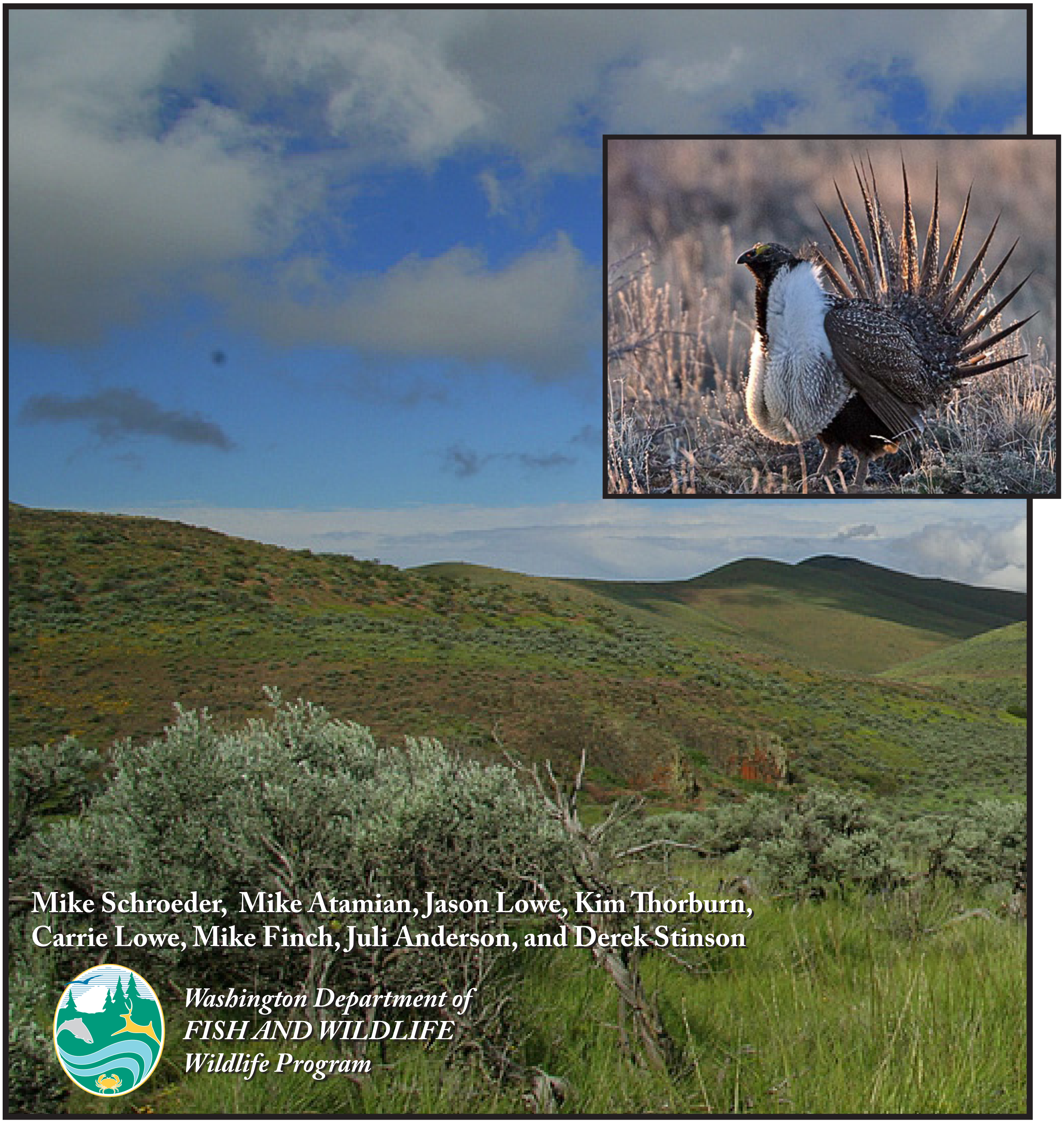
STATE OF WASHINGTON Progress Report December 2015

Restoration of Greater Sage-grouse in Washington: Progress Report



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ABSTRACT

Declining populations and distribution of greater sage-grouse (*Centrocercus urophasianus*) in Washington have resulted in serious concerns for their long-term conservation status. The overall population was estimated to be 1004 in 2015, associated with 27 leks. The Washington Department of Fish and Wildlife, in cooperation with the U.S. Bureau of Land Management, initiated a project in 2008 to reintroduce greater sage-grouse to the Swanson Lakes Wildlife Area in Lincoln County, Washington. The project was designed to reestablish a population in the state in an area with more than 200 km^2 of shrubsteppe habitat on public lands. Prior to the first translocation in 2008 there were rare observations of sage-grouse in the release area. It was not clear whether these observations were birds dispersing from the closest population in Douglas County or whether these birds were ‘remnants’ from an endemic population known to occupy the area through the mid-1980s. From spring 2008 to spring 2015, 280 greater sage-grouse were translocated from southern Oregon to the Washington release site and their movements, productivity, habitat use, and survival have been monitored. In 2010 three males were observed strutting for two hens post release. In 2011 a couple hundred meters to the north of the 2010 strutting site a lek formed with 7 males observed pre-release. Since 2010 the lek has remained active and steadily grown. In 2015, 15 males were observed on the lek, pre-release. Though the lek appears to be firmly established, the overall population is still below minimum viability. We propose closely monitoring the population for at least two springs without additional translocations to examine how the population will respond.

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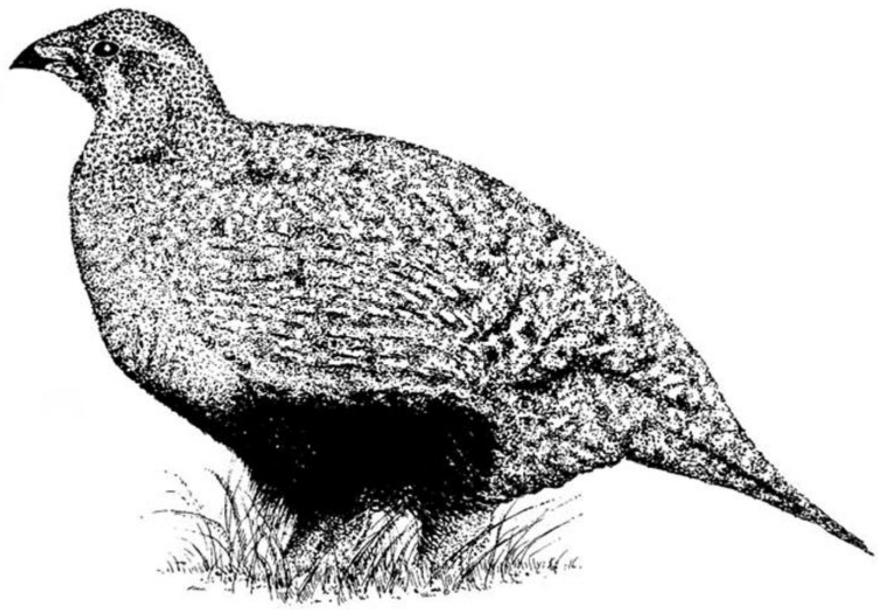
On the cover: Background photo by Mark Teske; Male Sage-grouse on a lek in Oregon by Joe Higbee. Title page and back cover illustration by Darrell Pruett.

RESTORATION OF GREATER SAGE-GROUSE IN WASHINGTON: PROGRESS REPORT



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BACKGROUND

Greater sage-grouse have declined dramatically in both distribution and population size in Washington. Of 71 lek complexes documented since 1960, 62% are currently vacant. Many of these vacant lek complexes (45%) are in areas where sage-grouse have been absent since the 1960s. The current range for endemic sage-grouse is about 8% of the historic range, occurring in 2 relatively isolated areas; one primarily on the Yakima Training Center (YTC) in southern Washington and the other centered in the Moses Coulee area of Douglas County in northern Washington (Schroeder et al. 2000, Fig. 1). These observed declines in populations and distribution in Washington (Fig. 2) were consistent with the observations of rapid loss of genetic heterogeneity in northern Washington (Oyler-McCance et al. 2005). Based on changes in number of males counted on lek complexes, 27 of which were active in 2015, the sage-grouse population size in Washington declined about 75% from 1970 to 2015. The 2015 spring population was estimated to be about 247 in the Yakima Training Center (YTC, U.S. Department of Defense) population and 666 in the Moses Coulee population. Because additional sage-grouse are now in the Crab Creek area (centered near the Swanson Lakes Wildlife Area, ~62 birds) and the Yakama Nation (~29 birds), the total population in Washington is estimated to be 1004.

Long-term declines in distribution and abundance of greater sage-grouse in Washington are the primary reasons why the Washington Department of Fish and Wildlife (WDFW) listed sage-grouse as ‘threatened’ within the state (Hays et al. 1998). These population declines (Schroeder et al. 2000, Connelly et al. 2004, Garton 2011) and their isolated nature were also considered by the U.S. Fish and Wildlife Service to determine that greater sage-grouse in Washington and northern Oregon represented a distinct population segment and that the population warranted a federal listing as ‘threatened’, though listing was precluded by higher listing priorities (U.S. Fish and Wildlife Service 2001). The “warranted” and “distinct population segment” decisions were both reversed in 2015 (U.S. Fish and Wildlife Service).

Historic and recent declines of greater sage-grouse in Washington are linked to conversion of native habitat for production of crops and degradation and isolation of the remaining native habitat (WDFW 1995, Hays et al. 1998, Stinson et al. 2004, Shirk et al. 2015). In the Moses Coulee population centered in Douglas County (Fig. 1), sage-grouse occupy a 3,500 km^2 mosaic of mostly private lands used for dryland farming (mostly wheat), lands enrolled in the federal Conservation Reserve Program (CRP), or lands with high-quality shrubsteppe (Table 1, Schroeder and Vander Haegen 2011). In contrast, the YTC population in Yakima and Kittitas counties occupies about 1,200 km^2, which is one of the largest, high-quality shrubsteppe sites remaining in the state. Good habitat quality on the YTC is largely due to its complex topography, isolated nature, and history of low intensity livestock grazing. Grazing by livestock was completely eliminated in 1995. Military training and fires pose the greatest threat to habitat security. Cross-country maneuvers with military vehicles decrease habitat quality through sagebrush mortality (Cadwell et al. 1996, Stephan et al. 1996) and disturbance to understory communities (Cadwell et al. 2001). Training activities also ignite wildfires that pose a significant threat to the existing habitat.

