's not known if any nests were present in the surrounding area and destroyed during plowing (J. Heinlen, pers. comm.). Hart et al. (1950) reported that in Utah during 1937–1939, 4.7% of females and 1% of juveniles in 150 broods were killed by farm implements. Plowing destroyed 82% of 35 nests in stubble fields and mowing destroyed 53% of 67 nests in alfalfa (Hart et al. 1950). Bernhoft (1969) indicated one brood was likely killed by the removal of cover by haying at a time of severe weather; he suggested that haying in early July was an important limiting factor in southwestern North Dakota.

Most recent studies indicate females usually select grassland for nesting; alfalfa or hay fields are sometimes used, but stubble fields are only occasionally used for nesting (Christenson 1970, Bernhoft 1969, Meints 1991, Giesen 1997, McDonald 1998). However, hayfields that are cut for hay attract nesting females and mowing can destroy eggs and young chicks (Bernhoft 1969).

Insecticides and toxins. Pesticides sprayed on or near areas occupied by sharp-tailed grouse may cause mortality. McEwen and Brown (1966) studied the effects of dieldrin and malathion on sharp-tailed grouse, two insecticides used for grasshopper control. Dieldrin is a highly toxic and persistent organochlorine pesticide that is no longer approved for use in the United States. Sharp-tails were administered dosages of 170–300 mg/kg malathion, and 6 of 19 birds died; the LD_{50} appeared to lie between 200 and 240 mg/kg (McEwen and Brown 1966). Grouse exposed to sublethal insecticide intake may be more vulnerable to predation because alertness and flight capability are negatively affected (McEwen and Brown 1966).

Greater sage-grouse in Idaho died after feeding, roosting, and loafing in alfalfa fields sprayed with dimethoate (Blus et al. 1989). In 1985, predators were attracted to the dead and incapacitated grouse. Of about 200 grouse that were present when a field was sprayed, 63 were later found dead. Based on a sample of 43 radio-tagged birds, there was a 25% probability of dying from pesticide poisoning during the 72-day study. Sage-grouse that occupied potato fields sprayed with methamidophos also died or suffered adverse affects (Blus et al. 1989). Dimethoate and methamidophos are organophosphate insecticides used on a variety of crops. Sub-lethal doses of insecticide may increase the rate of mortality from diseases or parasites. Bobwhite quail fed the insecticide Sevin at rates of single doses from 2.5 to 50 μg were more susceptible to the parasites that carry blackhead disease and experienced high rates of mortality (Zeakes et al 1981, *in* Peterle 1991).

Like all birds, sharp-tailed grouse are susceptible to lead poisoning. While it has not been diagnosed in sharptails, poisoning by spent lead shot has been documented in ruffed grouse, chukar, gray partridge (*Perdix perdix*), ring-necked pheasant, and quail (*Callipepla squamata*, *Colinus virginianus*; Locke and Friend 1992, Walter and Reese 2003, Fisher et al. 2006, Schulz et al. 2006, Pain et al. 2009).

Demographics, Density, and Population Dynamics

Bergerud (1988b:578) listed six parameters that affect the number of grouse each year: percentages of females nesting and re-nesting; clutch size; nesting success; chick survival in summer; juvenile survival in winter; and, the mortality rate of adults. Normally, all female sharp-tailed grouse attempt to nest. If the mortality rates in winter remain relatively constant, the size of the population each year would depend on reproductive success (Bergerud 1988b).

Sex ratio. There is no evidence that sharp-tailed grouse sex ratios at hatch differ from 1:1, and no clear evidence of a consistent bias of sex ratios in juveniles or adults based on trapping or hunter harvest. There may, however, be local or regional differences by sex in mortality rates due to predation or harvest. Bergerud (1988b:624) states that adult male:female ratio is commonly 55:45, but the data from the 4 studies cited do not seem to support this generalization. The studies with the largest sample sizes have the most even sex ratios (51 and 52% male; Kobriger 1981, Robel et al. 1972). In one study, the pooled sample was 52% male, but Robel et al. (1972) reported that the trapped birds favored males (57%) in one study area and females in the other (58%), suggesting differential trapability, or mortality. Giesen (1997) reported that among 93 adults killed, 54.8% were females, but the sample was not adequate to be statistically significant, and he concluded there was no evidence that sex ratios of harvested birds differ markedly from 1:1 (Geisen 1997).

Population density. In Washington, Hofmann and Dobler (1988a) estimated a winter density of about one sharp-tailed grouse per 3 ha (7.4 ac) in 340 ha of riparian and deciduous habitat within 5 km of active leks in Lincoln, Douglas, and Okanogan counties. In Colorado, Rogers (1969) used lek counts to estimate an overall spring density of 22–32 ha/bird in good habitat, to 86–259 ha/bird in low quality habitat. In Idaho, Ulliman (1995) estimated density of 77–186 ha/bird for the Curlew Valley, and 67–128 ha/bird in the Pocatello Valley. Ulliman (1995) calculated densities for the Curlew Valley of 74–162 ha/bird in 1974 after a mild winter, and 52–802 ha/bird in 1975 after a harsh winter, based on data in McArdle (1977). Several studies of plains and prairie sharp-tailed grouse report densities ranging from 4–370 ha/bird (Ulliman 1995).

Population cycles. Regular cycles of abundance and scarcity have long been recognized in northern populations of grouse, snowshoe hares (*Lepus americanus*), and their predators, but there is no consensus on their cause. Among grouse species, this roughly 10-year cycle is most pronounced in northern populations of ruffed grouse and ptarmigan (Bergerud 1988b, Lindstrom 1994). Fedy and Doherty (2011) reported greater sage-grouse and cottontail rabbits (*Sylvilagus* sp.) have highly correlated ($r = 0.77$) 7-year cycles in Wyoming. Sharp-tailed grouse do not exhibit clear cycles of abundance in Washington, but may have historically when they were much more abundant.

Cyclic populations are found in areas of extensive blocks of habitat and at northern latitudes where there are fewer predator species. In areas that formerly exhibited cyclic populations of ruffed grouse, but have undergone extensive habitat change or fragmentation, such as in New York, New Brunswick, and Maine, cycles have dampened or disappeared (Bergerud 1988b, Moss and Watson 2001). Habitat fragmentation can result in dispersal into sink habitats, and increases in generalist predators (Moss and Watson 2001). Bergerud (1988b) summarized data showing that a boundary between cyclic and noncyclic populations of sharp-tailed and ruffed grouse runs along the southern boundary of aspen parkland habitat from Alberta to Minnesota. For example, populations of sharp-tailed grouse in relic blocks of habitat scattered among agricultural lands in Manitoba do not cycle (Bergerud 1988b). However, lek count data from the Crex Meadows area in Wisconsin appears to exhibit a cycle (Evrard et al. 2000), apparently contradicting the pattern reported by Bergerud (1988b). Williams et al. (2004) analyzed 27 long-term data sets for ruffed grouse, sharp-tailed grouse, and greater prairie-chickens and concluded that population cycles collapsed from north to south due to a lengthening of the cycle period. They state this result was in contrast to studies that suggest cycles in Europe shortened from north to south and eventually collapsed in southern populations (Williams et al. 2004).

Diet

Plants comprise most of the diet of sharp-tailed grouse year-round. All sharp-tailed grouse consume insects, particularly grasshoppers, ants, and beetles, when available, but insects comprise only a small proportion of the diet of adults. In Washington, the spring diet of sharp-tailed grouse included grass blades, especially Sandberg bluegrass (*Poa secunda*), sagebrush buttercup (*Ranunculus glaberrimus*), common dandelion flowers (*Taraxacum officinale*), beetles, and grasshoppers (Jones 1966). Jewett et al. (1953) noted that in the Palouse region of Washington, sharp-tailed grouse congregated in canyons in winter, feeding on hawthorn fruits (*Crataegus douglasii*). Lord (1866:303-304) stated that the principal summer and fall foods of sharp-tailed grouse near Fort Colville, in present day Stevens County, were common snowberry (*Symphoricarpos albus*), kinnikinnik (*Arctostaphylos uva-ursi*), rose (*Rosa* spp.), and huckleberries (*Vaccinium* spp.). He also mentioned finding wheat, insect larvae, grass seeds, and small wildflowers in their crops. Jones (1966) reported that sharp-tailed grouse consumed fewer insects than other species of prairie grouse. However, chicks in the first few weeks of life rely heavily on insects for food (Hart et al. 1950, Parker 1970, Bernhoft 1969, Johnsgard 1983). Chicks primarily consumed insects, particularly grasshoppers and beetles (and unidentified insects) until 4 to 5 weeks of age in Utah (Hart et al. 1950). Bernhoft (1969) reported a decline in the percent insect material in the diet of 56 immature sharp-tailed grouse in North Dakota from 100% at 2 weeks of age, to

26% at 11 weeks. Invertebrates provide much higher concentrations of methionine and cystine than vegetation, amino acids that are critical to plumage development (Hurst 1972, Wise 1982). Feeding experiments in gray partridge showed that growth and feather development is drastically slowed when fed a diet lacking insects (Potts 1986).

Recent studies indicate the importance of diet on survival. Goddard and Dawson (2009) reported that female body condition was a factor, although a minor one, in the probability of survival of their chicks during the first 14 days post-hatch. Juvenile lesser prairie-chickens that were heavier than average at 50-60 days, were more likely to survive the winter in Kansas (Pitman et al. 2006), and invertebrate biomass in brood habitat has been linked with juvenile body mass in lesser prairie chickens (Hagen at el. 2005b), and red grouse (Park et al. 2001). Gregg and Crawford (2009) reported a direct link between food resources, namely Lepidoptera larvae and slender phlox (*Phlox gracilis*), and survival of greater sage-grouse chicks and broods. Evidence from gray partridge and rock ptarmigan (*Lagopus muta*) suggest that maternal nutrition affects egg quality or clutch size (Rands 1988). The availability of preferred insects during the first 20 days post-hatch is an important factor in survival of gray partridge chicks and subsequent breeding densities (Rands 1988). Fertilization of plots led to increased production of larger broods and smaller territories in red grouse; whether as a result of improved female body condition, or if immigration and improved nesting cover were also important was unclear (Rands 1988).

In Idaho, fruit from shrubs and trees found in mountain and riparian habitat were consumed by sharp-tailed grouse during summer (Marks and Marks 1987a). The availability of forbs and perennial bunchgrasses declines during summer and when droughts occur (Sauer and Uresk 1976). However, stream drainages generally contain fruits and berries year-round; these drainages are important foraging areas for sharp-tailed grouse in late summer and during droughts (Hofmann and Dobler 1988b). Other foods eaten in the spring and summer include clover (*Trifolium repens*), goldenrod (*Solidago* spp.), Canadian hawkweed (*Hieracium canadense*), corn (*Zea mays*), gromwell (*Lithospermum* spp.), smartweed (*Polygonum* spp.), alfalfa, creeping barberry (*Mahonia repens*), yellow salsify (*Tragopogon dubius*), wheat, yarrow (*Achillea millefolium*), dock (*Wyethia amplexicaulus*), ants, and moths (Connelly et al. 1998).

During fall, sharp-tailed grouse often feed on agricultural grains, insects, and weed seeds (Marshall and Jensen 1937, Hart et al. 1950, Jones 1966). Jones (1966) listed grasshoppers, dandelion seeds, and grass leaves among important foods in fall (presumably early fall). Based on 85 crops collected from hunter bags in northeastern Montana during 1976 and 1979, Mitchell and Riegert (1994) noted that samples were 34% grasshoppers by volume in 1976 when grasshopper populations were extraordinarily high, compared to 7% in 1979. Grasshoppers consumed were primarily *Melanoplus* spp, but included 22 species of Acrididae. Juniper cones (*Juniperus* spp.) and rose hips (*Rosa woodsii*) were the most abundant plant items consumed in 1976 by frequency and volume. Silver buffaloberry fruits (*Shepherdia argentea*) and skunkbush sumac (*Rhus aromatica*) were not detected at all in 1976, but were the most abundant plant items in 1979 (Mitchell and Riegert 1994). Yde (1977) obtained 103 crops from plains sharp-tailed grouse in September in northeastern Montana. Grasshoppers made up about 45% of the combined samples, but juvenile sharp-tailed grouse ate more than adults (56% vs. 30%). Most of the plant material was buffaloberry fruits the first year, and juniper berries (*Juniperus horizontalis*) the second year when buffaloberrries were not available (Yde 1977). Brown (1967a) noted that important items consumed in September in Montana included seed pods of prickly lettuce (*Lactuca serriola*), yellow salsify, and waste grain; later in the fall, fruits of chokecherry (*Prunus virginiana*) and serviceberry (*Amelanchier alnifolia*) were important, and in winter, buds, especially serviceberry were essential.

The winter diet of Columbian sharp-tailed grouse consists of: the buds of deciduous trees and shrubs, particularly serviceberry, chokecherry, hawthorn, water birch (*Betula occidentalis*), and quaking aspen (*Populus tremuloides*); fruits of hawthorn, juniper, wild rose, and snowberry; and green vegetation at seeps (Jones 1966, Marks and Marks 1987a, Hofmann and Dobler 1988a, Leupin 2003). In Washington, Zeigler (1979) reported that the buds and branches of water birch were very important food items for sharp-tailed grouse during winter, but other species seemed to be preferred where available (M. Schroeder, pers. obs.). Hart et al. (1950) noted that in late fall and early winter in Utah, waste grains were an important part of the diet, but as snow accumulated, buds of serviceberry, chokecherry, and willow (*Salix* spp.), and rose fruits became more important. Marks and Marks (1987a) recorded feeding observations during 3 winters in western Idaho. Sharp-tailed grouse fed extensively on hawthorn fruits in December 1983- January 1984; the following winter (1984-85), the hawthorn fruits had been eaten by grasshoppers that were extremely abundant in late summer, so grouse fed on buds, particularly serviceberry and chokecherry. Grouse also fed on buds during 1985-86 when the hawthorn crop failed for unknown reasons. Serviceberry seemed to be preferred while bittercherry buds (*P. emarginata*), though abundant, were rarely eaten. Schneider (1994) reported sharp-tailed grouse eating midge galls (Diptera: Ceridomyiidae) in sagebrush and Russian olive fruits in the Curlew Valley of Idaho during winter; the crop of one bird contained >300 galls. Birds that remained in CRP fields during a mild winter in southeastern Idaho, likely survived on alfalfa, salsify, draba (*Draba* spp.), and other forbs, grasses and grains (Schneider 1994). Other fall and winter foods listed by Connelly et al. (1998) included sunflower (*Helianthus* spp.), goldenrod, and dock.

During cold conditions (<20° F) in Washington in 1996 or 1997, sharp-tailed grouse used snow burrows in unharvested food plots of wheat, barley, and triticale (M. Finch, pers. comm.). During a mild winter in which birds remained in CRP fields, birds selected grasses and forbs with higher than average fat, sodium, and potassium content (Schneider 1994). CRP fields provided foods with more protein, macro and trace elements, and less fiber, while shrub forages provided lower ash and higher gross energy. It was unknown why some birds moved into riparian and mountain shrub habitat, despite the availability of CRP that seemed to contain higher quality forage (Schnieder 1994), but the shrub habitats may have provided greater security cover.

Evans and Dietz (1974) analyzed the energy available from several foods in the winter diet of sharp-tailed grouse. They found that fruits of hawthorn, Russian olive, silver buffaloberry, and frozen snowberry provided a positive nitrogen balance indicating storage of protein in the body, while plains cottonwood buds (*Populus deltoides*), Wood's rose, and air-dried snowberry would not allow birds to maintain their weight. Hawthorn fruits were low in metabolizable energy and crude protein, but sharp-tailed grouse can maintain or gain weight on them because of the large quantity that they will consume. Silver buffaloberry was the best native food tested, being high in energy, it was readily eaten, and persisted on shrubs throughout the winter (Evans and Dietz 1974). Silver buffaloberry is not native to Washington; russet buffaloberry (*S. canadensis*) occurs in Okanogan County in Washington; although reported to be eaten by grouse, it has not been reported in sharp-tailed grouse diets (Connelly et al. 1998).

Home Range, Seasonal Movements, and Dispersal

Home range. Home range size depends on topography, vegetative cover, season, and availability of food (Table 4). Sharp-tailed grouse have relatively small home ranges in the spring and summer (Giesen and Connelly 1993), but ranges are much larger in poor quality habitat. In Washington, spring home ranges of 3 males were 11 to 46 ha (27–114 ac) (Hofmann and Dobler 1988b). In Idaho, median home range size of 15 sharp-tailed grouse from spring to fall was 147 ha (364 ac) (Marks and Marks 1987a); they noted that home ranges were >2 times larger in an area that was heavily grazed, compared to a lightly grazed unit. Median home ranges were much larger in shrub-steppe than in mine reclamation areas in Colorado, particularly during a drought year (Collins 2004).

Daily and seasonal movements. Sharp-tailed grouse in Wisconsin moved up to several hundred meters between feeding and loafing areas and night roosts even though cover was similar (Gratson 1988). Sharptails also moved roost locations on successive

Table 4. Seasonal home range sizes of Columbian sharp-tailed grouse.

Season / Location and study	*N* and sex or age[a]	Median home range (ha)	Estimation method
Year-round			
Lincoln County, Washington			
Atamian (unpubl. data)[b]	26f	1,110[c]	100% minimum convex polygon
	42m	1,480[c]	
	50a	1,260[c]	
	18y	1,540[c]	
Spring			
North-central Washington			
Hofmann and Dobler (1988b)	3m	22.4	100% minimum convex polygon
Spring-fall			
Western Idaho			
Marks and Marks (1987a)	13m, 2f	147	100% minimum convex polygon
Northwestern Colorado			
Geisen (1987)	13m, 7f	80	100% minimum convex polygon
Collins (2004)			95% fixed kernel, least squares cross-validation
Shrub-steppe, 2001	18f	246	
Shrub-steppe, 2002	25f	1,168	
Mine reclamation, 2001	13f	75	
Mine reclamation, 2002	14f	69	
Summer-fall			
Northwestern Colorado			
Boisvert (2002)			95% fixed kernel, least squares cross-validation
Mine reclamation	34[d]	75	
CRP	20[d]	112	
Pooled	54	86.3	
Winter			
Northwestern Colorado			
Boisvert (2002)	6f	185	95% fixed kernel, least squares cross-validation
	5m	337	
Southeastern Idaho			
Ulliman (1995)			90% Epanechnikov adaptive kernel
1992	3f	44	
1992	6m	140	
1993	8f	177	
1993	3m	313	

[a]m = male, f = female, a = adult, y = yearling.
[b]This data is from translocated birds released in Lincoln County.
[c]Mean home range
[d]Sex not specified by habitat; estimate included 18 males, 36 females.

nights, and generally moved to a new location each day and night. Gratson (1988:188–189) speculated that these movements were an adaptation to confound hunting efforts of predators. Daily movements of both sexes were <300 m during summer (Gratson 1988). Median daily winter movements of Columbian sharp-tailed grouse in southern Idaho were 221 m for females and 286 m for males (Ulliman 1995). Sharp-tailed grouse in Utah moved shorter distances on a daily basis in spring and summer than in fall and winter because food and cover are readily available near leks, nests, and brood-rearing areas (Hart et al. 1950). In summer, daily movements were <100 m to 400 m (methods, *n* and sex not given) in Utah (Hart et al. 1950), and < 100 m for broods of radio- marked females in Idaho (Meints et al. 1992). Apa (1998) reported that median daily movement of females with broods in the Curlew Valley, Idaho was 86 m/day (37–154 m, *n* = 13), and 98 m/day (52–340 m, *n* = 7) for females without broods.

From the spring through the autumn, most sharp-tailed grouse remained close to the lek where they were captured. Female sharp-tailed grouse often nest within 2 km of their lek of capture (Gratson 1988, Meints 1991, Giesen 1997, Apa 1998, McDonald 1998, Collins 2004, Boisvert et al. 2005, Greer 2010). In Washington, all 54 radio-tagged females moved <3.5 km from their lek of capture to their nest site, except for two females that moved 6.7 km and 7.0 km (McDonald 1998). The mean distance from a female's initial nest to her renest was 1,121 m (range 55–3150 m, *n* = 14). Nesting success seemed to affect the distance between nests of successive years. In 1996, 3 females nested an average of 403 ± 28 m (range 358–453) from their 1995 successful nest, but 4 females nested an average of 2,521 ± 1,492 m (range 414–6,912) from their previous unsuccessful nests, but the sample sizes were small and the difference was not statistically significant (McDonald 1998). In northern Utah, the distance from lek of capture to nest was <1.2 km for 3 of 4 females; one nest was 3.3 km from the female's lek of capture (Greer 2010).

In one Colorado study, 96% of females raised their brood within 1.4 km of where they nested (Boisvert et al. 2005). Boisvert et al. (2005) reported that 85% of birds remained within 2.0 km of the lek of capture, and 90% of females located on nests were found within 2.5 km of the lek of capture. During the summer-fall period, 96% of males remained within 2.0 km of their lek (Boisvert et al. 2005). In an earlier Colorado study, >90% of telemetry locations of 38 grouse during April–December were within 2.0 km, and 95% were within 3 km of the lek of capture (Giesen 1997); males remained closer to leks in the spring and summer than did females. Females with broods occasionally make long distance movements, for example, a brood suddenly moved 28 km in its fifth week after hatch (Schiller 1973; *not seen, in* Bergerud and Gratson 1988); Bergerud and Gratson (1988) suggest that such sudden movements may result from an encounter with a predator. One banded bird in North Dakota moved 93 km (58 miles) in 22 months (Aldous 1943). Robel et al. (1972) reported that a banded juvenile female moved 148.8 km.

Sharp-tailed grouse do not regularly migrate south of their breeding range, but exhibit a limited migration in which some birds move between breeding and wintering sites, and others remain near breeding sites throughout the year. The lack of consistent southward or downslope movements, suggested that sharp-tailed grouse were not seeking milder climatic conditions for wintering. Movements to wooded wintering areas were downslope in some locations, and upslope in others. Several studies reported that sharp-tailed grouse travel an average of 1.6 to 8 km from leks to winter sites (Janson 1950, Hamerstrom and Hamerstrom 1951, Marks and Marks 1987a, Gratson 1988, Meints 1991). In Washington, sharp-tailed grouse moved up to 14 km (8.5 miles) between breeding and wintering ranges (Schroeder 1994), but the average was 2.8 km for 41 males and 4.4 km for 28 females (Schroeder 1996). In Idaho, Marks and Marks (1988) located most sharp-tailed grouse in winter ≤2 km (1 mi) from the lek used in spring, and Ulliman (1995) reported that only 16% of birds moved >4 km from their lek of capture. Meints et al. (1992) considered the area ≤6.5 km (4 mi) around each lek as potential wintering area. Movements in winter are likely affected by weather and its effect on food availability (Hart et al. 1950); during a mild winter with little snow, sharp-tailed grouse in southeast Idaho remained in CRP fields instead of moving to more typical wintering habitat (Schneider 1994).

McDonald (1998) noted that females (*n* = 6) on the Colville Reservation moved longer distances (up to 11 km) than males (*n* = 2) to winter habitat (5.5 vs. 1.0 km) that appeared no better than winter habitat much closer to their summer range; however, sample sizes were small. McDonald's (1998) observations agreed with that of Ulliman (1995) and Collins

(2004), who both speculated that females may move further to avoid competition with male sharp-tailed grouse or to avoid predators that would be attracted to large winter flocks, particularly when feeding in the upper branches of deciduous shrubs. They suggested that sharp-tails may disperse across available wintering habitat to improve survival. Giesen and Connelly (1993) suggested that where winter foods are limited, Columbian sharp-tailed grouse are forced to move further to winter habitats. In a Colorado study, however, Boisvert et al. (2005) reported that 87% of radio-marked birds wintered >10 km from where they were trapped (median 21.5 km, range 3.1– 41.5 km, n = 30) despite the abundance of suitable wintering habitat near breeding sites; there was no difference between sexes in the distances moved.

Seasonal migrations of some distance by sharp-tailed grouse apparently occurred historically, but either no longer occur in southern subspecies, or distances are shorter (<34 km, 21 mi,) due to habitat changes (Connelly et al. 1998). Long distance movements may still occur in northern subspecies, but there are few data (Connelly et al. 1998). Hamerstrom and Hamerstrom (1951) reviewed available data on seasonal movements and noted that, "Fifty to a hundred years ago… there were conspicuous seasonal movements between breeding and wintering areas." Hamerstrom and Hamerstrom (1951) concluded that seasonal movements between summer and wintering areas are shorter than they were historically because the breeding habitat on prairies further from wintering habitat has largely been eliminated by agriculture. Dawson and Bowles (1909) noted that the availability of haystacks and grain in stubblefields allowed at least some sharp-tailed grouse in Washington to forego the seasonal movement to wooded draws.

Spectacular one-way mass movements, or partial migrations, of sharp-tailed grouse have been reported. Snyder (1935, *in* Tsuji and DeIuliis 2003) and Cade and Buckley (1953) describe two cases of autumn mass emigration. Hamerstrom and Hamerstrom (1951), Buss (1984), and Cade and Buckley (1953) recount what Buss (1984) called "the great 1932 sharp-tail exodus" from the vicinity of James and Hudson bays originally described by Snyder (1935). Small (4 birds) and large flocks (>100 birds) moved steadily through the western James Bay region for 3 consecutive weeks (Snyder 1935). Snyder (1935) mentioned evidence of two other such mass emigrations that occurred in 1865 and 1896 in the same region. The 1932 movement occurred at a time when large areas of habitat had been defoliated by the birch skeletonizer moth (*Bucculatrix canadensisella*) (Buss 1984). Cade and Buckley (1953) describe a mass emigration in Alaska in 1934. Sharp-tailed grouse populations were very high in the vicinity of Fairbanks and College, Alaska in the early 1930s. One day in October 1934, a huge number of grouse suddenly arose en masse and flew off to the south; the flock was estimated to be 2–3 mi long by ½ mi wide (3.2-4.3 x 0.8 km). Rowan (1948, *in* Hamerstrom and Hamerstrom 1951) also described a mass flight in Alberta in 1942. Buss (1984) describes an apparent southward movement of sharp-tailed grouse observed along 436 km (~700 mi) of U.S. Highway 12 in Montana in November 1978.

Natal dispersal. Natal dispersal distance, or the distance between site of hatching to the site of first breeding, has important implications for connectivity of populations and gene flow. For female sharp-tailed grouse, natal dispersal distance would be the distance between their natal nest to their initial nest the following spring, and for a male, it would be the distance from hatch site to the lek where it established a territory. In most avian species, median distances of natal dispersal are greater for females than males (Clarke et al. 1997). Several studies report distances moved by sharp-tailed grouse to wintering areas, but only one reports a natal dispersal distance. Gratson (1988:178) reported a female in Wisconsin nested 1.4 km from the home range she occupied as a juvenile the previous September. Data from lesser prairie-chickens are consistent with most species; 17 of 27 juvenile males moved 0.0–0.7 km, and 3 of 5 females moved >3.2 km between their autumn/winter range and their first breeding area (Copelin 1963). Jamison (2000) reported that two males banded as chicks were captured on a lek in autumn 2.2 and 2.3 km from their hatch sites. Data from sage-grouse, ruffed grouse, dusky grouse, spruce grouse, and white-tailed ptarmigan also indicate that natal dispersal distances are typically greater for females (Dunn and Braun 1985, Schroeder 1985, Small and Rusch 1989, Clarke et al. 1997).

Fidelity to leks and wintering areas. Most male sharp-tailed grouse return to the same lek or lek complex in the fall and again the following spring (Evans 1969, Bergerud 1988a, Giesen and Connelly 1993, Drummer et al. 2011). Males exhibit greater fidelity to leks than females (Boisvert 2002, Drummer et al. 2011). Males probably return to the same lek because they are familiar with the site and rival males there, and because they want to maintain or improve their territorial positions (Giesen 1987, Bergerud 1988a). Drummer et al. (2011) observed a male visit 2 leks on the same day on two occasions. Adult males may occasionally establish new leks, as leks are abandoned because of habitat changes, decline of local populations, or other unknown reasons (Rippin and Boag 1974, Sexton and Gillespie 1979, Gratson 1988, Berger and Baydack 1992).

Columbian sharp-tailed grouse in Colorado seemed to show some fidelity to traditional winter areas. Four grouse monitored for 2 winters in Colorado, returned to the same area, and observations of radioed birds subsequent to the study suggested use of traditional winter ranges (Boisvert et al. 2005). Birds captured from the same breeding population moved to the same general wintering area during successive winters (Collins 2004). The median distance between the home range centers for 3 of 6 sharp-tailed grouse monitored in successive winters was 2.4 km (Collins 2004).

Ecological Relationships

Interspecific competition. Little information is available on the impact of interspecific competition in grouse species. In Washington, the range of Columbian sharp-tailed grouse overlaps those of dusky grouse and greater sage-grouse. Sharp-tailed grouse also share range with non-native game birds, including gray partridge, chukar, California quail (*Callipepla californica*), ring-necked pheasant, and wild turkey. Potential competition for nesting and wintering sites and interference with reproduction may be the most likely forms of competition. Hart et al. (1950) noted that domestic turkeys eat green vegetation, waste grain, and grasshoppers, and that turkey grazing was detrimental to sharp-tailed grouse habitat. Sharp-tailed grouse did not return to an area for two months after it was grazed by domestic turkeys (Hart et al. 1950). Large flocks of wild turkeys may have similar negative impacts on sharptails, but this has not been reported. Introduced game birds may also support a higher year-round density of predators that could prey on sharp-tailed grouse.

Vance and Westemeier (1979) expressed concern about disruption of prairie-chicken leks by aggressive pheasant cocks and Sharp (1957) noted that daily attacks by ring-necked pheasants drove prairie-chickens from long-established leks. Vance and Westemeier (1979) stated that pheasant disturbance may be especially harmful to small leks, including the incipient leks of a reintroduction project. However, Sharp (1957) stated that sharp-tailed grouse defeated the larger cock pheasants in all encounters observed. He noted that from its aggressive crouch position, the sharp-tailed grouse darts under a pheasant to grab tail or rump feathers and hangs on stubbornly, frightening the pheasant into retreat (Sharp 1957).

The historical ranges of Columbian sharp-tailed grouse and greater sage-grouse overlapped in eight states, including Washington. R. Hoffman (pers. comm.) notes that it is common to find both species together in Colorado. Klott and Lindzey (1990) studied the habitat use of greater sage-grouse and sharp-tailed grouse broods in shrub-steppe in south-central Wyoming. They found that sage-grouse and sharp-tailed grouse broods used somewhat different habitats; they do not state whether they ever found both species present at the same site, at the same time, or separated in time. Sharp-tailed grouse used mountain shrub and sagebrush/snowberry habitats found in the transition zone between sagebrush/grass and forest. Sharp-tailed grouse broods used sites with greater forb diversity, taller snowberry and sagebrush, and greater snowberry and grass cover than those used by sage-grouse (Klott and Lindzey 1990).

In the Curlew Valley of Idaho, Apa (1998) reported that there was minimal, or no competition for nesting habitat between sharp-tailed grouse and greater sage-grouse. Sharp-tailed grouse and sage-grouse partitioned nesting habitat somewhat by topographic and vegetation characteristics; sharp-tailed grouse did not nest on slopes >19%, whereas sage-grouse nested on slopes up to 30%, and steeper slopes tended to be at higher elevations. Sharptail nests were found throughout the gradient of shrub canopy cover, but sage-grouse required higher sagebrush canopy cover; they nested under larger sagebrush plants and in areas of taller sagebrush. Forty-nine percent of sharptails nested under shrubs, whereas all but one sage-grouse (n = 38) nested under shrubs, primarily sagebrush. The difference in use of slopes disappeared during brood rearing as sharp-tailed grouse broods moved to areas with higher cover values, while sage-grouse used steeper slopes less. Sharp-tailed grouse brood use was concentrated in areas with medium to high grass cover and taller sagebrush; sage-grouse broods used sites with lower grass cover. The broods of both species used sites with twice the cover of forbs (8%) as independent sites. If situations occur where forbs are limiting, interspecific competition for brood habitat could exist and limit the less competitive species (Apa 1998).

At the more mesic, higher elevation portion of the Columbian sharp-tailed grouse's range, there is overlap with dusky grouse during summer. R. Hoffman (pers. comm.) has observed dusky grouse males displaying on sharp-tailed grouse leks, where they were ignored by the sharptails. Dusky grouse occur in steppe communities out to 2+ km from the forest edge, and the two species seem to have very similar summer diet and brood-rearing habitat needs (Zwickel 1992). There is substantial seasonal overlap in the occurrance of sharp-tailed and dusky grouse in northern Douglas and Okanogan counties. Niche relationships between dusky and sharp-tailed grouse have not been studied. Dusky grouse are seasonal migrants that move to conifer forest for the winter.

Livestock and wild ungulates can negatively affect winter habitat by browsing deciduous woody cover. Even where livestock are excluded, efforts to restore woody riparian shrubs in Washington for sharp-tailed grouse winter habitat have often failed unless shrubs are protected from deer by fencing. Braun et al. (1991) described an apparent competitive relationship between elk and white-tailed ptarmigan in Colorado for willow.

Nest parasitism by ring-necked pheasants. Ring-necked pheasants have been documented parasitizing nests (i.e. adding eggs to a clutch) of prairie chickens, but it is unknown if pheasants parasitize sharptail nests in Washington. Pheasant parasitism of prairie-chicken nests can lead to the female abandoning her own clutch when the pheasant eggs hatch because pheasant eggs require only 23 days to hatch, while greater prairie-chicken eggs require 25 days (Vance and Westemeier 1979, Deeble 1996). Parasitism of greater prairie-chicken nests by pheasants in Illinois reduced egg hatchability (Westemeier et al. 1998b). Nest parasitism by pheasants may be less of a problem for sharp-tailed grouse because their incubation period is 21–23 days, although Boisvert (2002) reported incubation of up to 26 days at a high elevation study area.

Extirpations of remnant prairie-chicken populations attributed to interactions with pheasants have been reported in Wisconsin, Illinois, Indiana, and Michigan (Westemeier et al. 1998b). Declines of other species attributed to interactions with pheasants include black grouse (*Tetroa tetrix*) and gray partridge. Westemeier et al. (1998b) speculated that suppressed hatchability of fertile host eggs may have been a factor. They do not recommend managing for pheasants in areas supporting remnant flocks of prairie-chickens. In a southwestern Kansas study, only 3 of 75 lesser prairie-chicken nests were parasitized by pheasants; 2 nests hatched eggs, but no pheasant chicks survived >9 days (Hagen et al. 2002). Hagen et al. (2007a) reported that pheasants and lesser prairie-chickens in the Kansas study area were largely spatially separated, with pheasants exhibiting a strong affinity for edge habitats while prairie-chickens were closely tied to large blocks of native prairie. They concluded that pheasants were having no measurable effects on nesting and brood-rearing habitat use or productivity of lesser prairie-chickens in southwestern Kansas. They cautioned, however, that additional habitat loss or fragmentation might favor pheasants and lead to nest site competition, nest parasitism by pheasants, and disease transmission that would negatively impact prairie-chickens (Hagen et al. 2007a).

Sharp-tailed grouse as prey in grassland communities. The historical abundance of sharp-tailed grouse on grasslands in Washington suggest that eggs, young chicks, and adult sharp-tailed grouse were an important seasonal prey of many species (e.g., coyotes, badgers, ravens, short-eared owls, rough-legged hawk, etc.) and were a significant part of grassland communities.

HABITAT REQUIREMENTS

Vegetation and precipitation zones. Good sharp-tailed grouse habitat contains perennial bunchgrasses, forbs, and key species of deciduous shrubs, typically in steppe (shrub-steppe and meadow steppe), mountain shrub, and riparian deciduous habitats. Meadow steppe is a descriptive term for plant communities that are dense at ground level, support many grasses and forbs, and have few shrubs. Meadow steppe is barely dry enough to exclude trees and generally has meadow characteristics (Franklin and Dyrness 1973, Daubenmire 1970). Typical meadow steppe communities in Washington have several grasses, including bluebunch wheatgrass (*Pseudoroegneria spicata*) and Idaho fescue (*Festuca idahoensis*) (Daubenmire 1970). Shrub-steppe communities in Washington contain a conspicuous, but discontinuous, layer of big sagebrush (*Artemisia tridentata*), three-tipped sagebrush (*A. tripartita*), or bitterbrush (*Purshia tridentata*), and various perennial grasses and forbs (Daubenmire 1970). Of the vegetation zones mapped by Cassidy (1997), the most important for sharp-tailed grouse were probably the Palouse, Wheatgrass/Fescue, Three-tip Sagebrush, Big Sage/Fescue, and Central Arid Steppe (Fig. 6). The highest densities of sharp-tailed grouse were probably in the more mesic grassland and meadow steppe types. Most historical records are from areas that average ≥11 inches of annual precipitation (Fig. 7). The Palouse and Wheatgrass/Fescue zones were largely converted to cropland long ago, but may have excellent potential for habitat restoration.

Dice (1916) reported that in Walla Walla and Columbia counties, sharp-tails were most abundant in bunchgrass prairie, and he included them as "reported--resident" in the sagebrush habitat of western Walla Walla County. Some of the Central Arid Steppe, or Wyoming Big Sage-Warm Potential Vegetation Type (Bunting et al. 2002), is likely too dry and monotypic to support the high vegetative diversity needed for year-round use by sharp-tailed grouse, except where it includes wetlands, springs, or other sites with more mesic grassland and shrubs. These drier areas may support seasonal use, but generally in much lower density. With the exception of a few historical records from the Yakima Valley, there are very few records for the driest areas of the Columbia Basin (<11" precip zone), and most of these records were near rivers. Hillman and Jackson (1973) indicated that "prime" sharp-tailed grouse habitat in South Dakota occurred in the 15–19" precipitation zones.

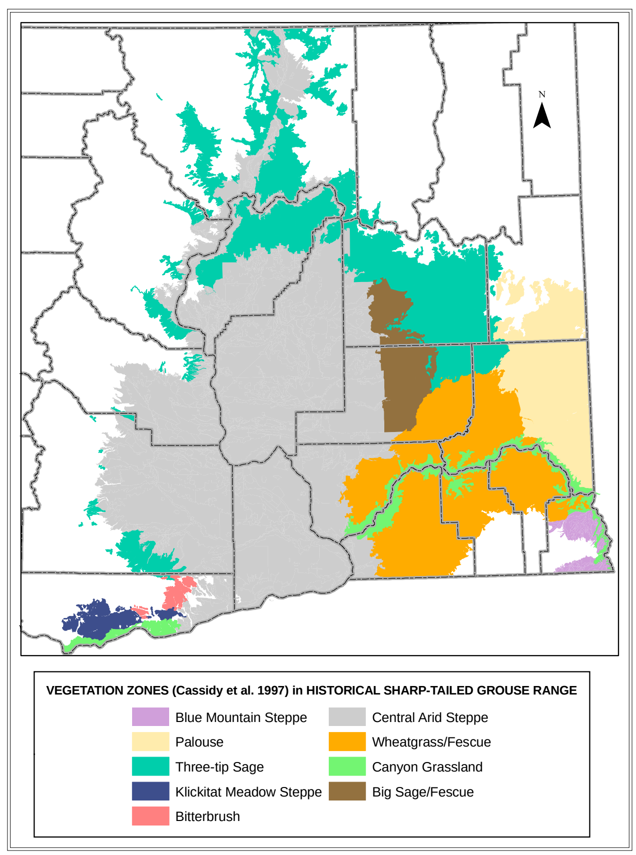

Figure 6. Steppe Vegetation Zones (Cassidy 1997) in the historical range of Columbian sharp-tailed grouse in Washington.

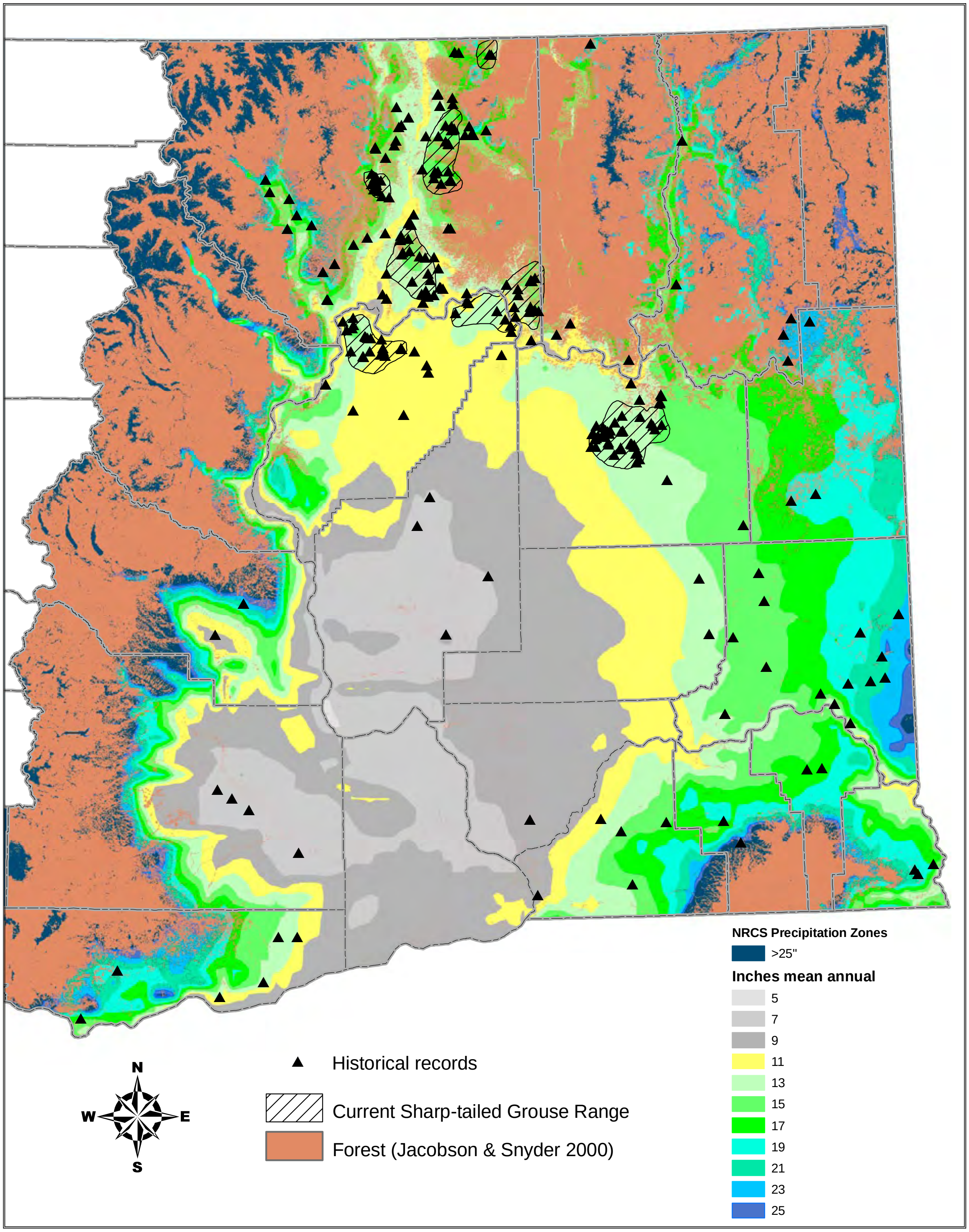

Figure 7. The historical and recent distribution of Columbian sharp-tailed grouse in Washington in relation to mean annual precipitation (WDFW and Natural Resources Conservation Service data).

Productive sharp-tailed grouse habitat contains well developed perennial bunchgrasses, and many species of forbs and shrubs (Oedekovan 1985, Marks and Marks 1987a, Meints 1991). Sharp-tailed grouse choose habitat based primarily on height and density of vegetation and secondarily on species composition (Kirsch 1969, Hofmann and Dobler 1988b, Stralser 1991). They often use areas near edges where two habitats meet, especially when the area contains a mixture of vegetative species and structure (Marks and Marks 1987a, Meints et al. 1992, Stralser 1991). McDonald (1998) concluded that seasonal habitat use by sharp-tailed grouse seems to be driven by the preferences and availability of foods. Grasses and forbs are important and preferred foods and birds are found where they are available. When grass and forbs were not available, sharp-tailed grouse fed on wheat. Where wheat was not available, or when it became covered with snow, sharp-tails shifted to riparian shrubs to feed on the catkins of water birch.

Mountain shrub communities are important Columbian sharp-tailed grouse habitats in Colorado, Wyoming, Idaho, and Utah, particularly in winter. Giesen and Connelly (1993) define mountain shrub as upland communities dominated by >1 deciduous shrub species including serviceberry, snowberry, common chokecherry, and Gambel oak (*Quercus gambelii*). Little of this upland habitat exists today in Washington, where sharptails depend on riparian deciduous trees and shrubs during winter (McDonald 1998). Historically in Washington, sharp-tailed grouse probably used the shrub communities on north slopes and other relatively moist sites in the Palouse region that included Douglas hawthorne, chokecherry, snowberry, and roses (*Rosa woodsii*, *R. nutkana*) (Daubenmire 1970, Aller et al. 1981). These shrub communities were of the *Festuca idahoensis-Symphoricarpus albus* and *Crataegus douglasii-Symphoricaprus albus* habitat types (Daubenmire 1970).

