Greater Sage-Grouse in Canada Population and Habitat Viability Assessment Workshop

Calgary, Canada, 14 – 17 January 2014

Final Report

Workshop organized by: Calgary Zoo; IUCN Reintroduction Specialist Group; Galliformes Specialist Group; and the IUCN SSC Conservation Breeding Specialist Group (CBSG)

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A PDF of *Greater Sage-Grouse in Canada Population and Habitat Viability Assessment Workshop Final Report* can be downloaded at: www.cbsg.org.

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CONTENTS

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SECTION 1

Executive Summary

Executive Summary

The greater sage-grouse (*Centrocercus urophasianus*) is one of the top priority species of conservation concern in Canada. Dependent upon sagebrush habitat for food and shelter, this species is at risk due to habitat loss and degradation, industrial disturbance, changing climatic conditions, and other threats. Populations now occupy only 7% of the historical range in Canada (in southern Alberta and Saskatchewan) and are estimated to have declined by 98% in the past 25-45 years. Population estimates in 2012 based on male lek counts estimate only 93-138 adults total in Canada split between two isolated populations (Environment Canada 2013). This critical situation calls for immediate attention to prevent further decline and eventual extinction.

In response, a Population and Habitat Viability Assessment (PHVA) workshop was conducted for the Canadian populations of this threatened species at the Calgary Zoo on 14-17 January 2014. This workshop was organized by the Calgary Zoo's Centre for Conservation and Research in collaboration with the IUCN SSC Reintroduction Specialist Group, Galliformes Specialist Group, and Conservation Breeding Specialist Group (CBSG). CBSG provided facilitation, process design and PVA modeling tools and skills, and financial support was provided by the Alberta Environment and Sustainable Resource Development (ESRD). This international multi-stakeholder workshop included over 40 participants representing a diversity of expertise and perspectives, from field researchers, wildlife modelers and government representatives to local ranchers and representatives from the energy industry. The workshop built upon existing recovery plans and strategies to further identify management actions to reduce the primary threats driving population decline and to explore intensive population management strategies to counteract the immediate risks to this small population and prevent imminent extirpation from Canada.

Workshop participants discussed their desired future for greater sage-grouse in Canada and its implications and generated the following vision:

> *To have a self-sustaining population of greater sage-grouse, which is genetically representative of ancestral populations, covering a portion of Canada's historic range, which is both appreciated by and capable of benefiting Canadians, and which functions as a model for species recovery and ecosystem stewardship.*

This vision is not achievable under current conditions and projected trends. Population modeling even under the optimistic conditions specified in this report (no habitat loss, climate change, or West Nile virus impacts) suggest that recent reproduction and survival rates are too low to sustain this population, and will likely result in extinction in Canada within 10-15 years or sooner if conservation action is not taken. Factors affecting sage-grouse population viability, including demographic and genetic impacts, were considered, and three working groups were formed to discuss these factors and potential actions in detail.

Workshop participants outlined strategies for addressing the primary causes of poor population growth, which include increasing functional sage-grouse habitat, minimizing disturbance and habitat fragmentation, and reducing high predation rates facilitated by power lines and industrial structures on the landscape in concert with loss of sagebrush. Population management strategies were discussed in detail as methods to offset the stochastic threats to this small, fragmented population and prevent extinction before other conservation measures

can be effectively achieved. This includes options for conservation translocations from wild-to-wild and captive-to-wild for both population reinforcement and reintroduction. The development of an *ex situ* population as an assurance population against extinction and a potential future source for translocations was viewed as an important and urgent need. Calgary Zoo is committed to this *ex situ* effort, with financial support from ESRD and Environment Canada. Recommendations were also made to promote institutional collaboration and effective governance that will promote conservation of greater sage-grouse populations and the Northern Sagebrush Steppe.

This workshop successfully integrated a wide diversity of stakeholders to evaluate and recommend both *ex situ* and *in situ* conservation management techniques as part of an integrated conservation plan to support the recovery of the greater sage-grouse in Canada. This joint collaboration of three IUCN SSC Specialist Groups encouraged the application of various IUCN guidelines – the new reintroduction guidelines, draft revised guidelines for *ex situ* management, and reintroduction guidelines for Galliformes – to properly assess and develop effective conservation strategies. The result is a strong example of the One Plan approach to species conservation planning in action.

This PHVA report and the recommendations within it are considered advisory to the local and provincial management teams for the greater sage-grouse and other collaborators to help guide actions thought to be beneficial to the long-term survival of the greater sage-grouse in Canada.

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SECTION 2

Status Review for Canada

Greater Sage-Grouse in Canada: Status Review

The following information on the status, threats and recovery strategies for the greater sage-grouse was taken in part from the Amended Recovery Strategy for the Greater Sage-Grouse (Centrocercus urophasianus urophasianus) in Canada (Environment Canada 2013), the Alberta Greater Sage-Grouse Recovery Plan 2013-2018 (AESRD 2013), and the Conservation Plan for Greater Sage-Grouse in Sasketchewan (2014 update).

Canadian Population Status Overview

The greater sage-grouse (*Centrocercus urophasianus*) is an indigenous North American grouse species that occurs in prairie regions of Canada and 11 western US states. The Canadian populations represent the northern edge of the species' range and occupy the silver sagebrush grassland regions of southeastern Alberta and southwestern Saskatchewan. Canadian sage-grouse are dependent on silver sagebrush as a source of food and shelter. Greater sage-grouse (GSG) have experienced decline in all parts of their range, and in Canada the species is listed as *Endangered* under the *Species at Risk Act* because of substantial decline in the small population.

In the 1980s the estimated GSG population in Canada was ~2491 birds. By 2012, only 13 males were counted at leks in Alberta and 18 males at leks in Saskatchewan. This suggests a population of 39-58 adults in Alberta and 54-80 adults in Saskatchewan, for a total Canadian population of 93-138 adult grouse. Both provincial populations have declined by 98% since their highest recorded population estimates (1968 in Alberta and 1988 in Saskatchewan).

The main current and future threats to greater sage-grouse in Canada include drought and extreme weather conditions, West Nile virus, sensory disturbance from vertical structures and chronic noise, increased predator pressure, habitat loss and degradation, alternation of natural hydrology, and threats inherent to small populations.

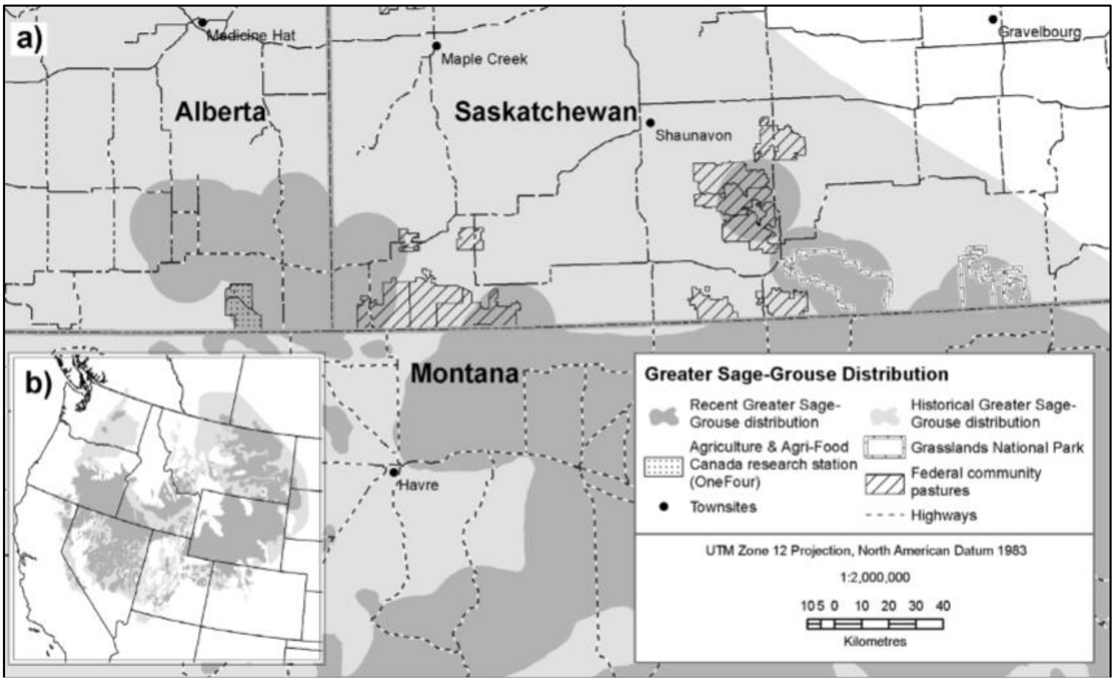

Image from Environment Canada 2013, Amended Recovery Strategy

Canadian Recovery Strategy

Despite numerous threats and challenges, the recovery of sage-grouse in Canada is deemed to be both technically and biologically feasible. A *Recovery Strategy for the Greater Sage-Grouse (Centrocercus urophasianus urophasianus) in Canada* was developed in 2008; this strategy was replaced by the *Amended Recovery Strategy for the Greater Sage-Grouse (Centrocercus urophasianus urophasianus) in Canada* in 2013. The population and distribution objectives listed in this plan are:

1. Immediately, stop the decline of the adult sage-grouse population in Canada.
2. In the short-term, reverse the population decline, and increase the number of active leks in both Alberta and Saskatchewan; and
3. In the long-term, achieve a stable or increasing sage-grouse population in Canada of:
   - At least 1095 adult GSG among 16 or more active leks in Alberta; and
   - At least 1500 adult GSG among 20 or more active leks in Saskatchewan.

Recovery will be conducted through the following broad strategies: 1) habitat assessment, management, conservation, and protection; 2) population management and species protection; 3) population monitoring and assessment; 4) research; 5) communication, collaboration and engagement; and 6) coordination with broader conservation planning programs.

Saskatchewan Conservation Plan

In 1987 Saskatchewan listed the greater sage-grouse as Threatened, and in 1992 the *Recovery and Management Plan for Sage-Grouse in Saskatchewan* was developed. Population decline led to its listing in 1999 as Endangered under Saskatchewan's *The Wildlife Act 1998*. Improved information on sage-grouse populations and habitat led to development of *A Conservation Plan for Greater Sage-Grouse in Saskatchewan* in 2012 (and updated in 2014) to incorporate new information on intensified and new threats to sage-grouse and its habitat. Although population estimates fluctuate, the population continues to decline, with only three active leks observed in Saskatchewan in 2014. The number of males per lek has also declined, from 17.1 in 1987 to 3.3 in 2014. Conservation goals are to ensure the persistence of a greater sage-grouse population in Saskatchewan, and to manage sage-grouse habitat to benefit both the species and the sagebrush-steppe ecosystem. An action plan for sage-grouse is anticipated to be completed by 2015 as part of the South of Divide Multi-Species Action Plan initiative for southwest Saskatchewan.

Alberta Recovery Strategy

In late 2002, the Minister of Environment and Sustainable Resource Development formally delegated the responsibility of drafting a provincial recovery plan for Alberta to the greater sage-grouse recovery team. In 2005, the greater sage-grouse recovery team produced the *Alberta Greater Sage-Grouse Recovery Plan 2005–2010* that recommended strategies and actions to recover the species in a manner that respected the livelihoods and land uses within sage-grouse range. The main goals of this plan were to: 1) enhance and maintain habitat for sage-grouse to support a viable population within its remaining historical range; and 2) achieve population recovery sufficient to allow sustainable recreational viewing and hunting.

Despite implementation of many of the actions outlined in the recovery plan, the Alberta population continued to decline, with the lowest count of 13 males recorded in the springs of both 2011 and 2012. As such, the goals specified in the inaugural plan are now considered long-term goals, and short-term goals to prevent extirpation of the species include the restoration and protection of critical and suitable habitat, and the reversal of population decline through population augmentation, predator management, and habitat remediation. A translocation program was initiated in 2011 using genetically similar birds from Montana to increase the Alberta breeding population (AESRD 2013).

Role of Population Management Strategies

Small populations are vulnerable to stochastic processes and genetic impacts that threaten the species' long-term persistence. Small populations are at risk of severe decline or even extinction due to random fluctuations in demographic rates (demographic stochasticity) and environmental conditions (environmental variation). 'Catastrophic' events, either natural or human-related, have especially negative impacts on populations that are small. Small populations also lose genetic variation faster and at a rate that cannot be replaced through mutation – meaning that the population loses its potential to adapt to new conditions and becomes increasingly vulnerable over time to inbreeding effects. These processes can lead to reduced survival, reduced reproduction, and/or a decline in population size, making the population even more vulnerable and likely to decline further – a feedback loop known as the "extinction vortex" (Gilpin and Soulé 1986). Once underway, this process becomes even more challenging to halt and reverse and can lead to population extinction.

For species such as greater sage-grouse in Canada that have declined to small populations, conservation strategies should not only address the primary threats that led to this decline but also short-term strategies preventing extinction while these larger threats are reduced. Increasingly, various population management strategies such as translocation and *ex situ* management are being used to counteract the impacts of stochastic processes that affect population size, demography, and genetics. These techniques can maintain short-term viability and prevent imminent extinction until all threats are reduced and the population can be expanded to a more secure size. Two recently revised IUCN guidelines – one for reintroduction and conservation translocation (IUCN 2013) and the second for *ex situ* management for species conservation (IUCN 2014) – provide a decision making process for considering such options. These options are being considered to improve the viability and persistence of GSG populations in Canada.

Overview Presentations

The following presentations were given at the beginning of the workshop to provide brief status overviews of various issues and topics relevant to the discussions of greater sage-grouse management. Summaries of many of these presentations are given here.

- Overview of sage-grouse research and threats (C. Aldridge)
- Galliformes reintroduction guidelines and sage-grouse research (M. Schroeder)
- Northern Sagebrush Steppe Initative (J. Nicholson, for Dale Eslinger)
- Updated Canadian recovery strategy (T. Wellicome)
- Conservation and Development Zones in Alberta (C. Gates)
- Translocation efforts (J. Nicholson)
- Captive management efforts (L. Wiechman)
- Genetics and population relatedness (K. Bird, via Skype)
- Landowners perspective (L. Finstad / D. Heydlauf)

Sage-Grouse Research and Threats – Cameron L. Aldridge

Greater sage-grouse (*Centrocercus urophasianus*) is a candidate species for protection in the United States. The species is Endangered and all but extirpated in Canada, with research implicating energy development as a major factor in population declines. Sagebrush habitats continue to be destroyed by agricultural practices that convert native habitats into crops, or by wildfire and management-induced fires that remove sagebrush. Infrastructure and associated energy developments (oil, gas, wind, oil shale, etc.) continue to increase through western North America, and resulting in ongoing degradation and fragmentation of sagebrush habitats. Energy development has caused direct habitat loss, functional habitat loss through alteration of sage-grouse behavior resulting in avoidance and increased dispersal, lowered vital rates, and ultimately, has been linked to population declines throughout the species' range, though these threats are most prevalent eastern populations. Western populations are primarily threatened by the invasion of annual plants such as cheatgrass (*Bromus tectorum*) into sagebrush ecosystems, which increases fire frequencies and results in loss and degradation of sagebrush habitats. Grazing by domestic and feral ungulates is a pervasive disturbance that can drastically degrade range conditions, possibly reducing habitat quality for sage-grouse and causing population declines. Recent developments to map cover components of sagebrush habitats has allowed spatially explicit models to be developed in Canada and Wyoming. These models predict seasonal habitat requirements for sage-grouse across large landscapes, identifying critical habitat needs for populations. These critical habitat 'maps' have formed the foundational component of a spatially explicit population viability analyses framework that will help to address questions about how continued (energy development, habitat loss, etc.) and future threats (i.e., climate change) may affect the long-term viability of sage-grouse populations. Roughly 60% of sagebrush habitats occur on publically owned lands, yet 80% of federally owned lands are currently leased for oil and gas development. Careful conservation strategies identified through these spatial modeling and conservation tools will be required to ensure long-term persistence of sage-grouse populations throughout their range.

Greater Sage-Grouse Translocation Guidelines – Michael A. Schroeder

Translocations have been used with mixed success in numerous efforts to re-establish and augment greater sage-grouse populations. An evaluation of successful translocations and consideration of the 2009 *IUCN Guidelines for the Re-introduction of Galliformes for Conservation Purposes* has produced a general approach. The first stage of a translocation is consideration of the release site. This consideration includes historical occupancy, documentation and understanding of the population decline and/or extirpation, and improvement of the habitat and/or other features that have resulted in the population stresses. The second stage of a translocation is consideration of the source population(s). This includes their genetic and demographic health, their genetic similarity to the remaining or former individuals at the release site, and political and/or logistical opportunity. The third stage of a translocation involves the actual capture and translocation of individuals from one population to another. In the case of captive-rearing, this stage can be quite complex as animal husbandry issues are also involved. The fourth and final stage is the monitoring and evaluation of the translocation. This stage is often overlooked, but is extremely important. Without this evaluation, it is difficult to learn from successes and failures so that those lessons can be applied to future translocations.

There is a great deal to learn from the past history of grouse translocations. Most translocation efforts have failed. Research has suggested that the single most important characteristic of a successful translocation is suitable quantity and quality of habitat. Unless this habitat issue is addressed, failure is the likely outcome. Another issue is the type of translocation being conducted. Some translocations are augmentations of existing populations and others are re-introductions into former range; augmentations are easier to conduct and generally more successful. Other differences in translocations include the direct release of birds captured in the wild versus the release of birds raised in captivity. With grouse translocations, all known successful translocations have involved the release of birds captured in the wild. Even with the numerous examples in Europe and the Attwater's prairie-chicken in Texas, none of the releases of captive-reared grouse has successfully produced a viable population. Despite the frequent failures and small number of success, there is still a great deal to learn about the methods for conducting a successful translocation. These skills will be increasingly important as the stress level on populations rises.

Northern Sage-brush Steppe Management and Research Partnership -- Dale Eslinger and Joel Nicholson

The Northern Sage-brush Steppe (NSS) occurs at the northern extent of the Great Plains. The western and southern boundary of the Northwest Glaciated Plains roughly coincides with the limits of continental glaciation. Glacial till covers gently undulating hills in the region, known as glacial till plain. This covers the tri-borders area of AB, SK, and MT. It is comprised of mixed grasslands and is a semi- to arid landscape where sagebrush is the dominant shrub. Silver sagebrush dominates north of the Milk River, with big sage-brush dominant near the Missouri River in MT. This area provides habitat for sagebrush dependent wildlife such as sage-grouse, as well as critical forage for pronghorn during harsh winters. Numerous other species use sage-brush for cover and nesting.

The NSS is a transboundary region experiencing habitat loss, fragmentation of native grasslands and pressure on wildlife species. Fish and wildlife agencies and non-government conservation groups were engaged in independent programs to address conservation issues. Existing multi-lateral initiatives did not provide mechanisms for coordination among agencies. Through a series of meetings in 2006 and 2007 the agencies recognized a need for coordination among themselves. Pronghorn migration, sage-grouse conservation and Chronic Wasting Disease were three matters of immediate common concern. As a result of these meetings, the three agencies (Alberta Fish & Wildlife, Saskatchewan Environment, and Montana Fish Wildlife & Parks) drafted a joint memorandum of understanding (MOU) outlining the intent for information exchange and cooperation regarding management of this area. Outlined as the Northern Sage-brush Steppe Initiative (NSSI), the Western Association of Fish and Wildlife Agencies (WAFWA) as well as provincial and state agencies (ADMs for provinces and Director in Montana) endorsed the MOU in 2007, which was renewed in 2012.

In the MOU, the Parties acknowledged and agreed that:

1. The NSS and dependent wildlife species are under accelerating cumulative pressure from land use activities.
2. Sage-grouse, pronghorn and mule deer are important indicators for the overall health of the system.
3. Maintaining ecological processes and socio-economically valuable populations requires conservation and land use planning at appropriate scales.
4. Cooperative efforts among the parties are necessary to conserve and manage the Northern Sagebrush Steppe.

The parties agreed to, at minimum, hold annual meetings to exchange information and coordinate research and management. Communication has resulted in the establishment of a large research program focused on pronghorn involving agencies and non-government partners. This work has elucidated pronghorn migratory movements throughout the program area. Further focus has been placed on sage-grouse, and the NSSI contributed greatly to the cooperative work required to undertake a sage-grouse translocation from MT to AB. Further work is also focusing on mule deer movements in relation to disease transmission. GIS specialists from the three partner agencies have also coordinated to develop seamless data layers for use in broad landscape analysis and visualization of the NSS ecosystem.

In conclusion, the importance of range continuity in this area cannot be overstated. Canadian populations like sage-grouse are likely dependent upon habitat connectivity to core populations in Montana. Cooperative management across jurisdictional boundaries will be necessary to ensure the persistence of a number of species in the NSS landscape.

Amended Recovery Strategy for the Greater Sage-Grouse in Canada – Troy Wellicome

The purposes of the *Species-At-Risk Act* (SARA) are to prevent wildlife species from being extirpated or becoming extinct, to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity, and to manage species of special concern to prevent them from becoming endangered or threatened. SARA dictates that every extirpated, endangered, and threatened species must have a Recovery Strategy, followed by an Action Plan. The sage-grouse is listed as endangered under the *Species at Risk Act* in Canada because the very small population has declined substantially. Both provincial populations have declined by 98% since their highest recorded population estimates in Alberta (1968) and in Saskatchewan (1988).

