GENERAL TECHNICAL REPORT PNW-187
1985

WILDLIFE HABITATS IN MANAGED RANGELANDS— THE GREAT BASIN OF SOUTHEASTERN OREGON

SAGE GROUSE

MAYO W. CALL and
CHRIS MASER

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE U. S. DEPARTMENT OF AGRICULTURE

This publication is part of the series **Wildlife Habitats in Managed Rangelands—The Great Basin of Southeastern Oregon.** The purpose of the series is to provide a range manager with the necessary information on wildlife and its relationship to habitat conditions in managed rangelands in order that the manager may make fully informed decisions.

The information in this series is specific to the Great Basin of southeastern Oregon and is generally applicable to the shrub-steppe areas of the Western United States. The principles and processes described, however, are generally applicable to all managed rangelands. The purpose of the series is to provide specific information for a particular area but in doing so to develop a process for considering the welfare of wildlife when range management decisions are made.

The series is composed of 14 separate publications designed to form a comprehensive whole. Although each part will be an independent treatment of a specific subject, when combined in sequence, the individual parts will be as chapters in a book.

Individual parts will be printed as they become available. In this way the information will be more quickly available to potential users. This means, however, that the sequence of printing will not be in the same order as the final organization of the separates into a comprehensive whole.

A list of the publications in the series, their current availability, and their final organization is shown on the inside back cover of this publication.

Wildlife Habitats in Managed Rangelands—The Great Basin of Southeastern Oregon is a cooperative effort of the USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, and United States Department of the Interior, Bureau of Land Management.

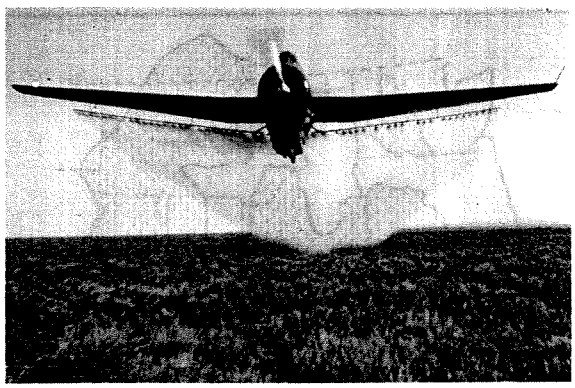

Figure 3.—Aerial spraying of herbicides has been one of the most common methods for killing sagebrush. Increased grass production for livestock results, but habitat for sage grouse may be eliminated.

Decreases in sage grouse followed the decrease in sagebrush. Other factors, such as unfavorable weather conditions at hatching time and increased predation, hunting, and disease have each been important at various times in localized areas but are probably not the most important factors in the overall downward trend.

The major factor that most adversely affects wildlife populations over the long term is the loss, in quality or quantity, of habitat (Call 1979). The number of sage grouse can be expected to decrease in areas where human populations and agricultural developments are expanding. In earlier years, habitat losses occurred primarily from the effects of heavy grazing by livestock or from programs that reduced sagebrush and increased grass production. More recently, habitat losses are occurring because of strip mining for coal, development of oil and gas fields, industrial developments, and related activities. The people required to operate the facilities often disturb surrounding lands so they are no longer suitable for grouse.

There has also been maximum exploitation of surface water for irrigation, mining, and other domestic purposes; entire streams have sometimes been diverted. In other instances the application of water to lands unsuitable for cultivation resulted in leaching of alkali salts that polluted stream courses and converted sagebrush lands into salt shrub areas (Patterson 1952).

Sage grouse suffered the same losses of habitat in Oregon as in other States. From 1934 through 1983, 157 198 ha (388,144 acres) of vegetation were treated to increase grass production in southeastern Oregon (U.S. Department of the Interior, Bureau of Land Management 1983). In addition, wildfires have altered large areas of sage grouse habitat, at least temporarily.

Sage grouse fluctuated considerably in different areas over the years.[2] The most important factors influencing productivity and survival are conjectural—predation, forb production, weather, hunting, and habitat changes.

Sage grouse have not adjusted, and probably will not adjust, their life processes to fit a pattern of land use that eliminates or adversely disturbs large tracts of sagebrush to which they are tied for food and nesting cover.

Fortunately, some changes resulting from livestock grazing, agricultural practices, and other land uses may have benefited sage grouse. The creation of openings in large sagebrush stands, from whatever causes, produced feeding and brooding areas and may have benefited sage grouse especially where water is close by. The creation of meadows (or meadowlike areas) within sagebrush stands improved the summer food supply of sage grouse. Where land use practices removed large, decadent sagebrush stands and permitted development of new, young plants, sage grouse habitat may have been improved. But the overall habitat is generally better where patches or strips of tall, dense sagebrush are retained for use as escape cover or for roosting.

[2]J. A. Crawford, Oregon State University, Corvallis, personal communication.

Assumptions

In this chapter, we define cover and forage components of optimum sage grouse habitat and describe how changes in plant community structure and composition affect habitat quality. Optimum habitat for sage grouse may not always be maintained because of other resource needs and uses, but compromises to meet the needs of the grouse can be made. Our intent is to help rangeland managers evaluate impacts and trade-offs of habitat manipulations for sage grouse.

We have made these assumptions:

1. Eastern and western sage grouse subspecies in Oregon have similar habitat requirements and respond similarly to habitat alterations.
2. Where there are conflicts between sage grouse and livestock on public lands, it may be essential to give priority to sage grouse if they are to continue to exist on these areas.
3. Research results and management principles are applicable for sage grouse from other areas provided modifications are made to account for local circumstances.
4. Oregon has different subspecies or varieties of sagebrush than those found in some other Western States, so there may be differences in sage grouse use of various subspecies of sagebrush for food and cover. Habitat management principles, however, remain essentially the same.
5. The needs of sage grouse will take precedence over livestock on important brood-rearing areas to ensure adequate food.
6. Land uses can be tailored to provide areas of sufficient size to maintain viable populations of sage grouse.

Habitat Requirements

Sage grouse densities vary in the Great Basin of southeastern Oregon, depending on the subspecies and structure of the sagebrush, composition and density of the understory vegetation, intensity of livestock grazing, presence of water, and human disturbance. Some of the general habitat requirements of sage grouse on sagebrush-grasslands follow.

ABIOTIC FACTORS

Topography

Although some forms of sagebrush grow on shallow, rocky soils found on ridges and sidehills, the most vigorous stands occur on the deeper soils of valleys and gently rolling terrain. Sage grouse depend primarily on sagebrush for cover, so most sage grouse are found in sagebrush habitats where slopes are less than 30 percent, although they are occasionally encountered on steeper slopes (fig. 4). Sage

Figure 4.—Low, rolling hills and adjacent valleys provide the best topography and habitat for sage grouse, especially where patches of big sagebrush are intermixed with areas of low sagebrush. Sage grouse commonly move to higher elevations to find more succulent forbs as summer progresses.

grouse often follow the development of succulent forbs by moving from valleys to higher elevations during early summer (Batterson and Morse 1948, Nelson 1955, Patterson 1952). Exceptions to such movement occur. Batterson and Morse (1948) noted that migrations in Baker County, Oregon, for example, involved movement down to the valleys in summer, up to the hills in late fall, and down to the strutting grounds in late winter.

Barriers to Movement

There are no known barriers that prevent the occupation of suitable habitat by sage grouse. If they are not found in good habitats, they likely have been extirpated.

Elevation

The best populations of sage grouse in the Great Basin of southeastern Oregon are between elevations of 1220 and 2438 m (4,000 and 8,000 ft), although individuals and small groups may be found at lower elevations.[3]

Climate

The highest densities of sage grouse occur where precipitation averages 25-38 cm (10-16 in) per year. Marginal populations occur in areas of lesser precipitation.

Water

We believe that free water is an essential component of sage grouse habitat. The need for free water in summer, however, probably depends on: (1) the amount of available, preferred, succulent vegetation produced; and (2) how early in summer the preferred forbs dry out. Other authors (Autenrieth 1981, Girard 1935, Griner 1939, Savage 1969) also consider free water essential, but a few do not (Batterson and Morse 1948, Nelson 1955, Trueblood 1954). For instance, Griner (1939) stated that all of the 161 nests he found were within 0.8 km (0.5 mi) of water. Keller et al. (1941) reported no preference for slope, exposure, or nearness to water. Patterson (1950) stated that nesting density was slightly higher on areas adjacent to main irrigation canals and creeks than on areas 1.6 to 3.2 km (1 to 2 mi) from running water. Girard (1935) found that sage grouse broods need water within a few hours after hatching and, consequently, move immediately to stream areas. Batterson and Morse (1948) raised a brood of chicks to 4 weeks without giving them free water, and without apparent ill effects. Trueblood (1954) believed that sage grouse chicks obtain most of their water from succulent vegetation and dew in years of above-average rainfall.

Nelson (1955) noted no connection between selection of nest site and the presence of water. The majority of the nests he observed were on sagebrush flats 1.6 to 4.8 km (1 to 3 mi) from the nearest permanent source of water. He stated, however, that spring rains and snows create many small standing pools in places with poor drainage, as well as in rock depressions. Consequently, there may be no need for sage grouse to move to permanent sources of water during most of the nesting period.

Migrating grouse gather around waterholes and in meadows along fall migration routes in Idaho. Although daily movements are modified by weather conditions, grouse often wait near waterholes until 0700 or 0800 h and then drink. Watering lasts 10 to 30 min (Dalke et al. 1963). Knowing that grouse use waterholes early in the morning in autumn, hunters frequently kill grouse at such places, especially where meadows are nearby.

Sage grouse regularly visited partially frozen streams in Eden Valley, Wyoming, in late fall to drink through holes in the ice. Ranchers told stories of flocks coming into their yards and drinking from livestock watering troughs (Patterson 1952).

Sage grouse may do well in the absence of free water where they have access to succulent vegetation. Moisture requirements are partially fulfilled through metabolic processes, and as vegetation (forbs) dries in late summer and fall the birds tend to move to areas where free water is available. High temperatures and the associated heat stress induce grouse to seek free

[3]R. R. Kindschy, Bureau of Land Management District Office, Vale, Oregon, personal communication.

water sources by early July in some years (Savage 1969). In winter, snow takes care of their moisture requirements, either directly or as it melts and provides free water.

BIOTIC FACTORS

Vegetation

A habitat manager must account for seasonal needs of sage grouse. For example, deep snow covering the spring and summer ranges may force the birds to migrate to some distant range for winter, only to return for nesting as snow depth decreases (Rogers 1964, Wallestad 1975). Where sage grouse nest and raise broods on sagebrush-covered mountain slopes or in high mountain valleys, they usually migrate to lower valleys in winter to find exposed sagebrush for food. This is common in Wyoming, Colorado, and Idaho but less true in southeastern Oregon where winters are milder and snow seldom covers sagebrush plants deep enough to make locating food a serious problem.

Vegetation structure and composition on leks (strutting grounds) differ from the vegetation complex on wintering areas or in nesting areas. Dense, tall sagebrush is seldom used for nesting cover (Patterson 1952) but is frequently used as loafing cover or as protective cover during severe winter storms (Beck 1977). In general, good habitat for sage grouse should contain openings less than 274 m (300 yd) in circumference, some dense sagebrush stands, and about equal amounts of tall and short sagebrush plants (Rogers 1964).

Breeding Habitat

In late February and early March, cocks begin moving from wintering areas to traditional leks. A few weeks later hens congregate at these sites for courtship and mating. Leks are usually small open areas from 0.04 to 4 ha (1/10 to 10 acres) in size, but they may be as large as 40.5 ha (100 acres) or more (Call 1979).

Leks may be located at a point intermediate between the winter and summer range. In some cases, the summer and winter range may be the same area. Sage grouse prefer relatively open areas as leks (Call 1979, Keller et al. 1941, Patterson 1952, Rogers 1964, Schlatterer 1960, Scott 1942, Wallestad 1975). Although sagebrush usually surrounds a lek, it may be low and sparse or dense (Scott 1942, Wallestad 1975). Grassy swales, natural and irrigated meadows where grass has been removed or grazed, burned areas, cultivated or natural fields adjacent to sagebrush-grass rangelands, cleared roadsides, abandoned homesteads, dry lakebeds, bare areas around small reservoirs, barren ridges, swales, bottom lands, and other open areas on all exposures may be used for strutting and mating (figs. 5, 6, and 7).