Slope, aspect, and elevation. Sharp-tailed grouse are found at elevations of 300 to 1,350 m (984 –4,429 ft) in Washington, but >2,900 m (9,000 ft) in Colorado (Evans 1968). Hart et al. (1950) reported that sharp-tailed grouse were found on rolling hills and benchland, extremely steep ground was seldom used in Utah. Hart et al. (1950) suggested that topography had little effect on sharp-tailed grouse except as it affects vegetation, snow cover, agriculture, and the siting of leks. Apa (1998) reported that none of 51 sharp-tailed grouse nests found in the Curlew Valley of southeastern Idaho were on slopes >19%. In western Idaho sharp-tailed grouse used slopes of up to 47% during summer, but 95% of use was on slopes <30%; slopes were used in proportion to availability 2 out of 3 years (Marks and Marks 1987a, Saab and Marks 1992). Birds generally only used the portions of steep slopes fairly close to flat areas at the top or bottom of slopes. Nine nests were found on gentle slopes, and nest placement showed no preference for aspect (Marks and Marks 1987a). Radio-tagged birds also showed no strong preference for aspect; northern aspects were selected and western aspects avoided during two years, but southern aspects were selected during one of three years. Giesen (1997) noted that sharp-tailed grouse in Colorado most often used areas with high shrub densities, generally on north and east slopes, but he did not test for selection of aspect. Sharp-tailed grouse seem to show preference for northern aspects in some study areas probably due to greater vegetation growth, residual cover, and moisture. Conover and Borgo (2009) reported that sharp-tailed grouse in Idaho selected loafing sites on windward slopes or ridgetops where wind velocity, updrafts, and turbulence would make them more difficult to find for olefactory predators.

Water. Sharp-tailed grouse do not usually drink water or make movements to available surface water, but apparently rely on dew and succulent vegetation for moisture (Oedekoven 1985, Prose 1987). Saab and Marks (1992) saw no evidence that sharp-tailed grouse sought free water. Sharp-tailed grouse were rarely found near open water in Idaho, even in summer (Parker 1970, Marks and Marks 1987a, Saab and Marks 1992). Mesic sites that maintain green vegetation during summer may be important sources of moisture (Connelly et al. 1998). Sharp-tailed grouse may obtain water by eating snow in winter (Aldous1943).

Spring, Summer, and Fall Habitat

During spring and summer, sharp-tailed grouse in Washington primarily use grassland habitats; shrubby habitats are used primarily as escape cover. Grass/forb, grass/shrub, and CRP cover types accounted for >80% of female locations and >65% of male locations, while these cover types accounted for only 11% of the landscape; sagebrush was used less than expected (McDonald 1998). In western Idaho, mountain shrub, riparian, and bitterbrush habitats were used primarily as escape cover during spring and summer (Saab and Marks 1992). As summer progressed and grass and forbs dried out and fruits became available, the use of grass/shrub and riparian/mountain shrub cover types increased (Saab and Marks 1992, McDonald 1998). An increase in the use of shrubs like sagebrush may reflect a need for shade in the hottest summer period.

Lek Sites. The focal point of the breeding season is the lek. Male sharp-tailed grouse prefer sites that are flat and open with good visibility that enables them to see predators and be seen by females while displaying (Hart et al. 1950, Zeigler 1979). Leks probably rarely form or persist unless suitable nesting habitat is nearby; females generally select nest sites <2 km from the lek at which they breed. Most leks are located on elevated ground, such as knolls and ridge tops (Fig. 8), where vegetation is short (Rippen 1970, Zeigler 1979, Oedekoven 1985, Boisvert 2002), and the site may contain thin, rocky soils or clay pan (Rogers 1969). In addition to knolls or ridges, sharp-tailed grouse may establish leks on roads, airport runways, cropland, or native rangeland grazed by livestock (Hart et al. 1950, Rogers 1969, Hillman and Jackson 1973, Oedekoven 1985). In southeastern Idaho, 58% of 50 leks were in CRP (seeded to crested wheatgrass, *Agropyron cristatus*, and alfalfa, *Medicago sativa*), 22% in sagebrush, 8% in pasture, 8% agricultural fields, and 4% in mountain shrub (Ulliman 1995).

Figure 8. Columbian sharp-tailed grouse habitat on Scotch Creek Wildlife Area, Washington.

Nesting habitat. The location of nests relative to the leks at which females breed has often been used to identify the most important habitat to protect and manage. Females generally select nest sites near the lek at which they breed (Table 5). In Washington, females nested an average of 1,387 and 1,886 m from their lek of capture on the Colville Indian Reservation and Swanson Lakes Wildlife Area (WLA), respectively (McDonald 1998). These means were not statistically different, but the median distances (855 vs. 2,134 m) indicated that females tended to nest closer to the lek on the Colville Reservation. McDonald (1998:71) suggested that this was probably due to higher quality and quantity of nesting habitat near leks on the reservation. The maximum distances from lek to nest were 3,214 m on Swanson Lakes WLA, and excluding 2 outliers of >6,500 m, was 3,473 m on the Colville Reservation (McDonald 1998:45).

Whether an area is suitable for nesting and brood rearing depends on the amount, height, and density of vegetation, especially forbs and grasses. Much of the cover available at nest initiation is residual cover from the previous growing season (Meints et al. 1992). Grasses and forbs conceal the nest and provide shelter for the brood during spring and ear-

Table 5. Distance from lek of capture to initial nest reported for Columbian sharp-tailed grouse in Washington, Idaho, and Colorado.

State	Reference	*N*	Mean ±SE km	Median	Range (km)
Washington	McDonald (1998)				
	Colville Reservation	37	1.4±0.26	0.9	0.2–7.0
	Swanson Lakes WLA	17	1.9±0.26	2.1	0.1–3.2
Idaho	Apa (1998)	41	-	1.4	0.2–12.8
	Meints (1991)	16	1.2±0.9		
Colorado	Collins (2004) [b]	130	1.5	1.0	0.2–21.8
	Boisvert (2002) [c]	58	1.3	0.6	0.1–11.3

ly summer (Marks and Marks 1987a, Meints et al. 1992, Giesen and Connelly 1993). Sharptails occasionally nest in agricultural fields when native vegetation is lacking (Hart et al. 1950, Zeigler 1979).

On the Swanson Lakes WLA and Colville Indian Reservation (Figs. 9, 10), most females selected nest sites in homogenous grasslands or CRP (McDonald 1998). Of 17 nests on the Swanson Lakes WLA, 11 were in CRP, and 5 in grass/forb; no nests were found in sagebrush cover type, though it accounted for >80% of the available cover. On the Colville Reservation, 33 of 37 nests were in grass/forb; 3 were in grass/shrub, 1 in CRP, and 0 in sagebrush cover type (defined as >9% of available cover, McDonald 1998). Most nests were located at the base of a bunchgrass, or between two bunches; four nests were under sagebrush (McDonald 1998). In the Curlew Valley of Idaho, about half the nests were under shrubs, and one fourth each under forbs and grass; plant form chosen did not affect nest success (Apa 1998).

In contrast, Meints (1991) and Marks and Marks (1987a) reported the use of shrub habitats by Columbian sharp-tailed grouse in areas that were predominantly shrubland in Idaho. The cover provided by shrubs, and the associated residual grass was essential for early spring nesting by plains sharp-tailed grouse in southern Alberta (Roersma 2001). Roersma (2001) described prime nesting areas as shrub cover with adequate amounts of grasses and forbs, with cover being 25–30 cm in height. He considered a 1:1:1 ratio of cover in shrubs, grasses, and forbs to be ideal.

Sharp-tailed grouse consistently nest in areas with higher cover compared to available sites (Apa 1998, McDonald 1998, Boisvert 2002, Collins 2004). In Washington, females selected nest sites with greater overhead cover, higher visual obstruction and litter cover, and less bare ground within 5

Figure 9. Columbian sharp-tailed grouse habitat in the Greenaway Springs area, Colville Indian Reservation, Washington.

m of the nest than occurred randomly in available cover types (McDonald 1998). All cover variables were higher, and there was less bare ground at successful compared to unsuccessful nests. Similar to findings of Meints (1991) and Marks and Marks (1987a), 'visual obstruction' appeared to be the most important vegetation variable distinguishing selected from random sites and successful from unsuccessful nests (McDonald 1998). In the Curlew Valley of Idaho, nesting areas averaged 62% shrub cover; grass cover and sagebrush height were important variables predicting nest locations (Apa 1998).

Figure 10. Columbian sharp-tailed grouse habitat in the Nespelem area, Colville Indian Reservation, Washington.

Visual obstruction readings (VOR) are the height of a cover pole obstructed by vegetation (to the nearest 5 cm [2 in]) (Robel et al. 1970). VOR is often reported for the nest bowl, for the nesting cover around the nest, and paired random locations in the same cover type. VOR data can be confusing, because researchers have varied in sampling details, such as the height (observer's eye level) and distance from the nest that VOR was recorded. The timing of data collection is also important because the vegetation is taller later in the nesting season (Collins 2004). VOR at the nest site is indicative of the type of site suited for nesting, but data from a wider area of nesting cover may be more helpful to managers. Researchers also may not report any indication of variance, which can be important. For example, two fields may both have a mean VOR of 15 cm, but one supports nesting because of many sites with >30 cm, but the other does not because there is little variation to provide good nest sites (Table 6). In a habitat suitability index model (HSI) for the Columbian sharp-tailed grouse, Meints et al. (1992) reported mean VOR of residual vegetation for fields used for nesting and brood rearing in Idaho collected in June at a distance of 4 m from a predetermined point, and 1 m above the ground, as suggested by Robel et al. (1970). VOR for various types of nest/brood cover ranged from 19–57 cm, but they concluded that optimal for nesting and brood rearing habitat in Idaho was $\geq$25 cm (10 in), with suitability declining to zero at 10 cm. In Washington, McDonald (1998) reported that VOR measured 5 m from the nest and at paired random sites at a distance of 50-100 m within the same nesting cover type as the associated nest (p 45; McDonald does not state the height at which recorded, but cites Robel et al. 1979, suggesting 1 m was used). Data were collected 10-86 days after nest termination. Mean VOR at nest sites was 23.7 cm vs. 16.6 at random sites; there was no difference between nest and random points at distances of 5–20 m. VOR was higher at successful nests (27.9 cm) vs. unsuccessful nests (23.6 cm) at 0–5 m, and at 10–20 m from the nest (19.2 cm vs. 15.5 cm).

Brood-rearing habitat. Brood-rearing occurs during late spring and summer. Brood-rearing habitat contains diverse cover of shrubs, forbs, and bunchgrasses, where insects are abundant. In Washington, >75% of brood locations were in grass/forb (Colville Reservation), or grass/forb and CRP (Swanson Lakes WLA) cover types (McDonald 1998). Summer habitat in Colorado contained $\geq$70% shrub cover (Giesen 1987); most successful females raised broods within 1 km of their nests, indicating that they selected nest sites in or adjacent to suitable brood habitat (Boisvert 2002, Collins 2004). Brood-rearing habitat in the Curlew Valley of Idaho was very similar to nesting habitat, except with greater cover values. Brood-rearing habitat also contained shrubs, forbs, and bunchgrasses in

Table 6. Visual obstruction (VOR; mean±SD), height of herbaceous vegetation, and forb cover in Columbian sharp-tailed grouse nesting and brood-rearing habitats.

Parameter	Vegetation measurement (cm)	Observation details	State	Study
VOR	23.7	All nests; 0–5 m, from 1 m height; 10-86 days after nest termination (successful nests: 27.9)	WA	McDonald (1998)
	16.6	Paired random sites		
	19.3±0.3	Within 20 m radius from nests from 1 m height		
	16.5±0.3	Paired random sites in same cover type		
	25±1.6	Nest and brood habitat; 4 m from 'nest point', 1 m height; June, mean of 4 study areas	ID	Meints (1992)
	29.9±12.6	1999: 1 m from nests at 1.5 m height,	CO	Boisvert (2002)
	12±7.9	Paired random sites in same cover type		
	33.3±14.6	2000: 1 m away from nests at 1.5 m height		
	10.0±6.8	Paired random sites in same cover type		
	49.9±15.2	1999: Brood-rearing sites,		
	44.1±18.3	Paired random sites in same cover type,		
	54.3±26.5	2000: Brood-rearing sites,		
	43.8±22.1	Paired random sites in same cover type,		
	48.9±21.1	Nests, 2.5 m away from 1.5 m height, in shrub-steppe or mountain shrub	CO	Collins (2004)
	43.6±29.7	Brood-rearing sites, 2.5 m away from 1.5 m height, in shrub-steppe		
Grass height	26.8±8.7	Successful nests	ID	Meints (1991)
	18.4±2.0	Unsuccessful nests		
	25.6, 41.9	Brood-rearing sites, 2 years		
	21.9±12.2	Nests sites in shrub-steppe or mountain shrub	CO	Collins (2004)
	19.1±5.7	Paired random sites in same cover type		
	24.8±8.1	Brood-rearing sites in shrub-steppe		
	19.2±6.1	Paired random sites in shrub-steppe		
	68, 93.5	Nests, 2 study years	CO	Boisvert (2002)
	84.7,64.6	Brood-rearing sites, 2 years		
Forb height	44, 31.6	Nests, 2 study years		
	11.2±3.6 9.9±2.8	Brood-rearing and random sites, shrub-steppe or mountain shrub	CO	Collins (2004)
Grass and forb height	53±7	Nest sites	ID	Apa (1998)
	40±7	20 m radius from nests		
% Forb cover	12.7±5.3%	Nest sites	WA	McDonald (1998)
	12.8±5.3%	Paired random sites in same cover type		
	15±5.8%	Brood-rearing sites	CO	Collins (2004)
	9.9±5.8%	Paired random sites in same cover type		

Idaho (Marks and Marks 1987a), Utah (Marshall and Jensen 1937, Hart et al. 1950), and Wyoming (Klott and Lindzey 1990).

Females prefer to raise broods in areas with abundant forbs and diverse vegetation because they contain abundant insects that chicks depend on for food (Bernhoft 1969, Marks and Marks 1987a, Klott and Lindzey 1990, Meints 1991). Some studies report an association of broods with habitat edges (Klottand Lindzey 1990, Meints 1991), but others found no relationship (Boisvert 2002).

Apa (1998) reported that brood-rearing areas had twice the forb cover (8%) of independent sites. Forbs typically found at brood sites included fleabanes (*Erigeron* spp.), poverty weed (*Iva axillaris*), tansyasters (*Machaeranthera* spp.), goldenrod, agoseris (*Agoseris* spp), hawksbeard (*Crepis* spp.), prickly lettuce (*Lactuca serriola*), skeleton plant (*Lygodesmia juncea*), common dandelion, and yellow salsify. Klott and Lindzey (1990) reported that key variables in distinguishing areas used by sharp-tailed grouse broods compared with greater sage-grouse broods, was the presence of oniongrass (*Melica* spp.) and sulphur-flower buckwheat (*Eriogonum umbellatum*).

Summer habitat used by females with broods may be different than habitat used by males or females without broods. In Idaho, Marks and Marks (1987a) reported that both male and female sharp-tailed grouse used areas containing more shrubs than random sites during summer, and McArdle (1977) found most grouse (77%) were in areas with 20 to 40% shrub canopy cover. In late summer and fall, sharp-tailed grouse females with broods in Colorado moved to riparian areas or mountain shrub cover type, where there was green vegetation, berries, and shade (Giesen 1987); green vegetation may be an important source of moisture.

Winter Habitat

Habitats with deciduous trees and shrubs are essential during winter because they provide cover, berries, seeds, buds, and catkins when the ground is snow-covered. In Washington, critical winter habitats are frequently in riparian areas. Some areas with suitable nesting and brood-rearing habitat may not be used because the areas lack adequate winter resources. Standing wheat or spilled grain in fields is an important winter food source in some locations; standing wheat is important when spilled grain is covered by snow.

Sharp-tailed grouse often use winter habitat relatively close (≤6.5 km) to summer areas (Meints et al. 1992), but in some locations move >20 km to winter habitat (Boisvert et al. 2005). Habitats with deciduous trees and shrubs located in riparian (Fig. 11) or mountain foothill areas provide essential food and cover for Columbian sharp-tailed grouse during winter (Marks and Marks 1988, Meints 1991, Giesen and Connelly 1993, Ulliman 1995). Ulliman (1995) concluded that riparian shrub habitat comprised only 2% of his study area, but received a disproportionate amount of use in most winters. The most important shrubs were serviceberry, chokecherry, and quaking aspen. Sharp-tailed grouse moved to deciduous trees and shrubs as snow depth increased in Washington (Weddell

Figure 11. Deciduous winter habitat on Poween Creek on the Colville Indian Reservation.

et al. 1991b, McDonald 1998), Idaho (Marks and Marks 1987a, 1988; Meints 1991, Ulliman 1995), Montana (Swenson 1985), Utah (Marshall and Jensen 1937), and Colorado (Boisvert 2002). During winter, sharp-tailed grouse often roost in woody vegetation (mostly shrubs) or under the snow (snow burrows) when deep, soft snow exists (Oedekoven 1985; Swenson 1985; Marks and Marks 1987a, 1988). Although snow depth that affected food availability caused grouse to move, they seemed otherwise unaffected by weather and cold temperatures, and they did not seem to select sites based on slope, aspect, or elevation (Ulliman 1995).

In Washington, sharp-tailed grouse winter in a variety of cover types (Schroeder 1996). Use of CRP, grass/forb, and grass/shrub cover types declined in winter and use of sagebrush and riparian/mountain shrub increased (McDonald 1998). On the Swanson Lakes WLA, the riparian/mountain shrub habitat (7.8% of detections) and wheat fields (17.7%) were only used during winter; the wheat fields used included wheat left standing for wildlife. Use of sagebrush was much higher than in other seasons (47% vs. 18%), but its importance is likely over-represented because many detections of birds in sagebrush were actually in snow burrows adjacent to riparian or mountain shrub where foraging likely occurred (McDonald 1998). Riparian and mountain shrub habitats were also used more in winter than other seasons (15.9 vs. 3.7%) on the Colville Indian Reservation (McDonald 1998). Water birch, rose, chokecherry, and big sagebrush are important winter food and cover species (Zeigler 1979, Hofmann and Dobler 1988a, Weddell et al. 1991b). Zeigler (1979) and Hofmann and Dobler (1988a) considered water birch the most important species.

During a mild winter, sharp-tails in the Pocatello Valley of Idaho remained in CRP and ate forbs (Schneider 1994, Ulliman 1995), but when snow was deeper the next winter they moved to riparian and mountain shrub habitats. During the same mild winter (1993), sharp-tailed grouse remained in the Curlew Valley and foraged on midge galls in sagebrush and Russian olive fruits (Schneider 1994), although these birds may have lost weight subsisting on this diet (Ulliman 1995). Sharp-tailed grouse in Ulliman's (1995) study made no use of wheat fields during winter. Sharp-tailed grouse in Wyoming moved to ridges, hilltops, and steeper slopes blown free of snow during late fall; during December to March they were observed in mixed shrubland and woody riparian habitat (Oedekovan 1985).

POPULATION STATUS

North America

Bendire (1892) considered sharp-tailed grouse one of the most abundant game birds of the Pacific Northwest. They were reported to be exceedingly abundant in eastern Oregon in the 1860s (Olson 1976). Although they were found in extraordinary numbers, populations began declining in much of their range in the late 19th century. A pioneer in Utah stated, "there were tens of thousands of these chickens until about 1875 when they began to dwindle" (Hart et al. 1950). Dr. W.W. Henderson of Utah State believed it would be possible to see 10,000, but noted that enormous numbers were killed and wasted (Hart et al. 1950). Populations in Idaho were said to be declining rapidly in 1917 (Rust 1917). In Nevada, sharp-tailed grouse were common in northern portions of the state, but they began declining around 1900 and the last record was in 1952; the success of a recent reintroduction project is uncertain (Starkey and Schnoes 1979, Bart 2000, Coates et al. 2006). Sharp-tailed grouse were common in the Modoc region of northern California, but were extinct by the late 1920s. Grinnel et al. (1918; *in* Starkey and Schnoes 1979) attributed their disappearance to the "incessant pursuit by man".

Columbian sharp-tailed grouse were declining rapidly in Oregon by 1899, and the last verified sighting was in 1967. They were extinct in Oregon for over 20 years until reintroduced into Wallowa County in northeastern Oregon during the 1990s (Bart 2000, Coggins 2003). A total of 357 birds from Idaho and Utah were released during 1991–1997, 2001–2002, 2006–2008 (Crawford and Snyder 1994, Coggins 2003, C. Hagen, pers. comm.). Numbers have remained low; September flush counts fluctuated between 24–56 birds between 2001–2007 (ODFW

2007). The amount of wintering habitat in the area may be limiting this population (C. Hagen, pers. comm.).

Columbian sharp-tailed grouse currently occupy about 8% of their historical range. The subspecies may have gone extinct in Montana within the last 5 years (Hoffman and Thomas 2007). Considering only public lands, Bart (2000) estimated that Columbian sharp-tailed grouse were imperiled on 91–95% of their current range. Bart (2000) estimated the total range-wide population at 56,000–62,000, with most of these birds in Idaho (40,000), Utah (5,100), Colorado (4,760; if these are considered *columbianus*), and British Columbia (4,700–9,600). As of 2000, they were separated into 15–20 isolated populations, with bird numbers declining in 8 populations, and 6 having fewer than 50 birds (Bart 2000). Very small populations without augmentation and recovery programs will likely go extinct within 10–20 years. Many of the local populations in the U. S. depend on lands enrolled in CRP, and the main populations in British Columbia are in clearcuts and dependent on timber harvest schedules maintaining habitat on the landscape.

Washington: historical distribution and abundance

Distribution and abundance during early Euro-American settlement. Historically, the Columbian sharp-tailed grouse was an important game bird to Native Americans and Euro-American settlers in eastern Washington (Darwin 1918, Post 1938, Buss and Dziedzic 1955, Yocum 1952). Lewis and Clark indicated that sharp-tailed grouse were locally common to abundant on the lower Snake and Columbia rivers as far west as The Dalles in 1806; Lewis wrote "they associate in large flocks in autumn & winter" (Zwickel and Schroeder 2003). David Douglas reported that at the trading post near Kettle Falls in 1826, dusky and sharp-tailed grouse were "so plentiful that they formed a principal part of food" (Douglas 1914:63). On 6 July 1834, John Kirk Townsend killed 22 sharp-tailed grouse during a morning's hunt near present-day Wallula (Townsend 1987). George Suckley reported that they were "exceedingly abundant wherever there is open country and a sufficiency of food," and J.G. Cooper found "flocks of several hundreds" in the "low alluvial prairies of the streams emptying into the Columbia" (Suckley and Cooper 1860:223-224).

An account by an early pioneer in the Palouse of southern Spokane County noted that in 1873 the family obtained hogs and cattle to supplement their diet of game, noting that, "prairie chicken and grouse populations remained stable" (Hergen 1990). Garret Kincaid who lived in the town of Palouse in Whitman County remarked that when his family arrived in 1877 there were "thousands of prairie chickens" in the area, but they soon declined with settlement and cultivation of the prairie (Kincaid and Harris 1979). Correspondance of early settlers in the steppe foothills of the Blue Mountains also indicate that they subsisted on sharp-tailed grouse (G. Green, pers. comm.). Orville Payne, who lived on the South Fork Touchet River, 5 mi southeast of Dayton, Columbia County, recalled that in about 1890, hundreds of sharp-tailed grouse came down to the creek bottoms after a heavy snow, and some flocks covered an acre (Buss and Dziedzic 1955). Kuykendall (1984:82) reported similar observations of flocks on Pataha Creek in Garfield County in the early 1880s, and noted that "prairie chickens" were "found in all parts of this and surrounding counties in almost limitless numbers, except in higher timbered sections." Earl Larrison noted that old settlers claimed that in the 1880s and 1890s, it was nothing to fill up the bed of a wagon with sharp-tailed grouse in a single day's hunt (Larrison and Sonnenberg 1968). In late fall and early winter, in the Big Bend country, they "…congregated in great flocks, sometimes several hundred birds could be seen in a single flock (Myers 1948:236). In the 1930s, H. Lee Hanford saw about 500 to 600 sharp-tailed grouse during the winter in the water birch in an area that now includes the Bridgeport Unit of the Wells Wildlife Area in Douglas County (M. Hallet, pers. comm.). Darwin (1918; *in* Merker 1988) states, "Walla Walla, Whitman, Spokane, Asotin, Garfield, Columbia, Lincoln, Ferry, and Stevens counties all … boasted of their great prairie chicken shooting…". Large flocks of sharp-tailed grouse were also found throughout the Klickitat Valley in the 1860s (Ballou 1938:171, Attwell 1977).

Based on museum specimens, historical accounts, and available habitat (Appendix C), sharp-tailed grouse were abundant, with the highest densities in the grasslands, meadow steppe, more mesic shrub-steppe habitats, and the edges between steppes and pine forest. There are few records from the drier Wyoming big sagebrush (*A. t. wyomingensis*) habitats of the central Columbia Basin, but they were apparently present in local areas, especially in river valleys, like the Yakima, and in the more mesic Big Sage/Fescue and Three-tip Sage vegetation zones (Cassidy 1997). Snodgrass (1904) led a collecting trip from Pullman to Yakima, and back, and reported that sharp-tailed grouse were abundant along the Touchet River in Walla Walla County, but were, "Not seen in any of the sagebrush regions of Franklin or Yakima [Yakima included Benton County at that time] Counties," Snodgrass (1904) noted, however, that sage-grouse were found throughout the entire sagebrush region. He describes large areas of the lower Columbia Basin as sand desert devoid of vegetation; these areas were later irrigated by the Columbia Basin Project. Dice (1916) also reported that sharp-tailed grouse were most abundant in bunchgrass prairie and noted that they were only "reported" for the sagebrush habitat of western Walla Walla County.

Initially, agriculture and logging may have seemed beneficial for sharp-tailed grouse because of an apparent temporary increase in their populations (Yocom 1952, Jewett et al. 1953, Smith 1986). However, sharp-tailed grouse may have simply been more concentrated near farms when wheat fields provided a new seasonal food source, but before widespread habitat loss (Merker 1988). Many sharp-tailed grouse used waste grain as a seasonal food. They also aggregated around, fed on, and burrowed into stacks of wheat hay during fall and winter (M. Hallet, pers. comm.).

The number of sharp-tailed grouse that inhabited Washington at the time of Euro-American settlement will never be known precisely, but a conservative estimate suggests the population may have exceeded 100,000. Sharp-tailed grouse densities likely varied widely, but were probably highest in the deep soil, high precipitation areas of the Palouse prairie, and lower in shrub-steppe.

Density estimates from other states provide a basis for a hypothetical historical population estimate. Columbian sharp-tailed grouse densities were estimated for "good habitat" in Colorado (0.013-0.019 birds/ac; Rogers 1969), and the Curlew and Pocatello valleys of Idaho which receive 13–18" annual precipitation (0.002–0.008 birds/ac; Ulliman 1995). However, >75% of the Curlew Valley was seeded with one to three species of non-native grasses and one or two species of forbs, and nest success was lower in non-native vegetation than in native vegetation (Apa 1998). Some density estimates for prairie sharp-tailed grouse are considerably higher. Edminster (1954) cites a 1930 estimate for Wisconsin by Aldo Leopold of 0.02 birds/ac, and estimates from Drummond Island, Michigan, during spring of 0.022 birds/ac, and 0.056 birds/ac during fall, by Amman. Gratson (1988) reported a spring density of 0.008 for a Wisconsin study area. Symington and Harper (1957) reported a density of 0.039–0.063 birds/ac in favorable habitat of the Sand Hills region of Saskatchewan.

The historical range in Washington, with steep slopes and low precipitation areas removed (slopes ≥40%, and precipitation zones ≤9"), totaled about 12.5 million acres; perhaps another 2 million ac was forest, emergent wetland or otherwise unsuitable. There were some birds in lower precipitation areas that we have left out of the range polygon (e.g. near Wallula), but these may have been only in river valleys. Assuming a density of 0.03 birds/ac for the 3.5 million ac that is now cropland (probably the most productive), and 0.002 birds/ac for the remaining 7 million ac of shrub-steppe and grassland, yields a total of 119,000 birds. Though populations were dramatically reduced by the 1950s, Schroeder et al. (2000), projecting rate-of-change from data from recent decades, suggested there were perhaps 10,000 sharp-tailed grouse in Washington in 1954 at a time when most of the habitat and, all of the best habitat, had already been lost, so this estimate may be reasonable.

Population decline. Sharp-tailed grouse remained abundant in the early stages of Euro-American settlement, but with high rates of harvest and increasing cultivation, declines became obvious by 1897 (Buss and Dziedzic 1955). By 1900 there were hundreds or thousands of farms in the Palouse, and in Douglas, Spokane, and Lincoln counties, and the valleys of northeastern Washington (Yocum 1952). In Whitman County, from 1879 to 1893 the hunting season was 1 August–1 January with a daily bag limit of 20 sharp-tailed grouse (Buss and Dziedzic 1955). By 1897, population declines resulted in the state legislature shortening the sharp-tailed grouse season statewide to August - November; in 1903, daily bag was reduced to 10 birds (Buss and Dziedzic 1955). In 1909, Whitman County further reduced the season to October–December with a daily bag limit of 5; in 1913 the county shortened the season again to 15 September –1 November. In 1918, the daily bag was 5 "prairie chickens," and there was a weekly limit of 25. The county closed the season in 1919 (Buss and Dziedzic 1955).

The range of sharp-tailed grouse in Washington contracted with the intensification of agriculture, in a somewhat predictable pattern (Fig. 12). Myers (1948:236) noted that after 1910, each succeeding year saw numbers diminished further. The last record of sharp-tailed grouse in the upper Columbia Valley is the 1915 report of "three pairs" by E. A. Blakely near Kettle Falls (Jewett (1953). Farming of the narrow valleys and unregulated hunting likely eliminated sharp-tailed grouse from these areas relatively quickly. Additionally, Dzeidzic (1951: 40) suggested that the use of poisoned grain placed along fencerows to control ground squirrels may have severely impacted the sharp-tailed grouse population, and poisoned grain used to control jackrabbits may have affected sharptails in Okanogan County in the 1950-1960s (P. Fowler, pers. comm.). In the Palouse, one period of steep population decline was 1910–1920, when burning and plowing of wheat stubble during the nesting season became common practice. One Palouse farmer found 16 sharp-tailed grouse nests after he burned 150 ac of stubble; he saw no sharp-tailed grouse on his farm after 1915 (Yocum 1952, Buss and Dziedzic 1955). Sharp-tailed grouse remained along the Snake River breaks and in the more rocky scablands of western Whitman County into the 1950s. The sparse sharp-tailed grouse populations in the drier portions of the Columbia Basin may have depended on winter habitat elsewhere, and been reduced along with it. The spread of irrigated cropland with the Columbia Basin Project may have eliminated remnant populations.

Prior to 1933, counties set their own hunting seasons. For a period of time, Okanogan, Ferry and Stevens counties maintained a season of 2–6 weeks with a bag limit of 5/day, and Klickitat County maintained a season from 1–10 September, with a bag of 3/day until 1924 (Buss and Dziedzic 1955). In 1933, a moratorium was placed on sharp-tailed grouse hunting statewide. The intensification and increased mechanization of farming continued to eliminate native vegetation until 1945 when practically all available land was under cultivation (Buss and Dziedzic1955). The last sharp-tailed grouse records from Klickitat County are from the 1940s. They may have still been present in southwest Stevens County in the early 1950s (Yocum 1952).

In 1953, a 2-day season on sharp-tailed grouse was re-opened in three counties with daily and possession limits of one and two, respectively. Harvest data

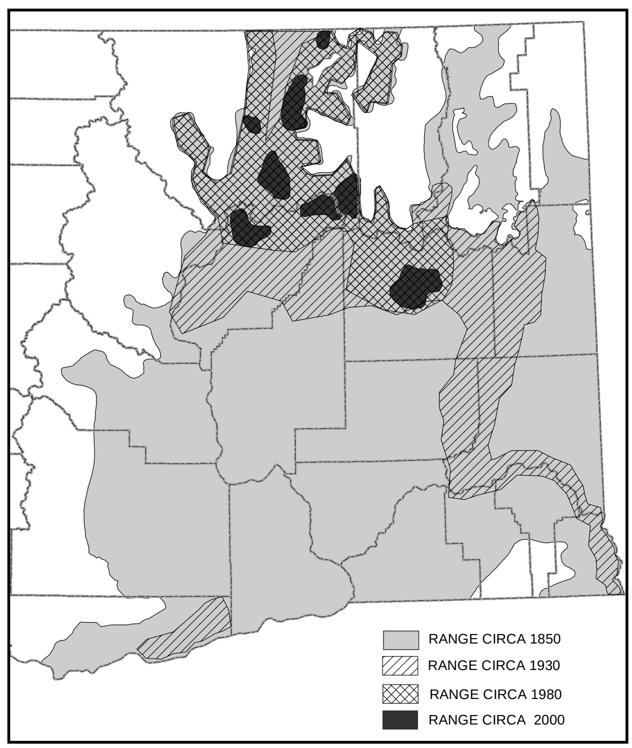

Figure 12. Approximate chronology of the range contraction of Columbian sharp-tailed grouse in Washington (based on Yocum 1952, Zeigler 1979, Merker 1988, Schroeder et al. 2000, and historical records in Appendix C).

for sharp-tailed grouse were never tallied separately from other grouse species, so harvest figures are unavailable. In 1954, the daily limit increased to two, the possession limit increased to four, and in Okanogan County, the season increased to 8 days. The illegal kill of sharp-tailed grouse by hunters seeking other species, and by orchard owners may have been significant during this period (J. Patterson, pers. comm., *in* Hays et al. 1998).

Some early attempts were made to restore local populations with translocation of birds from other areas. According to Dr. Phil Wright, University of Montana, who helped with the capture, there was a translocation of Columbian sharp-tailed grouse from the National Bison Range in Montana to eastern Washington "about 1930" (M. Schroeder, notes on a conversation 21 June 1994); no other details are known. In 1954, there was also a translocation of sharp-tailed grouse from the Tunk Valley in Okanogan County, where 200 sharp-tailed grouse were congregated at a haystack, to Turnbull National Wildlife Refuge, Spokane County. In the early 1960s, sharp-tailed grouse from Okanogan County were released on the Wooten Wildlife Area in Columbia and Garfield counties (Hays et al. 1998). These projects were not successful at re-establishing local populations, and had no effect on the long-term outcome for the local populations.

Washington: population status 1960–2011

There was little attempt to monitor sharp-tailed grouse populations in Washington until 1954 when annual lek counts began on a limited number of leks in Okanogan County (Zeigler 1979). [Some leks shift location up to a few hundred meters year-to-year, and over time mapped locations form a cluster of points that Schroeder et al. (2000) call a "lek complex"; for simplicity, we use the term, 'lek.'] Lek counts expanded to Lincoln and Spokane counties in 1959. The Deer Park Airport lek in northwestern Spokane County was last active in 1964 (Zeigler 1979).

Most of the leks surveyed between 1954 and 1969 were opportunistically visited by members of bird-watching organizations and WDFW personnel, consequently they provide limited information on population levels or trends, but do indicate the presence of birds in areas. Surveys of leks prior to 1970 typically consisted of a single count of the birds attending a lek during the breeding season; methods were not standardized. According to Steve Judd, biologist on the Colville Reservation for many years, sharp-tailed grouse were abundant in the eastern portions of the reservation in the 1940s, and were still present through the 1970s. WDFW and the Colville Confederated Tribes standardized methods and expanded surveys between 1970 and 1989 to include multiple (≥2) visits to specific leks and additional searches for new and/or previously undiscovered leks. The Watson Draw lek northeast of Pateros in southwestern Okanogan County was active into the 1980s. Biologists surveyed many more leks after 1987, and The Nature Conservancy assisted with surveys and the compilation and reporting of data in the early 1990's (Hofmann and Dobler 1989, Weddell et al. 1990, 1991a, Weddell and Johnston 1992a,b). Increased survey effort, greater frequency and standardization of lek counts, and the discovery of satellite leks (new locations near a primary lek) resulted in a higher number of birds counted on leks statewide from 1970 to 1996 (Hays et al. 1998). Since the early 1990s, WDFW and Colville Confederated Tribes have attempted to visit all leks that have been active in recent years on ≥2 occasions each spring. At least one sharp-tailed grouse lek persisted in the Methow Valley into the 1980s, and there were occasional individuals sighted in the 1990s.

All of eastern Washington was re-opened for sharp-tailed grouse hunting in 1965, presumably because of conventional dogma about compensatory mortality and hunting effort being self-limiting, and daily and possession limits remained at two and four until 1976. Possession limits were reduced to two in 1977. All counties except Lincoln were closed to sharp-tailed grouse hunting in 1985 because of population declines. Seasons were closed statewide in 1988.

One hundred thirty-six active lek complexes were documented in Washington between 1960 and 2011. From 1960 to 2011, the number of active leks declined 42%. The loss of active leks over time indicates a trend in reduced population, range, and the resulting isolation of populations of sharp-tailed grouse in the state. Hofmann and Dobler (1989) reported that many leks, though still active, exhibited a decline in the number of birds attending. For every lek with at least 7 years of data, the number of birds counted declined, and the longer the period, the greater the decline (Hofmann and Dobler 1989). The decline was experienced at both the state and county level. From 1980 to 1989, the Lincoln County population estimate declined from about 1,500 to 150 birds (Hickman 1989). Active leks in Douglas, Okanogan, and Lincoln counties disappeared at large rates (52%, 63.8%, and 77.4%, respectively) from 1954 to 2011. Of the 136 leks documented between 1960 and 2011, 92 (67.6%) are currently vacant; 28 (30.4%) of the vacant leks are in portions of the historical range that are no longer occupied. The remaining 64 vacant leks reflect declines in density within occupied portions of the historical range.

Statewide populations were estimated for Washington from 1970-2011. The annual estimates were derived from the highest number of birds observed on a single day for each lek for each year. Maximum attendance of birds at leks is often used to evaluate sharp-tailed grouse populations (Hart et al. 1950, Rogers 1969, Parker 1970, Marks and Marks 1987a, Giesen and Braun 1993, Ritcey 1995, Connelly et al. 1998). At the very least, lek counts provide a relative index of annual abundance, and at the most they provide an approximation of population size. The best surveys of sharp-tailed grouse require a relatively complete count of birds on all leks in a region. Rates of population change were analyzed by comparing the total number of birds counted at all leks surveyed in consecutive years (Schroeder et al. 2000, Connelly et al. 2004). Because counts were occasionally biased by lek size and accessibility, leks not counted in consecutive years or on both ends of a specific 2-year interval were excluded from the sample for that specific interval. The 2011 population was estimated by multiplying lek attendance numbers for each lek complex by 2; this technique assumes that most males attend leks, that lek counts include mostly males, and that the male:female sex ratio is approximately 1:1. Annual rates of population change were then used to estimate annual spring populations backward between 2011 and 1970 (Fig. 13). Because a few leks believed to be active in 2011 were not surveyed, the last counts available for these leks were used in the analysis of 2011 estimates (after being modified with the estimated annual rates of population change).

The analysis of annual changes in attendance at leks indicated that the average instantaneous rate of population change was -3.2% (SE = 3.2%) per year between 1970 and 2011. These annual changes were used to 'back-estimate' the population; the estimated population in 1970 was 3,737. The overall population declined almost continually between 1970 and 2001, particularly during the 1970s, when the estimated population declined from about 4,000 to about 2,000 birds. The overall estimated decline was 74.4% between 1970 and 2011. This analysis has inherent sources of bias and is limited by the lack of complete historical survey information, and therefore population numbers should be considered estimates. A few females are probably counted as males, but there may also be some males not attending a lek. Confidence intervals for these estimates cannot be readily calculated. The principle assumption is that changes in lek counts reflect changes in population size. The discussion and analyses above only look at leks that were active (birds present) in any year. The reduced monitoring when active leks became inactive limited the analysis.

Applegate (2000) objected to the use of lek surveys to estimate a statewide population, and stated that they were best used for detecting trends. An intensive banding or telemetry mark-resight study as described by Clifton and Krementz (2006) would likely provide a more accurate estimate, but would require a large financial expenditure. The telemetry study by Clifton and Krementz (2006) found that lek surveys consistently underestimated the local population of greater prairie-chickens in Kansas, this may also be true for sharp-tailed grouse. Drummer et al. (2011) reported that lek attendance by radio-marked sharp-tailed grouse exceeded 80% from 10 April to early May in Michigan; they developed a model of lek attendace that could be used to estimate abundance.

Currently in Washington, all known leks are counted

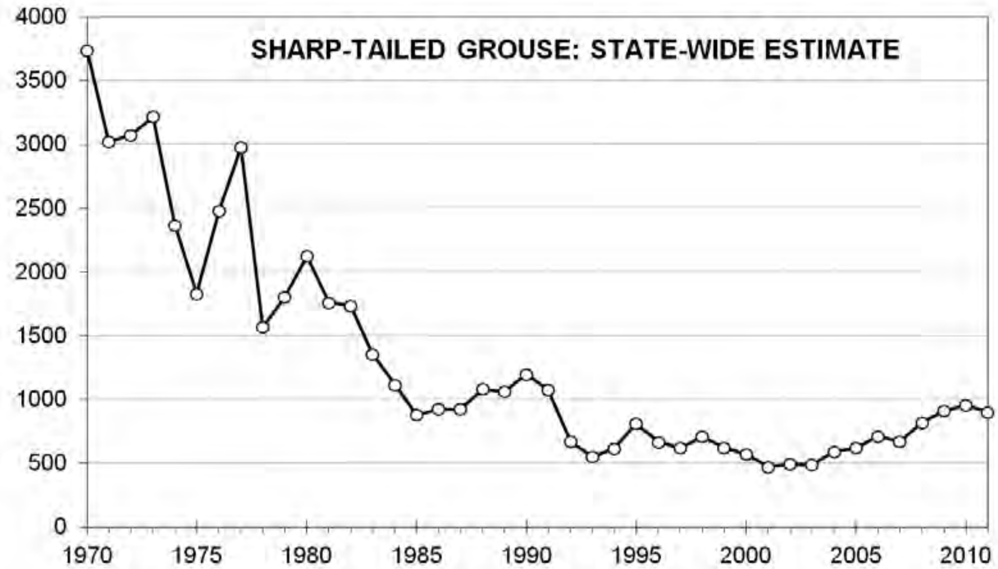

Figure 13. Estimated total population of Columbian sharp-tailed grouse in Washington based on lek count data, 1970-2011.

systematically each spring using standardized methods, and efforts are made to find new leks. Because the sharp-tailed grouse season is closed in Washington, the results do not affect decisions about harvest. The large magnitude of the downward trends in the distribution and abundance of sharp-tailed grouse in Washington indicate that overall conclusions are not likely to be altered by biases associated with lek counts, including lek movement and detectability, variability in lek attendance, and poorly defined male:female sex ratios.

Based on the distribution of active leks, sharp-tailed grouse appear to persist in seven relatively isolated populations that are separated by at least 20 km (Fig. 14). The distribution of sharp-tailed grouse has declined about 97% from historical levels and the overall abundance declined about 89% since 1970. The current distribution of 7 populations of sharp-tailed grouse in Washington cover approximately 2,173 km^2 (2.7% of the historical distribution): Chesaw (70 km^2); Tunk Valley (342 km^2); Scotch Creek (79 km^2); Greenaway Spring (340 km^2); Dyer Hill (308 km^2); Nespelem (513 km^2); and Swanson Lakes (521 km^2). The total population estimate declined from a high of 3,737 in 1970 to a low of 472 in 2001; some populations appeared to slowly increase to 2011. Greenaway Spring had no known leks in 2003–2011, but leks may have moved and gone undetected. The population in the Horse Springs Coulee area west of Tonasket, (Schroeder et al. 2000), now appears to be extinct. The remaining seven populations of Columbian sharp-tailed grouse in Washington totaled about 902 birds in 2011.

Populations in Washington may be too small to persist (Hamerstrom et al. 1957; Bouzat et al. 1998; Westemeier et al. 1998a). Two of the populations occupy areas <100 km^2 (Chesaw, Scotch Creek). A substantial portion of the habitat between existing populations consists of wheatfields, orchards, and reservoirs associated with dams. Although much of the habitat on state, federal, and tribal land is currently managed to benefit sharp-tailed grouse, it is critical to expand management efforts to incorporate both public and private lands into management areas that are large enough to support viable populations (Hamerstrom et al. 1957; Westemeier et al. 1998a).

Sharp-tailed grouse from healthy populations outside the state have been translocated to Washington to improve the vigor of local populations (Schroeder et al. 2011). Since 1998, a total of 391 sharp-tailed grouse have been translocated and released in areas where populations have been declining (see ***Population augmentation***).

HABITAT STATUS

Past

> On the slopes above the Palouse River were service berries, wild currants, and gooseberries in great abundance; the "luxuriant bunch grass" that grew everywhere provided excellent feed for the surveyors' horses."
>
> Theodore Kolecki, U.S. Army topographer (Mullan, 1863)

Reduction in the population and range of Columbian sharp-tailed grouse in Washington is primarily attributed to habitat loss. Initially, habitat was degraded by livestock grazing. Later, habitat was lost by widespread conversion to cropland and agricultural intensification, and then by continued degradation of the untillable remainder by livestock and invasive plants.