On December 20, 2013 the Proposed *Amended Recovery Strategy for the Greater Sage-Grouse in Canada* was posted on the SARA Public Registry for a 60-day public comment period. The main current and future threats to sage-grouse in Canada include sensory disturbance from vertical structures and noise, habitat loss and degradation, increased predator pressure, drought and extreme weather conditions, West Nile virus, alteration of natural hydrology, and additional threats inherent to small populations. The immediate population and distribution objectives of the Recovery Strategy are to stop the decline of the adult sage-grouse population in Canada. The short-term population and distribution objectives are to reverse the population decline, and increase the number of adults and active leks. In the long term, population and distribution objectives are to achieve a stable or increasing sage-grouse population in Canada of at least 1095 adult sage-grouse at $\geq$ 16 leks in Alberta and at least 1500 adults at $\geq$ 20 leks in Saskatchewan. Forty-one leks were identified as critical habitat, as well as a total of 2812 km^2 of nesting, brood-rearing and wintering critical habitat in Alberta and Saskatchewan. Recovery of sage-grouse will depend on finding ways to reduce or mitigate the key threats.

Once the *Amended Recovery Strategy for the Greater Sage-Grouse in Canada* is finalized and within 180 days of the posting of the final Recovery Strategy, critical habitat on federal protected areas is automatically protected and critical habitat on other federal lands must be protected by an Act of Parliament or Ministerial Order. Within 180 days of the posting of the final Recovery Strategy, the minister must determine whether or not critical habitat on non-federal land is protected by the laws of the province or conservation agreements. The minister must then report on progress to protect critical habitat on non-federal lands; if no progress is being made, the minister must recommend that Cabinet make a protection Order under SARA. However, the preferred approach to protecting critical habitat on non-federal lands would be either under the laws of the province or through incentive-based conservation agreements.

Land Use Zones, Standards and Guidelines for Sage-Grouse Conservation and Recovery in Alberta – C. Cormack Gates

A collaborative initiative has been underway since 2008 to create land use zones and standards for managing industrial activities and to mitigate impacts and protect key habitat in Alberta's sage-grouse range. The project consisted of habitat modeling and mapping, modeling and mapping land use intensity, creation of land use zones, and developing guidelines for industrial activities. Guidelines for agricultural activities were developed earlier and have been in place since 2004. A habitat model was based on a logistic regression developed by Parks Canada in which the dependent variable was nest site probability and predictor variables were sagebrush cover, sagebrush density class, and brightness. The resolution of model output was 30 x 30 m. Any legal subdivision (LSD; 40 acre unit) containing habitat defined by the model was mapped as 'active habitat'. This conservative map of sage-grouse habitat encompassed all known lek and nest sites and winter locations of sage grouse recorded in Alberta's Fish and Wildlife Information System. A land use intensity model was developed based on a hierarchy of footprints of anthropogenic features, including licenses of occupation, surface material mining and storage, active well sites, oil and gas facilities, pipelines, power lines, building and other urban structures, farm water well sites, roads, and converted fields including grain and forage crops. Land use intensity was the percent of an LSD occupied by the non-overlapping combined footprints of these features. It was mapped as the following classes: 0%; > 0 to 1%; >1 to 10%; > 10 to 30%; >30 to 75%; and > 75%. In a series of facilitated, technically supported workshops, Alberta land and wildlife managers developed a zoning scheme for managing oil and gas development and other industry activities in the province's sage-grouse range. Input on the approach was obtained from oil and gas company representatives with an interest in the sage-grouse area. The land use intensity map was overlaid on the 'active habitat' map. Participants drew on their professional experience, working knowledge of the area, and their knowledge of sage-grouse ecology to define land use zones and associated intentions. Five zones (areas) were defined:

- Zone 1, mapped as large contiguous areas of active habitat with no to very low development footprint. Priority land use intention - sage-grouse conservation.
- Zone 2, non-habitat with no to very low development footprint and high biodiversity value surrounded by Zone 1 areas. Land use intention is biodiversity conservation, maintaining light footprint, and minimum impact management.
- Zone 3, active habitat area with land use intensity exceeding a threshold for sustaining sage-grouse. Land use intention is long-term habitat restoration, continued energy activities with minimum impact management, on site and off-site mitigation, and restoration in the long term.
- Zone 4, outside the currently occupied sage-grouse area with some active habitat, a high biodiversity value and low land use intensity. Land use intention is biodiversity and natural features conservation, with minimum impact management.
- Zone 5, high land use intensity exceeding the threshold for sustaining sage-grouse. Agricultural crop production was the predominant land use in Zone 5 areas. Land use intention is to identify target areas for sage-grouse habitat restoration.

A table of land use guidelines was developed to inform decisions on oil and gas and other industrial activities in the sage-grouse area. The approach was vetted to the oil and gas industry for input and received support from this sector. The zones and land use guidelines were integrated into the Enhanced Approvals Process (EAP) for upstream oil and gas development in Alberta. Active sage-grouse habitat is mapped in the Landscape Analysis Tool (LAT), a component of the EAP, to enable industry to plan oil and gas activities and for preparing EAP submissions. The entire sage-grouse area (42 townships) is designated non-standard for upstream oil and gas development approvals, and hence requires discussion of proposed developments with Alberta Environment and Sustainable Resource Development staff in Medicine Hat. The approach created a transparent, collaborative consultation process that provides rigor in the land use approval process and a regulatory compliance mechanism within the EAP framework.

Greater Sage-Grouse Translocation in Alberta – Joel Nicholson

The greater sage-grouse is the most critically imperiled species in Alberta and possibly all of Canada. Declines from historic population levels have been estimated at as high as 98%. Many factors have been identified driving population decline, including habitat loss, industrial development in and around habitat, high predation pressure, West Nile virus, and lack of connectivity to populations in adjacent jurisdictions. The latest provincial recovery plan outlines a number of actions to be undertaken to prevent extirpation of sage-grouse from Alberta. These include population reinforcement through translocation, habitat restoration and enhancement, reclamation of industrial sites, and predator management through removal of predators and predator subsidies.

Translocation is viewed as a temporary measure, and long-term recovery must also focus on habitat conservation and restoration. After approval was obtained from the state agency and fish and wildlife commission, an initial translocation from Montana was conducted in 2011-2012. Thirty-eight hens and three cocks were captured using night lighting techniques from areas with healthy sage-grouse populations. They were released in Alberta at dawn near lek sites with displaying males. Sage-grouse were tracked using solar powered Global Positioning System (GPS) satellite transmitters. Many birds exhibited fidelity to the release areas and nested at levels similar to other translocations in the first year. The majority of nests have occurred in proximity to the release leks. High levels of predation contributed to low reproductive success; however the population has stabilized at an extremely low level, allowing additional time for emergency measures. In response to adult mortality and high levels of nest depredation, predator management has been implemented starting in winter 2013 and extending throughout the nesting and brood rearing season. This includes removal of both predators and predator subsidies from the landscape to promote higher levels of nest success and survival of remaining grouse. Monitoring of remaining birds and results of recovery efforts will be ongoing.

Sage-Grouse Captive Management Efforts – Lief Wiechman

Gunnison sage-grouse (*Centrocercus minimus*, hereafter GUSG) is a species of concern in Colorado. Two conservation issues addressed in the Gunnison Sage-grouse Rangewide Plan (RCP) are the population persistence of GUSG (especially the small populations) and the relatively low genetic diversity among GUSG. Augmenting small GUSG populations is a potentially useful management tool to address these conservation concerns. Five alternative techniques to transplanting yearling or adult individuals are discussed in the RCP, including use of captive-reared GUSG. Two separate Colorado Parks and Wildlife (CPW) research studies with greater sage-grouse (*C. urophasianus*) have evaluated different aspects of captive rearing techniques. The objectives for the GUSG captive-rearing project were to: 1) collect GUSG eggs from captive and wild females; 2) artificially incubate and hatch eggs; 3) develop captive breeding and husbandry techniques and protocol for GUSG; 4) determine if captive GUSG can initiate incubation and rear a brood in captivity; and 5) augment wild surrogate broods with captive-reared chicks at 1-, 3-, 5-, and 7- weeks of age. All five objectives were successfully achieved, although there were challenges related to captive females rearing chicks in captivity. Preliminary results indicate that wild brood adoption and chick survival was highest when releasing chicks at ~1 week of age.

Genetics and Population Relatedness – Krissy Bird

One of the biggest issues regarding translocation of sage-grouse to Canada from Montana concerns population genetics. During her presentation, Krissy Bird explained that greater sage-grouse from Montana that are located south of the Milk River (SMR) belong to a different sub-population than those from north of the Milk River (NMR). In response to a question regarding where individuals should come from for translocations or captive breeding, she indicated that preference should be: 1) Alberta, 2) Saskatchewan, and 3) Montana, NMR. To date, wild birds that have been translocated to Alberta have been taken from the SMR population and might therefore have altered the genetics of the Canadian/NMR population.

A Landowner's Perspective – David R. Heydlauff

My family has been on the land in the Wildhorse area since my grandfather got his first grazing lease that we still hold since January 1, 1901. It is a very fine balance; overgrazing destroys the habitat but light grazing or no grazing is just as bad. Most of the time what is good for the livestock is also good for the wildlife.

In the past Governments and NGOs have been helping to return land that the habitat has been destroyed on back to the way it was, but provided no help for maintaining it. We have had a lot of people tell us you have an awful lot of endangered species on your property but if you would do this or that it would be better. Some of their ideas are real good but would take a lot of money or time. Some of the things would not work as we have already tried them. Also, if we were doing too many things wrong we would not have so many species at risk. Cutting back too much on grazing cuts into the bottom line at the end of the year.

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SECTION 3

Vision and Threat Analysis Plenary Discussion

Plenary Discussion: Vision Statement and Threats Analysis

Vision Statement

A vision statement is a short statement that outlines the desired future state of the species and is long term and ambitious. There may be several different components to a vision statement, including the scope (i.e., geographic range, time scale) and representation, functionality, and desired degree of management intervention.

The PHVA workshop participants engaged in a plenary discussion of the desired future for greater sage-grouse in Canada and generated a list of components that were integrated to form the following vision:

> *To have a self-sustaining population of greater sage-grouse, which is genetically representative of ancestral populations, covering a portion of Canada's historic range, which is both appreciated by and capable of benefiting Canadians, and which functions as a model for species recovery and ecosystem stewardship.*

This helped to define a common understanding among the workshop participants on the ultimate goal for the species in Canada and to guide the development of objectives and actions to help achieve this vision.

Participants recognized that keeping sage-grouse on the landscape in Canada helps to keep habitat, political and economic issues more relevant for sage-grouse conservation. Many believed that achieving the vision for sage-grouse will be much more difficult if sage-grouse are completely lost from the landscape for a variety of reasons, from the loss of knowledge of traditional lekking sites to the potential increased vulnerability of the habitat to alteration. Although there are greater sage-grouse populations in the US, there may be genetic and/or behavioral adaptations in this peripheral northern population that may be important to retain.

Threats Analysis

A thorough understanding of factors that impact the viability of greater sage-grouse populations in Canada is important to identify and evaluate management strategies to address threats and promote viability. Many of these factors have been documented and are identified in existing sage-grouse recovery strategies and other publications. A group exercise was conducted at this stakeholder-diverse workshop to bring all of these threats and issues to the attention of all participants, to provide the participants with the opportunity to highlight additional threats, and to take advantage of their diverse expertise to identify potential causal relationships that may have implementations for mitigation or management.

Workshop participants were asked to brainstorm threats or challenges to greater sage-grouse conservation in Canada by writing each threat on a card and placing it on the wall. When relevant, additional factors that led to each threat were added along with arrows to identify possible causal relationships. Participants were asked to consider how each threat negatively impacts greater sage-grouse in one or more of the following ways:

1. Increased juvenile mortality
2. Increased adult mortality
3. Decreased reproduction
4. Decreased/small population size
5. Increased population fragmentation

The resulting diagram (Figure 1) and interconnectivity of factors served to inform the working group discussions as a starting point for further expansion. Some management actions may target the reduction or removal of these threats directly, while others may act by intervening at some point along a causal chain to reduce or eliminate their impact on sage-grouse. Many of these options were considered by the *Habitat and Landscape Management Working Group* and include both a short- and long-term perspective to threat reduction.

A complementary strategy is the application of one or more population management options to promote population viability and persistence of these small populations while long-term threat reduction is underway. Several types of conservation translocation can be implemented that vary across the source population (captive or wild), the recipient population (existing population or unoccupied habitat), and timeline (temporary or permanent). Participants considered how various population management strategies (reinforcement or reintroduction, including headstarting or captive breeding, or wild-wild translocations) might be able to address the five impacts on sage-grouse populations (Table 1). This information was generated in plenary as a general guideline to be considered by the *Population Management Working Group*, which discussed and evaluated these options in more detail. Assessment of population management options was aided by population modeling to help evaluate the impact and feasibility of different options.

Table 1. Population management strategies that have the potential to counter demographic and genetic impacts of threats on greater sage-grouse populations. These activities are not mutually exclusive but may be implemented in combination.

	GSG Population Problem				
Population Management Activity	High Juvenile Mortality (age < 1yr)	High Adult Mortality (age $\geq$ 1yr)	Low Reproduction (fewer breeders, nests, eggs, chicks)	Small Population Size	Population Fragmentation
Reinforcement of existing wild populations	X	X	X	X	X
Reintroduction to establish new wild populations				X	X
Headstarting (temporary removal of eggs or chicks from wild to captivity, back to wild)	X				
Captive breeding to provide a source population for reinforcement / reintroduction	X			X	

The *Collaboration, Stewardship and Policy Working Group* considered human, social and political factors that may promote or hinder effective implementation of conservation strategies. Group members discussed recommendations related to collaboration, stewardship and policy that will serve to support conservation actions recommended by the other working groups.

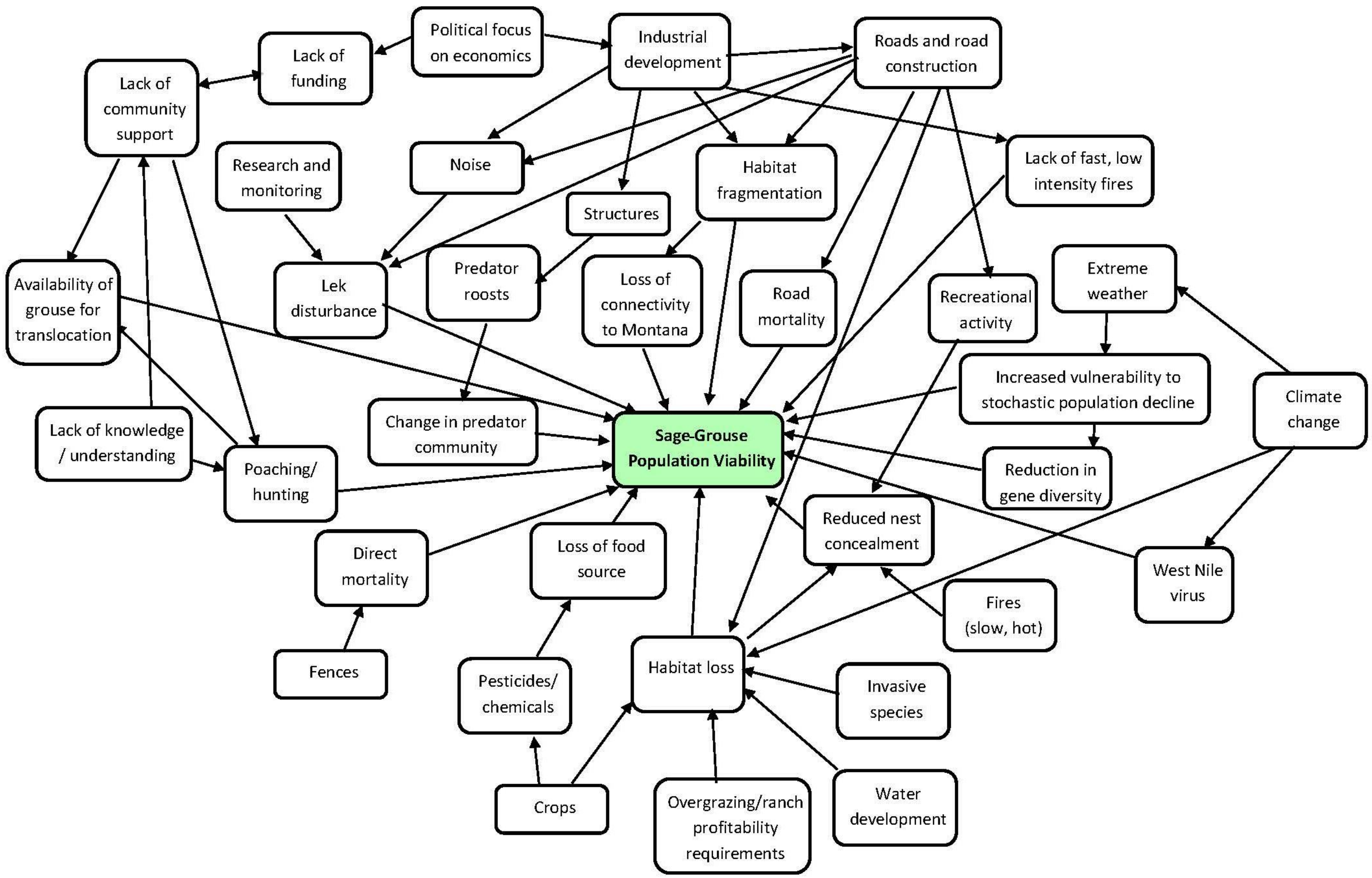

Figure 1. Threats and causal relationships impacting the viability of greater sage-grouse populations in Canada (general relationships generated in plenary discussion to guide working groups; this diagram should not be considered as a comprehensive depiction of all factors and relationships.

Greater Sage-Grouse in Canada Population and Habitat Viability Assessment Workshop

Calgary, Canada
14 – 17 January 2014

Final Report

SECTION 4

Habitat and Landscape Management Working Group Report

Working Group Report: Habitat and Landscape Management

Members: Kayla Balderson, Mark Boyce, Ervin Carlier, Beatriz Prieto Diaz, David Heydlaufe, Susan Patey LeDrew, Peter Neuhaus, Shelley Pruss, Adrian Sturch, Troy Wellicome, Todd Whiklo, Kelly Williamson

Introduction

This working group focused on issues and threats to greater sage-grouse populations that relate to habitat and landscape management. These issues were expanded from relevant issues identified in the plenary session, discussed, and grouped into the following categories: 1) grazing and fire; 2) predator management; 3) large-scale fragmentation; 4) anthropogenic development; 5) West Nile virus; and 6) invasive vegetation. For each of these categories, the group defined the problem, developed a goal and objectives to address the problem, and identified specific recommended actions. No explicit prioritization was done during the workshop with respect to actions; however, this would be valuable to guide those that would be most important to implement first.

Note: Although climate change and natural disasters are important phenomena influencing habitats and bird populations, this working group chose not to address them as we were not able to influence these factors with any actions.

GRAZING AND FIRE

Problem Statement

Grazing strategies to optimize sage-grouse habitat requirement have not been fully developed. Light intensity livestock grazing can be used to enhance habitats for greater sage-grouse. Specific guidelines will vary depending on site conditions but might include deferring grazing until after nesting, rest-rotation grazing, and seasonal scheduling of grazing.

***GOAL:* Work closely with ranchers, community pastures, and others to manage grazing in an effort to optimize vegetation conditions of seasonal habitats for greater sage-grouse.**

OBJECTIVE 1: Develop grazing management strategies that facilitate patchy vegetation structure, retain biodiversity, provide sufficient cover for nesting, and retain soil moisture and hydrology that benefit sage-grouse. Water development should be considered carefully to avoid altering hydrology that can influence the distribution of sagebrush.

ACTION: Redistribute livestock to optimize critical habitat attributes for GSG. Include contingencies for drought years and avoid using GSG habitats for sacrifice areas.

ACTION: Develop specific targets for vegetation in habitat types for GSG, including grass structural height, ground cover, litter retention, sagebrush density, forb diversity and biomass, and use grazing management to achieve these targets.

ACTION: Ranch-level grazing management plans for GSG and other species at risk, e.g., South of the Divide Ecosystem Stewards, Multi-SAR.

<u>OBJECTIVE 2:</u> Foster herd management to reduce reliance on fencing, and facilitate marking of existing fences.

<u>ACTION:</u> Review community pasture and private ranch management plans with a focus on pasture size, e.g., Sage Creek Grazing Reserve.

<u>OBJECTIVE 3:</u> Develop incentives to encourage grazing management practices that achieve sage-grouse habitat goals. Such incentives for habitat might include reduced lease fees, taxation reflecting intensity of use, conservation easements, results-based conservation agreements, market tools, access to grass banking, and carbon-offset programs.

<u>ACTION:</u> Explore incentives that reward grazing management that maintains optimal habitats for GSG.