Barring complete obliteration of the physical aspects of a lek itself, generation after generation of birds will use the same lek. Occupancy of individual grounds usually extends over many years, although in the interim, new grounds are established by young birds, and others are probably passing out of existence because of changes in habitat or disintegration of a local male population. There may also be a gradual shift of sage grouse use between leks over a long period. A shift in use of leks, small ones being abandoned and large ones increasingly used, may occur toward the end of the breeding season (Dalke et al. 1960, Patterson 1952, Wiley 1973). One lek in Idaho may have been used for 90 years, although not necessarily continuously; this conclusion is based on the finding of broken arrowheads used for hunting birds. Use of such leks year after year depends on the size of the grouse population for any given year. Larger grounds may be used each year, whereas smaller ones may be temporarily abandoned when populations are low (Dalke et al. 1963).

Sage grouse apparently prefer leks adjacent to dense brushy cover. Such cover is undoubtedly important during strutting when the birds are exposed to predators, particularly raptors (fig. 8). The loss of surrounding food and cover may cause a lek to be abandoned (Carr 1968, Trueblood 1954).

Loafing and roosting sites near leks invariably support the heaviest and densest sagebrush (Patterson 1952). Optimum loafing sites are found along stream bottoms, ravines, and draws. Wallestad and Schladweiler (1974) recorded sagebrush height and canopy cover at

Figure 5.—Bare, open areas are commonly selected as sage grouse leks (Oregon Department of Fish and Wildlife photograph by A. L. Miller).

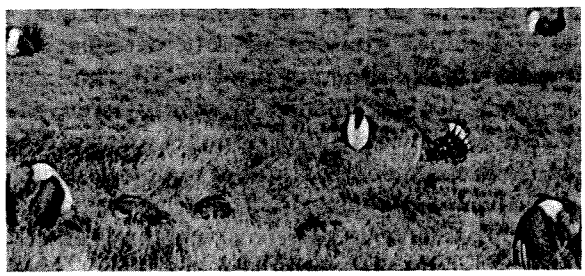

Figure 6.—Open areas of low vegetation may be used for breeding activities.

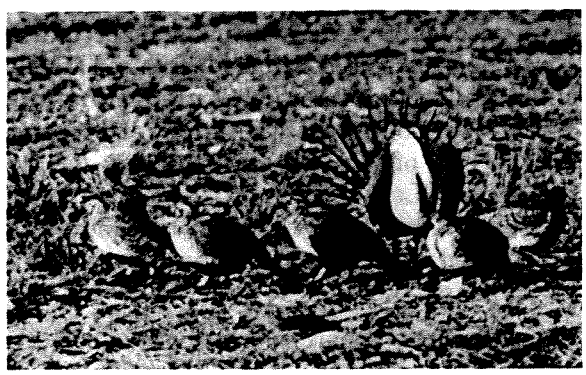

Figure 7.—Note hens on strutting grounds for breeding; they then move to outlying areas for nesting.

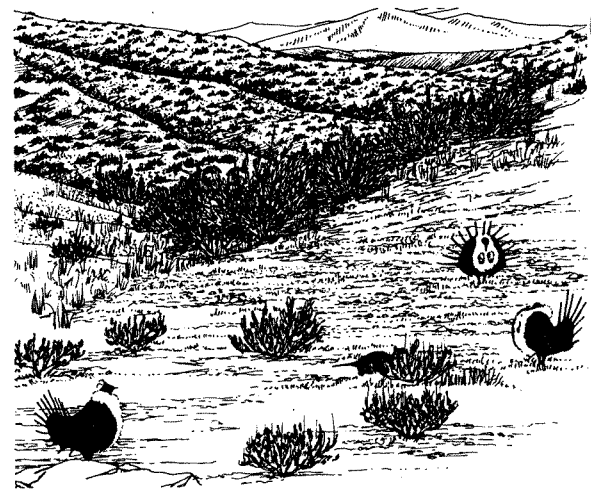

Figure 8.—Sage grouse apparently prefer leks adjacent to dense brushy cover.

110 feeding and loafing sites of cocks; 80 percent of the locations occurred in sagebrush with a canopy cover of 20-50 percent (this is also the range of canopy for which vegetation control is likely to be recommended to enhance livestock production).

Grouse may spend the day within 1.6 km (1 mi) of the leks, or they might move 3.2-4.8 km (2-3 mi) away (Batterson and Morse 1948, Scott 1942). The cruising radius of sage grouse in Idaho during the strutting season was thought to be less than 0.8 km (0.5 mi) (Pyrah 1954), whereas in Montana male grouse commonly moved up to 1.3 km (0.8 mi) from leks (Wallestad and Schladweiler 1974). Adult males in Colorado rarely ventured farther than 366 m (400 yd) from leks, but near the end of the strutting season they moved outward as much as 1.6 km (1 mi). Because sage grouse feed primarily on sagebrush during the early part of the mating season, they are more likely to abandon a lek if an adequate supply of food is not available within at least 1.6 km (1 mi). Although sage grouse may move a kilometer or more for food, they probably would not readily move that distance without adequate cover. Sagebrush should therefore be protected to a radius of at least 2.4 km (1.5 mi) from leks (Carr 1968, Gill 1965, Wallestad and Schladweiler 1974).

Figure 9.—Sage grouse nests are usually placed between or under sagebrush plants with some overhead cover (photograph courtesy of Dick Kerr).

Nesting Habitat

Sage grouse hens build nests in the vicinity of a lek within 7 to 10 days after breeding. The nest is frequently constructed between the lek and the area that will be used for brood-rearing and summering (Autenrieth 1981, Braun et al. 1969, Wallestad 1975). Nests are made by scratching out a shallow depression, usually beneath or between sagebrush plants, that is lined with dead grass, sage twigs, and feathers (fig. 9).

Egg laying normally begins about mid-April. A few renesting hens do not complete clutches until mid-May. Incubation takes 25 to 27 days; the peak of hatching varies from the last week in May to the second week in June. The mean hatching date in Oregon is the second week of June; 20 to 30 percent of hatching occurs in May and 15 to 20 percent in July (see footnote 3). Average clutch size is six to eight eggs. A few nests have as many as 12 eggs (Patterson 1952).

A basic requirement of nesting cover is concealment of the hen and her nest (Autenrieth 1981, Girard 1935, Keller et al. 1941, Patterson 1952). Nest locations are apparently related to cover condition. Autenrieth (1981) found that when good nesting cover was available near a lek, the proximity of the nest to the lek tended to be less than when sagebrush was sparse and found only in clumps. The proximity of 306 nests to a lek was (cumulative percentages): 0-1.6 km (0.96 mi), 28.4 percent; 0-3.2 km (1.92 mi), 59.0 percent; 0-4.8 km (2.88 mi), 73.4 percent; 0-6.4 km (3.84 mi), 85.0 percent; 0-8.0 km (4.80 mi), 96.2 percent; 0-9.6 km (5.76 mi), 97.2 percent; 0-12.8 km (6.72 mi), 100 percent.

Nest sites are usually located within 3.2 km (2 mi) of a lek. Wallestad and Pyrah (1974) found that 68 percent of all radio-marked hens in Montana nested within 2.4 km (1.5 mi) of a lek; one nest was found 9.1 km (5.7 mi) from a lek. Rogers (1964) reports an unusual situation in Colorado where hens traveled from 24 to 32 km (15 to 20 mi) from the lek to nest. Hens would visit leks until bred and would then move into a vicinity close to the location of the final nest site and remain relatively sedentary until they nested. Braun et al. (1969) stated that hens in Colorado tended to make their nests in the direction of the brood-rearing and summering areas after leaving the breeding grounds.

The specific use of sagebrush as nesting cover has been documented as follows: Wyoming, 92 percent of approximately 300 nests were under sagebrush (Patterson 1952); Colorado, 92 percent of 117 nests (Gill 1965); Wyoming, 50 nests (Girard 1937); Colorado, 94 percent of the nests (Keller et al. 1941); Idaho, 35 nests (Gray 1967); and Montana, 100 percent of the nests (Wallestad and Pyrah 1974).

Some biologists believe that dense vegetation and undergrowth are preferred for nesting (Dargan and Keller 1940; Rasmussen and Griner 1938); others stated that isolated plants and open stands were favored (Batterson and Morse 1948). Patterson (1952) thought that hens preferred to nest in short sagebrush of medium density, such as is found on drier sites, in preference to the dense, tall brush found along watercourses and on moist sites. In Idaho the number of big sagebrush plants per 0.4 ha (1 acre) of nesting habitat ranged from 4,960 to 10,790 (Autenrieth 1981), and in Montana the number of sagebrush plants within 68 cm (24 in) of successful nests was 6.4 (Wallestad and Pyrah 1974). Patterson (1952) was probably referring to sagebrush from 30 to 80 cm (12 to 15 in) in height and from 6,000 to 8,000 sagebrush plants per 0.4 ha (1 acre) in locations that would permit a quick and unimpeded escape for a hen.

Most nests are hidden from above by branches that provide an umbrella effect (Autenrieth 1981, Batterson and Morse 1948, Girard 1935, Nelson 1955, Patterson 1952). Although large, full sagebrush plants are not always used for nesting cover, good growth of understory grasses aids in nesting success because it helps conceal nests from aerial predators and contributes to a microclimate that is warmer than the air temperature 1 m (39 in) above the nest. Nest temperature drops less during a hen's absence where the understory is greatest. Hens usually leave the nests to feed for brief periods twice daily—0430 to 0630 and 1800 to 1900 (Autenrieth 1981; Girard 1935, 1937; Nelson 1955; Rasmussen and Griner 1938).

Wallestad and Pyrah (1974) compared the characteristics of sagebrush around 31 successful and 10 unsuccessful nests. A significantly greater cover of sagebrush within 60 cm (24 in) of the nest within a 9-m^2 (100-ft^2) plot was around successful nests (6.4 sagebrush plants compared with 4.5 for unsuccessful nests); and successful nests were located in stands of sagebrush with a higher average canopy cover (27 percent) than that of unsuccessful nests (20 percent). Patterson (1952) found nesting density to be lower on an overgrazed area than on an ungrazed area (one nest per 9.5 ha (23.5 acres) compared with one nest per 3.6 ha (9 acres)) and implied this was due to reduced ground cover, other than shrubs.

Height of sagebrush commonly used for nesting ranges from 17 to 79 cm (7 to 31 in). Most nests are located under the tallest bushes available at a particular site (Autenrieth 1981; Braun et al. 1977; Gray 1967; Keller et al. 1941; Klebenow 1969; Patterson 1950, 1952; Schlatterer 1960; Trueblood 1954; Wallestad and Pyrah 1974). Stands with 20 to 40 percent canopy cover are most frequently selected for nesting (fig. 10). Many studies do not give the average sagebrush height that predominates in the area, but those that do indicate preference for the higher plants under which to place nests (table 1). The variety of sagebrush species and subspecies that occur suggests that sage grouse will nest in sagebrush of different heights in different community types.

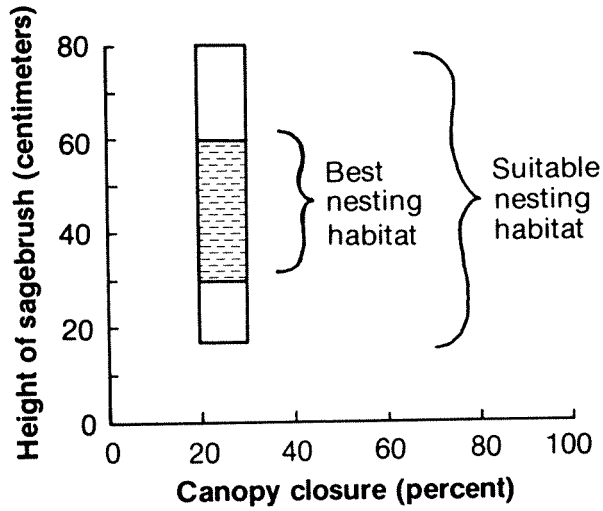

Figure 10.—The relationship of sagebrush height and percentage of canopy closure in producing suitable sage grouse nesting habitat.