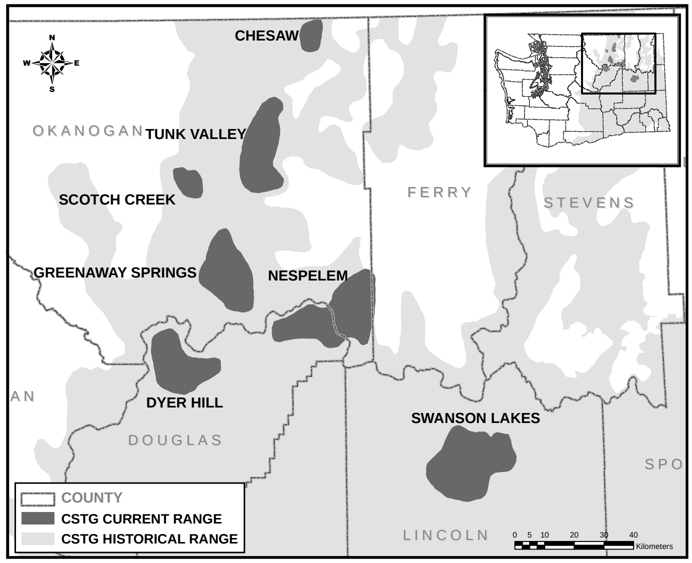

Figure 14. Areas currently occupied by Columbian sharp-tailed grouse in Washington.

The term 'Palouse' is used to refer to a geographic region of southeastern Washington and adjacent Idaho that historically supported meadow-steppe vegetation; in Washington it includes Whitman, southeastern Spokane, Asotin, and northern Garfield and Columbia counties. Daubenmire (1942) used the term 'Palouse grassland' as an ecological term that included the grasslands further west in Walla Walla County. More recently the vegetation of these regions has been termed Pacific Northwest Bunchgrass grassland, which is divided into Palouse Grassland and Canyon Grassland (Weddell and Lichthardt 1998). The term 'Palouse' is used in this plan in the geographic sense, and 'Palouse prairie' or 'Palouse grassland' is used to refer to the meadow-steppe vegetation of this region.

Before settlers arrived in the early 1800's, much of eastern Washington was covered with sagebrush/bunchgrass vegetation representative of shrub-steppe or native bunchgrasses/deciduous shrubs representative of the more mesic meadow-steppe (Daubenmire 1970). The Palouse region was characterized by bunchgrass prairies on dune-like hills of wind deposited loess up to 60 m (200 ft) deep (Cook and Gilmore 2004). The prevailing southwest winds resulted in steeper northeastern slopes where snow was deeper and shrubs, particularly Douglas hawthorn, snowberry, and *Rosa* spp. became established. Regional precipitation ranges from about 16" in the west to 22" at the Idaho state line. Deciduous shrubs in draws, northeast slopes, and riparian areas likely provided abundant buds and fruits for sharp-tailed grouse, including fruits from hawthorn, serviceberry, snowberry, rose, and chokecherry, and buds of birch, willow, aspen, dogwood, and others.

Within the shrub-steppe zone, sagebrush coverage ranged from 5 to 26% and perennial grass coverage ranged from 69 to 146% (sampling method accounts for overlapping plants) on undisturbed sites (Daubenmire 1970). Sharp-tailed grouse may have been more migratory in these drier areas where fewer deciduous shrubs for winter food were available. Few large ungulates inhabited these areas since the last glaciation and the vegetation evolved without intense grazing (Daubenmire 1970, Shinn 1980, Mack and Thompson 1982). Shallow streams meandered through meadows, and during spring flood, likely ran almost siltless (Victor 1935).

Human impacts in these areas were fairly modest. Native Americans made seasonal movements to harvest camas and other roots, berries, salmon and other fish, but there was almost no permanent human presence on the uplands of Palouse prairie (Meinig 1995, Black et al. 1999, Weddell 2002b).

Native Americans likely also burned some areas periodically or annually to improve yields of food plants (Marshall 1999).

Horses obtained by Native Americans in the Pacific Northwest around 1730 were the first large animals to graze eastern Washington in large numbers for at least several thousand years (Harris and Chaney 1984). By the early 19th century, the Yakama and Nez Perce tribes kept substantial herds of horses (Haines 1938, *in* Hessburg and Agee 2003). These herds grazed on the grasslands of the uplands during the summer and were wintered in the canyons (Tisdale 1986). Historical accounts of the large horse herds led Hessburg and Agee (2003) to speculate that localized damage from grazing may have already been occurring before Euro-American settlement. Tisdale (1986) indicated, however, that he observed no evidence of widespread heavy use or damage to the canyon grasslands from that period.

Euro-American settlement. Serious degradation of native prairie and steppe habitat began with early free-range (unconfined by fences) cattle operations. Ranchers were among the earliest Euro-American settlers in the Palouse region; they introduced cattle in 1834 and sheep in the 1880's. The number of horses increased between 1830 and 1880 (Daubenmire 1970). In addition to the lack of adaptation of the vegetation to grazing by large ungulates, the historical impact of livestock was aggravated by the high numbers of animals, the poor distribution of cattle in steeper terrain, and grazing during the spring and early summer when the native plants were particularly sensitive to damage (Tisdale 1986). Young (1943) reported that the result of prolonged grazing of Palouse grassland was the elimination of Idaho fescue and domination by Sandberg bluegrass and cheatgrass. Where steppe vegetation was grazed excessively, the density and canopy cover of native grasses was reduced allowing adapted alien species to invade (Daubenmire 1970). Concerning the native flora of the Columbia Basin, botanist John Leiberg wrote:

> "We will never know the complete flora of these regions…sheep and cattle are rapidly destroying the native plants and by the time private explorations reach these regions the flora will have been totally exterminated"
>
> (Leiberg 1896, *in* Weddell 2001a).

Rangeland in the Klickitat and Yakima areas was seriously overgrazed by 1879. In 1880, 72,000 head of cattle were driven to Wyoming from the Washington Territory (Meinig 1995: 286). In the Palouse and Walla Walla regions, ranching became restricted to the drier western parts and along the Snake River. The southern portion of the Big Bend region, from Crab Creek to Pasco, remained as free range and, along with the scablands, became important sheep areas in the mid-1880s. The range cattle industry peaked in the 1870s and largely ended in the 1880s (Meinig 1995).

Conversion of sharp-tailed grouse habitats to cropland. The Walla Walla River valley was one of the first areas to be permanently settled by Euro-Americans in eastern Washington. In 1859, valley bottoms in present-day Walla Walla County were being settled by farmers and ranchers (Mullan 1863). From 1860–1870, the human population of Walla Walla County grew from 1,300 to >5,000 as small farms proliferated and valleys were rapidly settled by homesteaders (Robbins and Wolf 1994). The discovery of gold near the headwaters of the Palouse River in present-day Idaho and in the Caribou region of British Columbia created a market for farm goods produced in eastern Washington, particularly flour and beef, though transport was limited to river boat, wagons, and cattle drives. Cattle drives to the mining districts peaked in 1862-1866, and totaled about 20,000 head each year; these tapered off with the gold and increasing self-sufficiency of the mining districts (Meinig 1995).

North of the Snake River, settlement along Union Flat Creek in present-day Whitman County occurred in 1869, and the county was organized in 1871. Spokane County first received settlers in the 1870s (Dziedzic 1951, Meinig 1995). In the late 1870s, the Palouse country was rapidly settled (Meinig 1995). Settlement of the area called the 'Big Bend country', including present-day Lincoln, Douglas, Grant and Okanogan counties, followed somewhat later. Douglas County settlement increased rapidly from 1883-1890 (Dziedzic 1951).

In the Palouse and Walla Walla areas, the bottomlands were farmed first and the uplands left for pasture; settlers were doubtful that the loess hills could grow wheat, but through experimentation the hills of loess proved perfectly suited for growing wheat and were less susceptible to spring frosts than the valleys (Kaiser 1961, Meinig 1995). Initially, spilled grain provided a new food source for sharp-tailed grouse (Yocom 1952). Considerable native vegetation remained at this time due to the need for much pasture for horses and the limits of farm technology and transport for agricultural goods. However, the arrival of railroads in the Palouse in 1885 allowed the transport of grain to larger markets outside the region, which promoted further land conversion to agriculture. The early development of dryland farming required large herds of horses, which grazed freely on rangelands when they were not being used for farming (Harris and Chaney 1984). Areas too steep or rocky to plow continued to be grazed, and most eventually were degraded to non-native vegetation, including annual bromes (*Bromus tectorum. B. japonicus, B. brizaeformis*) in the drier areas and Kentucky bluegrass (*Poa pratensis*) in moister areas.

By 1895, most tillable land in the Palouse had been converted to cropland, and by 1912, only small isolated tracts of well-developed prairie remained intact (Fig.15; Weddell 2001a). By 1920, 80% of the Palouse region available for agriculture was cultivated (Buss and Dziedzic 1955).

According to H. Lee Hanford (pers. comm. to M. Schroeder), when his father settled in the Bridgeport area about 1900, northern Douglas County was lush grassland that produced up to 1.5 tons/ac of grass hay; there was no sagebrush and little bitterbrush. Wilfred Shaw (pers. comm. to M. Schroeder) also indicated that the grass-dominated vegetation allowed horse-drawn combines to be used to cut native hay in the area. Livestock grazing and a long drought that began in the early 1930s had a dramatic effect and led to the abandonment of fields and large numbers of feral horses. These factors were believed to have led to the present condition of predominantly sagebrush cover. However, it is possible that climate factors may also have been involved in this change in vegetation.

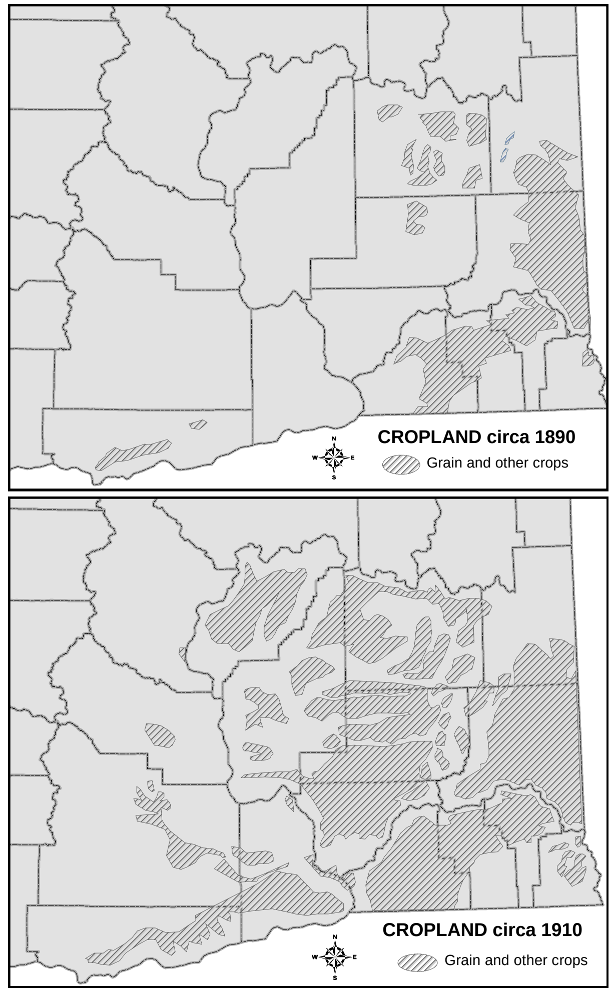

Figure 15. Rapid conversion of steppe habitat to cropland in eastern Washington, 1890–1910 (county boundaries are present-day; modified from Meinig 1995).

Sharptail habitat and the intensification of agriculture. The 20th century saw increasing intensification of agriculture and with it, the elimination of most remaining sharp-tailed grouse habitat (Dziedzic 1951, Yocom 1952). Small combines suited to the small hilly Palouse farms became available about 1910 (Meinig 1995). Prior to combines, wheat was harvested with headers or binders; stubble from a binder was short and easily tilled in, but headers left tall stubble that had to be burned (Jennings et al. 1990). Sharp-tailed grouse began using stubble fields for nesting, but burning of fields in spring resulted in the destruction of many nests (Yocom 1943, Myers 1948). Combine use greatly expanded in the 1920's and by 1930, 90% of

Palouse wheat was harvested by this method (Jennings et al. 1990, Black et al. 1999). The introduction of tractor farming and combines in the 1920's and 1930's eliminated the need for horses and temporarily allowed some recovery of rangeland, but continued improvements in farming equipment allowed the plowing of steeper slopes and resulted in most of the untilled pasture land being converted to cropland (Buss and Dziedzic 1955, Black et al. 1999).

Mechanization also enabled farmers to remove riparian habitat from drainage basins that separated small fields. Small fields were thus combined into large fields that were seldom used by sharp-tailed grouse. From 1920 to 1950, small numbers of sharp-tailed grouse occupied scattered patches of shrub/meadow steppe where cultivation was not practical (Hudson and Yocom 1954, Merker 1988). However, heavy livestock grazing on these patches contributed to the continued decline of sharp-tailed grouse (Merker 1988). Brushy draws and creek bottoms were replaced by ditches and gullies; pastures and fencerows formed of brush that had provided food and cover for sharptails were eliminated (Yocom 1952).

From 1947 to 1982, 301,500 ha (744,705 ac) of brush control occurred under the federal Agricultural Conservation Program and the Columbia Basin Project in Washington (Pedersen 1982). This included 88,393 ha (218,331 ac) of sagebrush chemically or mechanically treated and 213,120 ha (526,406 ac) converted to irrigated cropland and facilities. Twenty percent [60,800 ha (150,176 ac)] of all brush control occurred in Douglas, Lincoln, Kittitas, and Yakima counties. Douglas and Lincoln counties were core areas for the remaining sharp-tailed grouse populations at that time. Shrub control was used primarily to remove sagebrush on 12,360 ac on 138 farms in Lincoln and Spokane Counties between 1947 and 1967 (Adkins 1968). Although significant, the amount of sagebrush removed under federal programs was small compared to that removed by private landowners (Pedersen 1982).

Dams along the Columbia River resulted in additional loss of habitat due to flooding and expansion of irrigated farming. Hydropower development of the Columbia Basin and Snake River in the 20th century provided the irrigation water and the barge transportation that facilitated grain shipment for export markets that promoted the continued conversion of shrub-steppe and the drier grasslands to cropland (Cook and Gilmore 2004). The completion of Grand Coulee Dam in 1942 resulted in the inundation of 70,000 ac, including an estimated 32,000 ac of sharp-tailed grouse habitat that equated to an estimated loss of 2,800 birds (Howerton et al. 1986). Since 1951, the Columbia Basin Project has brought irrigation water to 671,000 ac (http://www.usbr.gov/dataweb/html/columbia.html).

Beaver and the loss and degradation of riparian sharptail habitat. Sharp-tailed grouse in Washington depend on deciduous vegetation along creeks in winter. Before Euro-American presence in Washington, beaver were likely present on many of the large and medium-sized streams in the semi-arid steppe regions, and beaver dams likely helped maintain riparian habitat used by sharp-tailed grouse. In the early 19th century, the Hudson's Bay Company conducted a deliberate campaign to eliminate fur resources from much of present-day Idaho, southeastern Washington, eastern Oregon, southwestern Montana and northern Utah. This was done first to keep Americans from coming west of the Continental Divide, and later in anticipation of losing British territorial claims (Mackie 1997, Ott 2003). Fur records indicate that from 1826-1852, >70,000 beaver pelts were traded at Forts Nez Perce (Walla Walla) and Colvile (HBC records, data on file). This eliminated beaver from much of the region.

Beaver dams dissipate stream energy, attenuate peak flows, trap sediment, raise the water table, and increase the effective area of the riparian corridor (Naiman et al. 1988, Pollock et al. 2003); these effects are particularly important for many species in semi-arid areas. The 19th century elimination of beaver may have initiated hydrologic and geomorphic changes in stream systems that eliminated many riparian forests (Pollock et al 1995). The subsequent failure of beaver dams caused erosion and down-cutting, resulting in channelized streams with narrow or no riparian vegetation, a lower water table, and more intermittent flow (Pollock et al. 1995). Much of the stream incision seen in the 20th century throughout the western United States may, at least partially, be a result of the widespread loss of beaver (Parker et al. 1985, Pollock at al. 2003).

The degradation of riparian habitat initiated by beaver removal was probably then accelerated by livestock grazing or conversion of meadows and stream banks to cropland. Kindschy (1985) reported that Pacific willow (*Salix lucida* Muhl. ssp. *lasiandra*) in southeastern Oregon maintained a high growth rate despite prolonged use by beaver. Beaver removed stems after the growing season when much of the plants reserves had shifted to the roots, but continual cropping of willow regrowth by cattle during the growing season reduced willow stands in many riparian corridors. Heavy use by livestock along with wild ungulates likely reduced or eliminated willow, alder, aspen, and cottonwoods from much habitat in the western United States (Kindschy 1985). Livestock browsing and agriculture eliminated riparian woody vegetation and with it, the possibility of beaver re-colonization that might have helped sustain sharptail winter habitat over time.

Continued loss of riparian and meadow habitats. Agiculture negatively affected riparian and moist meadow habitats by erosion and changes in hydrology. The destruction of prairie vegetation on Palouse hills exposed the loess soils to extraordinary erosion, and accelerated run-off increased the energy and erosion potential of area streams (Victor 1935). Larger streams with rock beds widened their channels and many smaller streams underwent rapid head erosion, advancing 20–100 feet per year (Victor 1935). Deadman Creek in Garfield County was crossed at any point by wagon in 1880, but in 1935 it was 25 feet deep and 100 feet wide (Victor 1935). When head erosion proceeded through wet meadows, the water table became lowered. Meadows and streams that were formerly too wet to farm and provided riparian and meadow habitat for sharp-tailed grouse became dry enough to plant wheat, often about 10–12 years after the surrounding land was converted to cropland (Victor 1935).

In addition to wintering, sharptail broods often move to riparian and moist meadows in summer for insects and green vegetation. Leiberg (1897, *in* Servheen et al. 2002) noted that with settlement, camas meadows were used as hay fields. The original extent of seasonal wet meadows and riparian vegetation is uncertain because much was lost before anyone was interested in quantifying it, but historical records suggest that camas meadows were common (Servheen et al. 2002, Weddell [no date], Weddell 2002b). Terrain analysis, soil survey data, and General Land Office records for two subwatersheds in eastern Whitman County suggest that seasonally moist meadows may have comprised 13% of the study area (Servheen et al. 2002). Loss of riparian habitat and shrubland continued in the 20th century. Dzeidzic (1951) noted that farmers around Pullman said that springs that were once present "everywhere" began drying up "about 20 years ago." Various county and U.S. Department of Agriculture programs encouraged the draining of wetlands and removal of shrubs to maximize production and control weeds. The removal of riparian shrubs continued from the 1940s to 1960s because they were considered a weed harbor by county extension agents, and supposedly had soil holding value inferior to grass (Dzidezic 1951). During this period, a Whitman County weed control supervisor stated that his objective was to remove all the trees from the county road right-of-ways, including waterways. This was done by spraying with the herbicide 2,4-D, which killed all broad-leaved vegetation (Dzeidzic 1951).

Adkins (1968) summarized the activities of the USDA Agricultural Conservation Program that impacted wildlife in Spokane, Lincoln, and Whitman counties between 1943–1967. These practices included land clearing, channel clearances, underground drainage, and shrub control. Under the land clearing practice, about 12,000 ac of habitat was destroyed on 964 farms in Whitman and Spokane counties; this practice was terminated in 1954 after objections by Washington Department of Game. Approximately 448 miles of stream were channelized on 487 farms, over 20 miles of tile were installed and 20,980 ac were drained on 1,508 farms, primarily in Whitman County. Draining and stream channelization were still ongoing in the early 1970s (J. Connelly, pers. comm.). From aerial photos of an 875 ha area of the Palouse on the state line

Figure 16. Down-cutting of West Foster Creek, related to past land uses and erodible substrate (Blanton 2004). All the trees visible in the 2003 photo on right were dead in 2010, representing a loss of sharptail winter habitat (photos by Dan Peterson).

near Viola, Idaho, Black et al. (1999) determined that 61% of the riparian areas existing in 1940 were gone by 1989 and noted that "stringers of riparian vegetation shrunk to thin broken tendrils, and shrub vegetation virtually disappeared."

Land use, climate, and weather, combined with erodible substrate, contributed to arroyo formation in the West Foster Creek watershed in Douglas County (Blanton 2004). Blanton (2004) noted that Government Land Office records made no mention of down-cutting in the 1880s. Intensive grazing and agricultural development probably resulted in greater damage during flood events (Fig. 16). According to H. Lee Hanford, a flash flood ravaged through the Dyer Hill area of Douglas County on 31 August 1922, and destroyed a large wet meadow in Fye Draw (M. Hallet, pers. comm.). This meadow area likely had excellent riparian habitat for sharp-tailed grouse, providing winter food and cover and green vegetation in summer, but it was drained due to the down-cutting, and the area is now shrub-steppe with a few scattered trees in the draws (Fig. 17). Aerial photographs of West Foster Creek indicate that the length of arroyo doubled between 1939 and 1949, and increased steadily until 1982 when land use changed to wildlife habitat and CRP (Blanton 2004).

Winter riparian habitat continued to be removed throughout areas occupied by sharp-tailed grouse. At the time of Euro-American settlement, birch was abundant in Okanogan County, and "thrived in every draw and bottomland area" (Don Chalmers, pers. comm., *in* Zeigler 1979). Birch was cut to clear land, for firewood, and to develop springs. Where a spring was present at a homestead, often non-native trees were planted that did not provide sharptail winter food. Cutting continued through much of the 20th century; Zeigler (1979) documented a 51% decline in water birch and aspen from 1945 to 1977 in Johnson Creek, Okanogan County. During this period, riparian deciduous "budding" habitat declined 26% in four areas measured from aerial photos (Zeigler 1979). In addition, 13% of landowners contacted in Okanogan County were planning to remove water birch or aspen (Zeigler 1979). Hofmann and Dobler (1988a) also reported the loss of water birch at two locations in Okanogan County in less than 3 months of observation. Sharp-tailed grouse no longer used these areas after water birch was removed (Hofmann and Dobler 1988a).

Present

Figure 17. Down-cutting in Fye Draw near West Foster Creek in Douglas County.

By the mid-1990s, McDonald and Reese (1998) reported that cropland and hay/pasture accounted for 51% of the total land area within Tirhi's (1995) more generalized historical range of sharp-tailed grouse in Washington. They estimated declines in the extent of grassland from 44 to 1.3%, mean grassland patch size from 3,765 to 299 ha (9,303 to 739 ac), and extent of sagebrush cover from 44.1 to 15.6%. Losses were particularly high in the the Palouse bioregion, where about 94% of the grasslands and most of the wetland had been converted to cropland, hay, or pasture (Black et al. 1999). In many agricultural areas, little untilled ground remained because of the application of clean farming practices such as burning, herbicide use, and tilling roadbed to roadbed (Black et al. 1999).

Current land cover. Existing land cover types in the historical and current ranges of sharp-tailed grouse in Washington were estimated using 2001 National Land Cover Data, with the driest areas ($\leq$9" annual precipitation) and steep slopes ($\geq$40%) removed from the analysis (Table 7, Fig. 18). In the historical range, which totals about 12.5 million acres, shrub/scrub types account for about 1/3 of the area, and the main cover types potentially suitable for sharp-tailed grouse (i.e., shrublands, grassland, and CRP) total about 47%. Grasslands, historically the most important cover types, account for 6.7%. Minor cover types that likely contain some essential winter and brood-rearing habitat (deciduous forest, emergent wetland, woody wetland) total 1.2%. Although 32% of the historical area is in cropland or hay fields, portions could be restored to provide sharp-tailed grouse habitat. About 4% has been converted to other human-related development. Another 16% is comprised of unsuitable habitats (i.e., open water, coniferous forest, and rock).

The Palouse prairie, perhaps the historical center of abundance of Columbian sharp-tailed grouse in Washington, is one of the most endangered ecosystems in the United States, with only about 0.1% of these grasslands remaining in a relatively natural state (Noss et al. 1995; Lichtardt and Moseley 1997, Weddell and Lichhardt 1998). Palouse prairie vegetation is largely restricted to small privately-owned remnants in the corners of fields or rocky areas that were not converted to cropland or pasture, and are surrounded by cropland, degraded by weed invasions, and threatened by residential development (Weddell and Lichthardt 1998).

A recent characterization of the South Fork Palouse River Watershed (72% in Washington, remainder in Idaho) indicated 82% was cropland and 8% was urban or roads; rangeland and riparian/wetlands comprised 2% each (Resource Planning Unlimited, Inc. 2002a). Of these riparian habitats, an estimated 88% of riparian areas are directly affected by agriculture, grazing, or development; 98% of wetlands have been drained or altered. A similar characterization of the North Fork Palouse River Watershed indicated that 96% was agricultural land, and <2% was riparian, and rangeland is not listed (Resource Planning Unlimited, Inc. 2002b).

In contrast to the historical range, over 2/3 of the currently occupied area is in shrub/scrub, and together with grassland and CRP total nearly 80%. Less than 10% of the occupied area is in cultivated crops. However, these occupied areas are relatively small (60–500 km^2), isolated from one another,

Table 7. Current land cover[a] within the historical (modified for slope and precipitation[b]) and current ranges of Columbian sharp-tailed grouse in Washington.

Land Cover Class Name	Percent		Acres	
	Historical range	Current range[c]	Historical range	Current range[c]
Shrub/scrub[d]	**33.1**	**69.1**	**4,129,750**	**368,685**
Grassland/herbaceous[d]	**6.7**	**6.4**	**881,443**	**34,234**
Conservation Reserve Program[d]	**7.1**	**4.4**	**836,276**	**23,295**
Cultivated crops	30.1	9.7	3,760,691	51,872
Conifer forest	14.4	5.8	1,799,867	27,619
Emergent herbaceous wetlands	0.8	2.1	100,021	10,976
Developed, open space	2.3	1.1	287,037	5,702
Open water	1.8	0.9	223,251	4,976
Pasture/hay	1.7	0.7	208,582	3760
Developed, low intensity	1.0	0.1	128,394	759
Developed, medium intensity	0.4	<0.1	45,716	88
Developed, high intensity	0.1	<0.1	7,834	6
Woody wetlands	0.3	0.2	39,084	908
Deciduous forest	0.1	0.1	15,229	713
Mixed forest	<0.1	<0.1	2,654	33
Barren land (rock/sand/clay)	<0.1	<0.1	2,805	7
Total	100	100	12,468,637	533,633

[a]Based on 2001 National Land Cover Data.
[b]Areas with 9” or less of annual precipitation, or >40% slope were deleted from the historical range polygon.
[c]Includes the 15,000 ac Horse Springs Coulee area, where sharp-tailed grouse may now be extinct.
[d]The most important cover types for sharp-tailed grouse.

and largely degraded (Schroeder et al. 2000).

Current habitat condition. While shrub/scrub accounts for 33% of the area, large portions of this type are in the 11” precipitation zone and have thin rocky soils. Many areas have been degraded by excessive grazing and are highly fragmented by agriculture and steep slopes. Stralser (1991) described the habitat around active and inactive leks in Lincoln County; the habitat around two abandoned leks had been degraded by shrub reduction treatments, high levels of annuals, and CRP that had been planted with exotic grasses. Most of the largest remaining areas of uncultivated native grassland are Canyon Grassland along the breaks of the Snake and Grand Ronde rivers; they have also been degraded by grazing except where inaccessible or too far from water for cattle (Tisdale 1986, Weddell 2001a). Although these grasslands were not plowed, due to their steepness (slopes of 45–70 %; Tisdale 1986) they may be only marginally suitable for sharp-tailed grouse.

Soil productivity is often correlated with bird populations through its effects on vegetation and insects (Newton 1998: 171-172, 187); areas of deep, productive soil would probably support higher densities of sharp-tailed grouse if restored to native vegetation than areas with thin, rocky soil. Substantial areas of the grassland and shrub-steppe habitat that remain are channeled scablands with shallow soils underlain by basalt or glacial outwash gravel, cobbles, and sand (Stockman 1981). These shallow soils often have lower water holding capacity and are more readily degraded by livestock grazing. Because of historical grazing, the cover of bluebunch wheatgrass and Idaho fescue is much reduced, and many areas are now dominated by Sandberg bluegrass, a grass of shorter stature that provides poorer cover for nesting and brood-rearing by sharp-tailed grouse.

Sharp-tailed grouse habitat in many locations has been invaded by noxious weeds including cheatgrass, Scotch cottonthistle (*Onopordum acanthium*), Canada thistle (*Cirsium arvense*), jointed goatgrass (*Aegilops cylindrical*), yellow starthistle (*Centaura solstitialis*), and diffuse and spotted

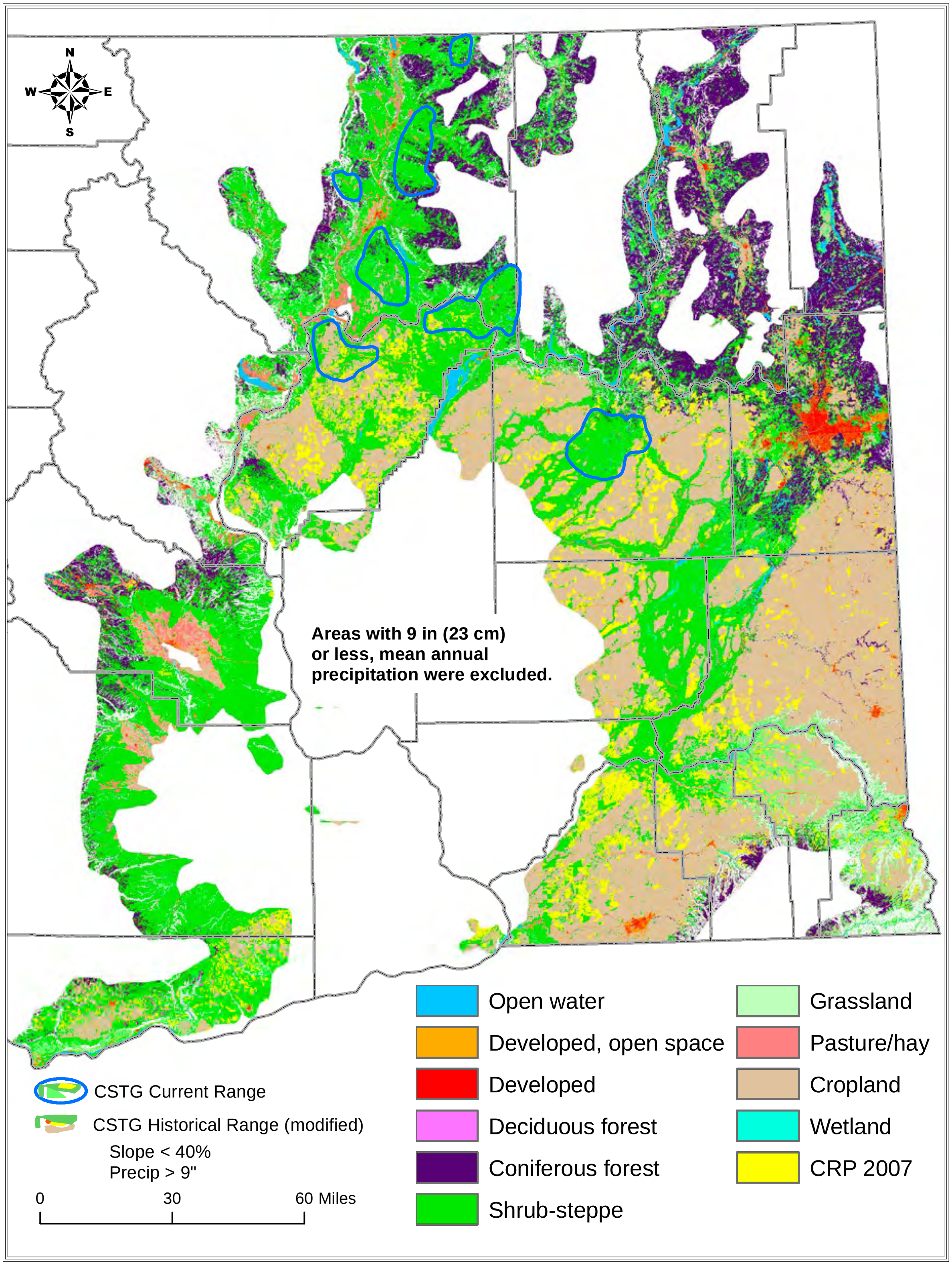

Figure 18. Land cover (2001 National Land Cover Data) and Conservation Reserve Program lands (2007 data) in the historical and current ranges of Columbian sharp-tailed grouse (steep slopes and low precipitation zones removed) in Washington.

knapweed (*Centaura diffusa*, *C. bibersteinii*) (Ashley and Stovall 2004a,b). White bryony (*Bryonia alba*), or wild hops, is a fast growing vine that forms dense mats. Like kudzu (*Pueraria montana*) in habit, bryony covers and eventually kills shrubs like Douglas hawthorne and is particularly destructive in the limited upland habitat remaining in the Palouse landscape.

The CRP benefits sharp-tailed grouse by establishing perennial vegetation, and allowing the reinvasion by sagebrush and other shrub species. Many acres of cropland in the counties that compose historical sharp-tailed grouse range were enrolled in CRP beginning in the late 1980's, and planted to exotic grasses that provide poor habitat. In recent years, however, the CRP program has increased its emphasis on the restoration of native vegetation and wildlife benefits. It provides essential habitat for supporting existing sharptail populations, particularly in Lincoln and Douglas counties. In Lincoln County, sharp-tailed grouse used CRP land for nesting, brood rearing, foraging, and thermal and escape cover (Stralser 1991, McDonald 1998). Of 17 nests located in the county in 1995, 11 were on CRP lands (McDonald 1998).

Habitat degradation by feral horses has become a problem on the Colville Indian Reservation in recent years; two long established leks were abandoned as a result of feral horses congregating on the sites. The tribe has begun addressing this by capturing and adopting out the horses (R. Whitney, pers. comm.).

Some areas that may otherwise be suitable for sharp-tailed grouse lack the riparian deciduous cover needed in winter. Assessments of the North and South Fork Palouse River watersheds indicated that about 98% of wetlands were drained or altered by drainage ditches, subsurface drain tiles, trees and shrub removal, and straightening of the natural watercourse. Many small intermittent streams are now managed as drainage ditches where vegetation has been removed and tillage occurs to the waters edge (Resource Planning Unlimited, Inc. 2002a,b).

Where riparian vegetation exists, native vegetation has been replaced by Kentucky bluegrass, non-native poplars, or reed canarygrass (*Phalaris arundinacea*). Reed canarygrass is one of the most noxious grass invaders in North America (Servheen et al. 2002, Lavergne and Molofsky 2006). It now dominates many moist and wet sites that have not been cultivated, forming dense monotypic stands throughout the Palouse prairie (Weddell 2002a). Although the species was native to parts of the west, it was not collected in the Palouse until 1917, and the invasive type may be a hybrid between the native and a non-native cultivar (Merigliano and Lesica 1998). Many springs and riparian sites have non-native Lombardi (*P. nigra, 'Italica'*), and white or silverleaf poplar (*P. alba*) crowding out native vegetation (Fig. 19). Suckers create dense stands of white poplar that outcompete the native species for sun and water eliminating the native species used by sharptails (birch, aspen, chokecherry, serviceberry, hawthorn, rose, etc), and drying up small streams and wetlands (Remaley and Swearingen 2005; M. Hallet, pers. comm.).

Habitat connectivity. Most of the seven areas currently occupied by sharp-tailed grouse in Washington

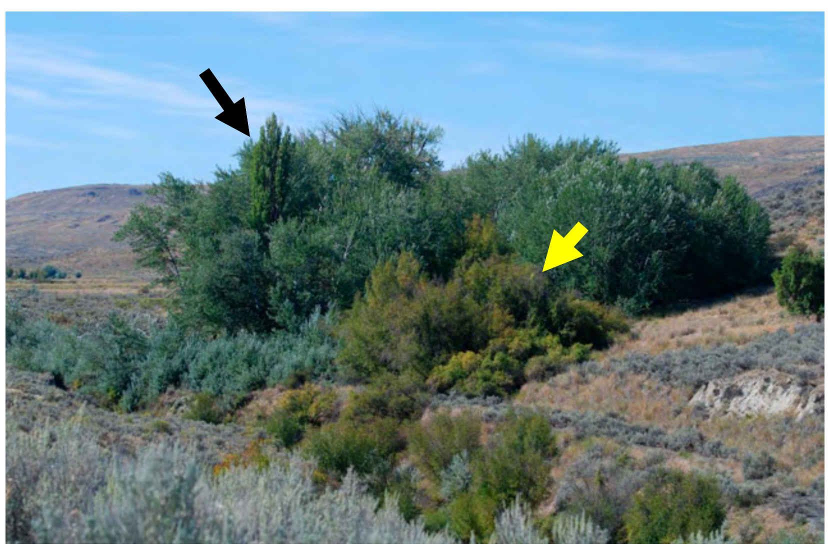

Figure 19. West Foster Creek below the Wells Wildlife Area Unit showing exotic white poplar (black arrow) and remnant water birch (yellow arrow; *photo by Marc Hallet, WDFW*).

are separated by 10–20 km. Some populations, however, are isolated by greater distances, for example, the Swanson Lakes population is separated from the closest population (Nespelem) by ~40 km. The isolation of these populations suggests that the intervening habitat is largely unsuitable for nesting and may contain barriers to movement. The Washington Wildlife Habitat Connectivity Working Group (WHCWG) recently completed an analysis of habitat connectivity patterns for sharp-tailed grouse in the Columbia Plateau (Robb and Schroeder 2012). Figure 20 shows the cost-weighted distance map developed for sharp-tailed grouse. Each cell of the cost-weighted distance map has a value (relative cost or resistance) reflecting the energetic cost, difficulty, or mortality risk for a sharp-tailed grouse moving across that cell. In the model, the resistance value is determined by characteristics of each cell, such as land cover, housing density, highways, etc.; the map indicates total movement resistance accumulated as animals move away from specific Habitat Concentration Areas (HCA; WHCWG 2012).

Eight HCAs in southern Okanogan and northern Douglas counties form a loose cluster (HCAs 6–13). There is good potential for movement from this HCA cluster to HCAs immediately to the north but resistance to the southeast towards Lincoln County is high; the area of lowest resistance to movement between these HCAs and the two in Lincoln County (HCAs 14, 15) follows the Columbia River. The cost-weighted distance shading indicates opportunity for movement from the Chesaw population (HCA 1) south to the Tunk Valley population (HCA 2) is limited and constrained by areas of high resistance. In the Okanogan Valley, the greatest potential for movement occurs north–south along the east side of the valley. The cost-weighted distance map suggests that opportunities for movement across the Okanogan Valley and at higher elevations are limited by forest and development. There is movement potential across the valley from Scotch Creek (HCA 4) to Tunk Valley (HCA 3), through an area of low resistance, but resistance accumulates rapidly to the south and southeast.

Land ownership. About 78% of the historical range is private land (Fig. 20). Ashley and Stovall (2004a) reported that most (85%) of Eastside (Interior) Grasslands in the southeast Washington Ecoregion can be characterized as having no conservation protection status, and only 3% are characterized as having medium (e.g. wildlife areas) or high (e.g. wilderness, national park, the Nature Conservancy) protection status; no grassland in the Palouse Subbasin was characterized as having high protection status. Areas that may have historically supported the greatest numbers of sharp-tailed grouse, including Whitman and Klickitat counties, have little public lands dedicated to conservation, although they have significant acreage enrolled in CRP contracts. Exceptions include the Columbia Hills (State Park and WDNR Natural Area Preserve) in Klickitat County, and WDFW Revere Wildlife Area in Whitman County.

WDNR manages the largest portion of the publically-owned land in the historical range polygon (5.8%; >700,000 ac; Table 8). However, only small portions are suitable for sharp-tailed grouse; large portions are timberland on the eastern edge of the Cascades in Yakima, Kittitas and Chelan counties; another portion is ‘school’ sections scattered throughout eastern Washington and managed to generate funds for public schools. These lands and other DNR lands in the non-timbered areas of eastern Washington are typically leased for cropland or livestock grazing, and sharp-tailed grouse management is not a high priority.

The next largest landowner of the historical range is the Colville Confederated Tribes at 5%; together with the Yakama Nation, Spokane, Kalispel, and Umatilla tribes, tribe-owned lands total 8.5% of the historical range (≈1 million ac). WDFW owns about 2% (>268,000 ac); but much of this is likely marginal for sharp-tailed grouse. The foothills of the Cascades in Kittitas County tend to have thin rocky soils and steppe is fragmented by forest and steep slopes. The Wooten, Asotin, and Chief Joseph Wildlife Areas in the foothills of the Blue Mountains and the Grande Ronde Canyon support some potential habitat, and there are a few sharp-tailed grouse records from the 1950s near Hell’s Canyon; however, these lands may be too fragmented by steep slopes to support significant populations, and are isolated from any existing sharp-tailed grouse

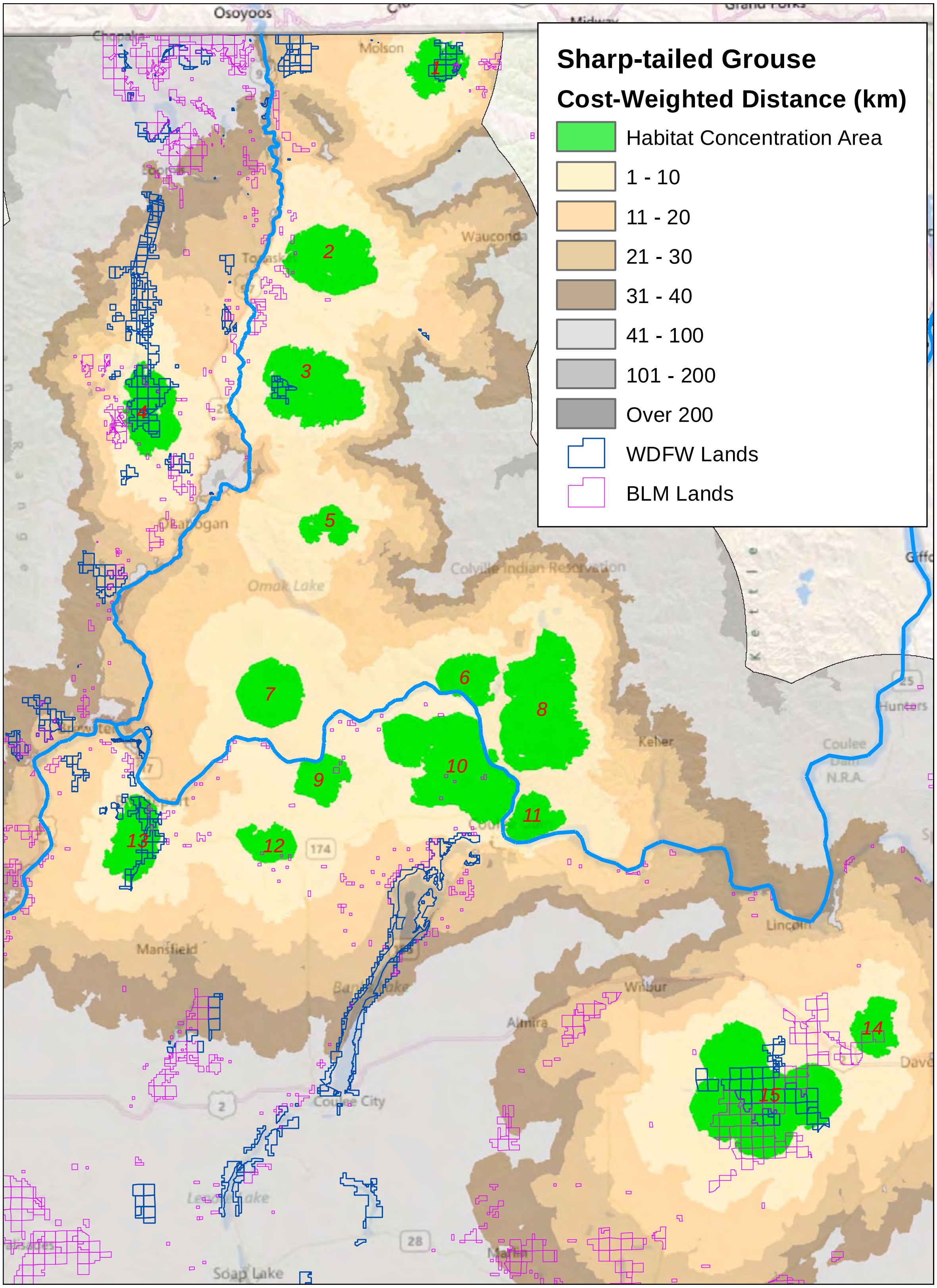

Figure 20. Modeled cost-weighted distance between occupied habitat concentration areas for sharp-tailed grouse in Washington (Robb and Schroeder 2012).

population.