<u>ACTION</u>: Encourage Agriculture Canada to retain management and oversight on PFRA lands that contain critical sage-grouse habitats, or if returned to the province, ensure that community pastures are continued under provincial oversight to ensure maintenance of GSG habitats.

<u>ACTION:</u> Subsidize removal of infrastructure such as stock ponds that might be detrimental to GSG habitat and aid in the water replacement that will be needed by livestock producers (wells, piping, etc.) to continue the operation of their livestock business

<u>ACTION:</u> Work with the Climate Change Emissions Management Corporation in Alberta to document the efficacy of native grasslands at sequestering and storing carbon, making available funds for carbon offsets.

<u>ACTION:</u> Explore how altering grazing management practices can constitute effective GRSG habitat protection. This could include research projects and stewardship agreements.

Problem Statement
High intensity fires are generally considered to be a negative influence on habitat for greater sage-grouse, but its role in altering grouse habitats in Canada is not fully understood.

<u>GOAL</u>: Design research to evaluate the potential benefits of fire management in silver sagebrush vegetation types and its potential value for sage-grouse.

<u>OBJECTIVE 1:</u> Evaluate the hypothesis that fire can rejuvenate silver sagebrush so long as the fire is not too intense. Likewise, fire might stimulate forb growth and in a patchy burn might enhance spring and summer habitats.

<u>ACTION:</u> Conduct experimental low intensity timed prescribed burns to test hypothesis and monitor sagebrush response.

*<u>OBJECTIVE 2</u>**:** As research results become available, develop a fire management policy that uses fire where beneficial and is controlled where its effects are detrimental (i.e., kills sagebrush).*

ACTION: Develop and implement regional fire management plans to manage fire in ways that benefit sage-grouse habitat and protection requirements.

RESEARCH GAP**:** The value of impoundments for sage-grouse is a data gap that warrants additional research.

PREDATOR MANAGEMENT

Problem Statement

Changes in the ecosystem have created a shift in the predator complex, likely causing increased pressure on sage-grouse.

GOAL: Reduce GSG mortality due to predation while increasing nesting success.

OBJECTIVE 1: Eliminate anthropogenic subsidies afforded to predators on the landscape.

ACTION: Carefully plan ferruginous hawk pole locations to minimize risks to GSG (e.g., AESB Stewardship Manual).

- Remove hawk poles when locations present a risk to GSG or are taken over by another raptor species.

ACTION: Remove abandoned buildings (Historical Resources will be maintained).

- Work closely with area farmers, residents, and others like local historic societies
- Public information outreach

ACTION: Remove and reclaim unused access roads to eliminate corridors, which may facilitate movement of predators.

- Collaborative access management plan

ACTION: Reduce predator numbers in the short term through focused culling in areas near sage-grouse leks. *See note below.*

ACTION: Implement a comprehensive predator management strategy, being sensitive to mesocarnivore dynamics. *See note below.*

ACTION: If necessary, use corvicide as a pilot in Alberta to control corvids (applied in eggs). *See note below.*

Note: These last actions were not unanimous and were controversial within the group. There were concerns that such methods and their outcomes have been unpredictable in the past, and that the outcomes have the potential to do more damage than benefit.

OBJECTIVE 2: Reduce natural nesting opportunities for known GSG predators, especially in association with anthropogenic structures.

ACTION: Remove trees associated with old farm sites, ditches, dug-outs, and in some places, curb aspen encroachment.

OBJECTIVE 3: Install predator deterrents when structure removal is not feasible.

ACTION: Place perch and nest deterrents on utility poles, bridges, fence posts, and industrial developments.

ACTION: Board up buildings when removal is not feasible.

ACTION: Research possibilities and successes of "shepherds" to help in predator control.

RESEARCH GAPS:

- Gain a better understanding of which predators are contributing to GSG mortalities and nest depredations.
- Inventory predator numbers and population demographics.
- Collect data on habitat associations of predation.

LARGE-SCALE FRAGMENTATION

Problem Statement

Large-scale conversion/cultivation of the native sagebrush grassland threatens sage-grouse by:

1. Decreasing total available habitat;
2. Impairing population connectivity; and
3. Increasing agri-philic predator populations (e.g. red fox, striped skunks, raccoons, corvids).

GOAL: Eliminate further cultivation and reclaim suitable/targeted cultivated land to maintain and create effective habitat corridors (genetic, migratory, dispersal, etc.).

OBJECTIVE 1: Encourage retention of sagebrush grassland habitats (e.g., stewardship, securements, etc.).

ACTION: Encourage and facilitate private land acquisition by conservation organizations such as Alberta Conservation Association, Nature Conservancy Canada, Ducks Unlimited, Alberta Fish and Game Association, SOD-CAP, and Pheasants Forever. Contact these organizations identifying critical habitat distribution and corridors, and alert these organizations when properties become available.

ACTION: Retain properties as Crown lands and prevent sale of these lands to private ownership, while ensuring that the lands are retained as native grasslands with sagebrush that provide habitats for GSG. If land is to be sold, ensure conservation easements are in place.

ACTION: Follow up outreach and education, including workshops, field trips, and publications to encourage industry, landowners, and agencies to manage landscapes to retain sagebrush habitats.

ACTION: Encourage proposals that perpetuate sagebrush landscapes, e.g., with Habitat Stewardship Program funding.

OBJECTIVE 2: *Reclaim cropland and improve tame pasture to become sagebrush grassland, focused on:*

a) *Surrounding existing areas of sagebrush grasslands, and*
b) *Areas that can provide large connected habitat corridors.*
c) *Include "suitable" landscapes even if they are not indigenous GSG landscapes.*

ACTION: Incentive programs to foster reclamation, including cropland conversion to permanent grassland cover.

ACTION: Encourage AER (Alberta) or Ministry of Economy (Saskatchewan) to enforce reclamation standards for oil/gas companies, and to encourage reclamation as soon as possible. Guidelines for reclamation timelines should be developed. Partnering with the Canadian Association of Petroleum Producers (CAPP) to encourage an industry response on reclamation in critical sage-grouse habitats provides opportunity for industry to demonstrate corporate social responsibility.

ACTION: Workshop for landowners and practitioners on best management practices to establish sagebrush using plugs, seeding, and other reclamation methods. Partner with the Prairie Conservation Action Plan (PCAP) and the Prairie Conservation Fund (PCF) to put on such workshops.

ACTION: On leased land, encourage conversion to permanent grassland cover with sagebrush restoration.

RESEARCH/MODELING GAPS:

- Big sage may become more suitable for AB and SK in light of climate change. Although this was not really considered at the workshop because of more pressing issues/urgency of the decline of GSG, it may be an important consideration for modelling of future available habitat.
- In the habitat viability analysis we need to consider target habitat and model how important it may be in X years in terms of climate change, drought, etc. The areas may be more or less important as a result of climate change and some of these predictions can be tested through modeling.

ANTHROPOGENIC DEVELOPMENT

Problem Statement

Impacts associated with existing and potential anthropogenic development in sage-grouse habitat probably lead to poor reproductive success and survivability of sage-grouse and reduce the capacity of the landscapes to support sage-grouse.

GOAL 1:* *Increase functional sage-grouse habitat.

OBJECTIVE 1: *Remove anthropogenic features that potentially serve as predator subsidies (see above).*

ACTION: Removing power poles or install perch proofing to eliminate perches for raptors, especially in areas identified as critical sage-grouse habitats.

ACTION: Removing old abandoned buildings that serve as habitats for raccoons, great-horned owls, and corvids (also predator control measures—see *Predator Management*).

ACTION: Suspended wells, inactive structures for oil/gas will be removed.

OBJECTIVE 2: Remove features that produce chronic noise within 3.2 km buffer surrounding leks and minimize noise-generating activities.

ACTION: Removing pumpjacks and roads.

ACTION: Speed limits to reduce traffic noise.

ACTION: Switch from propane to electric pumpjacks that are less noisy.

ACTION: Use hospital or residential-grade mufflers on engines driving pumpjacks.

OBJECTIVE 3: Remove or retrofit above-ground linear features.

ACTION: Placing pipelines and electrical cables in the same corridor, belowground when possible.

ACTION: Make these perch proof when not removed.

OBJECTIVE 4: Prioritize reclamation and restoration of functional sage-grouse habitat (beyond legislated criteria).

ACTION: In Alberta using C & D Zone process and Expand C & D Zone process into Saskatchewan.

ACTION: Mandating orphan-well fund (under the Alberta Energy Regulator, AER) in Alberta to prioritize reclamation of orphaned wells. In Saskatchewan this is managed by the Minister of Economy.

ACTION: Plant sagebrush plugs to hasten the recovery of disturbed sites.

ACTION: Ensure adequate sourcing and quality of silver sagebrush and native grassland seeds.

ACTION: Evaluate how reclamation activity might disturb sage-grouse and how could it be scheduled to minimize effects.

GOAL 2: Avoid future impacts to functional habitat through informed and collaborative planning and site-specific mitigation.

OBJECTIVE: Use planning processes such as the conservation and development zone process defined in Alberta's sage-grouse recovery plan. Apply such tools on a broader landscape to include Saskatchewan

ACTION: Encourage clear communication and coordination among provincial agencies and regulators, e.g., in Alberta: AER, ESRD, Energy, Agriculture; Saskatchewan: Ministries of Agriculture, Environment, Economy.

ACTION: Likewise ensuring clear communication between Environment Canada and provincial agencies.

ACTION: Sharing best management practices on the ground to ensure effective habitat management, e.g., field tours, meetings to coordinate practices.

WEST NILE VIRUS

Problem Statement
High adult mortality/potential mortality of sage-grouse due to West Nile Virus (WNV).

***GOAL:* Reduce mortality due to WNV. When possible use the WNV vaccinations currently available (e.g. Fort Dodge Equine vaccine, DNA plasmid vaccine, etc.).**

OBJECTIVE 1: Implement programs to monitor the presence of diseases and their vectors.

OBJECTIVE 2: Maintain suitable contiguous habitat to buffer against stochastic events.

OBJECTIVE 3: Study the effectiveness of control methods on mosquitoes, especially in dry years (control standing water sources through biological treatments against mosquitoes).

OBJECTIVE 4: Develop and test a more effective vaccine for sage-grouse, use available vaccines and vaccinate individuals bred in captivity or wild captures before release.

RESEARCH GAP: Evaluate causes of the WNV outbreaks and their spread dynamics.

INVASIVE VEGETATION

Problem Statement
Changes caused by invasive species to vegetation communities affect habitat attributes that sage-grouse require for their key life cycles: lekking, nesting, brood rearing and wintering.

***GOAL 1:* Minimize/control the introduction of invasive species.**

OBJECTIVE 1: Prevent/eliminate pathways for invasion.

ACTION: Prevent the spread of seeds or tillers of invasive species, e.g., requiring certified seed for reclamation. Vehicle checks, certified hay free of weed seeds.

ACTION: Education and prevention (encourage the planting of non-invasive/native species for reclamation and agriculture).

ACTION: Partner with organizations and stakeholders on weed management issues.

ACTION: Ensure non-invasive species planting in road right-of-ways, pipeline corridors, and disturbed sites.

OBJECTIVE 2: Control invasive species.

ACTION: Monitoring and rapid response protocol to new invasion sites. Urgent attention required for leafy spurge, saltcedar, spotted knapweed, and downy brome (cheatgrass).

ACTION: Partner with organizations and stakeholders on weed management issues.

ACTION: Use integrated pest management practices to control invasive species.

GOAL 2: Restore important invaded areas that are suitable for sage-grouse habitat.

OBJECTIVE: Prioritize invaded areas that have been previously identified as critical habitat and should be restored.

ACTION: Restore smooth brome and crested wheatgrass pastures to native grassland with sagebrush.

ACTION: Map areas that were previously GRSG habitat that have been invaded.

RESEARCH GAPS:

- Information about how sage-grouse use crested wheatgrass (and other invasive species) invaded areas.
- Impacts that invasive vegetation has on sage-grouse habitat attributes.

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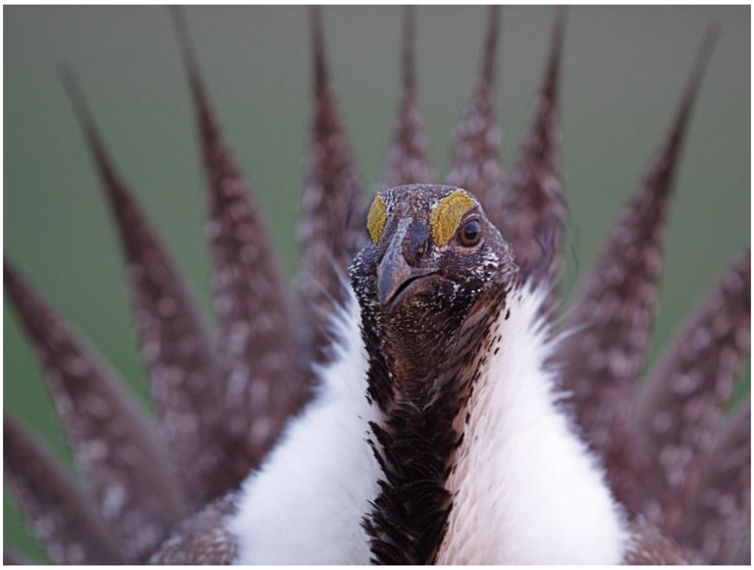

SECTION 5

Collaboration, Stewardship and Policy Working Group Report

Working Group Report: Collaboration, Stewardship and Policy

Members: Mark Brigham, Pat Fargey, Cormack Gates, Sue Michalsky, Beatriz Pietro Diaz, Kevin Redden, Cliff Wallis

Scope and Process of Working Group

This working group focused on issues related to collaboration among stakeholders and policy that pose challenges for greater sage-grouse conservation in Canada. The group began by discussing these issues and identified the following symptoms of the overall problem:

- Continued industrialization and degradation of northern sagebrush steppe;
- Greater sage-grouse decline; and
- PFRA pastures in Saskatchewan and Onefour Research Farm in Alberta devolution to provinces.

The group clustered the specific issues into categories, identified the overall key issues, and formulated a general problem statement related to collaboration, stewardship and policy and their impacts on greater sage-grouse populations. They then identified a goal, objectives, and recommended action to address this problem.

Below is the resulting problem statement, overall goal, and recommended action. This is followed by more detail on the components of the issues and analysis by the group, specific objectives, and details about the rationale and implementation of the recommended action.

Problem Statement

There is no common vision for conservation, remediation and stewardship of the northern sagebrush ecosystem, including greater sage-grouse. This ecosystem is being managed for short-term profits. This has resulted in the lack of a good governance model (mechanisms, organizations and policies) to conserve, remediate and steward the northern sagebrush steppe.

Goal

Effective governance for organizing institutions and people to achieve conservation, remediation, and stewardship of northern sagebrush steppe, including greater sage-grouse recovery.

Action

Premiers' task force will be 2-3 people (from Alberta and Saskatchewan). Formation of interprovincial Premier's task force to coordinate northern sagebrush steppe conservation, remediation and stewardship (authorized by Premiers and endorsed by federal Minister of Environment).

1. Focus will be on finalizing charter/Terms of Reference for interprovincial working group that will coordinate delivery of sagebrush steppe conservation, remediation and stewardship.
2. Interprovincial working group includes environment/wildlife, public lands, energy, and agriculture agencies.
3. Under that umbrella, stakeholders and land managers will be represented (ranching, ENGOs, energy industry, local governments).

Issues and Challenges

The group brainstormed issues and considerations related to collaboration, stewardship and policy, and grouped these issues as follows:

Policy/Regulatory Issues

- All governments have fractured jurisdiction problem; new Alberta energy regulator incorporates all competing mandates from old line agencies.
- Between provinces hierarchy (including British Columbia) and across countries—everyone primarily works in silos.
- Industry is telling government what are reasonable standards.
- Need standards that are developed collaboratively.
- No inter-jurisdictional forum exists where all stakeholders participate.
- Have differing provincial and national recovery plans.
- Problem is not different planning efforts; how do we coordinate all of the actions/efforts/players?
- Policies that drive habitat change – subsidies are for crops, not for rangelands; subsidies are for industry, not for grouse; etc.
- Need payments for ecological goods and services, i.e., pay ranchers to "grow" sage-grouse (i.e., provide proper habitat).
- Pay on results-based outcomes.
- Rebuild ecosystem and connectivity and pay people to do it (private land focus).
- Problem: selling off PFRA pastures in Saskatchewan and devolution of research farms, e.g., Onefour.
- Problem: Sale of Crown leases in Saskatchewan.
- Disconnect between surface land managers desires and subsurface disposition process (i.e., surface and subsurface).

Multi-jurisdictional Bridging Agency Issues

- Convince Premiers that this will pay off politically.
- Consider implications of cost to government (e.g., ministerial order, Cabinet screening, caucus approval).
- Need to get industry advocating for sagebrush ecosystem conservation.
- Species of common conservation concern (another initiative)—more likely to get traction for multiple species focus (shrub-steppe).

Resourcing Issues

- Habitat is the issue that has placed greater sage-grouse where it is.
- Existing heavy emphasis on management of population and not on habitat.
- Lots of funding for population work; not for habitat management.
- People think that government manages land, but ranchers and industry do most on the ground management (with some exceptions, e.g., parks).
- Management and restoration – inadequate emphasis on habitat management and restoration actions.
- Failure of government to surrender power to collaborative processes and fund them adequately.
- Need to support collaborative processes like Sage-Grouse Partnership, Ranchers Stewardship Alliance, Soddies.

- South of the Divide Species at Risk Initiative (multi-.species federal provincial action plan) could work if properly resourced and authorized
- There are legal and funding mechanisms available in Species at Risk Act and Alberta Land Stewardship Act to help.
- Organized collaboration supports good governance of ecosystem conservation and long-term sustainability.
- Government enables good governance but governance is not just government.

Legal Protection for Habitat Issues

- Conservationists do not have the whole pie, only crumbs; we need to grow the sagebrush/grassland habitat pie to what is needed for greater sage-grouse and others.
- Lack of conservation areas – need for large legislated /conservation protected areas (e.g., heritage rangelands) that prevent industrialization of critical habitat.
- Need legislated areas that prevent industrialization but maintain ecosystem, ranching, people still on the land deriving economic benefits, long-term sustainability.
- South Saskatchewan Regional Plan – has not yet recommended protection; barriers to success include property rights issues; existing perverse incentive to destroy habitat.
- Legal and regulatory deficit – need laws not guidelines.

Voluntary Stewardship for Habitat Issues

- Most critical habitat is on public land and most is grazed by cattle or bison.
- Saskatchewan ranchers have 100% control on public lands.
- Alberta ranchers have a more structured system.
- Montana lands have some Bureau of Land Management ownership, some private.
- Rangeland stewardship approaches are different in different jurisdictions.
- 15 different initiatives working independently on collaborative initiatives (NSSI, Crossing the Divide, WWF northern plains, TNC); no effective coordination, minimal communication; overlapping objectives that could deal with biodiversity GSG conservation, remediation and stewardship.

Other Issues

- Data gaps on sagebrush and fire
- Lack of fencing policy
- Need more consistent monitoring, more frequent monitoring.
- Water management—500 impediments to 1800 along watercourses in Alberta (affects overflow and blowout sites where sagebrush) – data gap on effects.
- Red tape around "historic" structures removal

Key Issues

This discussion led to the identification of the following six key issues pertinent to the scope of this working group that are negatively impacting the greater sage-grouse in Canada:

1. Inadequate mechanisms/follow-up actions at multiple jurisdictional scales to conserve (i.e., remediate and steward) sagebrush ecosystems;
2. Little support for collaborative processes and poor recognition (financial and authority) of day-to-day land managers and their contributions to biodiversity conservation;
3. Perverse incentives and policies that promote habitat degradation and destruction (industrial and agricultural);

4. Lack of incentives and policies/laws that encourage northern sagebrush steppe conservation, remediation and stewardship;
5. Poor government commitment support for sub-regional conservation initiatives and organizations; and
6. Fragmented/independent trans-boundary initiatives at multiple scales for conserving, remediating, and stewarding northern sagebrush steppe.

Addressing the Issues

Group members discussed considerations for improving governance and related issues.

Organization/Delivery

(to counter fractured jurisdiction and competing mandates through communication)

<u>Enabling Policies</u>:

1. Require effective federal and provincial government environmental policy integration that makes conservation, remediation and stewardship of northern sage steppe a priority.
2. Need policies that enable on the ground action (MOUs, payment systems, authorizations).

<u>Capacity</u>:

1. Must have human resources, training/technology transfer/extension.
2. Need commitment to long-term funding.

<u>Communication/Collaboration</u>:

1. Effective (connected) bridging organizations at local, regional and trans-boundary levels focused on conservation, remediation and stewardship of the northern sage steppe.
2. Land managers (individuals and organizations) manage landscapes for sustainability and conservation, remediation and stewardship of the northern sage steppe.
3. Effective communication through engagement and employment of people with authority who can develop trust and respect.

What Do We Need for Good Governance?

