

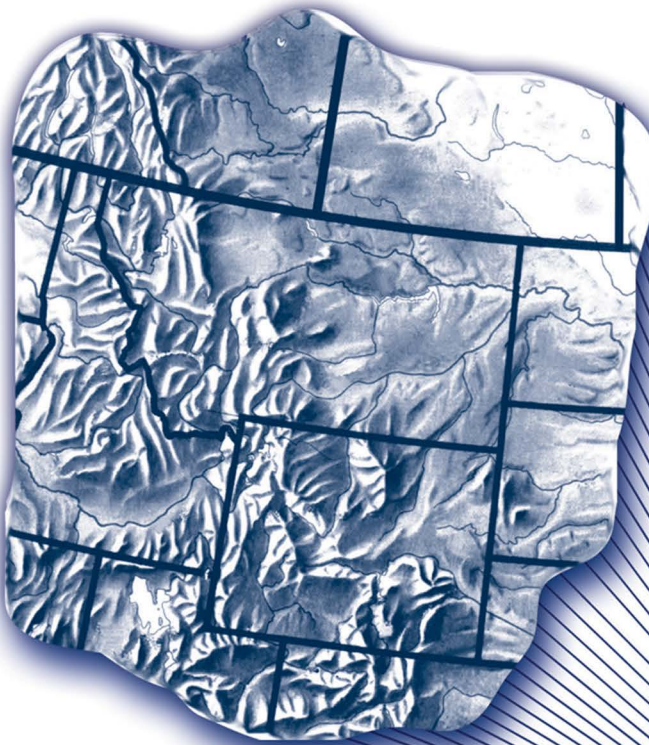
# *Intermountain Journal of Sciences*

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# JIS

*Issue devoted to the  
Ecology of Sagebrush  
and Sage Grouse*



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# INTERMOUNTAIN JOURNAL OF SCIENCES

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**INTERMOUNTAIN JOURNAL OF SCIENCES**

**ECOLOGY OF SAGEBRUSH  
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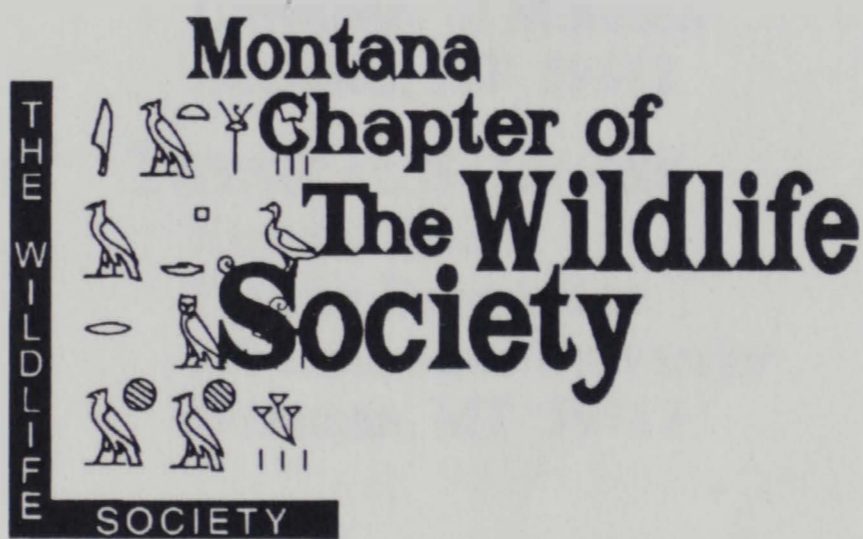
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Three hard copies of the submitted manuscript, with copies of the "Guidelines and checklist for IJS referees" attached are forwarded to the appropriate Associate Editor. The Associate Editor retains one copy of the manuscript and guidelines for his/her review, and submits a similar package to each of two other reviewers. A minimum of two reviewers, including the Associate Editor, is required for each manuscript. The two other reviewers are instructed to return the manuscript and their comments to the Associate Editor, who completes and returns to the EIC a blue "Cover Form" and all manuscripts and reviewer comments plus a recommendation for publication, with or without revisions, or rejection of the manuscript. This initial review process is limited to 30 days.

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For accepted manuscripts, each copy of the manuscript containing comments thereon and other comments are returned to the corresponding author. Revised manuscripts are to be returned to the EIC in hard copy, four copies if further review is required, or one hard copy plus the computer disk if only minor revision or formatting is necessary. The revised manuscript shall be returned to the EIC within 14 days of the notification. Review of the revised manuscript by the Associate Editor and reviewers shall be completed and returned to the EIC within 14 days. An accepted manuscript will then be forwarded to the Managing Editor (ME) for final

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Each manuscript submitted by an Associate Editor shall be reviewed by the EIC and a minimum of two other reviewers with expertise in the subject being addressed. Each manuscript submitted by the EIC shall be forwarded with the necessary review materials to the Chairman of the Editorial Board of IJS, who will serve as the EIC for that manuscript.

## **ABSTRACTS**

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## **COMMENTARY**

Submissions concerning management applications or viewpoints concerning current scientific or social issues of interest to the Intermountain region will be considered for publication in the "Commentary" Section. This section will feature concise, well-written manuscripts limited to 1,500 words. Commentaries will be limited to one per issue.

Submissions will be peer reviewed and page charges will be calculated at the same rate as for regular articles.

## **LITERATURE CITED**

Dusek, Gary L. 1995. Guidelines for manuscripts submitted to the *Intermountain Journal of Sciences*. Int. J. Sci. 1(1):61-70.

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Greater sage grouse  
(*Centrocercus urophasianus*)

## PREFACE

Carl L. Wambolt, Department of Animal and Range Sciences, Montana State University,  
Bozeman MT 59717

Michael R. Frisina, Montana Fish, Wildlife & Parks, 1330 West Gold Street, Butte MT  
59701

The landscape of the western United States is typified by diverse sagebrush flora. Many sagebrush taxa are habitat type dominants strongly associated with native fauna. No wildlife species illustrates this association better than the sage grouse (*Centrocercus urophasianus*), an important upland game bird species that is almost totally dependent on sagebrush for food and cover. The sage grouse and other native fauna associated with sagebrush plant communities have become a concern due to declining numbers in many areas. A range-wide petition has been filed for listing sage grouse under the Endangered Species Act. The black-tailed prairie dog (*Cynomys ludovicianus*), often associated with sagebrush-grass types, also has been petitioned for listing under the Endangered Species Act. Although the USDI Fish and Wildlife Service ruled that listing may be warranted, it has thus far been rejected to accommodate more immediate priorities with its status the subject of an annual review. The pygmy rabbit (*Brachylagus idahoensis*) is another species associated with sagebrush that is in decline and a petition for its listing also has been submitted. The trend indicates, as time goes on, that we should expect other indigenous wildlife that depend on sagebrush habitats to become candidates for listing. Even a relatively abundant species like the mule deer (*Odocoileus hemionus*) has been the subject of concern for some with evidence indicating this sagebrush-associated ungulate has experienced a slow, but steady decline over portions of its range for many years. Why the decline? Part of the reason is a long-standing attitude in the West that takes sagebrush plant communities for granted or even considers them a hindrance to agricultural uses. The result has been burning, spraying, plowing, and other altering of sagebrush communities on a large scale. Some experts believe we have lost half of our original sagebrush communities, and much of that which remains has been altered by man. The growing concern over wildlife associated with sagebrush reflects the status of our existing habitats and points to a need to finally recognize sagebrush communities for their uniqueness, diversity, and intrinsic values. Only through management based on an informed understanding of the ecology of sagebrush and associated wildlife can effective conservation occur. In that vein this issue of the *Intermountain Journal of Sciences* is dedicated to a series of papers on sagebrush and sage grouse.

# MONTANA SAGEBRUSH: A TAXONOMIC KEY AND HABITAT DESCRIPTIONS

Carl L. Wambolt, Department of Animal and Range Sciences, Montana State University, Bozeman MT 59717

Michael R. Frisina, Montana Fish, Wildlife & Parks, 1330 West Gold Street, Butte MT 59701

## ABSTRACT

We describe the 16 sagebrush (woody *Artemisia L.*) occurring in Montana and summarize their habitat characteristics, distributions, and relative importances. A taxonomic key and photographs for their identification also are provided.

**Key Words:** *Artemisia*, characteristics, distribution, habitat, Montana, sagebrush taxonomy.

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## INTRODUCTION

Sagebrush (woody *Artemisia L.*) also known as wormwood, mugwort, and sawwort are arguably the most important rangeland plants in Montana and the other western States. Sagebrush taxa occur on an estimated 109 million ha in the region (Beetle 1960, McArthur and Plummer 1978). Most of Montana's more than 25 million ha of rangeland contains at least one of the 16 different sagebrush taxa that occur within the state (Table 1).

Generally, the most important sagebrush are those that are widely distributed and/or dominate their communities. These dominant sagebrush taxa belong to the Asteraceae family, genus *Artemisia* within the subgenus *Tridentatae* (McArthur et al. 1981) (Table 1). The *Tridentatae* is endemic to western North America (Beetle 1960, McArthur et al. 1981). In a classification of western Montana grasslands and shrublands, Mueggler and Stewart (1980) recognized six distinct habitat types in which sagebrush taxa are dominants. Society for Range Management (1994) includes six and seven distinct rangeland cover types dominated by sagebrush in the northern Rocky Mountain and Great Basin regions, respectively, without partitioning for subspecies.

Our objective was to differentiate the 16 sagebrush taxa that occur in Montana by

contrasting their habitats, distributions, and relative importance (Table 2) and to create a taxonomic key to their identification (Table 3).

## SAGEBRUSH TAXA

### Low Sagebrush

One subspecies of low sagebrush (*Artemisia arbuscula* Nutt. *arbuscula*) occurs in Montana (Fig. 1). Low sagebrush is a small, stiff, many-branched shrub. Its distribution is limited to the southwestern part of the state, generally on well-drained alkaline soils. These soils usually have either a B horizon that is impermeable or bedrock near the surface. This taxon may occasionally layer and is found on dry plains and hilly sites where it may be the community dominant.

### Silver Sagebrush

Two subspecies occur in Montana, plains silver sagebrush (*Artemisia cana* Pursh. *cana*) and mountain silver sagebrush (*A. c. viscidula* [Osterhout] Beetle) (Fig. 2). The plains taxon is distributed mainly throughout central and eastern Montana and occasionally west of the continental divide whereas the mountain taxon is limited to mesic mid to high elevations mostly in southwestern Montana. Both taxa are associated with well-drained soils. Plains silver sagebrush is more prevalent on clayey

**Table 1.** Sagebrush<sup>1</sup> (*Artemisia*) taxa found in Montana.

| Taxon  | Common name                |
|--|----------------------------|
| <b><i>Tridentatae</i> (subgenus of ARTEMISIA)</b>          |                            |
| <i>A. arbuscula</i> Nutt. <i>arbuscula</i>                 | low sagebrush              |
| <i>A. cana</i> Pursh. <i>cana</i>                          | plains silver sagebrush    |
| <i>A. c. viscidula</i> (Osterhout) Beetle                  | mountain silver sagebrush  |
| <i>A. longiloba</i> (Osterhout) Beetle                     | alkali sagebrush           |
| <i>A. nova</i> Nels.                                       | black sagebrush            |
| <i>A. rigida</i> (Nutt.) Gray                              | scabland sagebrush         |
| <i>A. tridentata</i> Nutt. <i>tridentata</i>               | basin big sagebrush        |
| <i>A. t. wyomingensis</i> Beetle and Young                 | Wyoming big sagebrush      |
| <i>A. t. vaseyana</i> (Rydb.) Beetle                       | mountain big sagebrush     |
| <i>A. t. spiciformis</i> (Osterhout) Goodrich and McArthur | subalpine big sagebrush    |
| <i>A. tripartita</i> Rydb. <i>tripartita</i>               | tall threetip sagebrush    |
| <i>A. t. rupicola</i> Beetle                               | Wyoming threetip sagebrush |
| <b>Non – <i>Tridentatae</i> subshrubs and shrubs</b>       |                            |
| <i>A. frigida</i> Willd.                                   | fringed sagewort           |
| <i>A. longifolia</i> Nutt.                                 | longleaf sage              |
| <i>A. pedatifida</i> Nutt.                                 | birdfoot sage              |
| <i>A. spinescens</i> Eat.                                  | bud sage                   |

<sup>1</sup> There are an additional 11 *Artemisia* taxa in Montana that grow as forbs and are not included in this table.

sites, whereas mountain silver sagebrush is commonly associated with rocky sites near streams or areas that collect snow pack. Although subspecies were not designated, Hansen et al. (1995) recognized 2 silver sagebrush habitat types associated with riparian areas as follows: The [plains] silver sagebrush/western wheatgrass (*Agropyron smithii* Rydb.) habitat type is a major type throughout central and eastern Montana. This habitat type occurs on nearly level older alluvial terraces and alluvial fans in valleys. The other habitat type, [mountain] silver sagebrush/Idaho fescue (*Festuca idahoensis* Elmer), is incidental at mid-to-high elevations throughout the mountains and foothills of central and southwestern Montana. Not all sites dominated by silver sagebrush are considered riparian; some are considered upland sites.

### Alkali Sagebrush

As the name of this small shrub implies, alkali sagebrush (*Artemisia longiloba* [Osterhout] Beetle) is associated with alkaline and clayey soils on poorly drained sites in southwest Montana (Fig. 3).

This low shrub often layers from its lax spreading stems. Alkali sagebrush is distinctly separated from other sagebrushes by its large flower heads and early flowering habit. It also is known as early sagebrush because it flowers and sets seed much ahead of other sagebrush taxa with flowering beginning in early June and seeds ripening in August. Its habitat is often unusual for sagebrush as it grows in heavy, highly impermeable soils derived from very alkaline shales. However, it is sometimes found on light, limestone soils.

### Black Sagebrush

Black sagebrush (*Artemisia nova* Nels.) is distributed throughout southwest and southcentral Montana (Fig. 4). It is sometimes a community dominant on shallow sites rich in limestone. Typical plants have many erect branches that arise from a spreading base. Although the form of this taxon is similar to low sagebrush, the flower stalks are more numerous, darker, and more persistent on black sagebrush. Montana plants also have a darker leaf color than does low sagebrush. The leaves have a



**Table 3.** Key to Montana woody *Artemisia*

1. Low shrubs or subshrubs.
  2. Leaves mostly entire, linear and lance-linear, with silvery tomentose underneath; suffruticose base; alkaline soils of plains. *A. longifolia*
  2. Leaves divided.
    3. Base suffrutescent; leaves pinnatifid with 5-10+ divisions and silky-canescens; prairies and foothills primarily. *A. frigida*
    3. Base suffruticose.
      4. Branches spiny; base forms a low cushion; leaves 3-5 parted with divisions 3 lobed, deciduous; saline desert areas. *A. spinescens*
      4. Branches not spiny; low shrub < 1 dm from thick woody caudex; basal leaves cleft 3-5 times nearly to base; xeric soils. *A. pedatifida*
1. Obvious shrubs.
  5. Leaves mostly entire.
    6. Leaves broadly lanceolate, generally > 2 cm long, densely canescent; rhizomatous; plains, especially lowlands. *A. cana cana*
    6. Leaves narrowly lanceolate, generally < 2 cm long, perhaps with acute lobes, canescent to green, rhizomatous; along mountain streams and areas with heavy snow pack. *A. cana viscidula*
  5. Leaves not entire.
    7. Leaves cleft.
      8. Spike also has 3-cleft leaves similar to rest of plant; leaves deciduous; rocky scablands. *A. rigida*
      8. Panicle has only entire leaves.
        9. Plants relatively tall, > 2 dm, up to 2 m; leaves seldom > 2 cm long with lobes 0.5 –0.75 mm wide; mostly west of the continental divide on deep well drained dry soils. *A. tripartita tripartita*
        9. Short plants usually < 1.5 dm tall; leaves commonly 3 cm long with lobes 1 mm wide; east of the continental divide often on ridges with shallow soils. *A. tripartita rupicola*
    7. Leaves lobed.
      10. Mature plants usually < 50 cm tall.
        11. Persistent brown seed stalks arising to quite even lengths above crown; leaves dark green, viscid and flabelliform; shallow soils rich with limestone. *A. nova*
        11. Weakly persistent gray seed stalks; leaves gray and not viscid.
          12. Involucres narrow, heads few-flowered; not layering; most leaves cuneate; well drained, dry, commonly alkaline sites. *A. arbuscula arbuscula*
          12. Involucres broad, heads many flowered; often layering; the earliest flowering sagebrush with seed ripe in August (October for other *Artemisia* except some subshrubs); poorly drained, usually clay soils with high alkalinity. *A. longiloba*
      10. Mature plants usually > 50 cm tall.
        13. Tall plants 1-3 m at maturity; leaves long in relation to width and wedge shaped; panicles arise throughout a relatively uneven crown; deep, well-drained soils or along edges of talus slopes. *A. tridentata tridentata*
        13. Plants generally < than 1 m tall; leaves not wedge shaped with bases strongly tapered.
          14. Crown rounded with panicles arising throughout a relatively uneven crown; leaves are bell-shaped and shorter than other big sagebrush taxa; xeric soils that are shallow and heavy in clay or sometimes silt. *A. tridentata wyomingensis*
          14. Crown flat-topped with panicles arising to quite even lengths above the foliage.
            15. Leaves intermediate in size; crown relatively compact; 4-6 flowers per head, each <1.5 mm wide; not layered; a variety of soils receiving precipitation levels associated with mountains and foothills. *A. tridentata vaseyana*
            15. Leaves large; crown relatively open; >6 flowers per head, each > 1.5 mm wide; often layered; mesic sites compared to other big sagebrush, usually above 2100m elevation. *A. tridentata spiciformis*

viscid nature when touched that is provided by the high density of glandular trichomes on the surface and can often be seen as in Fig. 4.

### Scabland Sagebrush

Scabland sagebrush (*Artemisia rigida* [Nutt.] Gray) is a small shrub that prefers dry rocky scablands (Fig. 5). Although reported to be scarce, its Montana distribution is in the northwest portion of the state. Scabland sagebrush was named for its common habitat in the Pacific northwest of lava outcrops (Van Dersal 1938). This plant is rigid in stature with heavy branches that break up easily. It has a deciduous habit unlike most sagebrush that are evergreen. Leaves are usually spatulate and divided deeply into 3-5 narrow lobes. Infrequently linear-entire leaves may occur.

### Big Sagebrush

Big sagebrush (*Artemisia tridentata*) is the most common and widely distributed sagebrush species in Montana and the western United States (Fig. 6). The genus and species for big sagebrush were described by Nuttall in 1841 based on a specimen collected by him on the Snake River Plain of Idaho. Big sagebrush is also the most important sagebrush species due to the large areas its four subspecies occupy and often dominate under natural conditions. Although the subspecies may occasionally be found growing together, generally they require different environmental conditions (Table 2). Understanding of these requirements provides insight to the ecological variation that exists among the many communities occupied by big sagebrush.

It has been often stated that the land occupied by basin big sagebrush (*Artemisia tridentata* Nutt. *tridentata*) could be farmed. That is the case because this subspecies occupies deep, well-drained soils usually found in valley bottoms or other locations where such soils occur.

At the other habitat extreme among the big sagebrush taxa, Wyoming big sagebrush (*A. t. wyomingensis* Beetle and Young) occupies the most xeric locations. These

sites are usually the product of shallower soils and a large amount of clay or sometimes silt in the soil profile. The taxon does not do well on coarse-textured soils.

Mountain big sagebrush (*A. t. vaseyana* [Rydb.] Beetle), like basin big sagebrush, requires more moisture than does the Wyoming subspecies. However, mountain big sagebrush usually obtains its moisture by growing in localities with greater amounts of precipitation, rather than occupying very deep soils like basin big sagebrush grows in. The soils occupied by mountain big sagebrush range from sandy through silty and clayey textures, and may often be cobbly. However, generally finer textured soils appear to be favored by the taxon. Compared to surrounding upland community types, mountain big sagebrush usually occupies the deeper, more mesic locations.

The fourth subspecies of big sagebrush, subalpine sagebrush (*A. t. spiciformis* [Osterhout] Goodrich and McArthur) is of minor importance in Montana, as it is only known to occur in southwestern Montana near the Idaho border. It is found in the Centennial Valley and at the mouth of Cabin Creek near Hebgen Lake. Although it may occur occasionally elsewhere in southwestern Montana, it must be considered rare. Originally this taxon was considered to be a high elevation form of mountain big sagebrush. Subalpine big sagebrush is the only subspecies known to commonly root-sprout.

### Threetip Sagebrush

In general both subspecies, tall threetip sagebrush (*Artemisia tripartita* Rydb. *tripartita*) and Wyoming threetip sagebrush (*A. t. rupicola* Beetle) occur west and east of the continental divide, respectively (Fig. 7). However, tall threetip sagebrush is found in the southwest portion of Montana, both east and west of the continental divide, whereas Wyoming threetip sagebrush is only known to occur in the southcentral portion of the state. Tall threetip sagebrush is a mid-sized sagebrush preferring deep well drained soils. Wyoming threetip

sagebrush is a dwarf associated with shallow rocky, ridgeline soils. Both subspecies are known to layer in the field. This habit is most common in Wyoming threetip sagebrush. Only tall threetip sagebrush is known to be a prolific stump-sprouter under the right conditions such as following fire or herbicide application.

### Fringed Sagewort

The most widely distributed sagebrush subshrub in Montana, fringed sagewort (*Artemisia frigida* Willd.), occurs, throughout the state on relatively dry plains, foothills and breaks except in the northwest (Fig. 8). This mat-forming species is found on a variety of soil types and may readily pioneer recently disturbed sites. It occurs throughout successional stages to climax.

### Longleaf Sagebrush

Longleaf sagebrush (*Artemisia longifolia* Nutt.), a subshrub, is mostly limited in distribution to small populations in northcentral and northeastern Montana. It

is usually found on alkaline sites associated with river breaks (Fig. 9).

### Birdfoot Sagebrush

Birdfoot sagebrush (*Artemisia pedatifida* Nutt.), is a subshrub with limited distribution in southcentral Montana associated with xeric alkaline sites on plains and foothills (Fig. 10).

### Bud Sagebrush

Bud sagebrush (*Artemisia spinescens* Eat.) is a subshrub associated with xeric saline areas on plains and foothills sites in southwest and southcentral Montana (Fig. 11). The deciduous leaves on this subshrub fall during the dry period in midsummer. This exposes a stout many branched base with the same white-tomentum on the leaders as occurs on the leaves. In the Great Basin, new leaves occur early in February or March and blooming is also very early, generally occurring from late April through late May. In Montana, the same phenological stages occur somewhat later.



Figure 1. Low sagebrush (*Artemisia arbuscula arbuscula*).

