From:	Burgess, Angela
To:	Drizd, Lara
Subject:	Re: GRSG 2015 - Are you still entering things into RefWorks for chapter authors?
Date:	Monday, March 30, 2015 1:37:57 PM
Attachments:	Blus and Connelly 1998.pdf Moore and Mills 1977.pdf Willis et al 1993.pdf

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Awesome, thanks Lara! I've attached the list for the contaminants chapter - both completely new articles and ones that I found are already in RefWorks but don't have a link (I separated these into 2 different sections). Still waiting to see if I can get a couple of the links to new articles, and several of the articles I couldn't find a PDF online, so I've attached them here. Let me know if you have any questions!

And if you realize you can't get to them, just let me know and I'll see what I can do.

Thanks again!

Angela Burgess
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On Mon, Mar 30, 2015 at 11:42 AM, Drizd, Lara <lara_drizd@fws.gov> wrote:

> Hi Angela,
>
> Funny you should ask. I'm working on doing that for Holly's climate change chapter right now. If you've identified your list of references that are not already in RefWorks, I would be happy to enter those for you. It might take a little while like the last time but I'll be sure to get them in there eventually.
>
> On Mon, Mar 30, 2015 at 10:29 AM, Burgess, Angela <angela_burgess@fws.gov> wrote:
>
>> Hi Lara,
>> I'm wrapping up my chapters for the species report and have been working on the citations. For the recreation chapter, I sent you all the information for the citations that weren't in RefWorks, but I was wondering - do you still have time to do that for the citations for my other two chapters? Wanted to check with you before I bombard you, as I'm not sure if you still have time available to do that!
>>
>> Thanks,
>> Angela
>>
>> **Angela Burgess**
>> **Fish and Wildlife Biologist**
>> **Mountain Prairie Region - U.S. Fish and Wildlife Service**
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Radiotelemetry to determine exposure and effects of organophosphorus insecticides on sage grouse

Lawrence J. Blus and John W. Connelly

This chapter discusses the history of die-offs of sage grouse from organophosphorus (OP) pesticides in southeastern Idaho cropland. These die-offs and subsequent collections of birds around treated fields led to a study of effects of OP insecticides on sage grouse that were captured and fitted with transmitters in 1985 and 1986. Of 82 radio-marked grouse, at least 18% were in cropland at the time of spraying with the OP insecticides dimethoate and methamidophos, 17% became seriously intoxicated, and 11% died from poisoning by these 2 OPs, as determined by inhibition of brain cholinesterase (ChE) activity and residues of these compounds in ingesta. One large die-off occurred in 1986 when an alfalfa field was sprayed with dimethoate; about 200 sage grouse, including 7 radio-marked birds, occupied the field at the time of spraying; and 63 dead birds were found during 12 d after treatment. Residues in ingesta and assays of ChE activity in brains of 43 grouse indicated that dimethoate was responsible for the die-off. There was 65% mortality of 31 sage grouse initially radio marked when intoxicated from dimethoate. Proposed research will provide a more realistic indication of the risk of OPs to the sage grouse population as a whole by trapping birds on leks at various distances from cropland, by tracing survival over several years, and by using a proportional hazards model.

Replacement of long-lived organochlorine (OC) insecticides with the shorter-lived anticholinesterase (antiChE) OP and carbamate compounds generally reduced persistent problems on wildlife populations. Nevertheless, different modes of action of antiChE compounds have had negative effects, particularly from a short-term perspective where acute or subacute toxicity (Hill and Fleming 1982; Grue et al. 1983; Henny et al. 1985; White et al. 1990) and reductions in arthropod prey populations (Rands 1985; Potts 1986) are major concerns.

Die-offs of sage grouse *(Centrocercus urophasianus)* in agricultural fields in southeastern Idaho beginning in 1981 led to a radiotelemetry study in 1985 and 1986 where effects of OPs on sage grouse were documented (Blus et al. 1989). Our objectives here are to review the documented effects of OPs on sage grouse, offer new perspectives on these findings, and discuss the need for and probable success of continued ecotoxicological studies of radio-marked sage grouse.

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Southeastern Idaho sage grouse study, 1985 to 1986

Study area and methods

The study areas, methods, and materials are described in detail elsewhere (Blus et al. 1989). Briefly, sage grouse, primarily females and young, were captured by night-lighting (Giesen et al. 1982) in sagebrush (*Artemisia* spp.) near cropland in July 1985 and 1986. Eighty-two grouse (39 in 1985 and 43 in 1986) were fitted with radio collars and followed through the summer to termination of the field season (23 August 1985 and 3 September 1986). We also attached a transmitter to grouse found intoxicated after exposure to OPs. Brains of grouse found dead were assayed for ChE activity (Ellman et al. 1961; Hill and Fleming 1982). We also used a standard for ChE each day that samples were assayed. Exposure to an antiChE compound was indicated when activity was < 2 SD of the control mean which was derived each year from hunter-killed and road-killed birds from non-agricultural areas. AntiChE exposure is postulated as the cause of death with inhibition 50% (Ludke et al. 1975; Hill and Fleming 1982). Crop or gizzard contents of sage grouse collected or found dead were analyzed with a gas chromatograph equipped with an electron capture detector; 10% of the residue analyses were confirmed with a mass spectrometer (Blus et al. 1989).

Survival functions of radio-marked sage grouse were estimated with the Kaplan-Meier (product limit) nonparametric estimator (Lee 1980) with a staggered entry scheme to preserve the relationship between the survival function and the calendar date (Pollock et al. 1989). Using this method, we estimated the probability of grouse surviving beyond a specified time to a specified date or number of days since marking. A chi-square test was used to compare survival of adult and juvenile grouse that were radio marked either when apparently healthy or when intoxicated.