A larger portion of the current than the historical range (43.9 vs. 22.2%) of sharp-tailed grouse is public or tribal lands. A majority (56%) of the current range, however, is private land. Important portions of lands supporting current populations include 28% of on the Colville Reservation, which has the largest blocks of remaining habitat, and supports the largest remaining sharp-tailed grouse population. WDFW lands in Douglas and Okanogan counties, and the combined WDFW and BLM lands in Lincoln County; WDFW and BLM lands total 11% of the current range.

CONSERVATION STATUS

Columbian sharp-tailed grouse are listed as a game bird by WDFW, although the season has been closed since 1988. By policy, they were considered a State Candidate species for listing as Endangered, Threatened, or Sensitive by WDFW between 1991–1998. After a status review by Hays et al. (1998), sharp-tailed grouse were listed by the Washington Fish and Wildlife Commission as Threatened in April 1998. Sharp-tailed grouse are also designated a priority species and their habitat a priority habitat by the WDFW Priority Habitats and Species program.

The U.S. Fish and Wildlife Service (USFWS) considers Columbian sharp-tailed grouse to be a 'Species of Concern'. The USFWS was petitioned to list this subspecies as a Threatened or Endangered species under the federal Endangered Species Act in 1995 and 2004 (Carlton 1995, Banerjee 2004). In response to the 1995 petition, the USFWS conducted a status review (Bart 2000), and conclud-

Table 8. Land ownership[a] in the historical and current ranges of Columbian sharp-tailed grouse in Washington.

Land Owner or Manager	Percent		Acres	
	Historical range[b]	Current range[c]	Historical range[b]	Current range[c]
Private	77.8	56.1	9,698,889	299,114
Colville Confederated Tribes	5.1	28.1	635,089	150,037
Dept. Fish and Wildlife	2.2	6.9	268,035	36,834
Dept. of Natural Resources	5.8	4.8	720,830	25,655
US Bureau of Land Management	1.8	4.1	183,455	21,753
US Forest Service	1.5	<0.1	192,747	234
Yakama Nation	2.6	-	327,130	-
US Dept of Defense	1.5	-	184,228	-
US Bureau of Reclamation	0.8	-	98,510	-
Spokane Tribe	0.7	-	90,060	-
US Fish & Wildlife Service	0.2	-	23,713	-
State Parks & Recreation	0.1	<0.1	16,829	4
Counties	0.1	-	8,229	-
Universities	0.1	-	5,905	-
Kalispel Tribe	<0.1	-	4,806	-
Confederated Umatilla Tribes	<0.1	-	3,413	-
Other public agencies	0.1	-	5,742	-
Total	100	100	12,467,657	533,631

[a]Based on Washington Department of Natural Resources, Major Public Lands data, 2007.
[b]Areas with 9" or less of annual precipitation, or ≥40% slope were deleted.
[c]Includes Horse Springs Coulee area where sharp-tailed grouse appear to be recently extirpated.

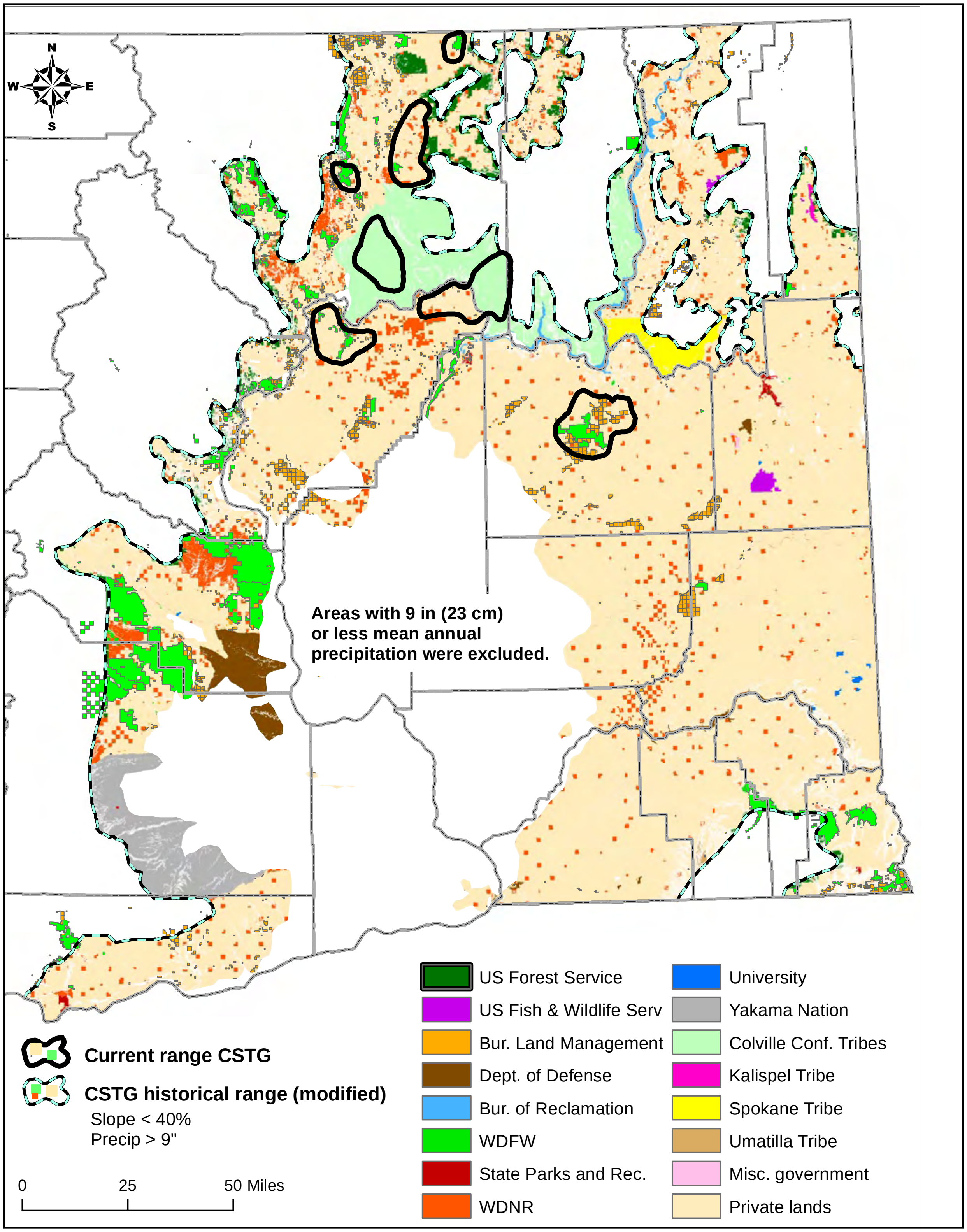

Figure 21. Land ownership or administration in the historical and current range of Columbian sharp-tailed grouse in Washington (WDNR Major Public Lands, 2007, and updates).

ed that listing was not warranted (USFWS 2000). They also concluded that a 2004 petition did not provide substantial information indicating that listing was warranted (USFWS 2006).

The Bureau of Land Management (BLM) classifies the Columbian sharp-tailed grouse as a Sensitive Species. The BLM Manual (6840.06), states:

> "Actions authorized by the BLM shall further the conservation of …Bureau sensitive species….Bureau sensitive species will be managed consistent with species and habitat management objectives in land use and implementation plans to promote their conservation and to minimize the likelihood and need for listing under the ESA."

MANAGEMENT ACTIVITIES IN WASHINGTON

Species monitoring. Since the 1950's, WDFW has conducted lek surveys of Columbian sharp-tailed grouse each spring to assess population status, and trends. Prior to the 1988 season closure, surveys were used to determine hunting seasons and bag limits. WDFW attempts to visit all leks active in recent years on ≥2 occasions each spring during the breeding season, and searches for newly established leks are periodically conducted. The Colville Confederated Tribes Fish and Wildlife Department has monitored active leks on the Colville Reservation in recent years (Berger et al. 2005, Gerlinger 2005). The WDFW, BLM, and Colville Tribe have also been monitoring the movements, habitat use, and nesting success of translocated birds with radio-tags. The BLM periodically inventories potential breeding and wintering habitats, especially on new land acquisitions.

Management plans. Columbian sharp-tailed grouse habitat management plans for the Tracy Rock area that later became the Swanson Lakes WLA were developed as part of the Bonneville Power Administration's (BPA) wildlife mitigation for Grand Coulee Dam (Ashley 1992, Cope and Berger 1992). A statewide management plan for sharp-tailed grouse was developed by WDFW in 1995 (Tirhi 1995); that plan is replaced by this recovery plan. The Colville Confederated Tribes completed a sharp-tailed grouse management plan in 2005 (Berger et al. 2005). That plan outlines tasks to increase sharp-tailed grouse populations, including habitat restoration, elimination of unmanaged grazing in occupied areas, monitoring of birds and habitat, translocation of birds within the reservation, and genetic augmentation with birds from outside Washington. The BLM develops Allotment Management Plans for allotments with occupied grouse habitat that describe the grazing system and permitted uses of parcels while addressing any local issues and providing for multiple uses.

Habitat acquisition. WDFW has been acquiring habitat for Columbian sharp-tailed grouse with funding from BPA and the Washington Wildlife and Recreation Program (WWRP). Additional lands have been acquired over the years with funds from the U.S. Fish and Wildlife Service through the Federal Aid in Wildlife Restoration (Pittman-Robertson Act) and Endangered Species Act-Section 6 programs. More than 40,000 ac have been purchased by WDFW in Okanogan, Lincoln, and Douglas counties primarily, or partly, for the protection and conservation of sharp-tailed grouse (Table 9); >25,000 ac of this are currently unoccupied by sharp-tailed grouse and has potential for population restoration. Additional areas that were acquired to protect mule deer winter range also contribute to protecting sharp-tailed grouse habitat or surrounding areas.

In 1974, WDFW entered into a wildlife mitigation agreement with the Douglas County Public Utilities District for the construction and operations of Wells Dam. The utility purchased 5,723 ac and gave WDFW title, forming the Wells WLA. WDFW also leases an additional 1,550 ac from WDNR in the Indian Dan Canyon area and BLM has 180 ac within the fenced boundary of this wildlife area. Recently 370 ac were added to the Central Ferry Canyon Unit. Washburn Island is managed by WDFW, but is owned by Douglas County Public Utility District.

In 1991, WDFW began acquiring land with WWRP funding to protect sharp-tailed grouse populations in Okanogan County (Olson 2006). These lands now total 22,860 ac, and include the Scotch Creek, Tunk Valley, Pogue Mountain and Chesaw units of the Scotch Creek WLA. Acquisitions in the last several years include 320 ac added to the Tunk Valley Unit, and the 6,300 ac Charles and Mary Eder Unit. Some other wildlife areas in the county (i.e., the Sinlahekin, Chiliwist, and Methow WLAs) were primarily purchased to protect mule deer winter range, but also preserve historical sharp-tailed grouse habitat (Fig. 22).

In 1990, an area near Tracy Rock in Lincoln County was identified as a potential area to mitigate impacts to sharp-tailed grouse from Grand Coulee Dam (Ashley 1992). The proposal was approved by BPA and the Northwest Power Planning Council, and 10,399 ac were acquired in 1993. An additional 9,387 ac were acquired from 1995–1997. WDFW also began leasing 1,280 ac from WDNR. The area became known as the Swanson Lakes WLA and currently totals about 21,000 ac. Acquisitions by BLM in the Twin Lakes, Telford, and Hawk Creek areas have brought the combined total BLM/WDFW in the area to >53,000 ac.

The Sagebrush Flat WLA was approved as a wildlife mitigation project in 1992 by BPA and the Northwest Power Planning Council to partially address adverse impacts caused by the construction of Chief Joseph and Grand Coulee hydroelectric dams (Peterson 2006). Ten separate purchases have contributed land since 1991. The Bridgeport Unit in northern Douglas County is the most important for sharp-tailed grouse, and acquisitions added 2,362 ac to the unit in 2005 and 200 ac in 2007.

Table 9. Columbian sharp-tailed grouse occurrence and area of Washington Department of Fish and Wildlife lands in north-central Washington.

Wildlife Area Management Unit	Sharp-tailed grouse occurrence[a] Breeding	 Wintering	Acres[b]
Scotch Creek Wildlife Area			
Scotch Creek Unit	√	√	8,694
Chesaw Unit	√	√	4,351
Tunk Valley Unit	√	√	1,399
Pogue Mountain Unit	x	x	1,146
Charles & Mary Eder Unit	x	?	6,300
Chiliwist Wildlife Area	x	?	4,889
Sinlahekin Wildlife Area[c]			14,000
Wells Wildlife Area			
West Foster Creek Unit	√	√	1,050
Central Ferry Canyon Unit	√	√	1,908
Indian Dan Canyon Unit	x	√	4,412
Sagebrush Flat Wildlife Area			
Bridgeport Unit	√	√	3,905
Methow Wildlife Area			
Methow Unit	x		14,800
Rendezvous Unit	x		4,225
Big Buck Unit	x		5,150
Swanson Lakes Wildlife Area	√	√	21,000

[a]Symbols: √ = sharp-tailed grouse known to be present; x = historical records of presence, but not observed in recent years; ? = uncertain.
[b]Lands owned or managed by WDFW.
[c]Most of the Sinlahekin is probably not suitable for sharp-tailed grouse.

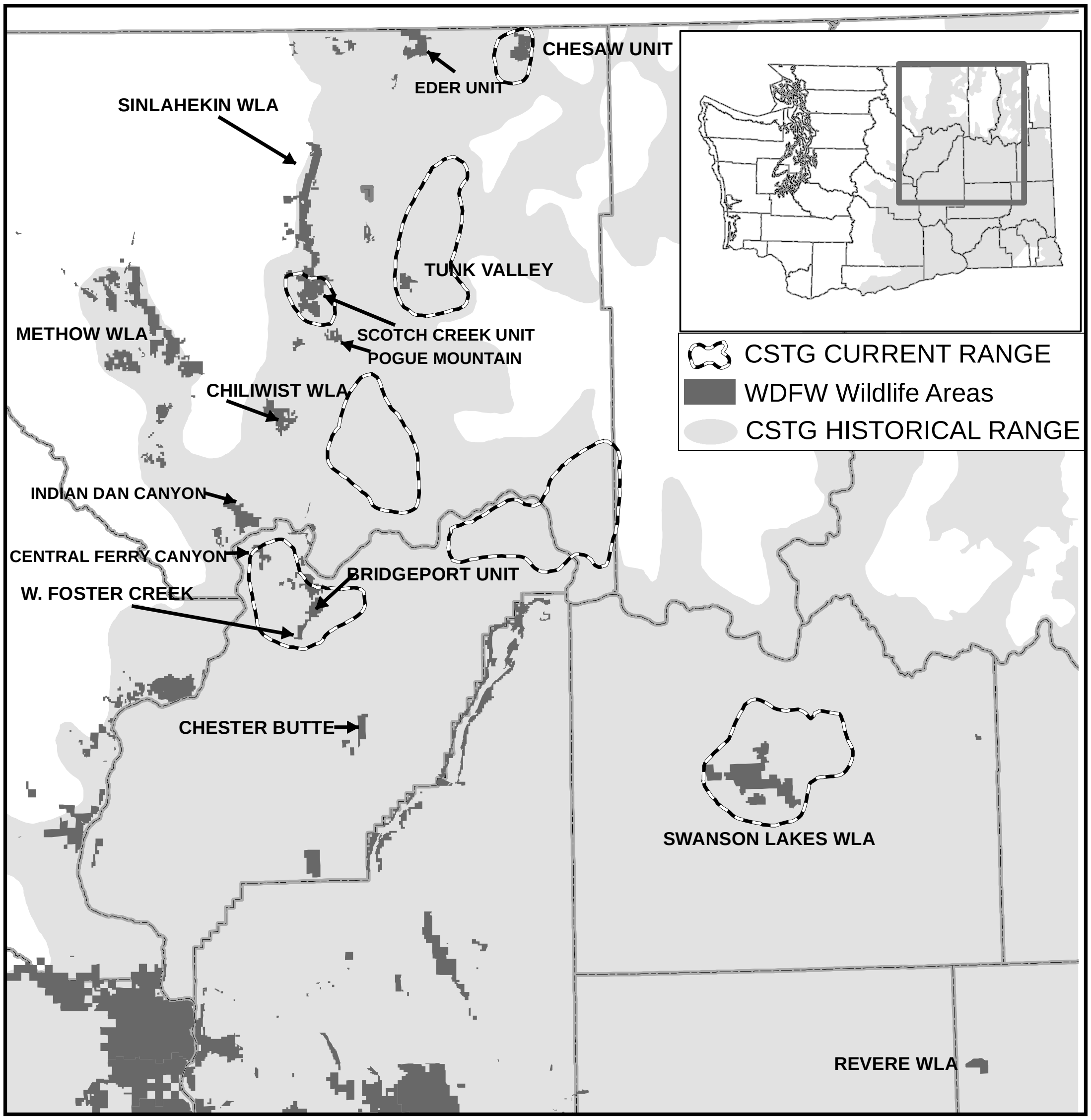

Figure 22. WDFW lands and areas currently occupied by Columbian sharp-tailed grouse in north-central Washington.

The Revere WLA, 2,291 ac of steppe and wetlands along Rock Creek in western Whitman County, was acquired in 1992 with funds from the U.S. Army Corp of Engineers through the Lower Snake River Fish and Wildlife Compensation Plan. The Revere WLA and 15,446 ac of adjacent BLM lands provide a nucleus to evaluate as a potential area for reintroduction of sharp-tailed grouse in the future. The BLM land was acquired after a long history of grazing by cattle and sheep, and at least some portion of the habitat is seriously degraded.

During the 1990s, BPA also funded the purchase of three ranches by the Colville Confederated Tribes totalling 16,100 ac for the Hellgate project on the Colville Reservation (Ashley and Berger 1997).

Habitat assessment, restoration and enhancement. Habitat assessments using Habitat Suitability Index models have been done on lands in Washington to measure habitat value for Columbian sharp-tailed grouse. Assessments of condition before and after habitat enhancements have been conducted on WDFW wildlife areas, most often with funding from BPA. Habitat assessments have also been done by the Colville Confederated Tribes (Gerlinger 2005), the Spokane Tribe (B.J. Kieffer, pers. comm.), and for the Coeur d'Alene Indian Reservation in Idaho, adjacent to Whitman County (G. Green, pers. comm.).

Figure 23. Restored former wheat field on the Chesaw Unit, Scotch Creek Wildlife Area, Washington.

Habitat on WDFW wildlife areas is being enhanced by restoring a diverse mix of native grasses and forbs on former agricultural fields, and on older CRP fields where non-native grasses were originally used. Restoration of native steppe and riparian vegetation is identified as a priority in WDFW wildlife area management plans (Anderson 2006, 2010; Hallet 2001–2007; McCoy 2010, Olson 2006, 2007, 2008; Peterson 2007, 2008, 2010; Romain-Bondi 2006, 2008). Sharp-tailed grouse nest success is known to be higher in native vegetation than in older CRP that was largely crested wheatgrass (Apa 1998). Riparian areas are enhanced through shrub and tree plantings. Weed control has been done on thousands of acres to promote native vegetation, and is a perennial activity. Habitat restoration efforts have been primarily funded by the BPA and the Washington Wildlife Recreation Program through the Recreation and Conservation Office.

Habitat enhancements have been conducted on the Scotch Creek WLA since 1991. These have included restoring native steppe vegetation on 2,772 ac of former cropland (Fig. 23), and the planting of >100,000 trees (including water birch) and shrubs in riparian areas, moist draws and north slopes (Olson 2006, 2007, 2008).

In addition, 60 mi of boundary fence have been erected, 20 miles have been repaired to exclude trespassing cattle, and 34 miles of interior fences have been removed. Lek counts on the Chesaw Unit indicate a recent increase in the sharp-tailed grouse population, with habitat restoration being partly responsible.

On the Wells WLA, 500 acres of former cropland on the West Foster Creek and Central Ferry Canyon units were restored to shrub-steppe in 1986 and 1987. From 2000–2006, an additional 65 acres were restored to shrub-steppe, and >29,000 trees and shrubs were planted (Fig. 24; Hallet 2001–2007). On the Bridgeport Unit of the Sagebrush Flat WLA, several thousand willow stems and 400 shrubs were planted in riparian sites in 2006, 400 trees were planted in 2007, and 110 ac of former cropland were restored in recent years (Peterson 2007, 2008). Restoration of another 413 ac on the Wells and Sagebrush Flat WLAs is currently underway.

With the help of Wenatchee Valley Sportsmen and an Aquatic Lands Enhancement Account (ALEA) grant, fences on WDFW lands in Douglas County are being marked with short pieces of vinyl to increase visibility and reduce mortalities of sharp-tails and

Figure 24. Water birch, rose and other shrubs planted in a deer exclosure near West Foster Creek, Wells Wildlife Area.

sage-grouse resulting from fence collisions. In 2011, over 28 miles of fences on Sagebrush Flats, Dormeir, Chester Butte, and West Foster Creek units were marked (Fig. 25).

Many shrub plantings were done on the Methow WLA in the 1950s–1960s; these saw high mortality from drought and deer damage, but many still survive (Romain-Bondi 2006, 2008). Later projects included 4,000 shrubs planted with drip lines that were damaged by porcupines in 1988, and 1,200 in 1992 that suffered heavy deer damage. Habitat enhancement work in 2006–2008 included seeding native vegetation on 140 ac of former cropland, laying plastic to control reed canarygrass, planting 275 shrubs, fencing a riparian site, and removal of 9 mi of old fencing. Volunteers helped with many of these efforts, including seeding 15 ac with native forbs. Restoring native vegetation in some former cropland is a high priority in the Methow WLA management plan (Romain-Bondi 2006, 2008).

On Swanson Lakes WLA and adjacent BLM lands from 1991–2006, 1,650 ac of cropland and non-native crested and tall wheatgrass (*Thinopyrum ponticum*) were restored with native and native-like grasses. Cattle grazing no longer occurs on Swanson Lakes WLA, except in rare circumstances. During 1996–1997, 41,900 shrubs and trees were planted in riparian zones, 58 mi of new fence were installed, 38 mi of fence were repaired to exclude cattle, and 53 mi of unneeded interior fence were removed (KWA Ecological Sciences, Inc. 2004). Recent habitat enhancement included 70 ac of crested wheatgrass restored with a mostly native seed mix, and 1,360 riparian shrubs and trees were planted, irrigated and fenced to prevent deer damage (Anderson 2006, 2007, 2008, 2010). In 2007, 113 ac of former wheat field were planted to native vegetation. Response of sharptails to this restoration has been excellent. A lek formed in an old barley field following restoration and augmentation, and is now one of the largest leks in Lincoln County (14 birds counted in 2012). In 2010-2011, 81% of sharptail nests on public lands in Lincoln County were in restored fields, and 66% of telemetry points (n = 3,710; 2005-2011) were in restored fields. Reseeding of an additional 500 ac of old CRP is a high priority for sharp-tailed grouse recovery. The Lincoln County Conservation District has also completed several riparian habitat restoration projects in the Crab Creek drainage (KWA Ecological Sciences, Inc. 2004). The district also removed 15 miles of unneeded fenceline on Swanson Lakes with a WDFW ALEA grant in 2010, and an additional 5 miles in 2011. During 2011, a BLM-funded crew marked 55 miles on Swanson Lakes WLA and 71 miles of fences on adjacent BLM lands.

The Colville Confederated Tribes have conducted

Figure 25. Fence near West Foster Creek marked with vinyl markers (inset).

habitat enhancement on the Colville Indian Reservation in recent years. A sharp-tailed grouse management plan included the expectation of planting 2,500 shrubs and trees, and 50,000 bunchgrass plugs annually for 5 years (Berger et al. 2005).

WDFW is also actively working to increase the benefits of CRP lands to sharp-tailed grouse. WDFW works with landowners and federal agencies to extend current CRP contracts and promote new contracts, such as the Douglas County sage and sharp-tailed grouse SAFE (State Acres for Wildlife Enhancement) program, while requiring vegetative plantings of native forbs, grasses, and sagebrush that are beneficial to grouse and other wildlife.

Population augmentations. Translocations of sharptails have been conducted in Washington to boost struggling populations and improve their genetic health. Microsatellite data indicated that the Swanson Lakes population exhibited lower genetic diversity than larger populations near Nespelem (Warheit and Schroeder 2003). Based on genetic sampling of Columbian sharp-tailed grouse from Utah, British Columbia, Idaho, and Washington, any population within these areas appears to be a genetically appropriate source population for augmenting Washington populations (Fig. 26).

Since 1998, a total of 391 sharp-tailed grouse have been translocated and released in Washington. During 1998−2000, 63 birds from southeastern Idaho (51 birds) and the Colville Indian Reservation in Washington (12 birds) were released on the Scotch Creek Unit (Fig. 27). Prior to the translocation, surveys indicated that only 2 males remained on the one remaining lek in the area, and 2 nests found contained infertile eggs. After the three-year translocation project, the population increased to approximately 100 birds using 3 leks in 2005. The population response to the augmentation was consistent with the hypothesis that the population suffered from poor genetic health prior to the translocations. A flock of 38 birds seen on 7 December 2008 was the largest observed since 1983 (J. Olson, pers. comm.).

Additional translocations conducted during 2005 – 2012 included 61 birds released on the West Foster Creek unit of Wells WLA, 166 at Swanson Lakes WLA, and 102 on the Colville Indian Reservation (Table 10, Fig. 28, Schroeder et al. 2011). The birds were captured from populations in Idaho (211 birds), Utah (78), and British Columbia (40). Populations at all three recent release sites have remained stable or increased slightly, but results are difficult to assess at this early stage of the augmentation process. Future projects may involve reintroductions of sharp-tailed grouse to unoccupied portions of the historical range.

Research. Early studies investigated the distribution, diet, and status of sharp-tailed grouse in eastern Washington (Dziedzic 1951, Yocom 1952, Buss and Dziedzic 1955, Jones 1966, Zeigler 1979). In the 1980s, Hofmann and Dobler (1988a, 1988b, 1989) investigated wintering densities, home range, habitat use, and spring movements of Columbian sharp-tailed grouse in Okanogan, Douglas, and Lincoln counties, and lek histories. Merker (1988) reviewed the status of sharp-tailed grouse in Wash-

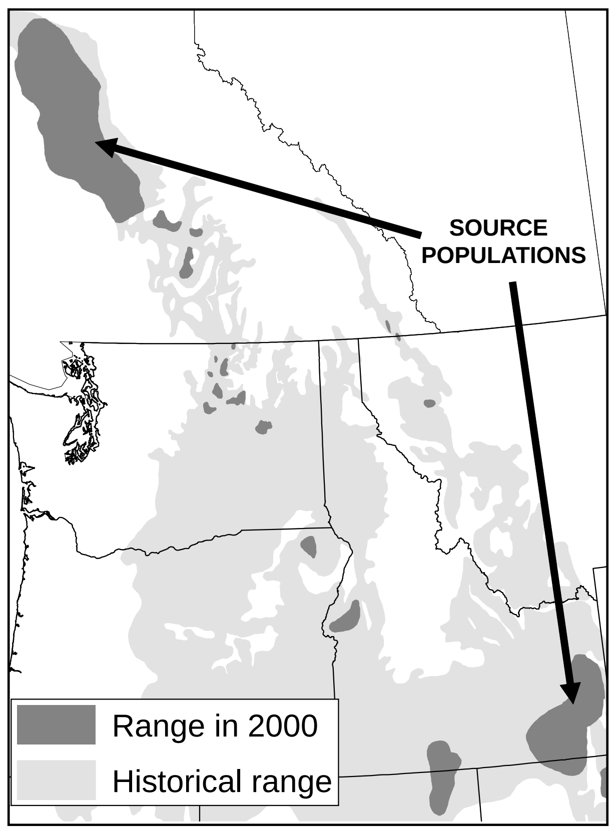

Figure 26. Location of source populations and target areas for 2005–2010 translocations of Columbian sharp-tailed grouse in Washington.

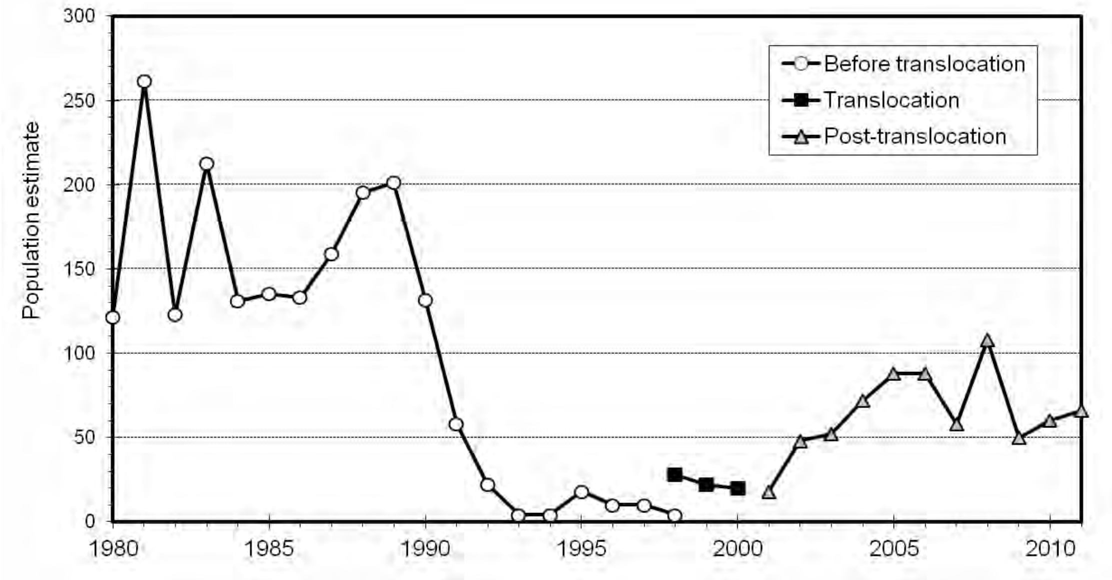

Figure 27. Population estimates of Columbian sharp-tailed grouse at the Scotch Creek Wildlife Area before, and since, the 1998-2000 augmentation project using birds from outside the area.

Table 10. Numbers and release locations for sharp-tailed grouse translocated to Washington, 2005-2012.

Release Location	2005	2006	2007	2008	2009	2010	2011	2012	Total
Swanson Lakes WLA	20	12	14	14	28	51	20	7	166
Dyer Hill/W. Foster Cr.	20	12	15	14	0	0	0	0	61
Colville Indian Res.	19	11	12	14	10	0	9	26	101
Totals	59	35	41	42	38	51	29	33	328

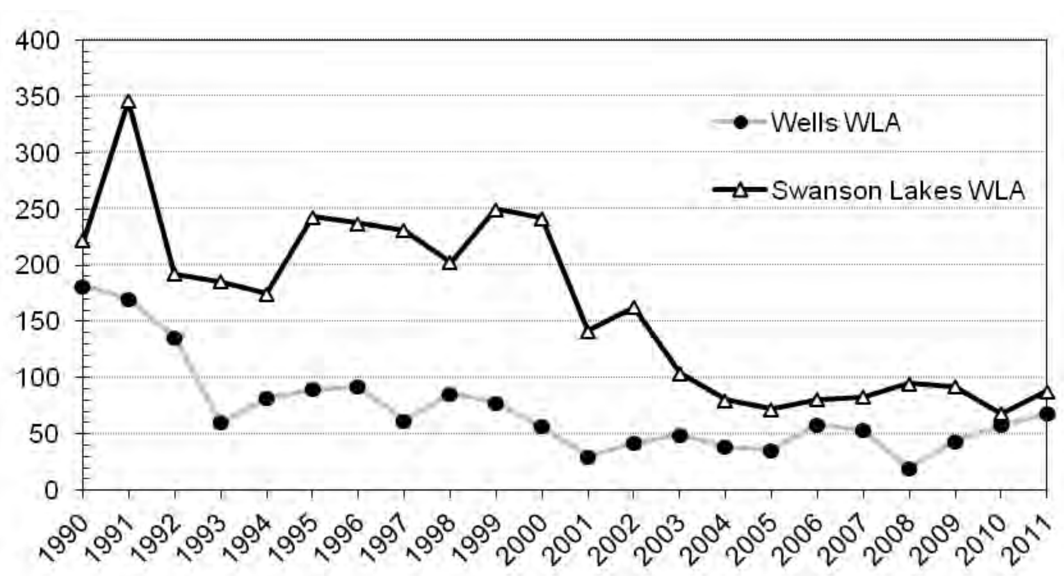

Figure 28. Population estimates of Columbian sharp-tailed grouse for two areas in Washington augmented with translocated birds; releases began in 2005.

ington and made recommendations for their conservation.

Research in the 1990s produced three M. S. theses from Eastern Washington University, and one from the University of Idaho. Stralser (1991) quantified habitat characteristics around active and inactive leks in Lincoln County. Paulson (1996) described the impacts of livestock grazing on woody riparian vegetation in areas used by sharp-tailed grouse in Lincoln County. Merker (1996) investigated captive rearing and release of hand-reared versus parent-reared chicks to evaluate the potential for use of captive rearing in reintroduction projects. McDonald (1998) examined seasonal habitat use and movements, nesting ecology, productivity, and survival in Washington. McDonald and Reese (1998) examined landscape changes in the historical range of sharp-tailed grouse and their distribution in Washington, and provided recommendations on where to augment populations.

The Nature Conservancy conducted extensive lek searches, lek surveys, and fall surveys in Washington during 1990–1992 (Weddell et al. 1990, 1991a, Weddell and Johnston 1992a, b). They also produced reports on winter habitat (Weddell et al. 1991b), and a review of the biology and conservation of the sharp-tailed grouse (Weddell 1992).

WDFW conducted a research project during 1992-1996 that focused on habitat use, population status, and estimating rates of mortality and recruitment (Schroeder 1996). Additional projects resulted in a paper on the decline of sharp-tailed grouse in Washington (Schroeder et al. 2000), and reports on genetics (Warheit and Schroeder 2001, 2003, Spaulding et al. 2006, Warheit and Dean 2009).

Research on movements, nesting habitat, and survival of telemetered sharptails and sage-grouse in Lincoln County is being conducted by a Washington State University graduate student; the resulting thesis may be completed late in 2012 (K. Stonehouse, pers. comm.).

Landscape analysis and planning. The Washington Wildlife Habitat Connectivity Working Group WHCWG investigated habitat connectivity patterns for sharp-tailed grouse. An analysis of statewide connectivity patterns was published in 2010 (WHCWG 2010) and an ecoregional analysis for the Columbia Plateau was completed in 2012 (Robb and Schroeder 2012). The latter analysis modeled habitat concentration areas and movement corridors for sharp-tailed grouse.

Coordination and partnership. WDFW coordinates with several agencies on habitat management issues for sharp-tailed grouse. The Fish and Wildlife Department of the Colville Confederated Tribes has been a cooperator with WDFW on sharp-tailed grouse research, translocation projects, and conservation for many years. WDFW, BLM, and Washington State University, with the help of volunteers, are cooperating in monitoring the sharp-tailed grouse and sage-grouse released in Lincoln County. WDFW and the Colville Confederated Tribes have collaborated with wildlife agencies in British Columbia, Idaho, Utah, and Oregon in conducting translocations of sharp-tailed grouse to Washington. WDFW, the Colville Confederated Tribes, and BLM co-sponsored the 24th Biennial Western Agencies Sage and Columbian Sharp-tailed Grouse Technical Committee Meeting in Wenatchee in 2004. WDFW was also a co-sponsor of the 16th Western Sage and Sharp-tailed Grouse Technical Committee Meeting in Moses Lake in 1989.

WDFW has facilitated annual meetings of an interagency Washington Sharp-tailed Grouse Working Group. The group has met annually since 2005 to share information and to coordinate cooperative research, restoration, and translocation activities.

WDFW is continuing to work with the Natural Resources Conservation Service and Farm Service Agency to extend current CRP contracts, promote new contracts in occupied areas or where potential reintroductions could occur, and to improve the benefits of CRP lands to wildlife.

State Acres for Wildlife Enhancement (SAFE) is an initiative under the CRP program authorized by the Farm Bill. Three SAFE projects have been authorized in Washington that may benefit sharp-tailed grouse. The Eastern Washington Shrub-steppe SAFE project is a partnership between FSA, WDFW, and the Colville Confederated Tribes with a goal of enrolling 5,200 ac to benefit shrub-steppe birds. The Palouse Prairie SAFE project is a partnership between FSA and WDFW with the goal of enrolling 2,000 ac to increase habitat for wildlife by re-establishing prairie vegetation. In 2010, a SAFE program to support sage and sharp-tailed grouse in Douglas County allocated up to 63,000 ac of 15-year contracts, and WDFW private lands biologists are writing the planting plans for these contracts.

Funds for sharp-tailed grouse research, habitat acquisition and enhancement, monitoring, and planning in Washington have been provided by many programs and cooperators including Federal Aid in Wildlife Restoration, U. S. Fish and Wildlife Service State Wildlife Grants, the Washington Wildlife and Recreation Program, Bonneville Power Administration, Douglas County Public Utility District, Tribal Wildlife Grants, Bureau of Land Management, and the Charlotte Martin Foundation through The Nature Conservancy.

Information and education. WDFW provides the public and other agencies with recommended methods for managing sharp-tailed grouse habitat through its Priority Habitats and Species Management Recommendations (Schroeder and Tirhi 2003). PHS management recommendations for shrub-steppe were completed in 2011 and provide information to minimize impacts of development in shrub-steppe landscapes (Azzerad et al. 2011). A manual for restoring shrub-steppe and grassland habitats in the Columbia River Basin was completed in 2011 (Benson et al. 2011).

FACTORS AFFECTING CONTINUED EXISTENCE

The primary factors affecting the continued existence of Columbian sharp-tailed grouse in Washington are habitat loss and alteration and the precarious nature of small, geographically isolated populations. Two of the major factors that contributed to the decline of sharp-tailed grouse and their habitat in Washington, conversion to agriculture and incompatible livestock grazing practices, are ongoing threats today. CRP lands have been of great benefit to sharptails in Idaho and elsewhere, and has tremendous potential in Washington, but its voluntary basis creates long-term uncertainty about habitat availability on private lands in the future. Habitat conversion to rural residential and commercial development and wind energy has become an important threat in recent years. The remaining populations are small and relatively isolated from one another, which increases their risk of extinction.

Adequacy of Existing Regulatory Mechanisms

Sharp-tailed grouse were protected from hunting with the closure of the hunting season by the Washington Fish and Wildlife Commission in 1988. Various state regulations provide some protection for habitat. The standards and process for issuance of grazing permits on WDFW lands are outlined in WAC 232-12-181 (Appendix B) and Fish and Wildlife Commission Policy C-6003. The Director must determine that a grazing permit will be “consistent with the desired ecological condiditon for those lands or the department’s strategic plan”… and shall negotiate permits to “ensure the highest benefits to fish and wildlife.” (WAC 232-12-181). There are no existing state or federal regulatory mechanisms that directly protect sharp-tailed grouse habitat on private lands, and no local, state, or federal regulations that adequately protect habitat that is currently unoccupied but needed for the species’ recovery. Many species and regional populations, including Columbian sharp-tailed grouse in Washington, may be doomed if the options for recovery are slowly eliminated by loss of habitat to development.

Washington’s Growth Management Act (GMA) requires counties to develop critical area ordinances to address protection of critical wildlife habitat if their human population is >50,000, but counties vary in where they are in the process, how ordinances address habitat, and how they are enforced. Ongoing development of private lands is precluding options for restoring sharp-tailed grouse populations in some areas. Okanogan and Lincoln counties are not yet required to plan for development under the GMA because their populations are <50,000. Proposed zoning changes in Okanogan County would allow densities as high as 1 residence/ac in important areas occupied by sharptails (e.g. Tunk Valley). Proliferation of private wells in Okanogan County is another concern because it will likely affect stream flows (Sumioka and Dinicola 2009), and degrade riparian vegetation.

Small Population Size, Isolation, and Genetic Health

The persistence of small populations can be affected by environmental, demographic, and genetic factors. Environmental events, such as severe droughts, fires, or disease can decimate small populations. Chance shifts in sex ratios or age distributions can affect breeding and recruitment, and small populations can rapidly lose the genetic diversity needed for adaptation to changing environments (Foose et al. 1995). Genetic and demographic factors can interact so that a small population continues to decline in what has been called an extinction vortex (Fig. 29). Microsatellite data indicated that the Swanson Lakes population exhibited lower genetic diversity than larger populations near Nespelem (Warheit and Schroeder 2003). The small isolated populations in Washington may have lost some of their intrinsic ability to respond positively to habitat improvements because they have endured severe population 'bottlenecks' that reduced their genetic diversity (Westemeier et al. 1998a, Bellinger et al. 2003, Johnson et al. 2003). None of the existing sharp-tailed grouse populations in Washington currently exceed a few hundred birds. An increasing number of studies indicate that goals to maintain viable populations of vertebrates need to be in the order of several thousands, rather than hundreds (Reed et al. 2003), although much smaller populations may sometimes persist for some time (Pacheco 2004). Sharp-tailed grouse populations seem to naturally fluctuate with weather, habitat condition, and perhaps disease. This natural variability puts smaller populations at greater risk of local extinction.

Population isolation could affect the continued existence of sharp-tailed grouse in Washington. Many authors indicate that long-term survival (>100 years) of isolated populations requires many more individuals than populations that occasionally exchange genetic material with other populations (Lande and Barrowclough 1987, Dawson et al. 1987, Grumbine 1990). The remaining sharp-tailed grouse in Washington exist as seven populations separated by >10 km. Limited data from radio-marked birds suggest that movements sufficient to allow regular interchange of individuals among the populations in north-central Washington may be rare. The negative effects of habitat change are amplified when populations become isolated. For example, dispersal by juveniles 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.

Genetic health (represented by adequate genetic heterogeneity and allelic diversity) is a major consideration for species reduced to small populations, and is an important issue for sharp-tailed grouse in Washington. Poor genetic diversity can result in weak immune systems, low hatchability of eggs, and reduced ability to adapt. Spielman et al. (2004) reported that on average, heterozygosity was 35% lower in 170 threatened taxa compared with closely related non-threatened taxa. In a review of rare mammals, Garner et al. (2005) report that there has been a pervasive and consistent loss in genetic diversity in populations that face a demographic threat. They concluded that by the time species

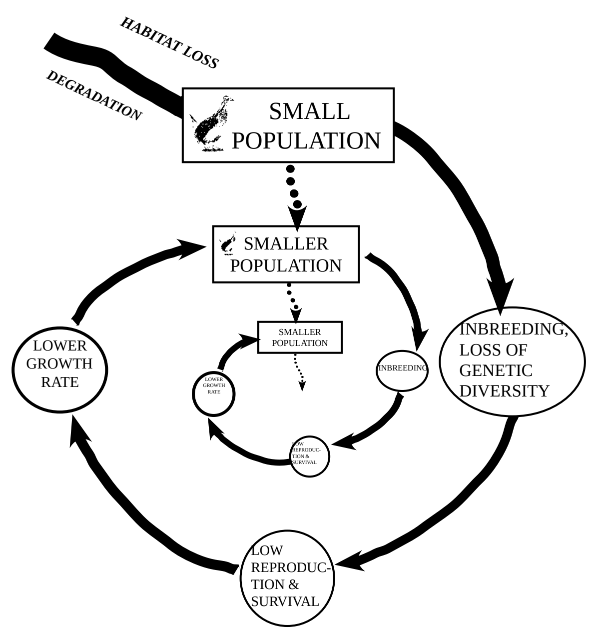

Figure 29. Extinction vortex (Frankham et al. 2002).

receive official conservation status (i.e., listing as threatened or endangered), they have already lost a substantial portion of their genetic variation. Warheit and Schroeder (2003) reported that data suggest that historically, the Columbian sharp-tailed grouse existed in very large populations with extensive gene flow across large geographic areas. Washington populations of sharp-tailed grouse may be showing symptoms of isolation; the Swanson Lakes population was approximately 25% lower in gene diversity and allelic richness than birds in Alberta, the most diverse population. A wide variety of genetic problems can occur with small isolated populations and can interact with demographic and habitat problems, leading to a population's extinction (Gilpin and Soule 1986, Lacy 1987, Reed and Frankham 2003). The decline in allelic diversity associated with small population size is often expressed by reduced resistance to disease (Allendorf and Ryman 2002).

Inbreeding depression has contributed to declines and extinctions of several grouse and prairie-chicken populations in the wild (Brook et al. 2002). Inbreeding has been reported to affect male fitness in black grouse (Höglund et al. 2002). Bellinger et al. (2003) reported the loss of genetic variation in greater prairie-chickens following a population bottleneck in Wisconsin. Westemeier et al. (1998a) and Bouzat et al. (1998) reported reduced heterogeneity and fertility in a declining, remnant population of greater prairie-chickens in Illinois. Johnson et al. (2003) reported that genetic variation was significantly reduced in isolated populations of <2,000 greater prairie-chickens. Fertility, hatching rate, and the population size of the Illinois population increased following augmentation with birds from large healthy populations (Westemeier et al. 1998a). The small populations of sharp-tailed grouse at Scotch Creek and Dyer Hill in Washington both exhibited an increase in numbers following augmentation projects in recent years (Schroeder et al. 2011), but it is too early to tell if this indicates the start of sustained populations increases as a result of improved genetic health.