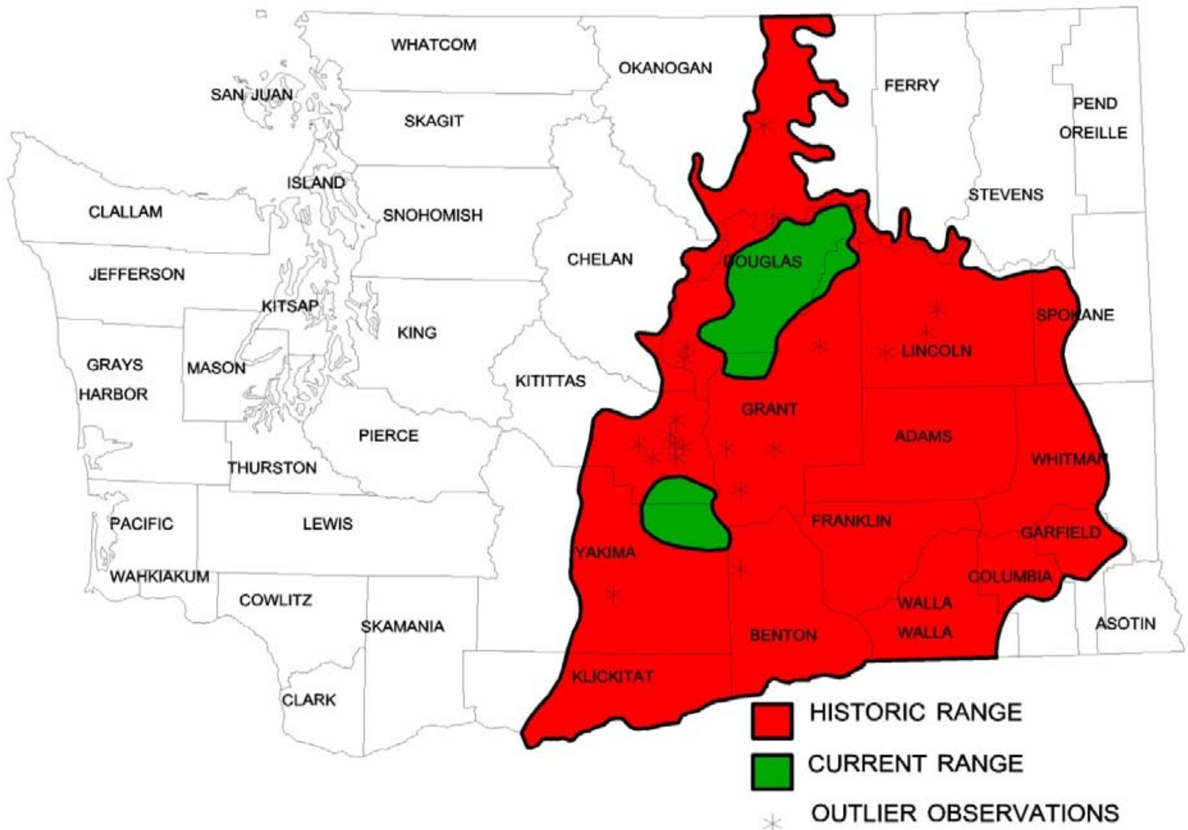

Fig. 1. Estimated historic and current range of greater sage-grouse in Washington prior to translocation efforts (Schroeder et al. 2000).

Isolation poses a significant threat to the viability of remaining populations (Stinson et al. 2004, Shirk et al. 2015). Westemeier et al. (1998) described the reduction in genetic diversity and in population fitness over a 35-year period in a small, declining greater prairie chicken (*Tympanuchus cupido*) population in Illinois. They reported that declines in fertility and egg hatchability correlated with a population decline from 2000 individuals in 1962 to less than 50 by 1994. Bouzat et al. (1998) genetically compared the same population with larger populations in Kansas, Nebraska, and Minnesota and found that it had approximately 2/3 the allelic diversity of the other populations. Bellinger et al. (2003) found a similar reduction in genetic variation, though not in reproductive success, in greater prairie chickens in Wisconsin. Their comparison of samples collected in 1951 with those collected from 1996 through 1999 revealed a 29% allelic loss.

Genetic work by Benedict et al. (2003) and Oyler-McCance et al. (2005) indicated that the two Washington sage-grouse populations might have experienced similar loss of genetic diversity. They based their conclusions on diversity and divergence of mitochondrial and molecular DNA. Samples were collected from more than 1000 greater sage-grouse from 45 populations throughout the range. The YTC population had only 1 of 38 mitochondrial haplotypes and the Moses Coulee population had 3 of 38 haplotypes present (Benedict et al. 2003). This is in comparison to an average of 6.4 haplotypes across 16 populations with sufficient samples to study. Microsatellite variation in Washington illustrated similar trends suggesting a need for immediate conservation action (Oyler-McCance et al. 2005).

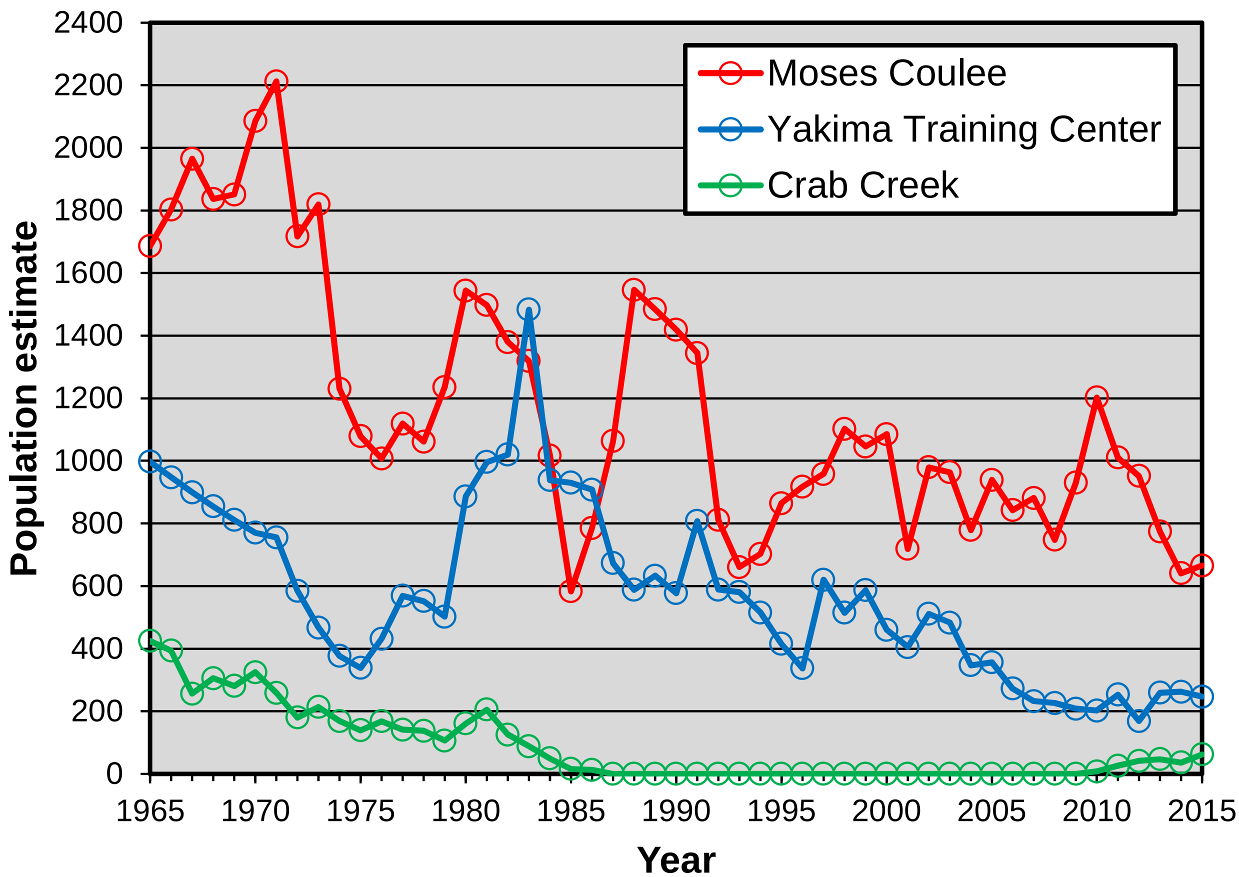

Fig. 2. Estimates of population size for greater sage-grouse within Washington, 1965-2015.

Table 1. Potential habitat quantity in relation to current and historic distribution of greater sage-grouse in Washington (adapted from Table 1 in Schroeder et al. 2000; population names from Fig. 2).

Range or population	Proportion of area (%)				Total area (km^2)
	Shrubsteppe[a]	Cropland[a]	CRP[b]	Other[b]	
Moses Coulee/Mansfield Plateau	44.3	35.1	16.7	3.9	3,529
Yakima Training Center	95.6	0.5	1.9	1.9	1,154
Crab Creek	52.0	36.0	11.0	1.0	3,276
Total occupied range[c]	57.0	26.6	13.0	3.4	4,683
Unoccupied range	42.3	42.8	5.5	9.4	53,058
Total historical range	43.5	41.5	6.1	8.9	57,741

[a]Landsat Thematic Mapper, 1993.

[b]Determined from aerial photos dated 1996.

[c]The total occupied range does not include the Crab Creek area.

CURRENT MANAGEMENT AND RECOVERY EFFORTS

A greater sage-grouse recovery plan was published in 2004 for Washington, which stated as its primary goal "to establish a viable population of sage-grouse in a substantial portion of the species' historic range in Washington" (Stinson et al. 2004). The recovery plan also listed the following strategies, all of which have been applied and/or attempted in at least a portion of the greater sage-grouse range in Washington (Stinson et al. 2004:57).

1) Inventory and monitor the greater sage-grouse populations in Washington.
2) Protect sage-grouse populations.
3) Enhance existing populations and re-establish additional populations.
4) Protect sage-grouse habitat on public lands.
5) Work with landowners to protect the most important sage-grouse habitat on private land.
6) Facilitate and promote the use of incentives, such as Farm Bill conservation programs, to benefit sage-grouse.
7) Facilitate management of agricultural and rangelands that are compatible with the conservation of sage-grouse.
8) Restore degraded and burned sage-grouse habitat within sage-grouse management units.
9) Conduct research necessary to conserve sage-grouse populations.
10) Cooperate and coordinate with other agencies and landowners in the conservation, protection, and restoration of sage-grouse in Washington.
11) Develop public information materials and educational programs for landowners, schools, community organizations, and conservation groups as needed.