Movements of sage grouse

The basic movement pattern of radio-marked sage grouse was to feed in cropland and to roost in sagebrush; 85% of marked grouse were recorded in cropland. Grouse tended to occupy crop fields nearest the area where they were trapped. Maximum movements of sage grouse from sagebrush into cropland were 2.3 and 3.9 km in 1985 and 1986, respectively; these grouse utilized cropland for several weeks. By late August, grouse tended to move farther into sagebrush and to make less use of cropland.

Generally, sage grouse in southeastern Idaho are migratory (Dalke et al. 1963; Connelly et al. 1988; Wakkinen 1990); movement to summer range, including cropland, begins in June. Maximum movement of adult sage grouse from winter to summer range was 82 km (Connelly and Markham 1983; Connelly et al. 1988). Distances moved from the nest to summer range by females with broods ranged from 3 to 21 km; 82% of sage grouse trapped and marked on leks subsequently moved to irrigated cropland (Gates 1983). Based on results of this study and others, most of the sage grouse breeding in relatively xeric (20 to 26 cm of precipitation) sagebrush habitats in southeastern Idaho use cropland for summer range; use of cropland increases sharply during extended periods of hot and dry weather. In southeastern Idaho, spraying of crops with pesticides is initiated in late spring, but most applications occur in July and August at the peak of cropland use by sage grouse. Under these conditions, there is potential for a large segment of the sage grouse population in southeastern Idaho to be exposed to pesticides; such exposure may contribute to population declines of this species and other gallinaceous game birds.

Exposure, intoxication, and mortality

Because grouse occupied alfalfa and potato fields during the time of heaviest applications of pesticides, many birds were exposed to the sprays. This exposure resulted in intoxication and death of a number of birds. In 1985, 6 of 39 radio-marked grouse (15%) became intoxicated after the alfalfa field they occupied was sprayed with the OP dimethoate; 2 of these died with 62 and 73% inhibition of brain ChE activity compared with the mean value obtained from control samples. The intoxicated birds could not walk or fly; they were emaciated, had diarrhea, frequently salivated, and sometimes uttered faint vocalizations. These signs are characteristic of poisoning by antiChE compounds such as OPs and carbamates. The biochemical lesion is phosphorylation or carbamylation of acetylcholinesterase and resultant accumulation of acetylcholine that disrupts nerve transmissions. The sequence of poisoning is inhibition of ChE; acetylcholine accumulation; disruption of nerve function, either centrally or peripherally; respiratory failure; and death by asphyxia (O'Brien 1960). Sublethal inhibition of ChE is reversible; 4 of the intoxicated grouse recovered after approximately 1 week. These birds appeared normal when they were shot 9 or 18 d postspray, but their brain ChE activity was still inhibited 31 to 35%.

While searching for intoxicated radio-marked grouse in alfalfa in 1985, we encountered 3 unmarked, intoxicated grouse. Brain ChE activity was inhibited 66 and 67% in 2 of these grouse that were euthanatized. The third intoxicated grouse recovered after it was radio marked, but it had 37% inhibition of brain ChE activity when shot 18 d postspray (Table 4-1).

In 1986, we observed approximately 100 sick or dead grouse around 3 alfalfa fields that were sprayed with dimethoate. The major die-off occurred on 1 August when an alfalfa field that contained a flock of about 200 sage grouse (including 7 radio-marked birds) was sprayed with dimethoate. About 30 intoxicated or dead grouse were observed on 2 August, and the last verified mortality was recorded on 12 August. We saw at least 2 grouse fall to the ground from flight. We found 63 dead grouse in the alfalfa field, including 5 of the 7 radio marked when healthy, 20 of 31 radio marked when intoxicated, and 38 birds without radios. Of the 31 grouse radio marked when intoxicated, 20 (65%) apparently died from dimethoate; 10 of these deaths were verified by brain ChE assays (Table 4-1). Most of the sick grouse attempted to move from alfalfa into sagebrush that bordered the field. Most grouse died in or at the edge of the alfalfa field, but 2 grouse radio marked when intoxicated died in sagebrush 0.8 and 1 km from the field border.

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Table 4-1 Brain chloinesterase activity of sage grouse controls compared to birds collected or found dead in summer in or near southeastern Idaho cropland, 1985 and 1986 (from Blus et al. 1989)

Year	n	OP[b]	Condition	% Change from Control[a] Mean	Range	% of Grouse Exposed[c]	With ≥ 50% inhibition
1985	2	DI	Dead	-67	-73 to -62	100	100
	3	–	Dead[d]	+1	-10 to +14	0	0
	5	DI	Shot	-34	-37 to -31	100	0
	11	–	Shot	+7	-61 to +38	9	9
	2	DI	Sick	-67	-67 to -66	100	100
1986	43	DI	Dead	-74	-90 to -51	100	100
	2	ME	Dead	-41	-43 to -39	100	0
	8	DI	Shot	-14	-30 to +5	25	0
	1	–	Dead[e]		-8	0	0

[a] Results of control ChE assays (mean micromoles of substrate [acetylcholine iodide] hydrolyzed/min/g of brain tissue ± 2 SD) were 12.5 ± 2.2 for 11 birds in 1985 and 15.3 ± 3.3 for 7 birds in 1986
[b] Exposure to DI dimethoate or ME methamidophos; – no known exposure
[c] Less than control mean 2 SD
[d] Includes roadkill, predator kill, and undetermined cause of death
[e] Roadkill

Avian and mammalian predators were attracted to the dead and dying grouse; 17 depredated grouse carcasses were found within 2 weeks postspray.

