COSEWIC
Assessment and Update Status Report

on the

Greater Sage-Grouse
Centrocercus urophasianus

Phaios subspecies (*Centrocercus urophasianus phaios*)
Urophasianus subspecies (*Centrocercus urophasianus urophasianus*)

in Canada

EXTIRPATED – *Phaios* subspecies (British Columbia population)
ENDANGERED – *Urophasianus* subspecies (Prairie population)
2008

COSEWIC
Committee on the Status of Endangered Wildlife in Canada

COSEPAC
Comité sur la situation des espèces en péril au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC. 2008. COSEWIC assessment and update status report on the Greater Sage-Grouse *Centrocercus urophasianus, Phaios* subspecies and *Urophasianus* subspecies, *Centrocercus urophasianus urophasianus,* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 38 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Previous reports:

COSEWIC. 2000. COSEWIC assessment and status report on the Greater Sage-Grouse *Centrocercus urophasianus urophasianus* and *Centrocercus urophasianus phaios* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 34 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Hyslop, Colleen (ed.). 1998 (based on draft 1997 report). COSEWIC status report on the Sage-Grouse *Centrocercus urophasianus urophasianus* (Prairie population) *Centrocercus urophasianus phaios* (B.C. population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-34 pp.

Production note:
COSEWIC acknowledges Doris Hausleitner for writing the update status report on the Greater Sage-Grouse *Centrocercus urophasianus, Phaios* subspecies and *Urophasianus* subspecies, *Centrocercus urophasianus urophasianus*, prepared under contract with Environment Canada. This report was overseen and edited by Richard Cannings, Co-chair COSEWIC Birds Specialist Subcommittee.

A first draft of this report from 1997 is on file with COSEWIC Secretariat. The Greater Sage-Grouse (*Centrocercus urophasianus phaios* and *Centrocercus urophasianus urophasianus*) was formerly designated by COSEWIC as the Sage-Grouse (*Centrocercus urophasianus*) Prairie Population (*Centrocercus urophasianus urophasianus*) and the British Columbia Population (*Centrocercus urophasianus phaios*).

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le tétras des armoises de la sous-espèce *phaios* (*Centrocercus urophasianus phaios*) et de la sous espèce *urophasianus* (*Centrocercus urophasianus urophasianus*) au Canada – Mise à jour.

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Sage-Grouse — ©U.S. Fish and Wildlife Services.

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COSEWIC
Assessment Summary

Assessment Summary – April 2008

Common name
Greater Sage-Grouse – British Columbia population

Scientific name
Centrocercus urophasianus phaios

Status
Extirpated

Reason for designation
This subspecies has not been seen in its former range in the Okanagan Valley of British Columbia for about a century.

Occurrence
Formerly British Columbia

Status history
Has not been reported since the 1960s. Designated Extirpated in April 1997. Status re–examined and confirmed in May 2000 and April 2008. Last assessment based on an update status report.

Assessment Summary – April 2008

Common name
Greater Sage-Grouse – Prairie population

Scientific name
Centrocercus urophasianus urophasianus

Status
Endangered

Reason for designation
This large grouse is restricted to sagebrush grasslands in southern Alberta and Saskatchewan and has suffered significant population declines (42% over the last 10 years, 88% since 1988). The number of leks (male display sites) has decreased by 50% in the last 10 years and there are now less than a thousand breeding birds in the population. Causes for the decline are largely due to the loss, fragmentation and degradation of its native grassland habitats through oil and gas exploration, overgrazing and conversion to crops.

Occurrence
Alberta, Saskatchewan

Status history
Given conditional designation of Threatened in April 1997. Status re–examined and designated Endangered in April 1998 based on a revised status report. Status re–examined and confirmed in May 2000 and April 2008. Last assessment based on an update status report.

COSEWIC
Executive Summary

Greater Sage-Grouse
Centrocercus urophasianus

Phaios subspecies (*Centrocercus urophasianus phaios*)
Urophasianus subspecies (*Centrocercus urophasianus urophasianus*)

Species information

Greater Sage-Grouse (*Centrocercus urophasianus*) is the largest grouse in North America. It is one of two *Centrocercus* species; the other is the Gunnison Sage-Grouse, *Centrocercus minimus,* restricted to the Gunnison Valley of Colorado. Two subspecies of Greater Sage-Grouse are known from Canada: *C. u. urophasianus* in Alberta and Saskatchewan and *C. u. phaios* in the south Okanagan Valley of British Columbia. The latter form is extirpated.

Preliminary genetic analysis indicates Greater Sage-Grouse north of the Missouri River form a single population which is likely further divided into 3 sub-populations: Sage Creek (western Saskatchewan, Alberta, and northern Blaine County, Montana), Grasslands (Grasslands National Park, Saskatchewan and northern Phillips and Valley Counties, Montana), and South of the Milk River (southern Blaine, Phillips, and Valley Counties).

Distribution

Greater Sage-Grouse exhibit a near-obligate relationship with sagebrush and are found within the sagebrush range in western North America. Grouse found in Alberta and Saskatchewan are at the northern edge of the species' range and represent less than 1% of the global population. Based on historical accounts, there has been a 90% reduction in range and substantial declines in the number of breeding locations.

Habitat

Greater Sage-Grouse inhabit the mixed grassland ecoregion of Alberta and Saskatchewan, which has been reduced significantly. Their distribution is closely associated with that of silver sagebrush. Specific attributes within the sagebrush community are required during breeding, nesting, brood-rearing and over-wintering. Herbaceous cover for nesting and brood-rearing may be limited for Greater Sage-Grouse in Canada.

Biology

Greater Sage-Grouse are long-lived and chick survival may be driving population declines. Productivity is associated with local vegetation, age and condition of the breeding female, spring precipitation, anthropogenic disturbances, and spatial distribution and density. Nest initiation rates, clutch sizes, and nesting and breeding success are normal-high compared to rates reported in the species range. This suggests that intrinsic reproductive rates and success are not factors limiting the population. However, chick survival is low and may be the demographically limiting factor.

Given their small population in Canada, Greater Sage-Grouse are susceptible to climate and stochastic events. Extended drought may exacerbate the already limited amount of herbaceous cover for nesting and brood-rearing and degrade silver sagebrush habitat. Greater Sage-Grouse are difficult to raise in captivity and are not good candidates for translocation. Currently, however, adequate gene flow exists in Canada.

Population sizes and trends

Monitoring by lek counts has occurred since 1968 and 1987 in Alberta and Saskatchewan, respectively. Survey effort and protocol has varied within and between provinces and between years. The accuracy of using lek counts to monitor abundance is questionable. Crude population estimates are made with assumptions of sex ratio, male sightability on leks and the number of occupied leks. Using lower population estimates, the number of individuals in both provinces has declined from 777 in 1996 to 450 in 2006, a 42% decline. From 1988 to 2006 the total Canadian population declined 88%. Similar results are shown for leks, which declined in number from 30 to 15 from 1996 to 2006 (50% decline).

There appears to be an essential corridor for gene flow in western Saskatchewan that connects the Alberta grouse to Saskatchewan and Montana.

Limiting factors and threats

Current population declines are likely due to an accumulation of causes but loss and degradation of habitat is thought to be the most important limiting factor. This has occurred through cultivation of rangeland for agriculture and overgrazing in the United States of America, expansions in oil and gas exploration and changes in hydrology. The effect of West Nile Virus and loss of genetic variability are not fully understood, but may have serious implications for a small population.

Special significance of the species

Greater Sage-Grouse are considered an indicator of the health of the mixed grassland ecosystem, and their range-wide declines may be cause for concern. They have high public appeal due to their unique, colourful breeding display, making them a perfect ambassador for the ecosystem they inhabit.

Existing protection or other status designations

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the *urophasianus* subspecies of Greater Sage-Grouse as Endangered in 1998 and the *phaios* subspecies as Extirpated in 1997. Provincially, the Greater Sage-Grouse was listed as endangered in Saskatchewan and Alberta in 1999 and 2000, respectively. It was listed under the Species at Risk Act in 2003. Provincial representatives established a recovery team in 1997 and produced a Canadian Sage-Grouse recovery strategy in 2001. A Species at Risk compliant Recovery Strategy was compiled in 2006, outlining species biology and recovery goals.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS (2008)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

** Formerly described as "Not In Any Category", or "No Designation Required."

*** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.

Environment Canada
Canadian Wildlife Service

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Canada

The Canadian Wildlife Service, Environment Canada, provides full administrative and financial support to the COSEWIC Secretariat.

Update
COSEWIC Status Report

on the

Greater Sage-Grouse
Centrocercus urophasianus

Phaios subspecies (*Centrocercus urophasianus phaios*)
Urophasianus subspecies (*Centrocercus urophasianus urophasianus*)

in Canada

2008

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SPECIES INFORMATION

Name and classification

The Greater Sage-Grouse was first described as *Tetrao urophasianus* (Bonaparte 1828) and renamed *Centrocercus urophasianus* in 1831 (Aldrich 1963). The Latin name is derived from the Greek word “kentron” meaning spiny, “kerkos” meaning tail, and “oura phasianos” meaning tail of a pheasant (Gill 1966). *Centrocercus* is one of 10 genera in the sub-family Tetraoninae, family Phasianidae, of the order Galliformes.