In order to implement these strategies and achieve these goals, the recovery plan established numerous management units (Fig. 3) to aid in the identification and implementation of management and recovery actions (Stinson et al. 2004). The northern population (Moses Coulee population) is located primarily in the Mansfield Plateau and Moses Coulee management units while the southern population is primarily in the Yakima Training Center Management Unit. Greater sage-grouse have also been observed in all other management units, and in some cases outside established management units (e.g. a male was photographed near Haley Creek, east of Omak on 30 January 2004). The management units were not designed to limit management and recovery activities, but to focus activities.

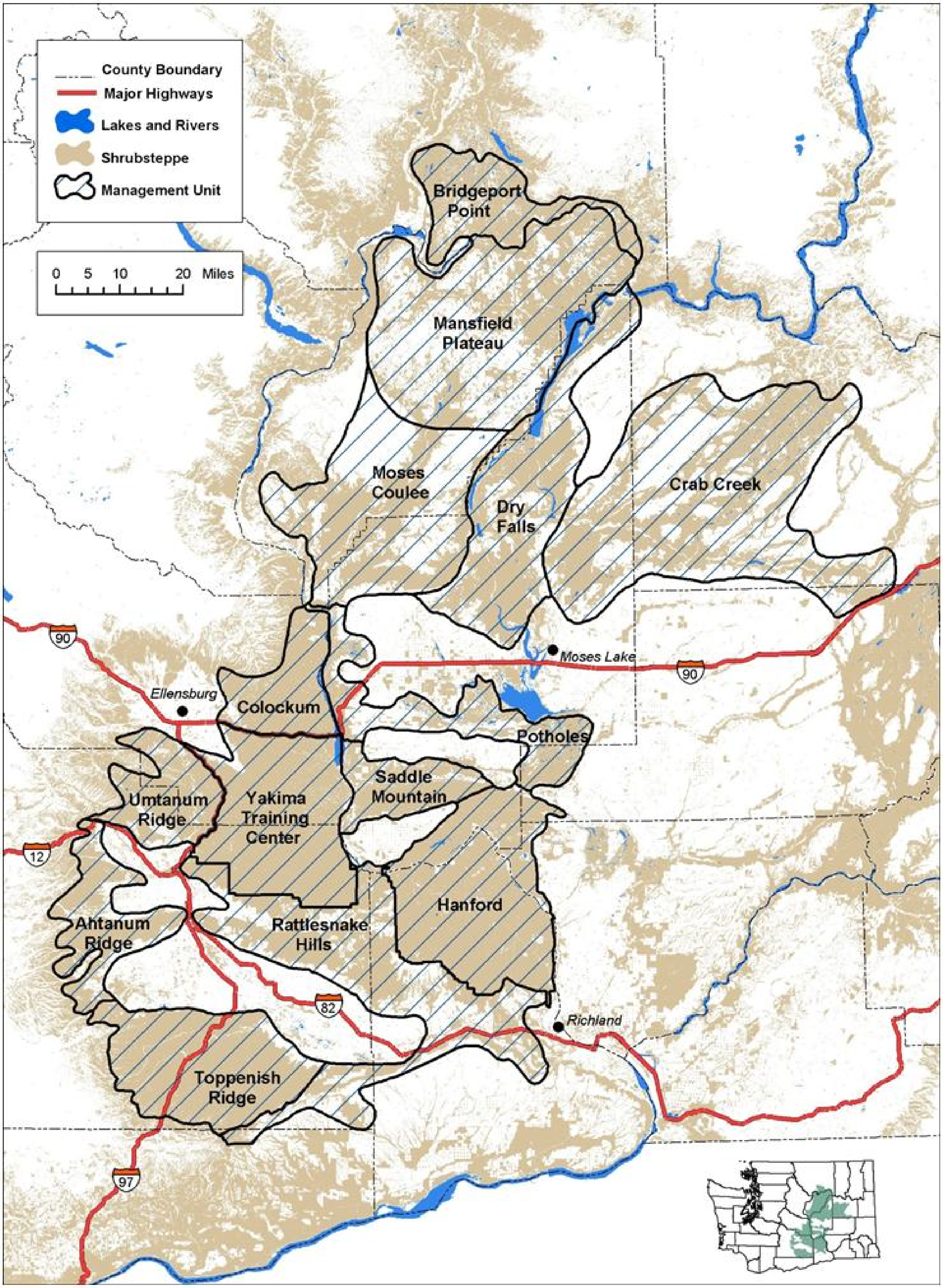

Fig. 3. Greater sage-grouse management units in relation to shrubsteppe cover types in Washington.

Enhancement of existing populations was identified as a high priority in the greater sage-grouse Recovery Plan (Stinson et al. 2004, Stinson and Schroeder 2014). Because the majority of the Moses Coulee population occupies private land, most management efforts have focused on programs designed to encourage management practices that benefit sage-grouse. Chief among these are federal conservation programs such as the Conservation Reserve Program (CRP) and State Acres for Wildlife Enhancement (SAFE) which support nesting sage-grouse (Schroeder and Vander Haegen 2011).

Within the Yakima Training Center population, the U.S. Army restricts training in many core sage-grouse areas (approximately 18,000 ha) and implements aggressive fire prevention and fighting techniques (YTC 2002). In order to restore areas impacted by military maneuvers and wildfires, the Army seeds bunchgrasses and forbs and plants tens of thousands of bare root seedlings of Wyoming big sagebrush on hundreds of hectares each year (YTC 2002). Firing range observation towers also have been removed in key sage-grouse areas to reduce the number of perches and nesting platforms for raptors and common ravens (*Corvus corax*). In addition to the management responses to military activities, the YTC also discontinued grazing by livestock in 1995 (Stinson et al. 2004).

A population augmentation effort was initiated in 2004 to address genetic issues associated with the YTC population (e.g., lack of heterogeneity and small population size). In addition, by translocating birds from 'healthy' populations, a basic hypothesis can be tested. Specifically, is habitat limiting the growth and/or expansion of the YTC population or is the problem related to the intrinsic 'health' of the birds? An increasing population trend following augmentation would support the hypothesis that a population 'health' problem existed. If the population size remains the same or continues to decline, and monitoring indicates that the translocated birds remained in the area and survived to attempt reproduction, data will support the conclusion that habitat quality and/or quantity is limiting population growth.

In March 2004, 25 female sage-grouse were captured with the aid of night-lights (Wakkinen et al. 1992) in Elko and Humboldt Counties, Nevada, and translocated to the YTC. In March 2005, 18 female and 5 male addition sage-grouse were translocated from the Hart Mountain National Antelope Refuge in Lake County, Oregon (Hart Mountain). In August 2006, 14 females and 2 males were translocated from Hart Mountain. Ten females were translocated from southern Idaho to the YTC in March 2014 and another 8 were translocated in March 2015. All of these translocations (total of 75 females and 8 males) were designed to augment the existing population. In addition, 12 female and 19 male sage-grouse were captured at Hart Mountain in March 2006 and released on the Yakama Nation adjacent to the southern Washington population in an effort to re-introduce birds to a portion of their historic range. An additional 5 males were translocated from the Wind River Indian Reservation in April 2006, 4 females and 5 males were translocated from Hart Mountain in August 2006, 4 females and 11 males were translocated from Hart Mountain in March-April 2007, 11 females and 19 males were translocated from Nevada in March-April 2013, and 12 females and 26 males were translocated from Nevada in March-April 2014 (total of 43 females and 85 males).

Although successful breeding has been documented for the 211 translocated sage-grouse in southern Washington, the results are preliminary and additional work is currently underway to evaluate movement, survival, and productivity of the released birds as well as a possible population-level response to the overall translocation effort. A rebound in the YTC population has not been observed to date; the reasons may relate to a reported rangewide population low, or habitat issues. In recent years, habitat on the YTC has been affected by an increase in Army training and also by an associated increase in wildfires. Although genetic samples have been analyzed to determine if the augmentation was successful at introducing new genetic material to the population, these results have not been conclusive. A similar project involving translocation of 63 sharp-tailed grouse (*Tympanuchus phasianellus*) onto the Scotch Creek Wildlife Area in north-central Washington revealed that even a positive response might be delayed a few years following a translocation effort (Fig. 4). The reason for this delay is that a portion of the translocated individuals die before they are able to breed, a portion are not able to either breed and/or nest successfully, and a portion of the young produced do not survive to successfully reproduce. Consequently, it is essential that translocation efforts be supported with multi-year commitments by the agencies and individuals involved.