The group characterized the existing situation as follows:

- Have national recovery strategy.
- Emergency Order will be law.
- National – ensure SARA compliance; monitoring outcomes (also provincial).
- International agreements, e.g. 2002, Canada and US shared concerns for species at risk (Species of Common Conservation Concern).
- There is a bilateral agreement between Saskatchewan and Feds on implementation of SARA; this was used for south of the divide multispecies action plan (SOD).
- There is a draft bilateral agreement with Alberta and Feds but not in place.
- Alberta has Resource Action Groups (Sage-Grouse Recovery Team).
- Landscape Conservation Cooperatives (LCCs) – one exists for BC/Washington (not for sage-grouse); could do in Northern Sagebrush Steppe.
- LCC for Plains and Prairie Potholes exists for this area but does not involve Canada much.

Ideas on how to organize people to plan and deliver:

- Establish an organization that provides effective communication and coordination and engagement in a Canadian and trans-boundary context.
- Would achieve our objective of communication and coordination.
- Has been difficult for federal government to be involved under WAFWA – this might be addressed in big initiative.
- Need interprovincial working group to deal with northern sagebrush steppe, greater sage-grouse, SARA species, provincially listed species and other species of common conservation concern.
- Develop concept (federal and provincial agencies) (not just lands/wildlife but also energy and agriculture agencies).
- Wildlife, public lands, energy, agriculture agencies.
- Under that umbrella, stakeholders need to be represented (ranching, ENGOs, energy industry, local governments).
- Need for Premiers and PM and Western Governors to be on same page, committed coordinated, etc.
- Informal meeting to come up with proposal (to get provinces together and propose to Premiers) to formalize an interprovincial body with federal involvement; provincial co-chairs.
- Wildlife agencies could get together and draft this.
- Needs authority (charge and reporting) and mandate.
- Need for technical group (formalized, funded).
- Western Association of Fish and Wildlife Agencies might be a coordinating body that already exists (range-wide sage-grouse conservation team).
- Northern Sagebrush Steppe Initiative (under WAFWA)—needs to be informed by our interprovincial body; MOU exists for NSSI-area in Montana south of Grasslands National Park is a priority area for greater sage-grouse.

Other thoughts:

- Need is for immediate on the ground action.
- Need legislated conservation landscapes which focus on maintaining or restoring the best of what's left and needed connectivity.
- Need protection for PFRA pastures being devolved to provinces.
- South Saskatchewan Offset Pilot (restoring degraded or cultivated areas to native sagebrush habitat) is an example of on the ground action that could be focused in 42 townships in SE Alberta (and also needs to be developed for SW Saskatchewan).

Objectives

1. **<u>Develop effective communication and coordination</u>** and engagement for conservation, remediation and stewardship of northern sagebrush steppe;
2. **<u>Secure societal support</u>** for conservation, remediation and stewardship of the northern sagebrush steppe;
3. **<u>Eliminate perverse incentives</u>**;
4. **<u>Develop and support bridging organizations</u>** and collaborative processes;
5. **<u>Secure long-term commitments</u>**;
6. **<u>Promote legislation/policy to pay for ecological goods and services</u>** (Saskatchewan);

7. **<u>Establish legislated areas for conservation, remediation and stewardship</u>** of northern sagebrush steppe (prevent industrialization but maintain ecosystem, ranching, people still on the land deriving economic benefits, long-term sustainability); and
8. **<u>Establish big initiative</u>** for restoring northern sagebrush steppe and connectivity and paying people to do it (private land focus).

Action

Premiers' task force will be 2-3 people (from Alberta and Saskatchewan). Formation of interprovincial Premier's task force to coordinate northern sagebrush steppe conservation, remediation and stewardship (authorized by Premiers and endorsed by federal Minister of Environment).

1. Focus will be on finalizing charter/Terms of Reference for interprovincial working group that will coordinate delivery of sagebrush steppe conservation, remediation and stewardship.
2. Interprovincial working group includes environment/wildlife, public lands, energy, and agriculture agencies.
3. Under that umbrella, stakeholders and land managers will be represented (ranching, ENGOs, energy industry, local governments).

<u>Collaborators</u>:

Will network with/through:

- Western Governors Association
- Western Association of Fish and Wildlife Agencies might be a coordinating body that already exists (range-wide sage-grouse conservation team).
- Northern Sagebrush Steppe Initiative (under WAFWA)—needs to be informed by our interprovincial body; MOU exists for NSSI-area in Montana south of Grasslands National Park and is a priority area for greater sage-grouse.
- Possibly Landscape Conservation Cooperative (LCC) for Plains and Prairie Potholes (exists for this area but does not involve Canada much).
- Many other initiatives at the local or watershed level.

***<u>Action Request/Rationale</u>*:**

- Inadequate government support/coordination on governance for northern sagebrush steppe species and habitats.
- SARA, Critical Habitat, and Emergency Order are drivers of need for good governance of northern sagebrush steppe.
- Presents opportunity to build upon what we have been doing/trying to do.
- Need to think of big picture, not just a single species.
- There are many species of concern (SARA, provincial, species of common conservation concern under 2002 agreement, etc.).
- Large landscape of northern sagebrush steppe needs conservation, remediation and stewardship in order to meet stated government objectives.
- Need a bridging organization that provides effective communication and coordination and engagement in a Canadian and trans-boundary context.
- South Saskatchewan Regional Plan is being formulated in Alberta.
- Planets have never been better aligned to get this done.
- Need for immediate on the ground action.

Immediate Subtasks Needed to Establish Task Force:

1. This workshop makes this a prime recommendation to discuss concept with two Premiers and federal minister; recommendation is “to establish an interprovincial working group for conservation, remediation and stewardship of the northern sagebrush steppe ecosystem”.
2. Working group at this workshop will prepare draft considerations for briefings/ rationale for interprovincial working group; frame as outcome from this workshop; "Premiers’ Task Force" will finalize Terms of Reference
3. Discussions/Information to Premier Level:
   - Federal and Alberta ministers attending event at zoo next week will be made aware of initiative; could be an action request.
   - Ministers and ministries need to be informed (at top, bottom and middle of ministries) – need to prepare briefing notes (e.g., Beatriz Pietro Diaz from Saskatchewan and Pat Fargey from Alberta).
   - Senior administrators with wildlife and energy agencies and CEOs of energy industry and leaders of ranching community and ENGOs to support interprovincial task force and the interprovincial working group separately to Premiers of Alberta and Saskatchewan.

Risks:

- Risks are ongoing legal challenge could put some parties offside or lead to paralysis.
- Risk of Failure to Launch—but moderate chance of success for conservation, remediation and stewardship of sagebrush steppe if it is initiated.

Timeline: 3 to 6 months to establish

Resources Needed:

- $250,000 annually between three jurisdictions
- Secretariat, consultants, GIS, travel

Priority: This is the BIG priority.

APPENDIX 1:
Interprovincial Partnership for Conservation, Remediation and Stewardship of the Northern Sagebrush Steppe
Draft Mandate

Seeks to:

- Build awareness of common interests and issues in the Northern Sagebrush Steppe Ecosystem;
- Integrate greater sage-grouse conservation into land use planning;
- Build relationships and opportunities for collaboration and cooperation among agencies, land managers/owners, industry and conservation organizations; and
- Build consensus on actions needed to conserve, remediate and steward biodiversity and ecosystem function and services and identify priorities for resource allocation.

Tasks include:

- Building public awareness of the importance of the Northern Sagebrush Steppe Ecosystem;
- Identifying individual and cumulative effects of human activities and change on the Northern Sagebrush Steppe Ecosystem;
- Delineating priority areas for conservation, remediation and stewardship of biodiversity and ecosystem services;
- Identifying and communicating actions required to avoid or mitigate impacts of human activities;
- Identifying and communicating actions to support the conservation and recovery of species at risk;
- Identifying and communicating actions for conserving other species and ecosystem structure and function; and
- Fostering shared responsibility for conservation, remediation and stewardship of the Northern Sagebrush Steppe.

APPENDIX 2: Considerations for Briefings

Issue Statement

- Federal Government is imposing Emergency Protection Order for Sage-Grouse in February 2014 and impending declaration of Critical Habitat – sets a precedent and impacts areas of provincial jurisdiction.
- There is stakeholder (energy industry, ranchers, agriculture, municipal governments) concern for how they will be impacted.

Background

- Sage-grouse are going to zero quickly (fewer than 10 years projected to extinction).
- Existing commitments from governments of Alberta, Saskatchewan, and Montana for conservation of northern sagebrush steppe.
- Several uncoordinated efforts exist in multiple jurisdictions for conservation of the northern sagebrush steppe.
- Many species of conservation concern, including other SARA listed species and those in international agreements.
- Potential for future impacts under SARA, including litigation.

Recommended Actions

- Formation of Premiers' Task Force charged with developing the terms of reference for an interprovincial working group on northern sagebrush steppe conservation.

Expected Outcomes

- Opportunity to address issues on landscape-wide basis
- Protection of multiple species of concern
- Address stakeholder concerns in a fair and coordinated manner
- Certainty for industry
- Covers legal obligations under the Emergency Protection Order as well as future potential issues arising from SARA-listed species

Greater Sage-Grouse in Canada Population and Habitat Viability Assessment Workshop

Calgary, Canada
14 – 17 January 2014

Final Report

SECTION 6

Population Management Working Group Report

Working Group Report: Population Management

Members: Cam Aldridge, Kelly Boyle, Typhenn Brichieri-Colombi, Jamie Dorgan, Ryan Fisher, David Gummer, Natasha Lloyd, Axel Moehrenschlager, Joel Nicholson, Bob Peel Mike Schroeder, Judit Smits, Jake Veasey, Lief Wiechman

This working group focused on population management strategies that could be implemented to improve greater sage-grouse population viability for the Canadian populations and minimize their risk of extinction. Group discussions addressed translocation strategies and options as well as the potential establishment of a captive breeding population as a source population as well as an assurance population. Discussions moved quickly due to time limitations, and a few participants submitted amended opinions or additional information after workshop – these comments are noted appropriately in this working group report. The group began its discussion with development of the following problem statement:

Problem Statement
Canada's greater sage-grouse populations are rapidly declining, due to high mortality rates and low reproductive success. Without significant intervention, the greater sage-grouse (GSG) may go extinct in Canada in the next 2-5 years. Habitat conservation, enhancement, and stewardship should be the top priority for conserving this species. As an interim measure, population management scenarios are also considered in an attempt to offset losses in the wild population.

CONSERVATION ROLE: Assurance/Source Population

In order to preserve the existing genetic diversity of Canada's GSG, a captive population should be established. This captive flock would serve as an assurance population should the wild Canadian population go extinct. It would also provide individuals for future reinforcement or reintroduction efforts, if needed. Additional benefits of an assurance population of GSG include opportunities for research and education.

***GOAL:* Provide a genetic "safety net" for Canadian greater sage-grouse, in the event that they go extinct in the wild.**

OBJECTIVE: Establish and maintain a captive population of GSG with a reasonable degree of genetic diversity until the wild population is sustainable. Ensure this population is capable of retaining 95% of the source population's genetic diversity for 50 years.

Program Components: 40 founder individuals (20 male, 20 female), from eggs removed from the wild over several years, to establish a population in captivity and retain genetic variability of 95% for 50 years.

Risks:

- Removal of individuals from the wild may have a negative impact on the source population (e.g., by directly reducing the growth of the population, or by disturbing natural behaviors such as nesting and foraging).
- Individuals brought into captivity may be subject to new threats associated with captivity (e.g. disease transmission in close quarters).
- Health risks in captivity are hard to manage.

- Genetic drift in wild and captive populations.
- Captive parents are often not as “good” as wild parents.

Resources Needed:

- Captive breeding facility (1 or more)
- Field operations
- Political will
- Cross-jurisdictional support
- Long-term funding
- Expertise
- Landowner support at source location
- Studbook
- Meta-population management plan

CONSERVATION ROLE: Translocation

To use translocation (moving individuals from wild and/or captivity) as a tool to accomplish population management goals (demographic and genetic), focusing on increasing greater sage-grouse numbers in the wild in Canada. The group prioritized reinforcement (of existing populations) over reintroduction (into new habitat) as a conservation translocation strategy at this time but recognize that reintroductions might be needed in the future.

***GOAL:* Increase (reinforce/augment) the wild populations of sage-grouse in Canada to help sustain the recovery efforts in order to keep this species on the Canadian landscape.**

OBJECTIVES – see details below:

1. *Identify genetically and demographically appropriate source populations (both wild and captive source populations).*
2. *Identify suitable areas for release.*
3. *Identify main age groups to augment and risks for each age group.*
4. *Identify release techniques and timing.*
5. *Monitor survival of released birds and reproduction of released birds.*

OBJECTIVE 1: Identify genetically and demographically appropriate source populations for wild translocations, captive breeding, and population augmentation.

Risks (wild-to-wild translocations):

- Approval from Montana/other states/other provinces
- Decline of source population
- Translocated birds may impact genetics of recipient population (into which birds are released)
- Demography of source population
- Phenotypic differences between source and receiving populations

Risks (captive-to-wild translocations):

- Difficulty locating founder nests (if using eggs)
- Difficulty obtaining appropriate male/female ratios
- Compromising wild females and eggs
- Captive birds may expose wild birds to increase disease and predation risk
- Reinforcement efforts may reduce the perceived urgency for habitat improvement
- Captive-reared chicks have lower survival in the wild

It was noted that the risks associated with wild-to-wild translocations are substantially lower than those associated with captive-to-wild translocations. There is substantial literature documenting wild-to-wild translocation to guide management; this is not available for captive-to-wild translocation.

Resources:

- Long-term funding
- Collaborations
- Permits
- Equipment/Staff
- In-kind support (expert knowledge)
- West Nile Virus vaccination development for GSG and availability of vaccinations

Challenges:

- Weather
- International transport
- Animal welfare
- Vaccinations

OBJECTIVE 2: Identify suitable areas for release.

Risks (wild-to-wild translocations):

- Difficulty finding/reaching active leks
- Identifying historical active leks for release, when they are actually inactive
- Weather (i.e., stress on birds, access to sites)
- Incorrectly identify release site as a source habitat when it is in fact a sink habitat
- High concentration of predators
- Landowners feeling threatened
- WNV outbreak and other diseases
- Structures/noise/sensory disturbances
- Habitat issues that resulted in the original declines and/or extirpation have not been sufficiently addressed.

Risks (captive-to-wild translocations):
In addition to most of the risks listed above:

- Finding brooding females
- Finding nests for egg augmentation
- Habitat recognition by foreign birds
- Inability of captive-reared birds to adequately avoid predation risk.
- Inability of captive birds to adequately nest and raise chicks
- Habitat issues that resulted in the original declines and/or extirpation have not been sufficiently addressed.

Resources:

- Habitat suitability map
- Adequate lek surveys
- People/equipment/permits/money

Challenges:
- Access
- Weather
- Permission
- Identifying appropriate future release areas (in light of climate change)

OBJECTIVE 3: Identify age groups to augment and outline risks for each age group.

Risks (wild-to-wild and captive-to-wild translocations):
- Predation
- Negative effects of transmitters on translocated birds plus transmitter malfunction
- Increasing clutch size beyond typical/natural clutch sizes
- For adult releases, movement from release site based on stress
- Age/sex of dispersing birds
- Abandonment of nest by hens

Risks (captive-to-wild translocations only):
- Lack of fitness of released chicks
- Behavioral differences between captive and wild chicks
- Inability of captive birds to adequately avoid predation risks.
- Finding broods with chicks less than 10 days old

Resources:
- Staff/equipment/money
- Detailed predation study
- Transmitters

Challenges:
- Differences in opinion regarding animal welfare and predator control
- Weather
- Capturing resident birds to transmitter

OBJECTIVE 4: Identify release techniques and timing of release.

Risks:
- Predation
- Movement of released birds due to stress, searches for other birds, and searches for recognizable landmarks
- Mortality/injury birds during transportation
- Time in captivity
- Collision with soft release (cages)
- Stress
- Aggression
- Spring release: low rate of nest success
- Summer release: movement of broods and lack of experience by young birds
- Winter release: logistical constraints

Resources:
- Predator control strategy
- Supplemental feeding
- Transmitters
- Equipment

Challenges:
- Sufficient staff to run release protocol
- Transportation of birds
- Equipment/money
- Weather
- Access to release sites

***OBJECTIVE 5*: Monitor survival and reproduction of released birds.**

Risks:
- Loss of transmitters = inability to monitor released birds effectively
- Continued disturbance to all birds

Resources:
- Funding
- Expertise
- Manpower
- Field equipment
- Data management system

Challenges:
- Obtaining sufficient funding for long term monitoring
- Retaining public interest and political support after birds have been translocated

Discussion

Major Considerations for the Development of a Captive Population of GSG

It was agreed that establishing a captive breeding population is necessary to prevent further loss of Canadian GSG genetic variation, as well as to provide a future source for reinforcement of the wild population. Immediate action is required – hesitating will only reduce the number of birds/eggs in the source population and the genetic variation among remaining individuals for future efforts. A well-managed captive population will also ensure that birds are available for future reinforcement or reintroduction efforts, if necessary.

Where to obtain founder individuals?

Over the course of the workshop, considerable debate ensued over the possible genetic differences between Alberta, Saskatchewan, and Northern Montana GSG "populations", as well as between these three "populations" and those that are south of the Milk River in Montana. Current genetic data (presented by Krissy Bird in her paper; Bush *et al.* 2011. *Conservation Genetics* 12:527-542) suggest that birds north of the Milk River are part of a single population. However, these results may not tell the whole story, given that some genetic differentiation may not have been captured by the 19 or fewer microsatellite loci used in that study. There was concern that Canadian birds may be locally adapted to the silver sage brush relative to more southern populations that utilize big sage brush habitats. It was generally agreed that maintaining Canadian GSG genetics is important, based on what we know now. There is the possibility of managing separate populations in captivity, until the population structure of northern and southern GSG is further clarified.

It was also recognized that we may find ourselves in a "beggars can't be choosers" situation, given the difficulty in finding and obtaining eggs or individuals in the wild. The "best" source population (genetically) may not be available or may not be able to withstand immediate removal of eggs or individuals. Obtaining birds outside of Canada may also be difficult because we are dependent on other jurisdictions to allow us to access and remove birds. This will likely hinge on the population status in Montana (increasing or declining) and on receiving the proper permits needed to bring eggs/birds across the international border. Depending where the source birds come from, we may also need to consider potential behavioral differences between source and wild birds.

How many founder individuals are required for a captive population?
Given that it is not feasible to capture all of the allelic diversity in the wild, the CBSG population modelers suggested that 20 males and 20 females (40 unrelated individuals) would be a suitable goal for establishing a founder population (from eggs). Sage-grouse have a fast generation time; therefore genetic diversity may be lost rapidly in a captive population. Bringing in 10 individuals a year for 4 years is preferable to bringing in all 40 at once because a certain percentage may be lost in the first year or so as techniques are developed (CBSG, pers. comm.). Husbandry techniques still need to be discussed.

***Post-Workshop Comments**:*
From L. Wiechman (LW): Realistically, I would recommend trying to collect 20-30 eggs from 3-5 females the first year. Any of those eggs that hatch and become adults will be the start of your founder population. At that point, genetics can be determined to see how many of those individuals should be allowed to be part of the "genetic" founder with the rest becoming 'egg-producers' for the wild brood augmentation efforts. Then in subsequent years, a smaller amount of eggs can be selected to help round out the founder population of 40 as well as fill in for captive grouse that die in captivity and need to be replaced.

At what life stage should individuals be obtained from the wild for captive breeding?
Completely wild animals are much more difficult to care for in captivity than those that are born/hatched in captivity. It is therefore preferable to obtain GSG eggs from the wild and hatch them in captivity. These chicks will be habituated to human presence and have much lower stress levels than captured wild adults. In establishing a captive population, "tame" founders are preferable for ease of care and maximizing reproductive success, if they do well at breeding with other sage-grouse. These founders would not be released into the wild, but their offspring likely would (Veasey and Dorgan, pers. comm.), and care would be taken to promote natural behaviors in released birds.

The general consensus at the workshop was that adult birds should not be brought into captivity unless absolutely necessary.

How readily can we locate nests in order to collect eggs?
Greater sage-grouse nests can be difficult to locate, but odds may increase with the assistance of experienced field technicians (Wiechman, pers. comm.). However, there is a concern that Canadian populations are already so low that the likelihood of finding enough wild females

(either prior to or during nesting season) is also very low. Tracking females via telemetry would greatly increase the odds of locating nests, due to the extremely low density of birds in the wild. However, the only birds currently being tracked in Alberta are those that were recently translocated from south of the Milk River (a population thought to be genetically different from Canadian GSG). In terms of genetic composition, these birds might be the least preferable source for establishing a captive flock (though there is still some disagreement behind this issue). But given the urgency of the situation, and understanding that these translocated females will have mated with local males, it was agreed that their offspring should be included in the captive breeding program. Any eggs taken from the nests of these females can be managed separately in captivity. The risk of not finding nests of local females is too high to exclude the translocated females. Efforts should also be made to place transmitters on more birds as soon as possible (either in Alberta or Saskatchewan) to facilitate the location of more nests in the future.