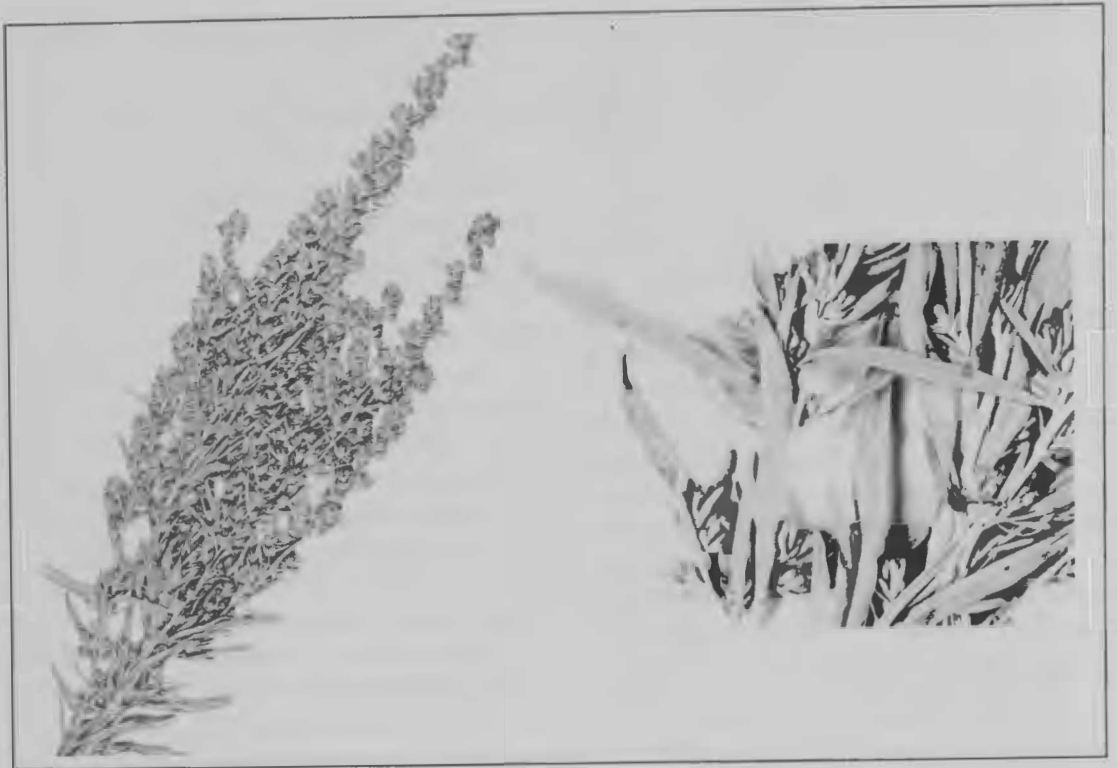


Figure 2. Plains silver sagebrush (*Artemisia cana cana*) top; Mountain silver sagebrush (*A.c. viscidula*) bottom.



Figure 3. Alkali sagebrush (*Artemisia longiloba*)



Figure 4. Black sagebrush (*Artemisia nova*)



Figure 5. Scabland sagebrush (*Artemisia rigida*).



Figure 6. Basin big sagebrush (*Artemisia tridentata tridentata*).



Figure 6 (continued). Wyoming big sagebrush (*A.t. wyomingensis*) top; Mountain big sagebrush (*A.t. vaseyana*) bottom.



Figure 6 (continued). Alpine sagebrush (*A. t. spiciformis*).



Figure 7. Tall threetip sagebrush (*Artemisia tripartita tripartita*) top.



Figure 7 (continued). Wyoming threetip sagebrush (*A.t. rupicola*).



Figure 8. Fringed sagewort (*Artemisia frigida*).



Figure 9. Longleaf sage (*Artemisia longifolia*).



Figure 10. Birdfoot sage (*Artemisia pedatifida*).



Figure 11. Bud sage (*Artemisia spinescens*)

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# A HISTORICAL PERSPECTIVE OF MONTANA'S SAGEBRUSH

Robert D. Harrington, Montana Fish, Wildlife and Parks, Bozeman, MT 59717-0322

## ABSTRACT

Sagebrush (*Artemisia*)/grasslands are declining in Montana and throughout the West. Sagebrush grasslands have existed for over 10,000 years in equilibrium with climatic conditions and just over 100 years under the influence of livestock grazing and other human interventions. Observations from early explorers and settlers indicate that big sagebrush was a dominant plant on much of the western rangeland region. Until 1934 sagebrush/grassland was used in whatever fashion the land users chose. The Forest Reserve Act gave the first authority to manage what became the National Forest Lands. The Taylor Grazing Act began Federal management of overgrazed rangelands on the remaining public lands known as the Public Domain. Since World War II the destruction of sagebrush has been accomplished through plowing, reseeding, chaining, chemical treatments, prescribed and wild fire, and increased agriculture conversion. Less than one half of the original sagebrush/grasslands remain. Conservation efforts of Montana Fish, Wildlife and Parks and other organizations protect some of these important rangelands.

**Key Words:** *Artemisia* spp., conservation, decline, human management, sagebrush/grasslands

## INTRODUCTION

Sagebrush (*Artemisia* spp.) includes some of the most important plants occupying western rangelands (Beetle 1960). Evidence suggests that sagebrush was present in significant amounts prior to settlement of the West (Vale 1975). For over 100 years sagebrush/grasslands have experienced overgrazing, plowing and reseeding, chaining, chemical treatment, prescribed and wild fire, agriculture conversion, and urban obliteration resulting in less than half of the original sagebrush/grasslands remaining in the western United States. This paper provides a historical perspective of human influences on sagebrush taxa.

## PRE - 1900

Sagebrush/grasslands developed during a time of general desiccation that followed mountain building at the end of the Tertiary and the start of the Quaternary and

continued to evolve through the extreme climatic fluctuations of the Pleistocene (Axelrod 1950). Sagebrush/grasslands have existed for only 10,000 years in equilibrium with climatic conditions and just over 100 years under the influence of livestock grazing and human intervention.

Vegetation observations by early western explorers can be found in the journals of Townsend (1834), Wislizenus (1839), Fremont (1845), the U.S. War Department (1855), Hayden Expedition (1879), Merriam (1890), and Russell (1902). All of these explorers observed the abundance of sagebrush in essentially the same regions that now have sagebrush components. Wislizenus (1839) described vegetation near present day Casper, Wyoming, as "the constant presence of wild sage." Fremont (1845) described the area west of Fort Laramie continuing west across Wyoming and southern Idaho as having abundant sagebrush. Fremont (1842) provided an eloquent description of how the land changed while traveling from east to

west (in Smucker 1856). “With the change in the geological formation on leaving Fort Laramie, the whole face of the country has entirely altered its appearance... Westward of Laramie river the region is sandy, and apparently sterile; and the place of the grass is usurped by the artemisia [sic] and other odoriferous plants, to whose growth the sandy soil and dry air of this elevated region seem highly favorable.”

Fremont (1845) continues: “One of the prominent characteristics in the face of the country is the extraordinary abundance of the ‘artemisia’ [sic]. They grow everywhere on the hills, and over the river bottoms, in tough, twisted, wiry clumps; and, wherever the beaten tract was left, they rendered the progress of the carts rough and slow. As the country increased in elevation on our advance to the west, they increased in size; and with the whole air strongly impregnated and saturated with the odor of camphor and spirits of turpentine which belongs to this plant. This climate has been found very favorable to restoration of health, particularly in cases of consumption; and possibly the respiration of air so highly impregnated by aromatic plants may have some influence.”

Historical records of explorers traveling in Montana differ in vegetative detail. Thwaites (1904) cites the Journals of Lewis and Clark as a source of vegetative information. Lewis describes the area of Armstead (now under Clark Canyon Reservoir): “...The uplands are covered with prickly pears and twisted or bearded grass and are but poor; some parts of the bottom lands are covered with grass and tolerable fertile; but much greater portion is covered with prickly pears, sedge, twisted grass, the pulpy leafed thorn, southernwood, wild sage, etc., and the uplands is very inferior in point of soil.” Additionally, Moulton (1993) reports the Lewis and Clark Expedition encountered sagebrush between Bannack and Horse Prairie: A...great quantities of the species hysoop (*Artemisia tridentata*) and shrubs common to the Missouri plains are scattered in those hills and valleys. Granville Stuart (1866) traveling from the

Snake River Plains of Idaho into Montana reported sagebrush present at Bannack, Virginia City, and Ford and Flatwillow Creeks near Lewistown. Lesica and Cooper (1997) summarized Mullan's 1853 observations. Mullan (1855) described sagebrush in much of the Red Rock River Valley in 1853: “We found the soil of this valley principally of a yellowish or grayish yellow colored clay, upon which, throughout its whole length, the wild sage grows in the greatest abundance. On the lower and upper portions of this valley we found the grass to be exceedingly rich, but near the middle nothing growing save the wild sage bushes.” Mullan (1855) provided additional sagebrush observations throughout southern Beaverhead County. Around present-day Dell and in the Sage Creek Valley he commented: “The portion of the valley bordering these buttes is formed of reddish clay, a soil resulting from the washings of these buttes up which nothing grows but artemisia or wild sage. The valleys between these low ridges were covered with artemisia or wild sage growing from eighteen inches to three feet high.” Mullan (1855) continued to describe the area southeast of Big Hole Pass: “After crossing the divide above referred to, our trail led us through a large prairie plain covered with the artemisia or wild sage growing to a height of two or three feet.”

The presence of sagebrush is well documented by early explorers of the West. Unfortunately their observations were only that—observations. No quantified sagebrush data are available from that era. However, observations do indicate that big sagebrush was a dominant vegetative type in Montana and throughout the western rangelands. Early vegetation maps of the west were generally produced by the U.S. Geological Survey and focused on timber and minerals. Examination of maps produced by Leiberg (1899) reveal detailed information describing forest reserves with huge areas lumped together as “prairie.” No further delineation of the prairie type is present. Early focus in the west apparently was on fur trade, timber, passage to the

coast, and minerals, e.g., gold and silver, and not on native shrubs such as sagebrush. Chronology of Western settlement in the sagebrush/grassland type can be briefly described as follows: fur trappers (1809), Mormon settlements (1847), California Gold Rush (1849), Oregon Trail (1843), Comstock Lode (1859), California expansion, Homestead Act (1862), and post Civil War westward migration. All of these activities increased livestock grazing, cultivation for hay and crops, and other land practices that often occurred at the expense of sagebrush/grassland. However, in the spring of 1890, western rangelands had fewer livestock than in the previous 30 years as a result of a series of bad winters and dry growing seasons.

## 1900 - PRESENT

At the turn of the century, pioneering range scientists studied the sagebrush/grasslands (Young et al. 1979). During the summers of 1900, 1901, and 1903, P.B. Kennedy, S.B. Dutton and David Griffith conducted rangeland appraisals (Young et al. 1979). They described some Nevada rangelands as dust beds, accelerated soil erosion occurring, hay production on large ranches, most sagebrush/grasslands were overgrazed, high elevation ranges were damaged from concentrations of sheep, and wildfires were common in sagebrush/grassland types (Young et al. 1979). Though these reports do not divulge information about Montana rangelands specifically, some of the same conditions undoubtedly were present throughout the West.

Over-grazing of native bunchgrasses in the sagebrush/grasslands near the turn of the 20<sup>th</sup> century is well documented. Jardine and Anderson (1919) stated that the native plant communities associated with the sagebrush/grassland type are extraordinarily susceptible to alien plant invasion. Hironka and Tisdale (1963) claim that Russian thistle (*Salsola iberica*), tumble mustard (*Sisymbrium altissimum*) and downy brome (*Bromus tectorum*) drastically changed succession in the sagebrush/grasslands. These species are quite competitive and

make seedling establishment by perennial grasses difficult. The implications of alien plant invasion to the ecology of the sagebrush/grasslands were detailed by the research of Piemeisel (1951) as he documented how alien plant invasion permanently changed the ecology of sagebrush/grasslands. Piemeisel (1951) stated that sagebrush/grasslands were so abused that if aliens had not invaded, accelerated erosion would have destroyed the potential of many sites. Daubenmire (1946) further demonstrated the permanence of exotic plant invasion when he reported that downy brome had established itself in a bunchgrass stand that had not been burned or grazed for as long as 50 years.

Young et al. (1979) summarized the early role of science in natural resource management. A.W. Sampson (1913) published an article for the National Wool Growers and suggested using science as a tool to manage western rangelands. This new concept grew slowly in popularity over the next couple of decades. Some early range scientists who recognized the role of plant succession in range management included J. T. Jardine (Jardine 1916, Jardine and Anderson 1919) and Sampson (1919). The Great Basin Experiment Station conducted much of the early sagebrush/grassland research (Keck 1972). Resulting from Sampson's work, Lincoln Ellison created condition and trend indicators (Ellison et al. 1951). Fleming (1922) studied plant community dynamics and possible influence of grazing management on them. Additionally, Hall and Clements (1923) published a thorough dissertation on the taxonomy of sagebrush (*Artemisia* spp.), rabbitbrush (*Chrysothamnus* spp.), and saltbush (*Atriplex* spp.). Evidence suggested that western sagebrush/grasslands were receiving attention from government agencies and the scientific community at the turn of the century.

Until 1934, much of the sagebrush/grassland type was used in whatever fashion land users chose. From 1914 to 1934 many bills were introduced in Congress in an

effort to address grazing on public land (Buckman 1935). Examples are the Kent, Colton, and Garfield bills. Eventually the Taylor Grazing Act passed Congress on 28 June 1934 that encompassed the remaining public lands (not under USFS management) known as the Public Domain. Holechek et al. (1989) described passage of this act as initiation of an era of land retention by the federal government in which it enabled management of extensive arid rangelands of the west previously damaged by severe overgrazing. The economic, climatic, and social conditions of the early 1930s set the stage for passage of the Taylor Grazing Act. Agriculture was struggling; the drought of the early 1930s also hurt western rangelands, and many western ranches were facing bankruptcy (Young et al. 1979).

The modern day assault on sagebrush started sometime in the mid-1930s but accelerated after World War II. Trying to restore degraded rangelands, the government experimented with reseeding native grasses with little or no success. Meanwhile several species of wheatgrass (*Agropyron* spp.) from Asia were being tested in the northern Great Plains (Hanson 1972) of which crested wheatgrass (*A. cristatum*) demonstrated to be most drought tolerant (Love and Hansen 1932). After World War II the effort of “reseeding” increased dramatically with millions of acres plowed and seeded (Plummer et al. 1955). At the same time, 2, 4-D [(2, 4-dichlorophenoxy) acetic acid] was being sprayed on millions of acres of sagebrush/grasslands (Pechanec et al. 1964). Since the mid 1940s, plowing and reseeding, chaining, chemical treatments, prescribed and wild fire, increased agriculture conversion, and urban development have left millions of acres of sagebrush/grassland permanently altered.

## DISCUSSION

The value of big sagebrush as wildlife cover and forage in Montana is well documented. Three species of sagebrush comprise 93 percent of the winter diet of Montana antelope (Cole 1955). Pyrah

(1987) determined that antelope rely primarily on shrubs (chiefly sagebrush) from fall to spring and secondarily from spring to fall. Wilkins (1956) ascertained that during December, January, and February big sagebrush was the primary component of mule deer diets in the Bridger Mountains of Montana. Elk and deer on the northern Yellowstone winter range near Gardner, Montana, depend significantly on four species of sagebrush (Wambolt 1996). Sage grouse winter diets in Montana are 100 percent sagebrush (Rouse 1957). Green and Flinders (1980) found that the respective winter and summer diets of the pygmy rabbit (*Brachylagus idahoensis*) were 99 and 51 percent sagebrush.

Crude protein level and digestibility of sagebrush during winter are higher than other shrubs and grasses. Welch and McArthur (1979) found the winter crude protein level of sagebrush to be 12.4 percent, 10.6 percent for curlleaf mountain mahogany (*Cercocarpus ledifolius*) and 3.7 percent for dormant grasses. Big sagebrush and curlleaf mountain mahogany meet or exceed the protein needs of wintering mule deer (Thompson et al. 1973, Welch et al. 1979).

Sagebrush also provides wildlife with cover for nesting, resting, and escape. Swenson (1983) determined through aerial observations that winter habitat use by mule deer is strongly associated with sagebrush-grassland in rough topography. Best (1970) concluded that Brewer’s sparrow (*Spizella breweri*) nest in the canopy of big sagebrush. Sage grouse use big sagebrush habitat with a canopy cover ranging from 20-50 percent (Eng and Schladweiler 1972, Wallestad 1972, Wallestad and Schladweiler 1974). Eng and Schladweiler (1972) reported wintering grouse were located in an average of 28 percent sagebrush canopy cover. Another big sagebrush dependent species is the pigmy rabbit, which requires tall dense sagebrush (Green 1980a, Green 1980b, Campbell 1982, Weiss 1984, Lyman 1991).

Sagebrush has been greatly reduced from its potential. Beetle (1960) estimated

sagebrush once occupied 60 million ha. Bruce Welch, Rocky Mountain Research Station Laboratory, U.S. Forest Service estimates that more than one half of the sagebrush throughout the West has been lost (personal communication). Montana Fish, Wildlife and Parks is focused on protecting sagebrush-grasslands. Land acquisition (Wildlife Management Areas) was the principle method protecting winter range for elk and nesting and resting areas for waterfowl. In 1987, House Bill 526 (HB526) provided an earmarked funding source for a wildlife habitat acquisition program with approximately \$2.8 million available annually. The Upland Game Bird Program and Conservation Easements are two programs funded by HB526 and are effective sagebrush conservation tools. Stipulations of each program typically include a grazing management plan allowing adequate rest for sagebrush and associated rangeland species and a “no sagebrush manipulation” clause. There are 101 Wildlife Management Areas conserving 189,800 ha. at an annual cost of \$500,000. To date the Upland Game Bird Program spends \$700,000 annually and has protected over 161,900 ha. of wildlife habitat, a great portion being sagebrush/grassland. The Department has purchased 32 conservation easements affecting over 60,700 ha and has \$2.8 million available each year for additional conservation easements. Comprehensive long-term vegetation monitoring sites are located on many of these projects.

## CONCLUSIONS

Sagebrush was a dominant native shrub species providing critical forage and habitat for many wildlife species in Montana and throughout the West prior to settlement by European Americans. Despite its ecological importance, the historic distribution of sagebrush has been reduced by a number of human interventions. Land managers do not know how much sagebrush remains in Montana. Therefore, on-the-ground inventorying and mapping of sagebrush throughout the state should be a

management priority because it would provide increased emphasis on this critical range taxon and allow us to monitor and improve the sagebrush/grassland type.

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# THE ECOLOGY AND STATUS OF SAGE GROUSE IN MONTANA

Gary L. Dusek, Montana Fish, Wildlife and Parks, P.O. Box 173220, Bozeman Montana 59717  
Charles D. Eustace, Montana Fish, Wildlife and Parks, 2300 Lake Elmo Dr., Billings, MT 59105  
Joel G. Peterson, Montana Fish, Wildlife and Parks, 1400 S. 19<sup>th</sup> Ave., Bozeman, MT 59718

## ABSTRACT

We describe the ecology and status of the greater sage grouse (*Centrocercus urophasianus*) in Montana as part of an effort to develop a species conservation plan. Sage grouse are primarily associated with big sagebrush (*Artemisia tridentata*)-grassland although the original range has been greatly reduced or fragmented by a variety of human uses and activities. Efforts by the State's wildlife agency to delineate distribution of sage grouse in Montana during the 1960s and 1970s suggested that sage grouse occupied about 4.4 million ha in eastern and southwest Montana although more recent efforts to assess sage grouse habitat suggest occupied habitat could be as much as 10.9 million ha. Findings from studies during that period suggested that yearlong distribution and movements reflect regional or local conditions. That is, sage grouse tend to be nonmigratory in eastern Montana, where close interspersions of seasonal habitats rarely requires large movements, and migratory in the intermountain valleys of southwest Montana. Habitat requirements of sage grouse vary seasonally, in terms of structure and composition, to accommodate successful breeding and brood rearing and over-winter survival. Yearly precipitation patterns, in addition to habitat quality, can affect nesting success and chick survival. Data from statewide wing collections suggest that productivity of sage grouse declined from an average of 2.63 juveniles/hen during 1962-1979 to an average of 2.08 juveniles/hen during 1980-1992; drought conditions were more frequent during the latter period. An estimate of mortality of sage grouse during the first year of life approaches 85 percent of which about two-thirds occurs prior to the opening of the upland bird hunting season in September. Sage grouse populations in southwestern Montana have declined from the 1960s through the 1980s following a period of large-scale sagebrush manipulation and conversion of native range to cropland. Numbers of birds remain relatively abundant throughout areas of central and eastern Montana that continue to support large, unfragmented stands of big sagebrush. Several state-initiated programs offer incentives to private landowners to maintain or enhance habitat quality for sage grouse and other wildlife species.

**Key Words:** *Artemisia* spp., *Centrocercus urophasianus*, ecology, greater sage grouse, management, Montana, sagebrush, status

## INTRODUCTION

Loss of presettlement sagebrush (*Artemisia* spp.) rangeland in the West has approached or exceeded 50 percent as a result of agricultural practices and other human-related activities (Dobler 1994, Braun 1998, Knick 1999). Despite efforts directed at reducing this loss of habitat, Connelly and Braun (1997) reported declines in breeding populations and

production of the greater sage grouse (*Centrocercus urophasianus*) after 1985 from long-term averages across several western states. They reported a decline in breeding populations in Montana of about 30 percent of a long-term average and a decline in production (chicks/hen) of 17 percent. These and other published findings (e.g., Braun et al. 1977, Swenson et al. 1987) suggested continuing loss and degradation of the sagebrush steppe.

Montana sportsmen and resource managers became concerned about the status of sage grouse and sagebrush-grasslands in the 1950s and 1960s with knowledge of the effectiveness of chemical treatment to eliminate or reduce sagebrush and increase production of grasses. Out of this concern, a 10-year research project was initiated in central Montana in 1965 to determine the effects of treatment of sagebrush on associated vegetation and wildlife from which findings have been reported by Wallestad (1975), Jorgensen (1979), Pyrah (1987), and others. Growing concern about the status of sagebrush steppe, declines in sage grouse numbers, and long-term survival of sage grouse resurfaced again in the 1990s. A Memorandum of understanding (MOU) for conservation and management of sage grouse between member states of the Western Association of Fish and Wildlife Agencies (WAFWA) and natural resource management agencies among the U.S. Departments of Agriculture and Interior formally initiated an effort to develop conservation strategies by member states. Each state member of WAFWA agreed to convene a working group to develop state or local conservation plans by July 2000. More than 25 people with widely diverse perspectives, of which all hold an interest in the issue, constitute the Montana Sage Grouse Working Group (SGWG).

We describe the ecology and status of sage grouse in Montana based on what is known about past and present land uses, anecdotal accounts of distribution and abundance, a review of pertinent research, and estimates of population trends and vital rates based on long-term monitoring. This along with identifying the need of additional information, is fundamental to developing strategies to guide conservation of the sagebrush steppe and maintain or enhance populations of sage grouse in the northern Great Plains and intermountain valley habitats that have historically supported sage grouse.

## **GEOGRAPHICAL DISTRIBUTION**

Sage grouse, native to the sagebrush steppe of western North America, originally occupied portions of 16 states and three provinces (Braun 1998). The species presently occurs in 11 western states and two provinces having disappeared from scattered areas around the periphery of its original range, including Arizona, British Columbia, Kansas, Nebraska, New Mexico, and Oklahoma.