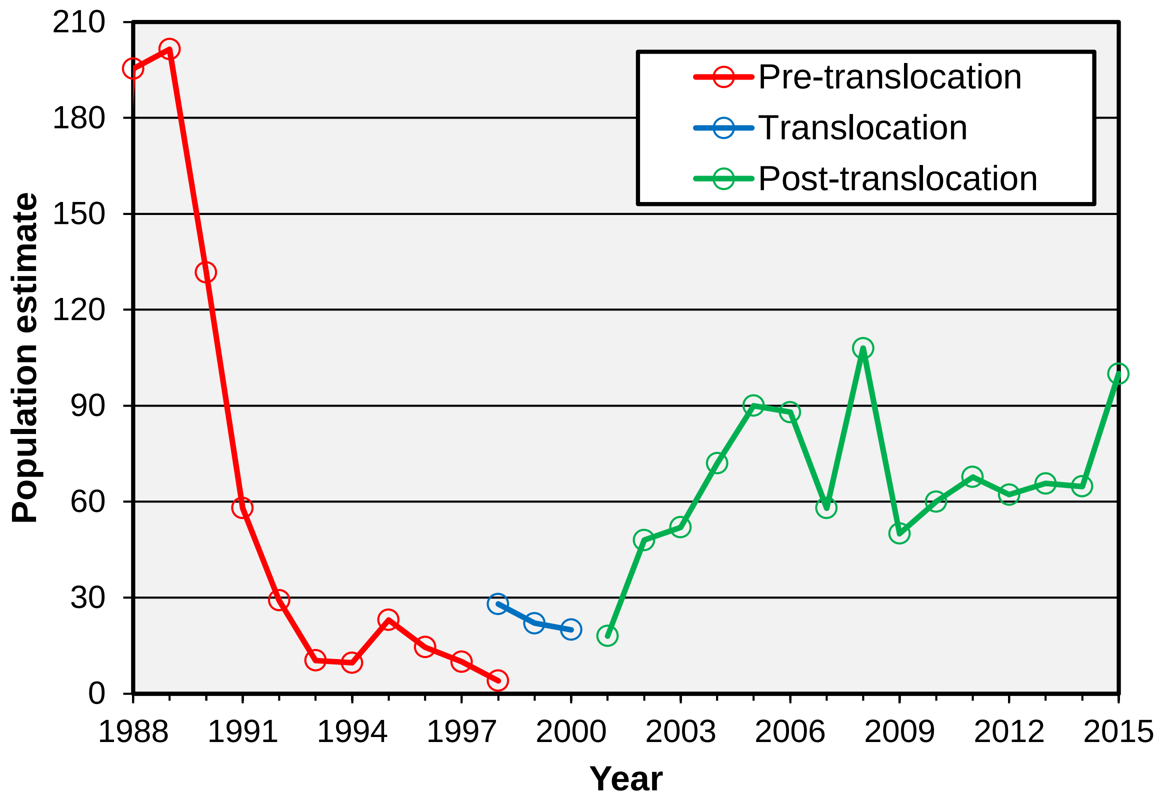

Fig. 4. Estimated population of sharp-tailed grouse on the Scotch Creek Wildlife Area in Washington before and after translocation of 63 sharp-tailed grouse in 1998, 1999, and 2000.

LINCOLN COUNTY TRANSLOCATION PROJECT

Translocations of greater sage-grouse should include four basic stages in order to maximize the opportunities for successful re-establishment or augmentation efforts (similar to Griffith et al. 1989). The first stage is to identify potential release sites based on quantity and quality of habitat on, and near, the sites. In addition, the historic presence and current status of greater sage-grouse near the release sites needs to be established. The second stage is to identify source populations for translocation to the proposed release sites. This should include a genetic analysis. The third stage is to conduct the translocation as efficiently as possible in a way that minimizes the length of captivity and maximizes survival and productivity. The fourth stage is to monitor and evaluate the success or failure of the re-establishment or augmentation effort and to determine future management goals and efforts. This fourth stage is particularly important so that all translocation efforts, even those that are unsuccessful, will provide valuable information for future efforts. The translocation effort was designed to adhere to recommendations outlined by Reese and Connelly (1997).

Stage 1: Release Sites

Because of declines in greater sage-grouse throughout Washington (overall population estimate of 902 in 2014) and the isolation and small size of remaining populations, there are four different locations that were considered for translocation efforts. Two priority areas include the YTC population (population estimated to be 247 in 2015), which was initially augmented in 2004, and the Yakama Nation, which was initially reintroduced in 2006 (see earlier background discussion). A third priority area is the northern population of greater sage-grouse centered in Douglas County (population estimated to be 666 in 2015). Although this area is still being considered for a translocation, it is likely that any effort will be delayed until additional genetic information can be obtained and analyzed. The reason for caution is that sage-grouse in Douglas County have been documented to have at least one unique haplotype (Benedict et al. 2003) and the importance of this characteristic has yet to be assessed. Furthermore, reproductive data collected for radio-marked birds in north-central Washington have shown that they have the largest average clutch size and the highest rate of nesting and renesting of any studied population in North America (Schroeder 1997). When these factors are considered, along with population data showing that the population is relatively stable over the long term (Fig. 2), the need to augment the population is not believed to be critical at this time.

The fourth priority area for translocations is the Crab Creek Management Unit, primarily in Lincoln County (Fig. 3). The historic presence of sage-grouse in the Crab Creek area has been well-established (Yocum 1956), as well as their extirpation (Fig. 2, Schroeder et al. 2000). Five leks were documented in the Crab Creek area for the 1954-1986 period; they were last known to be active in 1954 (Cormana Lake), 1978 (Marlin and Odessa), 1984 (Cannawai Creek), and 1986 (Creston Butte). The breeding population appears to have been extirpated in the area prior to the recent translocation.

Why was the population of greater sage-grouse eliminated in the Crab Creek Management Unit? Has subsequent management on the prospective release site adequately addressed the explanations for previous declines in numbers of sage-grouse? There are numerous possible reasons for the sage-grouse population decline and extirpation. These include historic declines in habitat quantity and quality, changes in densities of predators such as coyotes and common ravens, and isolation of remnant populations due to the lack of dispersal corridors between adjacent populations. Some of the explanations for the declines in sage-grouse have been directly addressed with management activities (Stinson and Schroeder 2014). These restoration activities include habitat restoration, removal and marking of fences, treatment of invasive species, and habitat acquisition.

The WDFW purchased 8,094 ha in Lincoln County in the early 1990s, which became the Swanson Lakes Wildlife Area (Fig. 5). An additional 518 ha of land owned by the Washington Department of Natural Resources was leased. Because the acquisition was funded by the Bonneville Power Administration to compensate for habitat lost during the construction and operation of hydroelectric projects in the Columbia Basin (Northwest Power Planning Council 2000), WDFW is actively managing habitat at Swanson Lakes for the benefit of prairie grouse (including both sharp-tailed grouse and greater sage-grouse). The BLM has acquired land adjacent to and near the Swanson Lakes Wildlife Area. The Lakeview Ranch is a 5,135 ha parcel located approximately 10 km north of the town of Odessa in southwest Lincoln County. Twin Lakes is a 6,201 ha parcel located approximately 25 km southwest of Davenport in central Lincoln County. Coffeepot Lake is a 377 ha parcel located 17 km west of Harrington in Lincoln County. Management of the BLM areas has focused on supporting wildlife habitat, seasonal livestock grazing, and wildlife-based recreational opportunities. The BLM also is considering prairie grouse in their management plans and is involved in the national strategy to "develop the partnerships needed to design and implement actions to support robust populations of sage-grouse and the landscapes and habitats upon which they depend" (Stiver et al. 2007).

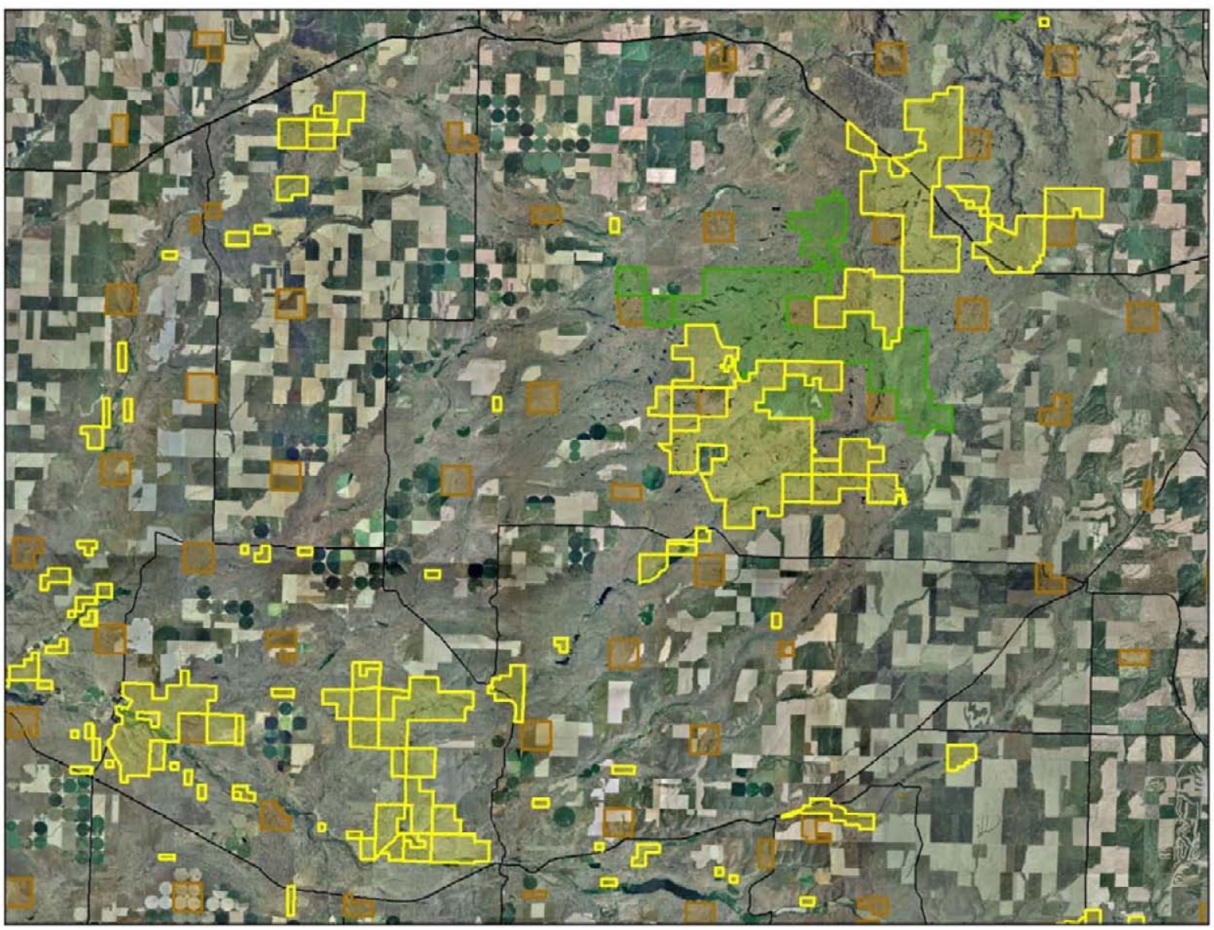

Fig. 5. Major public lands and landcover of the greater sage-grouse reintroduction area in the Crab Creek Sage-grouse Management Unit, Washington. BLM lands are outlined with yellow, WDFW lands with green, and WDNR lands with brown.

There is a greater proportion of shrubsteppe in the Crab Creek area (Table 2) than there is within the perimeter of the Moses Coulee population of greater sage-grouse in Douglas County (Table 1). When the revised patterns of land ownership are considered (following acquisition by the WDFW and BLM), along with the relatively large blocks of suitable and/or improving habitats (Fig. 5), it is clear that the management potential for sage-grouse in the Crab Creek Management Unit has improved dramatically since the birds were extirpated in the mid-1980s.