Assays of brains of 43 of the 63 sage grouse found dead (9 of the 43 were depredated) in the alfalfa field sprayed 1 August revealed 51 to 90% inhibition of ChE activity (Table 4-1). Brain ChE activity was depressed from 51 to 86% in the 9 depredated grouse. Nine grouse were radio marked when intoxicated and subsequently recovered: 5 shot on 3 September had brain ChE activity inhibited from 9 to 30%, 3 shot on 17 September had brain ChE activity that ranged from 87 to 106% of control values, and we lost the signal of the ninth bird (Table 4-1). The major differences in the die-offs from dimethoate in 1985 and 1986 were the number of birds involved and the time to the initial deaths. Also, none of the birds that died from dimethoate in 1985 had food in their crops; the gizzard contents of one contained a trace of dimethoate (0.02 µg/g). Crops of most grouse found dead the day after spray in 1986 contained ingested food, primarily alfalfa; residues of dimethoate ranged from 3 to 30 µg/g.

In August 1986, 2 of 12 sage grouse radio marked when apparently healthy near potato fields were found buried in or near a potato field the day after it was sprayed with methamidophos. The carcasses were partially eaten and then buried by coyotes *(Canis latrans)*. Brain ChE activity of the 2 grouse was depressed 39 and 43%, and crop contents of 1 grouse contained 18 µg/g methamidophos; these were the only sage grouse suspected of dying of OPs that had < 50% inhibition of brain ChE activity. Experimental evidence suggests that deaths of these two grouse resulted from exposure to methamidophos. For example, Japanese quail *(Coturnix japonica)* were critically intoxicated when euthanatized 1 h after receiving an oral dose of the OP dicrotophos; however, brain ChE activity was inhibited only about 40% (Hill 1989). Several experimental mallards killed by methamidophos had about 40% inhibition of brain ChE activity (CE Grue, personal communication).

The die-offs from dimethoate described here were apparently the first verified records of wildlife losses from this OP; we found only one other record of a die-off of birds from an application of methamidophos (Smith 1987). Factors that increased risk of dimethoate to sage grouse were their use of alfalfa fields for roosting, loafing, and feeding on sprayed alfalfa foliage. The conditions associated with methamidophos applications to potatoes that resulted in risk to sage grouse were similar to those associated with dimethoate applications to alfalfa. The crops of grouse shot or found dead in potato fields contained foliage of weeds and small amounts of insect material; however, sage grouse may occasionally eat potato foliage.

In other studies, the half-life of dimethoate and methamidophos on plants was < 4 d; however, residues of these systemic insecticides may persist for several weeks (Szeto et al. 1984; Westcott et al. 1987). Thus, intoxicated sage grouse in cropland may be reexposed to the OPs when ChE reversal is initiated and the grouse resume feeding on contaminated foliage or move to other recently treated fields.

Sublethal depression of ChE activity in the brain was not demonstrated to have persistent physiological effects in experimental birds in earlier studies (Metz 1958; Glow and Rose 1966; Banks and Russell 1967), but more recent studies presented evidence that certain OPs are capable of inducing long-term effects (Farage-Elawar and Francis 1987, 1988). In chickens, methamidophos had irreversible effects on neurotoxic target esterase that resulted in OP-induced delayed polyneuropathy (Johnson et al. 1989). These effects have not been noted in wild birds, but without a properly designed radiotelemetry study, there is essentially no possibility of identifying long-term effects.

The approximate time required for reactivation of ChE activity in brains of sage grouse intoxicated from dimethoate in this study was similar to the 26-d recovery period (from 55 to 64% inhibition to within 2 SD of the control mean) in experimental birds (Fleming and Grue 1981); however, additional research is required to more closely define this period.

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Survival analysis

Survival analysis of the 39 sage grouse radio marked when apparently healthy in 1985 indicated that the probability of these grouse dying during the 45-d tracking period was 0.25 (mortality = 1 - survival); however, only 2 of 9 documented deaths were related to dimethoate intoxication (probability of dying from OPs = 0.10). Signals from 17 of the 39 grouse were lost before the study ended because of the short range of the transmitters (< 1.3 km) and related problems; thus, the mortality values were minimal estimates with low precision.

Ten of 43 sage grouse that were fitted with transmitters while healthy in 1986 died within 72 d with an overall mortality rate of 0.32. Of grouse radio marked when healthy, 7 juveniles died from OPs (5 from dimethoate and 2 from methamidophos), and 3 other birds (2 juveniles and an adult female) were depredated from 15 August to 17 September. The probability of a grouse dying from OP poisoning was 0.25. Although the last 3 birds that died spent 3 to 20 d after spraying in cropland, there was no evidence of their exposure to OP sprays, and their brains were not available for ChE assays.

The probability of mortality for 31 grouse, radio marked when found intoxicated in 2 alfalfa fields from 25 July (2 birds) up to 7 August 1986 (29 birds), was 0.76 up to 12 August when the last OP mortality from the second incident was verified and 0.78 to 3 September when several were collected by shooting. Dimethoate apparently accounted for deaths of 20 of the 31 grouse; ChE activity was inhibited > 50% in brains of each of 10 birds suitable for assay, and residues of dimethoate were detected in ingesta of some birds. All 8 intoxicated grouse that were radio marked the day following the second spray incident on 1 August died within 4 d; 12 of 21 grouse that were fitted with transmitters when intoxicated on 3 to 7 August died between 4 and 12 August. The grouse that died on 12 August was depredated; however, brain ChE activity was inhibited 55%. The longer range (2.0 to 2.5 km) of the transmitters used in 1986 improved efficiency of tracking compared to 1985; nevertheless, signals of 5 grouse were lost before the end of the study.

Age effects

Concerning sage grouse radio marked when apparently healthy in 1986, 7 of 28 juveniles died compared to 0 of 15 adults ($P < 0.05$) (Table 4-2). There was no significant difference ($P > 0.05$) in survival of adults and juveniles fitted with transmitters when intoxicated; however, all 5 adults died compared with 14 of 25 juveniles. Two adults were among 38 unmarked birds that probably died from dimethoate; however, sex and age were not determined for 13 birds.