How many eggs should we collect from the nests that are located?
Although our goal is to obtain 40 founder individuals, it is not possible to collect and hatch a large number of GSG eggs in the immediate future. The Calgary Zoo is the only facility identified thus far, and it does not currently have infrastructure designed specifically for sage-grouse (although existing pens are currently being retrofitted to accommodate sage-grouse, and new captive breeding facilities will be built for 2015; Peel, pers. comm.). There are also concerns about how pulling eggs from nests will impact the wild population, so a cautious approach was encouraged, building on work previously done by Wiechman and colleagues in Colorado. Close monitoring of hens from "collected" and "uncollected" nests was suggested to detect negative impacts over time.

The decision of whether to collect entire clutches from nests or a sample of eggs from each nest was unresolved. Some argued that removal of entire clutch was the wiser choice, provided the eggs are taken early enough in the season to allow the female to re-clutch. If just a few eggs are removed, there is the risk that the female will abandon the nest, resulting in the loss of the remaining eggs; however, this risk can be minimized with the use of decoy eggs to swap partial clutches. Others emphasized genetic considerations once the basic methodology has been perfected – eggs from a variety of nests are preferable. Ultimately, the decision of whether to pull partial or full clutches may depend on the number of nests located and the timing within the breeding season. Risk of abandonment may also be site specific (Schroeder, pers. comm.). Careful monitoring of female behavior after egg removal (e.g. nest abandonment, re-clutch, or no apparent change in behavior) is recommended, in order to modify the protocol accordingly.

It was generally agreed that the removal of a few eggs (never more than half the clutch (or one more than half in an odd-numbered clutch size), and depending on whether the female is laying or incubating) from located nests would have limited impact on the population, given the very low probability that those eggs would survive in the wild. However, there are still risks with the removal of a few eggs.

***Post-Workshop Comments**:*
M.A. Schroeder (MAS) commented that this would assume that the hatching rate for eggs brought into captivity was very high (though LW believes that a 90% expected hatching success is difficult). He estimated that there is roughly a 5-10% chance that the egg wouldn't have hatched in the wild (even if the nest were successful) and that it is likely to be a greater risk in captivity. Because of the high cost of telemetry, location of nests, and risk of hatching

eggs in captivity, it might make sense to collect the whole clutch. In addition, multiple hatched chicks in a clutch will likely improve the process of socialization in captivity. As such, the position is still debated.

Major Considerations for the Release of Captive Individuals into Wild Populations

At what life stage should individuals be released into the wild?
Considerations for the appropriate age to release captive bred GSG pertain to survival rates in the wild and the logistical constraints associated with rearing birds in captivity. At present, the probability of a wild egg surviving to breeding age is 6%, based on the modeling approach that is lower than actual field research conducted in GSG (see Table 1, Scenario 1). Survivorship of wild adults is considerably higher. One might assume that releasing older birds would improve their odds of survival; however, LW reported the opposite trend in his work with Gunnison sage-grouse captive breeding and release in Colorado. Released older chicks that were reared in captivity will have higher mortality than their wild counterparts, and may need training in predator avoidance and foraging prior to release. LW noted that captive-reared Gunnison sage-grouse tended to be "lousy" parents – they would protect the chicks if a human entered the enclosure, but otherwise paid little attention to their young. It may also be difficult to obtain and provide an appropriate diet for captive-reared chicks that are intended for release, though Wiechman and colleagues did not have any difficulties with this. Captive bred or reared birds may also become habituated to humans, but the consequences of this (once the birds are released into the wild) are not clear, though most probably will result in death. Protocols for decreasing the chance of habituation on humans for birds intended to be released should be identified and improved upon, and used in the captive facility.

The age of captive–reared GSG chicks at release would have a large impact on the method of release. The working group agreed that releasing eggs or young chicks (less than 7 days) would be the preferred method of reinforcement (based on the experience of LW and others). By supplementing wild nests with additional eggs, we could bypass the difficulties associated with raising birds in captivity (e.g., disease, behavioral issues, human habituation, foraging and diet constraints) and allow chicks to learn from wild parents. Under current conditions, supplementing chicks or eggs would have minimal impact on the growth of the wild population. However, it is hoped that the rapid decline of the population could be slowed if egg/chick supplementation is accompanied by predator control and habitat improvement.

***Post-Workshop Comments**:*
From MAS: I believe this strategy would be very difficult, extremely risky, and logistically not feasible. For example, what if the eggs are not at the same stage of incubation (off by 1-2 days). The hen could walk off with only a portion of her brood. Which portion would it be? It depends on which errors we make. In retrospect, the most logical strategy is to replace entire clutches. LW agrees with respect to replacing eggs; releasing chicks post-hatch is a different situation and would be preferable to replacing eggs.

Our ability to release GSG as eggs would depend on careful synchronization of wild and captive oviposition and incubation, which will be very difficult. As well, the number of eggs placed in a nest would depend on the number of wild eggs already present. Ten or eleven eggs are thought to be the maximum number a hen could effectively incubate (Wiechman, pers. comm.), given the maximum brood size observed in the wild. Supplementing too many eggs/chicks in a nest could increase predator detection and have negative consequences for the wild individuals in the brood. Therefore it was recommended that the addition of eggs into a clutch would never cause that clutch to exceed 9 or 10 eggs. A similar maximum of 9-10 chicks would be in place when releasing young chicks into existing already hatched broods. If releasing chicks, 1 week of age post hatch (+/- 2 days) is believed to be the best period of time to do so because of the marked decrease in survivorship observed for Gunnison sage-grouse if chicks are released at 3 or 5 weeks of age or later (Wiechman, pers. comm.). Whether releasing eggs or chicks, the method would involve monitoring the wild female and supplementing the nest with eggs in her absence. This method is preferred to minimize stress and reduce the likelihood of nest abandonment in response to human disturbance. It was also suggested that supplementing nests with eggs is best done early in the season, which would allow birds to re-clutch.

In addition to the risk of stressing the wild hens that remain in Canada, there is also a concern that manipulating clutch or brood sizes in the wild (via egg or chick supplementation) will attract predators. Corvids are quick to note when human presence is associated with food and may follow researchers who are releasing chicks or eggs into nests (Schroeder, pers. comm.). As well, population modeling during the workshop showed that manipulating clutch size, in the absence of predator control, could reduce the mean time to extinction but ultimately would not reverse the negative growth of the population, no matter how many nests were supplemented. The importance of reducing predation and improving habitat cannot be overstated.

Release of captive bred juveniles/adults was not completely ruled out as an option. If juveniles or adults were to be released, it would be preferable to release them onto leks during the mating season (to encourage the birds to remain in the area and model the behavior of their wild counterparts), or perhaps in the winter, due to lower predation pressure and flocking behavior of resident birds during the colder months. Minimizing exposure to predators prior to the nesting season was also a consideration – releasing birds just before breeding season should increase their likelihood of surviving to reproduce. However, releasing the birds at a younger age is still the preferred method, to reduce the logistical, health, and (potentially) behavioral consequences of breeding birds in captivity until adulthood. The release of adult, captive-bred birds should not be explored until other efforts have been refined.

How can we improve the survival of released individuals (in addition to habitat improvement)?

Given the high mortality rate of GSG in the wild, reinforcement alone cannot reverse the steep and steady decline of Canadian GSG populations. The working group agreed that further intervention would be required for captive-bred and released individuals to survive and to reproduce. Much discussion surrounded the possibility of protecting the hens and broods that have been supplemented with eggs or chicks, at least until the chicks reach 4 weeks of age (at which point their odds of survival increase significantly (Table 2)).

Protection of GSG chicks could be accomplished by a human "bodyguard", tasked with monitoring the supplemented brood and deterring predators. This idea formed out of discussions about a foraging experiment with shepherded Gunnison sage-grouse. However, LW emphasized that this experiment required imprinting of Gunnison's chicks onto humans – something that is best avoided with greater sage-grouse released into the wild. Furthermore, the imprinted Gunnison's sage-grouse chicks did not all survive to adulthood, and some were lost even in the presence of a shepherd. It would likely be difficult to closely monitor a sage-grouse hen and her chicks in the wild. Physically guarding wild birds would be costly and could also greatly increase their stress levels, as the bodyguard would have to remain in fairly close proximity to locate and continually observe the brood and at all hours of the day. The use of temporary enclosures was posed as an alternative to bodyguarding birds that are constantly moving and difficult to locate. Enclosures that are open overhead could be placed around birds during the day, allowing the hen to fly out but also protecting the chicks from terrestrial predators. A bodyguard could then remain nearby, watching for avian predators. However, concerns were raised about the possibility that hens would have trouble re-entering the enclosure (previous experiences of the group suggest that the hen would simply walk around the enclosure looking for an opening, despite having easily flown out). Alternately, an enclosure may be placed overnight, when the hen is roosting. This method may pose risks to the hen however, if she flushes in the night and hits the enclosure. It was recommended that those working with Attwater's prairie chicken should be contacted and involved.

Additional modifications to the enclosure/body guarding method may include using electric fencing, hiring landowners and/or their young adult children to monitor the broods, and actively reducing predator density in the area by culling predators on sight.

No consensus was reached on the best method to pursue. Bodyguarding/shepherding and the use of predator exclosures will be further explored as options.

How can we minimize the genetic consequences of bodyguarding a subset of nests?
Actively protecting particular nests in the wild to improve their survival is essentially a form of artificial selection. The working group agreed that it is important to maximize the genetic diversity present in protected nests if fencing or bodyguarding is employed in the future. One way to achieve this is by swapping eggs between wild nests and/or between captive and wild nests. The eggs in a protected nest could be from multiple different wild parents, as well as from the captive population. Chicks may also be swapped among broods. As mentioned previously, egg supplementation or swapping would ideally be done when the hen has left the nest to forage (e.g., first thing in the morning).

How can we maximize the number of individuals released into the wild?
Releasing GSG eggs or chicks into the wild and/or protecting them from predators depends entirely on the ability to find nests in the first place. At present, there are six translocated females in Alberta that have GPS transmitters, but not all will necessarily nest this year. Consequently, it was suggested that surrogate birds be used to incubate captive-bred eggs or chicks in the wild. Surrogate birds could fall into one of two categories: 1) sharp-tailed sage-grouse from the local area; and 2) greater sage-grouse from Wyoming (or elsewhere). Using sharp-tailed grouse as surrogates was generally dismissed by the group, given the likelihood of imprinting GSG chicks onto sharp-tailed grouse, which could lead to hybridization (hybridization has already been observed in Alberta, so the likelihood of this happening is high). Using GSG from Wyoming was viewed more positively – these translocated birds could have their primary feathers clipped and be fitted with transmitters to facilitate their capture after the nesting season. However, concerns were raised over the risk of genetic introgression if these birds were to mate with local males. In addition, there was mention that birds in this category could receive two transmitters. The first would be a solar-power satellite transmitter that would allow the bird to be tracked over long distances (similar to what is currently being used). The second transmitter would be a necklace type that could be used effectively in close proximity. Each transmitter would serve as a backup to the other, in

the event of failure. The general consensus of the group was to further explore the option for using non-native GSG as surrogate brooders in the wild, based on existing proven methodologies.

Major Considerations for Wild-to-Wild Translocations (from Montana to Alberta)

Genetics of source population
The biggest discussion around translocating birds from Montana concerned population genetics. During her presentation, Krissy Bird (KB) explained that birds from Montana that are located south of the Milk River (SMR) belong to a different sub-population than those from the North of the Milk River (NMR). In response to a question regarding where individuals should come from for translocations or captive breeding, KB indicated that preference should be: 1) Alberta, 2) Saskatchewan, and 3) Montana, NMR. To date, wild birds that have been translocated to Alberta have been taken from the SMR population and might therefore have altered the genetics of the Canadian/NMR population. There was some discussion regarding whether J. Nicholson (JN) and colleagues should continue with translocations from the SMR or other populations; however, the group did not agree upon a plan of action. Some people believed the preferred action would be to continue the wild-to-wild translocations, but this depends on the status and availability of birds from the Montana population. Wild-to-wild translocations could be done in combination with other actions (i.e., simultaneous with initiating a captive breeding program). JN and colleagues have already developed translocation protocols for moving birds from Montana into Alberta; however, the best source population for future translocations is still up for debate.

Working agreements with Montana
We need to keep up great collaborations between jurisdictions. JN has been working with Montana, and we need to continue cross border communication. It was commented that JN and Beatriz Prieto Diaz should attend Range-wide Interagency Sage-grouse Conservation Team and WAFWA Sage- and Columbian Sharp-tailed Grouse Working Group Meetings. While there is still debate about whether wild-to-wild translocations could be continued, translocations are the cheapest and easiest way to increase the wild Canadian population, provided Montana will grant permits for birds used in translocations.

All agencies involved will require funding for translocations. JN estimated that each translocation they have already done cost approximately $50,000. Along with monetary investment, we need in-kind support, staff and equipment from all agencies. We also need and have expert knowledge for this endeavor.

Release of wild birds
For wild-to-wild translocations, it was agreed that translocating adult birds is the best strategy. One risk associated with releasing adults is the potential for large-scale movements after release due to stress on the translocated birds. There was no knowledge of whether males or females were more prone to large-scale movements after release. We have to consider the social aspect of this species: GSG are a lekking and flocking species and seem to seek other conspecifics out on the landscape. Birds have been seen to “explore” their surroundings up to a certain distance around a release site, and they may also find historic lek sites. It is more likely that a released bird will remain close to the release site if they encounter conspecifics. Thus if we are reintroducing birds instead of reinforcing populations, one strategy might be to release males at the lek first and then release females after.

Animal welfare was also identified as a concern for any translocations. In wild-to-wild translocations, birds must be transported in padded crates or cardboard boxes to minimize the risk of injury. If transporting birds across the US-Canadian border, the most direct route should be chosen. In general, it is critical to keep transport time as short as possible and at least under 36 hours (JN - translocation protocol). There is a risk of heat stress during transport, and giving watermelon to captive birds during transport was suggested as a means of providing fluids. It was also noted that translocated birds that are fitted with transmitters may be at increased risk of mortality and injury.

Timing of capture and release was also debated. Spring might be the best or easiest time to find and catch adult birds for wild translocations because they are displaying or mating on their leks. However, winter translocations allow for releases to be planned around moon phases, as it is best to trap before or after the new moon. Additionally, winter trapping might prove to be better timing relative to grazing activities, as cattle should be in winter feeding areas at this time. We also need to consider the timing of oil and gas activities and what timing might be best for landowners. We therefore need to consider the surrounding landscape and prioritize areas for release that have minimal sensory disturbance from oil and gas or any landscape structure and noise, especially if we release during mating season. Working closely with landowners to determine if they are happy to have sage-grouse released onto their land is also of crucial importance.

Predation at the release site is another risk and releases need to be coupled with effective predation management techniques (e.g., predator control, fencing, guarding). Predator management could focus on reducing coyote numbers, removal of stick nests, and removal of great horned owls around active lek and nest sites. There is also the potential for Alberta to test out DRC 1339 for the removal of corvids in Alberta, but this would not be an option for Grasslands National Park in Saskatchewan.

Similarly, concerns about West Nile Virus (WNV) or other disease outbreaks at any one release site were raised. We identified the need to have more than one release site, and the need for possible vaccinations prior to release. While no effective WNV vaccines exist to date, development is in progress.

Identifying and prioritizing areas for releasing individuals will also be a challenge. The Canadian population is so low that we may not be able to find active leks (defined as at least one male bird on the lek) or we may not be able to access the lek at the best time due to weather (as has happened in the past). Additionally, what if birds released on active leks are actually released into sink habitat? More information is needed to prioritize the best habitat for releases; this also needs to correspond to where birds exist on the landscape (if we want to reinforce versus reintroduce). We also need to consider weather and climate change scenarios and identify areas for release that might become prime sage-grouse habitat under climate change scenarios.

We all agreed that if there are areas that we are uncertain about, we need to have an adaptive management approach to modifying release techniques or areas if needed. We can look to translocations of similar species (some translocations done in Utah caught intact broods and released them together) and different release techniques.

Depending on whether one uses a hard or soft release technique the risks are different. Soft releases that involve temporary cages or enclosures are accompanied by the risk of injury to the bird (if the bird flushes and hits the cage); however this risk might be lower for captive-bred birds that have been trained with cages.

MS recommends a soft release technique in which birds are put in a large flat wooden box with multiple compartments. He then takes the birds to the release site and places them in the release box about 30 minutes prior to release and then let them go remotely and simultaneously (usually when birds have started displaying on the lek). If the released bird is male, it will respond to the sound of other males and likely come out of the box strutting. If there are no other males (or only a few) a tape player with vocalizations can be used to help the males associate with the lek. However, there is the risk of stress for the bird in the box. Additional soft release techniques include the use of flight pens (has been done with Attwater's prairie chickens and rock ptarmigan) and supplemental feeding to increase survival. When transporting either keep individuals separate in the boxes or if you have multiple birds together in a box then do not mix the sexes together. Other strategies include using decoys in leks to help males think there is more competition, and mowing lek sites to help increase lekking habitat. In sum, we can use experimental setups to try to answer questions for releasing birds.

Actions

The working group identified several action points for three population management roles (captive breeding assurance population, captive breeding for wild population augmentation or reintroduction, and wild-to-wild translocations). Persons or agencies designated in *italics* as 'responsible parties' indicate leads for taking action.

Wild-to-Wild Translocations

ACTION: Determine if wild-to-wild translocations are still a good idea. JN would like to continue with translocating birds from Montana to Alberta if possible.

Captive Breeding (for assurance and release)

ACTION: Continue talks with appropriate organizations for acquisition of eggs for captive breeding.
Responsible parties: J. Nicholson (Alberta, Montana); A. Sturch and B. Prieto Diaz (Saskatchewan)

ACTION: Create a studbook and meta-population management plan. This plan will use the PMx software program to examine the genetics of birds brought into captivity. Captive breeding will prioritize genetics from the Canadian/NMR population, followed by genetics from the Montana SMR population or Canadian hybrids with the SMR population (i.e., genetics taken from birds translocated from Montana by JN and colleagues that have already bred with Canadian birds).
Responsible parties: Calgary Zoo – specifically J. Veasey and J. Dorgan

ACTION: Create a management plan to receive eggs in captivity and how to manage the population
Responsible party: Calgary Zoo.

ACTION: Explore the possibility/feasibility of shepherding GSG. This action includes researching who has used this technique for similar species, determining whether or not this is a good thing to do or if it is even feasible, and whether it could potentially engage landowners by asking their children to be involved, thereby promoting stewardship.
Responsible parties: M. Schroeder and L. Wiechman

Post-Workshop Comments:
From LW: The more I think about this, I would not recommend this. This does not get at the original mission identified as "having a self-sustaining population". If that mission is changed, then this could be explored. I think while it might be feasible, it is a temporary solution. The 'bodyguarding' would have to occur over such a large period of time, it will likely be cost prohibitive and not result in any guarantees of increased success or survival. MAS agrees.

ACTION: Explore the possibility/feasibility of fencing to improve survivorship of released birds. This action includes evaluating methods of fencing (how long will the fence be needed and how big does it have to be); consideration of risks (ensuring aerial predators cannot used fences for perching, whether the hen can get back into the fence if she flies out for foraging, collision risk with the fence, etc.); and improvement strategies (e.g., considering electric top on fence to keep out raptors, or using fences just at night, etc.). For example, a version of this strategy was used for Attwater's prairie chickens in Texas, where large outdoor and on-site flight pens were used to acclimate the released birds to being in the wild.
Responsible party: Centre for Conservation Research, Calgary Zoo

ACTION: Develop a behavioral study protocol for captive populations
Responsible party: Centre for Conservation Research, Calgary Zoo

ACTION: Draft a protocol for the best way to collect eggs and release eggs or chicks based on JN's translocation protocol (including questions regarding taking full or partial clutches when collecting eggs.
Responsible party: J. Nicholson, L. Wiechman

As a final discussion point, the working group presented a question to be addressed by all workshop participants:

Should we remove 2-3 eggs/nest this year from the wild Canadian population for establishment of a breeding population?

From this question, a general discussion ensued in which we discussed the risks and benefits of taking immediate action.

The overarching idea is that if we do not take action immediately, the wild Canadian population might go extinct before we are able to capture 95% of the genetics of the wild population. While it is risky to take eggs or adults from the existing wild GSG population (taking eggs vs. adults have different associated levels of risk), some argue that the risk of doing nothing is greater.

This question also promoted discussion about whether to take all of the wild birds into captivity now, thereby ensuring we collect the entire genetic population, or only take eggs or part of the wild population. The risks of taking action include negatively impacting the wild population, being unsuccessful at establishing and continuing a captive population, not getting enough birds, or failing in the captive breeding process. Though not formally decided, the general consensus (with some reservations) was that taking only select individuals from the wild was preferable to taking the entire wild population.

From these discussions, the workshop came to a consensus that taking immediate action is better than waiting until 2015. Moreover, it was generally acknowledged that augmenting existing wild populations in the future is easier and better for released birds than reintroducing birds to areas where there are none, so only taking eggs would be wiser.

> ACTION: The workshop participants agreed upon a captive breeding statement (see Appendix).

> ACTION: As a follow-up on this statement, a short, 2-3 page document explaining the rationale behind the decision and potential methods will be developed.

Strategies Moving Forward

The only way to recover GSG in Canada is by increasing their vital rates in the wild through habitat management (long-term strategy) and predator mitigation (short-term strategy), with support from the community and governance. Captive breeding to establish an assurance population is a safeguard in case of the extirpation of GSG in Canada. Population augmentation will (at best) slow the population crash in Canada to give us enough time to address more pressing habitat and governance issues.