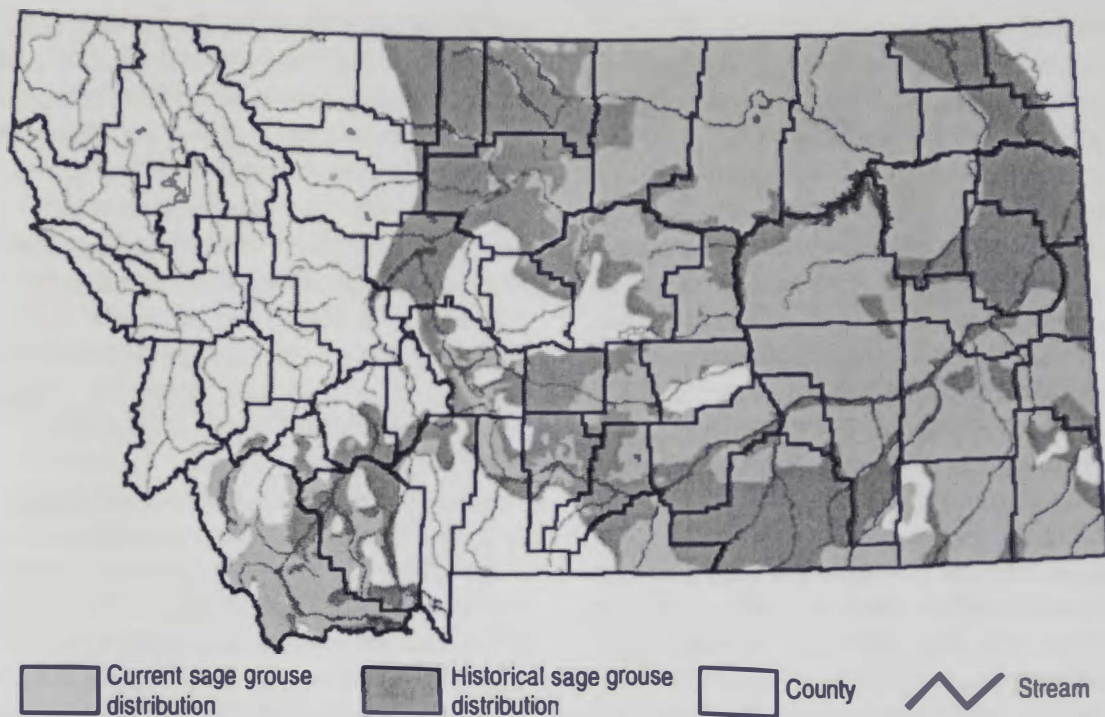
Current distribution of sage grouse in Montana, based on the best local information available to area biologists (Fig. 1), includes the eastern one-half and southwest corner of Montana. Available sources of information for historical distribution of sage grouse in Montana are from minutes of the Fish and Game Commission dated 1926-1956 (unpubl.) a map from a biennial report to the Fish and Game Commission, 1941-1942, and a GIS layer developed by Schroeder (2000). Figure 1 represents an edited version of those sources having been reviewed by FWP field personnel (L. Bailey, GIS Programmer, FWP, personal communication).

During the 1970s sage grouse occupied approximately 4.4 million ha of sagebrush-grassland in 39 counties in the state (Wallestad 1975) and are still known to occur in 39 counties. Distribution of sage grouse along a portion of the Hi-Line, primarily Chouteau, Hill, and Blaine counties include small and scattered populations corresponding to the distribution of sagebrush. Liberty and Teton counties may have sage grouse, but sightings are unconfirmed (G. Taylor 2001, FWP Wildlife Manager for Region 4, personal communication). The Milk River valley in Phillips County probably represents the northernmost limit of the distribution of big sagebrush.

## **HABITAT REQUIREMENTS**

### **Yearlong**

In eastern Montana, where close interspersions of wintering, nesting, and



**Figure 1.** Current and historical distribution of sage grouse in Montana (FWP, Information Services). The entire shaded area represents historical distribution of sage grouse, and the light-shaded area represents their current distribution.

brooding habitat rarely requires large seasonal movements, sage grouse are essentially nonmigratory (Eng and Schladweiler 1972); birds rarely move more than 17 km. Meeting yearlong habitat needs, however, may require comparatively long seasonal movements between disjunct habitat patches. North of the Milk River in north-central Montana, sage grouse primarily occupy silver sagebrush (*A. cana*)-grassland habitats similar to those described for southeastern Alberta (Aldridge 1998).

Some sage grouse in southwestern Montana migrate between separate summer and winter areas (Martin 1970) as similarly observed among sage grouse on the Snake River plains in Idaho where 48-80 km may separate seasonal ranges (Dalke et al. 1963, Connelly et al. 1988). Migration also can be elevational and related to availability of succulent herbaceous vegetation during late summer and early fall. Ongoing research has documented such summer migratory movement of sage grouse from an area in eastern Idaho, including Crooked Creek,

Lidy Flats, and Medicine Lodge, to Big Sheep Creek Basin in southwestern Beaverhead County, Montana (J. W. Connelly 2001, personal communication, Roscoe this issue).

### Seasonal

*Breeding.*—Wallestad (1975) found strutting grounds or “leks,” where breeding actually occurs, to be key activity areas within wintering-nesting complexes. Leks most often consist of clearings surrounded by sagebrush cover. Such areas may include natural clearings, old burns, or ground cleared by homesteaders. In Idaho, sage grouse used recent burns or man-made clearings as leks only in the absence of natural openings (Connelly et al. 1981).

Wallestad and Schladweiler (1974) measured sagebrush at feeding and loafing sites of strutting cocks on the Yellow Water Triangle (YWT) in central Montana; 80 percent of these sites had a sagebrush canopy of 20-50 percent. Average sagebrush canopy overall was 32 percent (Eng and Schladweiler 1972). Slightly more

than half the total sagebrush plants measured at sites used by sage grouse occurred in the 15- to 30-cm height class.

Sage grouse invariably prefer sagebrush for nesting cover across their inhabited range (Patterson 1952, Klebenow 1969, Wallestad and Pyrah 1974, Sveum et al. 1998). Results from various studies in Montana and elsewhere documented a positive relationship between quality of nesting cover and nesting success (Wallestad and Pyrah 1974, DeLong et al. 1995, Sveum et al. 1998). Concealment was the basic requirement of nesting cover; nest fate may be positively associated with tall grass cover and medium-height shrub cover collectively (DeLong et al. 1995). Sage grouse most frequently selected sagebrush stands with a canopy of 15-31 percent (Klebenow 1969, Wallestad and Pyrah 1974). Most nesting ( $\geq 60\%$ ) occurs within 3 km of a lek in Montana and Colorado (Wallestad and Pyrah 1974, Braun et al. 1977) although Wakkinen et al. (1992) reported a random distribution of nests relative to lek location in Idaho. Sage grouse exhibit high nest-area fidelity but do not nest under the same bush from year to year, which might reduce the risk of nest predation (Fischer et al. 1993).

*Brood-rearing.*—Succulent forbs, the preferred food of sage grouse broods, provide key summer habitat for sage grouse (Klebenow 1969, Martin 1970, Peterson 1970a, Wallestad 1971). As palatability of forbs declines, sage grouse move to moist areas that still support succulent vegetation including alfalfa fields, roadside ditches, and other moist sites. During summers of high precipitation, sage grouse in Montana may remain widely distributed throughout the entire summer due to the wide distribution of succulent forbs in both time and space (Peterson 1970a). Elsewhere, grouse moved to mountain meadows during late summer where elevation influences forb succulence (Dalke et al. 1963, Connelly et al. 1988).

Sage grouse broods in the YWT **preferred** relatively open stands of **sagebrush** during summer, generally with a

canopy ranging from 1 to 25 percent (Wallestad 1975). Broods also used roadside ditches throughout June and July. About 65 percent of all grouse observations during August and September were in alfalfa fields, greasewood (*Sarcobatus vermiculatus*) in bottomlands, and roadside ditches where succulent forbs remained relatively abundant. Increased use of sagebrush stands with high shrub density in late September or October coincided with transition to a winter diet of sagebrush (Wallestad 1971).

Canopy of sagebrush stands at brood sites in southwest Montana and southern Idaho averaged 14 and 8.5 percent, respectively (Klebenow 1969, Martin 1970). However, adults used sites with relatively dense canopy (25%) during the same period (Martin 1970); relative to canopy height, big sagebrush ranged from 23 to 38 cm at brood sites compared with 18-64 cm at adult locations.

Males remained segregated from broods and hen flocks through summer and early fall. Because adult cocks utilized the same types of areas used by broods and hen flocks, segregation probably was more social than habitat-related. Most male flocks in the YWT utilized areas within 3-5 km of a lek. Flocks of broodless hens typically utilized areas of dense sagebrush throughout summer (Wallestad 1975).

The importance of "free water" to sage grouse has not been widely documented or quantified (Connelly and Doughty 1990). Although some have suggested that distribution of open water is important to sage grouse, studies of radio-marked grouse in central Montana and southeastern Idaho failed to demonstrate the importance of open water to grouse, even during dry years (Wallestad 1971, Connelly and Doughty 1990). Grouse apparently redistribute themselves in response to a lack of succulent vegetation rather than to absence of open water.

*Winter.*—Sage grouse generally select relatively tall and dense stands of sagebrush during winter. Winter ranges in eastern Montana included large expanses of dense

(20% canopy) sagebrush with an average height of 25.4 cm on relatively flat sites (Eng and Schladweiler 1972). This association with dense stands of sagebrush usually begins in September (Wallestad 1971) and continues through the breeding (Wallestad and Schladweiler 1974) and nesting seasons (Wallestad and Pyrah 1974). No adult males were observed in areas having <10 percent canopy coverage.

## POPULATION DYNAMICS

Biologists have used counts of males on leks during spring since the mid-1950s to provide an index of relative size of breeding populations (Eng 1954, Wallestad 1975). Based on these spring counts from 1966 to 2001, sage grouse numbers probably increased, at least at a statewide scale, from the mid 1960s through 1973 when the average number of males/lek exceeded 30 and fluctuated about that level until reaching a peak in 1984 (Table 1). The average number of males attending leks declined rather sharply from 1991 through 1996 and increased to a level above 30 males/lek during 2000 and 2001. Although we cannot assume that all sage grouse leks have been located, monitoring male attendance on comparable leks would appear to provide a reasonable index of relative change in breeding populations in response to prevailing environmental conditions. Yearly variation in chick productivity and survival account for dramatic short-term population fluctuations, whereas habitat loss, as reflected by loss or abandonment of leks, influences gradual, long-term population declines (Eustace this issue).

Harvest trends, based on post-hunt surveys of hunters, roughly follow that of spring counts of males on leks (Fig. 2), and interpreted along with lek counts, also provide insight to short-term changes in sage grouse numbers at a statewide scale. For example, years of high harvest generally followed a spring of high average numbers of males/lek. Conversely, years of relatively low harvest followed a spring of low numbers of males/lek.

## Reproduction

Trends in sage grouse productivity have been estimated using ratios of young/hen from examination of wings of birds taken by hunters (Eng 1955). Results of statewide wing collections from hunter-killed birds appear in Table 2. From 1962 to 1979 statewide productivity averaged 2.63 juveniles/hen and 2.08 juveniles/hen during 1980-1992, a decline of 21 percent. Production and survival of chicks/hen followed a similar trend in FWP's Region 5 in south-central Montana during the same period of time (Table 2).

Timing of precipitation may affect annual production and population dynamics of sage grouse. In central Montana Wallestad and Watts (1972) reported an inverse relationship between productivity and rainfall during the egg-laying period; rainfall >2.5 cm during the egg-laying period delayed the hatch and reduced productivity. Total spring precipitation, as it potentially affects spring green-up of vegetation, further explained variations in productivity (Wallestad and Watts 1972). Even with optimal rainfall during the egg-laying period, production was poor if total spring precipitation during the growing season was <7.6 cm from mid-April through mid-June. They observed neither a relationship between productivity and rainfall during hatching that typically peaked during the 2<sup>nd</sup> week in June nor a relationship between temperature and productivity.

Drought cycles, as expressed by the Palmer Drought Severity Index (PDSI; NOAA 1962-1992), also may affect productivity of sage grouse. Because drought severity often varies across the state, we examined only production data for south-central Montana. The period of nesting and brood-rearing (May-August) were characterized by mild to severe drought conditions during only three of 18 years during 1962-1979 (Table 2). South-central Montana experienced drought conditions during the same period in seven of the 13 years from 1980 to 1992. A least

**Table 1.** Summary of sage grouse lek surveys in Montana, 1955-2001, that were surveyed  $\geq 10$  consecutive years.

| Year                   | No. leks surveyed | No. males       | No. males/lek    |
|------------------------|-------------------|-----------------|------------------|
| 1955-1965 <sup>a</sup> | $\leq 7$          | $\bar{x} = 169$ | $\bar{x} = 31.5$ |
| 1966 <sup>b</sup>      | 12                | 249             | 20.8             |
| 1967                   | 12                | 237             | 19.8             |
| 1968                   | 12                | 304             | 25.3             |
| 1969                   | 19                | 606             | 31.9             |
| 1970                   | 20                | 568             | 28.4             |
| 1971                   | 20                | 574             | 28.7             |
| 1972                   | 27                | 826             | 30.6             |
| 1973                   | 32                | 1078            | 33.              |
| 1974                   | 35                | 1009            | 28.8             |
| 1975                   | 45                | 1140            | 25.3             |
| 1976                   | 45                | 1230            | 27.3             |
| 1977                   | 47                | 1500            | 31.9             |
| 1978                   | 52                | 1663            | 32.0             |
| 1979                   | 56                | 1733            | 30.9             |
| 1980                   | 64                | 2208            | 34.5             |
| 1981                   | 72                | 2185            | 30.3             |
| 1982                   | 74                | 7525            | 34.8             |
| 1983                   | 73                | 2599            | 35.6             |
| 1984                   | 73                | 2673            | 36.6             |
| 1985                   | 72                | 1493            | 20.7             |
| 1986                   | 72                | 1398            | 19.4             |
| 1987                   | 74                | 1809            | 24.4             |
| 1988                   | 74                | 2484            | 33.6             |
| 1989                   | 74                | 2291            | 31.0             |
| 1990                   | 79                | 2370            | 30.0             |
| 1991                   | 72                | 2429            | 33.7             |
| 1992                   | 73                | 1667            | 22.8             |
| 1993                   | 73                | 1444            | 19.8             |
| 1994                   | 70                | 1200            | 17.1             |
| 1995                   | 65                | 1230            | 18.9             |
| 1996                   | 64                | 1305            | 20.4             |
| 1997                   | 65                | 1343            | 20.7             |
| 1998                   | 65                | 1538            | 23.7             |
| 1999                   | 68                | 1696            | 24.9             |
| 2000                   | 70                | 2325            | 33.2             |
| 2001                   | 72                | 2391            | 33.2             |

<sup>a</sup> Surveys were conducted only in north-central Montana (Region 6) during 1955-59. Surveys began in south-central Montana (Region 5) in 1960 and in southwest Montana (Region 3) in 1962.

<sup>b</sup> Surveys were initiated in central Montana (Region 4) in 1966 and in southeastern Montana (Region 7) in 1969.

squares linear regression suggested an inverse relationship between the PDSI and productivity for each of the four months although only the relationship during May was significant ( $r^2 = 0.14$ ,  $P = 0.04$ ). Eustace (this issue) demonstrated that drought severity over an extended period has a more profound effect on sage grouse productivity; relative drought severity over

a 22-month period prior to and including the month of hatch explained 58 percent of the variability in chick survival.

Findings from research in central Montana suggested that years of chick survival of  $< 3.60$  juveniles/hen were accompanied by population declines (Wallestad 1975). However, from a statewide perspective chick survival was

## Sage Grouse Lek Counts vs. Harvest

Montana 1962-2000

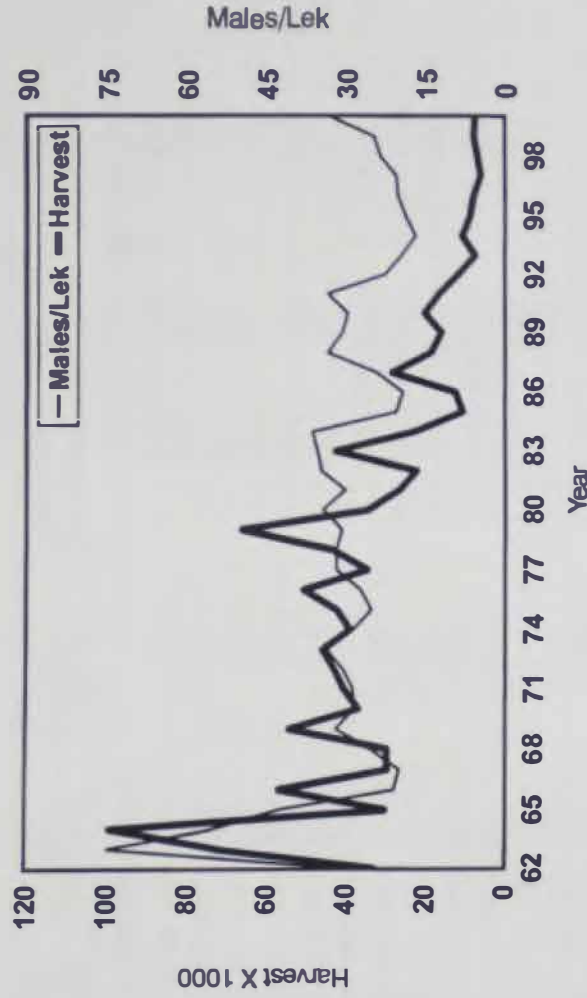


Figure 2. Sage grouse lek attendance and harvest in Montana, 1962-2000.

≥3.60 juveniles/hen in only two of 31 years (Table 2). The average number of males attending leks over the same period of ≥30 males/lek occurred during 14 of those years (Table 1). Thus, a threshold value for chick survival at a broad scale that would coincide with short-term population declines, reflected by numbers of males attending leks, probably would occur closer to the 31-yr mean of 2.40 juveniles/hen (Table 2). For example, years in which productivity was >2.40 juveniles/hen were followed by increased numbers of males/lek the following spring 86 percent of the time (12 of 14 yrs; Tables 1 and 2). If productivity was <2.40 juveniles/hen, there was a decrease in the lek count during the following spring 75 percent of the time (9 of 12 yrs).

### Mortality

Over a 10-yr period, Wallestad and Watts (1972) documented an average mortality rate of 56 percent in central Montana from the egg-laying period in April to the opening of the upland bird

season in September. This included an average nest mortality of 30 percent and an average juvenile mortality to 1 September of 37 percent. Assuming a juvenile mortality rate from 1 September to 1 April (fall-winter) at least equal to that of yearling hens (65%) would yield an annual juvenile mortality rate of 85 percent.

Both avian and mammalian predators take sage grouse. Predators destroyed 13 percent of known nests on the Yellow Water Triangle (Wallestad and Pyrah 1974). Nest predators included coyotes (*Canis latrans*), badgers (*Taxidea taxus*), and magpies (*Pica pica*). In the same study, approximately 40 percent of juvenile sage grouse succumbed to some form of mortality between hatching and early fall although the proportion attributable to predation was unknown. Golden eagle (*Aquila chrysaetos*) and hawks, including the marsh (*Circus cyaneus*), Swainson's (*Buteo swainsoni*), red-tailed (*B. jamaicensis*) and rough-legged (*B. lagopus*) posed the most probable threat to young birds. Although eagles commonly take sage grouse on leks

**Table 2.** Sage grouse production from statewide collection of wings from hunter-killed birds, 1962-1992.

| Year                  | Statewide  |                |                      | South-central Montana <sup>a</sup> |                |                      |
|-----------------------|------------|----------------|----------------------|------------------------------------|----------------|----------------------|
|                       | No. chicks | No. adult hens | Chicks/<br>adult hen | No. chicks                         | No. adult hens | Chicks/<br>adult hen |
| 1962                  | 849        | 271            | 3.13                 | 122                                | 32             | 3.81                 |
| 1963                  | 1593       | 496            | 3.21                 | 359                                | 75             | 4.79                 |
| 1964                  | 1213       | 752            | 1.61                 | 331                                | 161            | 2.06                 |
| 1965                  | 1149       | 490            | 2.34                 | 204                                | 64             | 3.19                 |
| 1966                  | 1044       | 420            | 2.49                 | 120                                | 59             | 2.03                 |
| 1967                  | 844        | 293            | 2.88                 | 97                                 | 34             | 2.85                 |
| 1968                  | 1333       | 368            | 3.52                 | 196                                | 45             | 4.36                 |
| 1969                  | 1299       | 535            | 2.43                 | 109                                | 54             | 2.02                 |
| 1970                  | 1009       | 379            | 2.66                 | 187                                | 42             | 4.45                 |
| 1971                  | 1409       | 496            | 2.84                 | 211                                | 52             | 4.06                 |
| 1972                  | 1188       | 411            | 2.89                 | 223                                | 68             | 3.28                 |
| 1973                  | 793        | 434            | 1.83                 | 222                                | 80             | 2.78                 |
| 1974                  | 972        | 452            | 2.15                 | 257                                | 116            | 2.22                 |
| 1975                  | 1189       | 516            | 2.30                 | 476                                | 161            | 2.96                 |
| 1976                  | 1349       | 610            | 2.21                 | 387                                | 178            | 2.17                 |
| 1977                  | 872        | 443            | 1.97                 | 243                                | 85             | 2.86                 |
| 1978                  | 1256       | 404            | 3.11                 | 338                                | 103            | 3.28                 |
| 1979                  | 1950       | 528            | 3.69                 | 392                                | 81             | 4.84                 |
| 1980                  | 851        | 598            | 1.42                 | 242                                | 161            | 1.50                 |
| 1981                  | 1122       | 499            | 2.25                 | 286                                | 125            | 2.29                 |
| 1982                  | 798        | 398            | 2.01                 | 241                                | 117            | 2.06                 |
| 1983                  | 1371       | 403            | 3.40                 | 461                                | 105            | 4.39                 |
| 1984                  | 462        | 314            | 1.47                 | 159                                | 123            | 1.29                 |
| 1985                  | 130        | 95             | 1.37                 | 20                                 | 20             | 1.00                 |
| 1986                  | 158        | 96             | 1.65                 | 51                                 | 21             | 2.43                 |
| 1987                  | 306        | 95             | 3.22                 | 79                                 | 31             | 2.55                 |
| 1988                  | 70         | 77             | 0.91                 | 45                                 | 53             | 0.85                 |
| 1989                  | 278        | 135            | 2.06                 | 129                                | 61             | 2.12                 |
| 1990                  | 437        | 110            | 3.97                 | 142                                | 44             | 3.23                 |
| 1991                  | 135        | 100            | 1.35                 | 72                                 | 79             | 0.91                 |
| 1992                  | 77         | 39             | 1.97                 | 77                                 | 39             | 1.97                 |
| $\bar{x}$ chicks/ hen |            |                | 2.40                 |                                    |                | 2.73                 |

<sup>a</sup>Data are from FWP Region 5 for years from which a string of long-term statewide data were available.

during spring, predation on adult birds appeared minor. Predators killed only three of about 70 radio-equipped adult sage grouse on the Yellow Water Triangle (Wallestad 1975).

Diseased birds have occasionally been observed in Montana, particularly in the vicinity of irrigation ditches and alfalfa fields (Wallestad 1975). Necropsy revealed coccidiosis. Outbreaks may occur in late July and August when sage grouse concentrate on areas where forbs remain

succulent that include open water. The problem will generally subside with dispersal of birds to fall and winter ranges.

Simon (1940) described parasites commonly found in sage grouse in Wyoming. The incidence and infestation of all parasites except the protozoan *Tritrichomonas* was higher in young birds than in adults. Most sage grouse were infected with tapeworms but exhibited no serious ill effects.