Conclusions

Findings in 1985–1986 suggest that OPs may adversely affect sage grouse populations; however, we only considered those birds whose summer range included cropland. The mortality rate and sublethal intoxication of our marked population, induced by OPs and possibly other pesticides, was probably underestimated because: 1) sage grouse were radio tracked during only part of the season when OPs and other pesticides were applied, 2) signals were lost from a number of grouse before the study terminated each year, 3) transmitters were removed from 5 healthy birds in 1986 and placed on intoxicated grouse, 4) some unrecorded exposure of marked grouse may have occurred between radio locations because the birds were not tracked continuously, and 5) delayed effects may have occurred. Circumstantial evidence indicates that the problem may be continuing in southeastern Idaho; an unverified report in 1989 indicated that a large number of sage grouse died at a cropland-sagebrush interface (Justin Naderman, personal communication). One objective of the workshop is to formulate or refine study designs for using radiotelemetry to investigate effects of pesticides on birds; therefore, the remainder of this book is directed toward that objective.

Table 4-2 Incidence of organophosphorus pesticide-related mortality of sage grouse by age and sex, southeastern Idaho, 1986 (from Blus et al. 1989)

	Female		Male		Unknown sex	Unknown sex and age
Condition	Adult	Juvenile	Adult	Juvenile	Juvenile	
Radiomarked						
Healthy	11 (0)[a]	9 (3)	4 (0)	9 (4)	10 (0)	
Intoxicated	4 (4)	11 (5)	1 (1)	14 (9)		1 (1)
Not marked						
Dead	(1)	(7)	(1)	(13)	(3)	(13)

[a] Number of grouse radiomarked with the number dying from OPs in parentheses

Although declines in the sage grouse population in southeastern Idaho are likely caused by habitat deterioration and adverse weather, population declines may be exacerbated by use of insecticides. Comparative toxicological data of OP and carbamate pesticides for gallinaceous birds indicate a wide spectrum of LD50 estimates for this order (Hudson et al. 1984). Evidence suggests that sage grouse are unusually sensitive to antiChE compounds; additional work is required to clarify this relationship.

This study, to be conducted over 3 years and involving the radio marking and monitoring of a large subsample of the sage grouse population, has the potential for generating data necessary to estimate the potential effects that pesticides have on sage grouse summering near croplands. A likelihood model for avian exposure data will be developed during the course of the study to depict the relationship between exposure to the pesticides and population recruitment and survival. Ultimately, the information obtained from this study may be useful for regulatory purposes to evaluate pesticide management practices in agricultural areas in southeastern Idaho and possibly in other areas.

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Radiotelemetry Applications for Wildlife Toxicology Field Studies

Edited by

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Ecotoxicology & Biosystems Associates, Inc.
Kathleen A. Fagerstone
National Wildlife Research Center

Proceedings of the Pellston Workshop on Avian Radiotelemetry in Support of Pesticide Field Studies
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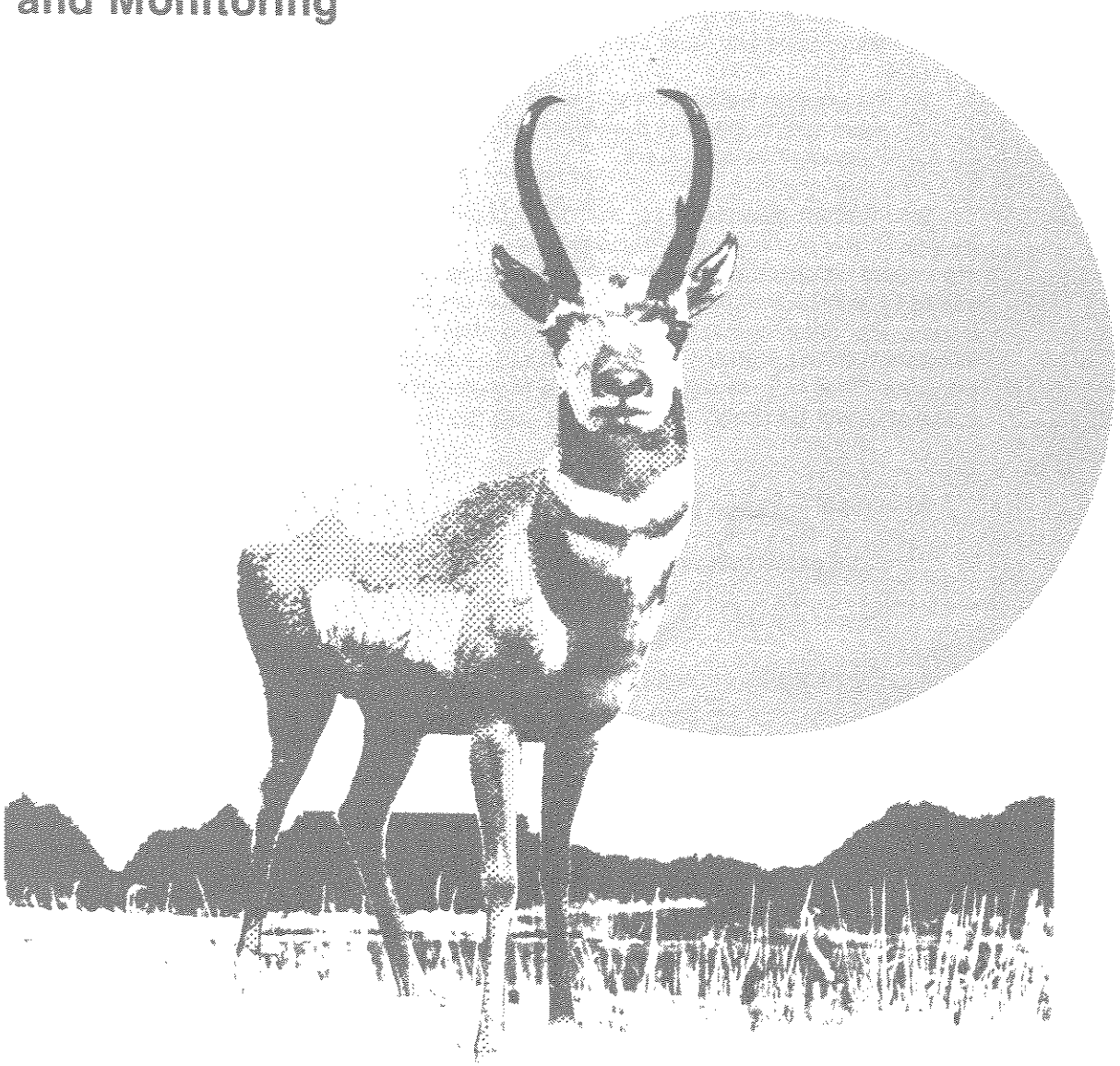
FWS/OBS-78/04
December 1977