The Vortex model developed for this PHVA workshop was used to model augmentation scenarios to estimate the minimum number of released birds need to prevent population decline (see Section 7 of this report for model details). These models indicated that in order for augmentation to be effective, 7 yearling females need to be added to the Alberta population annually to keep stochastic growth rate at zero (stable) under current threat conditions. Under this scenario, the probability of extinction for GSG drops to 8.4% in 50 years. For Saskatchewan, 8 yearling females need to be added to keep the stochastic growth rate at 0, reducing the probability of extinction to 3.9% in 50 years.

Using these numbers as a base for the number of additional surviving adult female sage-grouse desired on the landscape, the working group estimated the number of eggs that need to be added to the wild population in order to result in 7 surviving yearling females in Alberta and 8 yearling females in Saskatchewan (using release strategies that are to be determined under different management scenarios). This was done by some of the group members by estimating various age/stage-specific survival rates under three different conditions, using data available from the field and research efforts as well as expert opinion. Many of these rates are unknown and can only be estimated, and so these calculations should be considered as guidelines only.

If survival rates remain the same and no predator mitigation, habitat management efforts, or intensive management for released populations (i.e., shepherding or fencing) are used, an estimated total of 244 eggs need to be released into the wild in both Alberta and in Saskatchewan (Table 2, Scenario 1).

The number of eggs needed diminishes if we intensively manage the released eggs and chicks. If we release "tame" surrogate females into the wild and body-guard their captive-bred, surrogate offspring until they reach 35 days of age, we can potentially increase egg and chick survival substantially. Thus, the number of eggs needed to obtain 7 breeding females could drop significantly, potentially to 30 eggs as estimated in Scenario 2 (*but see additional comments below*). However, the cost for this management scenario could be over $100,000.

A third management option is to increase nest survival and egg viability by guarding nesting/ surrogate females until the eggs have hatched, but to cease guarding at this stage. Under this scenario, an estimated 88 eggs need to be released in order to add 7 breeding females to the population (*but see additional comments below*).

Table 2. Survival rates for sage-grouse at different life stages, under three management scenarios (original estimates by C. Aldridge and J. Veasey); alternate scenario calculations based on comments and estimates by M. Schroeder and L. Wiechman).

	Scenario 1: Current survival rates (no management)	Scenario 2: Intensive management of surrogates	Scenario 3: Intensive management of nests only	ALTERNATE Scenario 2: Intensive management of surrogates	ALTERNATE Scenario 3: Intensive management of nests only
Nest survival	0.31	0.80	0.80	0.4-0.6	0.4-0.6
Egg viability	0.92	0.98	0.98	0.94	0.94
Chick survival to 35 days	0.27	0.8	0.27	0.5	0.1-0.2
Survival from 35 days to breeding	0.75	0.75	0.75	0.5	0.5
Total survival (%)	6%	47%	16%	9-14%	2-6%
Total females (%)	3%	24%	8%	5-7%	1-3%
Number eggs needed for 7 surviving females	242	30	88	100-150	248-745

Additional Post-Workshop Comments:
Upon greater reflection after the workshop, M. Schroeder and L. Wiechman had some concerns and additional comments regarding the calculated survival rates for Scenarios 2 and 3 in Table 2. Specifically:

Nest survival: Both participants believe that 80% is too high, is not supported by existing research, and may not be achievable for either scenario. Some hens may abandon nests, some predators may get 'lucky', and some predators might not be affected by the protection provided by guarding.

Egg viability: Both participants believe there is no reason to expect egg viability rates to be much higher than in Scenario 1. While it may be possible to eliminate infertile eggs, the number of non-viable eggs may increase (chicks that die during incubation or are too weak to get out of the shell). Comment applies to both scenarios.

Chick survival to 35 days:
Scenario 2 – both participants believe the proposed increase to 80% is not realistic. Some chicks die due to weather. In Texas, insects kill a large number of young chicks. MAS suggests that we could hope for an increase to 50%.

Scenario 3 – MAS believes that since these are captive-reared females, then survival of chicks will be lower than in Scenario 1 and suggests that it perhaps might be only 10%.

Survival from 35 days to breeding age: Both participants agree that survival will be lower with 'tame' females than with wild grouse and suggest ~50% (for both scenarios).

Thus, MAS disagrees with the estimate that it will take only 30 eggs to obtain 7 breeding females. In addition, he notes that the data for Attwater's prairie chickens suggest that although the number of chicks may be increased, the 'quality' of the chicks produced may be lower. Tame surrogates do not perform that well. It is good to keep in mind that the prairie chicken folks have been doing this for decades.

Given the expert opinion of these two participants, additional columns were added to Table 2 after the workshop to reflect possible revised calculations. These results indicate that the estimated number of translocated eggs needed to achieve the goal may be substantially higher than originally estimated at the workshop. Scenario 2 still estimates a significantly smaller number of eggs needed, but at substantial economic cost and potential differences in birds raised by surrogates. It is less clear if Scenario 3 holds an advantage, and may be dependent upon the survival rate of chicks under surrogate females. All of these rates are estimates only, based on expert opinion and not on quantitative research, for appropriate consideration when evaluating potential management strategies.

Appendix

Captive Breeding Statement

The greater sage-grouse is no longer viable without urgent intervention; population trends indicate this species is at imminent risk of extinction within Canada. This endangered Canadian population is an important part of the genetically distinct sub-population north of the Milk River in Montana.

Ultimately, in the longer-term habitat conservation, remediation and stewardship are vital. Reinforcement of extant populations and reintroduction are recognized as potentially crucial measures to prevent the imminent and permanent extinction of the Canadian population. In light of this, and given the perilous state of the Canadian population, the greater sage-grouse PHVA workshop recommends the establishment of a representative captive population as the most urgent priority.

This would ideally be achieved by removing selected eggs from wild birds across Saskatchewan, Alberta and potentially north of the Milk River in Montana, beginning as early as the nesting season of 2014. The eggs removed from wild greater sage-grouse would form the basis of a captive breeding population to be managed by the Calgary Zoological Society, for and on behalf of the Provinces of Alberta and Saskatchewan and the Government of Canada.

The removal of eggs would be carried out in a manner devised to minimize negative impacts upon wild birds and populations; recognizing that currently each egg laid in the wild has only a 6% chance of yielding a breeding age bird.

***Addendum**:*

Upon greater reflection after the workshop, two participants (MAS and LW) expressed that they believe that the establishment of a representative captive population is not the most urgent priority for sage-grouse conservation action. While this is certainly a priority, the most urgent need is to reverse the declines in habitat quantity and quality. Without changes in habitat management, all translocations (whether wild-to-wild or captive-to-wild) are doomed to failure.

Greater Sage-Grouse in Canada Population and Habitat Viability Assessment Workshop

Calgary, Canada
14 – 17 January 2014

Draft Report

SECTION 7

Vortex Population Modeling Results

Vortex Population Modeling Working Group Report

Members: Jennifer Mickelberg, Kathy Traylor-Holzer, Tara Stephens, Cameron Aldridge, Julie Heinrichs

Purpose

The task of the Population Modelling Working Group was to develop a *Vortex* population model for the Canadian greater sage-grouse that could be used to identify those factors that are most critical to population viability and to provide a tool to the other PHVA working groups to investigate the impact of various management actions on the viability of the Canadian greater sage-grouse populations.

Vortex Simulation Model

Computer modeling is a valuable and versatile tool for quantitatively assessing risk of decline and extinction of wildlife populations, both free ranging and managed. Complex and interacting factors that influence population persistence and health can be explored, including natural and anthropogenic causes. Models can also be used to evaluate the effects of alternative management strategies to identify the most effective conservation actions for a population or species and to identify research needs. Such an evaluation of population persistence under current and varying conditions is commonly referred to as a population viability analysis (PVA).

The simulation software program *Vortex* (v9.99) was used to examine the viability of the Canadian greater sage-grouse population. *Vortex* is a Monte Carlo simulation of the effects of deterministic forces as well as demographic, environmental, and genetic stochastic events on wild or captive small populations. *Vortex* models population dynamics as discrete sequential events that occur according to defined probabilities. The program begins by either creating individuals to form the starting population or importing individuals from a studbook database and then stepping through life cycle events (e.g., births, deaths, dispersal, catastrophic events), typically on an annual basis. Events such as breeding success, litter size, sex at birth, and survival are determined based upon designated probabilities that incorporate both demographic stochasticity and annual environmental variation. Consequently, each run (iteration) of the model gives a different result. By running the model hundreds of times, it is possible to examine the probable outcome and range of possibilities. For a more detailed explanation of *Vortex* and its use in population viability analysis, see Lacy (1993, 2000) and Miller and Lacy (2005).

Modeling Questions

Modeling questions were derived before the workshop as well as during the working group sessions. The following questions were addressed by the Population Modeling Working Group:

1. What are the primary demographic factors that drive growth of greater sage-grouse populations in Canada?
2. How vulnerable are greater sage-grouse populations in Canada to decline or extinction under current management conditions?
3. What factors are needed to have positive population growth?
4. What are the predicted impacts of current and potential future levels of drought and climate change on greater sage-grouse populations in Canada?

5. What are the predicted impacts of current and potential future levels of West Nile Virus on greater sage-grouse populations in Canada?
6. How might intensive population management strategies be used to increase the viability of greater sage-grouse populations in Canada?

Sufficient data were not available at the workshop to explore the impacts of climate change and West Nile virus through modeling; however, it is recognized that these threats have the potential for significant negative impacts to the Canadian sage-grouse population (Walker and Naugle 2011).

Development of the Baseline Model
A baseline *Vortex* model for wild populations of Canadian greater sage-grouse (GSG) was developed prior to the PHVA workshop and then further refined after discussion with sage-grouse biologists. Model input values were derived using published literature and reports on GSG (Schroeder *et al*. 1999, Aldridge and Brigham 2001, Zablan 2003, Aldridge 2005, Alberta Sage-Grouse Recovery Action Group 2005, Taylor *et al.* 2011, Alberta Environment and Sustainable Resource Development 2013). Alberta data (Aldridge research) was largely used for the model except for the few cases where Canada-specific data were not available or were not applicable. This research provided annual estimates of many of the parameters needed for the *Vortex* model.

This preliminary population model was reviewed, discussed and revised prior to and during the first day of the workshop following meetings with greater sage-grouse biologists and population modelers. Input from this group led to the final baseline model that was used during the PHVA as a basis for viability analyses, sensitivity testing, and the assessment of management actions.

Vortex Baseline Model Parameters

Model Assumptions and Cautions
The Vortex model incorporates the best estimate of current demographic rates and habitat availability for the greater sage-grouse based on available data and expert opinion of the participants at the time of the PHVA workshop. While the most up-to-date data were used, some vital rates were calculated from field data from the early 2000s (Aldridge data) prior to habitat loss and land use changes that may be impacting current demographic rates. The model describes a situation in which the population is below the estimated theoretical habitat carrying capacity (K) but for which population growth is limited by low recruitment.

No future reduction in K or increase in existing or new threats are included in the model; that is, the model assumes no future habitat loss, development, or other land use or infrastructure changes that impact GSG, and does not include changes associated with climate change or the potential impact of West Nile virus. For these reasons, the model results may be considered to be optimistic projections of future population viability. The final input values used in the baseline model are described below.

General Model Parameters
<u>Number of iterations</u>: *1000*
<u>Number of years</u>: *50 (about 15 generations)*
<u>Extinction definition</u>: *Only one sex remains*

Population Parameters

Number of populations: *Two populations*

The current population of GSG in Canada is divided into two populations with no movement between them. The West population is primarily composed of the Alberta populations and a small area of habitat in western Saskatchewan, although it was concluded that the western Saskatchewan leks have been vacant since around 2009. The East population is the eastern Saskatchewan population. Some migration is observed between the eastern Saskatchewan population and Montana population; however, since the biologists believed the same individuals that overwinter in Montana return in the spring to Saskatchewan (Tack 2009), this movement was not included in the model.

Initial population size (N_i): *West: 49; East: 72*

These estimates are derived from annual census reports (Environment Canada 2013). Age distribution was modified slightly from stable age distribution given current sex and age ratios from field data and expert opinion (see below).

Age	WEST		EAST	
Class	Males	Females	Males	Females
1	10	12	14	17
2	6	8	9	11
3	3	4	4	6
4	1	3	2	4
5	0	1	1	2
6	0	1	0	1
7	0	0	0	1
Total	20	29	30	42

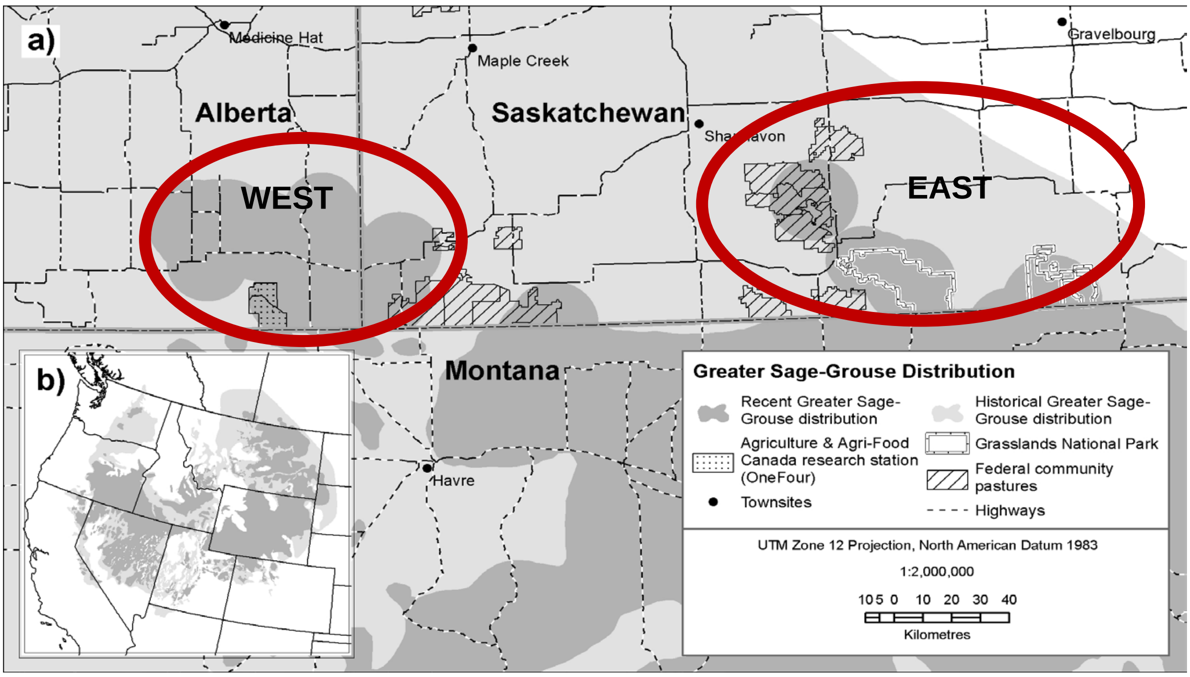

Image from Environment Canada 2013, Amended Recovery Strategy

<u>Carrying capacity (K)</u>: *West: 663; East: 512*
Vortex requires a quantitative carrying capacity to limit maximum population size. A spatially-explicit, individual-based model (constructed in the HexSim modeling platform) was used to estimate the capacity of the habitat (as defined in Aldridge *et al*. 2007) to provide non-overlapping female ranges (Heinrichs and Aldridge, pers. comm.) Estimates of 400-600 females in the East and 400-900 in the West were generated based on two assumptions: 1) All habitat (above the habitat/non-habitat threshold) was of equal quality, or 2) the predicted occurrence values indicated a continuum of habitat quality that influenced range sizes. However, many field observations suggest that females have overlapping ranges with other females and hence, estimates based on the above territorial assumptions of behavior may underestimate the capacity of the landscape to support sage-grouse. Capacity estimates are also based on the most current, but dated (early 2000s), habitat characterizations and do not include functional losses in capacity resulting from avoidance of disturbed areas. This may overestimate current habitat capacities. It should be noted that for almost all scenarios modeled in this report, demographic rates were insufficient for the population to grow significantly; thus, K is only relevant to Levels 5 and 6 of Scenario 1 simulations that incorporate significantly improved vital rates.

Reproductive Parameters

<u>Mating system</u>: *Short-term polygyny*
The mating system was set as polygynous, which allows males to mate with more than one female. Therefore, under conditions of unequal sex ratio in which there are fewer males than females, ‘extra’ females will have the opportunity to breed rather than remain unpaired for the year. Each population is assumed to be panmictic (i.e., all breeding adults of the opposite sex are potential mates). Breeding partners are reshuffled each year (i.e., multi-year pair bonds were not used in the model). No reproductive senescence was included (e.g., all adult birds are considered to be capable of reproduction).

<u>Age of first offspring</u>: *1 year (females); 2 years (males)*
This parameter represents the average age of first reproduction, not the age of sexual maturity or earliest reproductive age observed.

<u>Percent adult females breeding</u>: *36.3% (EV=14.6%)*
This was based on 10 years of annual reproduction data from Aldridge and represents the mean percent of adult females that hatched at least one chick in a given year. The environmental variation (EV) was calculated from annual field data after removing demographic variation.

<u>Density-dependent reproduction</u>: *No*
Reproductive rates are assumed to be independent of population density.

<u>Percent adult males in the breeding pool</u>: *75% (100% if < 7 adult males)*
The base value was for 75% of the adult males to be in the breeding pool (i.e., potential breeders on leks) each year, which was based on use of 75% of males on leks for some population estimates (Environment Canada 2013). To prevent an unintentional demographic effect at very small population sizes, all adult males were assumed to be potential breeders when the number of adult males was small (fewer than 7).

Maximum number of offspring per year: *11*
One clutch is typically observed, but if the first nest fails, female may lay a second clutch. The maximum clutch size observed is 11 eggs. Sex ratio at hatch is assumed to be 50:50.

Clutch size and distribution (annual): *100% one clutch; mean = 7.34 chicks*
Most females produce one clutch, but if the first nest fails, they may produce a second nest. First and possible second clutch data were combined, as the rates for the first and second nests were comparable in Canadian populations. The average clutch size (number of eggs) is 7.78 and 92% of these hatch. Since an individual is "born" in the model when it hatches, we calculated the distribution of the number of offspring per brood by using the average (7.78) multiplied by the hatchability (92%) = 7.34 (SD=1.89).

Survival Parameters

Mortality rates: *Age- and sex-specific*

Age (yr)	Female (%)	Male (%)	Reference
0-1	78 (4)	82 (4)	Female: Aldridge, unpublished data; M. Schroeder, personal communication (adjusted for observed sex ratio differences) Males: Zablan 2003
1-2	35 (2)	36.5 (3)	Female: Aldridge, unpublished data; Taylor *et al*. 2011 Males: Zablan 2003
2+ (annual)	42 (1.75)	55(1)	Female: Aldridge, unpublished data,; Taylor *et al*. 2011 Males: Zablan 2003

As noted earlier, Age 0 in the model is at hatch (not at egg). Table values are mean mortality rates with EV in parentheses.

Maximum age: *10 years*
Individuals are removed from the model after they pass the maximum age (i.e., survive their 10th year). Data were not available for longevity; however, biologists have observed a few females breeding at 10 or 11 years of age. Participants agreed that 10 was a reasonable estimate of maximum age for greater sage-grouse.

Inbreeding depression: *6 lethal equivalents*
Inbreeding can have major effects on many aspects of reproduction and survival, especially in small populations, and so was included in the model. *Vortex* models inbreeding depression as reduced survival in inbred juveniles; the severity of the effect is determined by the number of lethal equivalents (LE) in the model. The median number of LEs calculated from studbook data for 38 captive mammal species is 3.14 (Ralls *et al*. 1988), while O'Grady *et al*. (2006) concluded that 12.3 lethal equivalents spread across survival and reproduction is a realistic estimate of inbreeding depression for wild populations across several taxa. The GSG baseline model incorporated 6 LEs as a reasonable estimate of inbreeding effects based on O'Grady *et al*. (2006), 50% of which were assigned to lethal alleles and subject to purging. It should be noted that this model may underestimate the impact of inbreeding, as *Vortex* assumes all individuals in the initial population to be unrelated and only models effects on juvenile mortality.

Concordance between environmental variation in reproduction and survival: *Yes*
Environmental variation (EV) is the annual variation in reproduction and survival due to random variation in environmental conditions. For most species, these two parameters are linked; this default setting was used in this model. This means that 'good' years for

reproduction are also ‘good’ years for survival; conversely, ‘bad’ years for reproduction are linked to ‘bad’ years for survival (worst case scenario for environmental variation).

Additional Model Options

Catastrophes: *1 (non-specified)*
Reed *et al.* (2003) examined 88 vertebrate populations and found the risk of severe population decline (≥ 50%) to be ~ 14% per generation. Therefore, in the absence of specific catastrophe data, a recommended risk of catastrophic events for sage-grouse populations is about 5.8% per year (i.e., on average, once per ~7 generations; if generation time T = 2.4, this is once per ~ 17 years). This value was incorporated stochastically into the GSG *Vortex* model with a severity factor of 50% reduction in survival in a catastrophic year.