Table 1—Average sagebrush height used for nesting cover

State	Average sagebrush height used for nesting		Average sagebrush height in immediate area		Authority
	Centimeters	Inches	Centimeters	Inches	
Oregon	48	19			Nelson (1955)
Wyoming	25.4-50.8	10-20			Patterson (1952)
Montana	40.4	15.9			Wallestad (1975)
Idaho	57-80	22.4-31.5	23-79	9-31	Autenrieth (1981)
Colorado	52.3	20.6	32.3	12.7	Peterson (1980)
Utah:					
Reseeded	29.2	11.5			Trueblood (1954)
Not reseeded	53.3	21.0			

Brood-Rearing Habitat

Brood rearing is an important phase of grouse production. Fall population levels depend on the survival of young through the summer. This means that hens require well-sheltered areas that provide maximum protection for them while brooding. Protection of the brood from adverse weather and predation is extremely important immediately after hatching. Chicks may be killed by adverse weather (Carr 1968, Dalke et al. 1960, Griner 1939, Nelson 1955, Patterson 1952, Pyrah 1960).

Dargan and Keller (1940) attributed high mortality of chicks to predation rather than to adverse weather. Predation accounts for considerable mortality in chicks. Most egg predation and nest destruction in Oregon has been attributed to ravens (Batterson and Morse 1948, Girard 1935, Nelson 1955). Thus, protection from adverse weather (low temperatures, snow, rain, and high winds) and predation during the chicks' first weeks of life appears to be critical factors determining fall densities (Carr 1968).

Broods usually stay near the nest for several hours after hatching. Chicks begin feeding as soon as they leave the nest but are limited in mobility, so food in the form of suitable insects and forbs must be close by (Carr 1968, Girard 1935, Griner 1939, Nelson 1955).

The diet of chicks during their first week is chiefly insects, especially beetles and ants. Succulent forbs—such as common dandelion, common salsify, western yarrow, prickly lettuce, clover, aster, and phlox and shrub foliage—become more important as time passes (fig. 11). The succulence of favored foods appears to be an important factor influencing brood movements. Use of forbs depends on availability, so hens and chicks often remain in the vicinity of the nests for the first 2 or 3 weeks after hatching if insects and succulent forbs are available (Klebenow and Gray 1968, Patterson 1952, Peterson 1970a, Pyrah 1954, Savage 1969).

As plants mature and dry, grouse move to areas still supporting succulent vegetation. These may be lower elevation native meadows or irrigated meadows when no uplands with green vegetation are in the area (fig. 12). Grouse may also migrate upward, seeking

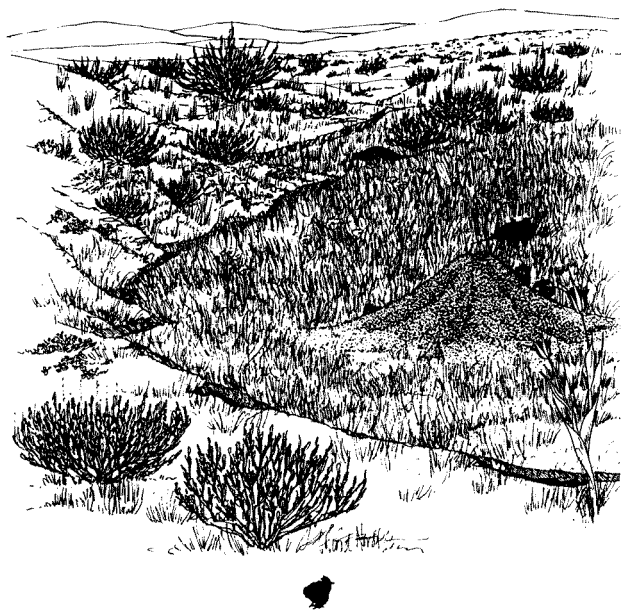

Figure 11.—The diet of chicks the first week is insects, especially beetles and ants. Succulent forbs become important later.

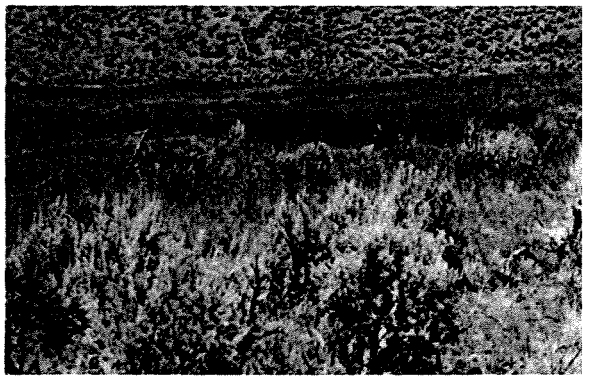

Figure 12.—Wet meadows adjacent to sagebrush stands are excellent brood-rearing areas. Succulent forbs and insects, the main items in diets of young grouse, abound in wet meadows. (Photograph courtesy of Robert R. Kindschy.)

habitats with succulent forbs, such as drainages at higher elevations, mountain meadows, and more mesic swales. The importance of upland meadows in some of the drier areas of southeastern Oregon cannot be overemphasized.[4] Improper livestock grazing can cause gulley erosion that results in lowered water tables, drying out of meadows, and loss of valuable feeding habitat for sage grouse.

[4]D. A. Klebenow, University of Nevada, Reno, personal communication.

Further, piping water from springs to livestock troughs frequently dries up small, wet meadows that often occur around undeveloped springs (Thomas et al. 1979). In some States, roadsides and borrow pits are frequently used during June and July because of the moisture and succulent vegetation present, but roadsides in Nevada and southeastern Oregon are generally too dry for succulent vegetation to develop (Batterson and Morse 1948, Crawford 1960, Eng 1952, Gill 1965, Klebenow 1972, Nelson 1955, Patterson 1952, Rogers 1964).

A delay in maturing of forbs has a noticeable effect on bird movements. Savage (1968) noted that grouse did not use meadows one summer when the range was in good condition because succulent forbs were available elsewhere. Meadows are important, however, for three primary reasons: (1) Forbs are important in the diet of young birds and meadows are their primary source, especially in dry years; (2) free water is often found in meadows; and (3) young birds eat large numbers of ants that are commonly found associated with meadow ecotones and meadow remnants (Savage 1969).

Meadowlands or alfalfa fields are used as brood feeding sites; willows and sagebrush are used for resting and shading; and areas of sparse, low-growing sagebrush (within 3.2 km (2 mi) of the feeding areas) are preferred as night roosting areas (Griner 1939, Patterson 1952). In Montana, approximately 65 percent of all observations of grouse in August and September were recorded in bottom land types, such as alfalfa fields and black greasewood flats. Grouse may also be attracted to hay and alfalfa meadows by the overall lush vegetational aspect and not specifically to alfalfa as a food item (Wallestad 1970, 1975).

Although suitable food is important, all studies emphasize the need for cover to enhance brood-rearing. Brooding hens prefer relatively open sagebrush compared with dense stands. The percentage of canopy cover of big sagebrush at brood sites in southern Idaho was 8.5, significantly less than the average for the entire area, 14.3. Only 3 of 98 broods were found where total shrub cover was 40 to 49 percent; the rest were found where cover was less than 31 percent. Where there was an interspersion of openings mixed with dense sagebrush, broods used the more open portions. The most important variable in discriminating between habitat used by broods and that not used was the number of big sagebrush plants per 37.2 m^2(400 ft^2). Broods occupied sites with fewer big sagebrush plants than in the overall big sagebrush vegetation type (64.3 vs. 103.7 big sagebrush per 37.2 m^2 (400 ft^2)). Broods used areas where forbs were most abundant (Klebenow 1969, 1972). Broods in Montana were found where sagebrush canopy cover was less than 14 percent in June, July, and August and less than 21 percent in September (Wallestad 1971). Although large tracts of dense sagebrush seem to be undesirable brood habitat, small islands of big sagebrush, located within stands of low sagebrush, are frequently used as brood cover (Savage 1969, Wallestad 1971).

Grouse consumption of sagebrush intensifies as meadows and foliage of forbs dry and the incidence of frost increases, in late August at high elevations or in September and October in lower areas (Klebenow 1972, Savage 1969).

Hens with broods do not usually associate with other hens and broods early in summer, but as food plants desiccate, broods move to more mesic sites and begin to associate with other broods. Flocks of hens in late summer vary in size from several broods to several hundred sage grouse. These associations may be the initiation of fall and winter hen flocks (Wallestad 1975).

Wintering Habitat

As snow begins to accumulate on their summer-fall ranges, sage grouse start moving to lowlands or other sites, such as windblown ridges, where their needs for forage and cover can be met throughout the winter. The extent of seasonal movements varies with the severity of winter weather, topography, and vegetative cover. Sedentary populations meet all their seasonal requirements in the same general area and, as winter approaches, simply change their use areas from meadows to sagebrush, because they live almost entirely on the leaves of sagebrush in winter (Bean 1941, Beck 1975, Patterson 1952, Wallestad 1975). Other populations

are migratory and move 24 to 32 km (15 to 20 mi) from nesting to wintering areas in Colorado (Rogers 1964), 48 to 80 km (30 to 50 mi) on the Snake River Plains in Idaho (Dalke et al. 1963), and 80 to 160 km (50 to 100 mi) in Eden Valley, Wyoming (Patterson 1952). In eastern Montana, on the other hand, movements farther than 16 km (10 mi) are uncommon (Wallestad 1975).

In seeking wintering areas, grouse initially select areas with the most palatable sagebrush; if those areas become covered with snow, they shift to available sagebrush (figs. 13 and 14). Although wintering areas may be selected primarily on the basis of the amount of snow rather than the affinity of grouse for a particular site, the forage quality of sagebrush (chemical composition) may influence which areas are used. Wintering flocks in Idaho concentrate where low sagebrush or black sagebrush occurs. They may remain on areas supporting black sagebrush until snow covers the plants and return when the plants are again available (Autenrieth 1981, Beck 1977, Call 1979, Crawford 1960, Dalke et al. 1963, Pyrah 1954). Black sagebrush in Oregon occurs primarily in southern Malheur, Harney, and Lake Counties (Dealy et al. 1981) and is probably used as winter forage where available.

Other plant communities are also used by sage grouse in southeastern Oregon (fig. 11). Low sagebrush/bunchgrass communities typically occur adjacent to or intermixed with big sagebrush communities but are distinctly separate stands associated with shallow, stony soils (fig. 15). Cleftleaf sagebrush/bunchgrass communities occur in similar situations. Threetip sagebrush occurs in Baker and northern Harney Counties and occasionally in Malheur County. Usually found adjacent to mountain big sagebrush, threetip sagebrush retains its integrity and is used by sage grouse where available (Dealy et al. 1981).

Wyoming big sagebrush is the most common sagebrush throughout the high desert in Oregon. It is more common at elevations less than 1830 m (6,000 ft) and on more xeric mountain sites than other big sagebrush communities (Winward 1980). Sage grouse use it for winter cover and forage and for loafing and nesting

Figure 13.—In winter, sage grouse seek areas where palatable sagebrush is available as forage. The grouse will migrate to find such areas. (Oregon Department of Fish and Wildlife photograph by Vic Masson.)

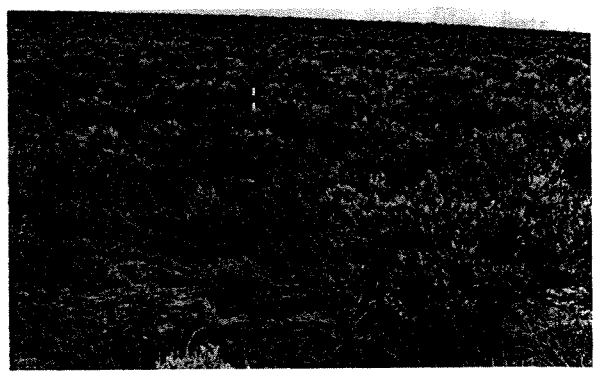

Figure 14.—Stands of low sagebrush are excellent habitat for sage grouse, especially during spring, summer, and fall. Low sagebrush is also used as winter habitat where snow cover permits. (Photograph courtesy of Robert R. Kindschy.)

Figure 15.—Sage grouse winter habitat with sufficiently dense sagebrush to provide ample forage and cover.

cover where it meets the criteria for canopy cover and density.

Basin big sagebrush extends from the southern end of the Blue Mountains in northeastern Oregon and throughout the central and southeastern portions of the State. The land area occupied by basin big sagebrush constitutes a minor portion of the sagebrush complex in Oregon; much of its former range is now cultivated land. It provides good cover but poor forage.