AN ENVIRONMENTAL GUIDE TO WESTERN SURFACE MINING PART TWO: Impacts, Mitigation and Monitoring



Fish and Wildlife Service

U.S. Department of the Interior

FWS/OBS-78/04
December 1977

AN ENVIRONMETAL GUIDE TO WESTERN SURFACE MINING. PART TWO: IMPACTS, MITIGATION AND MONITORING

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Western Energy and Land Use Team
Office of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior

EXECUTIVE SUMMARY

This manual assembles information about the effects of surface mining in the Western United States on fish and wildlife resources and recommends ways to mitigate these effects through carefully planned lease and permit stipulations.

Chapter I describes the content of the manual and provides guidance to the reader in how to use it most efficiently.

Chapter II - Regional Ecology and Mining Descriptions - introduces the reader to the regional ecology, the distribution of minerals, and the surface mining techniques likely to be utilized within the three major geomorphic regions.

Chapter III - Effects of Surface Mining - provides a detailed list of impact activities associated with surface mining and traces the way in which these activities affect fish and wildlife resources. The effects of these activities are evaluated with respect to various ecosystem components.

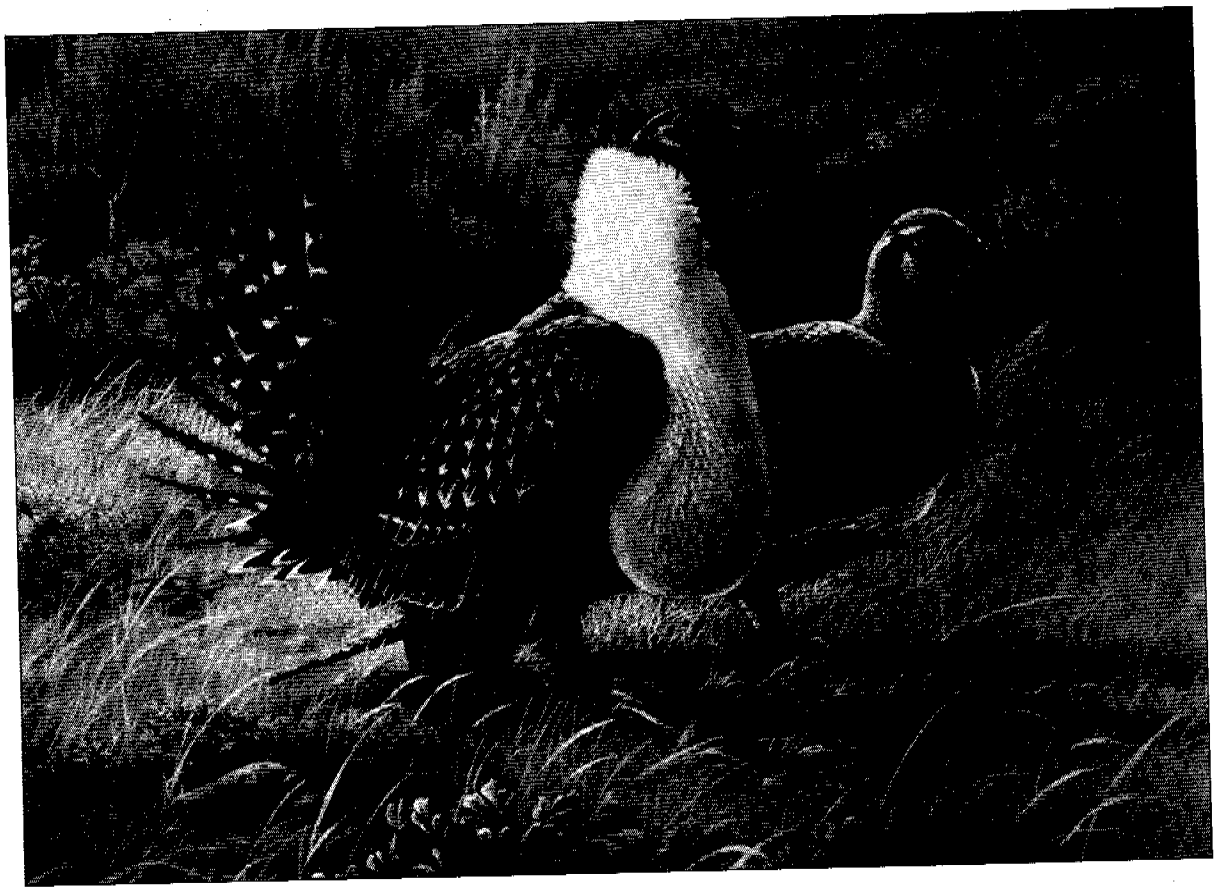
Chapter IV - Recommendations for Reducing Adverse Effects - contains discussions of how the various mine-related effects may be mitigated at high, medium, and low levels of effort. It also provides an evaluation of existing stipulations which have been commonly used toward these same objectives.