Habitat Quantity, Condition, and Continued Loss

> "It is not enough to simply improve habitat; former habitat must be restored. Simply put, prairie grouse require prairie and lots of it."
>
> Silvy et al. (2004)

The predominant reason for the isolation and small size of remnant sharp-tailed grouse populations in Washington is the loss of habitat. McDonald and Reese (1998) reported dramatic declines in mean patch size of sagebrush, grassland, and herbaceous wetlands in the historical range of sharp-tailed grouse in Washington. In addition to the issues of demographic and genetic isolation, habitat fragmentation creates or exacerbates other impacts to sharp-tailed grouse, including higher predation in habitat patches (Schroeder and Baydack 2001), encroachment by noxious weeds, and impacts of herbicides and insecticides sprayed on adjacent cropland. Bousquet and Rotella (1998) attributed the high nest success (74%) in their study partially to the lack of fragmentation of the grassland in their Montana study area.

Schroeder et al. (2000) noted that the unoccupied portion of the sharptail's historical range in Washington was 38% cropland, while occupied areas were 11.3% cropland; Dyer Hill, which was 12% CRP, was an exception to this pattern. Most of the remaining habitat with native vegetation is in areas with thin or rocky soils that are poorly suited to cultivation. This includes extensive scablands that were stripped of soil by repeated ice age floods resulting from the catastrophic draining of Lake Missoula (USDI/GS 1976). These areas with thin soils have typically been used for livestock grazing, and in most cases the native vegetation continues to display the effects of heavy historical grazing. It is uncertain if management efforts can result in these lands becoming highly productive for sharp-tailed grouse. McCleery et al. (2007) and Silvy et al. (2004) reported that lesser prairie-chicken recovery efforts have been focused on proximate factors and shinnery oak habitat because that is where relict populations occur. However, shinnery oak is likely marginal habitat, and the preferred prairie habitat was converted to cropland long ago. Similarly, sharp-tailed grouse recovery in Washington may require restoration of some areas of deep soil in areas like Palouse prairie where the birds were historically abundant.

Sharp-tailed grouse in Douglas and Okanogan counties, and to a lesser degree in Lincoln County, are now generally restricted to habitats, mostly at higher elevations, where the impacts of grazing and conversion to wheat and orchards have been less severe (Schroeder 1996). Lower elevation areas historically provided important winter habitat. Relatively high winter mortality resulting from declining quantity and quality of winter habitat may be an important factor inhibiting recovery of sharp-tailed grouse populations in Washington (Schroeder 1996).

Habitat quality on WDFW and BLM lands in Lincoln, Douglas, and Okanogan counties has improved in areas actively managed for sharp-tailed grouse. Keeping private lands enrolled in CRP is also important to improve habitat quality in Lincoln and Douglas counties. Habitat quality on private and tribal lands will depend on the intensity of grazing and extent of fragmentation by residential development. Habitat condition appears to have improved in the Methow Valley in recent years due to reduced grazing pressure, but many sites have been lost to residential development. Habitat restoration is needed to provide habitat connections between populations of sharp-tailed grouse where possible, and to increase populations to a level at which genetic health, wildfires, and episodic weather extremes are no longer a major concern.

Habitat loss to residential development. Ranches and farmland, particularly in Okanogan, Lincoln, and Spokane counties, are being subdivided and sold (Hallet 2006, Swedberg 2006, J. Anderson, pers. comm., S. Fitkin, pers. comm.). In the Okanogan Valley, 45% of ranches >400 ac in size changed hands between 1993 and 2008; 33% were sold to developers and 6% to government agencies (Haggerty and Gude 2008). The conversion of ranches and farmland to residential areas probably results in unsuitable conditions for sharp-tailed grouse because of increases in fences, roads, traffic, structures, grazed horse pastures, dogs, cats, and corvids. Residential development will affect the ability to connect populations and limit options for sharp-tailed grouse recovery.

Features characteristic of fragmentation, such as roads and fences, can affect grouse survival. Patten et al. (2005) described differences in survival and reproduction between populations of lesser prairie-chicken in Oklahoma and New Mexico which have a 10-fold difference in parcel size. Oklahoma had much smaller farms and a higher density of fences, powerlines, and roads that affected female survival. Females in Oklahoma exhibited larger clutch sizes and higher renesting rates, but on average they nested fewer years due to their lower survival. A population model suggested the Oklahoma population was more susceptible to year-to-year environmental variations such as weather because females concentrated their reproductive effort into one year (Patten et al. 2005). Patten et al. (2005) suggested that the habitat differences and lower female survival rate had resulted in an evolutionary change in life history strategy, with the unfortunate side-effect of reducing the likelihood of persistence of the population.

Okanogan County's draft comprehensive plan would include at least one valley occupied by sharp-tailed grouse (e.g. Tunk Valley) in the high density rural zone proposed for 1 residence/ac (Okanogan County Planning Dept, Comprehensive Plan and Map, 10/14/10). Many areas that may be occupied or are important for wintering or connecting known populations (e.g. Antoine Creek, Bonaparte Creek, Aeneas Valley, and Havillah) are also prposed to be zoned as high density. A density of 1 residence/ac would render these areas unsuitable. In addition, nearly all the remaining private lands would be zoned 'low density rural,' which allows 1 residence/5 ac, likely still unsuitable for sharptail nesting.

Residential development also includes the proliferation of wells that can affect stream flow and degrade riparian vegetation. This is a concern along tributaries of the Okanogan River, including Tunk, Bonaparte, Antoine, and Tonasket creeks (Sumioka and Dinicola 2009). The Okanogan Conservation District is leading the planning and implementation of a long-range watershed plan for the Okanogan River basin that will be used to ensure that future water demands in the basin are met while protecting fish and wildlife resources. If the plan is completed and implemented before additional impacts to stream flow occur, it may prevent impacts to riparian habitat due to excess water withdrawal.

Spreading of weeds along roads. Invasive vegetation can degrade sharptail habitat by displacing species more suitable for food and cover; noxious weeds also may require the use of herbicides which negatively impact native forb cover. Roads that facilitate residential and other development also degrade habitat by promoting the spread of weedy vegetation (Gelbard and Belnap 2003). Vehicles and filling during road construction transport weed seeds to roadside verges and act as a conduit to invasion of adjacent habitats. Soil disturbance, regular herbicide applications, and the greater moisture present on roadside verges favor some exotics over native species. For example, cheatgrass cover along verges of paved roads in southern Utah was 3 times greater than along 4-wheel drive tracks (Gelbard and Belnap 2003).

Use of herbicides to control weeds or shrubs. The use of herbicides is often necessary to control infestations of noxious weeds, but may also kill native forbs and shrubs that provide food for sharptails. The loss of deciduous trees, sagebrush, and other shrubs by chemical control was associated with declining sharp-tailed grouse populations in Washington (Zeigler 1979) and Utah (Hart et al. 1950). Chemical treatment of vegetation in sharp-tailed grouse habitat is detrimental due to the direct loss of vegetation (McArdle 1977, Blaisdell et al. 1982, Kessler and Bosch 1982, Oedekoven 1985, Klott 1987). Stralser (1991) reported that two abandoned leks in Lincoln County were surrounded by habitat that had been degraded by brush control using herbicides and fire, and had higher coverage of annuals than two active leks that had more intact shrub-steppe habitat and more native perennial vegetation.

Livestock Grazing

> "Current information thus suggests that within the United States grazing, and secondary effects such as change in fire frequency and invasion of exotics, were the primary cause of extirpation of Columbian sharp-tailed grouse… on roughly 75% of the historic range."
> (Bart 2000)

Livestock grazing is an important factor affecting sharp-tailed grouse populations (Evans 1968, Kessler and Bosch 1982, Bart 2000). Although many sharp-tailed grouse studies report the negative impacts of grazing, keeping large private ranches intact may be essential for recovery of the species. Livestock grazing may be compatible with sharp-tailed grouse in uplands if habitat characteristics needed for breeding and nesting can be consistently maintained (Giesen and Connelly 1993). Whether this is possible on any particular site probably depends on many factors including grazing history of the site; site condition; precipitation zone and year-to-year precipitation; livestock type; stocking rate; and season, intensity, frequency, and duration of grazing.

Although habitat conversion was a more important factor in the species' historical decline in Washington, the degraded condition of remaining habitat resulting from past heavy grazing is still an important factor affecting sharp-tailed grouse populations and recovery. In experiments designed to investigate sheep grazing and grouse, Baines (1996) and Calladine et al. (2002) reported that grazing reductions on moors in northern England were associated with more successful breeding and higher densities of black grouse; the heavily grazed moors were essentially sink habitat where grouse populations were supported by immigration. With the exception of Kirby and Grosz (1995), there have been no experimental studies designed to investigate the effects of grazing on sharp-tailed grouse populations. However, there have been many experimental studies on the effects of grazing on native vegetation, and many correlative studies have documented low use and productivity, or absence of sharp-tailed grouse associated with heavy grazing (Brown 1966, 1968, Parker 1970, Hillman and Jackson 1973, Kirsch et al. 1973, Marks and Marks 1987a, Klott and Lindzey 1990).

Livestock grazing has the potential to: 1) affect sharp-tailed grouse reproductive success through reduction of key food plants and insects available to females and broods (Hoffman and Thomas 2007); 2) decrease available nesting cover and reduce residual vegetation making females, nests, and chicks more vulnerable to predation (Schroeder and Baydack 2001, Flanders-Wanner et al. 2004, Manzer 2004); and 3) degrade riparian winter habitat. These impacts can eliminate local populations (Brown 1968, Zeigler 1979, Kessler and Bosch 1982, Giesen and Connelly 1993, Hoffman and Thomas 2007). Sharp-tailed grouse have been observed shifting use to ungrazed areas following livestock use of traditional sites (Brown 1968). Brown (1966) noted a clear relationship between cover provided by residual vegetation, numbers of male sharp-tailed grouse, and the establishment of new leks. He also noted that females appear to be more sensitive to the amount of cover; males outnumbered females up to 4:1 on areas with little residual cover, but females often outnumbered males 3:1 near newly established leks in heavy standing herbage with good shrub interspersion. Apa (1998) suggested that any management practice, including livestock grazing, that reduced nesting and security cover within 2 km of leks would make females and eggs more vulnerable to predation. Livestock grazing during drought in southern Idaho rangeland generally reduced grasshopper populations (Fielding and Brusven 1995), which are an important food of growing chicks (Hart et al. 1950, Bernhoft 1969, Mitchell and Riegert 1994).

In a comparison of two study areas, Marks and Marks (1987a) found that sharp-tailed grouse were rare on the site severely modified by livestock and agricultural development, which had less vertical and horizontal plant cover, lower diversity of forbs and shrubs, lower canopy closure of plants that decrease with grazing, and fewer and more severely damaged mountain shrub and riparian areas. Saab and Marks (1992) reported that sharp-tailed grouse locations had higher proportions of plant species known to decline with increased grazing than random sites. Birds preferred microhabitats with more bluebunch wheatgrass and arrowleaf balsamroot, both of which decrease with increased grazing intensity and are critical for cover during a drought year. Kirsch et al. (1973) reported that lightly to moderately grazed grasslands in North Dakota were of limited value for sharp-tailed grouse and no leks were located on hay fields or heavily grazed pastures without adjacent 'retired' cropland. They recommended suspension of annual grazing and a management regime of prescribed burning.

Additional effects of livestock include trampling of nests and behavioral avoidance by grouse. McDonald (1998) reported that at least two sharp-tailed grouse nests were trampled by livestock during his study in Washington. Nielsen and Yde (1982) reported that sharp-tailed grouse in Montana appeared to exhibit behavioural avoidance of cattle; only 3 of 1,279 observations were within 150 m of cattle. Indirect impacts of livestock ranching include fences that can be a source of sharp-tailed grouse mortality, roads that fragment habitat; roads and livestock also facilitate the spread of weeds that eventually require the use of herbicides that can impact native forbs and shrubs (Freilich et al. 2003). Ranching also sometimes includes spraying, burning, and mechanical treatments of sagebrush, seeding of crested wheatgrass to increase livestock forage and an increase in noxious weeds (Beck and Mitchell 2000).

Cattle are the most common livestock affecting sharp-tailed grouse habitat in Washington, but horses and sheep have also affected habitat quality in some areas. Two leks on the Colville Indian Reservation have moved or been eliminated in recent years because increasing numbers of feral horses congregated on the ridgetop sites chosen by sharp-tailed grouse for leks. 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; there were 6.7 times the number of shrubs in plots protected from horse grazing (Beever and Brussard 2000). Exclosures in mountain rangeland 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).

Sheep may compete directly with grouse for forbs (Miller and Eddleman 2000, Pedersen et al. 2003). Herds of sheep or goats often occur at much higher densities on the landscape than native ungulates to which the vegetation is adapted, which makes them more likely to cause serious damage. Laycock (1967) reported that heavy spring grazing in three-tipped sagebrush by sheep near Dubois, Idaho, caused rapid deterioration of range, including an 85% increase in sagebrush and a 50-85% decline of grasses and forbs. Heavy grazing by sheep only in late fall was less destructive of the vegetation but decreases residual herbaceous cover needed for nesting cover by sharp-tailed grouse the subsequent spring.

Livestock grazing in Columbia Basin shrub-steppe. 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 cool season bunchgrasses and a biotic crust (Belnap et al. 2001), reflects a recent evolutionary history without high numbers of large herbivores (Tisdale 1961, Daubenmire 1970, Shinn 1980, Mack and Thompson 1982). Although elk (*Cervus canadensis*), deer (*Odocoileus hemionus*), and bighorn sheep (*Ovis canadensis*) were at least seasonally or locally present, and bison (*Bos bison*) were at least sporadically present in modest numbers, grazing by large ungulates seems to have played little part in the evolution of shrub-steppe organisms in Washington prior to the influences of Euro-Americans. 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 the effects of grazing on an ecosystem. This suggests that the impact of livestock grazing in the Columbia Basin would be different than in other regions, such as the Great Plains where sod-forming and warm season grasses were subjected to continuous high selection pressure by large herding bison (Mack and Thompson 1982).

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 the Palouse and sagebrush communities are sensitive to defoliation in the late spring and early summer, when heavy grazing reduces their vigor and coverage (Tisdale 1961, Crawford et al. 2004). Tisdale (1986) reported that standing crop from nine depleted Canyon Grassland sites averaged 6% perennial grass (mostly Kentucky bluegrass), 57% annual grasses and 37% forbs (mostly exotic annuals). Bluebunch wheatgrass produced <1% of the total. In contrast, relatively undisturbed sites had 70% native perennial grasses, 19% perennial forbs, 5% annual grasses, and 5% annual forbs (mostly native).

Trampling impacts to the biotic crust may affect the ability of native vascular plants to survive and recover from disturbance (Belnap et al. 2001), suggesting that excessive grazing can have long-term effects on sharptail habitat quality. 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."

Cheatgrass, weeds, and their spread by livestock grazing. Cheatgrass competes with native bunchgrasses and forbs that provide better food and cover for sharp-tailed grouse. Cheatgrass is an annual grass native to Eurasia that was first reported in North America in 1889 in British Columbia, and 1893 in Washington, and it quickly spread throughout degraded rangelands (Mack 1981). Increases in cheatgrass facilitate an increase in fire frequency by providing a highly combustible, continuous fuel blanket, resulting in more intense and frequent fires that can eliminate sagebrush (Whisenant 1990, Peters and Bunting 1994). Many shrub-steppe sites that have had repeated or intense disturbance in Washington are dominated by cheatgrass, while more moist steppe with annual precipitation >45 cm (17"), not converted to agriculture is often dominated by Kentucky bluegrass (*Poa pretense*), a perennial sod-forming grass which displaces native bunchgrasses (Cook and Gilmore 2004). Additional weed species that have invaded Washington steppe are medusahead (*Taeniatherium caputmedusa ssp. asperum*), rush skeletonweed (*Chrondilla juncea*), leafy spurge (*Euphorbia esula*), yellow starthistle (*Centaurea solstitialis*), and knapweeds (*Centaurea* spp.).

Livestock disperse cheatgrass and weed seeds in their dung and fur (Belsky and Gelbard 2000), and affect the soil and native vegetation in ways that facilitate invasion. Trampling disturbance to soil, nitrogen concentration from dung and urine, destruction of biological soil crust, and selective grazing of native species, all aid the establishment of exotic weedy species (Rickard 1985, Miller et al. 1994, Belnap et al. 2001, Chambers et la. 2007). A number of major weeds, such as yellow starthistle, medusahead, bull thistle (*Cirsium vulgare*), diffuse knapweed (*C. diffusa*), Russian thistle (*Salsola kali*), and tall tumblemustard (*Sisymbrium altissimum*), occur less frequently in ungrazed or lightly grazed communities than in more disturbed ones (Belsky and Gelbard 2000). In Benton County shrub-steppe, Rickard (1985) reported that cheatgrass and tall tumblemustard quickly colonized trampled ground near gates and water troughs with only 3 years of cattle use. Serious weed infestations do occur in some ungrazed, undisturbed communities, but seem to be relatively rare (Belsky and Gelbard 2000), and healthy, undisturbed sagebrush communities are relatively resistant to invasion (Chambers et al. 2007). Cheatgrass may not be as invasive in the vegetation zones most important for sharp-tailed grouse in Washington (three-tip sagebrush and fescue grasslands) as in Wyoming big sage types (Bunting et al. 2002). Cessation of grazing can lead to recovery of native perennials and decline in many exotic species, but in seriously degraded sites, it may require more than 10 years for improvements to be evident (McLean and Tisdale 1972, Green and Kauffman 1995). Bunting et al. (2002) suggest that, “aggressive weed control measures and changes in livestock management may prevent increasing invasive plant dominance and additional displacement of native species.”

Livestock grazing of riparian habitat. Loss and damage to riparian deciduous habitat is perhaps the most important negative impact of livestock on sharp-tailed grouse habitat in Washington. Woody deciduous cover provides critical foraging areas and escape cover for sharp-tailed grouse throughout the year, but is particularly important in winter (Zeigler 1979, Marks and Marks 1987a). Livestock spend a disproportionate amount of time in riparian areas, particularly in summer and fall, because of the available water, green forage, shade, and lower temperature (Kauffmen and Krueger 1984). Excessive grazing, trampling, and rubbing can reduce deciduous trees and shrubs in riparian areas, thus reducing winter food and shelter for sharp-tailed grouse (Parker 1970, Nielsen and Yde 1982, Kessler and Bosch 1982, Marks and Marks 1987a). These activities can also eliminate stream bank vegetation, resulting in channel widening, channel aggradation, and lowering of the water table (Kauffman and Krueger 1984, Armour et al. 1991). Lowering of the water table can result in the replacement of riparian vegetation with upland vegetation and exotic weeds (Belsky et al 1999) (Fig. 30). It should be noted that grazing is often not the only factor involved, and stream incision and erosion events during flooding is often related to cropland or a combination of factors.

In many eastern Washington riparian areas, the regeneration of shrubs, such as hawthorn, snowberry, chokecherry, serviceberry, black cottonwood (*Populus balsamifera trichocarpa*), aspen, willows,

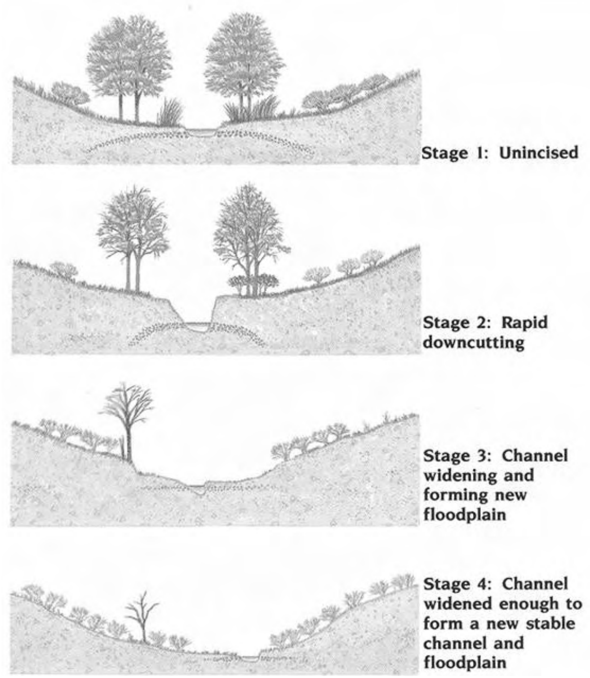

Figure 30. Potential degradation of stream channel and riparian vegetation from prolonged heavy grazing (from Chaney et al. 1993).

and water birch, has been suppressed by decades of grazing (Franklin and Dyrness 1973, Paulson 1996). Deciduous species have often been replaced by sagebrush and rabbitbrush and grazing-resistant exotics such as bluegrass, thistles (*Cirsium* spp.), teasel (*Dipsacus fullonum*), common dandelion, and reed canarygrass (Chaney et al. 1993).

Paulson (1996) investigated the effects of intensive grazing on riparian habitat in Lincoln County. Riparian stands of aspen and birch were common on the study area before the number of AUMs (animal unit months) were increased by 50% in 1974. After 17 years, density and canopy cover of trees and shrubs >5 ft were >3 times greater in the ungrazed section of the creek than in the intensively grazed area. Paulson (1996) noted that the most obvious missing element was the 5–10 ft layer. Seedlings and saplings of aspen, birch, willow, and hawthorn were extremely rare, and no chokecherry and serviceberry were present in the grazed area.

Grazing in spring and summer habitat. Some shrub-steppe areas in Washington, though currently lightly or moderately grazed, have little perennial grass or forb cover, a legacy of past heavy grazing. In west-central Idaho, Saab and Marks (1992) found sharp-tailed grouse using home ranges in areas that were least modified by livestock grazing, and they considered Columbian sharp-tailed grouse as an indicator of good range condition in mesic shrub-steppe.

In Wyoming, key variables for sites used by broods were presence of oniongrass and sulphur-flower buckwheat, both of which decrease with grazing (Klott and Lindzey 1990); areas used were diverse in forb and grass species, therefore grazing pressure that reduces species diversity would be detrimental. In Colorado, Hoffman (2001) reported a higher density of leks and greater number of males per lek on CRP and mine reclamation lands than on grazed shrub-steppe. Collins (2004) reported higher sharp-tailed grouse productivity on ungrazed mine reclamation land than on grazed shrub-steppe.

Results of studies of grazing and plains sharptailed grouse (e.g., Mattise 1978, Roersma 2001) may not be applicable to Washington, because of differences in vegetation, precipitation, and an evolutionary history that included large herds of bison. However, some observations may be applicable. For example, Nielsen and Yde (1982) noted that male sharp-tailed grouse did not shift to rested areas, and showed considerable behavioral attachment to areas near leks. Kirby and Grosz (1995) monitored nest success of plains sharp-tailed grouse in rotationally grazed pastures and adjacent nongrazed area in North Dakota. They reported that nests/100 ac in the nongrazed area was double that in the grazed pastures, and the number of successful nests/100 ac was 1.0 in grazed compared to 1.3 in nongrazed areas (significance not stated). The percent of nests that were successful was higher ($P < 0.05$, Mayfield method, 36 days exposure), however, in the grazed pastures (44%) than in nongrazed (26%) pastures; they could not explain the higher nest success in the grazed pastures, but hypothesized that the reduced cover and high human activity made the grazed pastures unattractive to mammalian predators. There was also a lower density of nests in the grazed pastures, affecting the success of predators searching for them.

Predation in altered landscapes and communities

Predation is the most important proximate cause of mortality for sharp-tailed grouse and the rate of predation is affected by the quality of habitat. Grouse have long coexisted with predators and have developed adaptations and strategies to improve their chances of survival, such as camouflage, flocking, distraction displays, reduced scent emission of incubating females (Reynolds et al. 1988), and roost site selection (Conover and Borgo 2008). Although sharp-tailed grouse are adapted for avoiding predators most of the time, habitat changes and human-associated food sources have generally increased the abundance of multiple species of predators in their range. In Washington, these include crows, ravens, magpies, and great horned owls (Sauer et al. 2008), and possibly coyotes, raccoons, striped skunks, and non-native red foxes. Losses to predation are sustainable in large populations, but have a more significant impact on small populations. Long-term declines in game birds, ground-nesting waterfowl, and songbirds have led to hypotheses about increased nest predation, likely related to changes in habitat and predator communities (Reynolds and Tapper 1996, Nelson 2001, Sovada et al. 2001, Brennan and Kuvlesky 2005).

The dramatic changes in the landscape of eastern Washington from agriculture and development have also changed the predator and prey community that affects sharp-tailed grouse. Fragmented agricultural landscapes may also support abundant rodents, pigeons (*Columba livia*) and Eurpoean starlings (*Sturna vulgaris*), that in-turn attract predators that then opportunistically prey on grouse (Dunn 1982, Rich 1986, Reynolds and Tapper 1996, Moulton et al. 2006). The presence of introduced ring-necked pheasants and California quail in Washington, particularly where supported by winter feeding stations, may support a greater density of resident predators, such as great horned owls, than was historically present. Also, introduced game birds may allow seasonal migrants, such as northern goshawks and rough-legged hawks, to linger in the area longer than otherwise and occasionally take sharp-tailed grouse.

Population declines in many bird species have been attributed to higher rates of nest predation in fragmented habitats, however, this and related hypotheses need further investigation (Chalfoun et al. 2002). Several studies of simulated or real nests report higher nest predation rates in smaller habitat patches of grassland or shrubland (Burger et al. 1994, Vander Haegen et al. 2002, Herkert et al. 2003). When available habitat is comprised of small patches, it limits the search area for predators to find nests (Phillips et al. 2003), resulting in higher predation rates. This may limit reproductive success and cause local areas to become population sinks (Pulliam 1988). Vander Haegen et al. (2002) and Vander Haegen (2007) reported that real and simulated songbird nests in a fragmented shrub-steppe/cropland landscape in Washington were nine times more likely to be depredated (mostly by common ravens or black-billed magpies) than those in continuous landscapes.

Manzer and Hannon (2005) reported that concealment cover was the most important variable for explaining sharp-tailed grouse nest success, and the relationship was strongest when analyzed at the 50 m scale. Nests were four times more likely to succeed in areas with <10% cropland (including hay fields) and with <35% total cropland and sparse grassland when analyzed at the 1,600 m scale. However, chick and hen survival was not statistically lower in the more fragmented landscapes (Manzer and Hannon 2008); predation accounted for 72% of chick mortality and 82% of hen mortality, with mammals taking the largest part in each case.

Habitat changes have also led to changes in predator communities. Populations of many predators of nests and birds that benefit from human-associated food and nesting structures are higher than they were historically. For example, orchards provide a food source for coyotes, foxes, raccoons, skunks, crows, and magpies. Human altered landscapes provide resource subsidies to corvids, such as ravens, that have led to increased reproduction and survival (Boarman 2003, Webb et al. 2004). The population of ravens has tripled in North America in the past 40 years (Sauer et al. 2008). Ravens nest on transmission towers, railroad trestles, highway overpasses, and abandoned farm buildings; they will feed on roadkill, livestock afterbirth and carcasses, and at landfills (Coates et al. 2007). Common ravens opportunistically feed on prairie grouse eggs and young (Schroeder and Baydack 2001). Coates and Delehanty (2010) reported that daily survival rate of greater sage-grouse nests in Nevada was directly related to local abundance of common ravens. Marzluff and Neatherlin (2006) reported that American crow abundance and survivorship was higher, and crows and ravens fledged more young/pair, near human-associated food sources, and the rate of predation on simulated nests was related to corvid abundance.

Black-billed magpies most often nest in riparian thickets of deciduous trees and shrubs and shrubby draws (Trost 2000), but also in trees and shrubs planted around farms. Vander Haegen (2007) noted that magpies were more abundant in landscapes fragmented by agriculture in eastern Washington. Magpies will respond to increased food availability by increasing densities, clustering nests near the resource patch and abandoning territorial defense (Stone and Trost 1991). In winter they sometimes aggregate at feedlots, garbage dumps and grain elevators (Stinson 2005). Jones and Hungerford (1972) reported that magpies were the primary predator of simulated nests in southern Idaho. Manzer and Hannon (2005) found higher magpie and crow densities in landscapes with higher proportions of cropland and sparse grassland; sharp-tailed grouse nests were eight times more likely to succeed in landscapes with lower densities of corvids.

The increase in non-native red foxes represents another effect of sharp-tailed grouse habitat changes. Red foxes are well adapted to a fragmented agricultural landscape, are tolerant of human activity, and can occur in high densities (Kamler and Ballard 2002, Gosselink et al. 2003). Foxes (*Vulpes* spp) were absent from the Columbia Basin in the 19th century (Aubry 1984). In the early 20th century, however, non-native red foxes from eastern states escaped from fur farms, including farms in Kittitas and Stevens counties (Aubry 1984). Non-native red foxes are now established in the lowlands of Kittitas and southern Chelan counties (Aubry 1984), and Lincoln County (M. Finch, pers. comm.) and have been sighted in all the counties of eastern Washington (Aubry 1984, D. Volsen, M. Finch, P. Wik, P. Fowler, pers. comm.). Red foxes are seen in forested portions of Okanogan County but have not been seen in the steppe regions where sharp-tailed grouse are present (J. Heinlen, pers. comm.). Coyotes are known to harass and prey on red foxes, and where common, may largely exclude foxes from areas, like the shrub-steppe areas in Washington (Voigt and Earle 1983, Sargeant et al. 1987). Coyote avoidance may be part of the reason foxes select human associated habitat such as rural residences and abandoned farmsteads (Dekker 1983, Gosselink et al. 2003). Red foxes frequently prey on ground-nesting birds and their nests, and are known to have a greater impact than coyotes on nest success (Sovada et al. 1995, Riley and Schultz 2001). Coyotes are an important predator of sharp-tailed grouse eggs, chicks, and females (Hart et al. 1950, McDonald 1998), but coyotes may play an important role in limiting the presence of non-native red foxes in occupied sharp-tailed grouse areas (Sovada et al. 2001, Gosselink et al. 2003); based on home range sizes, one coyote may displace five pairs of red foxes (Sergeant et al. 1987), so removal of coyotes could have unintended consequences.

Dependence on the Conservation Reserve Program

The CRP program was established by the 1985 Farm Bill to conserve topsoil by maintaining perennial vegetation on erodible lands. The program has also provided benefits to wildlife, particularly ground-nesting birds (Gray and Teels 2006). Rodgers and Hoffman (2005) reported that sharp-tailed grouse, and Columbian sharp-tailed grouse in particular, had increased in number and distribution in 10 of 12 states, including Washington, as a result of the program. Populations in southeastern and western Idaho increased sharply with the establishment of CRP grasslands, with over 80% of 172 new leks in 1995–1998 occurring in CRP fields (Rodgers and Hoffman 2005). Sharp-tailed grouse distribution increased 400% in Utah after CRP lands re-established connections between isolated populations. However, not all CRP fields are, or have remained, good sharp-tailed grouse habitat. Most of the early contracts involved planting with exotic grasses, such as crested wheatgrass (*Agropyron cristatum*) or smooth brome (*Bromus inermis*); some included alfalfa which may have temporarily boosted grouse populations, but many of these fields are now monocultures of the exotic grass that provide inadequate food and cover (McDonald 1998, Boisvert 2002). Boisvert (2002) reported low sharptail survival on some Colorado CRP land, which appeared to be 'sink' habitat, compared to a much more diverse mine reclaimation area.

Land enrolled in CRP contracts in Washington has increased from 55,000 ac in 1986 to over 1.5 million ac on 5,000 farms in fiscal year 2011. This is about 7% of the historical range and about 4% of the occupied range of sharp-tailed grouse in the state (Table 7). Although CRP covers a modest portion of the occupied range, it provides important nesting habitat in parts of Lincoln and Douglas counties and almost the only habitat in portions of the historical range. In areas with little public land, such as Whitman County, CRP provides most of the steppe habitat, thus any future recovery of sharp-tailed grouse would depend heavily on these private lands.

The quality of a CRP field depends on the type of vegetation planted and the length of time the field has been enrolled in the program. Although many early plantings of CRP fields in Washington are now monocultures of crested wheatgrass, some have been recolonized by sagebrush; these older CRP fields with sagebrush provide habitat for some shrub-steppe birds (e.g. sage thrasher, *Oreoscoptes montanus*; Brewer's sparrow, *Spizella breweri*), but the grass and forb diversity is probably inadequate for sharp-tailed grouse. In recent years, however, CRP fields have been planted with a diverse mix of native grasses and forbs more suitable for sharp-tailed grouse, and many older CRP fields are being improved with native species.

The 2008 Farm Bill extended CRP enrollment through September 2012; however, nationally the 29.6 million ac in the program will be reduced by 7 million ac by 2012. Douglas County received a waiver from the 25% county cropland enrollment limitation in the 1990s, allowing 33.4% of the county's cropland to be enrolled. However, waivers are no longer granted and the county is expected to lose 43,000 acres of CRP by 2012. In 2010, a new State Acres for Wildlife Enhancement (SAFE) program established under the CRP program allocated up to 63,000 ac of 15-year contracts in northern Douglas County to support sage and sharp-tailed grouse. This requires new cover plantings to have a minimum of 7 species, including 3 grasses, 3 forbs, and 1 shrub, whereas re-enrolled CRP land must have a minimum of 3 grasses, 1 forb, and 1 shrub, and must not have more than 25% cover of crested wheatgrass. The acreage enrolled in the SAFE program will be very important for maintaining the sharptail population in Douglas County over the next 15 years.

Because CRP is a voluntary program and dependent on congressional renewal in national farm bills, the long-term status of the program and the areas enrolled are uncertain. Spikes in wheat prices in the past have led to concerns that many CRP contracts may not be renewed or that some farmers may seek early release from contracts (Streitfeld 2008), which would drastically affect wildlife conservation efforts. Contracts on nearly 175,000 ac expired in 2011 and there has been reductions of CRP ac in some counties, but Washington was one the few states that saw an increase in enrolled acres (~30,000 ac) due to re-enrollments and sign-ups for SAFE contracts. Large numbers of contracts (>500,000 ac) will also expire in 2012-2013. If CRP habitat in Douglas and Okanogan counties were returned to cropland in the future, it could cause further declines in sharp-tailed grouse numbers and negatively impact recovery in additional areas. Large federal deficits also raise concerns about long-term funding assurances for the program. A major reduction of CRP contracts in Idaho and Utah could also negatively affect populations in those states and hence future translocations of sharp-tailed grouse to Washington. A SAFE program for sharp-tailed grouse in Idaho had 60,000–70,000 ac enrolled as of March 2012.

Effects of Fire on Sharp-tailed Grouse Habitat

The effects of fire on sharp-tailed grouse habitat in Washington vary with vegetation type and are not well understood. In the more mesic meadow steppe habitats where grasses and fire-tolerant shrubs predominate, habitat can recover quickly and fires may be benign or beneficial to sharp-tailed grouse. However, in drier shrub-steppe areas, wildfire is believed to be a serious threat to sage-dependent wildlife species (Fischer et al. 1996, Connelly et al. 2000a), because big sagebrush does not resprout after fire and must re-colonize a burn by seed. Fires can eliminate the shrub layer for a long period of time and often facilitate the spread of cheatgrass (Wambolt et al. 2001). Nearly all the areas currently occupied by sharptails in Washington, however, are in the Three-tip Sage Vegetation Zone, where damage from fires is reduced because precipitation is higher and three-tip sage usually resprouts after fire. Burns that leave patches of shrubs may be less detrimental to sharp-tailed grouse than sage-grouse, which depend on sagebrush for food.

The presence of cheatgrass has greatly increased the incidence of wildfire in the sagebrush-grass region (Whisenant 1990, Billings 1994, Mosley et al. 1999); it is highly flammable and forms a continuous carpet of fine-textured fuel. Burning may also facilitate invasion by noxious weeds. Cheatgrass is not as invasive in the Three-tip Sagebrush and Mountain Big Sagebrush Mesic West potential vegetation types (Bunting et al. 2002), which is more important to sharp-tailed grouse in Washington than the drier Wyoming big sagebrush vegetation types. 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.

Merker (1988) believed that three large prescribed fires in areas containing active leks in Lincoln County in the 1980's were directly responsible for the decline and elimination of local populations of both sharp-tailed grouse and sage-grouse. McArdle (1977) found less use by sharp-tailed grouse in burned areas compared to other vegetation manipulations. Likewise, Hart et al. (1950) reported that Columbian sharp-tailed grouse abandoned a lek site following a fire, which also caused a loss of nests and winter food and cover.

Historical fire regimes in Washington sharp-tailed grouse habitat. Information about historical fire frequency in the steppe of eastern Washington can be surmised from historical accounts of the landscape, fires, Native American burning, studies of charcoal deposits, and knowledge of the fire tolerances of vegetation (Agee 1994, Weddell 2001b, Welch 2005). The abundance of sagebrush and bitterbrush reported by early Euro-American explorers in eastern Washington suggests that fire was infrequent in most shrub-steppe communities because Wyoming big sagebrush and bitterbrush, the dominant shrubs in this vegetation type, are killed by fire (Daubenmire 1970). Some sagebrush-bunchgrass communities, particularly stiff sage (*Artemisia rigida*), contain sparse and discontinuous vegetation that does not sustain fires (Tisdale and Hironaka 1981). Fire return intervals in shrub-steppe vary depending on precipitation. Areas with higher precipitation (i.e. >13") more quickly regenerate plants and shrubs that can act as fuel for the next fire (Tisdale and Hironaka 1981), but the time when conditions are dry enough to burn is more brief (Welch and Criddle 2003, Welch 2005). Drier areas may have exceeded 200 years between fires. Baker (2006) presented evidence suggesting that pre-Euro-American fire rotations were 100–240 years in Wyoming big sagebrush and 70–200 years or more in mountain big sagebrush. He concluded that though fire is an important natural disturbance in sagebrush, it does not occur as often as suggested in the past, and given the long rotations, modern fire suppression has had little effect on most sagebrush areas.

Daubenmire (1970:8) concluded that soil and climate, not fire, were the major influences in shaping the distribution of vegetation types or species in eastern Washington. Tisdale (1986) reached similar conclusions about Canyon Grasslands, represented in Washington along the Snake and Grand Ronde River canyons. Sauer (1950) believed that no grasslands existed on deep soil except those maintained by reccurring fires, mostly set by humans. However, extensive grassland ecosystems existed for long periods before humans invaded North America (Vale 2002:297).

Native American burning in eastern Washington. A number of tribes, including the Klikitat, Kalispel, Coeur d'Alene, Umatilla, Spokan, and Nez Perce, used fires to hunt for game, open up the forest, and improve pasture (Stewart 2002), but the extent of this practice remains widely debated. Shinn (1980) believed that aboriginal burning in the inland Northwest was a widespread and long-standing practice, but noted that given the varied physiography of the region, fire was probably not used everywhere with equal regularity. Weddell (2001b) concluded from the various types of evidence that Native Americans in the northern intermountain region apparently did set fires in steppe environments, but with unknown frequency. Whitlock and Knox (2002) reported close correlation between climate and fire frequency in the Pacific Northwest during long prehistoric periods. They concluded that, "prehistoric peoples locally altered the landscape, but there is no strong evidence that their activities created new vegetation types at a regional scale" (p. 224). Anderson (2002) states that Stewart's (2002) monograph gives the false impression that Native Americans burned everywhere, "which is clearly not the case." Barrett et al. (2005) concluded,

> "A myth of human manipulation everywhere in pre-Columbus America is replacing the equally erroneous myth of a totally pristine wilderness. …the case for landscape-level fire use by American Indians has been dramatically

over-stated and overextrapolated."

Interviews of many elders during the 20th century indicate that Native Americans in eastern Washington and surrounding areas historically burned local areas to increase yield of important food plants, including camas, lomatiums, and berries (Hunn and Selam 1990, Boyd 1999, French 1999). Fire was used to concentrate game, clear the understory along trails, improve forage for elk, deer, and horses, and clean campsites of vegetation, snakes and vermin (Barrett and Arno 1999). They also may have used fire to gather crickets, lizards, acorns, and sunflower seeds (Shinn 1980, Boyd 1999, Marshall 1999). Locations where burning was used included the Klikitat Trail, Methow Valley, and Cayuse Mountain in southern Spokane County. One Methow elder, upon returning to the Methow Valley in 1979 after a long absence, recounted how they used to take care of the land by burning every fall, but "now it is a jungle" (Boyd 1999:1). The Klikitats, Nez Perce, and Spokans are known to have used fire to improve food patches (Marshall 1999, Norton et al. 1999, Ross 1999). Ross (1999) reported that Spokans fired the grassland near Cayuse Mountain to capture wild horses. The need for improving forage for expanding horse herds may have provided motivation to expand burning activities by Native Americans during the 18th and 19th centuries (Robbins 1997, *in* Hessburg and Agee 2003).

Though fire was used to manage vegetation at specific sites, it is not clear whether larger landscapes in steppe were intentionally burned. Shinn (1980) noted that 65% of 30 fires recounted in historical sources were attributed to Native American burning. This included reports from the Grande Ronde Valley, the upper Walla Walla watershed, and Hells Canyon; it is unclear how many of these fires were in steppe versus ponderosa pine forest. Baker (2002:53–54) points out, however, that historical accounts that attribute ignition to Native Americans, unless an eye-witness account, are unreliable, because of racial biases and historical ignorance of lightning as a frequent ignition source. Baker (2002:56) noted that the importance of lightning as an ignition source in grasslands was underestimated until the 1970s.

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, and consistent with estimates suggested by Baker (2006). Charcoal deposits of the more recent 500 years were much reduced, perhaps indicating a reduction in fire size (Scharf 2002).

Effects and potential benefits of prescribed fire in sharp-tailed grouse habitat. Fires in grasslands generally increase forbs, and fires in shrublands generally increase grass and forb cover at the expense of shrubs (Agee 1994). Fire is reported to improve site productivity and plant species composition, and reduce litter (Weddell 2001b). Bowker et al. (2003) reported that after burning in Canyon Grassland in the Hell's Canyon area of Oregon, there was no difference in lichen and moss species composition between burned and unburned plots, but their density was reduced; they hypothesized that soil crusts of grasslands in the Palouse region are relatively resistant to wildfire.

In Washington, prescribed fire could be considered as a potential habitat improvement tool for sharp-tailed grouse in prairie, or three-tip sagebrush communities (Weddell and Lichthardt 2001). Prescribed fire is not recommended in the dry Wyoming big sagebrush shrub-steppe (Stinson et al. 2004), and a wildfire in recent years on the Scotch Creek WLA did not appear to improve habitat for sharp-tailed grouse (J. Olson, pers. comm.). However, under some circumstances, burning can improve sharp-tailed grouse habitat. Sexton and Gillespie (1979) reported that sharp-tailed grouse returned to a traditional lek site from a new lek in Manitoba immediately after a fire that removed residual grass but did not affect woody vegetation; the fire apparently had reduced the vegetation to a more favorable height for displaying birds. Burning dense sagebrush and thickly wooded areas was found to improve sharp-tailed grouse habitat in Utah (Hart et al. 1950), North Dakota (Kirsh et al. 1973), Colorado (Rogers 1969), and Wyoming (Oedekoven 1985). Several important winter foods are often top-killed, but resprout readily after fire, including Douglas hawthorn, serviceberry, chokecherry, snowberry, and aspen (Giesen and Connelly 1993, Habeck 1991, Howard 1997, Keyser et al. 2005). Snowberry and other low shrubs of meadow steppe resprout and may return to their pre-burn condition within three years (Weddell 2001b). Native bunchgrasses, snowberry, chokecherry, and native rose are recovering well on the Chiliwist WLA subsequent to three wildfires which killed bitterbrush which is little used by sharp-tailed grouse (Swedberg 2006).

Modern fire suppression policies may have allowed conifers to invade in some areas to the detriment of sharp-tailed grouse populations. Juniper has expanded into some sagebrush steppe areas in Oregon and northern California; Washington does not have much juniper, but ponderosa pine and Douglas-fir have invaded and increased in density in steppe habitat in some areas, such as the Siwash Valley (Fig. 31). Giesen and Connelly (1993) indicated that prescribed burning may be effective in maintaining suitable habitats in these situations. Baker (2006) suggests that conifer invasion of sagebrush areas is not generally due to fire exclusion, but to other factors, such as heavy grazing. D. Swedberg (pers. comm.) however, notes there are areas of conifer encroachment on the Sinlahekin WLA where grazing does not occur.

Diseases

Diseases are among many factors that affect a species' ability to persist in small isolated populations. Disease is not known to be an important mortality factor for sharp-tailed grouse populations in Washington, but mortalities due to disease can be difficult to document. Given their habitat associations, there is a low likelihood of finding a grouse that died from the disease unless they were being intensively monitored with telemetry. Two diseases that may have the potential to affect sharp-tailed grouse populations include West Nile virus and Histomoniasis (see also ***Diseases and parasitism***).