Bolander silver sagebrush and mountain silver sagebrush/bunchgrass communities are found in seasonally moist areas in central and eastern Oregon. The two subspecies are associated with two distinct habitats, closed basins and streamside or pond-edge meadows. The basin subspecies, Bolander silver sagebrush, is distributed within the desert areas of Oregon from Prineville throughout the southeastern third of the State; the streamside-meadow subspecies, mountain silver sagebrush, is most common in east-central and southeastern Oregon where there are seasonally high water tables adjacent to streams and meadows (Winward 1980). Bolander silver sagebrush typically has a sparse understory and is poor brooding habitat, but both subspecies of silver sagebrush are palatable and are used by sage grouse for cover and winter food (Dealy et al. 1981). The different subspecies in Oregon vary considerably in palatability and plant structure. Even though they may look similar, some sagebrush ranges are much more important to sage grouse than others.

Habitat surveys conducted during the summer may give the impression of vast acreages of sagebrush available as winter range for grouse. Observations during winter, however, reveal that much of the habitat is not available because of snow depth or it is unsuitable for other reasons. For example, when snow depth in Montana exceeded 30.5 cm (12 in), sage grouse were restricted to taller sagebrush stands. Only 7 percent of the range was available when snow depth exceeded 30 cm (11.8 in) (Wallestad 1975). Sage grouse in Idaho moved to taller sagebrush types when snow depth reached about 33 cm (13 in) (Bean 1941).

Areas of greatest available canopy cover tend to be most used (Autenrieth 1981, Eng and Schladweiler 1972). Winter ranges in eastern Montana have little if any slope and are large expanses of dense (20 percent or greater canopy cover) sagebrush with an average height of 25.4 cm (10 in) (Eng and Schladweiler 1972). Grouse in Colorado used areas of less than 15 percent slope and preferred southwest exposures in winter (Beck 1975, Beck and Braun 1978). This association with dense stands of sagebrush usually begins in September and continues through the breeding and nesting seasons. In fact, 15 percent canopy cover of sagebrush appears to be the minimum acceptable for sage grouse winter and nesting habitat (Wallestad 1971, 1975; Wallestad and Schladweiler 1974).

Flocks may segregate by sex in the winter when females use denser stands of sagebrush than do males. Sagebrush density (determined for brush exposed above the snow) averaged from 46.0 to 63.7 plants/0.004 ha (0.001 acre) for males in two winters and 68.2 to 77.5 plants/0.004 ha for females (Beck 1977). The maximum may be about 49.6 plants/0.004 ha with an average height of 55.8 cm (22 in) and a canopy cover of 38.1 percent (Autenrieth 1981).

Winter is usually the critical period of the year for most wildlife and the most taxing on their physiological systems, but if the grouse have adequate and suitable sagebrush, they usually emerge from winter in good physical condition. Yearling and adult males and females even gained weight in late winter (January-March) in North Park, Colorado (Beck and Braun 1978).

Animal

PREDATION

Losses of sage grouse nests and young to predation are often high and are probably the most significant factor in determining annual recruitment to the population (Allred 1942, Autenrieth 1981, Batterson and Morse 1948, Gill 1964, Patterson 1950). For example, one study in Oregon in which 66 of 131 nests were destroyed by predators showed that the greatest single limiting factor of sage grouse was

nest predation by ravens (Batterson and Morse 1948). Ravens were also the only significant avian predator on sage grouse nests on Autenrieth's (1981) south-central Idaho study area. In other areas, magpies may be important nest predators (Brooks 1930). According to Gill (1965), hens are only present on the nest while actually laying eggs during the 10- to 14-day laying period. They are commonly absent from nests from one-half hour after sunrise to 1 hour before sunset, and nests are highly vulnerable to predators.

Crows also prey on young grouse (Grondahl 1956). But predation by crows is reduced when the grasses and forbs begin to grow and conceal the nests better. In addition, other food items, such as insects, become more plentiful as vegetation develops, and crows shift their feeding to those sources, which reduces their efforts to locate unattended nests. Avian predators have more difficulty finding nests that are concealed by vegetation. Terrestrial predators may find nests more by smell or by accident than by sight, and good cover probably makes their efforts to find nests less successful. Where badgers were abundant in Oregon, Nelson (1955) found that they were an important predator of sage grouse nests, and Gill (1965) found that badgers and Richardson ground squirrels in Colorado were efficient predators of sage grouse eggs. The Richardson ground squirrel may also be an important predator on young sage grouse (Keller et al. 1941).

Management Relationships

The effects of sagebrush removal and/or modification on a population of sage grouse can be evaluated by the following: (1) presence or absence of grouse on treated areas and the relative use of the areas by birds as indicated by dropping counts, (2) changes in population levels as indicated by numbers of strutting males on all leks, and (3) direct observation of birds on and around the treated areas (Wallestad 1975).

EFFECTS ON BREEDING ACTIVITIES

Sagebrush control may increase or decrease the desirability of leks, depending on circumstances. Although openings in sagebrush habitat may be created by killing the shrubs, increased grass density may prevent the openings from being used (Carr 1968). One of the best documented instances of the detrimental effects of sagebrush removal on sage grouse involved an isolated population in Meagher County, Montana. Five leks were eliminated as a result of sagebrush being sprayed and 49 percent (4781 ha or 11,808 acres) of available sagebrush types being converted to cropland (Peterson 1970b). One lek averaged 54 males during 13 breeding seasons. Within 2 years after it was sprayed only three males used it, and it was then totally abandoned (Peterson 1970b).

A 4858-ha (12,000-acre) sagebrush spray project in Wyoming was responsible for the elimination of sage grouse from a winter range that supported 1,000 birds prior to treatment. Four leks on the treated area declined from a total population of 50 males to none 4 years after treatment with 2,4-D (2,4-dichlorophenoxyacetic acid). Eight years after treatment, the leks had a total of 31 males. Adjacent grounds in unsprayed areas had only minor fluctuations in numbers of birds during this same period (Higby 1969). Complete block spraying of an area surrounding a large lek in Colorado resulted in almost complete abandonment of the lek within 7 years of spraying (Braun and Beck 1976).

Wallestad (1975 p. 37-39) observed that:

> Treatment of 751 acres (24 percent of the total suitable habitat adjacent to the King Ranch Strutting Ground) resulted in a 50 percent reduction in cocks the following year. However, 3 years post-treatment the population had recovered to pre-treatment levels. Spraying of 640 acres (11 percent reduction in suitable habitat) resulted in no significant post-treatment population change on the adjacent South Pike Creek Strutting Ground. A new ground (possibly because of spraying) was established 1.5 miles to the northeast, the

year following treatment. Two hundred fifty-three acres adjacent to the Highway Strutting Ground was scheduled for a partial kill of sagebrush (65 percent reduction in crown coverage); however, the small size of the area, combined with a light actual kill (25 percent reduction in coverage) produced no major effect on the strutting ground cock population.

Of the 1,090 acres of sagebrush sprayed adjacent to the North Yellow Water Strutting Ground, 839 acres (31 percent of the total suitable habitat) had a canopy coverage exceeding 15 percent prior to treatment. The sprayed area was also the largest block of continuous habitat in the area. In the two post-treatment years there was a 63 percent loss in cocks on the strutting ground while other grounds remained relatively stable.

Total numbers of male sage grouse on 3 leks within 0.5 miles of the treated area increased an average of 28 percent from pre- to post-treatment years. In the face of an increasing population, it appeared that sagebrush treatment had no effect on the sage grouse population. When compared to control leks in the same population, however, the effect became more pronounced. Total numbers of males on two grounds further than 2 miles from treated areas increased an average of 323 percent during the same period. Number of sage grouse observed on grounds within 0.5 miles of treated areas and those further than 2 miles led to the conclusion that differences were related to sagebrush spraying.

The effects of sagebrush removal on use of leks probably varies in different areas, depending on many factors, but evidence indicates that the results can be disastrous to some populations. Impacts seem to relate mostly to the amount of food and cover remaining within approximately 1.6 km (1 mi) of the leks.

EFFECTS ON NESTING HABITAT

Cover and food are important habitat requirements in nesting areas. Nesting commences in early spring before many plants have started growing, so sagebrush serves as the primary source of food during this period. From this standpoint, sagebrush control could eliminate nesting in an area by eliminating the hens' food supply. Grouse ceased nesting on newly sprayed areas with less than 5 percent live sagebrush canopy cover, and nesting was nearly nonexistent in older sprayed areas with about 5 percent live sagebrush cover. Broods were less affected by herbicide treatment, however, and they continued to use some sprayed areas (Carr 1968, Klebenow 1970).

Where sage grouse have been observed in areas with a strip-spray pattern, the majority were within 23 to 29 m (75 to 95 ft) of unsprayed strips. They apparently preferred unsprayed sagebrush sites, or sites with similar canopy cover, to treated areas (Martin 1965).

Sagebrush control with 2,4-D usually reduces the quality of nesting cover and nesting density, but dead sagebrush stalks and increased grass understory normally provide cover for a few years that partially offsets the loss of living sagebrush. The greatest limitation imposed on nesting distribution by control of sagebrush would be the elimination of food required by the incubating hens. Unlike plowing and reseeding, which tend to increase the amount and variety of forbs, 2,4-D tends to reduce forbs and sagebrush. Thus, alternative foods that could supplement sagebrush in the diet, at least toward the end of incubation, might also be reduced (Carr 1968).

Although nests may be found under dead sagebrush, protection and concealment are less than under live sagebrush. Consequently, desertion and destruction of nests in such circumstances are greater.

Trueblood (1954) compared seeded, reseeded, and nonreseeded areas and found that nesting density, nesting success, and hatching success were lower on plowed and reseeded areas. Reseeded lands produced one nest for every 9.5 ha (23.5 acres) and nonreseeded lands one nest per

7.8 ha (19.2 acres). The average height of nesting cover on reseeded lands was 29.2 cm (11.5 in) and 53.3 cm (21 in) on areas not reseeded. No nests were found more than 228.7 m (250 yd) from water. Hens nesting in reseeded areas preferred scattered remnants of sagebrush cover, but more than one-fourth of the nests were found beneath clumps of grass. Although nesting suitability was closely related to precipitation on reseeded ranges, it was relatively independent of precipitation on ranges not reseeded. Nesting hens were more easily detected by observers on reseeded areas than on areas not reseeded.

EFFECTS ON BROOD-REARING AND SUMMER HABITAT

The effects of sagebrush control on brood-rearing and summer areas seem to depend mainly on: (1) forb and grass production subsequent to treatment and (2) the amount of sagebrush retained for cover.

A reduction in cover of sagebrush caused by spraying can reduce the brood-carrying capacity of an area. Old sprayed areas where sagebrush and forbs have regrown since the original treatment may be used by broods, but not the more recently sprayed areas with high sagebrush kills (Klebenow 1970, Martin 1970, Rogers 1964).

Autenrieth (1969) conducted a 3-year study in Idaho after a 1965 spray project and concluded that spraying strips in a relatively high precipitation area (33 cm (13 in) annual precipitation) may benefit brood-rearing habitat because of a quick recovery of important forbs, such as dandelion and western yarrow. After 3 years, the average cover of dandelions in the spray strips was 17.2 percent compared with 11.2 percent in the leave strips. The leave strips were used by broods for feeding and occasional roosting. Because of the relatively high elevation (1784 m or 5,851 ft) and annual precipitation, a mountain meadow effect was created by strip spraying. Most sage grouse habitat occurs at low elevations with one-half (or less) the annual precipitation of the Idaho study area; in such areas eradication of sagebrush is usually detrimental to grouse populations (Braun et al. 1977).

Total forb cover is not as important to sage grouse as cover of highly preferred species of forbs. Sagebrush control with 2,4-D reduces most forbs and makes sprayed areas less suitable for summer feeding (Autenrieth 1970, Braun and Beck 1976, Carr 1968, Klebenow and Gray 1968, Martin 1970, Peterson 1970a). Many insects eaten by young sage grouse are killed by the 2,4-D ester used with an oil carrier (Hanson 1952).