Chapter V - Recommendations for Monitoring - contains a conceptual approach to development of a site-specific monitoring program and provides recommendations for monitoring of individual ecosystem components.

This report was submitted in fulfillment of Contract Number 14-16-0009-77-008 by Ecology Consultants, Incorporated under the sponsorship of the Office of Biological Services, U.S. Fish and Wildlife Service. Work was completed as of October 7, 1977.

Sage Grouse In Oregon

Wildlife Research Report Number 15



April 1993

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Sage Grouse In Oregon

Wildlife Research Report Number 15

April 1993

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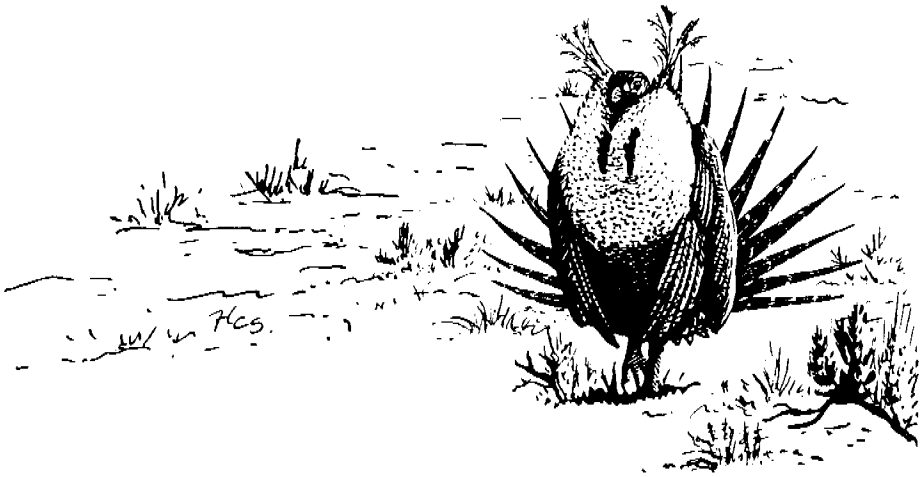

Abstract

Qualitative information on the abundance of sage grouse (*Centrocercus urophasianus*) in Oregon was gathered from several sources back to the turn of the century. Quantitative data were gathered primarily from Oregon Department of Fish and Wildlife district files and monthly reports from the 1950s to present and were compiled, summarized, and analyzed. Sage grouse numbers in Oregon fluctuated during the last 100 years from periods of scarcity to abundance. From several accounts, there was grave concern over the continued existence of the bird at the turn of the century. A peak occurred around 1918 followed by a decline. Large populations existed during the late 1940s and the late 1950s. Since that time, populations and productivity fluctuated with a decline in sage grouse productivity indices, which occurred during the early to mid-1970s. Data do not indicate a corresponding decrease in the adult population, as measured by males/lek. The current minimum population was estimated at between approximately 28,000 and 66,000 adults and we believe at a self-sustaining level, although increases in productivity are desirable. Recent harvest rates were less than 7% of the current annual production and less than 3% of the estimated minimum population. Sage grouse use of habitat is described and factors affecting sage grouse are discussed. Throughout the range of the species, the most detrimental factor to sage grouse abundance was the complete conversion of large areas of sagebrush (*Artemisia sp.*) steppe habitat, primarily for intensive agriculture, which caused the elimination of sage grouse from large areas. In southeastern Oregon, this has not occurred to the extent experienced elsewhere, however an estimated 2,760 mi^2 of big sagebrush (*A. tridentata*) were converted, mostly to crested wheatgrass (*Agropyron cristatum*), and probably was detrimental to sage grouse. Fluctuations in predator abundance have probably been the most important factor affecting fluctuations in annual productivity indices of sage grouse. An increase in predator abundance since the ban of 1080 poison in 1972 may have highly influenced the decline in productivity noted after that time. Other factors detrimental to sage grouse in Oregon include overgrazing by livestock in some areas (particularly in the late 1800s and early 1900s), decreased fire frequency, introduction of exotic grass and forb species, and the use of chemicals for intensive agriculture and grasshopper control. Water developments created since the 1940s may have benefited sage grouse by allowing them to use drier habitats during drought periods. However, they may also have contributed to the increase and better distribution of predators, livestock, and spread of disease some years. Reduction in grazing, which began in the 1930s, and incorporation of grazing systems (which regulate timing and duration of grazing) on public lands since the early 1960s produced a general improvement in ecological conditions. We believe that further habitat improvements are necessary to achieve long term improvements in sage grouse productivity and population levels. Actions designed to maintain and enhance habitat conditions and topics for further investigation are recommended.

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Introduction

In recent years there has been increasing interest in the status of sage grouse in Oregon. Because the bird is relatively unseen by most people due to its secretive nature and distribution over a large area of low human population density, that status is not readily apparent. The only time of the year the birds can be easily seen is during the spring on strutting grounds (leks), and several of these are visited heavily by interested people. The rest of the year the bird is not readily observed due to its secretive nature and cryptic coloration. However, accounts of sage grouse abundance are available back to the turn of the century and data pertaining to population levels and productivity of the species were collected, primarily by the Oregon Department of Fish and Wildlife (ODFW), starting in 1946 and continuing to present. In addition, numerous studies of sage grouse were conducted throughout its range, including several in Oregon related to diet, habitat use, and nesting and brood success. This report was written to summarize and interpret the available and pertinent information on sage grouse. Specific objectives were to:

1) assemble and analyze all ODFW biological data on sage grouse;
2) prepare a map showing sage grouse distribution, production routes, leks, and recent sagebrush conversions;
3) prepare a statewide summary of existing data;
4) establish a sage grouse population estimate for the state;
5) assess factors affecting sage grouse populations and productivity; and
6) make recommendations concerning management of sage grouse in Oregon.