Harvest and Supplementation: *Not included in baseline model*

Baseline Model Results

Deterministic Output

The demographic rates (reproduction, mortality and catastrophes) included in the baseline model can be used to calculate deterministic characteristics of the model population. These values reflect the expected growth rate of the population in the absence of stochastic fluctuations (both demographic and environmental variation), inbreeding depression, limitation of mates, and immigration/emigration/supplementation. It is valuable to examine deterministic growth rates and generation length to assess whether they appear realistic for the species and population being modelled.

The baseline model describes a population with a negative growth rate (deterministic r = -0.115; λ=0.892) when not impacted by stochastic events. In the absence of these forces, the population is declining at about 11% per year. Generation time (T), which is the average age of reproduction, is 2.4 years. These values appear reasonable given the current situation for the greater sage-grouse in Canada.

Stochastic Output

Small populations, such as the greater sage-grouse population, are especially vulnerable to the effects of stochastic (chance) events. When stochastic events such as random variations in reproductive and survival rates, environmental variation, and inbreeding depression are added into the model, population growth rate is smaller and the risk of extinction may increase.

Given the declining deterministic growth rates, the assumption was that lack of recruitment is one of the primary factors limiting growth in the Canadian greater sage-grouse populations. The *Vortex* baseline model reflects a population that, on average, shows a stochastic r = -0.226 for the entire Canadian meta-population (West: r = -0.218; East: r = -0.0223). Under these conditions, this small population has a 100% probability of extinction within 30 years (Figure 2). For the Canadian meta-population, the mean time to extinction (MTE) is in 15.7 years (West MTE = 12.2 yrs; East MTE = 13.8 yrs). Population size declines quickly, with only about 23 individuals (with reduced genetic variation) projected by year 10 in those simulations in which extinction has not already occurred by that time.

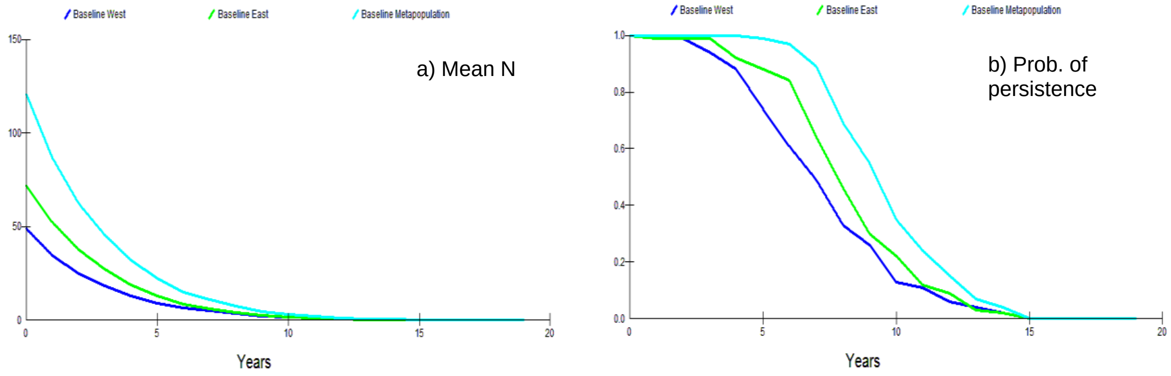

Figure 2. Base model results for the West (dark blue), East (green), and combined meta-population (light blue), showing the (a) mean population size and (b) probability of persistence over the next 20 years.

This baseline model incorporates input from the workshop participants and represents the best estimate of projected future outcomes for the GSG in Canada given the demographic extrapolations from conditions in the past decade. These projections may be optimistic, as the model does not explicitly include recent and potential future landscape changes that likely have an impact on the population, nor the additional potential threats of climate change and West Nile virus.

To validate the model, the model was initiated with population estimates from the 2000 census report and modeled for 12 years to see if the model would result in a population of similar size as the 2012 population census. The model performed well for the West population, with the final population size in the model (N = 40) matching the census estimate (N = 39), representing a 90% decline in 12 years. The model was more pessimistic for the East population than was observed in the field (census estimate = 54; model N = 19, SD=15.8), projecting a 95% decline vs the estimated population decline of 86%, but projected a similar trend in significant decline. Since the major of field data used to parameterize the model were from the western population, it is not surprising that this projection matches the census estimate more closely.

Sensitivity Testing of Demographic Parameters

General sensitivity analyses were performed on the primary demographic rates on the baseline model to determine which parameters most affect population viability. These analyses suggest those parameters that might be targeted through management to improve population viability and identify potential areas for future research in important areas of uncertainty. The following parameters were tested with an increase and decrease in the baseline value of ±10%:

- Female first year mortality
- Female adult mortality
- Male chick mortality
- Male yearling mortality
- Male adult mortality
- Percent adult females reproducing
- Clutch size (chicks)

Figure 3 shows the resulting stochastic growth rates for each parameter across those values tested. The ranges tested were biologically plausible for GSG. The parameter that shows the greatest sensitivity in its impact on the population's stochastic growth rate over the range of values modelled is female juvenile mortality (age 0-1). Adult female mortality also had a substantial effect on the stochastic growth rate. Altering the percent of females reproducing and clutch size were also important factors having a positive impact on population growth.

Overall, the recruitment of new female breeders into the population (either through the production of additional clutches and/or increased survival of juveniles) increases the stochastic growth rate. Loss of female breeders (juvenile and adult mortality) negatively impacts population viability. Management strategies that target any of these factors, including intensive population management strategies, would have the greatest impact on population growth rate.

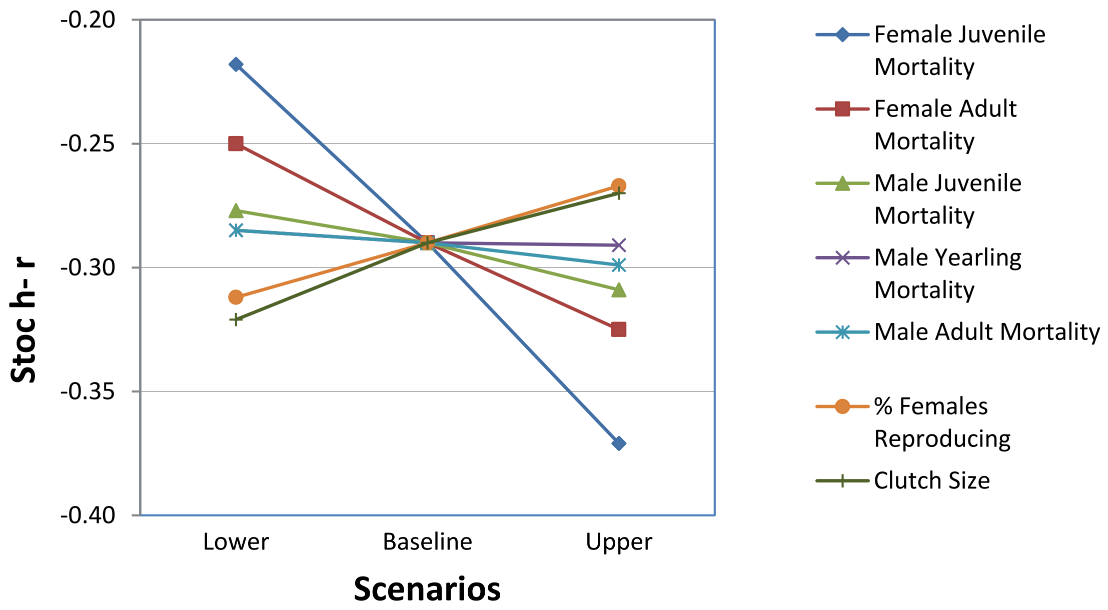

Figure 3. Sensitivity testing of primary demographic parameters for impacts on stochastic growth rate (Stoch -r).

Potential Management Actions

Canadian greater sage-grouse have been reduced to two very small populations. The lack of recruitment is a primary factor in these small populations, restricting population growth. Working groups discussed several management actions that could improve recruitment rates. The *Vortex* model was used to help predict the required level of change in vital rates to have an impact on population viability. Strategies explored were to increase the percent of females reproducing, reduce chick mortality, or increase clutch size. Other management actions were examined that could improve the viability of the Canadian populations, including adding translocation from other North American populations (wild or captive).

Several population status measures are given in the model results for the following scenarios:

- Stochastic r: mean population growth rate (r) over time, with 0 representing a population of relative stable size over time;
- Probability of extinction in 50 years;
- Mean time to extinction (in years);
- Mean population size (N) at year 50 (all iterations, including extinctions); and
- Mean gene diversity at year 50 (for non-extinct populations).

Scenario 1: Improvements in Vital Rates

Scenario Description

Low recruitment in Canadian greater sage-grouse is limiting population growth. Several factors contribute to this, but high mortality rates for chicks and juveniles is one of the primary concerns. One potential factor is predation. This scenario was originally designed to investigate the potential effect of predator control on population viability; however, this scenario could apply to any changes that would have a positive impact on vital rates (e.g., habitat improvements). In order to assess the effect of improving vital rates on population growth and viability, a combination of scenarios were modeled.

Vortex Model Parameters

At least two parameters could be affected by predator control: percent of females reproducing and chick mortality (0-35 days). The percent of females reproducing was increased by 10-60% of the baseline value, which provided a range of 36.3%-58.1% of females reproducing each year. Additionally, chick mortality (0-35 days) was decreased by 5-50% of the baseline value to reflect improvements on vital rates. This was factored into the full first year mortality rates for the model, which provided a range in mortality (0-1 age class) of 69% to 82% (see Table 3).

Model Results

Recruitment is the primary factor limiting growth in the Canadian population of GSG. Recruitment for this species could be affected by several variables, including predators and habitat quality. Increasing the percent of females reproducing as well as lowering juvenile mortality improved the population growth rate. Even small improvements in vital rates had an effect on population growth rates. Table 3 shows the changes in stochastic r, probability of extinction (PE) within 50 years, and mean time to extinction. Under a high carrying capacity (K=6000) such that K would not be a limiting factor in population growth, a 50% improvement of percent females breeding (to 54.5%) and 40% decrease in juvenile mortality (to 71% for females and 73% for males) was required to reach a positive stochastic growth rate (stoch r = 0.064). The model projected that if vital rates for these populations could be improved by any means, including efforts such as predator control and/or possible habitat improvement, the population eventually could become self-sustaining (non-negative population growth) assuming no concurrent adverse changes in habitat (Figure 4).

Table 3. Model results for the entire Canadian population with improved vital rates (K set at 6000).

	Model Input Values			Simulation Results				
Vital Rate Improvements	% Females Breeding	Juvenile Mortality (%) Female	Juvenile Mortality (%) Male	Stoch r	PE_{50yr}	Mean Time to Extinction	Mean N_{50yr}	% GD_{50yr}
Baseline	36.3	78	82	-0.226	100.0%	16	0	--
Level 1 (10%/5%)	39.9	77	79	-0.187	100.0%	19	0	--
Level 2 (20%/10%)	43.6	77	79	-0.159	99.8%	22	0	--
Level 3 (30%/20%)	47.2	75	77	-0.105	89.9%	30	6	71.5
Level 4 (40%/30%)	50.8	73	75	-0.026	41.0%	36	374	83.5
Level 5 (50%/40%)	54.5	71	73	0.064	6.1%	39	2326	91.5
Level 6 (60%/50%)	58.1	69	71	0.153	0.2%	23	4765	95.9

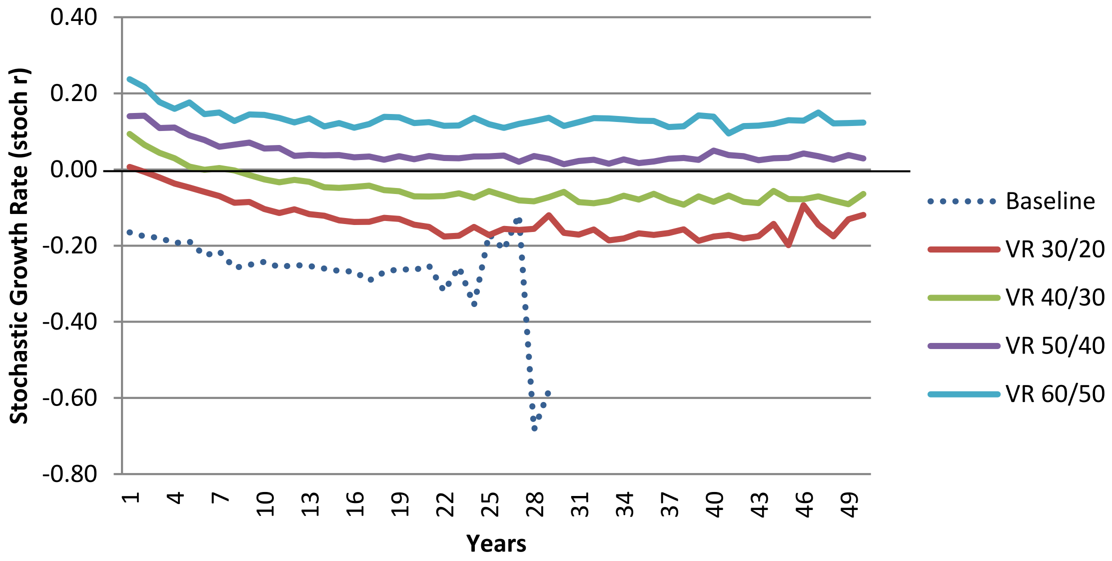

Figure 4. Stochastic growth rate with improved vital rates (percent females breeding and decrease in juvenile mortality rates). The dotted line represents the baseline; results show erratic variations after 20 years when most simulations have gone extinct (all runs are extinct after 30 years).

Scenario 2: Increasing Clutch Size through Egg Supplementation

Scenario Description

Sensitivity testing indicated that clutch size was an important determinant of population growth. One potential management strategy for Canadian greater sage-grouse is to artificially increase clutch size. This could be done by adding eggs (potentially laid in captivity or from alternate populations) to a nest. Females can care for up to 10 eggs in a nest. This scenario was used to explore the effect of increasing clutch size on population viability.

Vortex Model Parameters

To simulate what might be feasible for this management strategy, clutch size (number of offspring per female) was increased to 10 eggs (9 chicks after accounting for hatchability) for a certain percentage of the nests. Knowing that every nest may not be able to be supplemented, different scenarios were modeled with 25%, 50%, and 75% of nests being supplemented up to a total of 10 eggs per nest for every year of the simulation.

Model Results

Even when 75% of the nests were supplemented, the stochastic r for the populations remained negative. There was a positive effect on the mean time to extinction, however. The baseline model predicted a mean time to extinction (MTE) of 13.8 years for the East population and 12.2 years for the West population. With 75% of the nests being supplemented, the MTE was extended 18.9 years for the East population and 19.1 years for the West population. Table 4 lists the stochastic r values for each level of nest supplementation along with MTE. With an increasing percentage of clutches being supplemented, stochastic r improves but remains negative (Figure 5).

Table 4. Model results for the East and West populations with different levels of nest supplementation (with up to 10 eggs per supplementation).

Model Scenario		Simulation Results			
Scenario	Population	Stoc-r	Mean Time to Extinction	PE_{50yr}	Mean N_{50yr}
Baseline	East	-0.22	14	100%	0
25%	East	-0.20	15	100%	0
50%	East	-0.18	17	100%	0
75%	East	-0.16	19	99.7%	0
Baseline	West	-0.22	12	100%	0
25%	West	-0.20	13	100%	0
50%	West	-0.18	15	100%	0
75%	West	-0.16	16	99.8%	0

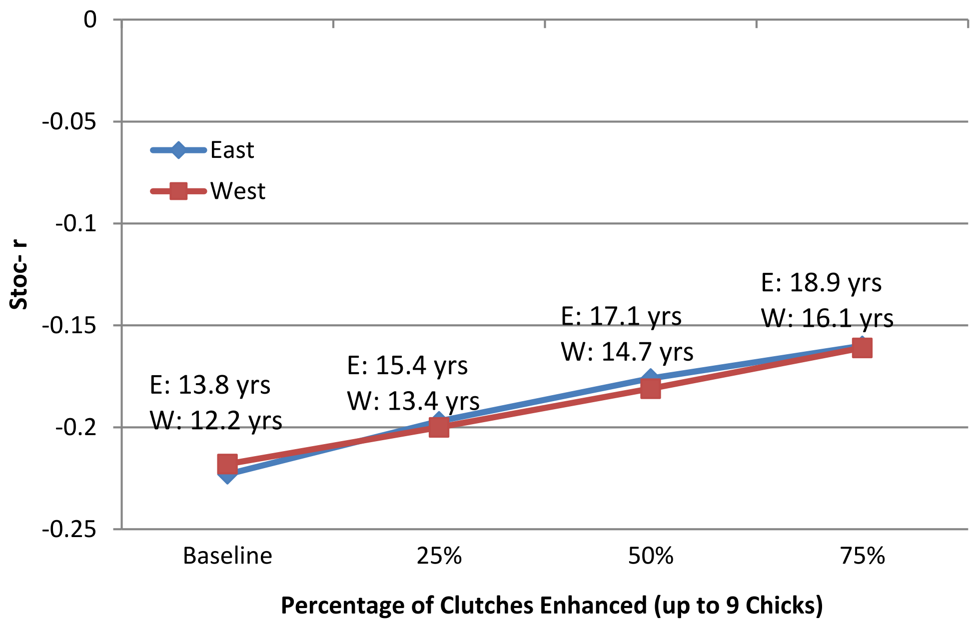

Figure 5. Effect of clutch size on stochastic r. Mean time to extinction is above each point for East and West.

Scenario 3: Impact of Short-Term Translocations

Translocation of wild birds from the US into the Canadian GSG population was deemed a possible strategy by the Population Management Working Group. In this scenario, supplementation of hens (1 year old females) at varying rates (number of individuals and time intervals) was modeled to explore the impact that translocation might have on growth rate and population viability. Estimates on the vital rates of translocated birds were made given past experience of the workshop participants.

Scenario Description

Several scenarios were developed to model the effect of translocating 20, 40, or 60 hens every 1, 2 or 3 years. These hens would come from outside of Canada and would therefore be considered new genetic founders to the Canadian GSG population. The model included translocations for up to either 5 or 10 years.

Vortex Model Parameters

Translocations were modeled by supplementing the East and West populations with new birds from an outside source. Each population was supplemented with 20, 40, or 60 adult female founders every 1, 2 or 3 years. Translocations began in Year 1 and were conducted for a period of either 5 or 10 years. Baseline vital rates were used since these were more conservative than the vital rate values from previous translocations in North America (Nicholson, pers. comm.). The values used seemed reasonable to the working group.

Model Results

Model projections suggest that translocation could be used to improve population size and growth, but that the population will not be able to maintain itself once translocations end, even under the most intensive early translocation scenario. Under the most extreme scenario with 60 hens being added to both the East and West population every year for the first 10 years, the long-term stochastic r was improved from -0.226 to -0.085 but remained negative (Table 5, Figure 6). While hens were being translocated, population size is maintained; however once translocation ends, the population declines due to low recruitment. While risk of extinction within 50 years remains very high (98-100%), early translocation of hens delays population decline compared with the baseline scenario (Figure 7). Mean time to extinction varied depending on how frequently translocations occur and how many hens are added (Table 3), but was the most improved for the scenario with 60 hens translocated every year for 10 years (MTE = 37 years).

Assuming that the vital rates of translocated birds are similar to resident grouse, translocation was deemed a potentially viable short-term management option, and could prove to be a beneficial tool to help ensure the short-term survival of the Canadian GSG population while other threats and factors affecting vital rates are addressed and population recruitment is improved. The actual success of any translocation efforts will be dependent upon several factors, including the vital rates of translocated birds.

Table 5. Model results for translocation of 20, 40, or 60 hens every 1, 2, or 3 years with a translocation program running either 5 or 10 years (duration). These results are for the entire Canadian population. The results in bold represents the most improved scenario. Baseline scenario results (no translocations) given at the top.