## POPULATION STATUS

Sage grouse were seemingly declining throughout the species' range during and prior to the 1930s (Braun 1998). However, systematic surveys were lacking before the late 1950s, and estimates, or perceptions, of sage grouse abundance were derived largely from anecdotal accounts.

Annual and biennial reports of the Montana Fish and Game Commission during the first decade of the 20<sup>th</sup> Century expressed alarm about the relative scarcity of sage grouse across Montana (C. D. Eustace, personal communication). A recommendation that the upland game bird season open 1 September and close 15 December appeared in a report dated December 1900. Perceived effects of market and subsistence hunting on sage grouse and other upland game birds during that period concerned both policy-makers and sportsmen. Scarcity of big game throughout eastern Montana in the early 1900s might have exacerbated any adverse effects that these largely unregulated activities had on sage grouse. The federal Lacey Act, enacted in 1900, prohibited the interstate traffic of game animals with the intent to address impacts of market hunting.

From about 1913 through the 1930s landowners, sportsmen, and agency personnel perceived sage grouse to be abundant in at least a portion of their inhabited range—most notably in Fergus, Petroleum, Rosebud, Garfield, Custer, and Powder River counties. Limited information suggested that sage grouse again started to decline in about 1943 and continued downward for several years despite closed seasons during 1945-1951 (Martin and Pyrah 1971). Harvest, and presumably grouse numbers, increased substantially during 1958-1964, a period over which daily bag limits varied from three to four birds.

### Regional Status

*Southwest Montana.*—Sage grouse still occur in Meagher County but appear in a state of decline (G. Taylor 2001, FWP Wildlife Manager for Region 4, personal

communication). Sage Grouse in nearby Park County declined in the 1970s and 1980s in response to significant losses in sagebrush habitat—primarily through conversion to cropland (Swenson et al. 1987). Populations have recovered somewhat since the late 1980s and have remained relatively stable during the 1990s. In extreme southwest Montana, primarily Beaverhead and Madison counties, populations declined from those of the 1960s and 1970s during a period of large-scale sagebrush manipulation programs, i.e., mostly spraying (J. Peterson 2001, FWP Wildlife Manager for Region 3, personal communication). A significant number of birds in southwest Montana migrate to Idaho winter ranges, much of which has been converted to cropland. Populations now appear more stable, seemingly as a result of a reduction in sagebrush control programs. However, small declines have occurred in recent years in some locations.

*Eastern Montana.*—Sage grouse populations across north-central Montana support relatively high numbers of birds with the exception of Chouteau and Hill counties (A. Rosgaard, personal communication). South Valley and Phillips counties support comparatively high numbers of birds compared to portions of the respective counties lying north of the Milk River. An incomplete survey of leks in Valley County during spring 2000 yielded 1300 male sage grouse that included 250 males in a 36,000-ha block of south Valley (Gunderson 2001). During spring 2000, 1600 male sage grouse were counted on leks in Fergus and northern Petroleum counties in central Montana (T. S. Stivers, personal communication).

Sage grouse occupying portions of the Hi-Line north of the Milk River are primarily associated with stands of silver sagebrush in a grass-dominated community. Although effort is underway to monitor sage grouse populations in that portion of the state, little information currently is available. The historical range of sage grouse in Alberta and Saskatchewan, entirely silver sagebrush-grassland on the

northern fringe of the species' range, has been reduced by about 90 percent (Aldridge 2002).

In south-central Montana, sage grouse densities are highest in Big Horn, Carbon, Golden Valley, Musselshell and Yellowstone counties that contain fairly contiguous stands of big sagebrush (C.D. Eustace, personal communication); leks are scattered randomly with an average spacing of 5.5 km between leks. Grouse occur at lower densities in Stillwater, Sweet Grass, and Wheatland counties with widely spaced leks across sparse to highly fragmented sagebrush habitat.

## HABITAT STATUS

The abundance and distribution of sagebrush steppe in Montana has not been well defined or quantified. Sage grouse seemingly are one of the more habitat-specific of North American grouse (Aldrich 1963) and rely on sagebrush for forage and/or cover throughout the year. A potential of about 11 million ha of sagebrush occurs in the portion of the state currently occupied by sage grouse, all of which has been influenced by human use in varying degrees since early settlement of the region.

### Habitat Loss or Degradation

As the Great Plains were homesteaded, sage grouse habitat deteriorated rapidly in some areas under intensive cropping and/or over grazing. Sage grouse habitat had been fragmented or severely reduced in many areas by the 1930s although some abandoned homesteads reverted back to native rangeland during the 1930s that eventually improved habitat for sage grouse (Wallestad 1975).

Sage grouse in several counties in central and southeastern Montana were perceived as abundant from about 1913 through the 1930s and is noteworthy because much of that part of the state has remained in native rangeland up to the present time. In the 1950s efforts to remove or alter stands of sagebrush became more efficient with the advent of the herbicide 2,4-D. By the early 1960s elimination or

reduction of sagebrush to increase grass production became a common practice on public as well as private rangeland (Martin 1970). Pyrah (1972) reported that adverse effects of treatment on sage grouse winter range were proportional to severity of treatment, i.e., partial kill strips < block partial kill < mechanical treatment < total kill. Those treatments doing the least damage to sagebrush affected sage grouse use the least, and duration of the adverse effects was shortest.

The federal farm program encouraged conversion of private rangeland to cropland, or "sodbusting," that affected an untold amount of sagebrush steppe during the 1970s and 1980s. For example, Swenson et al. (1987) documented a significant habitat loss with subsequent decline in grouse numbers in the Shields Valley. A similar loss of habitat and decline in sage grouse populations had occurred in Meagher County during 1950-1970 as a result of both mechanical, e.g., plowing, and chemical treatment (Peterson 1970b).

### Current Mapping Efforts

Effort to update estimates of sagebrush/sage grouse distribution based on the evolving technology of geographical information systems (GIS) began in 1997. A cooperative effort between the Wildlife Spatial Analysis Lab at the University of Montana and FWP created the Land Cover Type spatial layer (SILC-2) for eastern Montana based on supervised classification of LANDSAT TM imagery (J. Herbert 2002, personal communication). However, sagebrush classifications had a mean accuracy rate of 65 percent and incorporated an arbitrary minimum canopy coverage rate of 20 percent. This process likely underestimated the occurrence of sagebrush communities, particularly those occurring at canopy coverages <20 percent.

In 2001 FWP mapped sage grouse habitat distribution in cooperation with the Montana Natural Heritage Program and USDI Bureau of Land Management (BLM) using the Montana GAP Land Cover types as a base layer (J. Herbert 2002, personal communication). Polygons were created for

areas surveyed for sage grouse and areas that remain unsurveyed but where sage grouse potentially occur. FWP refined this distribution layer in May 2002 using the Natural Resource Conservation Service (NRCS) Legend for SILC-2 by removing land cover types, e.g., agricultural, wooded areas, and urban or developed lands, that likely would not provide habitat for sage grouse. This refinement generated an estimate of about 10.9 million ha of potentially occupied sage grouse habitat that compared to the estimate of 4.4 million ha reported by Wallestad (1975). The more recent estimate likely will be reduced as additional training data are acquired and further separation can be made of sagebrush communities at canopy rates of <20 percent from upland grassland and xeric shrub communities.

### Conservation Status

Sage grouse are currently protected exclusively under state authority including the statutory authority granted to the Fish, Wildlife and Parks Commission to regulate harvests. Legislative mandate designates sage grouse as an upland game bird (87-2-101, MCA).

In 1870 the first regulations that affected hunting of prairie grouse in Montana, i.e., sage and sharp-tailed grouse, prohibited hunting from March 1 to August 15 (Montana Fish, Wildlife and Parks 1991). By 1897 Montana shortened hunting seasons for prairie grouse further—August 15 to December 15—with a daily bag limit of 20 birds but no possession limit. Regulations in the early 1900s became progressively more restrictive. By the 1930s and 1940s hunting seasons for sage grouse were of short duration—generally about 1–4 days. The state of Montana prohibited sage grouse hunting during 1938 and 1945–1951. FWP has increased the area open to hunting of prairie grouse since 1960 and increased season length. Seasons were about 107 days in length by 1990, except the southwest portion in which seasons were of shorter duration.

### Management Activities in Montana

*Population Monitoring.*—FWP monitors prairie grouse populations during spring through census of displaying males on leks (Montana Fish, Wildlife and Parks 1991). Annual sage grouse production has been correlated to weather conditions (Wallestad and Watts 1973). Initial lek census included trend areas of approximately 130 km<sup>2</sup> in size from which complete aerial coverage was conducted during the breeding season (Martin and Pyrah 1971). Counts of maximum numbers of birds also were made on selected leks to provide year-to-year trends in relative abundance. Annual lek surveys do not currently provide the basis for annual harvest regulations because seasons are now set in advance of the period in which surveys are conducted (Montana Fish, Wildlife and Parks 1991). However, regional personnel have continued lek surveys to monitor long-term population trends, evaluate habitat projects and refine distribution of sage grouse in Montana.

The post-harvest telephone survey provides an estimate of harvest for all upland bird species, trend in hunter numbers, and number of birds taken by hunter by species. Wings from harvested sage grouse were used to estimate composition of the harvest by sex and age (Eng 1955) although collections discontinued on a statewide scale during the mid-1980s. Wing collections have continued in south-central Montana to provide an estimate of sex ratios among birds of breeding age and numbers of young:hen.

*Habitat Acquisition and Protection.*—FWP's habitat management initially emphasized preservation and maintenance of existing habitat that required investigation of proposed sagebrush control projects by agency personnel (Martin and Pyrah 1971).

The 1987 Montana Legislature created a process and funding source for FWP to acquire easements or purchase important

wildlife habitat in Montana (87-1-241 and 242, MCA). Referred to as "H.B. 526," it generates approximately \$2.8 million/year from an earmarked portion of license revenue and provides an innovative and effective tool to protect habitat at the state level.

The state-funded Upland Game Bird Habitat Enhancement program (87-1-246, MCA) also was enacted in 1987 and amended in 1989 authorizing FWP to use funds for habitat improvement for upland game birds (Montana Fish, Wildlife and Parks 1997). A cooperative program has evolved to help private landowners implement habitat projects that benefit upland game birds. FWP provides technical assistance and reimbursement for seed, plants, materials, and practices conducted by the landowner. In addition to establishing nesting cover and food plots, these projects also include range improvements on private land, i.e., managed grazing systems. Since initiation of the program in 1989, emphasis on habitat improvement for upland game birds has increased with approximately 233,283 ha enrolled in the program since 1989. FWP has implemented grazing systems on more than 121,406 ha of rangeland under the Upland Game Bird Habitat Enhancement Program that includes sagebrush steppe.

In January 2000 FWP held an interest in 200,690 ha of private and public land for administering its wildlife programs. FWP has jurisdiction over about 20,000 ha sagebrush steppe through conservation easements under H.B. 526 (S. Knapp 2002, personal communication). Protection of shrub grasslands has carried a high priority since 1993.

FWP establishes long-term vegetation monitoring sites on all wildlife management areas and conservation easements where a grazing system has been implemented. FWP currently monitors 58 sites, and each site is monitored on a rotating basis once every 5 years. Numbers of sites monitored should increase as new lands are enrolled in the program. The effort will document the

effectiveness of land management actions, i.e. livestock grazing systems, designed to improve range condition and trend. Monitoring addresses FWP's overall wildlife management goal of providing healthy vegetation communities for a diversity of bird and mammal species.

*Research.*—Research on sage grouse in Montana during the 1950s focused on monitoring strategies to determine population status and trend (Eng 1954, 1955). Efforts during the 1960s and 1970s addressed the effects of chemical and mechanical treatment of sagebrush on associated plant and animal communities (Martin 1970, Wallestad 1975, Jorgensen 1979, Pyrah 1972, 1987) that included sage grouse and other sagebrush-dependent wildlife. These studies provided a biological basis for managing sagebrush steppe in the northern Great Plains and intermountain valleys. Current research in eastern Montana includes determining the nature of interaction between population status of sage grouse, as expressed by estimated vital rates, and habitat condition (Moynahan et al. 2001). Another study in eastern Montana is designed to assess survivorship of sage grouse both in the presence and absence of hunting. An ongoing effort in southwest Montana attempts to identify resident and migratory populations of sage grouse, key habitats, and movements relevant to local conservation efforts (Roscoe this issue).

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# SAGE GROUSE HATCHING SUCCESS AND CHRONOLOGY FOR SOUTH-CENTRAL MONTANA

Charles D. Eustace, Montana Fish, Wildlife and Parks, Billings, MT 59105

## ABSTRACT

A recent short-term fluctuation in sage grouse (*Centrocercus urophasianus*) abundance for south-central Montana was attributed to dramatically reduced productivity. This period of low productivity was associated with a peak hatching date 2 weeks earlier than normal. Molt patterns for adult hens indicated the early hatch was due to a shift in breeding and nesting and not reduced survival during June. These molt patterns also indicated a significant attempt at renesting by hens  $\geq 2$  years of age during periods of low productivity. To test the influence of climatic conditions on hatching chronology, I selected years that were at least one standard deviation above or below the long-term average for hatches occurring before 1 June. I concluded that early hatches occurred during warm dry springs, which were also associated with drought conditions. Warm dry springs also may result in earlier dates for spring green-up and grasshopper hatches. I interpret early hatches as an adaptation by sage grouse hens to take the best possible advantage of cover and forage conditions during the first critical weeks of life for their chicks.

**Key words:** *Centrocercus urophasianus*, climate, grasshoppers, hatching chronology, hen molt, productivity, sage grouse

## INTRODUCTION

Sage grouse (*Centrocercus urophasianus*) abundance is affected by long-term and short-term population changes. In Montana, long-term population declines can be related to loss of sagebrush habitats essential to sage grouse (Martin 1970, Swenson et al. 1987). Although not irreversible in nature, conditions resulting in long-term declines are likely to persist. Within the long-term decline are short-term fluctuations in sage grouse abundance. Stochastic environmental events, e.g., weather, are important to short-term changes in abundance (Edwards 1988).

Historical records for Montana give anecdotal reference to short-term fluctuations. Declines in sage grouse populations in Montana were first noted during the late 1800s and early 1900s (Annual Report 1900, Biennial Report 1909-1910). By the 1920s, sage grouse in Garfield County had increased so much they were said to darken the sky (Eustace 1995). The Fish and Game Commission

was petitioned for relief from sage grouse in northern Fergus County because "they had become a pest and something must be done" (Commission minutes 1925). This period of abundance, lasting from the 1920s to the early 1930s, saw sportsmen requesting early hunting seasons in addition to regular fall seasons. Sage grouse population declines during the mid-1930s and 1940s prompted the Fish and Game Commission to close sage grouse hunting statewide in 1938 and 1945-1951.

Systematic hunter harvest surveys, initiated in 1958, estimated an annual statewide harvest of 20,900 sage grouse in 1958-1959. Annual statewide harvest levels increased rapidly to an average of 45,500 birds during the 1960s and 1970s. The first indication that sage grouse populations had again started to decline in south-central Montana occurred in 1985 when the number of active leks being monitored began to drop. By 1998, 33 leks that had been active in 1981 were reduced to 17. Male attendance on these leks indicated populations had bottomed out by the mid-

1990s with male attendance increasing 137 percent by 2000. This increase was accompanied by a new lek in an area unoccupied by a lek since 1994. Hunter harvests also declined during the 1980s and 1990s, finally stabilizing at an annual statewide harvest of around 8,200 birds from 1993-2000. Not all of the decline in harvest directly reflected declines in sage grouse populations. As sage grouse populations waned, so did hunter interest. By 1988 hunter days were 43 percent below their levels in the mid-to-late 1970s. In 1996 the Montana Fish, Wildlife and Parks Commission reduced the daily bag limit on sage grouse to two birds and cut the season length by 42 percent. The reduction in season length had no further impact on hunter days.

As populations of a game species fluctuate, the obvious solution is often found in regulation changes. This response may or may not have any influence on the fluctuation. While this is not likely to change, a better understanding of factors influencing short-term fluctuations in sage grouse can aid in making management decisions based on reality.

## METHODS

Sage grouse wings were collected through hunter check stations, field checks and wing envelopes mailed to upland bird hunters. Sex determination was based on color patterns on minor wing coverts (tetrices) (Dalke et al. 1963). Age was assigned as juvenile or adult based on retention or molting and shape of the outer two primaries, or length of the outer three primaries if they were unmolted (Petrides 1942, Eng 1955). Juveniles were aged to the nearest week based on the length of the last primary(s) molted (Pyrah 1963). Hatching dates for juveniles were then determined by back dating their age in weeks from the date shot.

Temperature and precipitation were obtained from Montana Climatological Data (National Climatic Data Center). I averaged data for three widely spaced weather stations representing sage grouse

habitat in south-central Montana (Flatwillow, Rapelje, and Billings Airport). Soil temperature data was tabulated from the Moccasin Experiment Station at 10.2 cm (4 in) below a sod surface. The Moccasin station, located in the geographical center of Montana, was the closest station with soil temperature data from a sod surface. The Palmer Drought Severity Index (PSDI) was accessed from state maps of NCDC climate zones at: <http://www.ncdc.noaa.gov/onlineprod/drought/main.thml>. For statistical analysis I used STATISTIX 1998; differences were considered significant at  $P \leq 0.10$ .

## RESULTS

### Productivity

Chick survival to the hunting season, referred to here as productivity, is influenced by many interacting factors, which vary in intensity each year, e.g. weather, food, cover, predation etc. Productivity, expressed as juveniles/100 adult hens, averaged 256 juveniles/100 adult hens from 1962 to 2000 (Table 1). Productivity was divided into three time periods corresponding with relatively stable population levels from 1962 to 1983, a short-term decline from 1984 to 1995, and a period of population recovery from 1996 to 2000. Productivity averaged 292, 173, and 293 juveniles/100 adult hens for 1962-1983, 1984-1995, and 1996-2000, respectively.

### Hatching

Hatch dates were available for 5837 juveniles for all years from 1962 to 2000, except 1968 (Table 2). Peak of hatch for this 38-yr period occurred during the second week of June. Plotting a hatching curve by 2-week intervals indicated 42 percent of the sage grouse chicks hatched during the first two weeks of June (Fig. 1). The peak of hatch normally occurs during 2-16 June in central Montana (Wallestad and Watts 1972). Birds hatching before June are called the early hatch, while birds hatching on or after 1 June are called the normal hatch.

**Table 1.** Sage grouse productivity for south-central Montana, 1962-2000.

| Year | Juv/100 Adult Hens* | Year | Juv/100 Adult Hens | Year | Juv/100 Adult Hens |
|------|---------------------|------|--------------------|------|--------------------|
| 1962 | 310                 | 1975 | 265                | 1988 | 77                 |
| 1963 | 387                 | 1976 | 219                | 1989 | 205                |
| 1964 | 184                 | 1977 | 235                | 1990 | 307                |
| 1965 | 253                 | 1978 | 339                | 1991 | 92                 |
| 1966 | 169                 | 1979 | 497                | 1992 | 197                |
| 1967 | 250                 | 1980 | 150                | 1993 | 162                |
| 1968 | 436                 | 1981 | 223                | 1994 | 163                |
| 1969 | 187                 | 1982 | 210                | 1995 | 155                |
| 1970 | 443                 | 1983 | 439                | 1996 | 433                |
| 1971 | 423                 | 1984 | 132                | 1997 | 243                |
| 1972 | 286                 | 1985 | 100                | 1998 | 289                |
| 1973 | 304                 | 1986 | 243                | 1999 | 344                |
| 1974 | 223                 | 1987 | 248                | 2000 | 158                |

\* Number of young/100 adult hens surviving from hatch to hunting season.

Dividing the hatch into three time intervals, and matching the three productivity time intervals, indicated a large early hatch accompanied low productivity. The early hatch averaged 28.3 percent of the total hatch from 1962 to 2000 and accounted for 21, 38, and 36 percent of the total hatch for the respective years 1962-1983, 1984-1995, and 1996-2000. The size of the early hatch for 1996-2000 was greater than expected considering the high productivity for this period. This is explained by 2000, which had low productivity (158 juveniles/100 adult hens) with 75 percent of the hatch occurring early. Productivity for 1996-1999 averaged 327 juveniles/100 adult hens with 26 percent of the productivity coming from the early hatch.

A large early hatch could result from: 1) an increase in early breeding, which would shift the timing of the hatch forward, or 2) reduced survival for chicks hatching in June, which would give the appearance of an early hatch. Although weather is only one of several factors influencing productivity, it directly or indirectly influences other less easily measured factors. To reduce stochastic weather factors that could influence productivity and hatching chronology, I compared years that were at least one standard deviation above

or below the long-term average for an early hatch ( $28.3\% \pm 17.2\%$ ). Normal hatches ( $\leq 11.3\%$  of the total hatch) occurred in 1964-65, 1970-71, 1973-75 and 1991. Large early hatches ( $\geq 45.3\%$  of the total hatch) occurred in 1986-87, 1992-94 and 2000. Comparing hatching curves for normal and large early hatches indicated a 2-wk difference in the peak of hatching (Fig. 2).

### Temperature

Eng (personal communication) suggested warm spring weather could shift breeding forward by at least a week. Bergerud and Gratson (1988) state that “the timing of breeding and nesting commonly varies a maximum of 2 weeks in grouse populations. Birds nest earlier in years when there is little snow in March and April and later when snow lingers in April.” With the exception of February, all months had higher average temperatures for years with large early hatches than years with normal hatches (Table 3). Differences in temperature were significant for January, March, April, and May. The greatest difference in temperature,  $6.2\text{ }^{\circ}\text{C}$ , occurred in March, the period of initial lek attendance by hens.