Methods

Historical reports were reviewed to understand trends in sage grouse abundance in Oregon between 1900 and about 1950 when quantitative data collection was initiated. Sage grouse inventory and production records were obtained from the office of each ODFW wildlife county (district) with sage grouse, Hart Mountain National Antelope Refuge (HMNAR), and four Bureau of Land Management (BLM) district offices. We interviewed current staff at all locations to obtain the history of sage grouse and sage grouse data collection in that jurisdiction. ODFW district sage grouse records and monthly reports were copied. Each wildlife district also provided locations on maps of leks, production routes, and recent disturbances such as fires or range conversions. Monthly reports were used to fill in gaps in wildlife district data. Originally we planned to use statewide annual report summaries, but found them less accurate than information obtained directly from district records.

We assembled two measures of productivity—chicks/adult and chicks/hen, and two measures of abundance—males/lek and grouse/10 miles of survey route. We selected these variables because they were collected most regularly. Three variables—chicks/hen, chicks/adult, and grouse/10 miles were collected during summer (mid-June to early August) production surveys. We preferred to use chicks/hen and chicks/brood as variables for productivity. However, chicks/brood reflects chick survival for successful hens and not productivity for the entire population. In addition, chicks/brood was often based on small sample sizes. Therefore we used chicks/adult and chicks/hen as data were available. Surveys were generally conducted through representative sage grouse habitat such that the best habitat was visited during early morning and late evening. They were intended to be run systematically and consistently. However, variability developed in number of miles and location of routes between years within a wildlife district, and surveys were conducted at different intensities between districts. In a few cases route locations changed as personnel, habitat suitability, or priorities changed.

Visibility of grouse and therefore the three indices collected on summer routes were affected by timing of the surveys and moisture conditions each year. Trend through time may be indicated, realiz-

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ing that values in any particular year may be biased. We believe that males/lek is the best measure of sage grouse population trend when sufficient samples are systematically collected. Braun (letter of 26 May 1992) stated *"The most useful data for estimating sage grouse population trends, outside of good wing collection/analysis programs, are total numbers of active leks and total males counted per unit area (i.e. district or region)."* In Baker and Malheur Counties, new leks were recently searched for and counted by the BLM using helicopters. To avoid including incidental observations as leks from aerial counts, we assumed that an area was a lek if it had at least 3 males present. In counties where ground counts were conducted and leks were counted only once, if no birds were seen at a particular lek, the results of that lek count were not included in the county summary that year. This was done to account for the fact that birds are not necessarily present at every lek everyday due to factors such as weather or presence of predators (i.e. golden eagles [*Aquila chrysaetos*]).

We divided counties into core (Harney, Lake, and Malheur) and peripheral (Crook, Deschutes, and Baker) based on the geographic location, the number of birds within the county, and total amount of sage grouse habitat contained within the county. Data were summarized by county, core and peripheral areas, and statewide. However, data from Hart Mountain (HMNAR) were not combined with Lake County data because of differences in sampling methods and intensity on production routes. A district's productivity data were included in summary values only if both pertinent measures (chicks and adults or chicks and hens) were reported; i.e., if no adults were enumerated for Malheur County in 1973, then neither the number of chicks nor adults were included in the chicks/adult ratio in Malheur County, core counties, or statewide for that year.

Data collected on production routes were dependent not only on visibility of the birds, but also on intensity of effort (number of miles driven and area inventoried). When effort or visibility were such that few birds or a small area were inventoried, it was difficult to compare with years of extensive effort or high visibility. Therefore, the necessary sample size was calculated for each variable such that we could be 80% confident that the sample mean was within ± 20% of the population mean. Data collected in Malheur, Harney, and Lake counties during 1992 were used and sample size was determined by:

$$n = t^2 s^2 / e^2 \qquad \text{(Jessen 1978:66)}$$

where, n = sample size
t = the tabular "t" value
e = the acceptable error = 0.2 x the mean

For grouse/10 miles and males/lek,

$$s^2 = \sum (x_i - \bar{x})^2 / (n - 1) \qquad \text{(Jessen 1978:39);}$$

and for numbers of chicks/hen and chicks/adult,

$$s^2 = pq \qquad \text{(Jessen 1978:41).}$$

where, p = proportion of total
$q = 1 - p$

This analysis indicated that approximately 30 leks need to be sampled. At low ratios, 85 hens and chicks (at 0.5 chicks/hen, the number of hens = 57) and 165 adults and chicks (at 0.25 chicks/adult, the number of adults = 132) must be classified.

This statistical method for calculating sample size did not, however, work well for estimating the number of miles necessary for grouse/10 miles. Because of the clumped distribution of sage grouse across the landscape during mid-summer, there was large variability (s^2 = 15,445; range 0 - 635) in the number of grouse/10 miles between routes; a sample of ~ 51,000 miles was calculated. Because that large a sample would be unfeasible, another approach was used to determine the sample size needed to have an acceptable measure of the trend in overall grouse abundance during summer. Route data were added such that the cumulative number of miles and grouse were tabulated and grouse/10 miles and % change from the previous estimate were calculated. As data from each route were added to the total, the % change in the estimate tended to decrease (Figure 1). A simple linear regression of these data, arranged in several orders, indicated that 27.5 routes ($\bar{x}$ = 28.73 miles) each for a total of 790 miles were needed to have no change in the estimate of grouse/10 miles.

While we preferred using sample sizes as calculated for minimum requirements for regression analysis of all indices, it was only possible for statewide chick ratios. Even though sample sizes for number of miles and leks did not meet statistical requirements for confidence levels defined above for any particular year, we believed the data reflected overall trends among years. Minimum sample sizes were set to eliminate years with very small sample sizes from statistical analyses so that among year comparisons could be made with data of similar sampling intensity (Table 1).