Table 2. Estimated landcover in relation to land ownership within the Crab Creek Sage-grouse Management Unit.

Ownership	**Proportion of area dominated by each habitat (%)**				**Total area (km^2)**
	Shrubsteppe	**Cropland**	**CRP**	**Other**	
WDFW - Swanson Lakes	81	10	6	3	77.19
DNR	76	21	2	1	141.74
BLM	92	05	1	2	204.04
Other government land	91	07	0	1	23.27
Private land	47	40	12	1	2,829.79
Total for management unit	52	36	11	1	3,276.04

Stage 2: Source Populations

To maximize the likelihood of a successful translocation, the source population should be relatively close, abundant, and occupy similar habitat (IUCN 1995). Since the only close populations (north-central and south-central Washington) are also experiencing declines, birds are being obtained from other states. All states have had long-term population declines; however, some states have experienced more dramatic declines than others including Washington, California, Utah, Colorado, North Dakota, and South Dakota, and the Canadian Provinces of Alberta and Saskatchewan (Connelly and Braun 1997, Connelly et al. 2004, Garton et al. 2011). States with populations considered to be relatively secure include Oregon, Nevada, Idaho, Montana, and Wyoming.

Although greater sage-grouse have been differentiated into two subspecies, *C. u. urophasianus* and *C. u. phaios* (Aldrich 1946), recent genetic analysis by Benedict et al. (2003) and Oyler-McCance et al (2005) do not support this subspecies distinction. Nevertheless, given the published reference to a western and eastern subspecies of sage-grouse, there still should be an effort to avoid translocating ‘eastern’ sage-grouse (eastern Idaho, Montana, Wyoming) to Washington unless absolutely necessary. Rangewide genetic data have indicated that although several greater sage-grouse populations might be suitable for translocation to Washington (Benedict et al. 2003), there is still enough variation between populations to warrant close scrutiny (Oyler-McCance 2005). For example, an examination of 45 populations through the range of greater sage-grouse showed that Washington sage-grouse were relatively homogenous with regard to genetic material and somewhat different from adjacent populations (Fig. 6, 7). Their analysis also showed that distance between populations was the largest factor explaining variation between most populations.

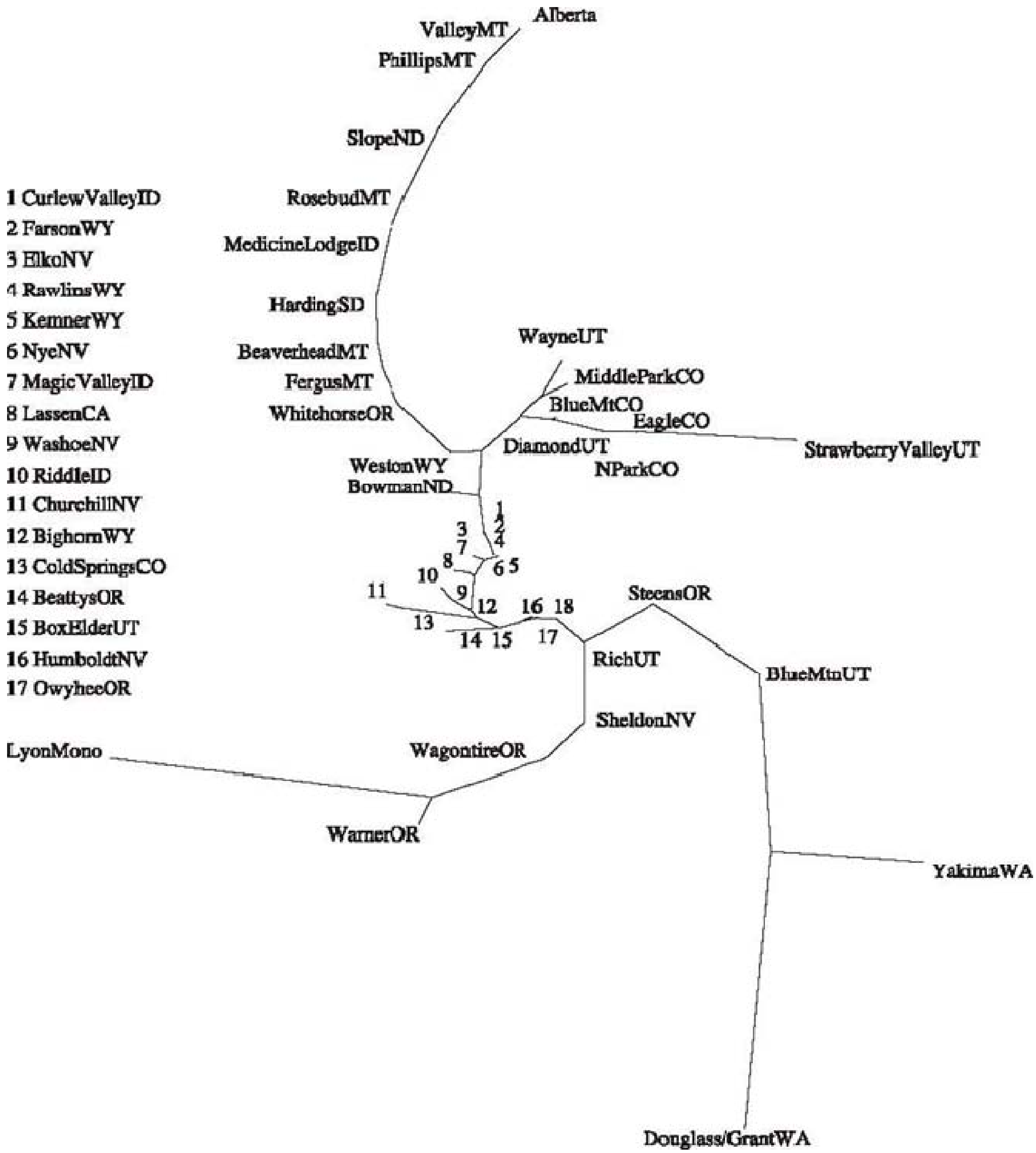

Fig. 6. Neighbor-joining tree constructed using the genetic distances for 45 populations of the greater sage-grouse (longer lines represent a greater genetic distance). Population names correspond with the map shown in Fig. 7 (Oyler-McCance et al. 2005).

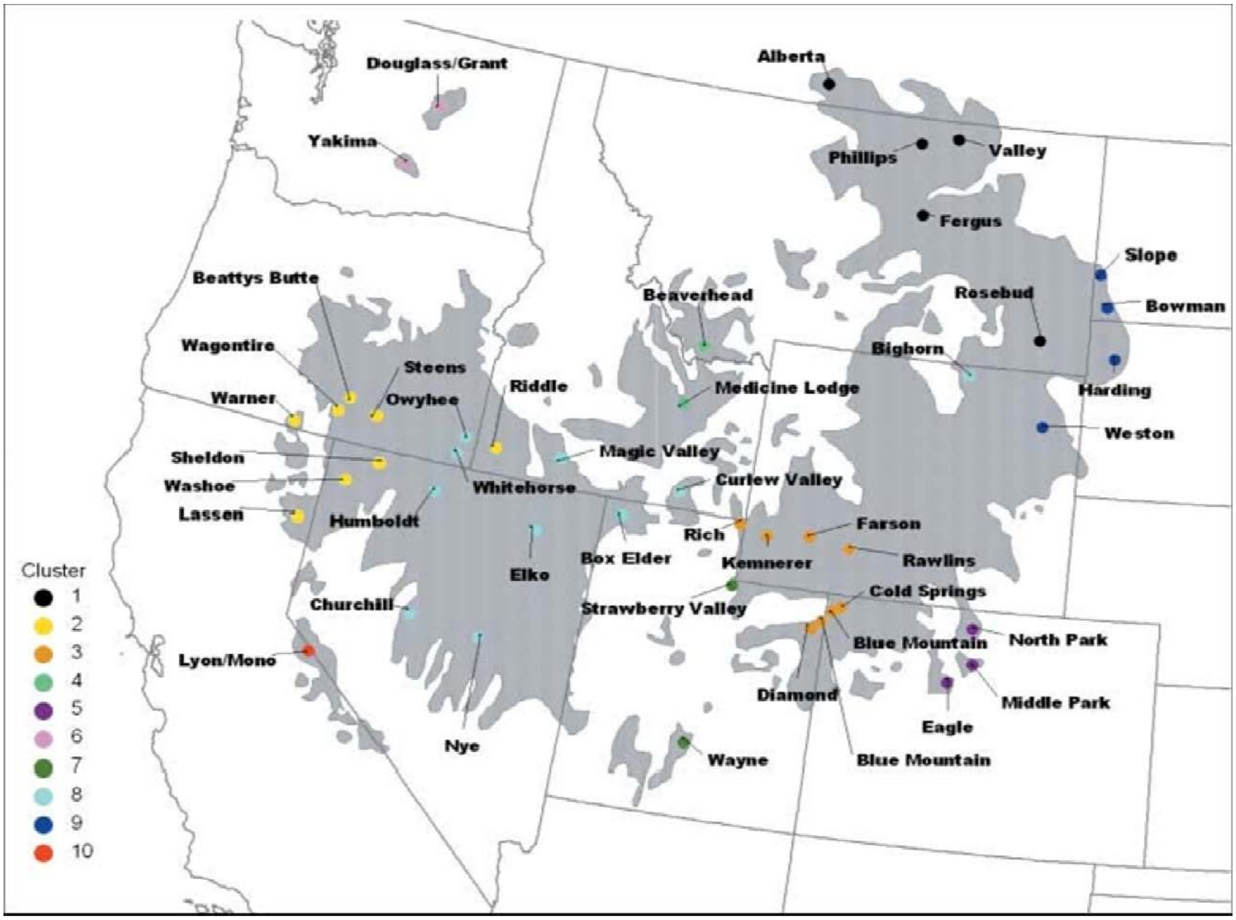

Fig. 7. Map of 45 sampling sites for a microsatellite analysis of greater sage-grouse. The populations are color coded by the cluster to which each population was assigned (Oyler-McCance et al. 2005).

Despite the slight differences between Washington sage-grouse and those found elsewhere, Oyler-McCance et al. (2005) recommended augmentation of Washington populations from the geographically closest populations (in this case southern Oregon and northern Nevada. Their recommendation for augmentation was based on a clear conservation concern supported by the lack of genetic heterogeneity in Washington. With these factors in mind, it was hoped that birds could be obtained from previously used sources in northern Nevada and southern Oregon.