Two species fall under the genera *Centrocercus* (Young *et al.* 2000): Greater Sage-Grouse, *C. urophasianus,* and Gunnison Sage-Grouse, *C. minimus*. Current research suggests the Greater Sage-Grouse population in California (Lyon/Mono) has been isolated from all other populations and may be sufficiently genetically distinct to warrant protection and management as a separate unit (Oyler-McCance *et al.* 2005). Vernacular names include Sage Chicken and Sage Hen (Patterson 1952).

Greater Sage-Grouse are separated into eastern *(C. u. urophasianus*) and western (*C. u. phaios*) subspecies (Hupp and Braun 1991, Schroeder *et al.* 1999). *C. u. urophasianus* is found in Alberta and Saskatchewan, while *C. u. phaios* was formerly present in the Okanagan Valley of British Columbia. *C. u. phaios* was extirpated from Canada in the early 1900s (Cannings *et al.* 1987). This report will deal almost entirely with the Canadian *C. u. urophasianus* populations. Recent genetic and ecological analysis of 16 populations (n = 332) throughout the North American range produced no evidence to support delineation of these subspecies (Benedict *et al.* 2003).

Morphological description

Greater Sage-Grouse are the largest grouse in North America (Beck and Braun 1978). Males can be distinguished from females by their conspicuous plumage and larger size (Figure 1). During courtship display, the males fan their tails and inflate air sacs, thus exposing two patches of bare, yellowish skin on the breast (Schroeder *et al.* 1999). Other features the males exhibit are yellow fleshy combs above the eyes and long filoplumes that arise from the nape (Figure 1,2). The undertail coverts of the male have white-tipped black feathers while the front of the neck and upper breast are white. Both genders have diagnostic black feathers on the belly. The female has more cryptic plumage, an inconspicuous comb above the eye, and is smaller (1.0-1.8 kg, length 50-60 cm) than the male (1.7-2.9 kg, length: 65-75 cm) (Schroeder *et al.* 1999) (Figure 1).

Figure 1. Male and female Greater Sage-Grouse on breeding grounds in southeastern Alberta (Photo: Krista L. Bush).

Figure 2. Adult male Greater Sage-Grouse in display in southeastern Alberta (Photo: Krista L. Bush).

Genetic description

A range-wide genetic survey was conducted for 46 populations and 1000 individuals using mitochondrial DNA and sequence data from 7 nuclear microsatellites (Oyler-McCance *et al.* 2005). Results indicated that Greater Sage-Grouse movements are mostly among neighbouring populations and not across the species' range (Oyler-McCance *et al.* 2005). In this study, grouse from Alberta scored the second highest level of genetic variation across the species' range (Oyler-McCance *et al.* 2005). The significance of these results may be compromised by variable sample sizes (Bush pers. comm. 2006).

Preliminary analysis of 19 microsatellite loci in Canada indicates Greater Sage-Grouse north of the Missouri River form a single population which is likely further divided into 3 sub-populations: Sage Creek (western Saskatchewan, Alberta, and northern Blaine County, Montana), Grasslands (Grasslands National Park, Saskatchewan and northern Phillips and Valley Counties, Montana), and South of the Milk River (southern Blaine, Phillips, and Valley Counties) (Bush pers. comm. 2006).

Designatable units

This report will use the two subspecies known from Canada as the most logical designatable units for this taxon. Although recent genetic and ecological analysis of 16 populations (n = 332) throughout the North American range produced no evidence to support delineation of these subspecies (Benedict *et al.* 2003), they are still recognized on morphological characters (Schroeder *et al.* 1999). The two subspecies occupy two different COSEWIC National Ecological Areas (Southern Mountains and Prairie) with substantial ecological differences (e.g. different sagebrush and grass species).

DISTRIBUTION

United States

Greater Sage-Grouse distribution is associated with habitat dominated by sagebrush (*Artemisia* spp.) in western North America (Schroeder *et al.* 1999). The amount of potential pre-settlement habitat available encompassed 1,200,483 km^2 (Schroeder *et al.* 2004). The species' current range extends 668,412 km^2 (Schroeder *et al.* 2004) and includes populations in southeastern Oregon; northeastern California; southern Idaho; northern two-thirds of Nevada; portions of northeast, north and south Utah; portions of western Colorado; Wyoming (except northwest and southeast corners); east and southwest Montana; northwest and southwest S. Dakota; North Dakota; and small populations in central Washington (Schroeder *et al.* 1999).

Canada

In Canada, Greater Sage-Grouse is at the northern-most extent of the species' range and represents < 1% of the global population (Lungle 2006). Their distribution is related to silver sagebrush (*A. cana*), the dominant sagebrush species in the mixed grassland ecoregion in Canada (Holcroft Weerstra 2001; Thorpe 2002). The current range (2002), based on occupied lek sites and telemetry locations, covers approximately 6,000 km^2 within southeast Alberta and southwest Saskatchewan (Aldridge and Brigham 2003) (Figure 3). The range prior to 1950 extended approximately 100,000 km^2 within Alberta and Saskatchewan (Figure 3). Historic range estimation is based on published information, museum specimens and anecdotal sightings (Aldridge and Brigham 2003).

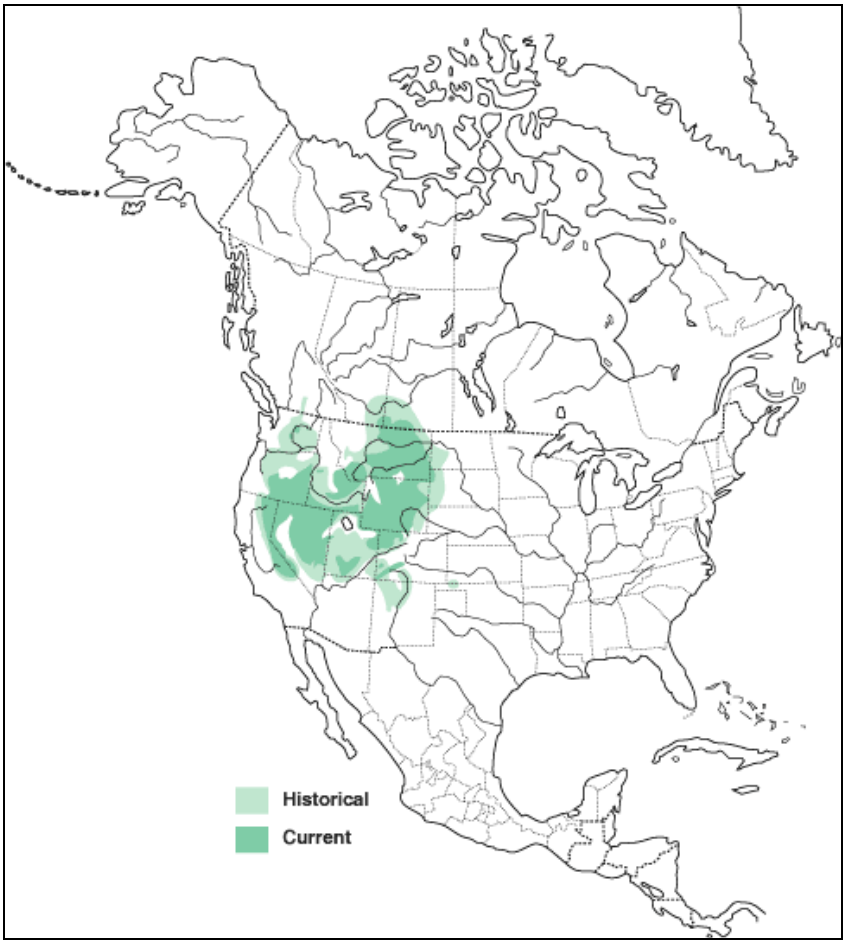

Figure 3. Distribution of Greater Sage-Grouse (from Schroeder *et al.* 1999).