Air temperature also influences soil temperature, which is important in initiating plant growth. I calculated the first date soil

**Table 2.** Percent of sage grouse hatching at one week intervals for south-central Montana, 1962-2000.

| Year    | Hatch* | May<br>(4/10) | May<br>(11/17) | May<br>(18/24) | May<br>(25/31) | June<br>(1/7) | June<br>(8/14) | June<br>(15/21) | June<br>(22/28) | June<br>(29+) |
|---------|--------|---------------|----------------|----------------|----------------|---------------|----------------|-----------------|-----------------|---------------|
| 1962    |        | 0.0           | 0.5            | 2.0            | 11.0           | 27.0          | 34.0           | 14.0            | 3.0             | 8.5           |
| 1963    |        | 0.6           | 0.6            | 4.3            | 15.8           | 21.1          | 26.5           | 20.7            | 5.7             | 4.9           |
| 1964    | n      | 0.3           | 1.5            | 2.6            | 4.3            | 15.9          | 30.6           | 31.8            | 9.3             | 3.8           |
| 1965    | n      | 0.0           | 0.6            | 2.3            | 4.1            | 14.6          | 26.3           | 29.2            | 11.7            | 11.1          |
| 1966    |        | 5.1           | 3.1            | 8.3            | 14.4           | 22.7          | 23.7           | 12.4            | 5.2             | 5.1           |
| 1967    |        | 1.4           | 0.0            | 6.8            | 4.1            | 6.8           | 6.8            | 27.0            | 17.6            | 29.8          |
| 1969    |        | 0.0           | 0.0            | 3.2            | 21.0           | 30.6          | 27.4           | 11.3            | 4.8             | 1.6           |
| 1970    | n      | 0.6           | 1.2            | 1.7            | 1.7            | 5.2           | 30.5           | 36.8            | 12.6            | 9.9           |
| 1971    | n      | 0.5           | 0.5            | 2.4            | 5.3            | 18.5          | 42.7           | 18.9            | 6.3             | 4.9           |
| 1972    |        | 0.9           | 0.9            | 5.9            | 18.6           | 30.5          | 24.1           | 6.4             | 8.2             | 4.6           |
| 1973    | n      | 0.6           | 2.2            | 2.8            | 3.3            | 12.0          | 32.0           | 25.4            | 16.0            | 6.2           |
| 1974    | n      | 0.4           | 1.7            | 2.0            | 2.9            | 21.0          | 37.0           | 19.8            | 8.0             | 7.2           |
| 1975    | n      | 0.0           | 0.7            | 2.0            | 2.0            | 10.7          | 38.0           | 24.3            | 10.7            | 11.7          |
| 1976    |        | 2.8           | 2.2            | 5.5            | 17.5           | 19.4          | 27.4           | 13.5            | 7.1             | 4.6           |
| 1977    |        | 1.4           | 4.8            | 8.8            | 21.1           | 28.6          | 23.1           | 8.2             | 2.7             | 1.4           |
| 1978    |        | 3.3           | 3.7            | 7.4            | 12.3           | 19.7          | 20.5           | 11.5            | 10.0            | 11.6          |
| 1979    |        | 5.6           | 7.0            | 4.6            | 8.3            | 16.6          | 29.1           | 19.2            | 5.3             | 4.3           |
| 1980    |        | 4.9           | 10.7           | 4.4            | 5.4            | 19.5          | 31.7           | 16.1            | 6.3             | 1.0           |
| 1981    |        | 2.0           | 4.0            | 13.0           | 22.5           | 19.5          | 15.0           | 10.5            | 7.0             | 6.5           |
| 1982    |        | 4.6           | 6.7            | 8.2            | 9.2            | 10.3          | 29.2           | 19.5            | 6.2             | 6.1           |
| 1983    |        | 7.2           | 3.2            | 8.5            | 15.4           | 23.9          | 22.8           | 11.4            | 6.1             | 1.6           |
| 1984    |        | 2.8           | 7.1            | 6.4            | 7.1            | 11.4          | 27.7           | 27.0            | 5.7             | 5.0           |
| 1985    |        | 0.0           | 7.4            | 11.1           | 18.5           | 18.5          | 37.0           | 3.7             | 3.7             | 0.0           |
| 1986    | e      | 10.5          | 5.3            | 23.7           | 15.8           | 10.5          | 13.2           | 7.9             | 10.5            | 2.6           |
| 1987    | e      | 1.4           | 4.2            | 22.2           | 36.1           | 27.8          | 1.4            | 5.6             | 1.4             | 0.0           |
| 1988    |        | 3.6           | 3.6            | 14.3           | 10.7           | 14.3          | 25.0           | 21.4            | 0.0             | 7.1           |
| 1989    |        | 6.0           | 1.0            | 2.0            | 14.9           | 21.8          | 23.8           | 15.8            | 10.9            | 4.0           |
| 1990    |        | 6.1           | 6.1            | 8.1            | 18.2           | 18.2          | 16.2           | 6.1             | 11.1            | 10.1          |
| 1991    | n      | 3.5           | 0.0            | 0.0            | 3.5            | 17.2          | 24.1           | 24.1            | 22.4            | 5.2           |
| 1992    | e      | 11.4          | 7.6            | 20.8           | 20.8           | 20.8          | 11.3           | 5.7             | 0.0             | 1.9           |
| 1993    | e      | 0.0           | 3.7            | 11.1           | 33.3           | 18.5          | 11.1           | 18.5            | 3.7             | 0.0           |
| 1994    | e      | 9.1           | 9.1            | 14.6           | 16.4           | 21.8          | 14.6           | 9.1             | 0.0             | 5.4           |
| 1995    |        | 9.8           | 7.8            | 2.0            | 11.8           | 9.8           | 9.8            | 9.8             | 11.8            | 27.4          |
| 1996    |        | 4.8           | 7.1            | 4.8            | 11.9           | 19.1          | 21.4           | 16.7            | 4.8             | 9.5           |
| 1997    |        | 0.0           | 4.2            | 8.3            | 0.0            | 33.3          | 20.8           | 16.7            | 4.2             | 12.6          |
| 1998    |        | 0.0           | 3.7            | 7.4            | 22.2           | 18.5          | 33.3           | 14.8            | 0.0             | 0.0           |
| 1999    |        | 5.7           | 1.9            | 5.7            | 17.0           | 22.6          | 18.9           | 9.4             | 7.6             | 11.4          |
| 2000    | e      | 14.3          | 7.1            | 25.0           | 28.6           | 10.7          | 3.6            | 3.6             | 3.6             | 3.6           |
| Average |        | 3.4           | 3.7            | 7.7            | 13.3           | 18.6          | 23.5           | 15.9            | 7.1             | 6.6           |

\*n = normal hatch where  $\leq 11.3\%$  of the total hatch occurs before June 1.

e = large early hatch where  $\geq 45.3\%$  of the total hatch occurs before June 1.

temperatures at 10.2 cm depth under sod averaged a minimum of 4.4, 10.0, and 15.6 °C for seven consecutive days (Table 4). After seven consecutive days the temperature seldom dropped below the designated minimum. On average, soil temperatures reached 4.4° C on 19 March and 6 April for early and normal hatch years respectively. This difference of 18 days was significant. Differences in dates for soil

temperatures reaching 10 and 15.6° C during early and normal hatch years were not significant. Early plant growth could benefit an early hatch by providing cover, forbs, and insects at an earlier date than usual.

### Precipitation

Total precipitation for January-June from the three weather stations averaged 19.1 and 24.5 cm for early and normal

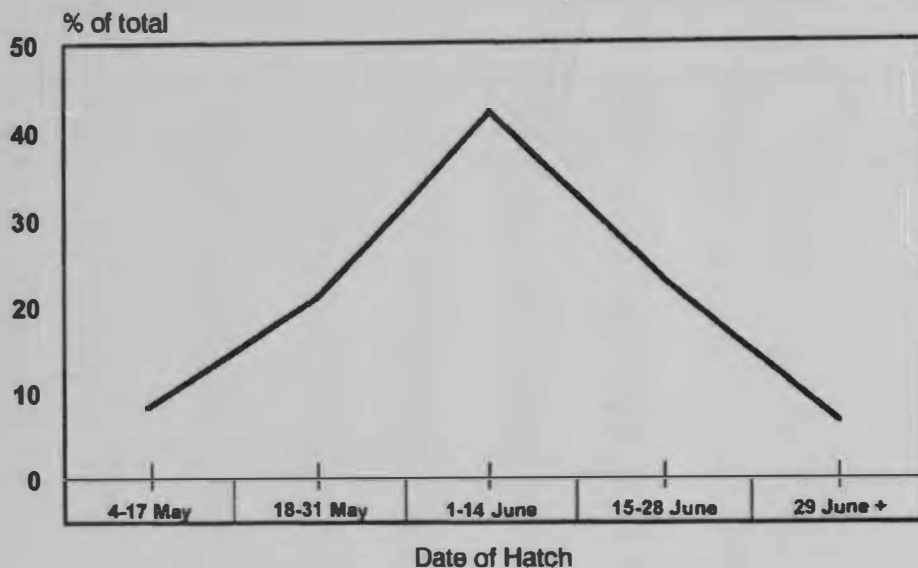


Figure 1. Sage grouse hatching dates for south-central Montana, 1962-2000

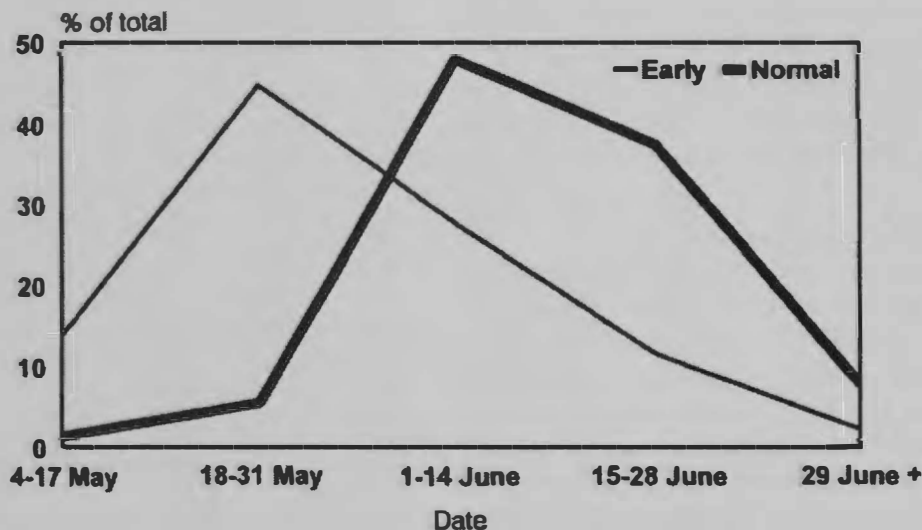


Figure 2. Sage grouse hatching dates for south-central Montana, early vs. normal hatch (early 1986-87, 1992-94, 2000; normal 1964-65, 1970-71, 1973-75)

hatches, respectively (Table 5). With the exception of February, all months had lower average precipitation for years with large early hatches than years with normal hatches. Differences in precipitation were significant for January and April, as was total precipitation for January through June. These data indicate that large early hatches

were associated with dry warm springs. Bergerud (1988) suggested that "wet cool springs may provide more cover and insects for steppe grouse," which correlates with higher chick survival associated with a normal hatch.

Moisture received prior to the year of hatch can influence productivity. Bergerud,

**Table 3.** Temperature (°C) for early and normal hatch years , south-central Montana.

| Early Hatch Years |      |      |      |      |      |      |         |
|-------------------|------|------|------|------|------|------|---------|
| Month             | 1986 | 1987 | 1992 | 1993 | 1994 | 2000 | Average |
| Jan.              | 2.7  | -0.8 | 1.6  | -8.7 | -2.7 | -3.6 | -1.9    |
| Feb.              | -4.7 | 1.1  | 3.7  | -6.7 | -6.1 | -0.7 | -2.2    |
| Mar.              | 7.5  | 2.9  | 5.9  | 4.1  | 7.6  | 8.3  | 6.1     |
| Apr.              | 6.8  | 11.5 | 8.8  | 7.6  | 7.8  | 8.3  | 8.5     |
| May               | 11.8 | 15.1 | 14.1 | 14.0 | 14.2 | 13.2 | 13.7    |
| Jun.              | 20.2 | 19.2 | 18.1 | 15.8 | 18.0 | 16.6 | 18.0    |

| Normal Hatch Years |      |      |      |      |      |      |      |      |         |
|--------------------|------|------|------|------|------|------|------|------|---------|
| Month              | 1964 | 1965 | 1970 | 1971 | 1973 | 1974 | 1975 | 1991 | Average |
| Jan.               | -2.0 | -3.3 | -6.8 | -7.5 | -4.6 | -5.9 | -4.1 | -6.4 | -5.1    |
| Feb.               | -0.3 | -4.3 | 0.3  | -2.8 | -1.9 | 1.6  | -8.4 | 4.4  | -1.4    |
| Mar.               | -1.2 | -6.8 | -1.1 | 0.8  | 3.3  | 1.8  | -1.4 | 2.7  | -0.2    |
| Apr.               | 6.4  | 7.1  | 3.6  | 6.7  | 4.9  | 8.4  | 2.4  | 6.3  | 5.7     |
| May                | 13.0 | 11.1 | 12.2 | 12.3 | 11.8 | 9.8  | 10.4 | 12.1 | 11.6    |
| Jun.               | 16.2 | 15.6 | 18.5 | 17.2 | 17.5 | 18.6 | 15.3 | 17.0 | 17.0    |

(1988) developed a 23-month soil moisture index to account for vegetative residual cover and new growth and correlated it with sharp-tailed grouse brood size. The influence soil moisture had on sharptail productivity increased as the moisture gradient decreased from Minnesota to the Dakotas. Bridges et al. (2001) found the PDSI as well as raw precipitation data more closely related to annual changes in quail abundance in relatively arid vs. wet regions of Texas. The PDSI indicates the severity of a wet or dry spell based on the principles

of a balance between moisture supply and demand, e.g., demand increases as temperature increases. I used the PDSI Palmer (1966) to compare moisture conditions between early and normal hatch years. The PDSI is not available for individual weather stations but is compiled for all the weather stations within a climatological division. I used the index from climatological division 5, that covers south-central Montana. A 22-month index was calculated by averaging the sum of the monthly PDSIs from September of year one

**Table 4.** Minimum soil temperature at 10.2 cm. Depth in sod for 7 consecutive days for early and normal hatch years, Mocassin station, central Montana.

| Early Hatch Years |         |         |        |         |         |         |           |
|-------------------|---------|---------|--------|---------|---------|---------|-----------|
| Temp.             | 1986    | 1987    | 1992   | 1993    | 1994    | 2000    | Ave. Date |
| 4.4°C             | 16 Mar. | 12 Mar. | 7 Mar. | 30 Mar. | 7 Apr.  | 11 Mar. | 19 Mar.   |
| 10°C              | 22 May  | 30 Apr. | NA*    | 9 May   | 24 Apr. | 27 Apr. | 5 May     |
| 15.6°C            | 5 Jun.  | 13 May  | NA     | 19 May  | 10 Jun. | 8 Jun.  | 20 May    |

| Normal Hatch Years |         |         |         |         |         |         |           |
|--------------------|---------|---------|---------|---------|---------|---------|-----------|
| Temp.              | 1970    | 1971    | 1973    | 1974    | 1975    | 1991    | Ave. Date |
| 4.4°C              | 12 Apr. | 6 Apr.  | 19 Mar. | 7 Apr.  | 30 Apr. | 26 Mar. | 6 Apr.    |
| 10°C               | 10 May  | 28 Apr. | NA      | 21 Apr. | 17 May  | 16 May  | 6 May     |
| 15.6°C             | 24 May  | 30 May  | NA      | 13 Jun. | 6 Jun.  | 8 Jun.  | 4 Jun.    |

**Table 5.** Precipitation in centimeters for early and normal hatch years, south-central Montana.

| Early Hatch Years |      |      |      |      |      |      |      |
|-------------------|------|------|------|------|------|------|------|
| Month             | 1986 | 1987 | 1992 | 1993 | 1994 | 2000 | Ave. |
| Jan.              | 1.0  | 0.3  | 0.4  | 1.8  | 1.1  | 1.3  | 1.0  |
| Feb.              | 3.6  | 1.1  | 0.3  | 0.9  | 0.8  | 2.5  | 1.6  |
| Mar.              | 1.5  | 3.8  | 2.1  | 1.7  | 0.9  | 1.5  | 2.0  |
| Apr.              | 6.4  | 0.7  | 5.0  | 2.2  | 5.0  | 2.4  | 3.6  |
| May               | 6.2  | 10.0 | 3.1  | 3.4  | 5.5  | 3.9  | 5.4  |
| Jun.              | 6.0  | 2.3  | 11.0 | 5.7  | 4.6  | 3.9  | 5.6  |

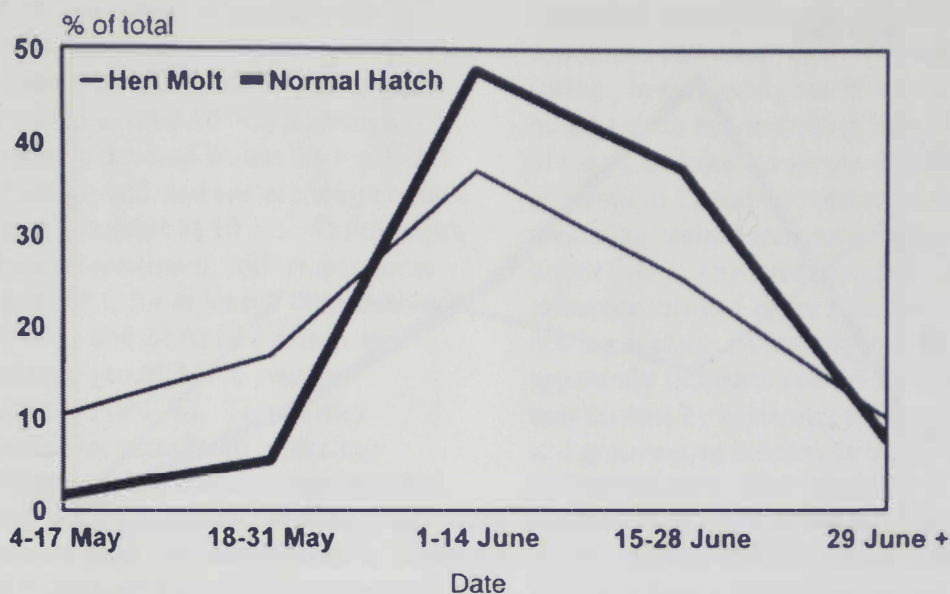
| Normal Hatch Years |      |      |      |      |      |      |      |      |      |
|--------------------|------|------|------|------|------|------|------|------|------|
| Month              | 1964 | 1965 | 1970 | 1971 | 1973 | 1974 | 1975 | 1991 | Ave. |
| Jan.               | 0.4  | 1.8  | 1.9  | 3.5  | 2.1  | 1.3  | 3.8  | 1.7  | 2.1  |
| Feb.               | 0.4  | 2.1  | 2.4  | 1.3  | 0.7  | 0.4  | 2.8  | 1.1  | 1.4  |
| Mar.               | 2.6  | 1.8  | 1.9  | 1.9  | 2.8  | 2.2  | 2.5  | 1.3  | 2.1  |
| Apr.               | 7.7  | 4.2  | 6.3  | 3.6  | 6.1  | 4.6  | 4.6  | 10.2 | 5.6  |
| May                | 9.0  | 5.3  | 9.2  | 4.9  | 2.9  | 8.5  | 9.8  | 7.6  | 7.2  |
| Jun.               | 11.7 | 5.7  | 4.5  | 2.8  | 4.0  | 3.7  | 6.9  | 10.3 | 6.2  |

through June of the year of hatch, year three. An unweighted least squares linear regression between productivity and the 22-month index indicated a positive correlation between productivity and increasing wetness, ( $P < 0.01$   $r^2 = 0.58$ ). There was no correlation between productivity and raw precipitation data averaged in the same manner for the same time periods.

### Adult Hen Molt

Eng (1963) and Pryah (1963) have suggested that sage grouse hens are in the same stage of molt as their brood. A juvenile with a molt pattern that indicates a hatching date during the first week of June should be accompanied by a hen with a similar molt pattern. Thus, a shift in the hatching curve for juveniles should be reflected by a similar shift in the adult hen molt curve. When the molt of the adult hen in weeks is plotted against the hatching curve for juveniles, hens falling outside the juvenile curve are considered unsuccessful either at breeding, nesting, or brood rearing (Wallestad and Watts, 1972). Juvenile and hen molt curves for the normal hatch mirror one another (Fig. 3) with the majority of unsuccessful hens molting from 4 to 31

May. The almost total lack of molting hens lying outside the hatching curve from 29 June on suggests that very little re-nesting occurred during years with a normal hatch, or those hens that did, had good success. The juvenile and hen molt curves for the early hatch were not as synchronous (Fig. 4). However, I believe the data suggested early breeding for the following reasons. There was a relatively large increase in the percent of juveniles hatching from 4 to 31 May, which it can be argued is to be expected considering the similarly large decline for June. However, I believe conditions sufficiently severe to reduce productivity by 58 percent during June would not favor a 7- to 8-fold increase in productivity during May. Almost no hatch occurred after 29 June and very few unsuccessful hens, both of which suggested a forward shift. The lack of a significant peak in the hen molt from 18–31 May, may be due to the large percent of unsuccessful hens during other time periods. The largest percent of hens in the molt curve occurred during 4-17 May. This represented a substantial number of hens that failed to nest, abandoned or lost their nest, or lost their brood.



**Figure 3.** Sage grouse hen molt vs. normal hatch for south-central Montana (1964-1965, 1970-1971, 1973-1975).

During the normal hatch years the molt pattern of hens  $\geq 2$  years old indicated they made up 43, 36, 46, 70, and 75 percent of all adult hens in the 4-17 May through 29 June + time periods, respectively. During the early hatch years hens  $\geq 2$  years old made up 58, 53, 59, 94, and 100 percent of all adult hens in the respective five time periods. The almost total absence of yearling hens from mid-June on in early hatch years indicated to me a significant reneesting attempt by more experienced age classes and virtually no reneesting by yearling hens. If this assumption is correct, the time needed to breed, lay, and incubate a second clutch would indicate that these hens were originally associated with the unsuccessful hens from the 4-17 May time period. This further suggested that conditions during the early part of the hatching season were not markedly more favorable to producing a brood than in June, which would lend credence to earlier breeding and nesting during early hatch years.

### **Productivity, Early vs. Normal Hatch**

Productivity averaged 195 and 273 juveniles/100 adult hens for early and

normal hatches, respectively. Generally, highest productivity for early hatches corresponded with lowest productivity for normal hatches except during 1964 and 1991. Wallestad and Watts (1972) showed a negative correlation between productivity and rainfall  $>2.54$  cm during the egg laying period for central Montana. The period for egg laying was determined by combining the 10-11 days necessary to lay a clutch of 7-8 eggs (Patterson 1952) and 26 days for incubation (Pyrah 1963). Egg laying for a normal hatch occurs from 24 April to 8 May. A total of 10.1 cm. of rain fell during this 2-wk period in 1964 that could account for lower production. Rainfall during this same time period was favorable for a good hatch in 1991, however, temperatures were more in line with an early hatch. February 1991 was 6.1° C warmer than average and warmer than any other February since 1962. March temperatures were mid-way between those for early and normal hatches. The egg laying period for an early hatch is 10-23 April. Temperatures averaged 12.4, 1.6, and 3.9° C the first, second and third week in April, respectively. A total of 71 cm of snow fell during 8-17 April with a maximum ground accumulation of 35.6 cm.

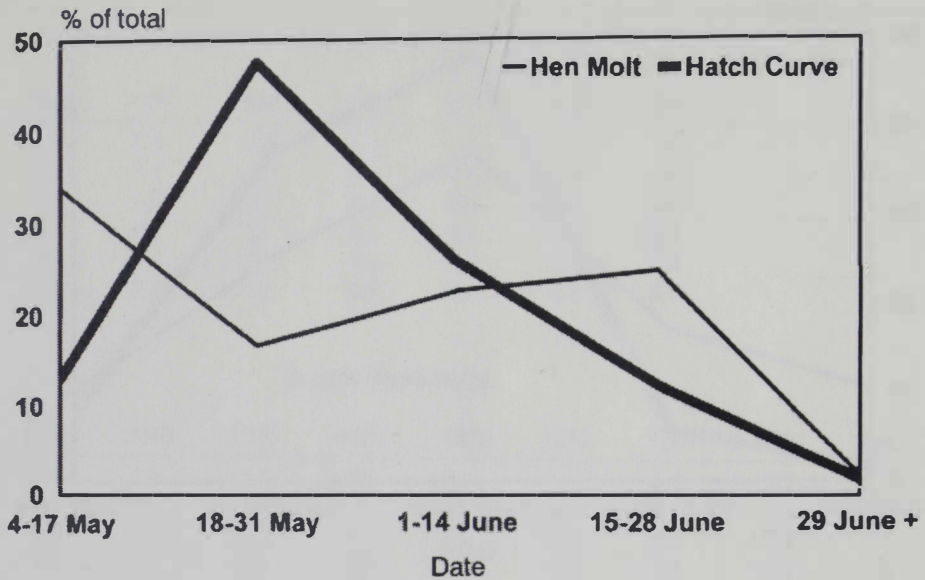


Figure 4. Sage grouse hen molt vs. early hatch for south-central Montana (1986-1987, 1992-1994, 2000).

of snow and 8.9 cm of moisture. Temperatures and the extremely low productivity that would be associated with early egg laying during a heavy snowfall indicated that 1991 fits the early hatch better than a normal hatch. Excluding 1964 and 1991 from the normal hatch increased productivity for normal years to 318 juveniles/100 adult hens. No other years appeared affected by precipitation during the egg-laying period, which averaged 2.0 and 2.9 cm during the egg laying period for respective early and normal hatches.