Stage 3: Capture and Translocation

Sage-grouse are generally captured during the spring breeding period (late March/early April) or in late summer or early autumn (e.g., October), but only when the situation proves favorable. Capture with the aid of night lighting (Giesen et al. 1982, Wakkinen et al. 1992) has proven to be very successful when birds are attending leks and spring releases have been determined to be more successful than other periods (Reese and Connelly 1997).

All birds destined for translocation receive a health certificate from a veterinarian that is accredited within the donor state. The U.S. Department of Agriculture maintains a disease list for which all translocated birds are screened. West Nile Virus (WNV) has recently been documented in greater sage-grouse from Wyoming, Montana, Oregon, and Alberta, Canada. Because infected birds either die or clear WNV and develop antibodies within 10 days, all areas where populations have had an outbreak of WNV within 10 days of the translocation are eliminated from consideration (K. Mansfield, WDFW Veterinarian, pers. comm.). This is not a concern since the vector of WNV, mosquitoes, are not active in early spring.

Sex and age were determined for all captured birds (Beck et al. 1975, Braun and Schroeder 2015). Blood & feather samples were obtained for both disease testing and genetic analysis. All birds were banded with a unique numbered metal band; all hens and a subset of males received necklace-mounted, battery-powered radio transmitters (predicted duration of 24 months) prior to release. In 2014 all males received a Northstar GPS Platform Transmitter Terminal. Birds were transported by car in individual boxes that are small enough to contain the birds' movement. The bottom of each box was lined with a material to reduce contact between feces and the birds' feet. The birds were released within 36 hours of capture, as soon as possible. They were released at first light on the newly established lek with the aid of a special box that permits the simultaneous remote release of multiple birds following a quiet acclimation period of at least 15 minutes.

This project was initiated in 2008. The first translocation in 2008 had multiple purposes. First, it was hoped the translocated birds would 'search' for other sage-grouse and high quality habitats near the release site, and thus they would provide some additional certainty about the current lack of sage-grouse in the area. Second, the released birds would help identify areas of suitable seasonal habitat, which would therefore enable refinement of the release site in subsequent years. Third, the released males would have the opportunity to develop a small lek that could provide a focal point for subsequent releases. Fourth, the released birds would provide an opportunity to evaluate the monitoring protocols as well as the potential for highlighting risk factors for the area, which may have been overlooked.

During 2008-2015 280 sage-grouse were released on the Swanson Lakes Wildlife Area (Table 3). All grouse in 2008 were captured with the aid of night lights on the Hart Mountain National Antelope Refuge, Oregon and released in the middle of SLWA (Fig. 8). In 2009, grouse were captured north of Plush, Oregon. The release site was moved about 3 km to an area closer to where the previous radio-marked birds were spending most of their time and where a lek eventually formed (Fig. 8). In 2010 and 2011 grouse were captured in two locations in Oregon, north of McDermitt, NV and southwest of Vale, Oregon. In 2012, grouse were captured on Hart Mountain National Antelope Refuge and on Steens Mountain, Oregon. In 2013, grouse were captured north and west of Plush, Oregon. In 2014, grouse were captured north and west of Plush and around Beatys Butte, Oregon. In 2015 birds were captured north and west of Plush and south of Beatys Butte, Oregon.

Starting with the Autumn 2008 release, birds were placed in a settling box for about 15 minutes and the box opened remotely to allow the birds to exit calmly on their own, and minimize the chances of panic flushes that could ultimately result in longer movements away from the release area. Since the release site was moved to the proximity of the newly-formed lek, males have been observed walking out of the settling boxes and immediately joining other displaying males.

Table 3. Number of greater sage-grouse translocated from southern Oregon and northern Nevada to the Swanson Lakes Wildlife Area in Lincoln County, Washington, 2008-2015.

Sex and age category	Spring 2008	Autumn 2008	Spring 2009	Spring 2010	Spring 2011	Spring 2012	Spring 2013	Spring 2014	Spring 2015	Total
Males – total	10	7	15	23	20	20	10	20	20	145
Adult	7	0	12	18	15	20	8	16	13	109
Yearling/Juv	3	7	3	5	5	0	2	4	7	36
Females – total	7	17	13	15	17	18	10	18	20	135
Adult	6	6	7	4	11	10	6	10	9	69
Yearling/Juv	1	11	6	11	6	8	4	8	11	66
Total	17	24	28	38	37	38	20	38	40	280

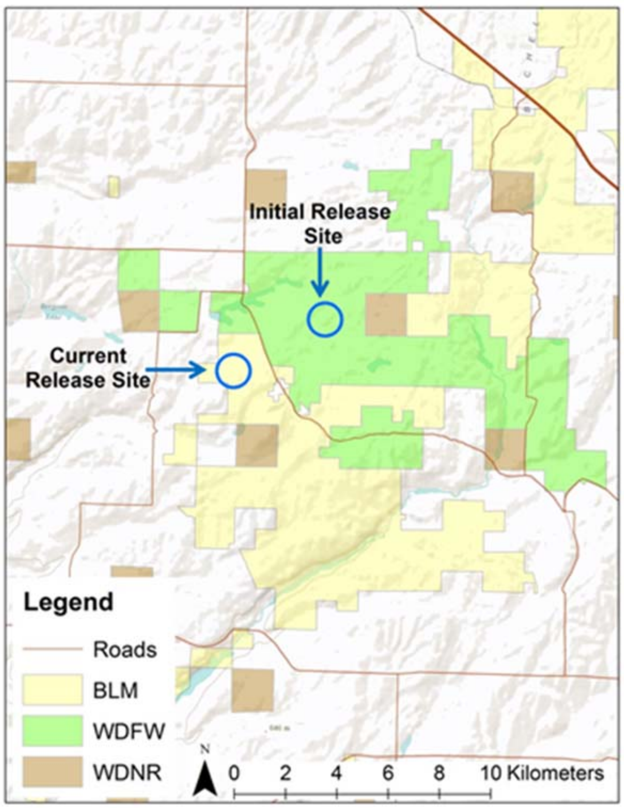

Fig. 8. Release sites for greater sage-grouse in Lincoln County, Washington. The initial location was selected because of habitat quality, lack of nearby fences, accessibility, and its location within a large patch of state (WDFW) and federal (BLM) land. The current site was selected because it was close to previously released grouse.

Stage 4: Monitoring and Evaluation

The success or failure of the re-establishment effort can be evaluated on and near the release site with the aid of VHS and GPS transmitters. Although establishment of the population over the long-term is the ultimate objective, success can also be addressed in the short-term following the release of radio-marked and GPS-marked birds. The specific objectives include examinations of movement, habitat and landscape use, productivity, survival, and population size. These evaluations provide essential information to determine whether additional translocations, habitat improvements, release locations, and/or translocation methodologies are necessary (Toepfer et al. 1990, IUCN 1995, Connelly and Reese 1997). Because these data are currently being collected, the following analysis is brief and incomplete. Nevertheless, it provides some indication of the progress.

Movement

Radio-marked sage-grouse are located with the aid of portable receivers and 3-element Yagi antennas. Birds are located daily either visually or with triangulation during the first two weeks following release and at least once each week during the breeding and brood rearing season and twice a month during the fall and winter. For triangulation, three or more azimuths are obtained < 1.5 km of target transmitters and at angles-of-incidence greater than 35° and less than 145°. All locations are recorded with a GPS unit using Universal Transverse Mercator coordinates (nearest 10-m interval). All attempts are made to avoid disturbance of birds, particularly at nest sites. Fixed-wing aircraft are used to locate lost birds on a regular basis throughout the year.

Between 2008 and 2015 6,807 locations were obtained for 221 radio-marked birds, 37 males were not radio marked, 2 radio-marked males died prior to release, and 20 males marked with GPS transmitters are not included (Fig. 9). An additional 17,118 locations have been obtained from the GPS transmitters in 2014 and 2015. These data are currently being analyzed by WSU graduate student and post-doctorate and are not included in summary statistics below. The maximum observed dispersal distance from the point of release was 85 km by a female released in the spring of 2011 and observed within the Douglas County population. The average of maximum observed dispersal from the release site for all animals released in Spring with 2 or more locations (216 birds) was 14.5 km (range 0.2 to 85 km) with no significant difference between the sexes or between years (Table 4), except for between males and female in 2012 (p-value 0.017). Average home range size (using minimum convex polygons) for all animals released in spring and with 3 or more locations (191 birds) was 84 km^2 (range 0.04 – 642 km^2) with no significant difference between the sexes or between years (Table 4). Birds released in Autumn showed shorter dispersals (10 ± 7km) and smaller ranges (27 ± 11 km^2), however all died very early biasing the results, and thus were censored from the above analysis.

Habitat use

Thirty nests for translocated greater sage-grouse were documented between 2008 and 2013. The primary protective cover was big sagebrush for 70%, gray rabbitbrush for 7%, big sagebrush and gray rabbitbrush for 3%, intermediate wheatgrass for 3%, and basin wildrye for 17%. The vast majority of observations (96%) for radio-marked grouse were in shrubsteppe habitat types. Twenty-three percent were in scabland, 5% were in shrubsteppe with dense (>25% cover) shrub, 25% were in shrubsteppe with moderate (5-25% cover) shrub, and 43% were in shrubsteppe with sparse (<5% cover) shrub. Most areas with sparse shrub cover used by sage grouse were CRP restored with native vegetation.