In many areas, streams flow through sagebrush-covered valleys and along draws in rolling hills. Meadowlike openings that can be created adjacent to streams by spraying or plowing the sagebrush could be beneficial to sage grouse broods, provided livestock are not permitted heavy early grazing in these areas. Livestock tend to concentrate on meadows, however, and to graze them so heavily that sheet erosion or gully erosion begins. Such intensive use of small meadows will render them of little value to grouse (Oakleaf 1971).

EFFECTS ON WINTER HABITAT

The effect of sagebrush control on sage grouse in winter depends mainly on the extent of sagebrush kill. Because sagebrush is practically the only food eaten by grouse in winter (Carr 1968, Patterson 1952, Wallestad 1975), the grouse will be forced to abandon areas where adequate food and associated cover are no longer present (fig. 16).

Figure 16.—This valley was converted from sagebrush to crested wheatgrass. Although increased grass production in some areas will reduce livestock grazing in adjacent sagebrush stands, the treated areas will be of little value to grouse. Evaluation of overall impacts on sage grouse should be made before sagebrush ranges are converted to grasslands.

Wintering areas hold some of the highest densities of sage grouse, and they may be used on an annual basis by birds from several leks. Such areas may be the primary habitat for 7 to 8 months of the year and may have considerable influence on grouse distribution over a wide area (Eng and Schladweiler 1972). Wallestad (1975) further stressed the importance of such areas by linking them with spring habitat and calling them wintering-nesting complexes. Thus, a sage grouse population may be more sensitive to the loss of wintering areas, which sometimes incorporate the breeding-nesting complex, than to the loss of habitat used during summer and fall (Eng et al. 1979).

Winter use of sagebrush control areas by grouse is proportional to the severity of treatment. Treatments that kill the smallest percentage of sagebrush affect grouse use the least, and the duration of the adverse effect is shortest. For example, Pyrah (1972) determined that herbicide applied in strips that killed only a part of the sagebrush sprayed, block partial kill, mechanical treatments, and total kill spray (in that order) were increasingly detrimental to grouse. Virtually no winter use occurred in areas of total sagebrush kill. Higby (1969) studied an area in Wyoming where more than 80 percent of the sagebrush cover was destroyed over a 5-year period in a 4858-ha (12,000-acre) treatment project. Prior to treatment the area supported approximately 1,000 birds in winter, but there was practically no winter use on the area during the 5-year post-treatment study.

EFFECTS OF FIRE ON GROUSE HABITAT

Wildfires are natural with effects that vary depending on areas burned and intensity of the fire. At times, hot wildfires destroy important wintering areas for sage grouse.

A fire in the right place, at the right time, and of the correct size and intensity can create an opening that birds may use as a lek. Such openings, 0.4 to 4 ha (1 to 10 acres) in size at the elevations used for breeding, may be beneficial to grouse in homogeneous sagebrush habitats (Dalke et al. 1963, Klebenow 1972, Schlatterer 1960).

Sage grouse prefer light to moderate sagebrush density for nesting. Where sagebrush is dense (in excess of 20 to 40 percent canopy cover) and greater than 61 cm (2 ft) in height, controlled burning to achieve a mosaic of sagebrush and grassland with a variety of sagebrush heights would probably be beneficial to the birds (fig. 17). Repeated burning could be adverse in this case, as would large, hot fires that removed an excessive amount of cover (fig. 18). Where cover is already limited, fires could cause adverse conditions for the grouse (Griner 1939, Pyrah 1963).

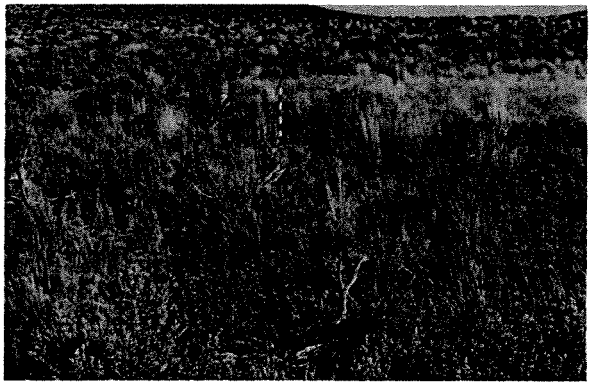

Figure 17.—Fires that create mosaic patterns in dense sagebrush stands and that leave sagebrush plants scattered throughout the burn create openings that are beneficial to sage grouse.

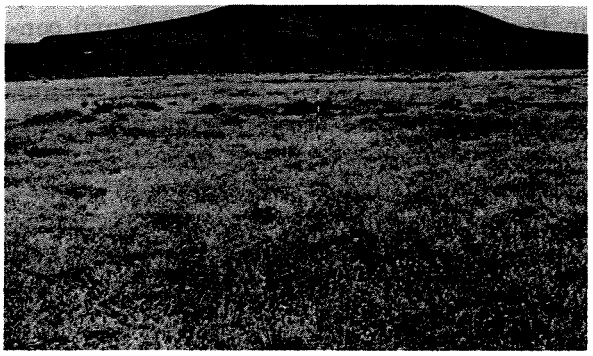

Figure 18.—A hot fire almost completely eliminated sagebrush from this large area and destroyed the area as sage grouse habitat.

Diversity of habitat types, both in terms of food and cover, should be the objective. Planned fire can produce favorable openings and higher yields of forbs for grouse in summer habitat (Blaisdell 1953). But fire is not desirable in winter habitats because retention of sagebrush is essential on winter ranges. Even tall, decadent sagebrush, not useful for nesting or brooding, may be important during severe winters when most other sagebrush could be covered by snow (Call 1979).

Fires are both beneficial and detrimental to sage grouse habitat, depending on the particular area and situation. Vegetation is a dynamic resource, and sage grouse needs are best met with a mixture of successional stages and plant species composition that *always* includes sagebrush. Such conditions have been accidentally achieved by wildfires and can be achieved intentionally with wise planning.

Animal Management

EFFECTS OF LIVESTOCK GRAZING

There are three primary effects of livestock grazing on sage grouse habitat: (1) changes in composition, density, and structure of vegetation; (2) disturbance of nesting hens and possible trampling of nests; and (3) removal of brood forage and cover in meadows.

Many sagebrush ranges on public lands are grazed by cattle in late spring, summer, fall, and winter and by domestic sheep in winter. Spring and early summer grazing by livestock removes a high percentage of grass and forbs at the time when sage grouse are turning to forbs as their primary forage. The presence of succulent forbs in brood-rearing areas is highly important to young sage grouse. Although the dependence of newly hatched chicks on insects is high, by the time they are 4 to 8 weeks old their diet consists of about 75 percent forbs and 15 percent sagebrush leaves (Savage 1969). Therefore, rapid removal of forbs by livestock on spring and summer ranges may have a substantial adverse impact on young grouse, especially where forbs are already scarce. By May, adult grouse also shift from diets dominated by sagebrush to diets dominated by forbs.

Grazing domestic sheep on sagebrush ranges is a common practice in winter. In some areas sagebrush has been grazed so heavily in consecutive winters that the brush has been severely damaged. If such use occurs on important sage grouse wintering areas, the grouse may have difficulty obtaining sufficient forage for their needs, especially during severe winters with deep snow (Call 1979). The degree of impact therefore varies with the time and intensity of grazing and the severity of the winters.

Forced movement of cattle and sheep across rangelands is commonly practiced, particularly in spring and fall. There may be significant impacts on nesting hens and young broods caught in the paths of such drives in the spring. Nests are known to have been deserted because of disturbance by sheep and cattle (Autenrieth 1981, Rasmussen and Griner 1938). In fact, grazing by sheep is much more detrimental to a sage grouse nesting area than is grazing by cattle (Girard 1937).

On two occasions bands of sheep were noted to have caused hens to flush and simultaneously to flip eggs out of their nests. Sheep subsequently stepped on these eggs, destroying them, and the nests were deserted in both cases (Patterson 1952). Sheep have also destroyed nests by stepping into them. In a few cases, nests were placed on open ground between shrubs and could have been destroyed by livestock activities, but no such destruction was recorded. There is no indication that livestock are a serious factor in destruction of nests, although desertion of nests because of livestock activities is frequent under certain conditions.

Desertion of nests by sage grouse is most prevalent in the vicinity of sheep bed-grounds. Bands of 2,000 to 3,000 sheep seriously disturb nesting activities. Patterson (1952) noted that a period of nest desertion coincided with several thousand sheep that began moving into his study area en route to their summer ranges. Most deserted nests were either preincubated or in the early stages of incubation. Nests were seldom deserted, however, after incubation was well underway. During incubation, several birds were flushed from nests by sheep, but the nests were not deserted.

Hens abandon their nests with little provocation during the egg-laying period (mid-April through early May). Yearling hens are prone to abandon their nests even when disturbed during incubation. The impact of a livestock drive could, therefore, be great because yearling hens are usually the largest reproductive age class. It is therefore best to avoid known nesting areas (within 3.2 km (2 mi) radius of leks) from mid-April to early June to reduce abandonment of nests by sage grouse (Autenrieth 1981).

Upland meadows have seriously deteriorated because of excessive livestock grazing on public lands in Nevada (Oakleaf 1971), Oregon, and other Western States. Sage grouse use in these areas has decreased because of the diminished food supply (fig. 19). Meadows provide a source of food, especially forbs, and water that is usually absent or not available on adjacent, more xeric rangelands (Savage 1969). Spring-fall and "season long" grazing have caused a marked deterioration in meadows with related gully cutting and lowering of the water table. This situation may be one of the most severe negative impacts on sage grouse in the Great Basin. Although excessive livestock grazing will cause upland meadows to gradually deteriorate, light grazing may produce benefits to grouse. Sage grouse are attracted to the green regrowth of aster, yarrow, and common dandelion on grazed meadows. The regrowth is more succulent and contains more crude protein and less fiber than ungrazed forage (see footnote 4, p. 9).

Mesic sites, such as stream bottoms, are usually heavily grazed by cattle before they seek forage on less accessible, rougher terrain (fig. 20). This is also true on upland meadows. It is difficult, expensive, and usually controversial to establish a livestock management system that will protect upland or streamside meadows. Autenrieth (1981) suggested, however, that one technique for protecting meadow forbs from livestock trampling and grazing is to fence the streamside meadow and leave access gaps for water. Even with this costly system, grazing may be allowed only once every 3 years on meadows if precipitation does not exceed 18 to 23 cm (7.1 to 9.1 in) per year. If precipitation approaches 30 cm (11.8 in) per year, he suggested grazing might be permitted in August when young birds have become mobile.

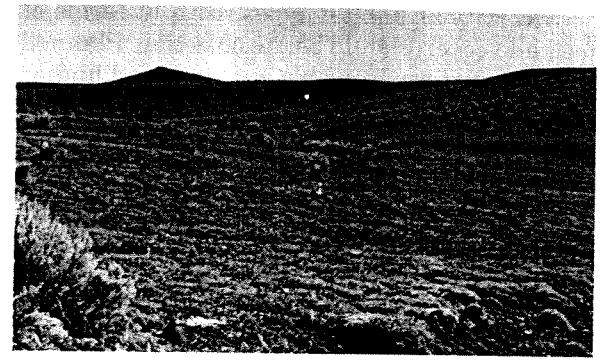

Figure 19.—Upland meadows in sagebrush stands are important to sage grouse broods. Intensive livestock grazing has caused serious deterioration of these meadows.

Figure 20.—Mesic habitats along stream bottoms usually receive intensive grazing by livestock (A). Such heavy grazing in spring and early summer removes most of the forbs preferred by sage grouse (B).

EFFECTS OF HUMAN DISTURBANCE

Human activities in sage grouse habitat cause degrees of disturbance. Such activities vary from occasional harassment to disruption of the nesting cycle to elimination of use on critical winter ranges.

Daily human disturbances on sage grouse leks could cause reduction in mating, and some reduction in total production. If flushed, grouse usually fly from the strutting ground and do not return again that day. Some leks are known to the public and are visited by photographers and other interested persons to watch the annual courtship rituals. Such activities need to be curtailed if they disrupt mating. Grouse are tolerant of automobiles and may be watched from fairly close range if the observers do not leave their vehicles. But the instant a person leaves a vehicle the grouse become alarmed and generally take flight, not to return again until the next day. Fortunately, the mating season is fairly long (up to 2 months) so receptive hens will usually be mated.