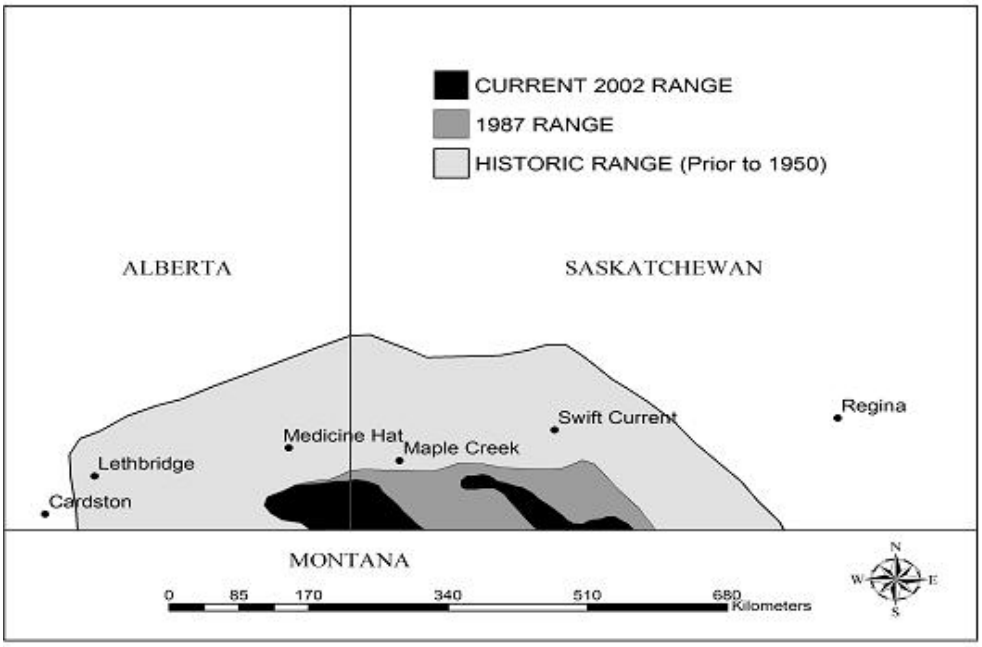

Figure 4. Current and historic distribution of Greater Sage-Grouse in Alberta and Saskatchewan (Adapted from Aldridge and Brigham 2003).

Using landscape-level occurrence models and radio-telemetry locations (111 nests, 669 brood locations), researchers in southeast Alberta were able to predict the probability of occurrence of Greater Sage-Grouse nests and broods (Aldridge 2005; Aldridge and Boyce 2007). Variables included to predict grouse occurrence were sagebrush cover, soil-moisture index (related to herbaceous cover), and anthropogenic landscape features. About 30% and 20% of the 1,110 km^2 study area would likely be used for nesting and brood-rearing, respectively (Aldridge and Boyce 2007). Extrapolating this proportion over the range in Canada (6,000 km^2) yields an area of occupancy for brood rearing and nesting of 1,800 km^2 and 1,200 km^2, respectively.

Monitoring by lek counts has occurred since 1968 in Alberta and 1987 in Saskatchewan. Survey effort and protocol has varied within and between provinces and between years (Aldridge and Brigham 2003; McAdam pers. comm. 2006; Connelly *et al.* 2004). Trends are further confounded when leks move or when satellite leks are discovered (Connelly *et al.* 2004). There have been no systematic searches for new leks in Saskatchewan (Sissons pers. comm. 2006) or Alberta (Eslinger pers. comm. 2006). A helicopter was used to successfully locate a previously unrecorded lek in Alberta in 2001 and aerial searches were conducted in Saskatchewan in 1983, 1984, 1988 and 2003 (McAdam 2003, McAdam, pers.. comm. 2006). From 1995-2005 only 5 new leks were discovered (Table 1).

HABITAT

Habitat requirements

Greater Sage-Grouse are associated with sagebrush habitat at all times of the year and exhibit specific requirements for breeding, nesting, brood-rearing, and wintering (Braun *et al.* 2005). In Canada, they inhabit the silver rather than big sagebrush (*A. tridentata*) dominated community that is characteristic of most of the species' range in the United States. This community exhibits less canopy cover and is lower in quality and carrying capacity (Kerwin 1971; Aldridge and Brigham 2002; Adams *et al.* 2004). Silver sagebrush is associated predominantly with alluvial landforms, which are characterized by deep, productive soil and occasional flooding (Thorpe 2002; McNeil and Sawyer 2003; Adams *et al.* 2004; Jones *et al.* 2005). Grasses are predominant in this mixed grassland ecoregion and include needle-and-thread grass (*Hesperostipa comata*), june grass (*Koeleria macrantha*), blue grama (*Bouteloua gracilis*) and western wheatgrass (*Pascopyrum smithii*) (Aldridge and Brigham 2003). In Alberta, dominant forbs are clover (*Trifolium* spp.), vetch (*Astragalus* spp.) and common dandelion (*Taraxacum officinale*) (Aldridge and Brigham 2003). Dominant forbs in southwestern Saskatchewan were pasture sage (*Artemisia frigidus*), scarlet mallow (*Sphaeralcea coccinea*), prairie selaginella (*Selaginella densa*) and moss phlox (*Phlox hoodii*) (McAdam 2003). Dominant forbs in the vicinity of Grasslands National Park are scarlet mallow, prairie selaginella, and common knotweed (*Polygonum aviculare*) (Thorpe *et al.* 2005).

Breeding

Leks typically have less shrub and herbaceous cover and are often situated on broad ridge tops, knolls, grassy swales, dry lake or creek beds, and burned areas (Scott 1942; Braun *et al.* 1977; Harris and Weidl 1988; Schroeder *et al.* 1999). Dense cover is found adjacent to breeding grounds (Call and Maser 1985). Lek sizes range from 0.3 to 1.1 hectares in Saskatchewan (Kerwin 1971) and are predominantly in areas of native vegetation (Thorpe *et al.* 2005). Leks in southern Alberta are associated with alluvial stands of silver sagebrush and western wheatgrass (McNeil and Sawyer 2001). In Alberta, leks were frequently lower than surrounding areas and adjacent to water (Aldridge 2000). In Saskatchewan no significant association was detected between lek occupancy and the amount of naturally occurring water sources (McAdam 2003).

Nesting

Nests are situated almost exclusively under sagebrush (Patterson 1952; Klebenow 1969; Braun *et al.* 1977; Connelly *et al.* 1991; Musil *et al.* 1994) and those associated with big sagebrush have higher nest success (Connelly *et al.* 1991). In Alberta, over 80% (n = 119) of nests were under silver sagebrush (Aldridge and Brigham 2002; Aldridge 2005).

The basic requirement of a nest site is concealing vegetation (Patterson 1952). Nest selection and success is positively associated with shrub and sagebrush cover (Klebenow 1969; Wallestad and Pyrah 1974; Gregg *et al.* 1994; Aldridge and Brigham 2002; Watters *et al.* 2002; Aldridge 2005; Holloran *et al.* 2005) shrub height (Wallestad and Pyrah 1974; Gregg *et al.* 1994; Delong *et al.* 1995; Aldridge and Brigham 2002; Watters *et al.* 2002), grass height (≥18 cm) (Klebenow 1969; Gregg *et al.* 1994; Delong *et al.* 1995; Aldridge 2005) and residual grass height and cover (Holloran *et al.* 2005). Lateral forb cover was a predictor of hatching success for both artificial and natural nests in Alberta (Aldridge and Brigham 2001; Watters *et al.* 2002).

Brood-rearing

Forage and cover are basic habitat requirements for brood-rearing. Early brood-rearing sites tend to be in sagebrush habitat close to nest areas. However, broods shift to more mesic sites later in the season as forbs begin to desiccate (Klebenow 1969; Wakkinen 1990; Fischer *et al.* 1996*a*). Kerwin (1971) noted broods in Grasslands National Park, Saskatchewan, selected meadows rich in forbs as summer progressed. This shift to mesic sites in late brood-rearing was not reported for 15 females radio-marked in southern Alberta (Aldridge and Brigham 2002). In southern Alberta, females with broods selected areas with greater sagebrush cover (Aldridge and Brigham 2002), contrary to studies where big sagebrush was the dominant shrub cover (Klebenow 1969; Dunn and Braun 1986). Authors suggest mesic brood-rearing habitat rich in forb cover may be limited in southeastern Alberta (Aldridge and Brigham 2002; Aldridge 2005; Aldridge and Boyce 2007).

Winter

Wintering habitat is relatively similar throughout the species range (Connelly *et al.* 2000a). Greater Sage-Grouse have a near-obligate relationship with sagebrush for forage and cover during winter (Eng and Schladweiler 1972; Wallestad *et al.* 1975) and distribution is limited by topography and availability of sagebrush above snow (Beck 1977; Hupp and Braun 1989). Due to habitat selection for increased sagebrush canopy cover and height (Eng and Schladweiler 1972; Wallestad *et al.* 1975; Aldridge *et al.* 2004), preferred winter sites include southwest slopes, draws, swales and wind-swept ridges (Beck 1977; Hupp and Braun 1989).

Habitat trends

Greater Sage-Grouse habitat in Canada is associated with silver sagebrush (McNeil and Sawyer 2001; Jones *et al.* 2005). Silver sagebrush is largely restricted to the mixed grassland ecoregion. Cultivation, and oil and gas development are primarily responsible for elimination of native vegetation in the mixed grassland ecoregion of Saskatchewan and Alberta (Hammermeister *et al.* 2001; Braun *et al.* 2002; Lungle 2006).