### Grasshoppers

Peterson (1970) documented grasshoppers as the most important insect in sage grouse diets in central Montana with heavy utilization beginning at 5 weeks of age. From 5 to 12 weeks of age grasshoppers occurred in 38 percent of 101 crops examined and averaged 19 percent of the volume for those crops. Forbs constituted over 70 percent of the volume in juvenile chicks  $\leq 12$  weeks of age (Peterson 1970). In addition to its influence on vegetation development, moisture can have a profound influence on insect populations. Annual grassland biomass production in

Montana and the proportion utilized by most grasshopper species are largely determined by environmental conditions during January through July (Kemp and Gigliano 1994). They found dry springs were detrimental to the development of forbs and annual grasses upon which grasshoppers depend. They documented a 56-percent decline in grasshopper species richness in eastern and south-central Montana following the severe 1988 drought. The influence of that decline was still apparent in insect abundance in 1992, indicating relatively long-lasting impacts of drought to some insect species. Extremely dry conditions did not have a direct negative effect on the growth or survival of eggs and small nymphs. Population losses were disproportionately associated with the large nymph and adult life stages (Kemp and Gigliano 1994). The small nymph stage covers the first 30 days of life followed by 20 days as a large nymph. This indicates that early hatches of grasshoppers, which normally occur during mid-to-late May in south-central Montana (Sword, personal communication) would start significant declines in mid to late June under very dry conditions. Fisher et al.

(1996) indicates that soil temperature influences the timing of grasshopper hatches with normal embryonic development commencing whenever soil temperatures exceed 10° C. Although grasshoppers develop within the top 1–2.5 cm. of the ground, sod surface temperatures were only available at 10 cm. At this depth the first date maximum soil temperatures averaged 10° C for at least 7 consecutive days was 13 and 24 April for early and normal sage grouse hatch years, respectively (Table 6). This 11-day difference was significant indicating grasshopper embryonic development, and hatching should occur sooner during early than normal sage grouse hatch years. This would benefit early hatching sage grouse chicks, but in extremely dry years could reduce the abundance of large nymphs available for chicks hatching during June. In summary then, dry warm springs would be detrimental to both forb and grasshopper production, which are important to juvenile sage grouse.

## DISCUSSION

Sage grouse populations in Montana have exhibited dramatic short-term swings in abundance. These periods of scarcity and abundance are driven by significant changes in productivity. The last major decline in productivity from 1984-1995 also was clearly accompanied by a 2-wk shift in the peak of hatching from early June to late

May. Early hatches and low productivity coincided with a period of extended drought conditions and warm dry weather during spring. In comparing the PDSI for the 22 months up to and including June of the year of hatch, incipient to severe drought occurred in 13 and 43 percent of the months preceding normal and early hatch years, respectively. This would significantly influence residual cover important to nesting success. Warm dry springs apparently influence conditions favorable to nest success by hastening spring green-up and grasshopper hatches through elevated soil temperature. The influence of elevated soil temperatures and low precipitation also can shorten the duration of conditions favorable to chick survival through desiccation of vegetation and declines in the number of large nymph and adult grasshopper life stages. Molt patterns of adult hens with early hatches indicated significant numbers of unsuccessful hens, either through nest loss and abandonment or poor chick survival. Molt patterns also indicated a significant re-nesting effort by hens  $\geq 2$  years of age, which would be expected with nest loss and abandonment. The PDSI indicated dramatically improved moisture conditions during the latter half of 1993 through 1998, but it took over 2 years for this to be reflected in dramatically improved productivity. The improved productivity resulted in a 145 percent increase in male lek attendance between

Table 6. Maximum soil temperature at 10.2 cm. Depth in sod for 7 consecutive days for early and normal hatch years, Mocassin station, central Montana.

| Early Hatch Years  |        |         |         |         |         |           |
|--------------------|--------|---------|---------|---------|---------|-----------|
| Temp.              | 1986   | 1987    | 1993    | 1994    | 2000    | Ave. Date |
| 10°C               | 7 Apr. | 11 Apr. | 7 Apr.  | 17 Apr. | 21 Apr. | 13        |
| 15.6°C             | 23 May | 1 May   | 16 May  | 14 May  | 24 May  | 16 May    |
| Normal Hatch Years |        |         |         |         |         |           |
| Temp.              | 1970   | 1971    | 1974    | 1975    | 1991    | Ave. Date |
| 10°C               | 10 May | 13 Apr. | 15 Apr. | 16 May  | 7 Apr.  | 24 Apr.   |
| 15.6°C             | 20 May | 8 May   | 11 May  | 19 May  | 23 May  | 16 May    |

1994 and 2000. Following 1 year of drought conditions in 1999, productivity again declined.

## CONCLUSION

Gradual long-term declines in sage grouse populations are associated with habitat loss. Dramatic short-term population fluctuations are driven by changes in chick productivity. Drought conditions existing at least 20 months prior to hatching and warm dry springs during the year of hatching often accompanied reduced productivity. Productivity also can be reduced by exceptionally heavy precipitation during the egg laying period. Warm dry springs apparently favored an advance in the peak of hatching by at least two weeks over the normal hatching peak of 1-14 June. Warm dry springs also may result in earlier growth of vegetation and earlier hatching of some insect species, notably grasshoppers. I interpreted earlier hatching as an involuntary response by sage grouse to take the best possible advantage of earlier cover and forage conditions during the first critical weeks of life for chicks. Protection and improvement of existing sagebrush habitats offer the best means of preserving sage grouse in the long term. Short-term fluctuations are best corrected by rainfall, which we must leave up to someone else.

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# SAGE GROUSE MOVEMENTS IN SOUTHWESTERN MONTANA

James W. Roscoe, Bureau of Land Management Dillon Field Office, Dillon, MT 59725

## ABSTRACT

Sage grouse (*Centrocercus urophasianus*) populations have declined throughout the western United States and in southwestern Montana since the 1970s. Conservation efforts rely on knowledge of seasonal habitat distribution and sage grouse movement patterns between these habitats. Both of these factors are poorly understood and undocumented in southwestern Montana. An ongoing, cooperative study was initiated in 1999 to radio-track sage grouse in southwestern Montana to identify resident and migratory populations, key habitats, and movement patterns relevant to local sagebrush and sage grouse conservation. Thirty-seven sage grouse were fitted with radio transmitters and monitored  $\leq 24$  months in Horse Prairie, Sweetwater Basin, and Big Sheep Creek Basin in Beaverhead and Madison Counties near Dillon, Montana. Data collection included aerial monitoring supplemented with ground relocations obtained between flights. Results indicated that some groups of sage grouse were resident within a particular habitat complex while others traveled greater distances to utilize suitable breeding, summer, and winter habitat. This study helped identify locally important brood-rearing and summer habitats. Annual mortality of radio-tracked birds has averaged 58 percent over 3 years, with 50-83 percent losses for males ( $n = 20$ ) and 14-50 percent losses for females ( $n = 4$ ).

**Key Words:** key habitats, migration, mortality, radio telemetry, sage grouse

## INTRODUCTION

Long-term population declines of sage grouse in southwest Montana have been documented for some time, but habitat quality and distribution have not been adequately investigated. Crowley and Connelly (1996) documented declining numbers of male sage grouse on nearly all leks in southwest Montana since the early 1970s, although numbers have stabilized or increased slightly since then. Martin (1970) described sage grouse habitat in Big Sheep Creek Basin and the effects of sagebrush removal on sage grouse use. An interagency, interstate study plan was proposed in 1987 to address this issue in southwest Montana and southeast Idaho, but funding problems limited implementation of the plan in Montana. Substantial sage grouse research information has been collected in southeast Idaho that is pertinent to southwest Montana, including some

evidence that migratory sage grouse are moving between southwestern Montana and southeastern Idaho (Connelly, et. al 1988, Connelly, et al. 1991). By 1999 with increasing need for conservation planning, the USDI Bureau of Land Management (BLM), Dillon Field Office, and Montana Fish Wildlife and Parks (MFWP) initiated a cooperative study of sage grouse movements and habitat inventory that could serve as the basis for expanded research and habitat conservation. Support for the project was derived through Challenge Cost Share partnerships between the BLM, MFWP, Big Sky Upland Bird Association, Gallatin Wildlife Association, Western Montana College, and USDA Forest Service (USFS), Beaverhead/Deerlodge National Forest, and the effort of many volunteers.

Our goal is to provide baseline information on specific sage grouse populations and habitats in southwest

Montana to use in conservation planning and land management decisions. This project was not designed to meet the rigorous standards of classic scientific methodology and statistical validity but rather to provide baseline information on sage grouse distribution and movements that might serve as a catalyst for more definitive research into sage grouse habitat selection and population dynamics.

## STUDY AREA DESCRIPTION

Sage grouse radio telemetry work began in 1999 west and south of Dillon, Montana, from Argenta and Bannack southwest into Horse Prairie to the Continental Divide at Bannack Pass (Fig. 1). This area encompasses 11,331 ha. Work was extended in 2000 into the Sweetwater Basin (4654 ha) east of Dillon, and again in 2001 to include Big Sheep Creek Basin (5868 ha) southwest of Dillon. Elevations in the study area range from 1850 to 2850m. Public land (BLM, USFS, Montana DNRC) comprises 64 percent of the combined area with the largest blocks in Horse Prairie and the least public land and the most fragmented land pattern in Sweetwater Basin. Horse Prairie was chosen since it contained the greatest concentration of sage grouse leks and winter habitat located on public land in southwest Montana and has sustained the largest numbers of "resident" sage grouse. Big Sheep Creek Basin was selected since winter habitat is limited in this area, and sage grouse were considered migratory, possibly moving southward across the Continental Divide into Idaho. Sweetwater Basin was chosen for its isolation from other sage grouse habitat. Although there may be some interchange of birds between these habitat areas, they are mostly discreet groups of sage grouse, and are considered "sub-populations" of a larger southwest Montana population.

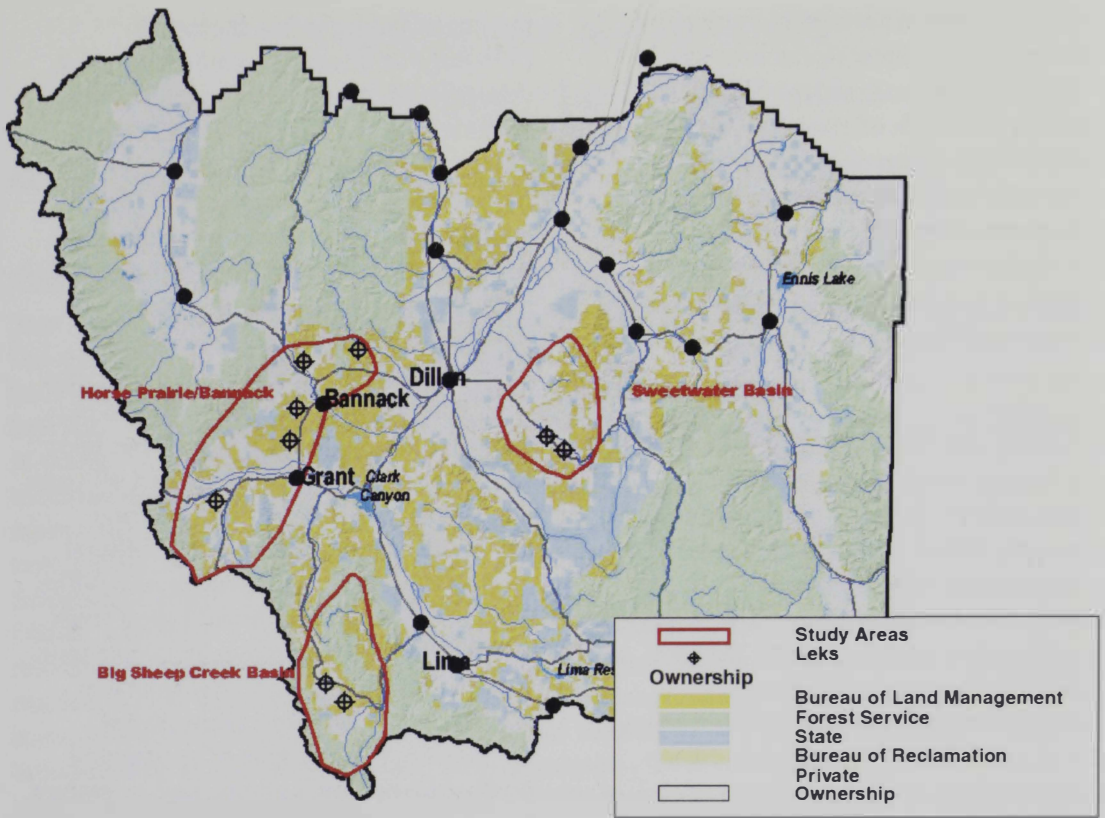
The study area provides a wide range of topography, soils, elevation, and precipitation that supports numerous sagebrush habitat types. Wyoming,

mountain and basin big sagebrush (*Artemisia tridentata wyomingensis*, *A. t. vasayana*, *A. t. tridentata*) dominate most suitable sites with low sage, early sage, silver sage, and black sage (*A. arbuscula*, *A. longiloba*, *A. cana*, *A. nova*) present on specific sites. Tall three-tip sagebrush (*A. tripartita*) is common at mid-elevations on sites that have been disturbed by fire. A widely diverse herbaceous community occurs with these various sagebrush types depending on site characteristics and past disturbances. Sagebrush habitat has been extensively modified over the past 40 years through various attempts at rangeland improvement, conversion to agricultural production, and some instances of wildfire and prescribed fire. National Forest lands supporting Douglas-fir and lodgepole pine forests surround much of this habitat at higher elevations. Most major valley bottoms are in some type of agricultural production for small grains, hay, or pasture. Due to intermingled and limited public land ownership at these lower elevations, much of the historical sagebrush habitat has been fragmented into small, discontinuous blocks.

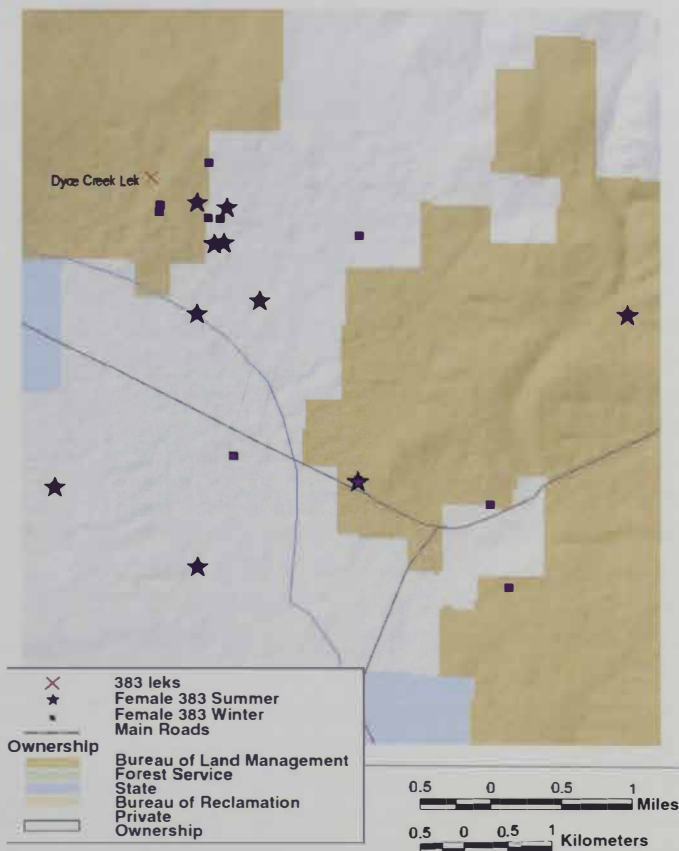
## METHODS AND MATERIALS

Sage grouse were captured on leks at night during March and April. Grouse were spotlighted from a vehicle and captured on the ground with large fishing nets. Trapping occurred early in the breeding season when hens and males were both present on leks. Dates were primarily scheduled to coincide with the new moon to take advantage of the darkest conditions possible. Trapping success was not affected by weather conditions but was definitely influenced by how well sage grouse could see. Time and manpower constraints limited efforts to selectively capture hen sage grouse, and all grouse captured were fitted with radio transmitters. Volunteers were the primary work force available for trapping over all 3 years.

Sage grouse were fitted with Advanced Telemetry Systems (ATS) Model 16M radio transmitters, each with a unique frequency.



**Figure 1.** Sage grouse radio telemetry study areas, SW Montana, 1999-2001. Lek locations (⊕) indicate primary leks where trapping activity was concentrated.



**Figure 2.** Typical female sage grouse movements (hen 383) in SW Montana, 1999-2001. December through May relocations are displayed as “winter” locations (■). June through November relocations are displayed as “summer” locations (★).

Continuous and 12-hr on/off transmitters were used. Transmitters were secured around the grouse's neck by a small-diameter plastic covered cable with the radio suspended beneath the bird's head and the antenna extending from behind the bird's head down along the back. Necklace cables were tightened enough to still allow a finger-width between the cable and neck so as not to interfere with feeding, breathing, or displaying.

Aerial monitoring of transmitted grouse was conducted monthly or bi-weekly during periods of greatest movement in spring and fall. Longer intervals between flights occurred during summer and winter when birds were more sedentary. I obtained relocations from the ground during intervals between flights to describe habitats characteristics and document the number of birds accompanying radio-equipped birds.

## RESULTS

### Relocations 1999

Trapping was conducted in Horse Prairie between 16 March and 15 April 1999 with 9 sage grouse (6 males, 3 hens) radio-marked on four different leks (Table 1). Several hens but no males were observed on the Dyce Creek lek. Locations of radio-equipped birds were obtained from the ground beginning in early May while sage grouse were still in the immediate vicinity of leks where captured. Aerial monitoring flights were conducted on 30 June, 8 August, and 27 August 1999. I obtained 74 relocations between May 1999 and February 2000.

All sage grouse stayed within 2-4 km of leks where captured until early-mid June. The three hens then moved 3-5 km directly to a large wet meadow/hayfield complex on private lands where they stayed through September. At least three flocks of 15-35 sage grouse occupied this area throughout this time. Successful nesting was not confirmed until hen No. 54 was observed with a brood in mid-August.

This preferred habitat area near Grasshopper Creek historically supported extensive Wyoming big sagebrush stands that were converted to irrigated hayland. Irrigation overflows around these fields have extended moist habitat into the remaining stringers and patches of sagebrush in small drainages and on steeper slopes. Sagebrush patches provided important cover despite having declining, mostly decadent canopies. An adjoining sub-irrigated pasture receives yearlong grazing by bison, and grasshoppers offered a readily available food source by midsummer. This area represented the largest moist habitat available in a much larger area that was relatively free of disturbance during spring and early summer and provided good foraging conditions.

Male sage grouse movements were more irregular and wide-ranging than for females, but males from the same leks moved to the same general areas. Some males moved directly to large irrigated meadows and stayed there, as did the hens although other males moved continuously during the summer and fall, traveling 30-50 km utilizing a variety of habitats.

Males No. 84 and 95 from the Badger Gulch leks were tracked over the longest period of time and displayed the greatest range of movements in 1999. Although they moved separately and usually with other grouse, timing and direction of movements mirrored each other throughout summer and early fall. These two males followed a circular route covering approximately 32 km from early June through November, but never extending further than 13-16 km from the Badger Gulch leks. The greatest single movement of 20 km occurred in early July, traveling from dry mid-elevation Wyoming big sagebrush into mountain big sagebrush habitat near Forest Service lands. In August, these birds used the highest elevation sagebrush stands available, surrounded by forested habitat. Late summer and early fall use focused on tall

three-tip sagebrush habitat in upper Reservoir Creek and Watson Creek. By November, the only surviving male (No. 84) was back into Wyoming big sagebrush winter habitat within 3 km of the North Badger Gulch lek where he remained for the rest of the winter.

By the end of 1999, two male sage grouse had been harvested by hunters, and cause of four additional male mortalities was undetermined. All three hens and one surviving male returned to the same winter habitat and leks where originally captured. One female was subsequently killed on winter range prior to the 2000 breeding season.

### Relocations 2000

Trapping was conducted between 27 March and 11 April 2000 with 16 sage grouse (10 males, 6 hens) radio-marked on eight different leks in Horse Prairie and Sweetwater Basin. Radio transmitters for one male and two hens were still in service in March 2000 (Table 1). For the second year, sage grouse hens were captured on or near the Dyce Creek lek, but I observed no males anywhere near this lek. Aerial monitoring during 1 May, 3 June, 29 June, 24 July, 21 August, 25 September 2000 and 2 January 2001 yielded a total of 133 relocations.

Sage grouse movements in Horse Prairie were similar to those observed in 1999. Newly radio-equipped birds used the same seasonal habitats as radioed birds in 1999. During August and September, six of eight Horse Prairie males moved 2-10 km from several different locations to a large private irrigated meadow on S.F. Watson Creek. This area is heavily grazed with an abundance of grasshoppers during summer. One hunting mortality and two deaths of undetermined cause occurred in this area.

Males from the Brenner lek in upper Horse Prairie traveled 16-19 km south toward Bannack Pass during June and spent the summer on the Continental Divide between Nip and Tuck Creek in Montana and Little Eightmile Creek in Idaho. Male No.172 was not relocated after 3 June

although limited searching extended into the Lemhi Valley in Idaho from Leadore northward to Tendoy.

Four of five hens in Horse Prairie again focused on the same wet meadow/hayfield complex used in 1999, and were again associated with at least two flocks of 25-40 other sage grouse. Movement from this area in late August roughly coincided with haying that might have displaced some sage grouse from the area. Based on repeated ground observations and movement patterns, none of the five hens in Horse Prairie nested during 2000.

The five sage grouse followed during 2000 in the Sweetwater Basin generally traveled directly from leks to a 1214-ha (3000-ac) area of sagebrush habitat on the northwest rim of Sweetwater Basin where they stayed most of the summer. This habitat included several small pastures along the ridge separating N.F. Sweetwater, M.F. Stone and Hoffman/Winnipeg creeks, and lies 10 km northwest of both Sweetwater leks. A mixed community of mountain big sagebrush/tall three-tip sagebrush and Idaho fescue (*Festuca idahoensis*) with a diverse herbaceous composition occurred in this area. Adjoining pastures generally have much less sagebrush canopy and structure. Only two of the Sweetwater Basin grouse survived the summer and fall. Hen No. 245 spent the following winter 20 km outside the Basin in the Beaverhead River Valley in an area with relatively little sagebrush that had previously been considered unsuitable for sage grouse.