Off-road vehicles occasionally run over a nest, but the amount of loss is probably insignificant. Organized motorcycle or four-wheel drive races across sage grouse nesting habitat, however, can cause substantial loss of production from direct destruction of nests, from abandonment of nests during egg-laying, from destruction of young chicks, or from all three. If sage grouse production is a management goal, then it is wise to postpone such races until after the first of September when the birds are old enough to fly out of harm's way.

There is also much exploration for oil and gas in some States. The effects of these activities on sage grouse and their habitat is poorly known and needs further evaluation.

Management Tips

Where sage grouse are to be managed as a featured species, their primary habitat requirements need to be identified and their habitat maintained or enhanced to meet those needs. The following management tips (adapted from Autenrieth et al. 1982, Braun et al. 1977) are designed to help a manager achieve this goal.

VEGETATION MANAGEMENT

Habitat management, which is largely sagebrush and forb management in the case of sage grouse, is critical to the perpetuation of grouse populations. Sagebrush-grassland ranges will continue to be altered, whether by design, by accident, or by natural succession. Planned modifications could include chemical control, chaining, plowing, beating, disking, and burning, with or without reseeding. Some project considerations for controlling sagebrush that will protect important grouse values are:

1. The Federal land management agency and the State wildlife agency should coordinate closely in planning sagebrush treatment projects. A minimum of four seasons is needed to gather data on grouse use of the area prior to preparing final project plans. Areas determined to be important for nesting, brood-rearing, or wintering should not be disturbed until, and unless, the treated sagebrush areas become suitable habitat for meeting these needs.

2. Project plans for sagebrush control should include provisions for long-term quantitative and qualitative measurements of vegetation before and after treatment. This will provide information on effects on grouse habitat and populations that will be valuable in planning further projects. The land managing agency could take the responsibility for evaluating the project as it relates to changes in habitat, and the wildlife agency could assume responsibility for measuring effects of the project on sage grouse and other wildlife.

3. No control work should be considered where live sagebrush cover is less than 20 percent, or on steep (20 percent or more gradient) upper slopes with skeletal soils where big sagebrush is 30 cm (12 in) or less in height.

4. Whenever sagebrush control is determined to be desirable in sage grouse habitat, for whatever reasons, less damage to sage grouse populations will occur with either (1) partial kill, whether by spraying, chaining, plowing, or other means; or (2) creation of strip patterns or mosaics (fig. 21). Partial kill leaves sagebrush and forbs essential for grouse survival and still permits substantial increase in grass production for livestock. It also helps to retain snow and moisture longer in the spring, which creates better growing conditions for forbs and grasses later in the season.

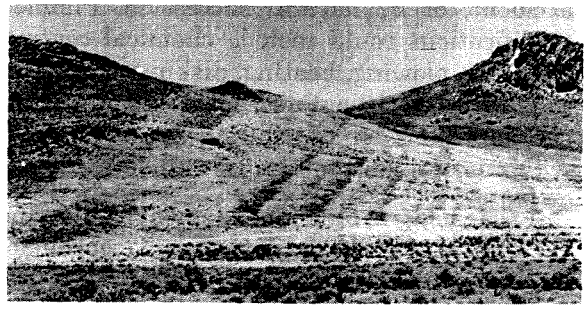

Figure 21.—Sagebrush treatment projects can be designed to produce benefits for livestock while maintaining adequate habitat for sage grouse. This project involved the strip spraying method. (Photograph courtesy of Robert R. Kindschy.)

In strip patterns, the widths of treated and untreated areas can vary for the convenience of the application technique, but treated areas should be a maximum of 30 m (100 ft) in width, and untreated areas need to be at least as wide as treated areas. Alternate strip sagebrush removal or spraying generally has little effect on sage grouse, especially where only partial kill (less than 60 percent) is involved. In creating mosaic patterns, the treated areas should be no more than 274 m (300 yd) in circumference with similar size areas of untreated brush interspersed between the treated areas. The untreated areas can be manipulated when food and cover plants in the treated areas attain composition (or value to grouse) comparable to that of the untreated areas.

5. Treatment of sagebrush is detrimental to sage grouse if undertaken within the breeding complex. No sagebrush control should be done within approximately 3 km (2 mi) of a lek. All areas to be protected from treatment need to be clearly defined on the project maps, and close supervision is critical.

6. Streamsides, meadows, and secondary drainages (dry or intermittent) need to retain their integrity. A minimum of 100 m (330 ft) of living sagebrush should be retained adjacent to the edges of meadows and drainages to provide essential cover for broods and adult birds that use these areas for foraging. Onsite inspections will enable biologists to assess the desirability of increasing the width of untreated strips in specific areas. Erosion along drainages has frequently been increased by excessive livestock grazing and trampling. Consequently, water tables have been lowered, which causes an increase in xeric species. Methods should be devised to raise water tables, decrease erosion, and increase mesic species that will benefit grouse and stabilize the watershed.

7. Sagebrush should not be treated in areas known to have supported wintering populations of sage grouse over the years. Periodic winter observations will enable biologists to determine the critical areas to be protected for survival of grouse.

8. Spraying should be done with either a helicopter or ground equipment to obtain precise application. Spray should be applied when wind velocity is less than 10 km (6 to 7 mi) per hour.

Chemicals other than 2,4-D should be considered for control of sagebrush. The loss of forbs on sage grouse range is one of the serious problems in spraying with 2,4-D. The phenological development of forbs is critical and must be evaluated carefully before treatment. Carpenter (1974) tested applications of 2,4-D on varying amounts of snow cover. As snow cover diminished, forb loss increased. For example, an application in Middle Park, Colorado, on April 4 killed 26 percent of the sagebrush with no forb mortality. An April 17 application killed 63 percent of the brush and 17 percent of the forbs.

Round-Up applied to sagebrush in winter will kill only vegetation protruding above the snow (Autenrieth 1981).[5] It kills all plants on contact, but forbs are dormant and are frequently covered by snow during this period. So the herbicide should have no effect on them.

Chaining sagebrush (pulling a 90-120-m (98-131-yd) ship's anchor chain between two crawler tractors) is one mechanical method of

[5]The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

destroying sagebrush by breaking off the woody portions or tearing up the entire plant. In this method the tractor operators can exercise precise control over areas treated and can produce any type of treatment patterns desired. The amount of brush removed can also be controlled; that is, some areas are chained twice to increase the amount of sagebrush killed.

Plowing of sagebrush with a crawler tractor will kill a high percentage of the brush. This method may be used where sagebrush is too low for chaining to be effective and the understory is not adequate to carry a controlled burn. Seeding of forbs and grasses will be necessary after plowing.

LIVESTOCK MANAGEMENT

1. Livestock grazing, primarily by cattle and sheep, is the dominant use of public rangelands. Where sage grouse are to be a featured species, it is paramount that only light grazing be permitted on important sage grouse wintering areas. Heavy grazing (in excess of 50 percent of current year's growth) may leave inadequate forage for grouse and will gradually cause a decline of sagebrush in the plant species composition. Light grazing (less than 30 percent of current year's growth) may benefit grouse in deep snow conditions by uncovering sagebrush plants, making them more available for use by grouse. Grazing by all ungulates will need to be monitored to ensure that sagebrush on the important wintering areas is not permitted to deteriorate.

2. Grazing domestic sheep on sage grouse nesting areas is best delayed until about the 1st week in June, or until the young grouse have hatched. Domestic sheep may cause considerable abandonment of nests by sage grouse around sheep bed-grounds, trailing areas, and feeding areas (Autenrieth 1981, Patterson 1952, Rasmussen and Griner 1938). Sheepherders can be instructed to bypass or otherwise avoid identified prime nesting areas when trailing sheep from winter to summer ranges.

3. Cattle do not commonly cause abandonment of nests or trampling of nests and may be grazed during any season as long as sagebrush and forb components do not deteriorate as a result of such activity.

4. Grazing management may be used to help create the plant structure and composition desired for sage grouse—manage the sagebrush for an average height of 30 to 80 cm (12 to 31 in) and an average composition of 20 to 30 percent. Good grouse habitat should have from 5,000 to 10,000 sagebrush plants per 0.4 ha (1 acre).

5. Livestock grazing of sagebrush ranges during years of unusually low precipitation and poor plant growth will cause an earlier than normal removal of grasses and forbs. This can have a serious impact on grouse dependent on forbs in that locality. In important sage grouse nesting and summering areas, livestock grazing should be monitored to protect at least 50 percent of the annual herbaceous vegetation (by weight) prior to mid-September. After mid-September, grouse commence feeding on sagebrush and increased livestock grazing on herbaceous vegetation will not be detrimental.

WATER DEVELOPMENT

Grouse concentrate around water sources in late summer and fall when forbs have desiccated. This suggests that grouse habitat can be improved by providing water near meadows or other good forb-producing areas, or by managing water for livestock so that water is available to grouse throughout the summer and fall. It is probably preferable to provide such water at ground level, such as from a water tank overflow, or by constructing small rocky pools with concrete bottoms, but any water that can be reached will be used (fig. 22).

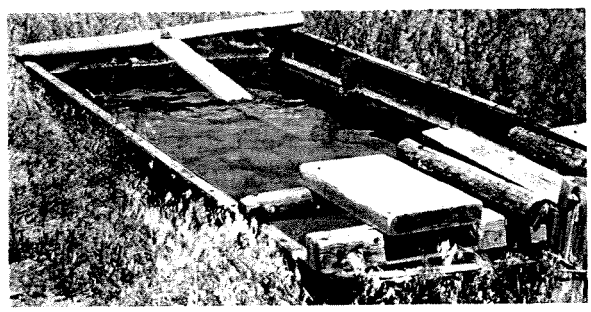

Figure 22.—Livestock water troughs are commonly used by sage grouse. Ramps for birds should be installed in all water troughs. Surplus water should be permitted to overflow onto the ground for use by all forms of wildlife.

It is best to fence springs in brood-rearing areas and to pipe water for livestock to an outside stock tank with a float valve system. When the tank is full, water can be allowed to run out of the spring and across the fenced meadow to stimulate production of forbs and grasses (Thomas et al. 1979).

It is good to fence reservoirs and to pipe water to an outside trough. Storing water in the reservoir will ensure availability of water for grouse and other wildlife in late summer.

Guzzlers can be installed on sage grouse summer range where free water is limited in quantity or is erratically available. Grouse will use water on a daily basis by late summer. A wide variety of guzzlers and water developments can be constructed to suit the needs in a given circumstance. Guzzler designs have been reviewed by Wilson (1977) and Roberts (1977).

FENCING

Barbed wire fences kill many large birds, especially when the fences are located in swales and on ridge lines where flying birds come on them unexpectedly. Owls, falcons, sage grouse, and other birds have flown into barbed wires and have been killed. At one site near Randolph, Utah, for example, a conservation officer of the Utah Division of Wildlife Resources counted approximately 36 carcasses of sage grouse along 3.2 km (2 mi) of fence in 3 winter months of the first winter the fence was in place (fig. 23). Steel posts were placed about 10 m (33 ft) apart with stays between, which made the fence somewhat inconspicuous (Call 1979). Trueblood (1954) also reported that young grouse were often killed when they flew into fences built to control cattle.

Sage grouse are bulky birds and not very maneuverable. They frequently fly low and fast across sagebrush flats, and new fences in sage grouse habitat can be deadly to birds that strike them. When a new fence is constructed in sage grouse habitat, the danger to sage grouse can be reduced by hanging colored tape or cloth strips from the top wire to make the fence more visible to flying birds.

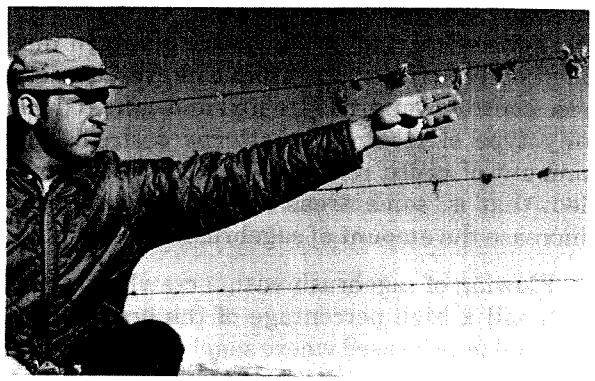

Figure 23.—A new fence to control cattle killed at least 36 sage grouse in a 3-month period; note the sage grouse feathers. Flagging should be hung on newly constructed fences in sage grouse habitat to warn birds of the fences.