Model Input Values				Simulation Results		
# Hens Translocated	Duration (years)	Frequency (years)	Total # of Hens Translocated	Stoc-r	PE_{50yr}	Mean Time to Extinction
0	0	0	0	-0.223	100%	12
20	5	1	100	-0.137	100%	26
		2	60	-0.152	100%	23
		3	40	-0.168	100%	21
	10	1	200	-0.110	100%	32
		2	100	-0.127	100%	28
		3	80	-0.131	100%	27
40	5	1	200	-0.118	100%	30
		2	120	-0.134	100%	26
		3	80	-0.145	100%	24
	10	1	400	-0.094	98%	36
		2	200	-0.109	100%	32
		3	160	-0.114	100%	31
60	5	1	300	-0.110	100%	31
		2	180	-0.123	100%	29
		3	120	-0.133	100%	26
	10	**1**	**600**	**-0.085**	**98%**	**37**
		2	300	-0.100	99%	34
		3	240	-0.104	100%	33

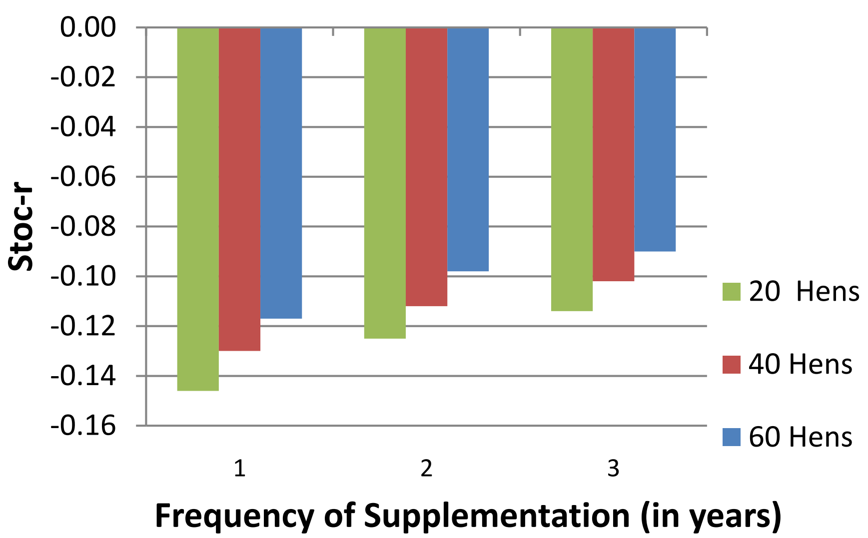

Figure 6. Effect of translocation on stochastic growth rate for the West population. Translocations were modeled every 1, 2, or 3 years with 20, 40 or 60 hens. The figure shown includes translocations for 5 years for the West population.

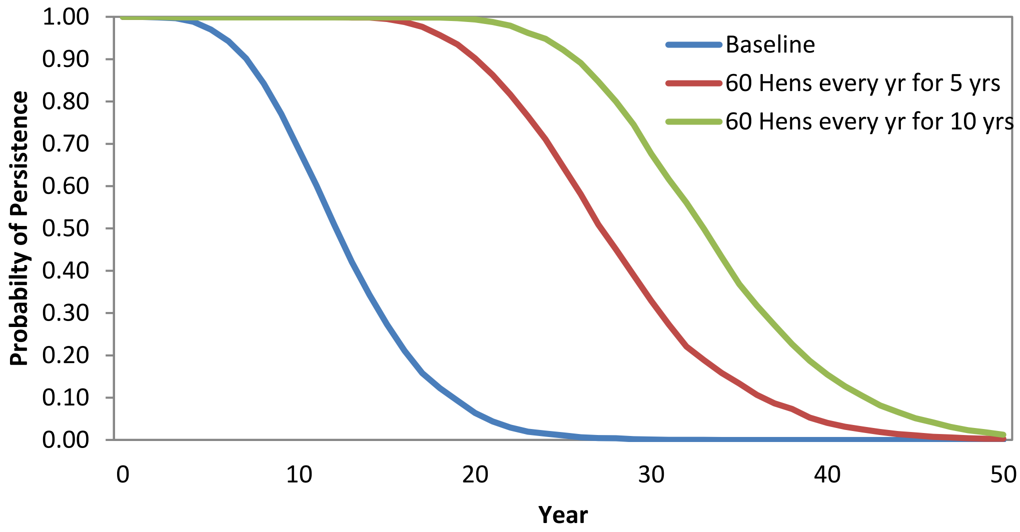

Figure 7. Effect of translocation on probability of population persistence compared with baseline for the Canadian meta-population. Blue line = baseline; red line = annual translocation of 60 hens into both East and West populations for first 5 years; and green line = annual translocation of 60 hens into both East and West populations for first 10 years.

Scenario 4: Annual Translocations to Stabilize Population (Zero Population Growth)
Given that the low level of recruitment is a primary factor in the lack of population growth for GSG in Canada, a scenario was modeled to determine how many birds would need to be added to the population to prevent population decline and maintain at least the current population size ($r \geq 0$). These birds would come from other source populations (wild or captive) and would be new genetic founders to the Canadian population. Several scenarios were explored to examine potential conditions under which the population size could be stabilized, or at least further population decline prevented. This scenario was viewed as a stopgap measure to retain the Canadian populations until other conservation actions are effective.

Scenario Description
The Population Management Working Group requested to explore how many birds need to be released into the wild population to prevent its decline and reach at least a long-term population growth rate that was not declining. The vital rates for wild GSG were used for released birds, and new founders (yearling females) were added until the population growth rate was greater or equal to 0.

Vortex Model Parameters
Using the baseline input values, separate scenarios were run, incrementally increasing the number of yearling females added each year until long-term stochastic r was no longer negative (equal to or greater than 0). This strategy was applied to each of the two populations (both West and East) so that females were added to both populations until stochastic r was not negative.

Model Results
Adding yearling females annually to a population decreased the risk of extinction and reduced the rate of decline for both the East and West populations. In order to prevent

population decline (i.e., r $\geq$ 0) in the West population, a minimum of 7 surviving yearling females need to be added annually (r = 0.004). This annual addition decreased the probability of extinction over 50 years (PE_{50yrs}) to 8.4% with an average final population size of 82 individuals. For the East population, 8 yearling females need to be added annually to maintain a non-negative growth rate (r=0.001) and results in PE_{50yrs} = 3.9% with a final population size of 70 individuals. In comparison, under baseline conditions PE_{50yrs} = 100%. By adding surviving females annually to the population, the model predicts a substantial decrease in the risk of extinction for both populations. Since growth rate is close to zero (this was the target for this scenario), population sizes are close to the starting population size. The supplemented females were treated as new founders, so the level of genetic diversity retained is high (96% for both populations). These results represent minimal estimates of the number of females needed; the actual number required for translocation could be higher if the circumstances deteriorate and/or females do not perform as well as wild individuals. However, adding yearling females to the population each year could potentially help maintain these populations at their current levels while efforts are put in place to improve vital rates for the Canadian population.

Additional Potential Threats to GSG Population Viability

Workshop participants recognized that several new and emerging potential threats may adversely affect GSG populations in Canada in the future, in particular West Nile virus climate change, as well as potential future changes in land use.

West Nile Virus

West Nile virus (WNv) was documented in the Alberta population of GSG in 2003. In other populations, WNv has decreased survival by 25% (Naugle *et al*. 2004). With the high mortality rates observed in some populations, Lungle and Pruss (2008) reference WNv as a concern for small population of GSG. While this is a potentially significant threat for Canadian greater sage-grouse, particularly when combined with other stressors (Walker and Naugle 2011), at the time of the workshop little Canada-specific data existed to model WNv in these populations, and it was not incorporated into the model due to data and time constraints. Therefore, the model results presented here do not specifically incorporate WNv or other emerging diseases.

Climate Change

Climate change, and in particular associated drought, can affect greater sage-grouse populations through the reduction of food resources and limiting the quality habitat for breeding (Lungle and Pruss 2008). When combined with other stressors, climate change could be a potential threat to the Canadian GSG populations. Little data exist to model the impact that this threat could have on population viability, so the reported results do not incorporate climate change as a potential threat.

Land Use Changes

Changes in habitat, particularly as a result of oil and gas development, are potential threats to the viability of the sage-grouse. Petroleum development may have a negative impact on survival and reproduction and may result in population decline (Alberta Environment and Sustainable Resource Development 2013). Birds may also be affected indirectly by being displaced into marginal habitats. Future habitat changes, and how these factors specifically affect vital rates, are still being quantified and therefore were not incorporated into this model.

Summary of Modeling Results

Through the efforts of workshop participants before and during the PHVA workshop, a baseline model was developed for the Canadian greater sage-grouse that is useful in estimating the relative viability of the population under various conditions and assumptions. A great deal of data were available for the Alberta population, which were generalized to the entire Canadian population under the assumption that the Alberta and Saskatchewan GSG populations are similar with respect to demographic rates and threats. Expert opinion was extensively used to modify and create the most accurate model possible. This model was used to help assess the viability of the population and estimate the relative effect of various management strategies and guide discussions on their feasibility.

The projected risk of extinction within 30 years is 100% for the Canadian GSG population under static habitat conditions. The Canadian population has a negative deterministic population growth, which indicates that recruitment is too low for the population to maintain itself even without stochastic threats. Management actions that target improvement of key vital rates (i.e., female survival, reproductive rate) may have the most significant impact on long-term population viability. Using intensive population management methods such as translocation may be viable options for reducing the risk of short-term extinction but would need to be conducted in concert with other conservation actions to address factors affecting demographic rates (e.g., predation, habitat quality) to secure long-term viable populations. Intensive effort would be needed, however, to sustain the population until survival and/or reproduction can be improved sufficiently to generate recruitment rates that will prevent population decline. Although a combination of concurrent management strategies was not specifically modeled here, future modeling could examine the additive effects of combining supplementation with habitat recovery and improved vital rates.

These model results do not incorporate additional future threats such as those potentially posed by land use change, industrial development, climate change, increased drought severity and/or frequency, or diseases such as West Nile virus. Such threats will likely impact GSG population viability in Canada and increase the effort needed (through intensive population management and/or amelioration of threats) to maintain viable GSG populations in Alberta and Saskatchewan. Additionally, this model, while individual based, is not spatially explicit and assumes that each population is panmictic. At the time of the workshop, spatially explicit models were being developed using HexSim (Heinrichs, pers. comm.) and should be considered in addition to the results presented in this report. Such models may be particularly useful in exploring habitat and land use changes due to human activities and climate change.

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Appendix. Parameter input values for the Vortex greater sage grouse baseline model (shaded cells indicate that baseline values were used).

Parameter	**Baseline**	**Sensitivity Testing (±10% base values)**	**Scenario 1 (Vital Rates)**	**Scenario 2 (Clutch Size)**	**Scenario 3 (Translocation)**	**Scenario 4 (ZPG)**
Breeding system	Polygyny (short term)					
Age of first offspring (♀/♂)	1/2					
Density dependent reproduction	No					
Adult females breeding/year (EV)	36.3 (14.6)	32.7, 39.9	36.3-58.1%			
Percent males in breeding pool	75% (100% if < 7 males) =75+(25*(M<7))					
Maximum brood size (eggs)	11					
Mean brood size (chicks)	7.34 (1.89)	6.6, 8.07		8.01 (1.89), 8.67 (1.5), 9.34 (1)		
Overall offspring sex ratio	1:1					
% annual mortality ♀/♂ (EV): 0-1 yrs 1-2 yrs 2-3 yrs	 78 (4) / 82 (4) 35 (2) / 36.5 (3) 42 (1.75) / 55 (1)	 70.2, 85.8/73.8, 90.2 31.5, 38.5/32.85, 40.15 37.8, 46.2/49.5, 60.5	 69-78 / 71-82			
Maximum age	10 years					
Inbreeding depression	6 lethal equivalents (50% lethal alleles)					
EV concordance (repro and surv)	Yes					
EV correlation among populations	0.5					
Catastrophes	1 (5.8% annual risk; 50% survival)					
Initial pop size/Carrying capacity West Population East Population	 N_0 = 49; K = 663 N_0 = 72; K = 512					
Supplementation	None				20, 40, 60 females every 1, 2, or 3 yrs for 5 or 10 years	Yearling females added to each pop (1-7 per year)

Greater Sage-Grouse in Canada Population and Habitat Viability Assessment Workshop

Calgary, Canada
14 – 17 January 2014

Draft Report

SECTION 8

Priority Goals and Actions

Priority Goals and Conservation Actions

Priority Conservation Needs

At the end of the PHVA workshop, the participants considered the goals and objectives across all working groups. While all goals were considered important for recovery of the greater sage-grouse in Canada, participants were asked to prioritize these goals with respect to: 1) their estimated conservation impact on sage-grouse; and 2) urgency for implementation. Table 6 gives the resulting general prioritization of these working group goals.

Because of the risk of imminent extinction of greater sage-grouse in Canada, the workshop participants identified the following as major outcomes and recommendations for the conservation of greater sage-grouse in Canada:

1. Agreement to promote establishment of an interprovincial governance group to help guide this process.

2. Agreement to establish an *ex situ* breeding center for sage-grouse as both an assurance population and as a potential source for population reinforcement and reintroduction.

3. Agreement that it is critical to improve sage-grouse survival and reproduction through habitat management (protection, enhancement, restoration, and stewardship) and through a reduction in predation (through a variety of appropriate methods).

It was agreed that sage-grouse conservation should be undertaken as a One Plan approach of integrated species conservation planning, utilizing all relevant management tools and involving all relevant stakeholder perspectives. The general situation with respect to threats and management can be characterized by Figure 8. Various threats (primary and stochastic) result in small population size, which is both a product of and a factor leading to decreased survival and reproduction. Population management strategies may be used to counteract demographic impacts and avoid further decline and extinction while primary threats are being addressed through other conservation actions such as management of habitat, predators, and other landscape issues. Such actions also can improve sage-grouse survival and reproduction.

Advisory Group

The recommendation was made to establish an Advisory Group quickly to assess and discuss those issues that are not yet decided. Suggested participants included: Cameron Aldridge, Tony Apa, Krissy Bird, Dave Nagle, Joel Nicholson, Tara Stephens, Jason Tack, Jake Veasey, Catherine Weiman, Lief Wiechman, Adrian Sturch, Sara Oyler-McCance. Jake Veasey agreed to serve as point person to initiate the formation of this advisory group.

Moving Forward

This PHVA report and the recommendations within it are considered advisory to the local and provincial management teams for the greater sage-grouse and other collaborators to help guide actions thought to be beneficial to the long-term survival of the greater sage-grouse in Canada. Establishment of a GSG Advisory Group may help refine these recommendations and facilitate implementation. Establishment of an interprovincial governance group also will promote effective conservation of the greater sage-grouse, its habitat, and its ecological function in Canada.

Table 6. Prioritization of all working group goals based on conservation impact and on urgency for implementation (results given as number of 'dots/votes' that each goal received.

Goal	Conservation Impact	Urgency
High Conservation Priority; Moderate Urgency		
Establish effective governance for organizing institutions and people to achieve conservation of Northern Sagebrush Steppe, including GSG recovery.	18	19
Increase functional sage-grouse habitat.	19	5
Reduce sage-grouse mortality due to predation while increasing nest success.	15	12
Minimize disturbance from industrial development.	14	9
Moderate Conservation Priority; High to Moderate Urgency		
Establish and maintain a captive population of GSG with reasonable genetic diversity until the wild population is sustainable (as both an assurance population and as a source population for release)	6	27
Translocate birds from either wild (first number) or captivity (second number) to wild populations within Canada to prevent imminent extinction.	2/2	8/4
Moderate Conservation Priority; Lower Urgency		
Manage grazing to optimize vegetation conditions for seasonal habitats for greater sage-grouse.	7	--
Reduce large-scale fragmentation by eliminating further cultivation, and reclaim selected cultivate lands to maintain and create effective habitat corridors (for maintaining gene flow, migration, and seasonal and annual dispersal).	6	1
Lower Conservation Priority; Lower Urgency		
Restore important already invaded areas that are suitable for sage-grouse habitat.	1	--
Reduce mortality (threat) due to West Nile virus.	--	2
Avoid future impacts to functional habitat through informed and collaborative planning and site-specific mitigation.	--	--
Minimize/control the introduction of invasive species.	--	--

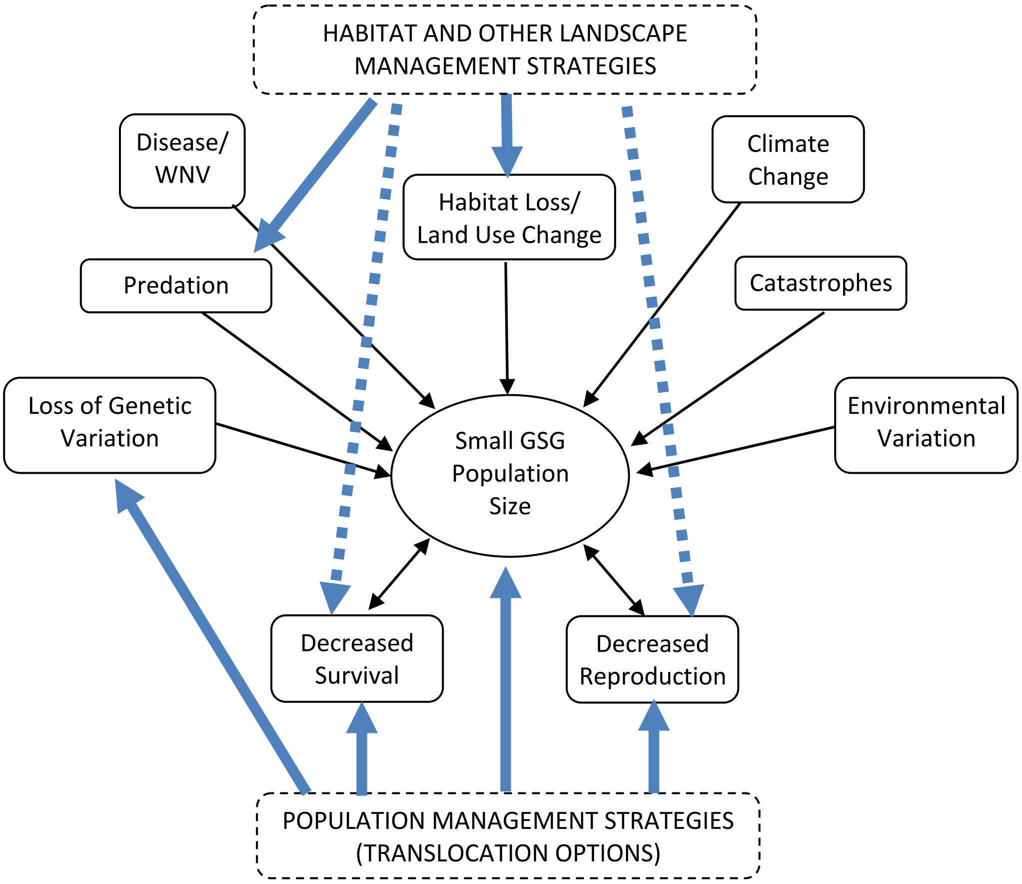

Figure 8. General characterization of threats affecting greater sage-grouse populations in Canada and management of those threats.

Greater Sage-Grouse in Canada Population and Habitat Viability Assessment Workshop

Calgary, Canada
14 – 17 January 2014

Draft Report

APPENDIX I

Workshop Participants

Workshop Participant List

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Greater Sage-Grouse in Canada PHVA Workshop
Calgary Zoo, Canada, 14 – 17 January 2014
Meeting Agenda

<u>14 January 2014 (Tuesday)</u> – DAY 1

AM Welcome and participant introductions
Introduction to workshop and PHVA process (K. Traylor-Holzer)
Overview of new IUCN reintroduction guidelines (A. Moehrenschlager)
Overview of new IUCN *ex situ* management guidelines and the One Plan approach (K. Traylor-Holzer)
Brief presentations on greater sage-grouse (15 min. each):
- Overview of sage-grouse research and threats (C. Aldridge)
- Galliformes reintroduction guidelines and sage-grouse research (M. Schroeder)
- Northern Sagebrush Steppe Initative (D. Eslinger, given by J. Nicholson)
- Updated Canadian recovery strategy (T. Wellicome)
- Conservation and Development Zones in Alberta (C. Gates)
- Translocation efforts (J. Nicholson)
- Captive management efforts (L. Wiechman)
- Genetics and population relatedness (K. Bird, via Skype)
- Landowners perspective (L. Finstad / D. Heydlauf)

PM Overview of PVA/Vortex/sage-grouse Vortex model (J. Mickelberg)
Identification and diagramming of threats/challenges to sage-grouse viability in Canada
Discussion of a vision for the greater sage-grouse in Canada
Identification of potential population management strategies
Formation of working groups and instructions

<u>15 January 2014 (Wednesday)</u> – DAY 2

AM Working groups (Habitat and Collaboration): Issue evaluation
- Issue descriptions, causes and consequences, prioritization
- Data assembly and data gaps
- Identification of invention opportunities

Working groups (Population Management): Conservation roles
- Problem identification
- Potential population management strategies and their conservation role

PM Working groups: Goals and objectives
- Generation of long-term goals to address issues
- Identification of short-term objectives to achieve goals
- Identification of additional modeling questions

Plenary session: Working groups reports and discussion

<u>16 January 2014 (Thursday)</u> – DAY 3

AM Working groups: Potential strategies
- Identification of potential strategies to achieve goals and objectives
- Evaluation of potential strategies (benefits, costs, likelihood of success)
- Plenary session: Modeling update (additional scenarios) (J. Mickelberg)

PM Working groups: Recommended actions
- Evaluation and selection of proposed strategies
- Description of recommended actions (detailed)

Plenary session: Working group reports and discussion

<u>17 January 2014 (Friday)</u> – DAY 4

AM Plenary session: Modeling update (additional scenarios) (J. Mickelberg)
Plenary session: Final working group reports and group prioritization of goals
Identification of major workshop outcomes
Next steps forward – beyond the PHVA workshop
Closing of workshop

Greater Sage-Grouse in Canada Population and Habitat Viability Assessment Workshop

Calgary, Canada
14 – 17 January 2014

Draft Report

APPENDIX II

Key Reference Literature

Key References (workshop briefing materials)

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