West Nile virus. West Nile virus, a disease new to North America, is affecting many bird populations and has caused high mortality in greater sage-grouse populations in some locations (see also, discussion p. 20)(Naugle et al. 2005). It is unknown if the observed declines in bird populations will continue; presumably species with robust populations will adapt and recover (Kilpatrick et al. 2007). Positive tests for West Nile in sharp-tailed grouse have not been reported, but there is little reason to expect they would not be susceptable. West Nile virus activity has been detected in most Washington counties; it has been detected in other bird species in Spokane and Grant counties, but not in Lincoln, Douglas, and Okanogan counties, where sharp-tailed grouse

Figure 31. Pine invasion in the Siwash Valley, Okanogan County.

occur. If West Nile virus causes significant mortality in sharp-tailed grouse in Washington, the impact on small populations could be very serious. Large populations would presumably be more likely to have birds that survive and pass on their ability to resist the disease to offspring.

Histomoniasis. Histomoniasis, or'blackhead,' can devastate populations of grouse and wild turkeys (Davidson and Doster n.d., Beyer and Moritz 2000, Peterson 2004, McDougald 2005). The nematode that can carry the protozoan disease agent has been reported in sharptailed grouse (see also, ***Heterakis gallinarum***). The disease has not been reported in sharp-tailed grouse, but most diseases in free-ranging wild birds go undetected. Pheasants are a carrier of histomaniasis and can transmit the organism causing the disease to other birds. The disease organism can also persist in earthworms (Lund and Chute 1972, McDougald 2005, Davidson and Doster n.d.). None of the WDFW Wildlife Areas that currently support sharp-tailed grouse populations are used for regular pheasant releases (Eastern Washington Pheasant Enhancement Program; http://wdfw.wa.gov/wlm/game/water/ewapheas.htm). However, the Chiliwist WLA, which historically supported sharp-tailed grouse and may support some seasonal use, is a pheasant release site. The Chelan Butte Unit of the Sagebrush Flats WLA and two parcels of the Sinlahekin WLA along the Okanogan River are also release sites, but are of lesser importance to sharp-tailed grouse.

Wind Energy Projects and Utility Infrastructure

There are an increasing number of wind energy projects completed, under construction, or proposed in eastern Washington. There are currently 1,527 turbines in operation, and an additional ~300 under construction or permitted. Many of these are in the historical range of sharp-tailed grouse, but none are in occupied areas. Recent proposals include a project in potential sharptail recovery area near Oakdale in Whitman County.

There are few data on the impact of wind turbines on sharp-tailed grouse. Among 21 studies of avian mortalities at wind energy projects, upland birds were the third most frequently killed bird group. Although pheasants, gray partridge, and chukar accounted for most of the mortalities, 5 sharp-tailed grouse were among the birds killed (Johnson and Holloran 2010).

In considering impacts of wind farms on wildlife, most of the focus has been on collision impacts to flying birds and bats (Anderson et al. 1999, Erickson et al. 2002). For prairie grouse, however, another important issue that has until recently received inadequate funding and research attention is the potential for habitat loss and fragmentation due to behavioral avoidance of towers (Pruett et al. 2009). Any potential further loss and fragmentation of remaining sharp-tailed grouse habitat is a significant concern. Prairie grouse and other grassland birds generally avoid areas with human disturbance and tall structures (Leddy et al. 1999, Hagen et al. 2004, Manville 2004, Pruett et all. 2009). This avoidance may be an instinctive response to tall structures that reduces the bird's vulnerability to avian predators. 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 has a negative impact on sage-grouse attendance at leks (Blickley et al. 2012), and probably on sharp-tail leks as well. Vodenhal (2009) reported that sharp-tailed grouse continued to display at leks in an area with 36 turbines in Nebraska four years post-construction, but there was no pre-construction data to evaluate effects on population trend or distribution. Sharp-tailed grouse use habitat near trees and feed in deciduous shrubs and trees in winter, suggesting that behavioral avoidance of tall structures may not be as important an issue for sharp-tailed grouse, as it seems to be for prairie-chickens and sage-grouse, but this needs more research. Any loss and fragmentation of sharp-tailed grouse habitat caused by wind energy development is a significant concern. Manville (2004) recommended a 5-mile buffer from active leks of prairie grouse, wherever feasible.

Wind energy projects include roads, powerlines, and some level of chronic disturbance. Powerlines, wire fences, and roads are all known to cause sharp-tailed grouse mortalities resulting from collissions. These structures also destroy, fragment, and degrade habitat and make it more hazardous for

Figure 32. Access roads being prepared for wind turbines in Klickitat County.

sharp-tailed grouse to move within otherwise suitable habitat and between habitat patches (Fig. 32). The concerns about behavioral avoidance of wind turbines are also true about electrical transmission lines and any other tall structures. Sage-grouse seemed to abandon leks near major transmission lines in Douglas County and on the Yakima Training Center (M. Schroeder, unpublished data). Sage-grouse and greater prairie will abandon leks and generally avoid transmission lines, residences, well-traveled roads, and compressor stations (Robel 2002, Manville 2004, Pruett et al. 2009). Smaller distribution lines that do not have tall towers may primarily be a concern as a collision hazard and raptor perches. In an Oklahoma study, power-line collisions resulted in 4 of 128 (3.1%) and 4 of 75 (5.3%) of mortalities in lesser and greater prairie-chickens, respectively (Pruett et al. 2009). The U.S. Fish and Wildlife Service has published Wind energy guidelines that outline a process for sighting, data collection when evaluating potential impacts to wildlife (USFWS 2012).

Climate Change

The impacts of climate change on sharp-tailed grouse and their habitat in Washington are uncertain. There is compelling evidence that climate change has altered the phenology, distribution, or density of many bird species (Crick 2004, Root et al. 2005). Many more significant changes can be expected with the much greater temperature increases and changes in precipitation predicted by 2100 (Littell et al. 2009). However, the combined effects on steppe vegetation of increased atmospheric CO_2, higher temperatures, longer frost-free period, and changes in precipitation are complicated and difficult to predict (Siemann et al. 2011).

Recent models generally predict a modest increase in precipitation in the winter and a modest decrease in summer in Washington (Miles and Lettenmaier 2007). A longer growing season and reduced summer precipitation may result in an increased area of aridity, suggesting that the drier edge of sharp-tailed grouse range may retreat. However, drier, nonirrigated cropland that is currently marginal for dryland agriculture may become less suited for dryland agriculture (Miles and Lettenmaier 2007) and, if irrigation water is not available, it may become rangeland or become available for conservation programs. An increase in fire frequencies could reduce invasion by pine forest into steppe habitats in some areas of Okanogan County (http://wdfw.

wa.gov/lands/wildlife_areas/sinlahekin/gallery/sinlahekin_historical.php), but may also expand areas with cheatgrass and frequent fires where sagebrush has been eliminated.

Increased CO_2 may affect plant chemical and nutrient composition and affect wildlife in ways that are not yet understood. Some studies indicate that there may be a reduction of protein value of forage (Inkley et al. 2004), which could affect sharp-tailed grouse reproduction or brood survival. Plant toxins influence diet choice in grouse and other herbivores. For instance, aspen (*Populus tremuloides*) produces coniferyl benzoate, a phenylpropanoid ester that inhibits feeding by ruffed grouse (Jakubas et al. 1993). And birches (*Betula*), which are an important winter food of sharp-tailed grouse in Washington, produce triterpene papyriferic acid as a deterrent to feeding (Swihart et al. 2009). Climate change may influence tolerance to plant toxins by grouse and further restrict use of some plant species, because increases in atmospheric CO_2 are predicted to increase concentrations of toxins in plants (Forbey 2012).

Additionally, the stresses and instability associated with climate change are predicted to have greater impact on small isolated populations, such as those characterizing sharp-tailed grouse in Washington. Climate change may also increase the impact of diseases on sharp-tailed grouse populations. This adds further importance to the restoration of sharp-tailed grouse populations in the state.

Human-related disturbance

Sharp-tailed grouse are vulnerable to disturbance when aggregated at leks and in riparian winter habitat. In addition to inadvertent disturbance from vehicles, livestock, and farming activities, there is also increasing interest by bird watchers and photographers in visiting leks while birds are displaying (Jim Olson, pers. comm.). Noise, machinery, livestock, and human presence related to farming, roads, and recreation (including bird watching and photography) can flush birds off leks and, if frequent, can affect mating activity. Blickley et al. (2012) reported a negative effect on sage-grouse lek attendance from noise, and sharptail leks are probably also sensitive to anthropogenic noise. Baydack and Hein (1987) conducted experimental disturbances, including parked vehicles, propane exploders, scarecrows, leashed dogs, snow fencing, and human presence on sharp-tailed grouse leks in Manitoba. They found that the attachment of males to a lek was sufficiently strong after flushing that they usually quickly returned to the lek despite ongoing disturbance, unless it included human presence. However, females never attended a lek during disturbance, limiting reproductive opportunities for both sexes. Baydack and Hein (1987) therefore concluded that although sharp-tailed grouse may continue to attend a lek during disturbance, the lek may actually become reproductively inactive. However, females are at least somewhat tolerant of the presence of traps, a nearby vehicle, and being flushed during trapping on leks for translocation projects (Schroeder et al. 2011).

Illegal and Accidental Killing

The current frequency of illegal and accidental shooting in the pursuit of other upland game birds is not known. During an intensive study in the early 1990s, two radio-collared sharptails were found shot during the upland bird season, and a radio-collared sage-grouse female released on Swanson Lakes was shot in October 2009 (Fig. 33). Three separate sharptail poaching incidences occurred in the late 1970s (M. Hallet, pers. comm.). Falconry

Figure 33. X-ray of female sage-grouse found dead on Swanson Lakes WLA in October 2009, revealing shotgun pellets.

may also result in mortalities of sharptails (M. Hallet, pers. comm.). Sharptails are potentially vulnerable to shooting during winter when feeding on tree buds along rural roads.

RECOVERY

Recovery Goal

The goal of the recovery strategy is to restore and maintain healthy populations of Columbian sharp-tailed grouse in a substantial portion of the species' historical range in Washington.

Recovery Objectives

The Columbian sharp-tailed grouse will be considered for down-listing from State Threatened to State Senstive status when:

1) **Washington has at least one population that has averaged >2,000 birds for a 10-year period.**

and

2) **The total number of sharp-tailed grouse in Washington has averaged $\geq$3,200 birds for a 10-year period.**

The Columbian sharp-tailed grouse will be considered for up-listing from State Threatened to State Endangered status if:

1) **The total population falls to <450 birds.**

Rationale and Assumptions

Healthy populations are those large enough to readily recover from fluctuations due to disease, drought, and extremes in weather and to adapt to some degree of changes in habitat. This will require substantially increasing the number and distribution of sharp-tailed grouse in the state.

Effective population size and viable populations. A desirable goal of species recovery is to restore a 'viable' population. There is no universally accepted definition of what constitutes a viable population, but generally, a minimum viable population is the smallest size at which populations can maintain genetic variability over time. It also relates to the ability of a population to withstand fluctuations in abundance and recruitment associated with annual variation in food supplies, predation, disease and habitat condition. Most conservation biologists agree that a population of a few thousand or more is desirable for long-term persistence (Lynch and Lande 1998, Frankham et al. 2002, Reed et al. 2003). Smaller populations are subject to loss of genetic diversity and are at higher risk of decline and eventual extinction as a result.

Population sizes of sharp-tailed grouse are difficult to estimate, but it is the 'effective population size' that determines whether the population is large enough to maintain genetic health and avoid inbreeding. The effective population (N_e) is the proportion of a population that can be expected to pass on their genetic information from one generation to the next (Frankham et al. 2002). To estimate the minimum viable population size for Columbian sharp-tailed grouse in Washington, the N_e needs to be determined (Reed et al. 1986). N_e is affected by fluctuations in population size, variance in litter size, and unequal sex ratio (Frankham 1995). Two characteristics of sharp-tailed grouse that can reduce N_e are population fluctuations and their lek mating system in which a minority of males do most of the breeding. Dramatic population fluctuations are a well-established feature of the population dynamics of grouse and strongly influence N_e (Lindstrom 1994, Frankham 1995, Vucetich and Waite 1998, Watson et al. 2000, Williams et al. 2004). Stiver et al. (2008) reported that N_e would also be affected by variance in female reproductive success, annual surviorship, and the frequency of off-lek copulations. In a metapopulation model for prairie sharp-tailed grouse in Wisconsin, Akcakaya et al. (2004) assumed that each male could mate with up to 10 females, and that the population exhibited a 10-year cycle, based on data in Evrard et al. (2000). We included maintaining the population numbers for 10 years to ensure the analysis period includes one or more low years that would expected. USFWS (2010) and Walk (2004) also included recovery objectives involving maintaining populations for 10 years for prairie chickens.

Allendorf and Ryman (2002) recommended retaining at least 95% of the heterozygosity in a population over 100 years. They suggested that the population size required to meet this criteria should not be a goal, but the lower limit below which genetic factors may reduce the likelihood of the population's persistence. If the generation interval for sharp-tailed grouse is about 2 years, then a N_e of 450–500 would be required to retain 95% of genetic heterozygosity for 100 years (Allendorf and Ryman 2002). In general, a N_e of about 500 is considered the minimum expected to maintain the species evolutionary potential (Frankel and Soulé 1981, Frankel 1983, Reed et al. 1986, Frankham et al. 2002:530).

The census population (N) needed to achieve a N_e of 500 is often calculated from the ratio of N_e to N. The relationship between N_e and N is unknown for sharp-tailed grouse because of the lack of sufficient census data and understanding of demography and population dynamics. Frankham et al. (2002) reviewed estimates of N_e from 192 studies of a wide variety of species. Estimates of N_e for populations with long term census data averaged 11% of the census population (N_e/N) (Frankham et al. 2002: 240), but Waples (2002) pointed out that these estimates were confounded by a statistical artifact in the use of time series data. Since N_e is often 0.10 to 0.3 of N, Lynch and Lande (1998) concluded that the actual population sizes necessary for the maintenance of genetic integrity must be "in excess of a few thousand." Palstra and Ruzzante (2008) reviewed studies that reported a N_e/N ratio using genetic methods, and found a median of 0.14. Studies of birds have reported N_e/N ratios ranging from 0.05 to 0.74, but most of these studies involved monogamous species. Sharp-tailed grouse are polygynous and the estimated ratio for the only polygynous species studied (white-winged wood duck, *Cairina scutelata*) were the lowest values (0.05–0.09) reported. Because grouse populations fluctuate dramatically, the N_e /N ratio is likely to be near the low end of this range. The N_e/N ratio for sharp-tailed grouse has not been estimated, but Schroeder (2000) estimated the a ratio at 0.156 for sage-grouse in Washington from 41 years of survey data. Stiver et al. (2008) estimated an N_e/N ratio of 0.19 for a population of Gunnison sage-grouse. This suggested that a breeding population of 3,200 sage-grouse would provide an N_e of 500 to maintain genetic diversity and be considered a minimum viable population. Walk (2004) hypothesized that a genetically effective minimum viable population of greater prairie-chickens required a census population of 860 to >2,500 birds, depending on the variances of reproductive success of males and females. He developed down-listing criteria of >3,000 birds for 5 years, with the stipulation that the population be >3,000 in 3 of 5 years, and it not decline to <2,400 in any of those years. USFWS (2010) estimated a population of 2,750 Attwater's prairie chickens was required to produce N_e of 500, based on an assumption of 10% of males breeding successfully. Additional research is needed to develop an estimate of the N_e/N ratio for sharp-tailed grouse.

Poor genetic health may be reflected in declining productivity and hence in declining population size, regardless of other factors such as habitat. Johnson et al. (2003) reported that genetic variation was significantly reduced in isolated populations of <2,000 greater prairie-chickens, and recommended that managers attempt to maintain populations of >2,000 birds. They contrasted Minnesota, where habitat is contiguous throughout 5 counties and the population has remained around 2,000 for 25 years, with Wisconsin, where a population of 2,000 is declining in number and genetic diversity because it is split among 4 increasingly isolated wildlife areas. This suggests that recovery of sharp-tailed grouse should include one or more populations of >2,000 birds.

The amount of area needed to support a breeding population of >2,000 grouse depends on the quality of habitat. Ulliman (1995) estimated densities in the Curlew and Pocatello valleys of Idaho, a landscape of wheat fields, CRP, and grassland, as ranging from 0.002–0.008 birds/ac. Density in the current range of sharp-tailed grouse in Washington (410,000 ac of shrub-steppe, grassland, CRP; from Table 7) approaches the low end of this range (0.002 birds/ac). If habitat improvements increased the density of birds to 0.008 per acre on WDFW and Colville reservation lands, and 0.002 per acre on remaining areas, the current range could support 2,100 sharp-tailed grouse. A reintroduction to the Methow Valley or northwestern Lincoln County may support 200 or more birds, but increasing the statewide population to >3,000 birds will require restoring additional lands. If a Palouse prairie reserve of sufficient size were established, it could potentially support a higher density (≈ 0.03−0.05 birds/ac), although it would be isolated from other current populations. Such a preserve of 25,000 ac could likely support >1,000 birds. An alternative, or supplement to a publicly owned management area, would be a large aggregation of privately owned cropland enrolled in a SAFE (Farm Bill) program. However, SAFE is a voluntary program and future funding is uncertain.

The current Washington population is fragmented into 7 populations, which are all separated by >10 km, so they may be genetically isolated. Ideally, the populations would be connected by periodic dispersers moving between them and the combined total of the populations could be considered in evaluating viability. Toepfer et al. (1990) reported historical evidence indicating that isolated populations of prairie grouse <200 birds do not persist. Therefore, a high priority for sharp-tailed grouse recovery in Washington must be to restore and enhance habitat to increase all populations to >200 birds, and to restore habitat where possible to establish connections or additional populations between existing populations.

Potential movement corridors between areas occupied by sharp-tailed grouse or areas of suitable habitat should be considered a priority for habitat protection, enhancement, restoration, and possible acquisition. A number of potential corridors and habitat concentration areas (HCAs) have been recently identified for this species in Washington (Fig. 34; Robb and Schroeder 2012). The modeling indicated that several of the corridors were long or had narrow pinch points that would be vulnerable to land-use changes, and only two corridors were modeled across the Okanogan River. The map also shows the importance of HCA 7 (Greenaway Springs) for maintaining connections among several populations. Connectivity considerations also suggest that establishing a population in northwestern Lincoln County would increase the chances of movements between populations in Lincoln and Okanogan counties.

The amount of immigration needed to connect populations genetically is not known, but movement of 1–10 individuals per year is generally enough to prevent genetic isolation (Mills and Allendorf 1996); this assumes that dispersing individuals breed successfully and movement is not in one direction. An interim strategy may include maintaining genetic connectivity between separate populations by a program of translocations and genetic monitoring.

Meeting recovery objectives for sharp-tailed grouse in Washington will require improvements in habitat quality, increases in population numbers and expansion of occupied areas. Once recovery objectives are achieved, the species will be evaluated for down-listing from State Threatened to Sensitive. A State Sensitive species is defined as a species "...that is likely to become endangered or threatened in a

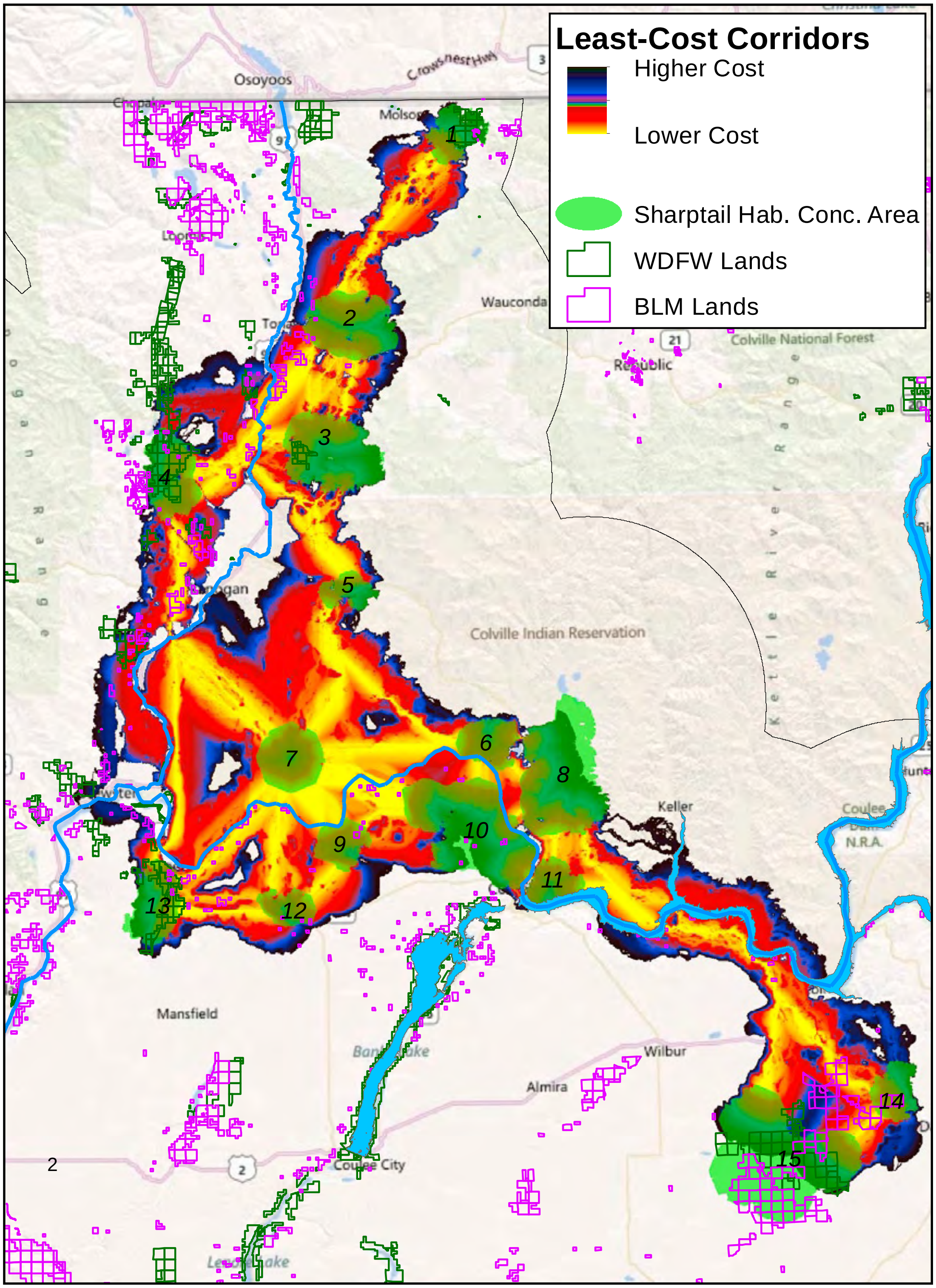

Figure 34. Modeled least-cost corridors for sharp-tailed grouse, and WDFW and BLM lands in north-central Washington (from Robb and Schroeder 2012). The map depicts modeled movement routes of varying difficulty that connect two HCAs or core areas. Least-cost corridors identify the path between two HCAs or core areas with the lowest possible travel cost; i.e., the easiest or most efficient path for sharp-tailed grouse. These potential corridors should be considered priority for habitat protection, enhancement, restoration, and consideration for land acquisitions.

significant portion of its range within the state without cooperative management or removal of threats" (WAC 232-12-297). Once the Columbian sharp-tailed grouse is down-listed to Sensitive, a management plan would be prepared outlining management needs and objectives to de-list the species. Recovery objectives may be modified as more is learned about the habitat needs, dispersal capabilities, and population dynamics of Columbian sharp-tailed grouse in Washington. Data on vital rates, dispersal and population dynamics, as well as a better understanding of habitat needs and habitat capability, are necessary to more accurately assess what population sizes are needed and possible to achieve with existing habitat and habitat that could be restored.

Translocation and Reintroduction

Translocation and reintroduction has been and will continue to be an important component of the recovery strategy for sharp-tailed grouse in Washington. The capture, movement, and release, or 'translocation' of wild-trapped or captive-reared wildlife is an increasingly common conservation practice, and has long been done with game birds. However, projects to establish populations of prairie grouse have had low success rates, in part due to the species' tendency to disperse away from the release site (Toepfer et al. 1990). Projects have also failed because they were limited to small numbers of birds or were short in duration. Pen-reared birds are not as mobile, are costly to produce, and tend to be much more vulnerable to predators (Toepfer et al. 1990, Merker 1996). Toepfer et al. (1990) noted that the amount of quality habitat is the ultimate factor determining success of a translocation. They recommended protecting or restoring habitat sufficient to support a population of ≥200 birds, which they estimated would require >1,000 ha of undisturbed grass-shrub habitat within a radius of 3.1 km. However, a greater amount of unfragmented cover is desirable, and dry locations would likely require a larger area.

Translocation of sharp-tailed grouse to augment existing populations has been conducted successfully in Washington, Idaho, and Kansas (Snyder et al. 1999, Schroeder et al. 2011). Augmentation projects that release birds at active leks of an existing population have had greater success than attempts to re-establish new populations. Populations have been re-established after extirpation in Idaho, Nevada, Colorado, and Kansas; success of a project in Oregon is being evaluated. Successful reintroductions of prairie-chickens have been done in Iowa, Illinois, Minnesota, and Missouri (Hoffman et al. 1992, Snyder et al. 1999, Toepfer et al. 2005:abstract).

Rodgers (1992) described a method used to re-establish a population of plains sharp-tailed grouse in Kansas that involved using an artificial lek with decoys, playback of vocalizations, and remotely opened release boxes. The mock lek was established to encourage released birds to remain at the site and prevent the dispersal that often caused the failure of earlier projects. Sharp-tailed grouse were kept in captivity for an average of 40 days and fed commercial grains and lettuce before release (Rodgers 1992). Schneider (1994) speculated, however, that an abrupt change in diet when sharp-tailed grouse are released may be stressful and cautioned that reintroductions involving periods of captivity may result in higher mortality. Crawford and Snyder (1994) experimented with this technique in the early years of a reintroduction project in Oregon. They suggested that decoys did not seem to retain birds at the site, but that vocalization playback might be important, although it may also interfere with vocalizations of released birds.

Snyder et al. (1999) reviewed past translocation projects involving sharp-tailed grouse and prairie-chickens in North America. They categorized projects as either "soft release" or "hard release," apparently based on the criteria of whether birds were released from remotely-operated boxes. Coates et al. (2006) uses the term for releases using a mock lek as well as the remotely opened boxes, as described by Rodgers (1992). Musil (1989) experimented with anesthetizing sage-grouse and placing them under a sagebrush plant as a "soft release" technique. The term "soft release" is more commonly used in the literature for translocations involving days or weeks of transitional confinement in the field and/or supplemental feeding of longer duration that allows animals time to adjust to the new environment and gain an attachment to the site (Scott and Carpenter 1987, Griffith et al. 1989, Teixeira et al. 2006). However, more elaborate soft-release schemes often involve captive-reared animals. The term 'hard release' for projects involving confinement for <36 hours and no supplemental feeding is more consistent with that used in the literature on translocation/reintroduction of other taxa. The term 'modified hard release' could also be applied when techniques are used to reduce panic flushing, such as remotely opened boxes, or decoys.

Snyder et al. (1999) concluded that the common features of successful sharp-tailed grouse and prairie-chicken translocation projects were: 1) a total of >100 birds were released; 2) projects were of long duration (i.e., several seasons); 3) birds were moved in spring, although the number of projects in other seasons was small ($n = 9$); and 4) projects used remotely operated settling boxes when releasing birds (Snyder et al. (1999). Reese and Connelly (1997) reviewed translocations of sage-grouse. They recommended translocations only after careful evaluation of the release area for year-round habitat, that birds be captured at leks in March or April, transported quickly, and released in groups from a holding pen from a hidden location.

Coates et al. (2006) conducted a reintroduction of Columbian sharp-tailed grouse in Nevada using the mock lek technique described by Rodgers (1992), and released birds from a box with separate compartments. They recommended closely monitoring birds during the initial year to fine-tune release site locations based on female selection of nesting habitat. They were uncertain about whether the mock lek was important, but concluded that habitat quality of the release area was a critical factor affecting the retention of nesting females. A predator control program was directed at coyotes and ravens in the release area, but they did not test the effect on survival of released birds. Coates and Delehanty (2006) reported that females captured later in the lek visitation period had a higher nest-attempt rate, and they hypothesized that females inseminated prior to capture at source leks may be more likely to nest following release than females not inseminated before capture.

A translocation to a site on Scotch Creek WLA with a lek that had declined to only two males appears to have successfully augmented the local population. Additional translocations are ongoing (Schroeder et al. 2011). No recent reintroductions of sharp-tailed grouse have been tried in Washington, but future attempts should benefit from the experiences of previous reintroductions in other states.

Recovery Area

Areas within the historical range of sharp-tailed grouse in Washington that still contain significant concentrations of steppe vegetation and have potential for contributing to recovery were outlined with the help of an interagency sharp-tailed grouse working group. The recovery area for sharp-tailed grouse in Washington includes the portions of the historical range that still support or have the greatest potential to support the species, taking into account mean annual precipitation, slope, current vegetation, and the potential for habitat restoration (Figs. 35, 36, 37). Twenty-two recovery units and two potential recovery recovery regions are identified in the recovery area (Table 11). The management focus and needs for recovery units and their importance for protecting known populations, recovery, potential for restoration and connectivity are identified. The intent of the recovery units map is not to restrict restoration activities, but to focus recovery efforts in those areas most likely to contribute to reaching recovery objectives.

These units are not the only areas with potential for use by sharp-tailed grouse, and much of southeastern

Washington and the Klickitat region are included as “potential recovery regions”. The Palouse and Wheatgrass/Fescue Zones (Cassidy 1997) of southeastern Washington are now largely cropland, with a small percentage in CRP, but historically they may have supported the highest density of sharp-tailed grouse in the state. The annual precipitation and deep soils of these areas would probably be productive for sharp-tailed grouse and facilitate restoration projects. What the region lacks is a nucleus of conservation lands with deep soil that could serve as a focal point for efforts to aggregate easements, conservation grant projects, acquisitions, and habitat restoration. In future revisions of the recovery area map, the large potential recovery area of southeastern Washington may be further subdivided to help focus and prioritize habitat work to facilitate future habitat restoration and reintroduction projects. Some parts of the recovery area may be removed in the future if habitat assessments suggest they have little potential to contribute significantly to recovery.

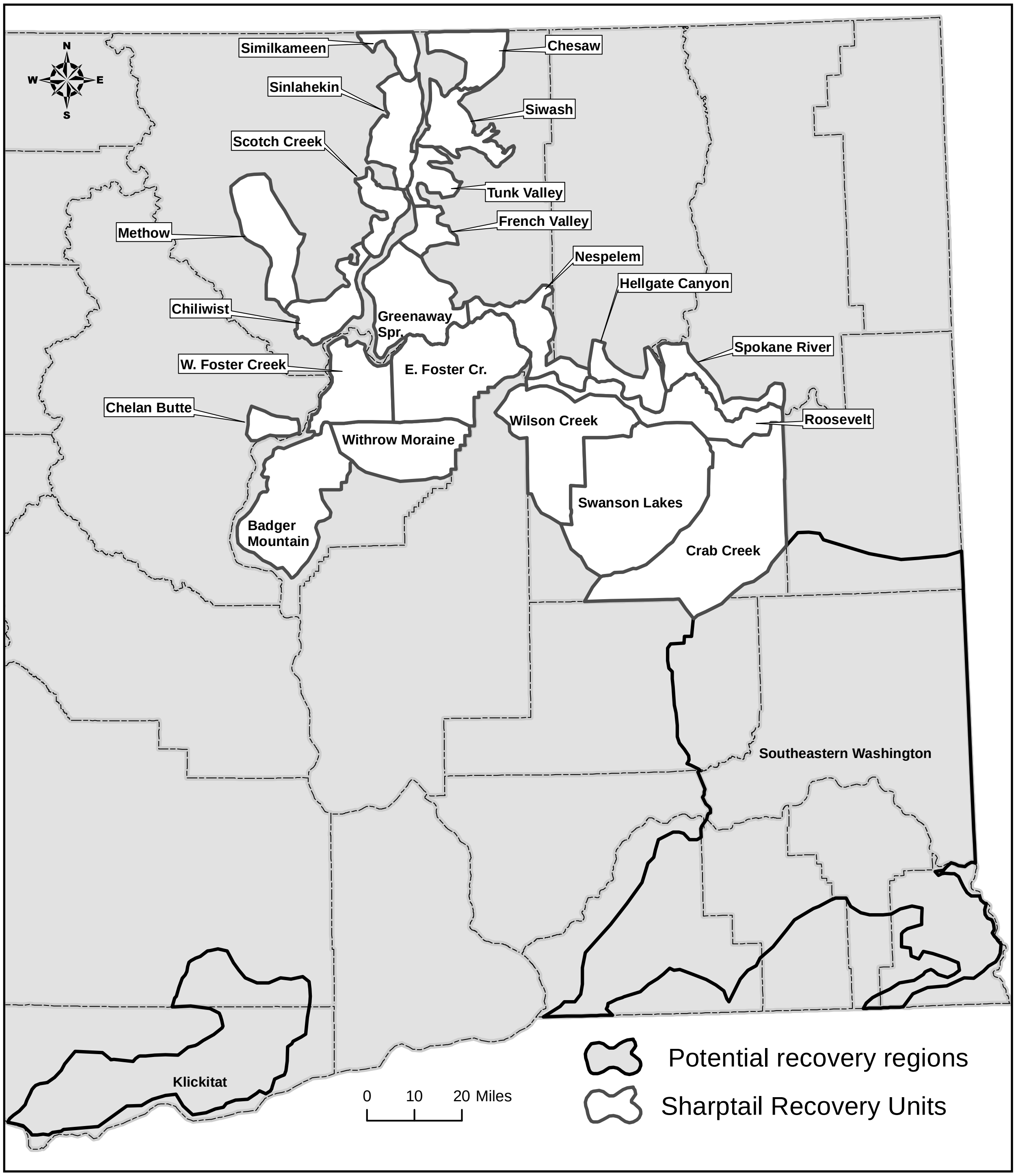

Figure 35. Twenty-two Columbian sharp-tailed grouse recovery units and two potential recovery regions in Washington.

Table 11. Population status, importance, and management issues for 22 sharp-tailed grouse recovery units and two potential recovery regions in Washington (Fig. 35).

Sharptail Recovery Units/Potential Recovery Regions	Population status	Notes and management needs
Badger Mountain	Extirpated	Unit somewhat peripheral; mostly cropland but has potential habitat and BLM lands.
Chelan Butte	None known	WDFW land; fragmented by topography but native vegetation being restored; half private lands
Chesaw	Breeding	Restored vegetation; population has potential to expand to WDFW lands further west; development risk on adjacent private lands.
Chiliwist	Possible low seasonal use	WDFW land; important for connectivity between Scotch Creek and Methow or W Foster Creek; management for deer winter range negatively affected habitat condition in past.
Crab Creek	Extirpated?	Good potential expansion area; mostly private but with some BLM land; most CRP may be older monoculture that needs enhancement.
E. Foster Creek	Breeding	WDFW land and private CRP; important are for connectivity; SAFE may increase occupied area.
French Valley	Breeding	Small population, but location is important for connectivity; ongoing survey/monitoring needs.
Greenaway Springs	Breeding?	No active leks known in 2010-2011, but population augmentation project initated in 2012; contains extensive habitat, and condition improved in recent years; needs include increased survey/monitoring to evaluate augmentation.
Hellgate Canyon	Unknown	Colville Confederated Tribes wildlife management lands present; area important for connectivity, but is fragmented by topography
Methow	Extirpated	Sharptails present until the 1980s; somewhat peripheral to the recovery area, but substantial public lands present; reduced grazing in the area has improved habitat in recent years; some WDFW lands have restoration underway, but more is needed.
Nespelem	Breeding	Hosts largest population in the state; contains Colville Confederated Tribes wildlife management areas; area important for connectivity; survey/monitoring needs; feral horses a problem in recent years.
Roosevelt	None known	Western part very important for connectivity; mostly private lands; development on river bluffs is increasing.
Scotch Creek	Breeding	WDFW land, recent and ongoing restoration projects for nesting and wintering habitat; also important for connectivity.
Similkameen	None known	Somewhat peripheral to other populations, but relatively close to occupied areas and contains significant BLM lands; habitat condition and potential needs to be assessed.
Sinlahekin	None known	Horse Springs Coulee population believed recently extirpated; important for connectivity if Similkameen were occupied; most of WDFW land is not suitable, and some potential habitat in poor condition.
Siwash	Breeding	Important for connectivity between Tunk Vally and Chesaw; DNR, TNC lands; private land at risk to development; grazing on DNR land and conifer invasion are issues.
Spokane River	None known	Spokane Indian Reservation and private lands; modest amount of habitat; potential expansion area, but peripheral to recovery area.
Swanson Lakes	Breeding	Population recently augmented by translocations; substantial WDFW and BLM lands; reseeding of old CRP fields underway, but additional reseeding needed.

Sharptail Recovery Units/Potential Recovery Regions	Population status	Notes and management needs
Tunk Valley	Breeding	Important for north-south connectivity; WDFW and private lands; high development risks.
W. Foster Creek	Breeding	WDFW and private CRP; important for connectivity; SAFE may increase occupied areas.
Wilson Creek	None known	Mostly private cropland, but location very important for connectivity; re-establishment of a breeding population would be very beneficial for recovery.
Withrow Moraine	Unknown	Shrub-steppe and lots of CRP; precipitation somewhat low; sparse wintering habitat; some WDFW, BLM lands.
Potential Recovery Regions		
Klickitat	Extirpated	Sharptails abundant historically; high precipitation would facilitate restoration, but isolated from remaining recovery area and public land is somewhat limited; private lands are increasingly affected by development and wind energy projects.
Southeastern Washington	Extirpated	Sharptails abundant historically; high precipitation would facilitate restoration; regional connectivity with Idaho, Oregon populations; problems include limited public lands in optimal locations and distance from occupied areas.

Columbian Sharp-tailed Grouse Recovery Area

STG Recovery Units
Potential recovery regions
CSTG Historical range (mod.)
Open water
Developed, open space
Developed
Deciduous forest
Forest
Shrub/scrub
Grassland
Pasture/hay
Cultivated cropland
Wetland
CRP 2007
State highways

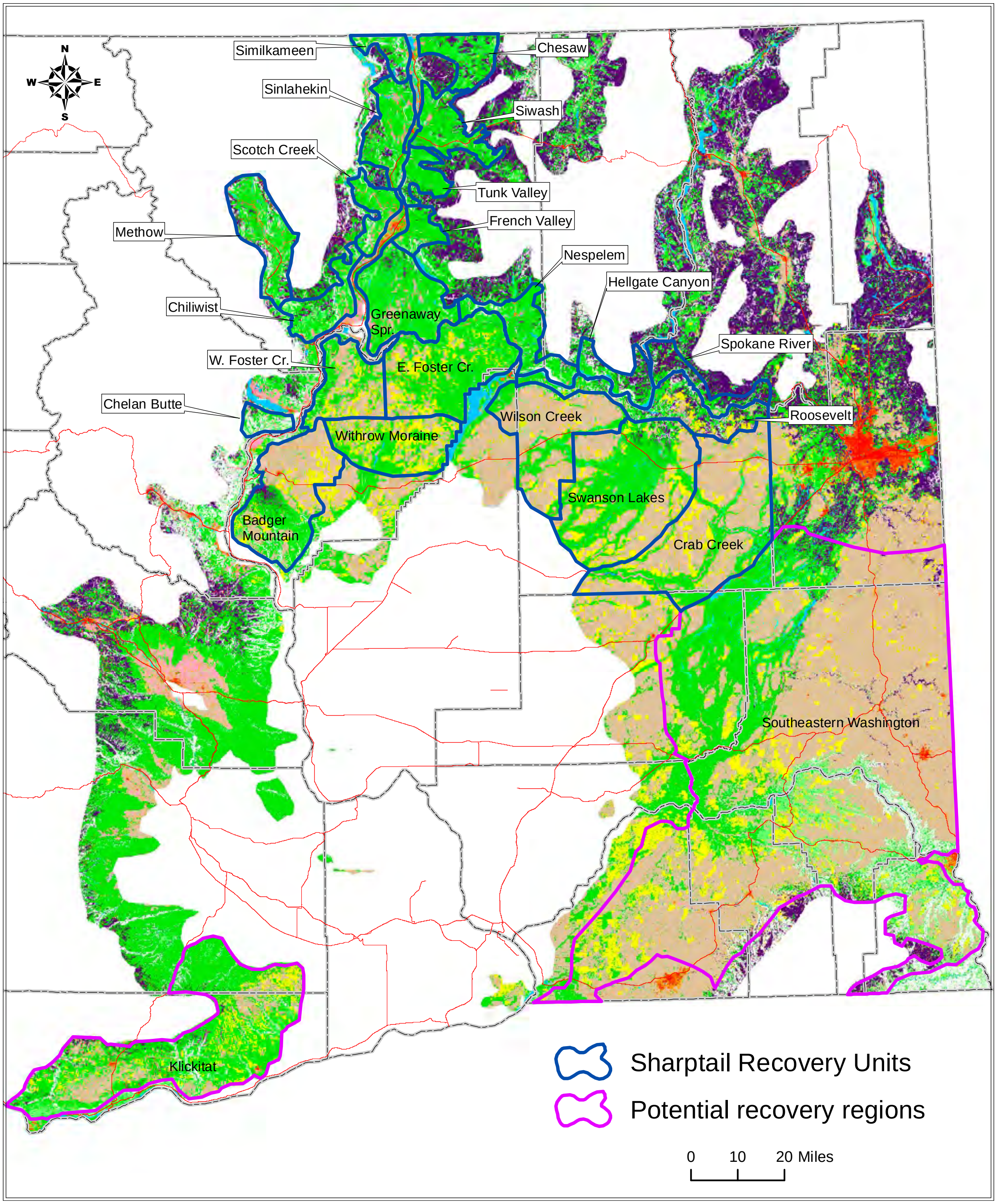

Figure 36. Columbian sharp-tailed grouse recovery areas and potential recovery units and current landcover in the historical range of sharp-tailed grouse (modified) in Washington.

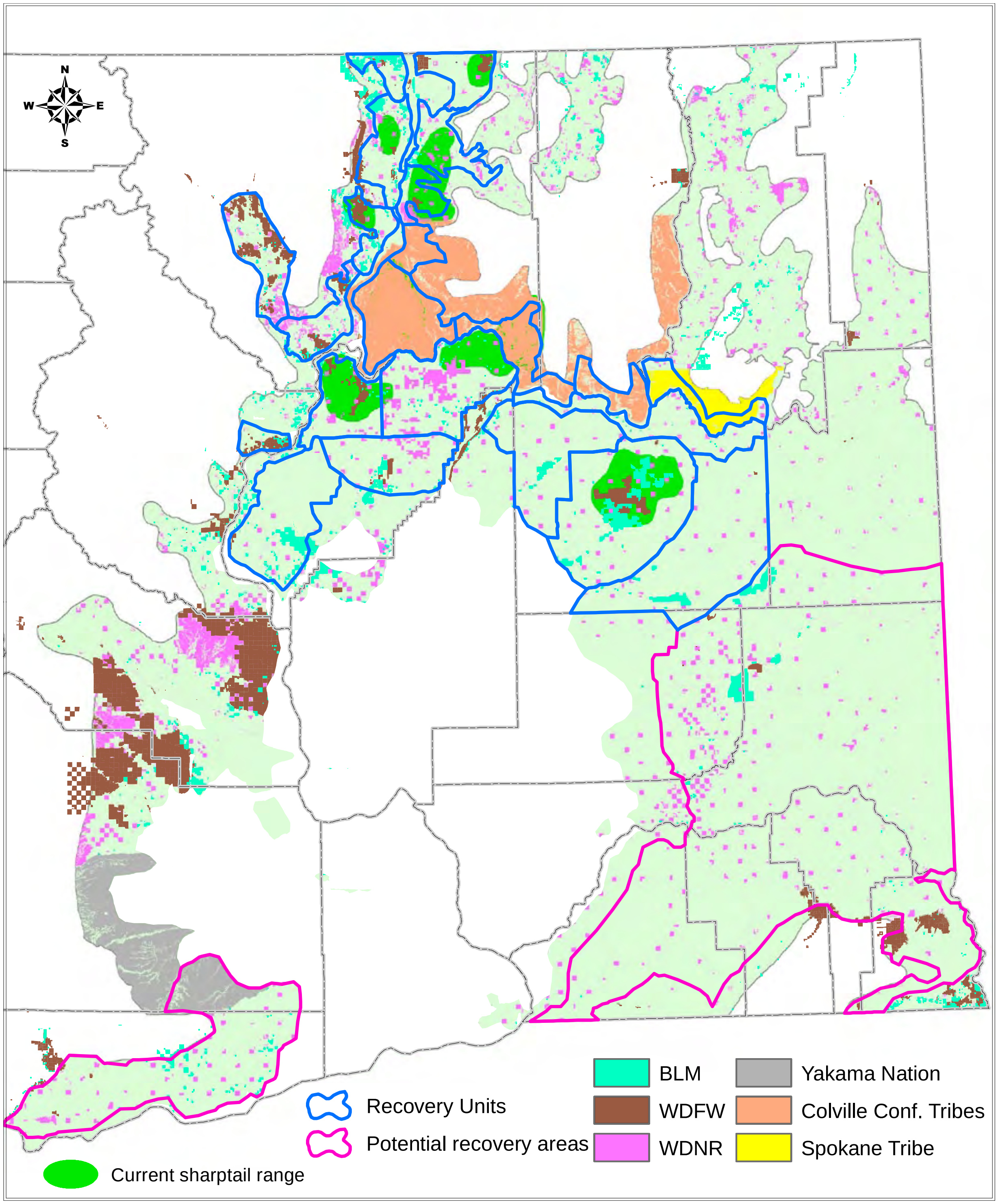

Figure 37. Columbian sharp-tailed grouse Recovery Units and potential recovery regions and important public and tribal lands in Washington.