Fencing meadows can protect them against excessive livestock grazing and can provide important advantages to the grouse. Meadows used by grouse for brood-rearing can be important to the survival of young grouse, especially the first 2 months after hatching.

VISITOR AND VEHICLE MANAGEMENT

Some sage grouse leks are well known to the people of local communities who enjoy visiting them to photograph or to watch the strutting activities of the grouse. Public awareness campaigns, including notices published in local newspapers each spring, should inform interested people to remain in their automobiles and not create disturbances that cause grouse to leave the leks. Notices (signs) making the same points can also be posted along roads leading to the lek.

Of primary concern on public lands is the authorization of use of off-road vehicles (ORV) in habitats critical to sage grouse. Public land managers must continue to evaluate all potential impacts on the environment before and during such events. It may be necessary to stipulate that all such events must be conducted after the sage grouse's reproductive period, or that activities must be conducted in areas where no loss of habitat will occur.

Organizers of ORV events on public lands must be aware of the potential for fire caused by hot mufflers and tailpipes or by sparks or hot exhausts in brushy or grassy areas. Close supervision of organized events is essential to keep unexpected fires from destroying important sage grouse habitats (Call 1979).

FIRE MANAGEMENT

Fire is a natural element to which most animals have become adapted. When properly applied, fire can be successfully used in perpetuating the kinds of habitats and desired structural conditions that are essential to sage grouse (Call 1979).

Wildfires that "hot burn" winter and nesting habitat can be devastating to a sage grouse population that depended on the areas burned (Autenrieth 1981). Sagebrush should be reestablished on such areas as soon as possible by the most appropriate reseeding or resprouting methods. Reseeding, the least expensive method, should be used if suitably adapted sagebrush seed can be obtained. Stem-cutting propagation is a method that can produce new sagebrush plants in a relatively short time but may be too expensive for establishing sagebrush plants over large areas. Wallace and Romney (1972) demonstrated that big sagebrush cuttings were easy to root when succulent, vigorous material from young plants was treated with 0.3 percent indolebutyric acid and maintained in a mist chamber. Cordero and McKell (1979) tested 8- to 12-cm (3.1- to 4.7- in) cuttings of terminal and lateral twigs in experiments with Wyoming big sagebrush and mountain big sagebrush. Results indicated that cuttings obtained in winter during dormancy showed more rooting activity than those collected from growing plants.

A list to consider when fire is used as a management tool follows:

1. Fire is an inexpensive tool that may be used for habitat manipulation, but all projects must be carefully evaluated, planned, and supervised. A set of clear objectives is essential.

2. Fire is best used in a manner that results in a mosaic pattern of shrubs and open areas, where the resultant openings range in size from 0.4 to 4.0 ha (1 to 10 acres).

3. Large, hot fires may remove an excessive amount of cover or may sterilize the soil.

4. Burning within an area should be done on a rotational basis, different patches burned every few years, with as long as 20 years between burning treatments on each site. This will produce a diversity of habitats within the general area. Timing of treatments over the years will depend on sagebrush response and growth rates at the specific sites.

5. Best results from burning occur in late April and early May when dry grasses and other herbaceous fuels from the previous growing season will carry a relatively cool fire. This will leave some sagebrush and still create openings for additional growth of grasses. Fires in late spring and early summer, however, could destroy many nesting birds and other young wildlife, including sage grouse; so use of fire is preferable when young are capable of escaping. At times, it may be necessary to use prescribed fire in the spring to obtain the desired changes in habitat. Strip burns that do not exceed 45 m (50 yd) in width and 90 m (100 yd) in length create desirable openings for sage grouse (Autenrieth 1981).

6. Sagebrush habitats identified as important wintering areas that are still in vigorous condition should remain intact. Grouse depend on leaves of sagebrush in such areas, not on potential development of grass and forbs in the understory or interspersed openings. If important stands of sagebrush used by grouse for wintering have deteriorated because of such things as insects, old age, or livestock grazing, the manager should initiate measures to rejuvenate the stand by light chaining, by reduced grazing, or by other means.

7. The burning techniques used by Beardall and Sylvester (1974) have been effective on sagebrush lands where precipitation is 30 cm (11.8 in) or more. The four primary elements needed for a successful burn are: (1) wet soil; (2) windspeed in excess of 12.8 km (8 mi) per hour and gusty; (3) fine fuels of 278-320 kg (611.6-704 lb) per 0.4 ha (1 acre); and (4) no burning after spring grass growth reaches 5 cm (2 in) unless burning is to improve the forbs in the community. Prescribed burns should be conducted when plants preferred as food by sage grouse are dormant (Wright 1974).

8. Livestock concentrate on burned areas and eat the new growth, so they need to be carefully managed. Haphazard burning and heavy grazing accelerate sagebrush reinvasion, soil erosion, and loss of forage plants desirable for both livestock and grouse (Pechanec et al. 1954). Grazing use must therefore be regulated to prevent excessive reinvasion by sagebrush (more than 10,000 plants per 0.4 ha (1 acre)) and to prevent removal of more than 50 percent of the annual herbaceous growth (by weight).

9. Species of sagebrush and their value to grouse need to be identified prior to burning. Some subspecies, such as *vaseyana,* may invade an area immediately after a burn and may not be as desirable for grouse as the original species or subspecies (Harniss and Murray 1973).

CREATION OF LEKS

It has been demonstrated that new leks may be established to replace traditional leks that have been destroyed by land use activities (Eng et al. 1979, Tate et al. 1979). Establishment of new leks should be attempted after such factors as proximity of nesting, brood-rearing, and wintering areas are considered. The relationship of a new lek to wintering areas is probably the most critical factor (Eng et al. 1979). Sage grouse may move more readily to a satellite lek where at least a few birds have strutted in past years (Tate et al. 1979). See Autenrieth et al. (1981) for information about mitigating losses of habitat for sage grouse caused by mining operations and other industrial developments.

Summary

Wildlife habitat has been a byproduct of management to enhance production of livestock on most rangelands. As demands continue to grow for a greater mix of products from rangelands, it is obvious that such cliches as "good range management is good wildlife management" will no longer suffice (Maser and Thomas 1983), certainly not for sage grouse. Pressure for increased production of livestock and other amenities is accompanied by growing public concern for wildlife. Ultimately, sage grouse can benefit from range management activities, but only if their welfare is planned in advance and their habitat requirements are no longer left to chance.

Literature Cited

Allred, W. J.
1942. Predation and sage grouse. Wyo. Wildl. 7(1):3-4.

American Ornithologists' Union.
1957. Check-list of North American birds. 5th ed. 691 p. Port City Press, Inc., Baltimore, Md.

American Ornithologists' Union.
1973. Thirty-second supplement to the American Ornithologists' Union check-list of North American birds. Auk 90:411-419.

Autenrieth, R. E.
1969. Impact of strip spray on vegetation and sage grouse use on summer habitat. Proc. West. States Sage Grouse Workshop 6:147-156.

Autenrieth, R. E.
1970. Sage grouse investigations. 4th Annu. Prog. Rep., 21 p. Idaho Fish and Game Dep., Boise.

Autenrieth, R. E.
1981. Sage grouse management in Idaho. P-R Proj. Rep. W-125-R and W-160-R. Wildl. Bull. 9, 238 p. Idaho Fish and Game Dep., Boise.

Autenrieth, R. E., W. Molini, and C. Braun, eds.
1982. Sage grouse management practices. Tech. Bull. 1, 42 p. West. States Sage Grouse Comm., Twin Falls, Idaho.

Batterson, W. M., and W. M. Morse.
1948. Oregon sage grouse. Oreg. Fauna Ser.1, 29 p. Oreg. Game Comm., Portland.

Bean, R. W.
1941. Life history studies of the sage grouse *(Centrocercus urophasianus)* in Clark County, Idaho. B.S. thesis. Utah State Coll., Logan. 44 p.

Beardall, L., and V. E. Sylvester.
1974. Spring burning for removal of sagebrush competition in Nevada. 9 p. Fire and Land Manage. Symp., Missoula, Mont.

Beck, T. D. I.
1975. Attributes of a wintering population of sage grouse, North Park, Colorado. M.S. thesis. Colo. State Univ., Fort Collins. 49 p.

Beck, T. D. I.
1977. Sage grouse flock characteristics and habitat selection in winter. J. Wildl. Manage. 41(1):18-26.

Beck, T. D. I., and C. B. Braun.
1978. Weights of Colorado sage grouse. Condor 80:241-243.

Blaisdell, J. P.
1953. Ecological effects of planned burning of sagebrush-grassland range on the upper Snake River Plains. U.S. Dep. Agric. Tech. Bull. 1075, 39 p. Washington, D.C.

Braun, C., and T. D. Beck.
1976. Effects of sagebrush control on distribution and abundance of sage grouse. Fed. Aid Wildl. Restoration Proj. W-37-R Final Rep., p. 21-84. Colo. Div. Wildl.

Braun, C. E., T. Britt, and R. O. Wallestad.
1977. Guidelines for maintenance of sage grouse habitats. Wildl. Soc. Bull. 5:99-106.

Braun, C., C. Crawford, H. Funk, D. Gore, D. Hoffman, S. Kind, C. McCord, J. Monarch, K. Morrison, M. Robertson, C. Wetherill, and T. A. May (Principal Investigator).
1969. Effects of sagebrush control on distribution and abundance of sage grouse. Fed. Aid Rep. W-37-R-23, 68 p. Colo. Fish and Game Dep., Denver.
Brooks, A. C.
1930. The specialized feathers of the sage hen. Condor 32:205-207.
Call, M. W.
1979. Habitat requirements and management recommendations for sage grouse. Tech. Note 330, 37 p. U.S. Dep. Inter., Bur. Land Manage., Denver Serv. Cent., Denver, Colo.
Carpenter, L. H.
1974. Middle Park deer study—range fertilization. Fed. Aid Wildl. Restoration Proj. W-38-R-28, p. 181-195. Colo. Div. Wildl.
Carr, H. D.
1968. A literature review on effects of herbicides on sage grouse. Colo. Div. Game, Fish and Parks Comm. Spec. Rep. 13, 16 p. Denver.
Cordero, E. A., and C. M. McKell.
1979. Stem cutting propagation of big sagebrush (*Artemisia tridentata* Nutt.). J. Range Manage. 32(2):141-143.
Crawford, J. E., Jr.
1960. The movements, productivity, and management of sage grouse in Clark and Fremont Counties, Idaho. M.S. thesis. Univ. Idaho, Moscow. 85 p.
Dalke, P. D., D. B. Pyrah, D. C. Stanton, J. E. Crawford, and E. Schlatterer.
1960. Seasonal movements and breeding behavior of sage grouse in Idaho. Trans. North Am. Wildl. Conf. 25:396-407.
Dalke, P. D., D. B. Pyrah, D. C. Stanton, J. E. Crawford, and E. Schlatterer.
1963. Ecology, productivity, and management of sage grouse in Idaho. J. Wildl. Manage. 27:811-841.
Dargan, L. M., and R. J. Keller.
1940. Survey of 1940, North Park, Jackson County, Colorado. Sage Grouse Surv. 22, 28 p. Colo. Game and Fish Comm., Denver.
Dargan, L. M., R. J. Keller, H. R. Shepherd, and R. N. Randall.
1942. Survey of 1941-42 food studies, parasite relations, habitat requirements, including preliminary data on sharp-tail grouse in Moffat and Routt Counties. Sage Grouse Surv. 4, 10 p. Colo. Game and Fish Comm., Denver.
Dealy, J. Edward, Donavin A. Leckenby, and Diane M. Concannon.
1981. Plant communities and their importance to wildlife. *In* Wildlife habitats in managed rangelands: The Great Basin of southeastern Oregon. USDA For. Serv. Gen. Tech. Rep. PNW-120, 66 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.
Eng, R. L.
1952. A two-summer study of the effects on bird populations of chlordane bait and aldrin spray as used for grasshopper control. J. Wildl. Manage. 16:326-337.
Eng, R. L., E. J. Pitcher, S. J. Scott, and R. J. Greene.
1979. Minimizing the effect of surface coal mining on a sage grouse population by a directed shift of breeding activities. *In* The mitigation symposium: A national workshop on mitigating losses of fish and wildlife habitats, p. 464-468. U.S. For. Serv., Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.
Eng, R. L., and P. Schladweiler.
1972. Sage grouse winter movements and habitat use in central Montana. J. Wildl. Manage. 36:141-146.
Garrison, G. A., J. M. Skovlin, C. E. Poulton, and A. H. Winward.
1976. Northwest plant names and symbols for ecosystem inventory and analysis. USDA For. Serv. Gen. Tech. Rep. PNW-46, 263 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.
Gill, R. B.
1964. Effects of sagebrush control on the distribution and abundance of sage grouse. Colo. Coop. Wildl. Res. Unit Q. Rep. 18(1):21-24.
Gill, R. B.
1965. Distribution and abundance of a population of sage grouse in North Park, Colorado. M.S. thesis. Colo. State Univ., Fort Collins. 147 p.
Girard, G. L.
1935. Life history, habits, and food of the sage grouse, *Centrocercus urophasianus*. M.S. thesis. Univ. Wyo., Laramie. 153 p.
Girard, G. L.
1937. Life history, habits, and food of the sage grouse, *Centrocercus urophasianus* Bonaparte. Univ. Wyo. Publ. 3:1-56.
Gray, G. M.
1967. An ecological study of sage grouse broods with reference to nesting, movements, food habits, and sagebrush strip spraying in the Medicine Lodge drainage, Clark County, Idaho. M.S. thesis. Univ. Idaho, Moscow. 200 p.
Griner, L. A.
1939. A study of the sage grouse (*Centrocercus urophasianus*), with special reference to life history, habitat requirements, and numbers and distribution. M.S. thesis. Utah State Agric. Coll., Logan. 111 p.
Grondahl, C. R.
1956. Predation studies using artificial pheasant nests. Fed. Aid Wildl. Restoration Proj. W-35-R-3, 14 p. N. D. Game and Fish Dep., Bismarck.
Hall, E. R.
1981. The mammals of North America. 1,181 p. John Wiley and Sons, New York.
Hanson, W. R.
1952. Effects of some herbicides and insecticides on biota of North Dakota marshes. J. Wildl. Manage. 16:299-308.