By late February 2001, eight sage grouse had died in Horse Prairie and Sweetwater Basin of which hunters had killed two. All three of the Sweetwater mortalities occurred within 3 km of each other in the preferred habitat area. Five birds remained in Horse Prairie and three birds in Sweetwater Basin.

### Relocations 2001

I observed none of the radio-equipped sage grouse monitored in 1999 and 2000 on

leks other than those from which they were captured. However, on 27 February 2001 four males and one hen visited leks that were 6-19 km from the leks where captured. One male and the hen were observed on their original leks by April while the other two males were not relocated. At the same time hen No. 245 was still outside Sweetwater Basin 11 km north of where she had spent the previous summer and 21 km northwest of the lek where she was captured in 2000.

Trapping in 2001 yielded only males, four in Sweetwater Basin, two in Horse Prairie, and seven in Big Sheep Creek Basin during 12-17 April (Table 1). Only five hens were observed during four trapping nights on the Sweetwater leks, whereas no hens were observed on leks in Big Sheep Basin or on the Brenner lek. Trapping was intentionally delayed about 2 weeks in Big Sheep Creek Basin since I assumed breeding activity at these leks might occur later than lower elevations.

A new lek was found in mid-May about 3 km from the Simpson Creek lek in Big Sheep Creek Basin. Two of the males from the Simpson Creek lek attended this new lek on 24 May.

By mid-June sage grouse in Horse Prairie again followed the patterns exhibited in 1999 and 2000. Ground locations found no indication that either of the Dyce Creek hens had mated, nested, or hatched young. Two new Brenner males were on the Continental Divide west of Bannack Pass in the same area used by male sage grouse in 2000. Males in Big Sheep Creek Basin had split into two loose groups. I located one group of three with 40-50 other sage grouse about 3 km west of the Simpson Creek lek in a large irrigated meadow on private land. The other group of three males moved northward about 13 km out of Big Sheep Creek Basin into high-elevation mountain big sagebrush habitat.

Aerial monitoring in July, August, and September suggested that most sage grouse had moved relatively little. Between mid-April and mid-July, all seven sage grouse from Sweetwater Basin died. Two found in

the Sweetwater Hills provided the first evidence of radioed grouse moving south out of Sweetwater Basin. In late August males in Horse Prairie and near Lima Reservoir moved 6-8 km from high-elevation, moist habitat onto lower, dry sagebrush habitats. The three males north of Big Sheep Basin moved back and forth 8-21 km along the top of the Tendoy Mountains. The other group of Big Sheep Basin males remained on preferred habitat in the Basin within 4-6 km of leks.

Between mid-September and late October, both Horse Prairie males had died in the same area between North Divide Creek and Black Canyon Creek where male sage grouse were lost in 2000.

I located only three grouse during a flight on 3 January 2002: Horse Prairie hen No. 383 occupied the same area in Dyce Creek she had used for two years; male No. 324 was observed on the Simpson Creek lek in Big Sheep Basin where he spent the previous summer; and male No. 172 was found near the Brenner lek in Horse Prairie. The latter has displayed the greatest movements of any grouse monitored during this study. After being captured on the Benner lek in April 2000, and moving 20 km south onto the Continental Divide near Bannack Pass, he was not relocated after 3 June 2000. On 2 January 2001, he was in lower Horse Prairie 19 km northeast of the lek where captured, and 29 km from where last located. On 27 February, this bird had traveled another 10 km north to the Reservoir Creek lek. The 14 June flight relocated this male 3 km southwest of Lima Dam in the Centennial Valley, 80 km from the 27 February location in lower Horse Prairie. This long-distance movement perhaps explained the bird's "disappearance" in 2000. He remained south of Lima Reservoir through November.

## DISCUSSION

The results of 3 years of radio telemetry work have documented sage grouse movements similar to those reported

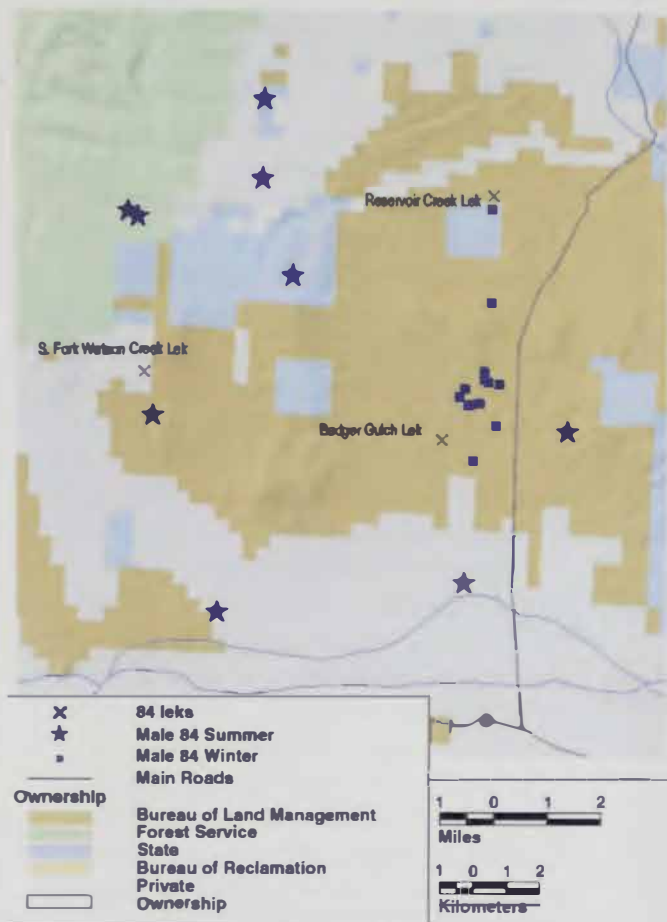
**Table 1.** Sage grouse numbers, capture locations, and fate, in southwest Montana, 1999-2001.

| Bird number* | Sex | Year | Capture location   | Number of Relocations | Fate                | Date  |
|--------------|-----|------|--------------------|-----------------------|---------------------|-------|
| 003          | F   | 1999 | Dyce Crk. Lek      | 11                    | Replaced with .205  | 4/00  |
| 015          | M   | 1999 | Ermont lek         | 4                     | Mortality - raptor  | 6/99  |
| 023          | F   | 1999 | Reservoir Crk. lek | 17                    | Radio failed        | 8/00  |
| 033          | M   | 1999 | Reservoir Crk. lek | 7                     | Mortality - unknown | 8/99  |
| 045          | M   | 1999 | Reservoir Crk. lek | 10                    | Mortality - hunter  | 9/99  |
| 054          | F   | 1999 | Reservoir Crk. lek | 10                    | Mortality - unknown | 3/00  |
| 072          | M   | 1999 | Ermont lek         | 5                     | Mortality - hunter  | 9/99  |
| 084          | M   | 1999 | N. Badger G. lek   | 25                    | Radio failed        | 2/01  |
| 095          | M   | 1999 | S. Badger G. lek   | 8                     | Mortality - unknown | 11/99 |
| 015          | M   | 2000 | L. Sweetwater lek  | 8                     | Mortality - unknown | 1/01  |
| 063          | M   | 2000 | L. Sweetwater lek  | 11                    | Mortality - unknown | 6/01  |
| 133          | M   | 2000 | L. Sweetwater lek  | 2                     | Mortality - unknown | 6/01  |
| 164          | M   | 2000 | L. Sweetwater lek  | 2                     | Mortality - raptor  | 6/00  |
| 172          | M   | 2000 | Brenner lek        | 20                    |                     |       |
| 192          | M   | 2000 | S.F. Watson lek    | 7                     | Mortality - hunter  | 9/00  |
| 205          | F   | 2000 | Dyce Crk. Lek      | 6                     | Radio failed        | 5/01  |
| 225          | M   | 2000 | S.F. Watson lek    | 3                     | Mortality - unknown | 6/00  |
| 245          | F   | 2000 | U. Sweetwater lek  | 10                    | Mortality - raptor  | 7/01  |
| 262          | F   | 2000 | S. Badger G. lek   | 7                     | Radio failed        | 8/00  |
| 284          | M   | 2000 | Reservoir Crk. lek | 11                    | Radio failed        | 2/01  |
| 301          | F   | 2000 | S. Badger G. lek   | 10                    | Mortality - unknown | 5/01  |
| 324          | M   | 2000 | Brenner lek        | 9                     | Mortality - unknown | 9/00  |
| 344          | M   | 2000 | N. Badger G. lek   | 7                     | Mortality - unknown | 1/01  |
| 364          | F   | 2000 | L. Sweetwater lek  | 7                     | Mortality - hunter  | 9/00  |
| 383          | F   | 2000 | Dyce Crk. Lek      | 16                    |                     |       |
| 003          | M   | 2001 | L. Sweetwater lek  | 2                     | Mortality - unknown | 5/01  |
| 015          | M   | 2001 | Brenner lek        | 9                     | Mortality - unknown | 9/01  |
| 033          | M   | 2001 | L. Sweetwater lek  | 2                     | Mortality - raptor  | 6/01  |
| 073          | M   | 2001 | Brenner lek        | 10                    | Mortality - unknown | 12/01 |
| 164          | M   | 2001 | U. Sweetwater lek  | 4                     | Mortality - unknown | 6/01  |
| 192          | M   | 2001 | L. Sweetwater lek  | 3                     | Mortality - unknown | 7/01  |
| 225          | M   | 2001 | Simpson Crk. lek   | 11                    | Radio failed (?)    | 12/01 |
| 324          | M   | 2001 | Alkali Crk. Lek    | 13                    |                     |       |
| 425          | M   | 2001 | Simpson Crk. lek   | 4                     | Mortality - unknown | 6/01  |
| 464          | M   | 2001 | Simpson Crk. lek   | 12                    | Radio failed        | 12/01 |
| 483          | M   | 2001 | Alkali Crk. Lek    | 9                     | Radio failed (?)    | 12/01 |
| 503          | M   | 2001 | Alkali Crk. Lek    | 9                     | Mortality - hunter  | 10/01 |
| 523          | M   | 2001 | Simpson Crk. lek   | 8                     | Radio failed (?)    | 12/01 |

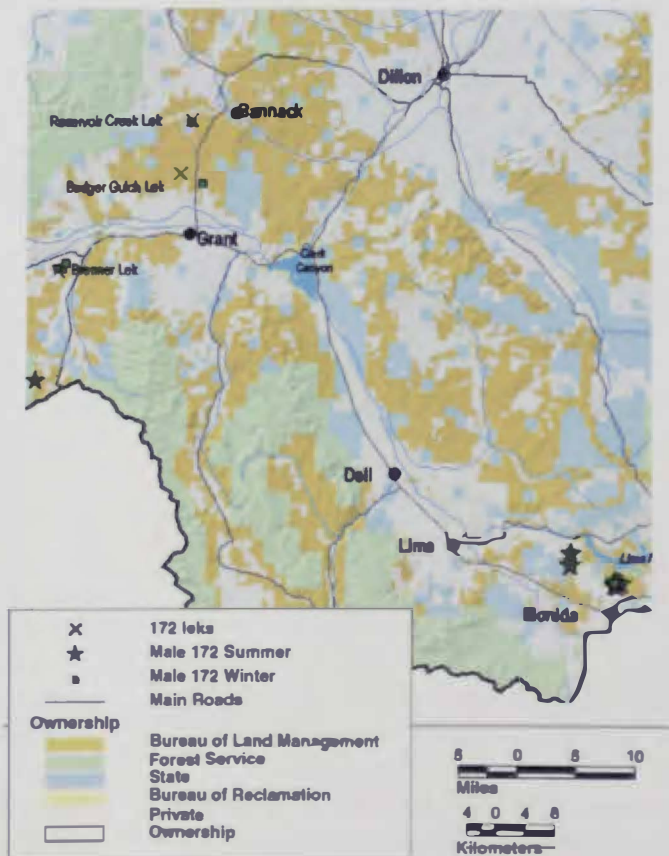
\*bird number represents the last three digits of individual radio frequencies, i.e. 150.003

for other areas, particularly in southeastern Idaho (Connelly et. al 1988, 1991). Hen sage grouse generally move the least and occupy a relatively small area. Movements of hen No. 383 from the Dyce Creek lek were typical for hens in this study (Fig. 2). Most “resident” males, such as male No. 84

from the North Badger lek, were more wide-ranging than hens but suggested strong fidelity for specific leks and summer and winter habitats that surround those leks (Fig. 3). In contrast, other males (male No. 172) exhibited long-range movements between breeding, summer, and winter habitats (Fig. 4).



**Figure 3.** Typical “resident” male sage grouse movements (male 84) in SW Montana, 1999-2000. December through May relocations are displayed as “winter” locations (■). June through November relocations are displayed as “summer” locations (★).



**Figure 4.** Long range male sage grouse movements (male 172) in SW Montana, 2000-2001. December through May relocations are displayed as “winter” locations (■). June through November relocations are displayed as “summer” locations (★).

## Summer Habitat

Two different strategies were apparent for sage grouse summer habitat selection in the study area. One strategy included selecting the largest moist habitat area available and using it exclusively during summer. Large wet meadow/riparian habitats selected by hens and some males may or may not have a significant sagebrush composition or canopy. For example, shrubby cinquefoil (*Potentilla fruticosa*), willows, grasses, and sedges dominated a preferred habitat area in Big Sheep Basin. Use of meadow habitats by sage grouse seemingly occurred independent of the amount of disturbance. Some areas in Horse Prairie that attracted sage grouse also were hayed or sustained heavy season-long or yearlong grazing by cattle or bison, whereas others were essentially undisturbed throughout summer and fall. Sage grouse use of these areas most often concentrated within 100 m of an "edge" between sagebrush and a moist site if an edge was available. Edges may be natural or created by activity such as irrigation or winter livestock feeding that reduces sagebrush canopy. Whether birds are attracted to these sites by the prevailing conditions or if they continue to move to traditional sagebrush sites having been converted to artificial moist habitats is unclear. Availability of lush forage or insects, particularly grasshoppers, apparently was a more important factor than sagebrush canopy in attracting grouse to some of these areas.

A second strategy for selecting summer habitat was that in which sage grouse traveled much more widely through extensive sagebrush areas utilizing smaller, dispersed moist areas. This included mostly males that dispersed individually or in small groups completing seasonal routes of 32-48 km. Routes may be centered on leks and winter ranges, or may be directional. Some male sage grouse moved sporadically 15-20 km from a preferred area to similar habitat and returned within a few weeks.

Relocations for male No. 84 between March 1999 and February 2001 were

representative of these seasonal movements (Fig.4). They show a distinct movement pattern from leks and winter habitat in Wyoming sagebrush to higher-elevation summer habitat dominated by mountain big sagebrush, often extending well into Douglas-fir and lodgepole forest. Sagebrush canopy in this habitat is fairly dense, often as high as 25-35 percent, and areas with the widest diversity of forbs, grasses and shrubs are preferred. Tall three-tip sagebrush is often a significant component in this habitat, whether occurring naturally or as a result of disturbance such as fire.

The bulk of sagebrush habitat in the Sweetwater Basin is in private ownership and has been altered significantly by burning, spraying, and conversion to agricultural crops. Sagebrush habitat on public land is more intact and occurs in small scattered blocks mostly around the perimeter of the Basin. Some private land that was previously treated now apparently provides suitable brood-rearing and summer habitat for sage grouse but which radioed birds bypassed to reach habitat on or near public lands. Many large wet meadow areas were available in Sweetwater Basin on private land but apparently do not attract sage grouse. Sheep graze most of these sites and could influence forage composition or insect availability. All birds monitored from the Sweetwater leks moved north 10 km from leks although suitable brood rearing and summer habitat apparently was available in the Sweetwater Hills 5 km south.

## Winter Habitat

Winter habitat distribution was well defined in Horse Prairie prior to this study, and monitoring radio-equipped sage grouse relocations has validated major wintering areas centered on the Reservoir Creek, Badger Gulch, and Ermont leks.

A large block of private land between the Reservoir Creek lek and the preferred hayfield/wet meadow complex was dominated by tall three-tip sagebrush and received heavy winter and spring use by sage grouse. This stand of sagebrush was

more uniform in extent and structure than other stands used by sage grouse in the study area.

Poor survival of sage grouse in Sweetwater Basin prevented identifying key winter habitats, but winter sage grouse habitat appeared to be limiting in Sweetwater Basin. Relatively few stands of tall dense sagebrush were available due to widespread vegetation treatments. Small stands are available in drainages in the lower portion of the Basin and along the ridge at the head of the N.F. Sweetwater Creek. In contrast to Horse Prairie and Big Sheep Creek Basin where leks were surrounded by winter habitat, leks and winter habitat in Sweetwater Basin are widely separated.

Hen No. 245 utilized habitat east of Dillon along the East Bench that had not been considered suitable for sage grouse, particularly during winter. This area provided some relatively intact stands of big sagebrush in drainages but most sagebrush stands have been converted to hay, grain fields, or non-native pasture. Black sage was available in several areas. The lack of significant snow accumulation in this area probably allows some sage grouse to make use of the East Bench.

## Populations

Groups of sage grouse that occupy particular lek and seasonal habitat complexes appeared to be discrete subpopulations and made use of the same preferred habitats. Where leks were close together, individual birds may visit more than one lek during the breeding season. Where leks are widely separated, as with the three study areas that are 55-65 km apart, I observed no interchange of sage grouse during the breeding season. However, this does not imply that these subpopulations were genetically isolated. I documented no large-scale seasonal movements by sage grouse that could be considered migrations. Individuals and small groups of sage grouse move substantially during summer, but none of

the studied subpopulations vacated one area of seasonal use and traveled a significant distance to another. This might emphasize a need to manage individual groups of sage grouse such as those in Horse Prairie or Sweetwater Basin to minimize population and habitat loss since immigration into vacant suitable habitat may not occur. Apparent segregation of widely separated breeding subpopulations could explain why lek attendance and population numbers have declined in areas affected by large wildfires during the past 15-20 years in the Rocky Hills and Sweetwater Hills. Habitat conditions there have seemingly recovered to provide large areas of suitable, but currently unoccupied, habitat.

Sage grouse using lek/winter complexes centered in Badger Gulch in Horse Prairie seemingly found adequate habitat within this area and were not migratory. This area also supported birds during winter, which typically travel significant distances to breeding and summering habitat, perhaps even into Idaho. Residual snow cover around high-elevation leks in upper Horse Prairie and Big Sheep Creek Basin appeared to delay breeding and nesting activity until slightly later in the spring than on lower elevation leks in the Reservoir Creek/Ermont/Dyce Creek areas.

Two discrete populations of sage grouse apparently utilize habitat in Big Sheep Creek Basin. One group may winter in the Basin or at lower elevations in Horse Prairie or Idaho, and then move to leks in the Basin. Connelly (personal communication) documented another group of birds moving from breeding areas in Idaho across the Continental Divide to summer in Big Sheep Creek Basin. Both groups of sage grouse could be considered migratory. To identify seasonal habitat for sage grouse in Big Sheep Creek Basin, and determine whether known long-range migratory movements are representative of the subpopulation or simply reflect individuals will require additional monitoring of radio-equipped birds.

**Table 2.** Sage grouse mortality in Horse Prairie, Sweetwater Basin, and Big Sheep Creek Basin, southwest Montana, 1999-2001. Trapping years extended from March 1 through February 28 the following years.

| MALES | # present March 1 | # mortalities | # radios failed | # present Feb. 28 |
|-------|-------------------|---------------|-----------------|-------------------|
| 1999  | 6                 | 5 (83%)       | 0               | 1                 |
| 2000  | 11                | 8 (73%)       | 2               | 1                 |
| 2001  | 14                | 7 (50%)       | 5               | 2                 |
| HENS  |                   |               |                 |                   |
| 1999  | 3                 | 1 (33%)       | 0               | 2                 |
| 2000  | 7                 | 1 (14%)       | 2               | 4                 |
| 2001  | 4                 | 2 (50%)       | 1               | 1                 |

**Table 3.** Seasonal distribution of sage grouse mortalities, southwest Montana, 1999-2001.

| Season        | # hens lost | # males lost |
|---------------|-------------|--------------|
| March - April | 0           | 0            |
| May - June    | 1           | 8            |
| July - August | 1           | 2            |
| Sept. - Nov.  | 1 (1)*      | 7 (4)*       |
| Dec. - Feb.   | 1           | 3            |

\* (# hunting mortalities)

## Mortality

Average sage grouse mortality for the term of this study was 58 percent. Annually, mortality of 50-80 percent occurred for male sage grouse, and 15-50 percent for hens (Table 2). Losses were spread throughout the year, but generally were less likely to occur during summer and winter (Table 3). Overall, 42 percent of the male mortality occurred in late May and early June, and 31 percent during fall. A few males always appear to be taken by raptors, probably golden eagles, shortly after leaving the lek in May. Hunting mortality accounted for 57 percent of the fall losses. Birds concentrated in moist habitats which, are directly accessible by roads, may be more vulnerable to opportunistic hunting harvest. Mortality was unexpectedly low for the male sage grouse in Big Sheep Creek Basin and the upper Medicine Lodge area since most of those birds remained in areas that are heavily hunted. Heavy sage grouse mortality in Sweetwater Basin may be a reflection of more widespread habitat fragmentation from agricultural conversion

and regular sagebrush burning and spraying. This could be forcing sage grouse to travel longer distances through marginal habitat to small islands of preferred habitat.

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# LIVESTOCK IMPACTS ON THE HERBACEOUS COMPONENTS OF SAGE GROUSE HABITAT: A REVIEW

Glenn A. Hockett, Rangeland Ecologist, Bozeman, MT 59718

## ABSTRACT

Sage grouse are a bird of climax vegetation. Productive sage grouse habitat is more than a “sea of sagebrush.” The grass/forb understory supplies food and cover components seasonally. Within the sagebrush community, a dense, residual herbaceous understory increases the likelihood of sage grouse nest success. Forbs and insects are essential foods for sage grouse from early spring to early fall. Although riparian areas typically make up less than 2 percent of the sagebrush landscape, interspersed springs, streams, and meadows offer watering and feeding sites for sage grouse during summer and early fall. Livestock selectively remove grasses and forbs within the sagebrush landscape while showing a strong preference for riparian meadows once upland vegetation cures. Livestock use can impact the amount and composition of herbaceous understory depending on the class of livestock, season of use, and grazing intensity. I reviewed the literature regarding sage grouse habitat and livestock impacts to the herbaceous understory. Ungrazed comparison areas, based on the seasonal needs of sage grouse, are lacking. Controls are recommended to advance our understanding of grazing impacts.

**Key Words:** forb, grass, habitat, herbaceous, livestock, riparian, sagebrush, sage grouse

## INTRODUCTION

Early sage grouse (*Centrocercus urophasianus*) research focused primarily on the conversion of sagebrush (*Artemisia* spp.) habitat to grassland or farm land (Braun et al. 1976, Braun et al. 1977, Braun 1987). Sage grouse are sagebrush obligates and their populations are closely related to the quantity and quality of sagebrush habitats (Connelly et al. 2000). Their long-term survival is dependent on the sagebrush habitat type (Braun et al. 1977).

In the late 1960s a consortium of State Fish and Game Departments, USDI Bureau of Land Management (BLM), the USDA Forest Service (USFS), and the Bureau of Sport Fisheries and Wildlife estimated that the integrity of about 2.4 million ha of western sagebrush range had been compromised by burning, spraying, plowing, disking, chaining, cutting, and beating (Guidelines for Habitat Modification in Sage Grouse Range, undated). Much of this conversion was designed to produce more forage for domestic livestock or convert sagebrush

habitat to farmland (Dalke et al. 1963). Recently, Apa (2001) reported sagebrush communities have been further reduced, with only 2-10 million ha remaining from an historical range of 58.7-109.3 million ha.