Within Saskatchewan, silver sagebrush is common south of the Cypress Hills and Wood Mountain, and from the Cypress Hills north to the South Saskatchewan River (Thorpe 2002). The amount of mixed grassland remaining in Saskatchewan is 2.7 million ha or approximately 31% of the ecoregion (Hammermeister *et al.* 2001; Nernberg and Ingstrup 2005). McAdam (2003) reviewed land use changes within 3.2 km of leks in Saskatchewan using aerial photographs from 1955, 1971, 1981, and 1996. Cultivation of native vegetation at occupied leks increased from 5.4 ha/year (1955 to 1971) to 24.3 ha/year (1971 to 1996). Similarly, cultivation surrounding abandoned leks increased from 25.5 ha/year to 63.7 ha/year (McAdam 2003). Thorpe *et al.* (2005) reported no net increase in cultivation at leks in Saskatchewan between 1981 and 2003.

In Alberta, only 2.6 million ha of mixed grassland remain, representing 54% of the historic extent (Nernberg and Ingstrup 2005). From the late 1970s to present, oil and gas development has been primarily responsible for elimination and fragmentation of native grassland vegetation in Alberta (Braun *et al.* 2002).

Considerable land ownership south of the Saskatchewan border in Montana is federal (Bureau of Land Management) and primary land use is livestock grazing (Carlson pers. comm. 2006). Rangeland is still relatively intact. However, significant areas of rangeland in northeastern Montana have been converted for agriculture or oil and gas development (Connelly *et al.* 2004; Carlson pers. comm. 2006).

Habitat protection/ownership

In Alberta, 75% of all occupied leks occur on Crown land. Thirty-three percent of remaining mixed prairie grassland in Alberta occurs on private land (Nernberg and Ingstrup 2005). Of 35 inactive and active leks, only 5 occur on private land (Nicholson pers. comm. 2006). Federal protection is afforded for one lek on the One-Four Agricultural Research Station, which has been inactive since 1976 (Nicholson pers. comm. 2006). Recommendations and guidelines are made by Alberta Fish and Wildlife to reduce the impact of oil and gas exploration, particularly in important breeding habitat. However, there is no current legislation that commits Alberta Public Lands or the Alberta Energy Utility Board to follow these recommendations (Braun *et al.* 2002).

In Saskatchewan, 66% of occupied leks occur in Grasslands National Park. The park encompasses 497 km^2 in both the East and West Blocks and may eventually cover up to 900 km^2 along the Canada-U.S. border (Parks Canada 2005). This additional acquisition will protect a known existing occupied lek and a second lek that may or may not be occupied (Fargey pers. comm. 2006). Another lek monitored by Grasslands National Park of Canada exists on Val Marie Prairie Farm Rehabilitation Administration (PFRA) pasture, which is afforded federal protection by the *Species at Risk Act* and the Representative Areas Network (RAN) (McAdam pers. comm. 2006). Occupied and abandoned leks monitored by Saskatchewan Environment are on provincial land protected by the *Wildlife Habitat Protection Act* (WHPA) or PFRA pastures (McAdam pers. comm. 2006).

Landscape level modelling has shown that good quality “source” habitat for nesting and brood-rearing is limited (Aldridge and Boyce 2007). Much of the habitat suitable for Greater Sage-Grouse in Canada is on provincial or federal crown lands, and with favourable management practices, can support Canadian populations (Lungle 2006).

BIOLOGY

Life cycle and reproduction

Leks are traditional areas where male Greater Sage-Grouse congregate in spring to jockey for the principal mating position (Scott 1942). A sub-dominant male, positioned near the dominant male at the centre of the lek is the primary competitor in mating. These 2 males obtained 74% (n = 174) of copulations in Wyoming (Scott 1942). Although yearling males are sexually mature, they surround the dominant and sub-dominant males and rarely breed (Schroeder *et al.* 1999).

Females arrive on leks later than males and attend for 2-3 days until they have successfully mated. Mean date of peak female lek attendance in southeastern Alberta occurred 5 April ± 0.9 days (Aldridge and Brigham 2001). Females fly or walk directly to the dominant male, seemingly indifferent to displays by other males on the lek (Scott 1942; Dalke *et al.* 1963), and solicit copulation by squatting, spreading their primaries on the ground and slightly lifting their wings (Schroeder *et al.* 1999). Hybridization of Greater Sage-Grouse with the sympatric Sharp-tailed Grouse (*Tympanuchus phasianellus*) has been documented in Alberta and Saskatchewan and is not uncommon across the species’ range (Aldridge *et al.* 2001).

Nesting tends to be associated with sagebrush habitat within 5 km of leks (Holloran and Anderson 2005), but has also occurred > 15 km from breeding grounds (Wakkinen *et al.* 1992; Holloran and Anderson 2005). Mean distance travelled from leks to nests in southern Alberta was 4.7 $\pm$ 0.7 km (n = 20), which falls within the range reported in other studies (Aldridge and Brigham 2001).

Mean nest initiation date in southeast Alberta was 3 May (range 27 April to 9 May, n = 20) and 7 June for renesting (range 29 May to 19 June, n = 5) (Aldridge and Brigham 2001). Females reach sexual maturity at 1 year. Bergerud (1988) suggested that some yearling females do not make nesting attempts. However, all females radio-marked in Washington (n = 129) and Alberta (n = 20) attempted nesting (Schroeder 1997; Aldridge and Brigham 2001), and research on follicular development indicated that 91-98% of females laid eggs in the previous season (Dalke *et al.* 1963; Braun 1979). Reported nest initiation rates range from 68% to 100% (Schroeder *et al.* 1999).

Incubation lasts 25 to 29 days (Schroeder 1997; Aldridge and Brigham 2001) and mean clutch size varies from 6.0 to 9.5 throughout the range of the species (Connelly *et al.* 2000a). Evaluation of DNA extracted from eggshell membranes and embryos, has shown the sex ratio at hatch in southern Alberta is biased towards females (57%,

n = 507) (Bush 2004). In Alberta, mean hatch date of successful nests occurred 5 June ± 4.6 days (n = 12) (Aldridge and Brigham 2001). Similarly estimated hatch dates in Saskatchewan were within the first 2 weeks of June (Kerwin 1971). Nest success is typically between 30-60% (Schroeder *et al.*1999).

In Alberta all tracked females initiated clutches, and clutch size (8.0 $\pm$ 0.4 eggs) was at the high end of the range for the species (Aldridge and Brigham 2001). Nest success rates were within the normal range of rates reported with 46% (n = 19) and 35% (n = 40) for 1998-1999 and 2001-2003, respectively (Aldridge and Brigham 2001; Aldridge 2005). Breeding success (55%) was also within the normal range, suggesting that reproductive rates and success are not factors limiting this population (Aldridge and Brigham 2001). Chick survival from hatch to 8 weeks was low for 1998-1999 (14-23%, n = 88) and 2001-2003 (12%, n = 41) and may be an important factor limiting the population (Aldridge and Brigham 2001; Aldridge 2005).

Productivity is associated with local vegetation (see Habitat: nesting), age and condition of the breeding female, spring precipitation, anthropogenic disturbances, and spatial distribution and density. Adult females tend to lay larger clutches (Wallestad and Pyrah 1974, Schroeder *et al.* 1999) and have greater nesting and breeding success than yearling females (Swenson 1986; Bergerud 1988; Aldridge and Brigham 2001; Gregg *et al.* 2006). Nest predation rates in Wyoming increased with association to leks or other nests (Holloran and Anderson 2005). However, nest success of artificial nests in Alberta was unrelated to distance from leks (Watters *et al.* 2002). Nest success rates vary as a function of habitat quality (Gregg *et al.* 1994; Watters *et al.* 2002; Crawford *et al.* 2004) and precipitation in spring and summer (Aldridge 2005; Holloran *et al.* 2005).

Greater Sage-Grouse are generally in excellent physiological condition in winter and in Colorado they gain weight on an exclusive diet of sagebrush (Beck and Braun 1978; Remington 1983). Adult females experience low mortality over winter (Connelly *et al.* 2000b; Hausleitner 2003; Aldridge *et al.* 2004). Apparent winter survival rates of radio-marked adult females in southeastern Alberta were 88% (n=16) and 73% (n=15) in 2002/03 and 2003/04, respectively (Aldridge *et al.* 2004). This, compared to apparent spring to fall survival rates, estimated at 57% (Aldridge and Brigham 2001). Apparent winter survival rates were much lower for juveniles in this study: only 3 of 7 survived the winter (Aldridge *et al.* 2004). Although the sample size is small, this result suggests that juvenile survival might be an important factor contributing to the low recruitment rates in Alberta (Aldridge *et al.* 2004).

Predation

Predation may be a factor limiting nest success (Gregg *et al.* 1994) and annual population recruitment (Autenrieth 1981, 1986; Crawford *et al.* 2004). Habitat alteration may result in a loss of concealment cover for grouse or change in predator community (Bowman and Harris 1980; Johnson *et al.* 1996; Connelly *et al.* 2000a; Aldridge and Brigham 2003; Crawford *et al.* 2004). Raccoons (*Procyon lotor*), striped skunks (*Mephitis mephitis*), coyotes (*Canis latrans),* and red fox (*Vulpes vulpes*) have all

increased on the Canadian prairies in the last half-century (Gudmundson 1996; Aldridge and Brigham 2003). Predation may be the proximate cause of mortality for grouse in poor body condition due to parasites/diseases or climatic factors (Atkinson and Van Riper III 1991; Hudson and Dobson 1991).