Harniss, R. O., and R. B. Murray.
1973. Thirty years of vegetal change following burning sagebrush/grass range. J. Range Manage. 26:322-325.
Higby, L. W.
1969. A summary of the Long Creek sagebrush control project. Proc. West. States Sage Grouse Workshop 6:164-168.
Keller, R. J., H. R. Shepherd, and R. N. Randall.
1941. Survey of 1941: North Park, Jackson County, Moffat County. Sage Grouse Surv. 3, 31 p. Colo. Game and Fish Comm., Denver.
Klebenow, D. A.
1969. Sage grouse nesting and brood habitat in Idaho. J. Wildl. Manage. 33:649-662.
Klebenow, D. A.
1970. Sage grouse versus sagebrush control in Idaho. J. Range Manage. 23:396-400.
Klebenow, D. A.
1972. The habitat requirements of sage grouse and the role of fire in management. Proc. Tall Timbers Fire Ecol. Conf. 12:305-315.
Klebenow, D. A., and G. M. Gray.
1968. Food habits of juvenile sage grouse. J. Range Manage. 21:80-83.
Martin, A. C., H. S. Zim, and A. L. Nelson.
1951. American wildlife and plants. 500 p. McGraw-Hill Book Co., Inc., New York.
Martin, N. S.
1965. Effects of chemical control of sagebrush on the occurrence of sage grouse in southwestern Montana. M.S. thesis. Mont. State Univ., Bozeman. 38 p.
Martin, N. S.
1970. Sagebrush control related to habitat and sage grouse occurrence. J. Wildl. Manage. 34:313-320.
Maser, Chris, and Jack Ward Thomas.
1983. Introduction. *In* Wildlife habitats in managed rangelands: The Great Basin of southeastern Oregon. USDA For. Serv. Gen. Tech. Rep. PNW-160, 15 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.
Masson, W. V., and R. U. Mace.
1974. Upland game birds. Wildl. Bull. 5, 44 p. Oreg. Wildl. Comm., Portland.
Nelson, O. C.
1955. A field study of the sage grouse in southeastern Oregon with special reference to reproduction and survival. M.S. thesis. Oreg. State Coll., Corvallis. 113 p.
Oakleaf, R. J.
1971. Relationship of sage grouse to upland meadows in Nevada. M.S. thesis. Univ. Nev., Reno. 73 p.
Patterson, R. L.
1950. Sage grouse populations and land-utilization patterns in the mountain west. North Am. Wildl. Conf. Trans. 15:384-398.
Patterson, R. L.
1952. The sage grouse in Wyoming. 341 p. Sage Books, Denver.
Pechanec, J. F., G. Stewart, and J. P. Blaisdell.
1954. Sagebrush burning: Good and bad. U.S. Dep. Agric. Farmers' Bull. 148, 34 p. Washington, D.C.
Peterson, B. E.
1980. Evaluation of the effects of changes in hunting regulations on sage grouse populations: Evaluation of censuses of females. Fed. Aid Wildl. Restoration Proj. W-37-R-33, p. 115-116. Colo. Div. Wildl., Denver.
Peterson, J. G.
1970a. The food habits and summer distribution of juvenile sage grouse in central Montana. J. Wildl. Manage. 34:147-155.
Peterson, J. G.
1970b. Gone with the sage. Mont. Outdoors 5:1-3.
Pyrah, D. B.
1954. A preliminary study toward sage grouse management in Clark and Fremont Counties based on seasonal movements. M.S. thesis. Univ. Idaho, Moscow. 90 p.
Pyrah, D. B.
1960. Eden Valley chicken seasons. Wyo. Wildl. 24(1):26-29.
Pyrah, D. B.
1963. Sage grouse investigations. Fed. Aid Wildl. Restoration Proj. W-125-R-2, Completion Rep., 71 p. Idaho Fish and Game Dep., Boise.
Pyrah, D. B.
1972. Effects of chemical and mechanical sagebrush control on sage grouse. Job Completion Rep. W-105-R-6, 12 p. Mont. Fish and Game Dep., Helena.
Rasmussen, D. I., and L. A. Griner.
1938. Life history and management studies of the sage grouse in Utah, with special reference to nesting and feeding habits. North Amer. Wildl. Conf. Trans. 30:852-864.
Roberts, R. F.
1977. Big game guzzlers. Rangeman's J. 4(3):80-82.
Rogers, G. E.
1964. Sage grouse investigations in Colorado. Tech. Publ. 16, 132 p. Colo. Game, Fish and Parks Dep., Denver.
Savage, D. E.
1968. The relationship of sage grouse to upland meadows in Nevada. M.S. thesis. Univ. Nev., Reno. 127 p.
Savage, D. E.
1969. The relationship of sage grouse to upland meadows in Nevada. Nev. Coop. Wildl. Res. Unit Rep., 101 p. Reno.
Schlatterer, E. F.
1960. Productivity and movements of a population of sage grouse in southeastern Idaho. M.S. thesis. Univ. Idaho, Moscow. 87 p.

Schneegas, E. R.
1967. Sage grouse and sagebrush control. Trans. North Am. Wildl. Conf. 32:270-274.
Scott, J. W.
1942. Mating behavior of the sage grouse. Auk 59:477-498.
Tate, J., Jr., M. S. Boyce, and T. R. Smith.
1979. Response of the sage grouse to artificially created display ground. *In* The mitigation symposium: A national workshop on mitigating losses of fish and wildlife habitats, July 16-20, 1979, Colorado State University. Gen. Tech. Rep. RM-65, p. 459-463. Rocky Mt. For. and Range Exp. Stn., Fort Collins, Colo.
Thomas, J. W., C. Maser, and J. E. Rodiek.
1979. Riparian zones. *In* Wildlife habitats in managed rangelands: The Great Basin of southeastern Oregon. USDA For. Serv. Gen. Tech. Rep. PNW-80, 18 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.
Trueblood, R. W.
1954. The effect of grass reseeding in sagebrush lands on sage grouse populations. M.S. thesis. Utah State Univ., Logan. 77 p.
U.S. Department of the Interior, Bureau of Land Management.
1970. The sage grouse: Species life history and habitat requirements. Tech. Suppl. 6601-3, MR 6601, 12 p. Denver Serv. Cent., Denver.
U.S. Department of the Interior, Bureau of Land Management.
1983. BLM facts: Oregon and Washington. 36 p. Portland, Oreg.
Wallace, A., and E. M. Romney.
1972. Radioecology and ecophysiology of desert plants at the Nevada test site. U.S. Atomic Energy Comm. Div. Biol. and Med. (TID 259-55). Natl. Tech. Inf. Serv. U.S. Dep. Commer., 405 p. Springfield, Va.
Wallestad, R. O.
1970. Summer movements and habitat use by sage grouse broods in central Montana. M.S. thesis. Mont. State Univ., Bozeman. 51 p.
Wallestad, R. O.
1971. Summer movements and habitat use by sage grouse broods in central Montana. J. Wildl. Manage. 35:129-136.
Wallestad, R. O.
1975. Life history and habitat requirements of sage grouse in central Montana. 65 p. Mont. Dep. Fish and Game, Helena.
Wallestad, R. O., J. G. Peterson, and R. L. Eng.
1975. Foods of adult sage grouse in central Montana. J. Wildl. Manage. 39:628-630.
Wallestad, R. O., and D. B. Pyrah.
1974. Movement and nesting of sage grouse hens in central Montana. J. Wildl. Manage. 38:630-633.
Wallestad, R. O., and P. Schladweiler.
1974. Breeding season movements and habitat selection of male sage grouse. J. Wildl. Manage. 38:634-637.
Wiley, R. H., Jr.
1973. The strut display of male sage grouse. A "fixed" action pattern. Behavior 47:129-152.
Wilson, L.
1977. Guidelines and recommendations for design and modification of livestock watering developments to facilitate safe use by wildlife. Tech. Note 305, 20 p. U.S. Dep. Inter., Bureau of Land Manage., Denver Serv. Cent., Denver, Colo.
Winward, A. H.
1980. Taxonomy and ecology of sagebrush in Oregon. Agric Exp. Stn. Bull. 642, 15 p. Oreg. State Univ., Corvallis.
Wright, H. A.
1974. Range burning. J. Range Manage. 27:5-11.

Appendix

COMMON AND SCIENTIFIC NAMES

Common name	Scientific name
	SHRUBS[1]
Basin big sagebrush	*Artemisia tridentata tridentata*
Big sagebrush	*Artemisia tridentata*
Black greasewood	*Sarcobatus vermiculatus*
Black sagebrush	*Artemisia nova*
Bolander silver sagebrush	*Artemisia cana bolanderi*
Cleftleaf sagebrush	*Artemisia arbuscula thermopola*
Low sagebrush	*Artemisia arbuscula*
Mountain big sagebrush	*Artemisia tridentata vaseyana*
Mountain silver sagebrush	*Artemisia cana viscidula*
Willow	*Salix* sp.
Wyoming big sagebrush	*Artemisia tridentata wyomingensis*
Threetip sagebrush	*Artemisia tripartita*
	GRASS
Crested wheatgrass	*Agropyron cristatum*
	FORBS
Alfalfa	*Medicago sativa*
Aster	*Aster* sp.
Clover	*Trifolium* sp.
Common dandelion	*Taraxacum officinale*
Common salsify	*Tragopogon dubius*
Phlox	*Phlox* sp.
Prickly lettuce	*Latuca serriola*
Western yarrow	*Achillea lanulosa*

[1]From Garrison et al. (1976).

Common name	Scientific name
INSECTS	
Beetles	*Coleoptera*
Ant	*Formica* sp.
BIRDS[2]	
Common crow	*Corvus brachyrhynchos*
Falcon	*Falco* sp.
Magpie	*Pica* sp.
Great horned owl	*Bubo virginianus*
Common raven	*Corvus corax*
Sage grouse (western)	*Centrocercus urophasianus urophasianus*
Sage grouse (eastern)	*Centrocercus urophasianus phaios*
MAMMALS[3]	
Badger	*Taxidea taxus*
Domestic cattle	*Bos taurus*
Domestic sheep	*Ovis aries*
Richardson ground squirrel	*Spermophilus richardsoni*
Ground squirrel	*Spermophilus* sp.

[2]From American Ornithologists' Union (1957, 1973).

[3]From Hall (1981).