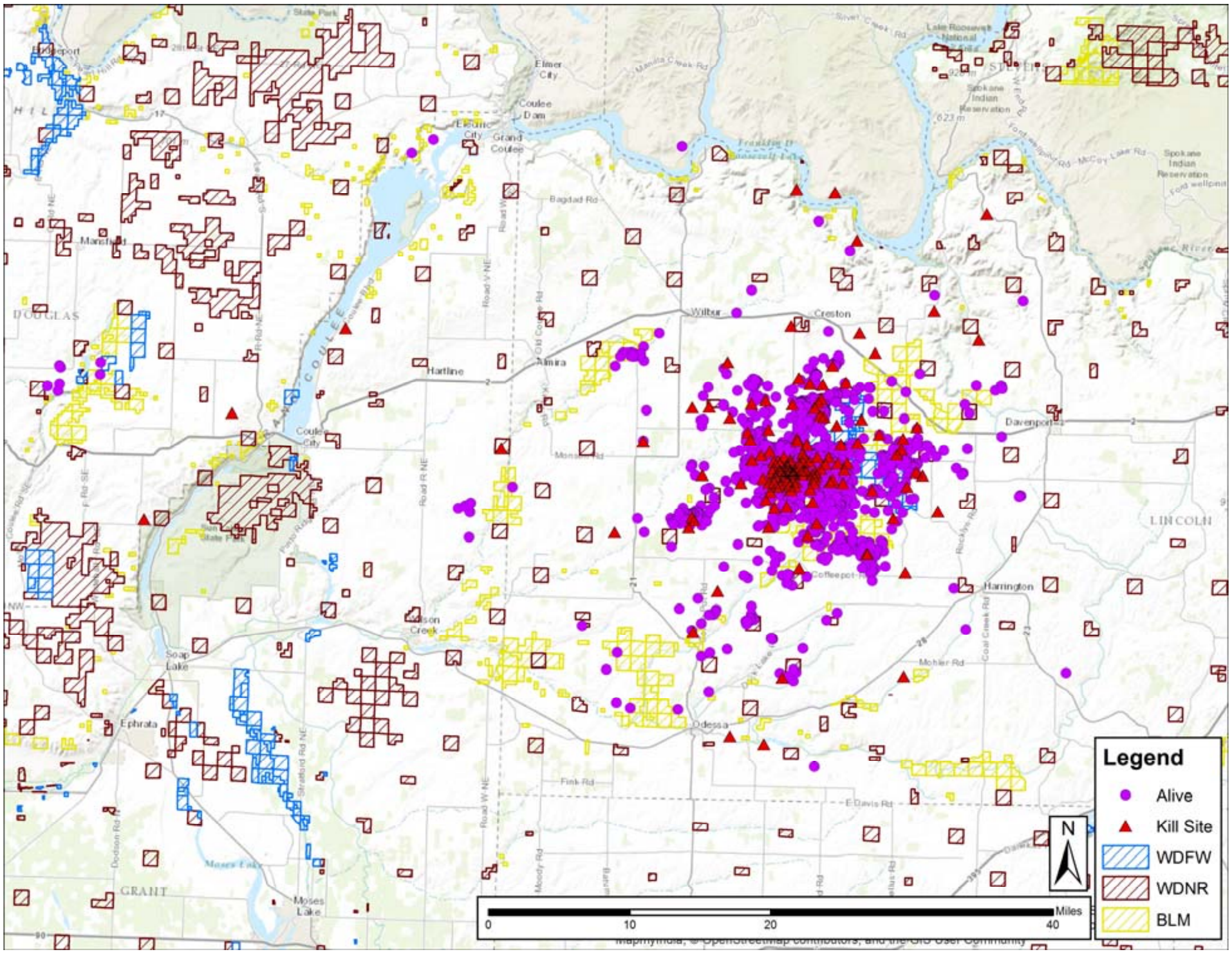

Fig. 9. All locations for sage grouse from initial release on March 31, 2008 through September 2015.

Table 4. Average maximum dispersal and average home range size (minimum convex polygon) for greater sage-grouse translocated from southern Oregon to the Swanson Lakes Wildlife Area in Lincoln County, Washington, 2008-2015. No males received VHF collars in 2013-2015 and the GPS marked males of 2014 were not included in the analysis.

Category	**Spring 2008**	**Spring 2009**	**Spring 2010**	**Spring 2011**	**Spring 2012**	**Spring 2013**	**Spring 2014**	**Spring 2015**	**Total**
Average maximum dispersal (km) ± Standard Error (n)									
Males	10±4 (9)	15±3 (15)	14±3 (20)	17±2 (19)	12±2 (15)				14±1 (78)
Females	14±6 (6)	13±2 (13)	12±2 (15)	19±5 (17)	25±5 (18)	10±2 (10)	13±2 (17)	9±2 (17)	15±1 (114)
Home range size (km^2) ± Standard Error (n)									
Males	27±17 (5)	115±47 (15)	128±37 (19)	102±19 (17)	81±27 (13)				103±16 (69)
Females	67±27 (4)	87±24 (13)	74±30 (15)	110±28 (16)	124±41 (15)	63±18 (9)	67±13 (16)	42±14 (15)	82±10 (103)

Productivity

Nest success is examined each breeding season (Schroeder 1997). Nests are considered successful if a minimum of 1 egg hatches. Specific evidence of possible predators is examined at unsuccessful nest sites. A hen was considered to have successful fledged her brood if at 45 days one chick is alive and present with the radio marked hen (assuming chicks can survive on their own after 45 days). If no chicks are detected on the first flush the hen is flushed again 2-3 days later.

Due to radio malfunction no nesting was observed in the 2008 release. In 2009 all 3 nesting attempts failed (Table 5), 2 were predated and 1 nest contained unfertilized eggs. Since 2009 the translocated population's annual apparent nest success has averaged 44% (range 23-62%), within the normal range for sage grouse. Percent fledged has been ≥ 50% each year also in the normal range for the species, with a minimum of 56 chicks fledged.

Table 5. Observed nest and brood success for greater sage-grouse translocated from southern Oregon to the Swanson Lakes Wildlife Area in Lincoln County, Washington, 2009-2015.

Category	2009	2010	2011	2012	2013	2014	2015	Totals
Nests Found	3	8	11	13	9	12	13	69
Nests Hatched		4	5	8	5	5	3	30
Broods fledged		2	3	4	4	3	3	19
Broods unknown success		1[a]		1[b]		1[b]		3

[a]Although the hen was found dead the day of the scheduled flush, it was observed with 4 chicks and another hen 7 days earlier.
[b]The radio transmitter died before the scheduled flush.

Of the 39 failed nests, 2 failed because none of the eggs was fertile (the researcher induced abandonment after a sufficient duration). An addition 2 nests failed when the hen was killed while off the nest (the nests were intact). The other 35 failed nests were attributed to predators; mammalian predators suspected in 18 cases, ravens in 4 cases, and the others unknown. A nest survival analysis assessing individual (e.g. hen age, years post release, etc.) and habitat effects (e.g. nest site vegetation, distance to roads, etc.) is being conducted by WSU. Preliminary results (2010-2014 data only) indicate bird age, nest age, and perennial grass height are significant parameters (beta estimates 95% CI did not overlap zero) effecting sage grouse nest success (Fig. 10; Adrian et. al. 2015). Using a 26 day incubation interval, mean nest survival was estimated at 63.8% (95% CI = 45.1, 77.1).

Survival

Monthly survival was estimated for radio-marked sage-grouse (2008-2012) using the Known Fate model in Program MARK 6.1 (White and Burnham 1999). A-prior models containing sex, age, release cohort, and season were assessed (Table 6). Seasons were modeled as follows Spring

(March-May), Summer (June-August), Fall (September-November), and Winter (December-February). The top model contained only an effect for spring of the first year post release (first Spring), with an estimated monthly survival of 0.92 ± 0.01 during the first Spring and 0.96 ± 0.01 for the remaining months. The first Spring effect is present in all of the models within 2 AICs of the top model and has a combined model weight of 0.84. The second ranked models contained an effect of sex interactive with the first Spring and indicated that males (0.91 ± 002) had lower survival than females (0.93 ± 0.02) during the first three months, but were the same for all months following. The third ranked models contained an effect of age interactive with the first Spring and indicated that adults (0.91 ± 002) had lower survival than juveniles (0.94 ± 0.02) during the first three months, but were the same for all months following. Annual survival estimates, from model averaging of the top three models (Table 7), indicate that though survival is lower in the first year post release it is well within the range for the species and in the years following it is on the higher side of the observed range (Schroeder et al 1999).

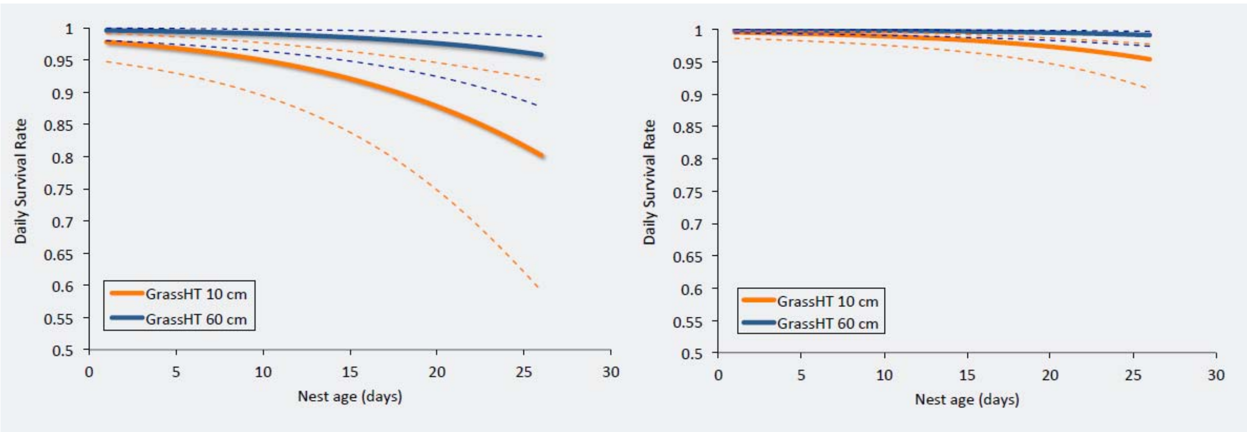

Fig. 10. The effects of nest age and perennial grass height (GrassHT) on the daily nest survival rates on yearling sage-grouse (left plot) and adult sage-grouse (right plot), Lincoln County, WA, 2010 -2014. The dashed lines represent the 95% CI for each grass height.

Sage-grouse illustrated some distinct tendencies following translocation. Most movements were concentrated in and around WDFW Swanson Lakes Wildlife Area and BLM's Twin Lakes Area, which tends to have greater sagebrush cover (Fig. 9). When birds did move long distances off the primary study area, their risk of mortality appeared to be relatively high. Mortality was particularly high for the autumn translocation, with 20 of the known mortalities occurring in the month following release (Table 8). It is not clear why this high mortality occurred, but one possible explanation is that most of the translocated birds were juveniles (Table 3) and the winter of 2008-2009 was a relatively heavy snow year. There were also 13 mortalities in which the entire bird was recovered. Based on field notes and necropsies they have been attributed to: 2 collisions with manmade objects (e.g. fences); 4 predators that lost or abandoned their kill; 1 disease; 1 human hunter; 1 collision with a vehicle; 1 collision with natural object (e.g. bluff); and 3 cause of death unknown. As a result of these observations, additional management efforts have been directed toward marking of fences to make them more visible, removal of unnecessary fences, and posting of additional signs to educate hunters in areas with endemic and reintroduced populations of sage and sharp-tailed grouse.