For many grouse species, nest predation is an important reason for reduced productivity (Reynolds *et al.* 1988). In Bergerud's (1988) summary of nest success and predation rates for 9 species of grouse, Greater Sage-Grouse showed the lowest nest success (35%) and the highest rates of nest predation (47%). Alternatively, Connelly *et al.* (2000a) reported most nest success rates to be > 40%, indicating predation is not a significant limiting factor. Nest success rates in Alberta (35-46%) are within ranges reported for the species (Aldridge and Brigham 2001; Aldridge 2005). Nest predation in Wyoming decreased with increasing distance from leks and other nests suggesting predators concentrate their search effort (Holloran and Anderson 2005). Common nest predators in Canada include Richardson's ground squirrels (*Spermophilus richardsonii*), badgers (*Taxidea taxus*), Black-billed Magpies (*Pica hudsonia*), American Crows (*Corvus brachyrhynchos*), weasels (*Mustela* spp.), raccoons, striped skunks, and red fox (Harris and Weidl 1988; Watters *et al.* 2002; Aldridge and Brigham 2003).

Annual recruitment may be limited by survival of Greater Sage-Grouse from hatch to the following breeding season (Crawford *et al.* 2004). Survival rates to 8 weeks and over winter in Alberta are low at 12-23%, and 43%, respectively, resulting in low annual recruitment (Aldridge and Brigham 2001; Aldridge *et al.* 2004; Aldridge 2005). American Kestrels (*Falco sparverius*), Merlins (*F. columbarius*), Northern Harriers (*Circus cyaneus*), and weasels have been known to prey upon juveniles (Schroeder *et al.* 1999).

Greater Sage-Grouse are long-lived compared to other Tetranonids and predation does not limit annual survival of breeding-aged birds (Connelly *et al.* 2000a; Connelly *et al.* 2004; Crawford *et al.* 2004). Apparent annual female survival in southeastern Alberta was 43-50%, somewhat lower than range-wide estimates (Aldridge *et al.* 2004). Avian predators of adults in Canada may include Golden Eagles, Gyrfalcons (*Falco rusticolus*), Great Horned Owls (*Bubo virginianus*), Cooper's Hawk (*Accipiter cooperii*), Northern Goshawk (*A. gentilis*), Swainson's Hawk (*Buteo swainsoni*), Red-Tailed Hawk (*B. jamaicensis*), Ferruginous Hawk (*B. regalis*) (Schroeder *et al.* 1999) and Northern Harriers (Fletcher *et al.* 2003). Bobcat, mink (*Mustela vison*), coyote, red fox and swift fox (*Vulpes velox*) are potential mammalian predators (Schroeder *et al.* 1999; ASGRAG 2005).

Dispersal / migration

Greater Sage-Grouse exhibit some philopatry to natal leks, although dispersal is not uncommon (Dunn and Braun 1985). Dispersal rates are similar in males and females (Dunn and Braun 1985, Bush pers. comm. 2006), although female dispersal distance is greater than that of males (Dunn and Braun 1985). Current genetic research in Alberta and Saskatchewan indicates some leks are genetically isolated from each other while others act as hubs for genetic flow from Montana (Bush pers. comm. 2006).

Females exhibit fidelity to nests (Fisher *et al.* 1993, Holloran and Anderson 2005) and winter sites (Berry and Eng 1985; Aldridge *et al.* 2004). Greater Sage-Grouse populations have been described as migratory or non-migratory (Eng and Schladweiler 1972; Wallestad 1975; Connelly *et al.* 1988). Migration can occur between winter/breeding and summer areas, winter and breeding/summer areas or by a combination of movements between winter, breeding and summer areas (Connelly *et al.* 2000a). Non-migratory grouse have been defined as those that do not make seasonal movements > 10 km (Connelly *et al.* 2000a). Greater Sage-Grouse in Alberta and Saskatchewan are described as non-migratory, although seasonal habitat movements > 10 km are common (Aldridge 1998; McAdam 2003). An important corridor between western Saskatchewan and Alberta appears to be linking Alberta to the remaining population in Saskatchewan and Montana, enabling gene flow (Bush pers. comm. 2006). Movement distances > 200 km were documented from Alberta to Montana (Bush pers. comm. 2006).

Diet

Greater Sage-Grouse have a near obligate relationship with sagebrush for food and cover year-round (see Habitat). Sagebrush constitutes > 47-60% of adult diet in summer and 100% in winter (Kerwin 1971; Wallestad *et al.* 1975). Greater Sage-Grouse lack a grinding gizzard but have adapted a long ceca and a soft food diet to aid digestion (Remington 1989).

Dietary requirements vary with age, reproductive stage, and season. Forbs make up the remainder of adult summer diet and may be important to reproductive success of pre-laying hens (Barnett and Crawford 1994; Gregg *et al.* 2006). Forbs are associated with invertebrate biomass in sagebrush (Jamison *et al.* 2002) and invertebrates are critical in the diet of chicks in their first weeks post-hatch (Klebenow and Gray 1968; Johnson and Boyce 1990; Drut *et al.* 1994). As chicks develop, there is a dietary shift to include forbs and succulent shrubs (Patterson 1952; Klebenow and Gray 1968; Klebenow 1969). In Saskatchewan, forbs were predominant in the summer diet of Greater Sage-Grouse broods (Kerwin 1971). Forbs have greater protein content than other vegetation types (Peterson 1970) and may influence chick growth rates (Huwer 2004) and survival (Johnson and Boyce 1990; Aldridge 2005; Dunbar *et al.* 2005). Sagebrush becomes increasingly important to chicks as they approach 3 months of age (Peterson 1970).

Adaptability

Given their small population in Canada, Greater Sage-Grouse are susceptible to climate and stochastic events. Extended drought may exacerbate the already limited amount of herbaceous cover for nesting and brood-rearing (Aldridge and Brigham 2002; Aldridge and Boyce 2007). Hot, dry years with low precipitation in spring and summer have been shown to increase the risk of nest and chick failure influencing annual population recruitment (Aldridge 2005). Heavy grazing may further impact herbaceous cover available for nesting and brood-rearing; livestock concentrate in areas of greater moisture during drought conditions (Braun 1998; Adams *et al.* 2004). Dry conditions, such as those seen in southeast Alberta from 1978-1995, adversely impact Greater Sage-Grouse habitat (McNeil and Sawyer 2003). Conversely, cool weather or heavy precipitation coinciding with hatch of chicks can negatively influence fall recruitment (Patterson 1952). Additionally, deep snow can severely reduce habitat quality in winter (Beck 1977; Hupp and Braun 1989).

Translocations to introduce, reestablish, or augment a population have met with limited success. Greater Sage-Grouse are difficult to raise in captivity and are poor candidates for release. Few chicks (5%, n = 148) captured by Johnson and Boyce (1990) survived to maturity; mortality was attributed primarily to disease. Breeding success for those that reached reproductive age was minimal (Johnson and Boyce 1990). Egg collection, storage and incubation techniques were effective in hatching 73% (n =112) of eggs in northwest Colorado for experimentation (Huwer 2004). However, meeting the nutritional needs of the human-imprinted chicks was difficult and most chicks succumbed from malnutrition (Huwer 2004). Successful attempts at husbandry have occurred at the Buttes Environmental Research Facility in Laramie, Wyoming (Spurrier *et al.* 1994) and at the United States Department of Agriculture's National Wildlife Research Center in Fort Collins, Colorado (Oesterle *et al.* 2005). The 21 juvenile grouse kept at the latter facility experienced low mortality (17%) and breeding was attempted (Oesterle *et al.* 2005).

Restocking populations from captive-bred individuals has not been attempted, although it is known that wild individuals do not translocate well. Fifty-seven juvenile grouse from Oregon were released north of Richter Lake, British Columbia in 1958. Greater Sage-Grouse were seen near Osoyoos in the early 1960s but are now considered extirpated (Cannings *et al.*1987). In Saskatchewan in 1972 an attempt to reintroduce Govenlock grouse to the Saskatchewan Landing area failed. A lone bird was captured and it died upon release (Roy 1996). Translocations of more than 7,200 Greater Sage-Grouse range-wide have also met with little success (< 5%, n = 56), and authors suggest translocations be viewed only as an experimental strategy to restore extirpated populations (Reese and Connelly 1997).

It is not surprising that failure rates of translocations are high, given that habitat quality and quantity is already limiting existing (or extirpated) populations (Schroeder *et al.* 2006). Translocations should only be considered as a management strategy if the configuration, quality, and quantity of available habitat can support a viable population with minimal long-term management intervention (IUCN 1998).