Clearly, the need to address the outright conversion of sagebrush has dominated our thinking and remains a concern. However, I address the effects livestock grazing may have on remaining sagebrush habitat, more specifically, the interspersed meadow and herbaceous understory.

## PRODUCTIVE HABITAT

### Beyond Sagebrush Protection

Sage grouse are a bird of climax vegetation and mature land forms (Patterson 1952). Protection and management of the remaining sagebrush steppe (semi-arid grassland), including quantity and quality of herbaceous understory, is critical to seasonal habitat needs of sage grouse (Connelly et al. 1991, 2000, Gregg 1991, Barnett and Crawford 1994, Drut et al. 1994a, Gregg et al. 1994, Beck and Mitchell



**Figure 1.** A riparian meadow interspersed within the sagebrush steppe offers important brood rearing habitat for sage grouse.

2001, Schroeder and Baydack 2001). Interspersed riparian meadows within the sagebrush steppe provide summer/fall habitat for brood-rearing (Dalke et al. 1963, Klebenow 1969, Call 1974; Fig. 1). Dunn and Braun (1986) suggested incorporating habitat heterogeneity and interspersed meadows, sagebrush, and aspen should be in close proximity. However, the proper balance of these seasonal components required for optimal sage grouse reproduction is not fully understood (Gregg 2001).

### **The Proper Mix**

Connelly et al. (2000) provided quantitative data supporting the importance of understory vegetation in sagebrush habitats to sage grouse. Breeding habitats should support 15-25 percent sagebrush canopy cover while providing at least 15 percent canopy of grasses and 10 percent canopy of forbs. The forb component should be diverse to provide adequate

forage for nesting hens and young chicks. Sage grouse prefer an understory canopy height  $\geq 18$  cm for breeding, nesting, and early brood rearing (Connelly et al. 2000).

In Oregon, Barnett and Crawford (1994) suggested productive habitat for pre-laying includes new spring growth with a diversity of green, leafy forbs within the sagebrush habitat type. Forbs, along with insects, supply protein on which sage grouse chicks depend during their first weeks of life (Peterson 1970, Drut et al. 1994b, Connelly et al. 2000). Dunn and Braun (1986) suggested preserving important forb producing areas, especially meadows in close proximity to sagebrush. Klebenow (1969) found grasses and forbs adjacent to shrubs were important cover for sage grouse nests. However, grouse moved to mesic sites in search of green food plants when forbs under adjacent sagebrush uplands cured. Riparian arteries and wet meadows dissect sagebrush steppe communities forming a web of life that supports brood-rearing hens and their chicks throughout summer and early fall (Dalke et al. 1963). Sagebrush provides food and cover throughout the year, accounting for 100 percent of the sage grouse diet during winter (Connelly et al. 2000). This landscape of seasonal habitat components must be protected and managed to ensure the long-term survival of sage grouse (Connelly et al. 2000).

### **Seasonal Habitat Fidelity**

Sage grouse show fidelity to seasonal ranges (Berry and Eng 1985, Fischer et al. 1993), and seasonal movements tend to be traditional (Connelly et al. 1988). Females return to the same general areas each year to breed, nest, raise broods, and winter (Berry and Eng 1985) although annual movements and home ranges may be quite large (Connelly et al. 2000). Patterson (1952) documented hens returning to the same areas year after year to nest. Two hens he studied located nests within 60 m of previous year's nests, and he commonly found new nests within meters of old nest sites.

# THE HERBACEOUS COMPONENT

## Nesting Habitat

Most sage grouse nest under a canopy of sagebrush (Connelly et al. 2000). However, herbaceous cover is an important factor in nest site selection (Connelly et al. 1991). Nest success is positively correlated with the presence of big sagebrush (*Artemisia tridentata*) and relatively thick grass and forb cover (Beck and Mitchell 2000, Connelly et al. 1991, Greg et al. 1994, Schroeder and Baydack 2001). DeLong et al. (1995) recommended management practices that increase cover and height of native grasses in sagebrush communities to enhance sage grouse productivity. Additionally, adequate availability of forbs during the pre-laying period may affect nutritional status of hens and reproductive success (Barnett and Crawford 1994).

## Brood Rearing Habitat

Early brood rearing occurs in sagebrush habitats that are relatively open, relatively close to the nest, and support a diversity of grasses and forbs (Patterson 1952, Connelly et al. 2000). Sveum et al. (1998) recommended increasing the cover of native perennial forbs and grasses within sagebrush types to enhance sage grouse nesting conditions and food and cover for broods. Young chicks depend on lush green forbs and insects during their first few weeks of life (Drut et al. 1994b); availability of primary foods directly affected diets of sage grouse chicks. Forbs and invertebrates comprised >75 percent of chick diets where forbs and arthropods were more available, whereas chicks consumed 65 percent sagebrush on less productive habitat. A strong relationship also existed between diversity and abundance of forbs and availability of insects. Drut et al. (1994b) concluded a useful goal for chick survival and recruitment was to employ practices resulting in abundant forb and insect foods while simultaneously providing grasses and sagebrush needed for cover.

Consequently, our understanding of grazing impacts to grass/forb diversity and height and arthropod habitat should be further investigated (Sneva 1979).

## Security Cover

Herbaceous cover is important for concealment, security, and shelter from weather and predators (Schroeder and Baydack 2001). Burkepile et al. (2001) found that >85 percent of chick mortality occurred in the first two weeks with predation a likely cause of 90-100 percent of the deaths. Schroeder and Baydack (2001) point out, however, that indirect management of the grouse-predator relationship is usually best accomplished by manipulating habitats and not by direct reduction of predator numbers. Patterson (1952) suggested concealment rather than flight was the primary escape method for both young and adult birds. Flight was utilized only when birds were closely pressured or danger was imminent (Patterson 1952).

## Livestock Grazing Impacts

Livestock have grazed most habitats occupied by sage grouse, typically in a repetitive, annual or biennial grazing period of varying timing and length (Braun 1998). Connelly and Braun (1997) and Beck and Mitchell (2000) have identified livestock grazing as an important factor associated with the widespread decline and degradation of sage grouse habitat. Patterson (1952) recognized livestock grazing as an important factor affecting quantity and quality of the grass-forb component of sage grouse habitat in Wyoming. Belsky et al. (1999) found livestock grazing has damaged approximately 80 percent of stream and riparian ecosystems in the western United States, and Fleischner (1994) outlined additional economic and environmental costs associated with livestock use.

Overall, grazing appears to most affect productivity of sage grouse populations by removing grass/forb cover that helps conceal sage grouse nests from predators (Beck and Mitchell 2000, Schroeder and

Baydack 2001). Burkepille et al. (2001) suggested conservation efforts focus on increasing survival of sage grouse chicks during their first two weeks of life. Klott et al. (1993) found areas with livestock present in Wyoming big sagebrush (*A. t. wyomingensis*) and low sagebrush (*A. arbuscula*) communities had less grass height and grass cover, fewer herbaceous species, less litter and lower Robel pole readings. However, forb cover and bare ground were greater in areas where livestock were present. The Wyoming Game and Fish Department (WGFD) found cover was the most important factor limiting upland game bird populations in Wyoming (WGFD undated [a]).

On the Upper Snake River Plains in Idaho, Mueggler (1950) found grazing in the spring (May) and late fall (November-December) by sheep severely reduced grass-forb production while increasing the abundance of shrubs, as compared to late fall grazing only. Spring-fall grazing treatments reduced forb production by 81 percent, grass production by 32 percent, and increased shrub production by 165 percent. Laycock (1967) expanded this study and found heavy spring grazing alone severely and rapidly deteriorated good condition range by reducing grass-forb production by > 50 percent while increasing abundance of sagebrush by 78 percent. However, complete protection from grazing or grazing when forbs and grasses were dormant, maintained the range in good condition and allowed deteriorated range to improve (Laycock 1967).

Patterson (1952) noted the reduction and elimination of perennial grasses and forbs due to drought and/or grazing imposed serious restrictions upon normal feeding habits of sage grouse females and young birds, particularly during the early stages of chick development. He observed young broods customarily dispersing from individual nest sites, concentrating in the vicinity of native meadows in search of insects and a variety of herbaceous plants. Grazing these traditional seasonal ranges, especially nesting and brood-rearing areas,

can fragment and degrade sage grouse habitat by removing herbaceous vegetation sage grouse rely on for food and cover (Patterson 1952, Dalke et al. 1963, Call 1974, Klott et al. 1993, Connelly and Braun 1997, Beck and Mitchell 2000).

Holechek et al. (1999) in an extensive review of grazing studies found conventional wisdom suggesting 50 percent use actually resulted in range deterioration on semi-arid grasslands. Holechek et al. (1999) found light use (30-35%) consistently benefited forage production in dry years, and serious financial losses have occurred under heavy stocking (50-60%) and drought. Despite these findings, the USDA Natural Resources Conservation Service continues to recommend 50 percent use of forage resources (Holechek et al. 1999). Estimating impacts from average range utilization measurements is compounded by the tendency of livestock to selectively graze preferred habitats and preferred plants (Harrison and Thatcher 1970). Although they estimated overall use of key species within a landscape dominated by big sagebrush at 40 percent, Harrison and Thatcher (1970) documented a selective grazing pattern by sheep that left some areas used as much as 80 percent while other areas were not used at all.

## **Livestock and Sage Grouse Preferences Overlap**

Livestock prefer succulent green plant material to dry vegetation, and generally select green leaves over stems (Reppert 1957). Consumption of forbs by livestock in spring and summer can be significant and may limit their availability for sage grouse broods (Call 1974). Livestock also tend to select the most lush, palatable, and nutritious forage species first (Reppert 1957).

Cattle generally show a preference for riparian habitats, especially once upland vegetation cures (Thomas et al. 1979, Gillen et al. 1984, Kauffman and Krueger 1984, Myers 1989, Clary et al. 1996). These mesic sites generally make up less than 1-2 percent of the overall sagebrush landscape



**Figure 2.** Severe livestock grazing and trampling can occur at watering sites. Compare the proected area in the background across the fence.

(Chaney et al. 1990, USDI Bureau of Land Management 1991, Chaney et al. 1993). Pyrah (1987) found plant succulence on upland sagebrush sites tended to decline after 15 June, while vegetation remained green longer in moist swales and meadows with deeper soils. On his study area in central Montana, mesic sites were actively selected by cattle and rapidly became unusable for antelope. Out-competed in swales and with upland vegetation desiccated, antelope moved to adjoining pastures not occupied by cattle (Pyrah 1987). Unlike antelope, however, sage grouse may not readily adapt to annual variations of livestock use on traditional seasonal habitats (Klott et al. 1993).

Connelly et al. (1988) suggested seasonal movements by sage grouse tend to be traditional, and migratory populations should be defined on a temporal and geographic basis that identifies important seasonal ranges and migration routes. Klott et al. (1993) detected no movements by

sage grouse with broods away from areas with livestock, suggesting direct competition in isolated meadows may exist (Call 1974). As with cattle, mesic sites become especially important to sage grouse when upland sagebrush habitats desiccate (Patterson 1952, Dalke et al. 1963, Klebenow 1969, Wallestad 1971, Dunn and Braun 1986, Connelly et al. 2000). Livestock grazing in summer and early fall can degrade riparian areas (Kauffman and Krueger 1984, Clary and Webster 1989, Myers 1989). Grazing within the sagebrush steppe has frequently resulted in “sacrifice areas” and the loss of wetland plants associated with isolated riparian habitats (Thomas et al. 1979, Kauffman and Krueger 1984, Clary et al. 1996). These traditional brood-rearing areas (Patterson 1952, Dalke et al. 1963, Klebenow 1969, Call 1974, Dunn and Braun 1986, USDI Bureau of Land Management 1993, Connelly et al. 2000, WGFU Undated [b]) are particularly susceptible to livestock concentrations and grazing damage (Kauffman and Krueger 1984, Clary et al. 1996), especially near open water sources (Clary and Webster 1989; Fig. 2).

Gillen et al. (1984) and Myers (1989) found late-season grazing increases cattle preference for meadows. Phillips (1965) documented cattle selectively overgrazing mesic areas (75-80% utilization) while slopes only 150 m away received  $\leq 5$  percent use. Given the opportunity, cattle will spend a disproportionate amount of time in riparian areas as compared to adjacent uplands, and this may be 5-30 times more than expected based on the extent of the riparian habitat (Clary and Webster 1989). Clary and Webster (1989) found no grazing system that ensured proper use of small riparian meadows within extensive upland range units. They concluded the most important consideration when managing livestock, was to site-specifically limit the level of utilization.

Although livestock usually consume little if any sagebrush (<10% of their diet) (Harrison and Thatcher (1970), Ngugi et al. (1992), and Call (1974) found some areas



**Figure 3 and 4.** Livestock water developments and salt grounds fragment sagebrush uplands by creating "sacrifice areas" of bare ground and compacted soil through increased grazing use, trampling and trailing.

so heavily grazed by livestock in winter that most sagebrush plants were nearly killed. If such use occurs on sage grouse winter range, sage grouse may have difficulty obtaining sufficient forage (Call 1974). Range management practices designed to improve livestock distribution, such as artificial stock water developments or salt licks, may lead to trailing, trampling and localized overgrazing of preferred upland sage grouse habitat (Klott et al. 1993; Figs. 3 and 4). Habitat degradation can occur on other sites, where for whatever reason, livestock congregate in sagebrush uplands (Patterson 1952). Sage grouse are more vulnerable to environmental stresses and predation under these deteriorated habitat conditions (Beck and Mitchell 2000, Schroeder and Baydack 2001).

### **Control Areas**

Most livestock enclosure studies suggest livestock operate as a keystone

species in rangeland ecosystems (Bock et al. 1993). Bock et al. (1993) suggested livestock frequently determine which species thrive and which will diminish when they share the same landscape. However, ungrazed comparison areas, based on seasonal needs of sage grouse, are lacking (Braun 1998). The lack of large representative tracts of ungrazed habitat makes it nearly impossible to determine and monitor the actual consequences of livestock grazing (Bock et al. 1993). Controls address the ambiguity surrounding actual ecological consequences of livestock use (Bock et al. 1993).

Beck and Mitchell (2000) have recommended replicated field experiments be designed and compared to ungrazed areas to determine the widespread, relative effects of grazing treatments and stocking intensities on sage grouse nesting and brood rearing areas. Controls, encompassing seasonal habitats for any given sage grouse population as defined by Connelly et al. (2000), will provide baseline scientific data relevant to the effects different classes of livestock, season of use, and/or grazing intensities have on sage grouse habitat and productivity over time (Beck and Mitchell 2000). These comparison areas may also prove effective, low input management strategies for riparian habitat recovery within the semi-arid sagebrush-steppe (Rickard and Cushing 1982).

## **CONCLUSION**

The sagebrush steppe is the critical foundation of productive sage grouse habitat (Patterson 1952, Wallestad 1975, Braun et al. 1977, Connelly et al. 2000). Protection and management of the sagebrush community, including the grass/forb understory and the interspersed riparian meadows are all essential to provide important seasonal habitats for sage grouse (Dalke et al. 1963, Klebenow 1969, Peterson 1970, Wallestad 1971, Call 1974, Connelly et al. 2000). Connelly and Braun (1997) and Beck and Mitchell (2000) have identified livestock grazing as a key factor

affecting sage grouse habitat productivity. Ungrazed comparison areas are lacking on sage grouse habitat (Braun 1998) and should be established (Beck and Mitchell 2000) to gather baseline data relevant to the effects different classes of livestock, season of use, and/or grazing intensities have on sage grouse habitat and productivity over time. Since domestic livestock currently graze the majority of sage grouse habitat (Braun 1987), I provide the following recommendations for consideration by livestock, land, and wildlife managers.

1. For migratory populations focus livestock grazing activities during the growing season on sage grouse winter range. Sage grouse are 100 percent dependent on sagebrush for forage during winter (Connelly 2000). The removal of herbaceous understory plants preferred by domestic livestock during the growing season can lead to an increase in the density of sagebrush stands over time (Mueggler 1950; Laycock 1967; Beck and Mitchell 2000). Livestock and sage grouse would be separated temporally under this scenario although impacts to other wildlife species may be significant.

2. Protect sage grouse nesting and brood-rearing habitat from livestock use to encourage climax vegetative conditions. If this is not feasible, limit grazing to the month of July with the exact timing of grazing varying with local conditions. Defer grazing until after the peak of the growing season with the intent of providing herbaceous cover and forage for the majority of the nesting, hatching, and early brood-rearing. Cessation of grazing by 1 August is designed to minimize livestock concentrations in wet meadows and riparian areas with open water by avoiding "hot season" use and to allow a 30-day regrowth period before the first killing frost as recommended by Myers (1989). Additionally, late summer-early fall regrowth is important for carbohydrate storage in roots and stem bases of cool season grasses (Stoddart et al. 1975) that enhances plant vigor while allowing

residual vegetation to accumulate cover for nesting and early brood-rearing the following spring.

3. Protect sage grouse spring, summer and fall ranges during periods of drought. Drought alone has been identified as a major factor contributing to the range-wide decline of sage grouse (Connelly and Braun 1997). Design adaptive management strategies to protect against the cumulative effects of grazing use on sage grouse forage and cover during drought.

4. Manage 25-33 percent of the sagebrush-riparian landscape for climax species and processes using concepts outlined by Bock et al. (1993). This can be done while still providing for deferred or rest-rotation grazing over the remaining 66-75 percent of the sagebrush landscape. Target key nesting and brood rearing habitat for climax vegetation to increase sage grouse productivity. Sage grouse nest densities increase along sagebrush riparian corridors (Patterson 1952). Therefore, manage for climax vegetative cover and forage along primary sagebrush-riparian interfaces including  $\geq 0.8$  km of sagebrush habitat type on either side of riparian corridors. Unless local data indicates additional protections are necessary, this partial climax conservation strategy on grazed sage grouse habitat offers some perpetual mitigation against the inevitable effects of drought while still allowing grazing over the majority of sagebrush landscape.

5. Avoid livestock water developments and salt grounds in traditional sage grouse spring, summer, and fall habitats. These developments significantly concentrate livestock and increase forage use, trailing, and soil compaction that fragment sagebrush habitat (Stoddart et al. 1975). These heavy-use areas may extend up to 0.8 km away from the site (Valentine 1947) providing a niche for noxious weeds and other undesirable or unpalatable vegetation to take hold. Such developments should only be considered if accompanied with climax management areas as outlined in recommendations 2 and 4 above.

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# GREATER SAGE GROUSE AT BOWDOIN NATIONAL WILDLIFE REFUGE, MONTANA

Dwain M. Prellwitz, Bowdoin National Wildlife Refuge, HC 65 Box 5700, Malta, Montana 59538

Bowdoin National Wildlife Refuge (NWR) is located 256 km west of the North Dakota border and 63 km south of the Canadian border in the Milk River Valley of central Phillips County, Montana. Most of the 6273-ha refuge has been ungrazed by domestic livestock since the mid-1970s. The refuge is approximately one-half shallow marshes and lakes and one-half upland grasslands. Grasslands on Bowdoin NWR are composed of mixed-grass species interspersed with shrubs and forbs. Plains silver sagebrush (*Artemisia cana cana*) is the predominant sage on the refuge, but its density is low throughout most of the grasslands. Much of the plains silver sagebrush is heavily browsed by pronghorn antelope (*Antilocapra americana*).

Greater sage grouse (*Centrocercus urophasianus*) are indigenous to the area and have been observed on Bowdoin NWR since the refuge was established in 1936. Early records documented several sage grouse broods near the refuge headquarters in 1940 and several broods at unknown locations in 1958.

Lek surveys for sage grouse since 1980 have been unsuccessful, with no traditional strutting grounds known to occur on the refuge. Single male sage grouse were observed on sharp-tailed grouse (*Tympanuchus phasianellus*) dancing grounds on several occasions. A male sage grouse was observed strutting with six male sharp-tailed grouse on 9 April 1980 on the southwest side of the refuge. Three years later a single strutting male sage grouse was photographed with 26 sharp-tailed grouse on Big Island near the center of the refuge. A third instance occurred on 15 April 1997 when a single male was observed on a sharp-tailed grouse lek near the north

boundary of Bowdoin NWR, but no sharp-tailed grouse were present. Sharptails had last used that lek in 1987. A lone sage grouse was heard on a different sharp-tailed grouse lek on 3 May 1997, but that record was quite late in the breeding season and strutting was not observed. Several strutting grounds were reported within 32 km of Bowdoin NWR on 10 March 2000 in more dense stands of big sagebrush (*Artemisia tridentata*) and plains silver sagebrush in the Beaver Creek Valley. Bowdoin NWR apparently supports a low density of sage grouse.

The population, although small in number, appears stable. Brood observations since 1988 ranged from one to three broods in nine out of 14 years. Average brood size from 12 observations during the 14 years from 28 May through 13 September was 5.0 (range 2-8). The latest brood on 13 September had six chicks. Refuge personnel observed a brood of eight chicks on 16 July and 11 August. I attributed survival of chicks to the abundance and proximity of moist areas where lush forbs and insects were available for food.

Refuge employees, while conducting annual waterfowl nesting studies, nest drag from 160-510 ha of upland grass habitat, and occasionally flush lone sage grouse in front of the drag. One sage grouse nest was found on 6 June 1988. The nest of seven eggs was found in dense grass cover beneath one of only a few plains silver sagebrush plants in the area. The nest hatched at least four eggs by 27 June during one of the hottest months on record when daytime highs were >32° C on 22 days with 9 of those days >38° C. Although this sage grouse nest survived despite the above-normal daytime temperatures, several nests

of other species dehydrated and were lost. Total precipitation in 1988 was 24.4 cm, far below the long-term average of 31.9 cm.

Harvest of sage grouse on Bowdoin NWR during the 1980-2001 period also has suggested a trend of population stability. The refuge has maintained an unstaffed hunter registration station since 1980. Hunters have been required to sign in and also report harvest of upland game birds when finished hunting. Sage grouse were reported in the harvest in 10 of 22 years with annual harvest ranging from zero to five birds. The longest period of no harvest was four years (1991-1994). Hunter opportunities to harvest sage grouse on the refuge may be limited since most sage grouse brood observations during the period were from the portion closed to upland bird hunting.

Sage grouse habitat on Bowdoin NWR may be less than optimum due to a low

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density of plains silver sagebrush in grassland habitats. Those individual sage grouse choosing to breed and nest at Bowdoin NWR appear to be productive with good survival of chicks. The refuge is located within 32 km of prime big sagebrush and plains silver sagebrush habitat and grouse may disperse from those large blocks of sagebrush to better nesting cover on Bowdoin NWR.

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| Past President                  | Frank Pickett<br>PP&L - Butte, MT   |
| Secretary-Treasurer<br>(Shared) | Jodie Canfield (Secretary)<br>USDA Forest Service - Townsend, MT<br>Helga Pac (Treasurer)<br>Montana Fish, Wildlife and Parks - Bozeman, MT |

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| Past President      | Mike Enk<br>USDA Forest Service - Great Falls, MT            |
| Secretary-Treasurer | Beth Gardner<br>USDA Forest Service - Lewistown, MT          |