RECOVERY STRATEGIES AND TASKS

1. Protect sharp-tailed grouse populations.

1.1. Reduce the collision hazards posed by wires and fences in sharp-tailed grouse habitat.

Fences and powerlines pose a collision hazard to grouse and provide perches for avian predators. New powerlines and utilities should use existing corridors or be located to minimize collision risk and damage to habitat. Burial of powerlines is expensive (≥$30,000/mi), but lines that clearly pose a hazard should be buried.

1.1.1 Promote removal of fences, powerlines, cables, and poles that are no longer in use.

1.1.2 Mark existing fences in areas occupied by sharp-tailed grouse to increase visibility.

Mark existing fences using pieces of vinyl undersill trim and reflective tape (not ‘J channel’ type trim) available from hardware and building material retailers (Fig. 25). Material cost is about $270/mile of fence. Heavy duty reflective tape alone may work, temporarily, on smooth wire. Use of volunteers for cutting and installation reduces project costs. Where necessary, remove vegetation along fences to improve visibility.

1.1.3 Modify existing fences to minimize collision hazard.

Modify existing fences that are still needed by reducing the number of wires and/or lowering the top wire, where feasible.

1.1.4 Minimize proliferation of additional power lines, towers, and fences.

1.2 Identify and minimize other human-related and natural sources of mortality.

Identify major mortality factors, both human-related and natural, for sharp-tailed grouse populations through intensive monitoring and research activities. Minimize identified mortality factors with activites such as increased information and education, enforcement presence, wildlife area management, or modifications to upland bird seasons.

1.2.1 Document incidents of illegal and accidental shooting of sharp-tailed grouse and evaluate the need for remedies.

The frequency of accidental shooting of sharp-tailed grouse during upland bird seasons is unknown. Shooting mortality may occur on public lands, particularly where sharp-tailed grouse co-occur with ring-necked pheasants, gray partridge, dusky grouse, chukar, or California quail. Incidents should be documented to help determine if additional education or local enforcement is needed.

Figure 38. Warning sign used on wildlife areas to reduce accidental shooting by upland bird hunters.

1.2.2 Minimize accidental killing of sharp-tailed grouse during hunting or falconry seasons.

Evaluate the need for increased enforcement presence during upland game bird seasons and where grouse concentrate during winter. Signs on wildlife areas warn of the presence of sharptails and their protected status (Fig. 38), and WLA staff provide information to hunters to minimize the potential for mis-identification (J. Anderson, pers. comm.). Signs should be added and replaced as needed. Accidental killing of sharp-tailed grouse during legal hunting of other upland bird species may be a problem, especially where local sharptail populations are low and hunting pressure is great. Lands that support sharp-tailed grouse populations should not be used as pheasant release sites. Steps should be taken such as increased hunter education, changes in pheasant stocking, or restrictions on local access during upland game seasons when sharp-tailed grouse are vulnerable. Local upland game bird hunting closures should be considered if incidents of accidental shooting occur.

1.2.3 Minimize destruction of nests during haying and tilling and by livestock trampling.

Where sharp-tailed grouse are known to nest, avoid haying and other mechanical disturbance from 1 April – 30 June. Share information about sharp-tailed grouse use areas with landowners and help them avoid destruction of nests and chicks. Avoid livestock grazing on portions of wildlife areas that can potentially support nesting and brood-rearing.

1.2.4 Minimize the risk of exposing sharp-tailed grouse to histomoniasis or other diseases by reducing overlap of sharp-tailed grouse and pheasant releases.

Pheasants should not be introduced to sites supporting sharp-tailed grouse or where sharp-tailed grouse reintroductions are being considered.

1.2.5 Reduce sources of disease vectors, such as mosquitoes.

New guzzlers and other manmade water sources should not be established because they may increase mosquitoes that spread West Nile Virus. Water-holding refuse, such as old tires, should be removed to eliminate potential mosquito breeding sites.

1.3 Reduce predation by human-associated predators.

1.3.1 Where feasible, eliminate poles, posts and structures used for nesting, unused equipment, and refuse from steppe and grassland habitats.

Fence posts, poles, rock piles, farm equipment, culverts, and abandoned buildings and associated trees can provide nesting and denning sites, hunting perches, or hiding places for hawks, owls, corvids, coyotes, skunks, and other predators. These structures should be removed whevever possible in areas occupied by sharp-tailed grouse. Where they can not be removed, they may be modified to make them unusable by predators.

1.3.2 Existing utility poles should be modified with perch guards to prevent use as raptor perch sites.

Use perch guards to reduce predation of grouse by raptors and corvids that use utility poles and posts as hunting perches.

1.3.3 Promote removal of human-related food sources for corvids, raptors, and carnivores.

Reduce the availability of garbage, livestock carcasses, and bird feeding stations that can support or concentrate predators that prey on sharptails opportunistically (Boarman 2003, Marzluff and Neatherlin 2006).

1.4 Protect sharp-tailed grouse from human-related disturbance.

1.4.1 Identify any human-related disturbance factors and avoid disturbing activities such as gravel crushing, ORV use, and recreation near leks (≈ 2 km).

Disturbing activities are those that cause a bird to flush or alter its behavior for a substantial length of time. Persistent disturbing activities are a more serious problem than short-term disturbance. Disturbance to sharp-tailed grouse nesting and foraging may result from noisy activities, recreational development, or repeated disruption of leks. Repeated or chronic disturbances within 2 km of lek sites are most harmful between the hours of 0500 and 0900 during March-April, but chronic disturbance of leks during fall should also be avoided as well. For example, a lek in Douglas County was abandoned after a rock-crushing operation began nearby. If areas are identified where humans seriously inhibit lekking, work with landowners, birding groups, and others to minimize and mitigate impacts. Restrict off-road vehicles, snowmobiles, camping, off-leash pets, and site visits, and close roads or limit area access as necessary to protect lek areas from disturbance during the lekking season. Farming activities on one or two days of the breeding season are not likely to be a significant problem, unless actually in nesting habitat or on a lek site. Noise reduces lek attendance by sage-grouse (Blickley et al. 2012), and probably sharp-tailed grouse.

1.4.2 Treat lek locations as sensitive data.

Lek and locational information for sharp-tailed grouse is considered sensitive and is not released by WDFW except under conditions defined in WDFW policy # 5210, and is exempt from public disclosure (RCW 42.56.430). To minimize disturbance from frequent visitations, WDFW personnel should not disclose lek locations or encourage viewing at leks. All observers should be encouraged to limit viewing activities to long-range observation from vehicles (preferably >1/4 mile away), except where closer viewing is required for agency lek counts. As populations recover, consider establishing a designated lek to provide controlled viewing and photographic opportunities.

2. Protect sharp-tailed grouse habitat.

2.1 Conduct additional fine scale analysis of habitats to identify locations to re-establish additional sharp-tailed grouse populations and movement corridors.

Assess habitat capability for reintroducing sharp-tailed grouse in parts of their historical range in Washington and maintaining the population through time. Potential focus areas include the Wilson Creek Recovery Unit that would improve connectivity between populations in Lincoln, Douglas, and southern Okanogan County.

Other potential focus areas include southeastern Washington, particularly parts of Whitman, southern Spokane, Asotin, Columbia, Garfield, and Walla Walla counties. The Revere WLA and adjacent BLM lands in western Whitman and eastern Adams counties total >15,000 ac and should be evaluated for potential habitat. The BLM lands had a long history of sheep grazing before they were acquired by BLM. If habitat condition can be improved, the area might provide a focus area for additional work with private landowners (through Farm Bill programs, easements, etc.). The Coeur d'Alene Indian Reservation, just across the Idaho state boundary, was evaluated as a potential sharptail reintroduction area by the tribe. Habitat modeling suggested that the quantity of currently suitable habitat was not adequate, without significant restoration.

In south-central Washington, the Columbia Hills area south west of Goldendale in Klickitat County has a nucleus of public lands, but a preliminary assessment suggested that conflicts with residential and/or wind power development might be problematic. The Yakama Nation also has some good grassland habitat, although limited in extent, and has expressed interest in eventually evaluating the potential for a reintroduction there (N. Burkepile, pers. comm.).

2.2 Ensure compatibility of grazing management on public lands in the sharp-tailed grouse recovery area.

Improving degraded sharp-tailed grouse nesting and security cover within 2 km of leks may lead to improved nesting success and survival of females (Apa 1998).

2.2.1 <u>Ensure that grazing leases on WDFW lands are compatible with sharp-tailed grouse habitat needs</u>.

Livestock grazing should not occur on WDFW lands occupied by sharp-tailed grouse, unless:

1) it will not disturb leks, nesting hens, or young broods;
2) it will increase or maintain herbaceous cover, residual spring nesting cover, and the composition and diversity of native vegetation as needed to restore and maintain optimal nesting habitat condition;
3) it will not require additional fencing or the maintenance of otherwise un-needed fencing;
4) plans and resources are in place to adequately monitor the effects on sharp-tailed grouse and the condition of their habitats.

Livestock grazing should not occur during the nesting and brood-rearing season on WLAs managed for sharp-tailed grouse. Grazing during the remainder of the year should be managed to maintain optimal residual spring nesting, brood rearing, and wintering cover, and diverse herbaceous vegetation.

Cattle grazing on the Chiliwist Wildlife Area is used to suppress grass and increase shrubs for mule deer winter forage (Swedberg 2006). Sharp-tailed grouse were present historically on the Chiliwist, but have not been observed there in recent years. The Chiliwist is part of an important habitat link between sharp-tailed grouse populations in Scotch Creek WLA and northern Douglas County, and would be a critical connection if a population was established in the Methow. Grazing on the Chiliwist should be evaluated relative to sharp-tailed grouse habitat condition.

2.2.2 Where grazing occurs on public lands in sharp-tailed grouse recovery areas, manage grazing so that the habitat characteristics needed for nesting, broodrearing, and wintering are consistently maintained.

Where sharptails are known to nest, avoid livestock grazing from 1 April – 30 June. 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. Whatever method is used to set stocking levels, the key consideration is that the habitat characteristics required for sharp-tailed grouse be maintained. Successful nest sites in Washington had a VOR of 27.9 cm; random sites 50–100 m away from nests (successful and unsuccessful) in the same cover type had a VOR of 16.6 cm (McDonald 1998). Optimal nesting habitat would have mean VOR of residual vegetation (measured from a height of 1 m, 4 m from the pole) of ≥25 cm (Meints et al.1992). Nesting cover with mean herbaceous vegetation height of >20 cm may be suitable, as long as numerous sites with higher (>30 cm) cover are present. Management should also maintain a diverse native forb component, ideally comprising ≥10% of vegetative cover. Some sites degraded to annual grassland will not recover sufficiently through grazing changes or livestock exclusion to be suitable for sharp-tailed grouse 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 be located at sites used by grouse unless designed to improve habitat for sharptails and reduce existing damage by livestock.

Grazing levels should be based on predicted use during periods of drought (i.e., less than 75% of average moisture during a period of ≥6 months). If it is determined through assessment, monitoring, and observation that sharp-tailed 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: 1) the area is degraded and restoration is unlikely under an altered grazing strategy; 2) there is increasing encroachment by noxious weeds; or 3) it is otherwise incompatible with use by sharp-tailed grouse.

2.2.3 Use fencing on public lands when necessary to manage livestock to protect and restore sharp-tailed grouse habitat.

New fencing may be needed to keep out livestock from adjacent lands, and to protect shrub plantings and vegetation in riparian zones and wet meadows from deer and livestock. Livestock should be excluded from riparian habitat, except where and when they can be closely monitored and removed before woody deciduous vegetation is damaged. Fences in areas with potential use by sharp-tailed grouse should be equipped with markers to increase their visibility and removed when no longer needed.

2.3 Manage riparian and meadow habitats on public lands to support sharp-tailed grouse.

Recovery of riparian and meadow vegetation may require careful monitoring and management of grazing or exclusion of livestock. Re-establishment of deciduous shrubs and trees may be required where they are lacking.

2.3.1 Avoid damage to wet meadows by road development, livestock, and human disturbance.

2.3.2 Manage or exclude livestock as needed to protect and enhance riparian habitat.

Livestock damage to riparian areas can be reduced by improved grazing methods; herding or fencing livestock away from streams; reducing stocking rates; improving the placement of salt and alternative water sources; and increasing rest (Belsky et al. 1999, Kauffman and Krueger 1984, Wyman et al. 2006). Often the best prescription for riparian habitat restoration is a long period of rest from livestock grazing (Ohmart 1994, Belsky et al. 1999). Reduction or elimination of grazing frequently results in rapid recovery of herbaceous vegetation and shrubs if seed sources are present (Rickard and Cushing 1982). Paulson (1996) suggested: 1) zero grazing was the fastest way to restore sharp-tailed grouse wintering habitat; 2) early spring grazing would have less impact on riparian trees and shrubs than summer or fall grazing; 3) cattle should be removed when consumption of key trees and shrubs is observed; and 4) careful monitoring of grazing intensity may be more important than the grazing system employed. In some cases, however, recovery of native vegetation may be extremely slow due to the degraded physical condition of the stream, dominance of exotic vegetation, and lack of native seed sources (Clary et al 1996). Wyman et al. (2006) and Knutson and Naef (1997) provide management strategies that can be used to minimize impacts and allow recovery of native vegetation where complete removal of livestock from a riparian area is not possible.

2.3.3 Control reed canarygrass to restore woody vegetation in riparian areas.

Control of reed canarygrass may be required before woody vegetation can recover. In areas dominated by reed canarygrass, grazing can be used to reduce canarygrass vigor and allow the establishment of more desirable native species (Antieau 2004). On Turnbull National Wildlife Refuge, grazed areas of canarygrass showed 40% more sedge and rush composition than areas excluded from grazing (Bennington 1972). However, spring grazing may not reduce the abundance of reed canarygrass (Hillhouse et al. 2010).

2.3.4 Remove white poplar and other exotic trees.

Some large exotic poplars may be viewed as local landmarks and provide habitat values to other species. Removal may need to be a gradual, or be accompanied with outreach to local residents.

2.4 Discourage expansion of roads and transmission lines on public lands in sharp-tailed grouse recovery units.

In addition to disturbance and collision mortalities of grouse from roads and powerlines, roads are a major conduit of weeds.

2.4.1 Avoid adding new roads, ORV trails, electrical transmission lines or right-of-ways that would destroy or fragment habitat or isolate populations.

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

2.4.3 Promote closures of unnecessary roads or those negatively impacting habitat quality.

Close roads on public lands that conflict with sharp-tailed grouse conservation and when not needed for area management.

2.5 Facilitate management of private agricultural and rangelands that is compatible with the conservation of sharp-tailed grouse.

2.5.1 Promote the protection of remnant areas of native grassland and shrub-steppe.

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

2.5.3 Work with landowners to avoid impacts on grouse nests and young broods when converting former CRP fields to grain.

2.5.4 Discourage use of insecticides and herbicides in grouse brood-rearing habitats and spraying practices that damage areas of native steppe.

Incidental spraying of shrub-steppe can occur where this habitat occurs near to croplands and road right-of-ways. 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). Use selective methods such as hand spraying near native vegetation where feasible and use farming methods that reduce the need for biocides.

2.5.6 Work with landowners interested in sharp-tailed grouse conservation to use range management practices that result in increased habitat value for grouse.

Private rangeland accounts for a significant portion of the sharp-tailed grouse recovery area in Washington. Assist ranchers by providing information on range management practices that benefit grouse. For mixed ownerships and leases on public lands, work collaboratively through Coordinated Resource Management or other processes to develop management solutions. Encourage healthy communities of native perennial grasses and associated forb and shrub communities on private rangeland to provide suitable habitat for sharp-tailed grouse nesting and brood concealment.

2.5.7 Discourage development of additional springs and water wells for livestock on private rangeland, unless it benefits sharp-tailed grouse by protecting wet meadow or riparian habitat and does not damage other sharptail habitats.

2.5.8 Encourage and provide technical assistance for the development of Habitat Conservation Plans (HCPs) that include protection of sharptail habitat on private lands.

2.5.9 Explore means of providing incentives to protect and enhance sharptail habitat on private lands.

2.6 Protect shrub-steppe habitat by reducing the risk and effects of wildfires.

Not all sharp-tailed grouse habitat is seriously affected by wildfires, but sagebrush in drier shrub-steppe can require decades to recover after fires, even when seed sources are present. Climate change may increase the incidence of wildfires. However, prescribed fire may be useful in restoring some grassland communities.

2.6.1 Reduce fire risk in shrub-steppe on WDFW lands and encourage appropriate fire management measures on other public lands.

2.6.2 Work with owners of private lands near and adjacent to WDFW and other public lands essential to sharp-tailed grouse at high risk of damaging fires to reduce risk of fires.

2.6.3 Aggressively control wildfires on WDFW wildlife areas where and when they will cause lasting damage to sharp-tailed grouse habitat.

2.7 Protect essential sharp-tailed grouse habitat through easements, cooperative agreements, and acquisitions.

Priorities for conservation easements, cooperative agreements, and acquisitions for sharp-tailed grouse are:

a) Areas that contain important habitat currently occupied by sharp-tailed grouse;
b) Locations adjacent to occupied areas that can be enhanced or restored to allow a sharp-tailed grouse population to increase or that provide potential corridors to connect isolated populations;
c) Areas that will increase and consolidate public or conservation lands in areas that have been identified for reintroduction projects, with preference for lands with deep soil and ≥13” mean annual precipitation.
d) Areas that are at risk of an alternate land use (such as development) that would isolate or fragment habitat and substantially impair recovery.

2.7.1 Use conservation easements or purchase of development rights agreements to keep large ranches intact and protect sharp-tailed grouse habitat.

Conservation easements have been used effectively to protect and manage blocks of private land, while preserving rural economies. Purchase of development rights agreements are being used throughout the western states by governments, nongovernmental organizations, and agricultural producers to maintain land in large blocks and allow landowners to continue ranching. This approach to habitat protection and management should be considered for its potential to protect large blocks of contiguous sharp-tailed grouse habitat. Cooperative agreements may also be used to develop management and protection strategies for sharp-tailed grouse habitat.

2.7.2 Consider acquisitions of important habitat if there are willing sellers and when it provides the best option to protect and/or restore critical habitats.

Identify important parcels of sharp-tailed grouse habitat on private land that may be at risk of development or loss. Where there are willing sellers, consider acquisitions that result in protection of key areas and/or better habitat connectivity of sharp-tailed grouse habitat. Facilitate protection and long-term management by adding them to conservation lands, such as land trusts, state research natural areas and natural area preserves, or state wildlife areas.

2.8 Provide data, information, and technical advice to conservation districts, counties, regulatory agencies, and landowners to increase protection of sharp-tailed grouse habitat.

2.8.1 Identify public lands important for sharp-tailed grouse conservation and recovery and provide that information to managing agencies.

2.8.2 As opportunities arise, work with WDNR, tribes, BLM, and other agencies to protect sharp-tailed grouse habitat.

2.8.3 Provide technical assistance to counties to minimize the effects of development on sharp-tailed grouse habitat.

Work with counties and conservation districts in eastern Washington to protect shrub-steppe and meadow steppe habitats important to sharp-tailed grouse. Encourage recognition of occupied sharp-tailed grouse areas, shrub-steppe, and prairie habitats as important and worthy of inclusion in critical area designations and updates of county ordinances under the state's Growth Management Act. Review and comment on proposed revisions of critical area and clearing and grading ordinances. Encourage counties to adopt clear standards of protection for sharp-tailed grouse habitat.

2.8.4 Update WDFW PHS maps as needed to include sharp-tailed grouse nesting, brood-rearing, and winter habitat.

2.8.5 Periodically update and revise WDFW's Priority Habitats and Species (PHS) management recommendations for the sharp-tailed grouse.

PHS recommendations represent "best management practices" used to protect sharp-tailed grouse habitat (Schroeder and Tirhi 2003). These will need to be periodically updated as new information becomes available. They provide the basis for good stewardship of sharp-tailed grouse and their habitat. Provide WDFW sharp-tailed grouse Priority Habitats and Species (PHS) management recommendations (Schroeder and Tirhi 2003) and maps to landowners and regulatory agencies.

2.8.6 Provide technical assistance to counties to minimize the effects of roadside spraying and road maintenance on sharp-tailed grouse habitat, including woody riparian vegetation.

Gelbard and Belnap (2003) recommended that road maintenance measures such as mowing, grading, and herbicide application be timed to maximize their impact on weeds while minimizing their effects on native plants.

2.9 Update planning documents and policies to facilitate recovery of sharp-tailed grouse.

2.9.1 Update WDFW Wildlife Area Management Plans with current sharp-tailed grouse management needs.

2.9.2 Develop and maintain a 5-year recovery task list to help identify and prioritize the most immediate conservation needs.

A list of conservation actions needed within the current 3 to 5-year period, and the funding status of tasks was developed but should be updated annually (Stinson 2011). This type of document can be used for prioritizing task and tracking funding needs by the technical working group.

2.9.3 Revise recovery objectives, recovery area map, and strategies for the sharp-tailed grouse as needed.

Use research results and new information to update and revise the sharp-tailed grouse recovery plan, as needed.

3. Enhance or restore sharp-tailed grouse habitat.

Priorities for habitat enhancement or restoration are: a) areas currently occupied by sharp-tailed grouse; b) areas adjacent to existing populations that provide potential corridors to connect populations or to expand occupied areas; and c) areas identified for reintroduction projects. Significant amounts of sharp-tailed grouse habitat owned by WDFW, other agencies, conservation organizations, and private landowners are in need of enhancement or restoration.

3.1 Analyze current habitat conditions to identify focus areas for enhancement or restoration.

Analyze habitat condition and capability using vegetation maps, satellite imagery, field data, and habitat models in areas targeted for sharp-tailed grouse recovery. A Habitat Suitability Index model and other models could be tested and used to evaluate habitat. Identify areas where riparian vegetation needs protection or restoration.

Areas that may be priorities for work include former CRP fields acquired by BLM and WDFW that have become monocultures of crested wheatgrass. Current priorities for restoration include older CRP fields on Swanson Lakes and Sagebrush Flats WLAs, and old wheat fields in the West Foster Creek Unit of the Wells WLA and the Fraser Creek area of the Methow WLA, but additional areas for restoration need to be identified. Other possible tasks include conifer invasions in the Siwash Valley and perhaps prescribed burns where woody shrubs may have negatively affected sharp-tailed grouse.

3.2 Enhance or restore sharp-tailed grouse habitat on WDFW lands.

3.2.1 Enhance or restore upland sharp-tailed grouse areas, including older CRP fields, grain and hay fields using native grasses, forbs, and selected shrubs.

Use mixtures of locally adapted varieties of native grasses, forbs, sagebrush and other shrubs when available. Benson et al. (2011) describes methods that have been successful in restoring native vegetation. Avoid seeding with nonnative species whenever possible, although alfalfa may be an exception (Rodgers and

Hoffman 2005). Also, some situations may necessitate non-natives that can compete with noxious weeds.

Suppress cheatgrass and noxious weeds. 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.

3.2.2 Enhance or restore riparian deciduous shrubs and trees, including seviceberry, water birch, chokecherry, hawthorn, *Rosa* spp., and aspen.

Management tools to restore riparian vegetation include restricting livestock grazing, planting native trees and shrubs and protecting plantings from deer damage. Restoration using beaver can improve degraded riparian areas, but the introduction of beaver in semi-arid regions can be difficult in areas without sufficient suitable streamside vegetation, especially where livestock and deer inhibit re-establishment of willows, cottonwoods, or aspen (Apple 1985, Saldi-Caromile et al. 2004). Often these habitats are generally not suitable for beaver until the stream channel is stabilized and riparian vegetation restored. Where gullying has occurred, bank stabilization structures and check dams or drop structures, and vegetation planting may be necessary (Collins 1993). Eliminate non-native poplar that competes with native riparian woody vegetation.

3.2.3 Control conifer invasion in meadow steppe/grassland communities using cutting, removal, and/or experimental prescribed burns, where appropriate.

Habitat on some wildlife areas might benefit from prescribed burns to reduce undesirable woody vegetation. Native bunchgrasses, *Rosa* sp., chokecherry, and snowberry, are all recovering well after wildfires on the Chiliwist WLA (Swedberg 2006).

3.3. Facilitate sharp-tailed grouse habitat enhancement and restoration on other public and private lands.

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

3.3.1 As opportunities occur, assist BLM, WDNR, TNC, and land trusts in the enhancement and restoration of healthy shrub-steppe, grasslands and riparian deciduous shrubs to improve habitat for sharp-tailed grouse.

3.3.2 Facilitate funding for habitat management for sharp-tailed grouse on BLM, WDNR, TNC, and land trusts lands.

3.3.3 Identify the best local opportunities for enhancing sharp-tailed grouse habitat on private lands.

3.3.4 Assist with securing grants for conservation easements, purchase of development rights, or habitat protection and restoration through various Farm Bill programs and other programs.

Work with the Farm Service Agency and the Natural Resources Conservation Service to enroll or re-enroll landowners in CRP and the Palouse Prairie and Eastern Washington Shrub-steppe, and Douglas County sage and sharp-tailed grouse SAFE programs. Interested landowners should be assisted in applying for grants intended to protect natural resources, restore habitat, and conserve wildlife on private lands. Additional grant programs authorized in the 2008 Farm Bill that may be used to enhance sharp-tailed grouse habitat include the Grassland Reserve Program, Wildlife Habitat Incentives Program, Environmental Quality Incentives Program, and the Conservation of Private Grazing Lands Program. Additional types of incentives, such as direct payments for sharp-tailed grouse production, should be explored.

3.3.5 Provide technical assistance and materials to landowners, such as cost-share for seed mixes that enhance sharp-tailed grouse habitat value of plantings above the minimum requirements of Farm Bill conservation programs.

4. Inventory and monitor sharp-tailed grouse populations.

4.1 Monitor the status of known sharp-tailed grouse populations.

4.1.1 Conduct annual lek counts.

Use established WDFW protocols to conduct annual lek counts, unless a more reliable monitoring technique is developed, tested, and proven to be more efficient.

4.1.2 Conduct inventory surveys for new or shifting leks.

Finding all leks is important to maintain the consistency of population estimates and trend information. Potential habitat should be periodically surveyed for lek complexes 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 near 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. Adjacent inactive lek complexes should be surveyed once every 3 to 5 years to determine if they are still inactive. One or more new lek locations on the Colville Indian Reservation were detected by helicopter in 2008, which may be an efficient means of finding leks when funds are available (R. Whitney, pers. comm.).

4.1.3 Collect feather, blood, or other samples as needed to monitor the genetic health of populations.

4.2 Coordinate cooperative surveys, monitoring, and data collection and

maintenance.

4.2.1 Coordinate data exchange and cooperative survey efforts with the Colville Confederated Tribes, BLM, and other cooperators.

Coordinate monitoring and survey efforts annually, as needed.

4.2.2 Maintain a statewide database of sharp-tailed grouse survey efforts and detections.

The Wildlife Survey Data Management (WSDM) section at WDFW, Olympia, currently maintains a statewide database of survey information on sharp-tailed grouse. To be fully effective, area surveyed, along with positive and negative results, should be reported. Work with cooperators to solicit data on sharp-tailed grouse surveys and results. Compile observations of wintering sites from agencies, landowners, and birders to identify critical winter cover and potential areas for planting shrubs.

4.3 Estimate population size and monitor population trend.

Sharp-tailed grouse population estimates are based on numbers of males counted at lek complexes. Despite potential biases and sources of error, it is currently the only cost effective method available to estimate grouse population sizes and monitor trends over time. 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 sharp-tailed grouse populations in North America. Total population size should be estimated by multiplying the total numbers of males at all lek complexes by 2. This assumes all males are counted and the male:female ratio is 1:1. All count data should be retained indefinitely, regardless of whether they are high counts or not. This will allow quantifying survey variability and perhaps additional analysis.

With the assistance of cooperating agencies, sharp-tailed grouse populations in Washington should be monitored using the results of periodic surveys. 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 when estimating rate of change.

5. Augment existing populations and establish new populations.

Columbian sharp-tailed grouse populations in Washington are found in relatively small isolated areas. An important recovery strategy is to use translocations to augment existing populations or to re-establish populations in unoccupied historical locations where none currently exist. Sharp-tailed grouse should only be reintroduced where they were present historically and where habitat in the release region is available in sufficient quantity, quality, and configuration to support a population year-round. Release sites will most often be locations with significant public land and cooperative adjacent private landowners. Release sites that provide opportunities for further population expansion into additional uninhabited areas are preferable.

5.1 Identify and prioritize populations in need of augmentation.

Use lek count and genetic data to determine when local populations may need augmentation to persist while habitat enhancement is ongoing and prioritize project areas considering habitat condition, connectivity, land ownership, etc.

5.2 Evaluate the feasibility of reintroductions for identified locations.

Evaluate the feasibility of reintroductions of project areas identified (Task 2.1). The Methow Valley is an area that probably should be evaluated. It hosted active sharptail leks in the 1970s and one (Balky Hill) into the 1980s. WDFW owns 31,000 ac in and around the valley. Although the habitat is somewhat fragmented with steep slopes and private lands, some habitat restoration has been done since the extinction of the local population and vegetation appears to be in better condition than it was in the early 1990s (M. Schroeder, pers. obs.). The matrix of private lands is threatened by development, although some is under conservation easements.

5.3 Conduct augmentations and reintroductions as needed.

5.3.1 Develop augmentation or reintroduction plans for local areas where needed.

Develop translocation plans with cooperators. These should include the number, timing, monitoring, and sources for sharp-tailed grouse. Evaluate and modify protocols used for the capture, transport, and release of grouse during augmentation and reintroduction projects as needed.

5.3.2 Where predation is demonstrated to cause excessive nest, chick, or hen mortalities, conduct limited predator control during reintroduction or augmentation projects.

Protection of an incipient population of birds reintroduced with great effort and expense warrants consideration of all methods to ensure success, including limited predator control. In projects of this type, predator control would not be a long-term management strategy, but would be conducted over limited geographic areas and time spans. Removal of nest predators has been shown to temporarily improve nest success, juvenile survival, and/or breeding population size in ground nesting birds, including grouse (Lawrence 1982, Kauhala et al. 2000, Coates and Delehanty 2004, Baines et al. 2008, Holt et al. 2008). Messmer et al. (1999) indicated that although the public is skeptical of predator control to increase game bird and waterfowl populations, people are more likely to support limited, surgically applied control activities to protect rare native species. Although predator control was standard practice on the moors and estates of Europe and the United Kingdom (Opermanis et al. 2005, Baines et al. 2008, Park et al. 2008), predation on North American grouse has more often been addressed through habitat improvement, which is considered a more economical, efficient, and effective long-term strategy than direct control of predator populations (Schroeder and Baydack 2001).

Smith et al. (2010) conducted a meta-analysis of predator removal studies with data from 83 studies for 128 bird species; predator removal had a significant positive effect on hatching success (+77%), fledging success (+79%), and breeding population size (+71%) compared to control areas. They concluded that predator removal is an effective conservation strategy for enhancing bird populations, but the effect is temporary.

Projects that removed the most frequent predator have more often been successful. Coates and Delehanty (2004) reported that sharp-tail nest success improved from 42% prior to raven removal to 75% during removal. Coates et al. (2007) reported that CPTH-treated egg baits can be effective, with low risk of secondary poisonings. Boarman (2003) suggested selective removal of offending ravens from special target areas, and Connelly et al. (2000b) suggested this technique for sage-grouse where corvids are identified as the dominant nest predator and nest success is <25%. However, some predator removal projects that removed a single species failed, either because the targeted species was not the primary nest predator, or it resulted in increased nest predation by other species (Henke and Bryant 1999, Slater 2003).

Smith et al. (2010) reported that predator control studies exhibited larger increases in breeding populations when removing all predators rather than a subset, thus preventing meso-predator release and population compensation (e.g. Trautman et al. 1974. Projects that involved intensive predator removal from large or isolated treatment areas were more likely to demonstrate an effect because of immigration and/or recruitment of predators on smaller treatment areas (Balser et al. 1968, Chesness et al. 1968, Trautman et al. 1974, Sargeant et al. 1995, Garrettson and Rohwer 2001, Chodachek 2003, Frey et al. 2003, Steen and Haugvold 2009, Pieron and Rohwer 2010). Predator control does not always increase breeding populations in subsequent seasons because winter food and cover, or other factors may be limiting the spring population (Reynolds et al. 1988, Cote and Sutherland 1997, Musil and Connelly 2007). Garretson and Rohwer (2001), Frey et al. (2003), Pearse and Ratti (2004), Frey and Conover (2007) and Baines et al. (2008) all reported indications of increases in the breeding population in addition to improved nest success.

Predator removal projects can be expensive (Chodachek 2003, Musil and Connelly 2009) and the benefits short-lived due to immigration (Harding et al. 2001, Sovada et al. 2001, Frey and Conover 2007, Baines et al. 2008). However, predator removal costs of $10–20/bird can not be sustained indefinitely, but are justified if needed to protect a threatened species during the early phases of recovery, particularly when using birds translocated at great expense.

Coyotes may be an important predator of sharp-tailed grouse eggs, chicks, and females (Hart et al. 1950, McDonald 1998), but coyotes may play an important role in limiting the presence of non-native red foxes in occupied sharp-tailed grouse areas (Sergeant et al. 1987, Sovada et al. 2001, Gosselink et al. 2003).

Non-lethal capture and moving of individual predators is an option in some cases. Small numbers of great horned owls that preyed on reintroduced sage-grouse in Lincoln County were captured and released some distance away during 2008-2010. Habitat management can reduce predation and eliminate the need for controlling predators, but foraging behavior of some predators may limit the effectiveness of cover improvements. For example, American crows are known to watch female behavior to find nests in dense cover (Jimenez and Conover 2001). Improved cover will help reduce predation by visual predators, but can be less effective for mammals which tend to use the sense of smell.

5.3.3 Conduct translocations of sharp-tailed grouse.

Translocation, particularly reintroductions require a multi-year commitment. Schroeder et al. (2011) described methods of the ongoing augmentation of populations.

5.3.4 Monitor the survival and productivity of translocated individuals.

Monitor released individuals with radio telemetry as needed to assess survival and reproduction. Ideally, monitoring should be intensive enough to be able to identify the reasons for project success or failure. Monitor movement, habitat use, productivity, survival, and size of the population.

5.4 Evaluate the success of augmentation/reintroduction projects.

The success or failure of re-introduction and augmentation efforts should be evaluated. Monitor the size and trend of the population, and periodically assess its genetic health to determine whether additional translocations or habitat improvements are necessary.

6. Conduct research necessary to conserve and restore sharp-tailed grouse populations.

6.1 Investigate the life history, demographics, and population dynamics of sharp-tailed grouse in Washington.

6.1.1 Investigate survival, productivity, and sources of mortality to identify vulnerable life stages and suggest means of improving survival of sharp-tailed grouse in Washington.

6.1.2 Investigate dynamics of sharp-tailed grouse populations to facilitate estimates of minimum viable populations and modeling of extinction risks.

6.2 Conduct research to improve understanding of habitat needs, seasonal movements, and dispersal of sharp-tailed grouse.

6.2.1 Evaluate the nutritional value of water birch and other native species for sharp-tailed grouse.

6.2.2 Develop a landscape model of year-round habitats that can be used to evaluate potential reintroduction areas.

6.3 Develop methods Uand conduct genetic analysis to monitor and improve the genetic health of sharp-tailed grouse populations.

Develop protocols for using feathers or other samples to 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.

6.4 Improve methods of restoring and maintaining sharp-tailed grouse habitat in Washington, including planting and prescribed burns.

6.4.1 Improve methods of restorating native vegetation and controlling weeds.

Document seed mixes, plant varieties, methods of controlling weeds, and deer damage and exchange information among managers to improve success and efficiency of habitat improvement projects.

6.4.2 Evaluate the effectiveness of prescribed burns in meadow steppe/grassland communities to control conifer invasion, maintain grassland, and improve habitat for sharp-tailed grouse.

The potential to use prescribed burns in meadow steppe/grassland should be carefully evaluated, and the response of any sharp-tailed grouse population present should be monitored. Fires in Idaho fescue communities may have created conditions that favored plant diversity; balsamroot, lupines (*Lupinus* spp.), and yarrow are favored by burning (Agee 1994).

6.5 Assess the potential impacts of wild turkeys on sharp-tailed grouse.

Assess the potential impacts of competitive interactions between sharp-tailed grouse and introduced wild turkeys.

6.6 Estimate the minimum viable population of sharp-tailed grouse and develop spatially explicit viability assessment for the species in Washington when feasible.

When sufficient data is available on sharp-tailed grouse demography, genetics, and population dynamics, estimate the N_e/N ratio and develop an estimate of minimum viable population, and viability of Washington's populations.

7. Coordinate and cooperate with other agencies, landowners, and private groups in the conservation, protection, and restoration of sharp-tailed

grouse in Washington.

7.1 Implement Farm Bill programs in Washington to benefit sharp-tailed grouse.

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

7.1.1 Identify priority areas in Washington where Farm Bill programs have the greatest potential to benefit sharp-tailed grouse.

7.1.2 Provide technical advice on planting requirements and management practices to enhance or restore potential sharp-tailed grouse habitat.

7.1.3 Review and comment during rule-making at the national level to ensure that Farm Bill programs continue to benefit sharp-tailed grouse in Washington and elsewhere.

7.2 Facilitate information exchange and meetings as needed to implement recovery actions and habitat restoration.

7.2.1 Facilitate information exchange with a technical interagency sharp-tailed grouse working group in cooperation with the BLM, WDNR, Colville Confederated Tribes, Spokane Tribe, Coeur d'Alene Tribe, and Yakama Nation concerning management of sharp-tailed grouse and restoration of habitats .

7.2.2 Facilitate information exchange with the Palouse Prairie Foundation, NRCS, TNC, land trusts, and other organizations involved in developing methods of restoring shrub-steppe, Palouse prairie, and other grassland habitats.

8. Develop public information and education programs.

8.1 Develop and provide identification materials to hunters to minimize accidental shooting of sharp-tailed grouse during hunting seasons for other game bird species.

8.2 Develop an education and outreach strategy to gain public support for sharp-tailed grouse recovery.

Resources should address species identification, habitat needs, and management conflicts, opportunities for habitat enhancement, habitat loss and degradation, and other threats.

8.2.1 Develop and disseminate information, education and interpretation materials about sharp-tailed grouse and recovery needs in Washington.

Develop educational materials on grouse identification, conservation, and habitat management. Materials should be designed for target audiences, such as landowners, school-aged children, or elected officials. For example, a brochure was designed to provide information to landowners and residents of other states where WDFW has obtained sharp-tailed grouse for translocation. The brochure is designed to help maintain support for cooperative translocation projects.

8.2.2 Identify media sponsors and public outreach and education partners to increase public knowledge and cooperation with recovery actions.

8.2.3 As populations recover, establish a Wildwatch video camera station at a lek, or a controlled access, public viewing/photo blind at a lek.

9. Secure funding for recovery activities.

9.1 Secure federal and nongovernmental foundation grants to conduct research, reintroductions, public education, and other recovery activities for sharp-tailed grouse.

9.2 Seek grants and partnerships for habitat acquisiton, restoration and enhancement.

Secure funding for acquiring and restoring sharp-tailed grouse habitat, purchase of development rights, and exploring direct payment incentive programs through federal, state, and private sources. Develop cooperative proposals with other agencies, conservation organizations, and land trusts. For appropriate habitats and locations, grants intended to improve stream bank conditions for salmon could recommend the use of tree and shrub species of value for sharp-tailed grouse winter habitat. Partner with Palouse prairie organizations to seek sponsors to establish and restore a reserve of sufficient size to support a sharptail population.

IMPLEMENTATION SCHEDULE

Identified below are the agencies, WDFW involvement, task priorities, and estimates of annual expenditures needed for sharp-tailed grouse recovery in Washington (Table 12). The listing of a party does not require them to implement the action(s) or to secure funding for implementing the action(s), but they are possible cooperators to accomplish the action(s). Cost estimates do not mean that funds have been designated or are necessarily available to complete the recovery tasks. **Implementation of recovery strategies is contingent upon availability of sufficient funds to undertake recovery tasks.**

The following conventions are used:
Priority 1: Actions needed to prevent the extinction of the species in Washington.
Priority 2: Actions to prevent a significant decline in population size or habitat quality, or some other significant negative impact short of extirpation.
Priority 3: All other actions necessary to meet recovery objectives.

Acronyms for cooperators

BLM	USDI Bureau of Land Management;
C	Counties;
CCT	Colville Confederated Tribes;
CD	Conservation districts;
DNR	Washington Department of Natural Resources;
FSA	Farm Services Agency;
FWS	USDI Fish and Wildlife Service;
NRCS	Natural Resources Conservation Service;
OS	Other states or provinces;
PL	Private landowners;
PPF	Palouse Prairie Foundation;
RCO	Recreation and Conservation Office;
TG	Other tribal governments, including Spokane Tribe, Coeur d'Alene, Yakama Nation, etc.;
TNC	The Nature Conservancy;
UR	University researchers;
VO	Non-governmental and volunteer organizations (such as Audubon Society chapters, Backcountry Horsemen, Inland Northwest Wildlife Council, Methow Conservancy, Washington Falconers, Wenatchee Sportsmen, etc.);
WDFW	Washington Department of Fish and Wildlife;
WT	Wild Turkey Federation.

Table 12. Implementation schedule and preliminary cost estimates for implementation of recovery tasks.

Priority	Recovery Task	Duration in years	Potential Cooperators	Est. Annual Cost ($1000's)	DFW Share[a]
1	1.1 Reduce collision hazards posed by wires, fences.	5	WDFW, BLM, VO	25	30%
2	1.2 Identify and minimize human-related and natural sources of mortality	5	WDFW, UR, BLM	Tbd[b]	50%
2	1.3 Reduce predation by human-associated predators	ongoing	WDFW	Tbd[b]	90%
2	1.4 Protect sharp-tailed grouse from disturbance	ongoing	PL, WDFW, DNR	Tbd[b]	80%

Priority	Recovery Task	Duration in years	Potential Cooperators	Est. Annual Cost ($1000's)	DFW Share[a]
2	2.1 Conduct fine-scale analysis of habitat to identify areas to re-establish populations and movement corridors	1	WDFW, CCT, UR, BLM	80	70%
2	2.2 Ensure compatibility of grazing on public lands in sharp-tailed grouse recovery area.	ongoing	BLM, WDFW, DNR	10	50%
1	2.3 Manage riparian habitats on public lands to support sharp-tailed grouse wintering.	ongoing	WDFW, BLM, DNR	10	60%
2	2.4 Discourage expansion of road systems on public lands in management units.	ongoing	C, WDFW, BLM, DNR	5	80%
2	2.5 Facilitate management of agricultural and rangelands that is compatible with sharp-tailed grouse.	ongoing	NRCS, BLM, PL, CD	Tbd[b]	50%
1	2.6 Protect shrub-steppe from wildfires.	ongoing	WDFW, WDNR, BLM, C PL	Tbd[b]	20%
1	2.7 Protect essential sharp-tailed grouse habitat through easements, cooperative agreements, and acquisitions.	10	RCO, FWS, BLM, TNC, PL	Tbd[b]	50%
2	2.8 Provide technical assistance to counties and regulatory agencies to protect sharp-tailed grouse and habitat.	ongoing	WDFW, DNR, BLM, CCT,	10	50%
2	2.9 Update planning documents and policies	cyclic	WDFW	10	90%
2	3.1 Analyze habitat to identify focus areas for restoration and reintroductions.	2	WDFW, BLM, CCT	Tbd[b]	30%
2	3.2 Enhance grouse habitat on WDFW lands.	ongoing	WDFW, VO	40	90%
2	3.3 Facilitate sharptail habitat enhancement.	ongoing	WDFW, BLM, DNR, CCT, VO, PL, NRCS, CD, FSA	Tbd[b]	20%
2	4.1 Monitor the status of sharp-tailed grouse populations.	annually	WDFW, BLM, CCT	15	80
2	4.2 Coordinate cooperative surveys, monitoring, and data.	ongoing	WDFW, CCT, BLM	2	100%
2	4.3 Estimate population size and monitor trend.	annually	WDFW	2	100%
2	5.1 Identify and prioritize population augmentation needs.	ongoing	WDFW	5	100%
2	5.2 Evaluate feasibility of locations to support reintroduced populations.	as needed	WDFW, UR	30	60%
1	5.3 Conduct augmentations and reintroductions.	10/cyclic	WDFW, BLM, CCT, OS	30	85%
2	5.4 Evaluate success of augmentations and reintroductions.	10/cyclic	WDFW, BLM, CCT, OS	5	100%
3	5.5 Revise recovery objectives, maps, documents as needed.	1	WDFW	5	100%

Priority	Recovery Task	Duration in years	Potential Cooperators	Est. Annual Cost ($1000's)	DFW Share[a]
2	6.1 Investigate life history, demographics, and population dynamics of sharp-tailed grouse.	10	WDFW, BLM, VO, CCT, UR	40	50%
2	6.2 Conduct research on habitat needs, seasonal movements, and dispersal.	10	WDFW, CCT, BLM, UR	15	50%
2	6.3 Develop methods of monitoring and improving the genetic health of sharp-tailed grouse populations.	5	WDFW	4	100%
3	6.4 Improve methods for restoring and maintaining sharp-tail habitat, including planting and prescribed burns.	5	WDFW, CCT, UR	Tbd[b]	60%
3	6.5 Assess potential impacts of competition with wild turkeys	4	WDFW, UR, WT	100	50
3	6.6 Estimate the minimum viable population of sharp-tailed grouse and develop spatially explicit viability assessment for Washington.	1, when feasible	WDFW	5	99
2	7.1 Implement Farm Bill programs to benefit sharp-tailed grouse.	ongoing	WDFW, PL, NRCS, FSA	10	10%
3	7.2 Facilitate/participate information exchange and meetings to implement recovery actions and habitat restoration.	2	WDFW, CCT, TG	2	80%
2	8.1 Develop and provide identification material to hunters to minimize incidental hunting mortality.	ongoing	WDFW, CCT	1	75%
3	8.2 Develop an education and outreach strategy.	1	WDFW	Tbd[b]	
1	9.1 Secure funding for research, translocations, education, etc.	ongoing	WDFW, CCT, BLM	5	60%
1	9.2 Secure funding for habitat acquisition, improvement	ongoing	WDFW, CCT, BLM, TNC, VO	5	80%

[a] Anticipated WDFW share of cost (%) if funds are available.
[b] Cost estimate to be determined.