POPULATION SIZES AND TRENDS

Search effort

Greater Sage-Grouse population trends and status are based largely on monitoring males on leks. Concerns have been raised regarding the validity of using lek counts as population indices (Walsh *et al.* 2004, Strohm 2005). Attendance varies daily, seasonally and annually (Walsh *et al.* 2004). Indices derived from lek counts are not corroborated in models with realistic demographic rates (Strohm 2005), and variable search effort may misrepresent population trends (Aldridge 2000, Aldridge and Brigham 2003). Lek counts were not performed on an annual basis in Alberta and Saskatchewan until the last decade (Table 1, 2) (See Distribution: Canadian Range for more information).

In Alberta, each lek receives a single count annually at the end of April over a 3-day period. Surveyors arrive at each lek 1 hour prior to sunrise and remain until after sunrise or the birds fly away for the day. Up to 2 hours can be spent at each active lek (Eslinger pers. comm. 2006). Monitoring of leks was sporadic from 1968-1996. From 1997 onward, lek counts were conducted annually at all occupied and previously occupied leks (Alberta Fish and Wildlife Division, Alberta Sustainable Resource Development 2006).

In Saskatchewan, monitoring has been undertaken by Saskatchewan Environment and Resource Management biologists (1987-1994) in collaboration with Grasslands National Park (1996-2006) (Wynn 1996). In Grasslands National Park prior to 1994, leks were enumerated 3 times each spring. From 1995-2006, leks were monitored 4 times on specified count days (Wynn 1996). On count days, observers arrive at each lek ½ hour prior to sunrise and remain for 2 hours. Unoccupied leks have not been monitored on an annual basis (Grasslands National Park of Canada 2006). Survey of the leks in southwest Saskatchewan is in accordance with protocol recommended by the Western States Sage-Grouse Technical Committee (McAdam pers. comm. 2006). Lek counts are conducted every 7-10 days between early April to early May and at least one lek count coincides with the day Alberta counts are done (McAdams pers. comm. 2006).

Abundance

Surveys in spring 2006 enumerated 90 males at 9 leks in Alberta, and 60 males on 6 leks in Saskatchewan, for a cumulative average of 10 males/lek in both provinces (Tables 2, 3). Population estimates reported previously in Canada use a low and high

estimate (Aldridge and Brigham 2003). The low estimate uses the high count of males on leks and assumes a sex ratio of 2 females: 1 male (Aldridge and Brigham 2003; Lungle 2006). A second, high estimate includes the 2:1 sex ratio, but also assumes only 90% of leks were counted and 75% of males were counted on leks. Using these assumptions, the Canadian estimate in 2006 is 450-667 birds. Population estimates are 270-400 in Alberta, and 180-267 in Saskatchewan.

Fluctuations and trends

Annual rates of change suggest long-term declines of 2%/year in Greater Sage-Grouse across western North America (Connelly *et al.* 2004). Greater Sage-Grouse populations in Canada appear to be cyclic (Tables 1, 2); however, inconsistent monitoring between years and provinces make it difficult to assess these cycles and annual rates of change (Aldridge 2000; Connelly *et al.* 2004). The overwhelming trend appears to be one of decline. In Alberta, the number of individuals may have declined by as much as 85% since 1968 and 34% in the past decade. Aldridge and Brigham (2003) and Connelly *et al.* (2004) calculated similar rates of population decline (66-92%: 1968-2002 and 80%: 1975-2003). Connelly *et al.* (2004) report the number of individuals in Saskatchewan has declined 28-51% in the past decade (1996-2006); since 1988, the Saskatchewan population has declined 90-94%. Similarly, declines of 60-90% were reported prior to 1994 (Aldridge and Brigham 2003; McAdam 2003, Connelly *et al.* 2004). Routine monitoring was only initiated in 1994 (Aldridge and Brigham 2003) making assessment of long-term population trends impossible (Connelly *et al.* 2004).

Using the lower population estimates, the number of individuals in both provinces has declined from 777 in 1996 to 450 in 2006, a 42% decline. From 1988 to 2006 the total Canadian population declined 88%. Similar results are shown for leks, which declined in number from 30 to 15 from 1996 to 2006 (50% decline, Table 3). Of 21 leks monitored in Alberta in 1968, 17 (81%) had been abandoned by 2006 (Alberta Fish and Wildlife Division, Alberta Sustainable Resource Development 2006). In Saskatchewan lek abandonment rates appear even greater. Of 61 leks occupied in 1988, 54 (89%) had been abandoned by 2005 (Grasslands National Park of Canada 2006). However, it appears that 22 (36%) leks occupied in 1988 were not monitored in subsequent years, and 4 (7%) did not have $\geq$ 2 males during the assessment period or within 5 years of that period.

Table 1. Summary of Greater Sage-Grouse surveys in Alberta and population estimates 1968-2006 (Data provided by Alberta Fish and Wildlife Division, Alberta Sustainable Resource Development 2006).

Year	Number of Active Leks [a]	Number of Males	Number of Males/Lek	Spring Population Estimate (Low)	Spring Population Estimate (High)
1968	21	613	29.2	1839	2724
1969	20	554	27.7	1662	2462
1975	19	212	11.2	636	942
1976	19	347	18.3	1041	1542
1977	13	286	22.0	858	1271

Year	Number of Active Leks [a]	Number of Males	Number of Males/Lek	Spring Population Estimate (Low)	Spring Population Estimate (High)
1978	13	235	18.1	705	1044
1979	11	198	18.0	594	880
1980	16	482	30.1	1446	2142
1981	16	524	32.8	1572	2329
1983	18 (1)	358	19.9	1074	1591
1985	14	208	14.9	624	924
1987	13	400	30.8	1200	1777
1989	12	344	28.7	1032	1529
1991	11	241	21.9	723	1071
1994	8	70	8.8	210	311
1995	12 (1)	110	9.2	330	489
1996	11 (2)	136	12.4	408	604
1997	8 (1)	122	15.3	366	542
1998	8	124	15.5	372	551
1999	9	117	13.0	351	520
2000	8	126	15.8	378	560
2001	9	114	12.7	342	507
2002	10 (2)	89	8.9	267	395
2003	9	94	10.4	282	418
2004	9	94	10.4	282	418
2005	9 (1)	95	10.6	285	422
2006	9 (1)	90	10.0	270	400

[a] Leks in parenthesis are included in the total count but they consisted of < 2 males during the assessment period or within 5 years of that period.

Table 2. Summary of Greater Sage-Grouse surveys in Saskatchewan and population estimates 1988-2006 (Data provided by Grasslands National Park of Canada).

Year	Number of Occupied Leks	Number of Males	Number of Males/Lek	Spring Population Estimate (Low)	Spring Population Estimate (High)
1988	61 (4)	934	15.3	2802	4150
1994	15 (1)	93	6.2	279	413
1995	16 (1)	105	6.6	315	467
1996	19 (2)	123	6.5	369	547
1997	10	61	6.1	183	271
1998	11	122	11.1	366	542
1999	8	101	12.6	303	449
2000	10	126	12.6	378	560
2001	10	106	10.6	318	471
2002	10	84	8.4	252	373
2003	10	81	8.1	243	360
2004	8	60	7.5	180	267
2005	8	62	7.8	186	276
2006	6	60	10.0	180	267

[a] Leks in parenthesis are included in the total count but they consisted of < 2 males during the assessment period or within 5 years of that period.

Table 3. Lek abandonment in Alberta and Saskatchewan 1996-2006. Leks in parenthesis are those consisting of < 2 males within the assessment period or within 5 years.

	Occupied Leks 1996	Occupied Leks 2006	Abandonment Rate
Saskatchewan	19 (2)	6 (0)	68%
Alberta	11 (2)	9 (1)	18%
Total	30 (4)	15 (1)	50%

Rescue effect

Vast tracts of sagebrush have been removed in northeastern Montana, effectively isolating the Alberta population (ASGRAG 2005, Carlson pers. comm. 2006). Movement of grouse between Alberta and eastern Montana is unlikely due to conversion of native rangeland (Carlson pers. comm. 2006). However, there appears to be an essential corridor for gene flow in western Saskatchewan that connects Alberta to the rest of the population and evidence exists of long-range dispersal events (> 200 km) between Alberta and Montana (Bush pers. comm. 2006). On going research at the University of Montana is hoping to elucidate the amount of cross-border movement of radio-marked Greater Sage-Grouse (Tack pers. comm. 2006).

Lek counts of Greater Sage-Grouse north of the Milk River in the USA suggest declines in Greater Sage-Grouse in the past decade mirroring the Canadian population trends (Carlson pers. comm. 2006). North of the Milk River, the habitat is mixed prairie-grassland with silver sagebrush dominating, whereas south of the river the community is a mixture of silver and big sagebrush (Carlson pers. comm. 2006). In regions south of the Milk River such as south Phillips and Valley Counties, the grouse population appears large and stable (Carlson pers. comm. 2006).