Table 6. Results from the Known Fate analyses of greater sage-grouse translocated from southern Oregon to Lincoln County, Washington, 2008-2012. Seasons modeled as follows Spring (March-May), Summer (June-August), Fall (September-November), and Winter (December-February).

Model	AICc	Delta AICc	AICc Weights	Number parameters	Deviance
1st Spring	544.3	0.0	0.37	2	219.9
1st Spring * Sex	545.3	1.1	0.21	3	219.0
1st Spring * Age	545.7	1.4	0.18	3	219.3
Spring	547.7	3.5	0.06	2	223.4
1st Year	548.0	3.7	0.06	2	223.6
1st Spr, Sum, Fall, Win	548.2	3.9	0.05	5	217.8
1st Spring * Sex * Age	549.1	4.8	0.03	5	218.7
Constant	551.4	7.2	0.01	1	229.1
All Seasons	551.5	7.3	0.01	4	223.1
Sex	552.7	8.4	0.01	2	228.3
Age	553.3	9.0	0.00	2	228.9
Age + Sex	554.7	10.4	0.00	3	228.3
Age * Sex	555.2	10.9	0.00	4	226.8
Monthly	557.3	13.1	0.00	12	212.8
Release Cohort	559.3	15.0	0.00	5	228.9

Table 7. Model averaged results for the top 3 models from the Known Fate analyses of greater sage-grouse translocated from southern Oregon to Lincoln County, Washington, 2008-2012.

Sex	Age	Monthly survival		Annual survival	
		First Spring	Post first Spring	First year	Post year one
Male	Adult	0.915 ± 0.018	0.962 ± 0.006	0.539 ± 0.030	0.626 ± 0.031
	Yearling	0.920 ± 0.021	0.962 ± 0.006	0.548 ± 0.030	0.626 ± 0.031
Female	Adult	0.922 ± 0.018	0.962 ± 0.006	0.552 ± 0.030	0.626 ± 0.031
	Yearling	0.928 ± 0.019	0.962 ± 0.006	0.562 ± 0.030	0.626 ± 0.031

Table 8. Mortality of greater sage-grouse translocated from southern Oregon to the Swanson Lakes Wildlife Area in Lincoln County, Washington, 2008-2015.

Category	2008	2009	2010	2011	2012	2013	2014	2015	Total
Mammalian	2	5	4	3	2	1	3	4	24
Raptor	3	4	2	4	3	3	10	5	34
Great horned owl	6	1	1	1	0	1	0	2	12
Manmade	1	0	1	0	2	0	0	1	5
Hunter	1	0	0	0	0	0	0	0	1
Disease/Natural	1	0	0	0	1	0	0	0	2
Unknown	9	9	6	7	14	7	9	1	62
Total	23	19	14	15	22	12	22	13	140

Predator Management

The re-introduction area supports a small and vulnerable grouse population persisting in an environment fragmented by agriculture (~9% of the Habitat Concentration Area) and has a high density of anthropogenic features such as roads, distribution lines, ranch buildings, and fencing (Stonehouse 2013, BLM 2014, Stonehouse et al. 2015). Fragmented agricultural landscapes can support abundant rodents, pigeons and Eurpoean starlings, that in-turn attract and sustain predators that then opportunistically prey on grouse (Dunn 1977, Rich 1986, Reynolds and Tapper 1996, Moulton et al. 2006). Losses to predation are sustainable in large populations, but have a more significant impact on small populations. Under these conditions various authors have suggested that predator reductions may be warranted in the short term to buffer grouse populations from elevated levels of predation (Connley et al. 2000, Hagen et al. 2011 USFWS 2013).

Removal of nest predators has been shown to temporarily improve nest success, juvenile survival, and 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). In a similar sage-grouse augmentation program in Strawberry Valley, Utah, predator control resulted in a 24% increase in spring-summer survival and a 2.6 fold increase in chick-to-hen ratios (Baxter et al. 2008). 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. Protection of an threatened population of birds reintroduced with great effort and expense warrants consideration of all methods to ensure success, including predator control. Predator control is not a long-term management strategy on this project, but will be conducted over limited geographic areas and time span, and in conjunction with non-lethal predator management activities.

Mammalian predators have been the suspected predator in 51% of our known predated nests. Coyotes are the primary mammalian predator in this area, with badgers a distant second, and few fox, raccoon, weasel, and skunk observations. Master Hunters have been funneled to the project area to hunt coyotes since 2009, but with little success. Given low success of hunters and multiple observations of coyotes taking adult sage-grouse at the lek and on nests, we increased predator control activities in the project area in 2014. We contracted with APHIS to implement focused coyote abatement and raven removal within 5 km of the lek. Ravens were included in this contract due to ravens being indicated as the predator in 20% of nest failures at that time.

A total of 39 coyotes were removed over two days (April 22 and May 14, 2014) via helicopter within 5 km of the lek. During the May flight 36 coyotes were removed from the area within 3 hours, and one coyote was shot actively stalking a group of 3 sage-grouse. Twelve sites associated with known raven nesting activity were chosen to be baited with chicken eggs treated with DRC-1339, an avicide specific to black-pigmented birds. Additionally, to increase probability that only ravens were affected, elevated stations at each site were selected or built to exclude mammals and each station was pre-baited with non-treated eggs and monitored directly and via remote camera for three weeks. Based on monitoring, 2 stations were removed because they did not demonstrate bait acceptance by ravens. On April 1st the 10 remaining stations were each baited with 2 treated eggs. Monitoring showed all eggs were removed from the stations in less than 24 hours. Assuming one raven was lethally removed per treated egg, we estimate 20 ravens were removed.

In 2015 APHIS was again contracted to conduct coyote removals via helicopter within 5km of the lek. The first flight was on March 9 and 43 coyotes were removed. A second flight was scheduled for late March early April, but was never flown due to helicopter mechanical issues and availability. Raven control via poison was not used this year due to raven survey results indicating overall density of ravens was not a significant issue. Individual ravens and nests were removed when in close vicinity to known grouse nest sites. A total of three adult ravens were lethal removed, multiple nests were knocked down but none had eggs present. Additionally, 11 Great Horned Owls were lethally removed. In conjunction with lethal control the following non-lethal activities have been implemented and/or ongoing:

- Restoration of ~2800 acres of old agricultural fields to shrub steppe habitat on WDFW and BLM lands since 2004 (WDFW 2014). With 300 more acres in the process of being restored and 1000 more proposed and awaiting funding.
- Cessation of grazing on 20,000 acres (Swanson Lakes Wildlife Area) to provide adequate hiding and nest concealment cover.
- Grazing under conservative stocking rates on 20,000 acres of BLM land that monitoring has shown is providing cover adequate to meet sage-grouse guidelines (BLM 2014).
- Approximately 20 miles of un-necessary fencing and associated fence posts often used as predator perches has been removed (WDFW 2014). An additional five miles is proposed and awaiting funding.
- Approximately 4.3 miles of power distributions lines representing 60 powerpoles have been removed by the BLM (WDFW 2014).
- A study on the effectiveness of various perch deterrent designs has been completed (Dwyer and Doloughan 2014), and a feasibility assessment to install perch deterrents or

remove or relocate additional powerlines is being prepared in partnership with the local power company.
- One unstable barn has been demolished by BLM for safety reasons, and another that routinely supports a raven nest is approved for removal in 2015.
- Roads accessing core areas of public land are closed to minimize disturbance and avoid route and trash proliferation.
- Refuse at the Swanson Lakes headquarters is securely covered in dumpsters that prevent ravens from accessing any food that might subsidize their population.
- All public land (WDFW and BLM) access sites are routinely monitored and kept free of litter and trash.
- A total of eight great horned owls were banded and relocated in winter 2009 and spring 2010. One owl was captured and relocated in 2014 and four in 2015. None of the banded owls have been observed in the study area. Great horned owls were causing a significant number of adult sage grouse mortalities (Table 8).

Population monitoring

Radio-marked males are located during the morning period to determine the locations of temporary and permanent leks. An attempt is made to regularly monitor these leks without disturbing the birds. In addition, all potential sage-grouse habitat within 20 km of the release site is inventoried to estimate lek density and attendance of males (Connelly et al. 2003). Surveys are conducted during March and April of each year. No lekking activity was documented in 2008 or 2009. In 2010 on two occasions, banded males were seen strutting together and females were seen or heard in the area. No unmarked birds were seen strutting with the banded males. In 2011 a lek site was established by males from previous years' releases, just north of the 2010 area. The highest count in 2011 was 7 males pre-release. The same lek was active again in 2012, 2013, 2014, and 2015 with high male counts of 7, 12, 13, and 15 pre-release and 14, 18, 11, and 24 post-release, respectively. Additionally, in 2012 a sage grouse male was observed strutting ~8 km from the established lek. This was notable because several nests were located in the vicinity and at least one other male was known to be in the area (based on telemetry). No males were observed strutting in this second area in 2013, 2014, or 2015 but hens and males were tracked in the area.

ADDITIONAL PROJECT OBJECTIVES AND BENEFITS

Agreement number F13AP00510 with the U.S. Fish and Wildlife Service, Lincoln County Sage-grouse Reintroduction identified the project objectives and benefits listed below (in italics). In addition to re-establish a sage-grouse population Lincoln County, powerline removal, and removal of a powerline was desired to reduce predation on grouse.

Objectives

1) Release up to 50 sage-grouse and monitor survival, movements, and reproduction.

We translocated 40 sage-grouse in 2015.

2) Monitor previously released sage-grouse and sharp-tailed grouse for survival, movements, and reproduction.

Grouse were monitored, by the seasonal staff and volunteers, and movements and mortalities mapped and documented.

3) Remove 2 miles of unneeded powerline.

A contractor completed this under a contract with BLM.

4) Complete WSU thesis project on habitat use by sympatric sage-grouse and Columbian sharp-tailed grouse.

The thesis project was completed in May 2013 (Stonehouse 2013) and the associated publication was completed in August 2015, and accepted for publication by Journal of Wildlife Management (Stonehouse et al. 2015).

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