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APPENDIX A. Washington Administrative Code 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.

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

1.1.2 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.

1.1.3 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.

1.1.4 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:

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

1.1.2 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.

1.1.3 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:

1.1.1 Historic, current, and future species population trends.

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

1.1.3 Historic and current habitat trends.

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

1.1.5 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.

1.1.1 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.

1.1.1 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.

1.1.2 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:

1.1.1 Target population objectives.

1.1.2 Criteria for reclassification.

1.1.3 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.

1.1.4 Public education needs.

1.1.5 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.

1.1.1 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.

1.1.2 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.

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

1.1.4 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:

1.1.1 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.

1.1.2 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.

[Statutory Authority: RCW 77.12.047, 77.12.655, 77.12.020. 02-02-062 (Order 01-283), § 232-12-297, filed 12/28/01, effective 1/28/02. Statutory Authority: RCW 77.12.040. 98-05-041 (Order 98-17), § 232-12-297, filed 2/11/98, effective 3/14/98. Statutory Authority: RCW 77.12.020. 90-11-066 (Order 442), § 232-12-297, filed 5/15/90, effective 6/15/90.]

APPENDIX B. Washington Administrative Code 232-12-181. Livestock grazing on department of fish and wildlife lands.

All persons wishing to apply for a grazing permit should contact the Washington Department of Fish and Wildlife, 600 North Capitol Way, Olympia, Washington 98501-1091.

(1) The director is authorized to enter into grazing permits when the director determines that a grazing permit will be consistent with the desired ecological condition for those lands or the department's strategic plan. Except for temporary permits, or permits that are being renewed or renegotiated with existing permittees, grazing permits shall first be submitted to the commission, which may review the permit to ensure it conforms with commission policy. If, within thirty days, the commission has not disapproved the permit, the director shall be deemed authorized to enter into that permit.

(2) The director shall negotiate grazing permits with potential grazing operators to ensure the highest benefits to fish and wildlife. The director may advertise and sell a permit to use department lands for grazing at public auction to the highest bidder. The director is authorized to reject any and all bids if it is determined to be in the best interest of the fish and wildlife to do so.

(3) The term of each grazing permit shall be no greater than five years. When an existing permit expires or is about to expire, the director may renew the permit for up to another five years, renegotiate the grazing permit with the existing permittee, negotiate a new permit with a new grazing operator, or sell the permit at public auction to the highest bidder. The director is authorized to reject any and all bids if it is determined to be in the best interest of the fish and wildlife to do so. The director may grant a term longer than five years only with the prior approval of the commission.

(4) A temporary permit may be granted by the director to satisfy short-term needs where benefits to wildlife management programs and the public interest can be demonstrated. The term of a temporary permit shall not exceed one year and no fee need be charged.

(5) Except for temporary permits lasting less than two weeks, each grazing permit proposal shall be accompanied by a domestic livestock grazing management plan that includes a description of ecological impacts, desired ecological condition, fish and wildlife benefits, a monitoring plan, and an evaluation schedule for lands that will be grazed by livestock. The department shall inspect the site of a grazing permit no less than two times each year. The director shall retain the right to alter any provision of the plan as required to benefit fish or wildlife management, public hunting and fishing, or other recreational uses.

(6) The director may cancel a permit (a) for noncompliance with the terms and conditions of the permit, or (b) if the area described in the permit is included in a land use plan determined by the agency to be a higher and better use, or (c) if the property is sold or conveyed, or (d) if damage to wildlife or wildlife habitat occurs.

(7) All lands covered by any grazing permit agreement shall at all times be open to public hunting, fishing and other wildlife recreational uses unless such lands have been closed by action of the commission or emergency order of the director.

[Statutory Authority: RCW 77.12.047, 77.12.020, 77.12.570, 77.12.210. 07-11-017 (Order 07-62), § 232-12-181, filed 5/3/07, effective 6/3/07. Statutory Authority: RCW 77.12.047. 03-03-016 (Order 03-03), § 232-12-181, filed 1/7/03, effective 2/7/03. Statutory Authority: RCW 77.12.210. 88-23-109 (Order 323), § 232-12-181, filed 11/22/88. Statutory Authority: RCW 77.12.040. 82-04-034 (Order 177), § 232-12-181, filed 1/28/82; 81-12-029 (Order 165), § 232-12-181, filed 6/1/81. Formerly WAC 232-12-405.]

APPENDIX C. Historical specimen records and selected reports of distribution and abundance of sharp-tailed grouse in Washington (see Map).

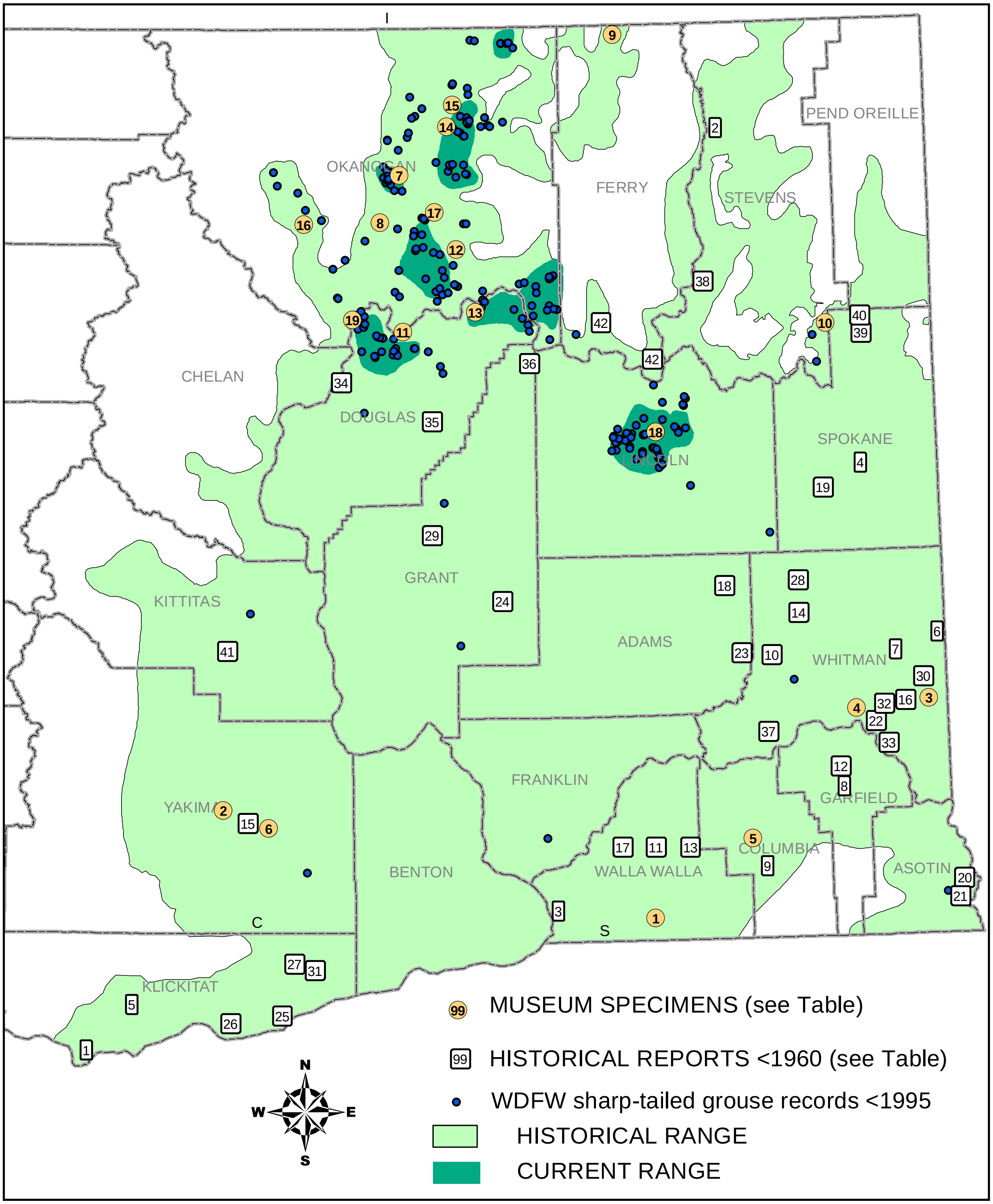
Map Point	Location	County	Year	Notes	Source or specimen number
Specimens (orange numbers on map)					
	Spokane River	Uncertain	1853		Coll. J. Cooper
1	Fort Walla Walla	Walla Walla	1880	Female	CMNH # 62153
	Fort Walla Walla	Walla Walla	1881	Female	CMNH # 62151
	Walla Walla	Walla Walla	?	Male	ANSP # 24304
	?	Whitman	1884	Egg (12)	CAS # 6959
2	Yakima	Yakima	1887	Eggs	UWBM# 3676
	Yakima	Yakima	1905	Male	AMNH 751239
3	Pullman	Whitman	1895		WSUCM # 420
	Pullman	Whitman	1895	Female	WSUCM # 681
4	Almota	Whitman	1895	Male	USNM # 141363
5	Dayton	Columbia	1897	Eggs (9)	SMUPS # 13571
	Dayton	Columbia	1897	Eggs (10)	CM # 899
	Dayton	Columbia	1897	Eggs (15)	WFVZ
	Dayton	Columbia	1897	Egg (10)	WFVZ
	Dayton	Columbia	1898	Eggs (8)	WFVZ
	Dayton	Columbia	1898	Egg	USNM # B43523
6	Toppenish	Yakima	1897		USNM # 157956
7	Conconully	Okanogan	1897		USNM # 157955
	Conconully	Okanogan	1897	Male	USNM # 157957
8	Okanogan	Okanogan	1906	Male	USNM # 270794
9	Danville	Ferry	1907	Female	USNM # 271895
	Danville	Ferry	1908	Female	USNM # 271896
10	Loon Lake	Stevens	1909	Female	No number assigned
11	Bridgeport	Douglas	1910	Female	WSUCM # 40-3
	?	Douglas	1952	Female	WSUCM # 53-22
	?	Douglas	1952	Male	WSUCM # 53-23
	?	Douglas	1952	Female	WSUCM # 53-24
	Bridgeport	Douglas	1973	Female	UWBM # 33950
	Bridgeport	Douglas	1975	Female	UWBM # 31342
12	Omak Lake	Okanogan	1953	Male	UWBM # 12175
13	Del Rio	Douglas	1953	Male	WSUCM # 54-115
14	Tonasket	Okanogan	1954	Female	WSUCM # 54-73
	Tonasket	Okanogan	1954	Female	WSUCM # 54-74
15	Mosquito Creek	Okanogan	1954	Male	WSUCM # 54-113
	Mosquito Creek	Okanogan	1954	Male	WSUCM # 54-114
16	Twisp	Okanogan	1960	Male	WSUCM # 61-214
	Riverside	Okanogan	1961	Male	SMUPS # 07052
17	Riverside	Okanogan	1961	Male	SMUPS # 07054
	Riverside	Okanogan	1961	Female	SMUPS # 07051
	Riverside	Okanogan	1961	Female	SMUPS # 07053
18	T24N R34E S4	Lincoln	1975		UWBM # 33419
	T24N R34E S4	Lincoln	1975	male	UWBM # 33420
19	Central Ferry Canyon	Douglas	1979	male	UWBM # 33090

Map Point	Location	County	Year	Notes	Source or specimen number
	Central Ferry Canyon	Douglas	1979	female	UWBM # 33091
	River	?	?		USNM # 429140
	Sinyakwateen	Okanogan	?		USNM # 022011
Historical Reports, prior to 1960 (white numbers on map)					
1	Dallesport vicinity	Klickitat	1805	Lewis & Clark Expedition shot 2	Zwickel and Schroeder (2003)
	Dallesport vicinity	Klickitat	1855	Young chicks	Suckley (1860)
2	Kettle Falls vicinity	Stevens	1826	Abundant	Douglas (1914)
	Kettle Falls vicinity	Stevens	1860	Vast numbers in stubble fields	Lord (1866:304)
	Kettle Falls vicinity	Stevens	1915	3 nests	Jewett (1953:215)
3	Wallula	Walla Walla	1834	Shot 22 in 1 day	Townsend (1987[1839])
4	Spangle	Spokane	1873	Frequent part of settler's diet	Hergen (1990?:93)
5	Klickitat Valley	Klickitat	1861	Thousands	Attwell (1977)
	Klickitat Valley	Klickitat	1860-70s	Large flocks in every part of the valley	Ballou (1938)
6	Palouse River near Palouse	Whitman	1877	Thousands	Kincaid and Harris (1979)
7	Colfax	Whitman	1880	Many	Downen (1977)
8	Pomeroy vicinity	Garfield	1880s	Found in almost limitless numbers; great flocks in cottonwoods along Pataha Crk after heavy snow	Kuykendall (1984)
9	S. Touchet River, 5 mi SE Dayton	Columbia	1890	Hundreds came to creek bottoms after heavy snow	O. Payne (Buss and Dziedzic 1955)
10	Rock Creek	Whitman	1902	Abundant, last single record 1947	F. Weidrich (Yocum1952)
11	Touchet Creek	Walla Walla	1903	Abundant	Snodgrass (1904)
12	[county]	Garfield	1903	A few seen	Snodgrass (1904)
13	Prescott vicinity	Walla Walla	1906	Abundant	Dice (1918)
14	Cherry Creek	Whitman	1908	Very numerous	W. Hegler (Yocum 1952)
15	Yakima Valley	Yakima	1909	Common, but absent by 1914	Kennedy (1914)
16	Pullman vicinity	Whitman	1910	50-75 birds on ranch, none after 1915	L.Hall (Buss and Dziedzic 1955)
	Pullman vicinity	Whitman	1941	2 seen	H. Eastlick (Yocum 1952)
17	Eureka	Walla Walla	1914	"A number seen in the grain fields and bunchgrass hills"	Dice 1918
18	Karakul Hills	Adams	1920s	Common	Ritzville H.S. Freshman class (1978)
19	Turnbull Slough	Spokane	1933	75; common in 1930s	Yocum (1952)

Map Point	Location	County	Year	Notes	Source or specimen number
20	Snake Riv. Breaks E of Anatone	Asotin	1938	2 seen	E&F. Hendrickson (Yocum 1952)
21	Anatone vicinity: 4-5 mi E, 4 mi S	Asotin	1936-40	A brood and small numbers seen	Yocum (1952)
22	Almota	Whitman	1939	17 seen; a few persisted to 1941	J. Drolet (Yocum 1952)
23	Twelve Mile Slough	Adams	<1940	Present unitl about 1940	Yocum (1952)
24	Moses Lake	Grant	1940	Small group present past several years	Larrison (1942)
25	Columbia breaks, Sundale-Roosevelt	Klickitat	1940	Flock of 6 seen; a few present N of Sundale	Yocum (1952)
26	Goodnoe Hills	Klickitat	1940	Flock of 10-15	H. Bryant (Yocum 1952)
27	Wood Gulch	Klickitat	1940	A flock seen	Yocum (1952)
28	Rock Lake	Adams	1941	3 seen S end of lake	Yocum (1952)
29	Ephrata, 1 mi S	Grant	1942	1 male along highway	Larrison (1942)
30	Whelan	Whitman	1942	5 seen around farm in summer	R. Held (Yocum 1952)
31	Alder Crk, 7 mi SE Bickleton	Klickitat	1945	A small flock	N. Mattsen (Yocum 1952)
32	Almota Cr/Little Almota Cr.	Whitman	1949	Flock of 10	E. Larrison (Yocum 1952)
	Almota, NE of	Whitman	1949	About 25 seen	Yocum (1952)
33	Wawawai	Whitman	1949	Pair flushed several dates	D. Earp, A, Canaris (Yocum 1952)
34	Columbia breaks, S to Waterville	Douglas	1952	A few present	R. Schwindel (Yocum 1952)
35	Jameson Lake	Douglas	1952	A few present	R. Schwindel (Yocum 1952)
36	S of Electric City	Grant	1952	Present in scablands E side Grand Coulee	R. Schwindel (Yocum 1952)
37	Hay vicinity	Whitman	1952	A few still present	Yocum (1952)
38	Hunters and Cedonia	Stevens	1950s	May be present	Yocum (1952)
	Snake River breaks		1954	A few still present	Hudson and Yocum (1954)
39	Deer Park Airport	Spokane	1959	Lek of 50; dwindled to2 in 1964, last active	Zeigler (1979)
40	Eloika Lake	Spokane	Late 1950s	Small lek	Zeigler (1979)
41	Ellensburg	Kittitas	?		A. Fisher (Jewett et al. 1953)
42	Colville Reservation, eastern part	Ferry	1940-70s	Abundant in 1940s, present through 1970s	S. Judd (Merker 1988)

[a]Museum abbreviations: AMNH = American Museum of Natural History, New York, New York; ANSP = The Academy of Natural Sciences, Philadelphia, Pennsylvania; CAS = California Academy of Sciences, San Francisco; CM = The Carnegie Museum of Natural History, Pittsburgh, Pennsylvania; CMNH = The Cleveland Museum of Natural History, Cleveland, Ohio; SMUPS = Slater Museum, University of Puget Sound, Tacoma; USNM = Smithsonian Institution National Museum of Natural History, Washington, D.C.; UWBM = University of Washington, Burke Museum, Seattle; WFVZ = Western Foundation of Vertebrate Zoology, Camarillo, California.

Appendix C.Historical distribution and abundance of Columbian Sharp-tailed Grouse in Washington (MAP).



APPENDIX D. Parasites documented in sharp-tailed grouse (modified from Peterson 2004).

Parasite	Locations	Intermediate host or vector	References
Mallophaga (lice)			
Amyrsidea sp.	MB, WI		16, 30
A. perdicis	SD		20
Goniodes sp.	ON, WI		2, 31
G. nebraskensis	MB, MT, NE, ND, SD, ON, WA		16, 20, 30
Lagopoecus gibsoni	MB		30
Lagopoecus perplexus	ON, SD, WA		1, 14, 16, 20
Mites			
Ornithonyssus sylviarum	MB		30
Unidentified sp.	SD		20
Ticks			
Haemaphysalis sp.	MN		3
H. chordeilis	MB, SD		20, 30
H. leporispalustris	MB, MI, SD, WI		2, 10, 20, 30
Diptera (Hippoboscidae?)			
Ornithoyia anchineuria	MB		30
Nematodes			
Ascaridia galli	MN, WI		12, 13
Capillaria contorta (crop)	WI		13
Cheilospirura spinosa (gizzard)	SD, WI	Grasshoppers	12, 13
Cyrenia colini (proventriculus)	SD, WI	Grasshoppers (*Melanoplus* spp.)	12, 20
Dispharynx nasuta	SD	Isopods (*Porcellio scabes, Armadillidium vulgare*)	20
Gongylonema phasianella	NE	Arthropod?	8
Heterakis gallinarum	SD, WI	Earthworms or direct	12, 13
Oxyspirura petrowi (eyeworm)	MI, SD	Insect?	5, 12, 23
Physoloptera sp.	MN, SD		12, 25
Splendidofilaria pectoralis	BC, AK	Black flies or biting midge?	22
Subulara strongylina (caecum)	SD, WI		12, 13, 20
Cestodes (tapeworms)			
Choanotaenia infundibulum	MN, WI		12, 13
Raillietina centrocerci	ND, SD		20, 24, 25
R. variabilis	ND, WI		2, 15
Rhabdometra nullicollis	MN, ND, SD, WI		2, 12, 13, 15
R. odiosa	QC		4
Trematodes			
Agamodistomum sp.	MN	Gastropods	12
Athesmia wehri	MT	Gastropods	7
Brachylaima furcatum	AK	Gastropods	17

	Parasite	Locations	Intermediate host or vector	References
	Echinostoma revolutum	SD	Gastropods	25
Hematozoa				
	Leucocytozoon sp.	MI		5, 10
	L. bonasae	MI, WI	Blackflies & midges	18, 19
	Plasmodium pediocetii	ND, CO		11, 14
	Trypanosoma avium	CO	Blackflies	21, 26
	Haemoproteus mansoni	?	Midges & hippoboscids	29
Other protozoans				
	Eimeria dispersa (coccidia)	MN, WI		12, 13
	Eimeria angusta (coccidia)	MN, WI		12, 13
	Histomonas maleagridis (flagellated protozoan) (assumed)	?	*Heterakis gallinarum* direct or via earthworms	32
	Sarcocystis sp.	AB	Unknown vertebrate	28
Bacteria				
	Francisella tularensis (etiological agent of tularemia)	MN	*H. leporispalustris* (tick)	3
	Clostridium colinum (causes ulcerative enteritis)	Captive birds		6
	Mycoplasma sp. (probable)	?		32
	Clamydophila psittici (probable)	?		32
Fungi				
	Trichophyton sp. (ringworm)	SD		25

References:

1 Kellogg 1899
2 Gross 1930
3 Green and Shillinger 1932
4 Swales 1934
5 Saunders 1935
6 Morely and Wetmore 1936
7 McIntosh 1937
8 Shillinger and Morely 1937
9 Wehr 1938
10 Baumgartner 1939
11 Wetmore 1939
12 Boughton 1937
13 Morgan and Hammerstrom 1941
14 Shillinger 1942
15 Aldous 1943
16 Emerson 1951
17 Babero 1952
18 Flakas 1952
19 Cowan and Peterle 1957
20 Boddicker and Hugghins 1965
21 Stabler et al. 1966
22 Gibson 1967
23 Addison and Anderson 1969
24 Bernhoft 1969
25 Hillman and Jackson 1973
26 Stabler et al. 1974
27 Stabler and Kitzmiller 1976
28 Drouin and Marht 1979
29 White and Bennett 1979
30 Dick 1981
31 Tsuji et al. 2001
32 Peterson 2004

APPENDIX E. Responses to written public comments received on the Draft Recovery Plan.

Note: page numbers refer to the Draft Columbian Sharp-tailed Grouse Recovery Plan, unless otherwise noted.

Section	Comment and response
General comments	I am in favor of implementing this plan to restore habitat so the Columbian sharp-tailed grouse does not go extinct.
	Thank you, we appreciate the support.
	We strongly recommend that Endangered Species Section sit down and work with affected parties and the other Sections of the WDFW prior to developing and releasing recovery plans. It is evident that this document was created in a vacuum and did not involve any of these parties. Until, the WDFW begins to work collaboratively with these affected parties you will not be able to develop plans that have widespread support and buy-in from affected parties.
	The recovery plan was developed with input and review by technical staff from tribes, the Bureau of Land Management, and WDFW Science, Game, and Lands divisions, as well as expert peer reviewers from other states. Recovery plans are based on science and the biology of the species, and are not a collaborative effort involving potentially affected political or economic entities, or individuals. Science can be ambiguous, but it is not negotiable. It is a fairly broad strategic document intended to provide direction for WDFW staff, and it has no regulatory authority or function. There are no "affected parties", unless or until, more specific local actions recommended in the Plan are proposed or undertaken. At that point in time, WDFW staff will work with any potentially affected parties.
	I think this is perhaps the most sophisticated, *best written*, scholarly piece on prairie grouse that I've ever had the pleasure of reading. It's full of delicious history, packed with good data, well interpreted, and casts the species in a positive light relative to the potential for recovery in Washington.
	Thank you, we appreciate the support.
Population Status	During summer and fall I see small groups of sharp-tailed grouse in the Mt. Annie area east of the Aeneas Valley; are these likely included in the estimate of 700 pairs?
	The 2011 estimate was 902 birds. The Mt. Annie birds may represent a lek that we are not aware of because it is a substantial distance from where we'd expect based on known leks. We plan to search the area for leks next year. If there is one, it would be good news, but it probably would not greatly increase our estimate. Thanks for the tip.
Conservation Status	WDFW should recommend up-listing Columbian Sharp-tailed Grouse from State "Threatened" to State "Endangered" now. The current population is well below the minimum number necessary to maintain species viability and threats to the grouse are likely to increase.

Section	Comment and response
	We have included an uplisting target in the recovery plan. If the population level falls below 450 birds, we would recommend to the Fish and Wildlife Commission that they be up-listed to Endangered.
Management Activities	It seems the recovery plan has no plans, but only history of what has failed. Each time I drive through Lincoln County, I think, "What is being done?" It is all about habitat! Introducing birds into an area only works if the habitat is in place for them to flourish.
	We agree that habitat is the key to recovery. We describe many of the things that are being done in the Management Activities section. In the last 20 years, we have acquired a total of over 40,000 ac for sharp-tailed grouse. The Swanson Lakes WLA, together with recently acquired BLM lands form an aggregation of >53,000 ac in central Lincoln County. We have also restored >2,840 ac of former wheat fields, planted >170,000 trees and shrubs, and removed >100 miles of fences. We are working with Lincoln County Conservation District to remove more fencing. Work is currently underway to restore an additional 413 ac of old grain fields in northern Douglas County to shrub-steppe with a $250,000 grant; we are also working with partners to mark fences that cannot be removed, to reduce grouse collision mortalities. These efforts are spread among Douglas, Okanogan, and Lincoln counties, so all are not evident at one location. It takes time and progress can be slow because each project requires funding, which is usually from external grants, and there are limited funds available. The Department also works with many partners to accomplish recovery activities. *The recovery plan includes a lengthy discussion of the land use history ("what has failed") that resulted in the current population status of sharptails, because it is important to understand how we got to this point. We have proceeded with translocating birds to Swanson Lakes WLA because: 1) to keep local populations from being extirpated; it is much easier to work with an existing population than to have to restart with a reintroduction; 2) bringing in birds should improve or maintain the genetic health of the population; 3) the habitat is better because some cropland has been restored, and grazing has been dramatically reduced in the area. We are currently reseeding 77 ac of old CRP fields at Swanson Lakes WLA and have been seeking funds to reseed another 400 ac.*
Factors Affecting: Adequacy of Existing Regulatory Mechanisms	The DRAFT Plan talks about a need to further regulate activities on private lands. We strongly oppose this idea and believe that the WDFW can achieve their resource goals via incentives much faster than via regulation. We disagree with the opinion that the Growth Management Act needs to be expanded to regulate critical wildlife habitat on private lands.
	We agree that incentives can be very effective, and we work with USDA and Congress to implement Farm Bill programs, such as CRP and SAFE to provide the wildlife habitat values intended. A direct incentive involving payments to landowners determined by grouse numbers would be an interesting experiment, but would require substantial funding. Where no incentive programs are in place we encourage and work with counties to effectively implement protection of the public wildlife resource. The Growth Management Act already requires counties to identify important wildlife resources, and develop critical area ordinances to protect them from incompatible

Section	Comment and response
	development. The Recovery Plan includes a recommendation to develop incentives for private landowners to protect or restore suitable grouse habitat and other recovery needs.
	A major threat to sharp-tailed grouse, particularly in Tunk Valley, is posed by the prospect of too many exempt wells being drilled and impacting riparian habitat. The USGS recently did a study of the Tunk Creek and concluded that even without any additional wells, the creek would lose flow, and ground water would be lost, due to climate change. The DFW purchased land bordering the Tunk Creek specifically for riparian winter habitat for Sharptail Grouse and it is at risk, due to unregulated drilling of wells. In the 1980's, there were only about 25 wells in all of Tunk Valley. Now there are more than ten times as many wells. One analysis of the USGS study estimated that just 12 more wells in Tunk Creek, at 5,000 gals per day, would dry up the creek. Water has been over-appropriated in Washington. Inevitably, exempt wells will be regulated. It needs to happen sooner, not later, in Tunk Valley. WDFW should put pressure on the Dept. of Ecology to place a moratorium on new wells in Tunk Valley, as happened recently in Kittitas County.
	We are unsure if you are referring to the report by Sumioka and Dinicola (2009); if so, we could find no mention of the risk to Tunk Creek of adding 12 more wells. The proliferation of private wells in Okanogan County can affect stream flows, and may eventually degrade riparian vegetation along tributaries of the Okanogan River, including Tunk, Bonaparte, Antoine, and Tonasket creeks. The summer flow of Tunk Creek also affects spawning and rearing by Upper Columbia Summer Steelhead, a threatened species under the Federal Endangered Species Act. The Okanogan Conservation District is leading the planning and implementation of a long-range watershed plan for the Okanogan River basin that will be used so that future water demands in the basin are met while protecting fish and wildlife resources. This plan may help prevent this problem if completed and implemented before additional impacts to stream flow occur. We added a mention of this problem in the recovery plan.
	The County should be required to place a moratorium on future exempt wells in Tunk Valley until such time as they can attain the information as to the actual carrying capacity of the Valley. The County should not allow unregulated drilling in Tunk Valley until the aquifer is depleted and Tunk Creek goes dry.
	This is an issue that would need to be addressed to the County. Your comment has been noted. However, we agree that this is an issue that needs attention to avoid over pumping ground water, and affecting federally listed Upper Columbia Summer Steelhead.

Section	Comment and response
	In Okanogan County, the threat of fragmentation of habitat to Sharptail Grouse has been brought to the attention of the authors of the Draft Critical Areas Ordinance and it has been willfully disregarded. The result is that the County is proposing to allow Tunk Valley, which has the largest contiguous block of shrub -steppe habitat in the County, to be divided into 5 acre parcels. Okanogan County, which is required to designate Resource Lands, has made the unprecedented move to remove that designation from all private lands, thereby making all private land in the County available for residential development. If indeed land in private ownership is critical to saving sharptail grouse, then the focus should be on leveraging the State requirements and regulating land use, rather than depending on the education and voluntary cooperation by landowners.
	Residential development of rural areas is a threat to suitable sharp-tailed grouse habitat. We hope that counties, agencies, and landowners will take measures to avoid or minimize impacts. Okanogan County is among those counties that are not required to plan for development under the Growth Management Act because its' human population is <50,000.
Factors Affecting: Livestock grazing	We are extremely disappointed with the anti-grazing bias that is evident throughout the DRAFT. Ranchers provide hundreds of thousands of acres of wildlife friendly habitat throughout the State. This document continues the attack on present grazing practices and basically states that grazing is not compatible to Sharp-Tailed Grouse habitat, setting a unproven and dangerous precedent.
	We attempted to objectively review all available literature pertinent to the effects of livestock grazing, past and present, on sharp-tailed grouse, and the potential for management compatible with maintaining suitable habitat condition, and this review underwent peer review. Re: grazing, the plan states on p.70: "Livestock grazing may be compatible with sharp-tailed grouse in uplands if habitat characteristics needed for breeding and nesting can be consistently maintained... . Whether this is possible on any particular site probably depends on many factors including the grazing history of the site, site condition, precipitation zone, year-to-year precipitation, livestock type, stocking rate, season, intensity, frequency, and duration of grazing." *There probably always is some level of impact of any land use activity, whether livestock grazing, or recreation, such as spreading weeds, disturbance, or trampling. Livestock grazing may be able to be managed in a way that is compatible with sharp-tailed grouse. However, such a management regime may or may not be economically sustainable on any particular area.*
	The plan should end livestock grazing on WDFW land used by sharp-tailed grouse. The authors make a compelling case against livestock grazing in sharp-tailed grouse habitat. Given the species' limited habitat in Washington and the many threats it faces, it is imperative that public land be managed to the highest benefit for the grouse.

Section	Comment and response
	The standards and process for issuance of grazing permits on WDFW lands are outlined in WAC 232-12-181 (Appendix B) and Fish and Wildlife Commission Policy C-6003. The Director must determine that a grazing permit will be "consistent with the desired ecological condition for those lands or the department's strategic plan"… and shall negotiate permits to "ensure the highest benefits to fish and wildlife." (WAC 232-12-181). *The plan recommends (under task 2.3.2) that livestock grazing, or any other activity, should not occur on WDFW lands occupied by sharp-tailed grouse, unless:* *1) it will not adversely impact sharp-tailed grouse by disturbance of leks, nesting hens, or young broods;* *2) it will increase or maintain herbaceous cover, residual spring nesting cover, and the composition and diversity of native vegetation as needed to restore and maintain optimal nesting habitat condition;* *3) it will not require additional fencing or the maintenance of otherwise un-needed fencing;* *4) plans and resources are in place to adequately monitor its effects on sharp-tailed grouse and condition of their habitats.*
	We believe WDFW should re-write the Plan and create a document that is reflective of the statement in this document, "*Restoring sufficient habitat for recovery will require a sustained effort involving many partners, and will not be possible without cooperation from many landowners".* The current plan will not receive any support from the livestock industry due to the anti-grazing focus that this document has taken. We would be happy to work with WDFW to develop a recovery plan that is a win-win for both cattlemen and the Sharp-Tailed Grouse.
	The plan provides information regarding the relationship of livestock grazing to maintaining suitable sharp-tailed grouse habitat based on scientific literature and studies available from Washington and other states.
	The livestock grazing section needs additional discussion of the contributions of grazing to the spread of nonnative plants, particularly cheatgrass (*Bromus tectorum*). Significant information exists implicating grazing in the spread of cheatgrass and the subsequent effects cheatgrass has on native plants, soil, and fire cycles. Cheatgrass is known to invade numerous habitat types, including higher elevation Mountain big sagebrush and associated communities. The effects of cheatgrass on western landscapes is catastrophic. Grazing on public lands should be curtailed wherever cheatgrass occurs; public agencies and private landowners must seek to eradicate cheatgrass and other invasives on public and private land.
	Information about cheatgrass has been added to the plan in the section on grazing and habitat degradation (p. 72-73).
	The plan should avoid using "overgrazing" and "over-grazing" when describing past and current grazing use. Past grazing was not considered "overgrazing" when it occurred; and any level of current grazing is probably still "overgrazing" the landscape. As the plan notes, Columbia Basin shrub-steppe did not evolve with grazing by numerous, large, herding, hooved ungulates. *Grazing*—not overgrazing—

Section	Comment and response
	has multiple negative effects on western landscapes. Grazing—just "grazing"—at any level is an important threat to CSTG.
	Whatever term is used, it refers to a level of grazing that is unsustainable, and leads to deterioration of the vegetation community. We changed the term"overgrazing" to "grazing" or "heavy grazing," in the plan because the term 'overgrazing' has often been criticized as ambiguous or imprecise. Although any level of livestock grazing in the dry shrub-steppe vegetation types damages the soil crust of undisturbed sites, and thereby leads to deterioration, the science is less clear whether, grazing "at any level is an important threat to CSTG," in the more mesic three-tip sagebrush and grasslands types.
Recovery	I would like to see more money going towards habitat or CRP type programs—if you build it they will come.
	So would we. If all the older CRP in crested wheatgrass or smooth brome in southeastern Washington was planted to a diverse native mix, a dramatic recovery of sharptails might occur. We have a staff biologist who works to improve CRP planting requirements, and to help secure funds for programs like the new SAFE program that includes 63,000 ac in Douglas County for sharptails and sage-grouse. WDFW also has private lands biologists that help facilitate enrollments in this and other Farm Bill programs. *Lands with deep soil and $\geq$ 13"precipitation are priorities for restoration, easements, or acquisitions, because once restored, they could be very productive for sharptailed grouse. However, it is also more difficult to secure funding to acquire cropland that requires restoration because granting agencies prefer funding lands that retain native vegetation and already support a wide variety of species of conservation concern.*
	I would advocate for a program of reintroducing beavers into Tunk Valley. Beavers used to be common along the length of Tunk Valley. The Okanogan Watershed Plan predicts reduced water availability in the Tunk Valley, in the future. Beaver dams are recognized as a very effective means of keeping moisture in riparian areas.
	A discussion about beavers and riparian habitat has been added to the Habitat Status *and the* Livestock grazing and riparian habitat *section under* Factors Affecting. *Beavers can be an important tool in restoring riparian habitat. However, returning beaver to the Tunk Valley might be problematic given the proximity of the road to the creek. The potential for flooding roads may inhibit the use of beaver in restoration.*
	The plan lacks specifics as to what, where, and when suggested recovery activities will be implemented. I cannot believe it took 10+ years to draft it.

Section	Comment and response
	The plan provides recovery targets to achieve downlisting from state-threatened status, over-arching guidance for recovery actions, and includes strategies and tasks. Specifics of implementation will come as individual task are undertaken. Many details have to be defined and determined as work progresses. The plan has been underway for 5 years, but has been delayed because of other high priority needs for the very limited staff available to write the plans. It has been >10 years since sharptails were state-listed, and the goal is to initate recovery plans within a year of listing; however, there are only two recovery staff available to write recovery plans and status reports. In the years since sharp-tailed grouse were listed, recovery actions have been ongoing, including habitat enhancements and the translocation of >300 birds to Washington.
	It would be nice to see a recovery plan with a listing of expected cost associated; in this way one can evaluate what is likely to be done as opposed to some general statements as to recovery strategy.
	The plan includes an implementation schedule, with estimates of costs to implement recovery tasks (Table 12). Some are 'to be determined' because it is not possible to predict them with any accuracy at this time. Costs don't necessarily indicate what is likely to be done, because it can often depend on the goals of the granting entitites with respect to the activites that get funded.
	I am always amazed how common sense is so vacant when it comes to wildlife. You are trying to save black bears in Central Park, please quit wasting our tax dollars.
	The Washington Department of Fish and Wildlife, "serves Washington's citizens by protecting, restoring and enhancing fish and wildlife and their habitats." Polls consistently show broad support for endangered species conservation. Recovery of sharp-tailed grouse is possible. With improvements in Farm Bill programs, strategic land acquisitions (past and future), habitat restoration, and working with landowners and partner organizations, sharp-tailed grouse can be recovered sufficiently that they remain a part of Washington's wildlife.
	I'm in favor of restoring lands for the sharp-tailed grouse in Washington.
	Thank you for your support. Habitat restoration of cropland to native grassland is an important task identified in the recovery plan.
	The plan should prioritize land acquisition (vs. easements, and agreements) among the options listed for protecting habitat (Draft, p.105-106). Most sharptail habitat in Washington is privately owned. A significant amount is enrolled in the CRP and the long-term status of these areas is unknown. Other important habitat is on private ranches that, if they were not grazed, might otherwise be subdivided for development. Conservation easements are costly and often still permit land uses that would harm sharptails. Public acquisition of key habitat is the most efficient, effective way to ensure that habitat is available and manageable for sharptails long-term.

Section	Comment and response
	For some key pieces of core habitat, fee title acquisition may be the best long-term option. However, the plan includes a range of options to conserve habitat. WDFW only works with willing sellers, and some landowners prefer management agreements or easements that will keep a ranch working while providing conservation benefits. Well crafted easements need not permit uses that significantly harm sharptails. Acquisitions also have the downside of opposition by some county leaders, and perpetual maintenance costs.
	During the past 15 + years the CRP has added **800,000+ acres** of habitat in 9"+ rainfall land (*without grazing*) to the available habitat for Sharp-Tailed Grouse, plus the over **40,000 acres** of Sharp-Tailed Grouse habitat *(Okanogan, Lincoln and Douglas counties)* that have been purchased by the WDFW in these counties. It appears that the additional land base has not had a positive impact on the Sharp-Tailed Grouse population. The population has remained fairly stable over the past 25 years. These facts would indicate that there must be other factors impeding the recovery of the Sharp-Tailed Grouse. We believe this proves that increasing the amount of Government controlled lands does not increase the recovery of the species.
	Sharptails numbers were crashing but stabilized somewhat about 1995 after WDFW acquired lands at Scotch Creek, Swanson Lakes, Chesaw, Tunk Valley, West Foster Creek, and other areas dedicated to sharp-tailed grouse management. The plan notes that "other factors impeding recovery" include widespread loss of riparian wintering habitat, and genetic factors for small isolated populations. The state lands that have been acquired to date are spread out, and part of the grouse populations present rely on surrounding lands; management of the state lands alone is not sufficient for dramatic recovery. *Most of the CRP was enrolled during the 1980s and 1990s when planting requirements were not adequate for grouse habitat. Much of that CRP is now a monoculture of crested wheatgrass or smooth brome, of little value for sharp-tailed grouse. If it were all replanted to a diverse mix of native grasses and forbs, as required by the Sage-grouse and Sharp-tailed Grouse SAFE program in Douglas County, dramatic recovery of local populations would likely begin.*
	WDFW should adopt an attitude that keeps working lands working and maintains large blocks of private land. Habitat loss due to development and conversion out of ranching is permanent. Increased regulations and the fear of new regulations drive land out of ranching.
	WDFW supports working landscapes. Conversion due to development usually represents permanent loss of habitat. The Department works with interested landowners to restore habitat, mark fences, and facilitate enrollment in Farm Bill programs, etc., to encourage habitat improvement. These activities are identified in the plan.
	We are disappointed that the Sharp-Tailed Grouse recovery Plan did not fully incorporate the **4P's** of wildlife and habitat management: People, Place, Predator and Prey. This document does not focus on the entire picture in regards to cause and effect in regards to the species recovery. This document highlights the problems and failures of protected single-species management. A prime example of this is the impacts that

Section	Comment and response
	protected avian predators have on Sharp-Tailed Grouse and the inability to manage these impacts. A single species management approach is not sustainable for the target species or any others in the ecosystem. Successful management plans must include the **4P's**.
	All of these factors are important and are discussed in the plan, including past and present land use history, the increasing problem of rural development, the problems associated with subsidized predators, and the potential for use of limited predator control during reintroductions.
	I was disappointed that there is nothing offered in the plan to protect Tunk Valley and its resident sharptail grouse. The plan states that there can be no recovery without the "cooperation" of private landowners, since the majority of the habitat is on private land. If this recovery plan depends on the voluntary cooperation of private landowners then perhaps the authors have in fact, written off Tunk Valley. The goodwill of private landowners cannot save the sharptails. People are not going to voluntarily keep their land in open space or refrain from building roads or fences or having cats and dogs and so on. If indeed land in private ownership is critical to saving sharptail grouse, then the focus should be on leveraging the State requirements and regulating land use, rather than depending on the education and voluntary cooperation by landowners.
	The plan notes that recovering sharp-tailed grouse in Washington will require partnerships among many entities. WDFW hopes to succeed with a combination of county protections, acquiring key pieces of habitat when possible, and working cooperatively with landowners to maintain and improve habitat.
	Okanogan County is trying to obstruct conservation easements and acquisitions. This seems unconstitutional. Okanogan can't tell landowners who they can and cannot sell their land to.
	Comment noted, but outside the scope of the plan.
	It would be nice to read in the Recovery Plan, specific plans to bring genetic diversity to the population in Tunk Valley. Preferably very soon.
	It isn't certain that genetics immediately affect the Tunk Valley population because there may be some exchange with other populations. Translocation of small numbers of birds may not affect their genetic health, and moving and monitoring large numbers is an expensive project. An increase in the Tunk population in recent years suggests that genetic (i.e. inbreeding depression) is not an immediate concern. For this area, habitat protection and improvement are currently higher priorities.

WASHINGTON STATE STATUS REPORTS AND RECOVERY PLANS

Status Reports

2007	Bald Eagle	√
2005	Mazama Pocket Gopher, Streaked Horned Lark, Taylor's Checkerspot	√
2005	Aleutian Canada Goose	√
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

2011	Columbian Sharp-tailed Grouse	√
2007	Western Gray Squirrel	√
2004	Greater Sage-Grouse	√
2003	Pygmy Rabbit: Addendum	√
2002	Sandhill Crane	√
2004	Sea Otter	√
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 the Department of Fish and Wildlife's web site: http://wdfw.wa.gov/wlm/diversty/soc/concern.htm.

To request a printed copy of reports, send an e-mail to wildthing@dfw.wa.gov or call 360-902-2515