LIMITING FACTORS AND THREATS

Current population declines are likely due to an accumulation of causes (Crawford *et al.* 2004). Loss and degradation of habitat was thought to be the most important factor influencing declines (Connelly *et al.* 2000a; Aldridge and Brigham 2002). Reseeding practices, alien plant invasion, water diversion, energy extraction and industrial development, insecticides, grazing and climate change, are also factors in habitat loss, degradation and fragmentation (Braun 1998; Miller and Eddleman 2000; Lyon and Anderson 2003; Adams *et al.* 2004; Aldridge 2007). Predation pressure and fire intensity may have increased as a function of habitat changes (Storch and Willebrand 1991; Crawford *et al.* 2004). West Nile Virus and loss of genetic diversity may pose additional threats to small populations.

Agricultural practices

Although many of the specific relationships between Greater Sage-Grouse demographics and habitat quality are unclear, the overall relationship is illustrated by the fact that remaining populations are associated with intact habitats (Crawford *et al.*

2004). Vast tracts of sagebrush have been removed in the USA since settlement for western rangeland improvement (Beck and Mitchell 2000). Methods of sagebrush removal have included herbicide applications (Klebenow 1970; Martin 1970; Wallestad 1975), fire (Fischer *et al.* 1996b; Nelle *et al.* 2000), and mechanical means (Swenson *et al.* 1987). There are few examples of similar management objectives to remove silver sagebrush on public rangelands in Canada (Adams *et al.* 2004). Cultivation of rangeland in Alberta likely caused the desertion of 2 leks (Aldridge and Brigham 2003). Cultivation did not appear to be associated with lek abandonment in Saskatchewan (McAdam 2003; Thorpe *et al.* 2005). Although cultivation has eliminated 60% of native vegetation in the Mixed Grassland Ecoregion of Saskatchewan (Hammermeister *et al.* 2001), the crash in provincial Greater Sage-Grouse cannot be linked to land use changes (Thorpe *et al.* 2005).

Historically, wild fires occurred every 30-50 years in arid sagebrush habitat and 100-200 years in low sagebrush types (Braun 1998; Miller and Eddleman 2000). Fires produced a mosaic of burned patches with enhanced herbaceous plant production (Pyle and Crawford 1996; Miller and Eddleman 2000), and reduced woody plant abundance (Miller and Eddleman 2000). In Canada, fires ended as an ecological force on the landscape in the early 1900s, during a period of extensive grazing by domestic livestock (Adams *et al.* 2004).

Regeneration of big sagebrush after fire is by reseeding, and prescribed burning has had negative short and long-term impacts on Greater Sage-Grouse food supplies, nesting habitat and abundance (Fischer *et al.* 1996b; Connelly *et al.* 2000c; Nelle *et al.* 2000). The impact of fire may be less severe on the silver sagebrush community as it is fairly resistant to fire and has strong regeneration potential (Aldridge and Brigham 2002; Thorpe 2002; Adams *et al.* 2004). Although a shortage of information exists on the impacts of natural or prescribed burning in the silver sagebrush community (Connelly *et al.* 2000a), at this time it is expected fire would further reduce habitat quality and availability in Canada (Adams *et al.* 2004).

Livestock grazing

Livestock grazing can have a strong influence on the productivity of Greater Sage-Grouse populations (Beck and Mitchell 2000). Grazing may directly affect the composition, density and structure of vegetation. Additionally, large areas of sagebrush-grassland have been converted to exotic crested wheat grass (*Agropyron desertorum*) for cattle forage (McAdoo *et al.* 1989). These introduced stands have limited potential in terms of winter forage, shrub and forb cover (Miller and Eddleman 2000). A reduction in shrub and herbaceous cover negatively affects nesting success (Gregg *et al.* 1994; Delong *et al.* 1995, Aldridge and Brigham 2002; Holloran *et al.* 2005) and forage and cover available for brood-rearing (Call and Maser 1985; Aldridge 2000). In southeastern Alberta, trampling on livestock wintering sites may be the principal reason for silver sagebrush decline (Adams *et al.* 2004). The loss of cover can negatively influence grouse by exposing them to weather and predators (Aldridge 2000) and reducing the amount of available winter range.

Human disturbance

Oil and gas exploration has had detrimental effects on Greater Sage-Grouse breeding behaviour, seasonal habitat selection and population demographics (Aldridge 2000; Braun *et al.* 2002; Lyon and Anderson 2003; Holloran 2005; Aldridge and Boyce 2007). Across the species range, oil and gas wells and associated pipelines influence 28% of the sagebrush habitats (Connelly *et al.* 2004). Oil and gas exploration began in Alberta in the 1940s and development intensified in the 1980's (Braun *et al.* 2002). Density of wells within Greater Sage-Grouse range in southern Alberta in 2002 was 1 active and 2 inactive wells per km^2 (Braun *et al.* 2002).

During an exploration boom in the 1980s the number of males displaying on leks in southern Alberta decreased by approximately 50% (Braun *et al.* 2002). Leks $\leq$ 200 m of a road or well sites were rendered inactive, and leks within view of a development were either reduced or inactivated (Aldridge 2000). Similarly, drilling within 5.0 km of leks in western Wyoming resulted in displacement of adult males and low recruitment of juveniles (Holloran 2005). Impacts continued even after drilling and construction activities ceased; the number of breeding males failed to recover within 3.0 km of producing wells (which typically remain on site from 30 to 50 years) even after drilling was completed. Light traffic disturbance from natural gas development (1-12 vehicles/day) during the breeding season in western Wyoming resulted in reduced nest initiation rates and increased lek to nest distances (Lyon and Anderson 2003). Females avoided gas field infrastructure when selecting nest and brood-rearing habitat (Holloran 2005; Aldridge and Boyce 2007), and chick survival decreased with increasing well site density (Aldridge and Boyce 2007).

Development has also fragmented sagebrush habitat through the addition of buildings, highways, trails, fences and electrical poles. These structures provide raptor perching sites (Connelly *et al.* 2000a) and can cause injury or death to Greater Sage-Grouse that fly into human-made objects or traffic (Patterson 1952; Crowley and Connelly 1996, ASGRAG 2005).

Silver sagebrush occurs on mesic sites with deep fertile soils requiring periodic flooding (Thorpe 2002; Jones *et al.* 2005). Drainage impediments such as dams, dugouts, berms and reservoirs have increased four-fold from 1951-2001 in southeastern Alberta, altering hydrological regimes and degrading silver sagebrush communities (McNeil and Sawyer 2003). More than 80% of current Greater Sage-Grouse range in Alberta is altered by impediments (ASGRAG 2005).

Diseases

Historically, disease was not considered a major factor in Greater Sage-Grouse population change until the discovery of the first West Nile Virus (WNv) caused mortality in 2003. A widespread, cross-border study reported dramatic impacts of WNv on survival of radio-marked populations (Naugle *et al.* 2004). Associated deaths with WNv decreased female survival in 2003 by 25% in 4 populations in Wyoming, Montana and

Alberta (Naugle *et al.* 2004). In 2004 and 2005, disease prevalence decreased range-wide and there was a single WNv-associated mortality in Alberta (Naugle *et al.* 2005; Nicholson pers. comm. 2006). This was likely a result of unseasonably cool temperatures in summer which reduced mosquito (*Culex tarsus*) production, the vector for WNv (Naugle *et al.* 2005). To date, the species has not developed any resistance to WNv and low survival rates could devastate small populations (Naugle *et al.* 2004, 2005).

Genetics

The decline and extinction of natural populations has been linked to the loss of heterozygosity and inbreeding, thus small populations are prone to a reduction in genetic diversity (Bush pers. comm. 2006). Genetic flow among and between populations is essential in maintaining population viability. Loss of genetic diversity in Greater Sage-Grouse populations may result in enhanced susceptibility to parasitic agents or disease (Oyler McCance *et al.* 2005).

Preliminary genetic analysis in Alberta indicates inbreeding may be resulting in a skewed sex ratio favoring females at hatch, and reproductive morphological deformities (Bush 2004). Analysis of Greater Sage-Grouse embryos indicated 13% (n = 48) exhibited external abnormalities (anophthalmia [no eyes], microphthalmia [small eyes], deformed beaks, and dwarfism) and 52% of abnormal and apparently “normal” embryos exhibited a variety of cranial abnormalities (anophthalmia, microphthalmia, deformed beaks, shortened beaks, malformed cranial cartilage, and deviated nasal septa) (Bush pers. comm. 2006). Inbreeding and selenium toxicity are being examined as potential causative factors.

SPECIAL SIGNIFICANCE OF THE SPECIES

The obligate relationship Greater Sage-Grouse exhibit with sagebrush makes them a good indicator of the health of the prairie ecosystem (CSGRT 2001). They have high public appeal due to their unique, colourful breeding display, making them a perfect ambassador for the ecosystem in which they live. Greater Sage-Grouse are declining throughout most of their range (Connelly *et al.* 2004; Crawford *et al.* 2004). They share habitat with other wildlife species of concern: the black-tailed prairie dog (*Cynomys ludovicianus*), swift fox, Long-billed Curlew (*Numenius americanus*), Mountain Plover (*Charadrius montanus*), Loggerhead Shrike (*Lanius ludovicianus*), Sage Thrasher (*Oreoscoptes montanus*), Burrowing Owl (*Athene cunicularia*), Ferruginous Hawk, Eastern Short-horned Lizard (*Phrynosoma hernandesi*), Eastern Yellow-bellied Racer (*Coluber constrictor flaviventris*) and Prairie Rattlesnake (*Crotalus viridis*).

In Grasslands National Park of Canada, increasing numbers of ecotourists are visiting leks for birdwatching or photography. Tourism in the park has increased by 25% a year (Saskatchewan Environment 2000) and 7,500 people visit annually (Sissons pers. comm. 2006). There are no guided lek tours in Alberta, and recreational viewing is actively discouraged (Nicholson pers. comm. 2006).

Hunting may be additive to other mortality causes of adult Greater Sage-Grouse and may result in lower breeding populations (Connelly *et al.* 2000*b*). Although no longer hunted in Canada, Greater Sage-Grouse were considered a game species in Saskatchewan (pre-1938) and Alberta (1967-1995) where they were hunted as a trophy species (Aldridge 2000). A statewide hunting season still exists in Montana (Carlson pers. comm. 2006).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

Canada

Due to declining population trends and limited distribution, the *urophasianus* subspecies of Greater Sage-Grouse was listed by COSEWIC as Threatened in 1997 and upgraded to Endangered in 1998. The *C. u. phaios* subspecies was listed as Extirpated in 1997. Provincial representatives established a national Sage-Grouse Recovery Team in 1997. The team is comprised of representatives from federal and provincial governments, land managers, landowners, conservation organizations and industry. The species was listed under Schedule 1 of the *Species at Risk Act* in 2003 (Lungle 2006). In 2001 and 2006, the Canadian Sage-Grouse recovery strategy reviewed the biology and background of the species and provided an outline for conservation and recovery (CSGRT 2001; Lungle 2006).

Saskatchewan

Saskatchewan listed the Greater Sage-Grouse as provincially threatened in 1987 based on a declining population and reduction of range. Their status was officially upgraded to endangered in the Wild Species at Risk Regulations in 1999. Legislation under the *Wildlife Habitat Protection Act* prevents cultivation of native grasslands and the sale of crown land containing Greater Sage-Grouse habitat (Aldridge and Brigham 2003). Furthermore, they are legally afforded protection on private, provincial and federal lands under part V of *The Saskatchewan Wildlife Act*. These regulations prohibit capture, killing or possession of the species and afford protection to breeding sites. Permanent development is prohibited within 500 m of a lek site and no construction is allowed within 100 m of leks between 15 March and 15 May (Saskatchewan Environment 2000). Similarly, development is restricted within 500 m of nests between 15 April and 15 June (Saskatchewan Environment 2000).

Alberta

In a review of the status of Alberta wildlife in 1996, Greater Sage-Grouse was included on a blue-list of species considered at risk (Alberta Environmental Protection 1997). In 2000 the species was listed provincially as endangered (Schedule 6, Part 1, sub-part 12, of Alberta Wildlife Regulation 143/97).

United States

The U.S. Fish and Wildlife Service completed a status review of the Greater Sage-Grouse throughout its range in 2005 and determined that the species did not warrant protection under the *Endangered Species Act* at that time (USFWS 2005). No federal laws afford the species any protection (Connelly *et al.* 2004). In 2000, the Gunnison Sage-Grouse became a Candidate for protection under the *Endangered Species Act* and in 2005, the U.S. Fish and Wildlife Service announced that they would be preparing a proposed rule to consider placing the Gunnison Sage-Grouse on the Endangered Species list.

TECHNICAL SUMMARY (1)

Centrocercus urophasianus phaios
Greater Sage-Grouse *phaios* subspecies Tétras des armoises de la sous-espèce *phaios*
Range of occurrence in Canada: formerly British Columbia

Extent and Area Information

• *Extent of occurrence (EO)(km²)*	0 km²
• *Specify trend in EO*	
• *Are there extreme fluctuations in EO?*	0
• *Area of occupancy (AO) (km²)*	0 km²
• *Specify trend in AO*	Not applicable in Canada; declining in USA
• *Are there extreme fluctuations in AO?*	No
• *Number of known or inferred current locations*	0
• *Specify trend in #*	
• *Are there extreme fluctuations in number of locations?*	
• *Specify trend in area, extent or quality of habitat*	

Population Information

• *Generation time (average age of parents in the population)*	Ca. 3 years
• *Number of mature individuals*	0
• *Total population trend:*	
• *% decline over the last/next 10 years or 3 generations.*	
• *Are there extreme fluctuations in number of mature individuals?*	
• *Is the total population severely fragmented?*	
• *Specify trend in number of populations*	
• *Are there extreme fluctuations in number of populations?*	
• List populations with number of mature individuals in each:	

Threats (actual or imminent threats to populations or habitats)

Habitat loss and fragmentation.

Rescue Effect (immigration from an outside source)

• *Status of outside population(s)?* USA: [Washington] population small and declining	
• *Is immigration known or possible?*	No
• *Would immigrants be adapted to survive in Canada?*	Yes
• *Is there sufficient habitat for immigrants in Canada?*	Probably not
• ***Is rescue from outside populations likely?***	No

Quantitative Analysis

Current Status

COSEWIC: Extirpated (2000 and 2008)

Status and Reasons for Designation

Status: Extirpated	**Alpha-numeric code:** Not applicable
Reasons for Designation: This subspecies has not been seen in its former range in the Okanagan Valley of British Columbia for about a century.	

Applicability of Criteria

Criterion A (Declining Total Population): Not applicable.
Criterion B (Small Distribution, and Decline or Fluctuation): Not applicable.
Criterion C (Small Total Population Size and Decline): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY (2)

Centrocercus urophasianus urophasianus
Greater Sage-Grouse *urophasianus* subspecies — Tétras des armoises de la sous-espèce *urophasianus*
Range of occurrence in Canada: Alberta, Saskatchewan

Extent and Area Information

• *Extent of occurrence (EO)(km²)* [Aldridge and Brigham (2003) based on radio-telemetry and lek locations]	6,000 km²
• *Specify trend in EO*	Declining (6% of former range)
• *Are there extreme fluctuations in EO?*	No
• *Area of occupancy (AO) (km²)* [extrapolated from Aldridge and Boyce 2007]	1, 800 km²
• *Specify trend in AO*	Declining
• *Are there extreme fluctuations in AO?*	No
• *Number of known or inferred current locations*	15
• *Specify trend in #*	Declining; 50% loss of leks in last 10 years
• *Are there extreme fluctuations in number of locations?*	No
• *Specify trend in area, extent or quality of habitat*	Declining

Population Information

• *Generation time (average age of parents in the population)*	Ca. 3 years
• *Number of mature individuals*	450-667
• *Total population trend:*	Declining
• *% decline over the last/next 10 years or 3 generations.*	42% (1996-2006) 83-88% (1988-2006)
• *Are there extreme fluctuations in number of mature individuals?*	No
• *Is the total population severely fragmented?*	No
• *Specify trend in number of populations*	Not applicable
• *Are there extreme fluctuations in number of populations?*	No
• List populations with number of mature individuals in each:	

Threats (actual or imminent threats to populations or habitats)

- Habitat loss and fragmentation through conversion of rangeland to crops and oil and gas development
- Habitat degradation from livestock overgrazing
- Direct disturbance to lekking and nesting birds
- Alteration in hydrology through construction of dugouts, dams and reservoirs
- Disease (West Nile Virus)
- Loss of genetic variability

Rescue Effect (immigration from an outside source)

• *Status of outside population(s)?* USA: [Montana] Populations north of the Milk River are declining; stable south of the Milk River	
• *Is immigration known or possible?*	Yes
• *Would immigrants be adapted to survive in Canada?*	Yes
• *Is there sufficient habitat for immigrants in Canada?*	Declining

• *Is rescue from outside populations likely?*	No; declining populations and habitat in northern Montana

Quantitative Analysis

Not done

Current Status

COSEWIC: Endangered (2000 and 2008)

Status and Reasons for Designation

Status: Endangered	Alpha-numeric code: A2b, C1
Reasons for Designation: This large grouse is restricted to sagebrush grasslands in southern Alberta and Saskatchewan and has suffered significant population declines (42% over the last 10 years, 88% since 1988). The number of leks (male display sites) has decreased by 50% in the last 10 years and there are now less than a thousand breeding birds in the population. Causes for the decline are largely due to the loss, fragmentation and degradation of its native grassland habitats through oil and gas exploration, overgrazing and conversion to crops.	

Applicability of Criteria

Criterion A (Declining Total Population): Meets Endangered A2b based on estimated population trend and declining number of leks.
Criterion B (Small Distribution, and Decline or Fluctuation): Has small distribution, but is not severely fragmented and number of locations 15.
Criterion C (Small Total Population Size and Decline): Meets Endangered C1 if present population decline continues.
Criterion D (Very Small Population or Restricted Distribution): Meets Threatened D1
Criterion E (Quantitative Analysis): Not done.

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