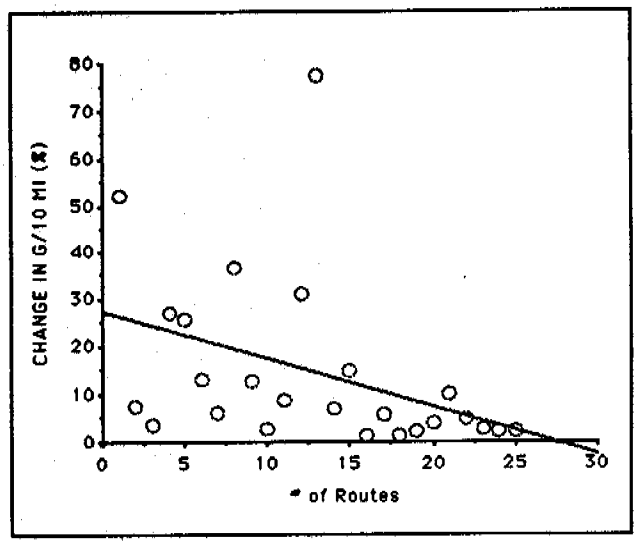

Figure 1. Change in the Grouse/10 Miles Estimate as Route Data are Added to the Cumulative Total.

Table 1. Minimum Sample Sizes Necessary for Trend Analysis of Historical Data in Oregon.

Variables	Statewide	Core Counties	Peripheral Counties
Miles (grouse/10 miles)	400	150	20
Leks (males/lek)	15	8	5
Hens (chicks/hen)	59	30	15
Adults (chicks/hens)	134	45	20

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Data Analysis

Immediately after the turn of the century, Quimby (1903:7) stated that, *"Sage hens are getting scarcer each year, and their complete extinction can not be a matter of more than a few years. While the habits of the bird make it an easy prey to the encroachments of civilization, there is little question in my mind that the coyote is also largely responsible for its extermination, killing many more than all the settlers and hunters combined."* The following year, Quimby (1903:26) again bespoke the imminent demise of the species: *"Sage hens, once so plentiful upon the sagebrush plains of eastern Oregon, are slowly but surely disappearing. This is the testimony of all sportsmen residing in the sagebrush district. The coyote is given credit for doing the lion's share of this destructive work. However, the rapid settlement of eastern Oregon, bringing in its wake the hunting dog and the man with the gun, is probably responsible for the alarming decimation of this bird in a large measure also. I would suggest, if this bird is at all valued as a game asset and its preservation is desired, the shooting of sage hens be prohibited entirely for a number of years. There is a possibility that such protection may result in a new lease on life."* Meyers (1946) and Batterson and Morse (1948) reported a large sage grouse population by 1918 and a rapid die off in 1919-20. The 1920, Oregon Game Commission Biennial Report (1920:8-9) stated: *"The western prairie chicken or sharp-tailed grouse and sage hen, more particularly the latter, are threatened with extinction. It is not believed that these two birds can long hold out, and in the course of a few years they will probably go the way of the passenger pigeon."*

However, local fluctuations occurred as evidenced by the Lakeview Examiner of 28 June 1928 in which the author reported: *"... plenty of feed and water more plentiful than usual has contributed to a large increase in the sage hen population of the area. That the spring hatch of the sagers has been a successful one is indicated in the prevalence of brood[s] from six to ten young sage chickens. In the past few years, with poorer conditions broods of two to four were more common."* In spite of such local fluctuations, populations remained relatively low until the late 1940s when the Oregon State Game Commission Annual Report (1954:29) stated: *"In 1948, conspicuous concentrations of sage grouse became apparent in southeastern Oregon counties."*

Following are summaries of the four sage grouse indices by county, core and peripheral areas, and statewide (data for each are included in Appendix A. Simple regression was used to determine trend in the sage grouse indices with time. The slope (b) of each regression line and statistical significance at a probability of P = 0.05 were reported.

Baker County

(Figure 2)

Productivity routes were not conducted in Baker County. Lek counts were carried out sporadically since 1946.

In 1941, Wes Batterson and William Morse conducted a research project to investigate factors limiting the range and abundance of sage grouse. They worked in Baker County, focusing on the Virtue Flat area where they found ravens (*Corvus corax*) were the principal limiting factor to grouse, and predator control was effective in enhancing nesting success (Batterson and Morse 1948).

The current ODFW wildlife biologist reported sagebrush removal, insecticide spraying, and overgrazing of riparian areas as factors significantly influencing sage grouse.

The BLM in Baker County has recently been active in searching for new sage grouse leks.

Data indicated no trend in males/lek over time.

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Crook County

(Figures 3–6)

Data for lek counts were not available until 1968. Counts were done by BLM and ODFW since that time with a major increase in number of leks counted in 1988-89 when the BLM began a special sage grouse project.

Sage grouse were counted in several active alfalfa fields in the 1970s and early 1980s but are no longer seen there as the fields have reverted to meadow land. The district wildlife biologist thought grazing pressure had moderated over time.

Although there were few years for which minimum sample sizes were obtained, Crook County data indicate significant declines through time in grouse/10 miles (b = -0.59), chicks/adult (b = -0.07), and males/lek (b = -1.24). Currently the BLM is following radio-collared sage grouse in Crook and Deschutes counties in order to determine habitat use and nest success.

Deschutes County

(Figures 7–10)

Lek counts were initiated in 1949 for Deschutes County. The number of leks counted met sample size criteria from 1955-70 and again since 1988. The BLM began counting leks in Deschutes County in 1979.

The ODFW wildlife biologist believed that habitat quality and quantity in Deschutes County had not changed much in the past 13 years. There was an increase in off-road vehicle use and public viewing at leks. Grazing was not believed to be the only problem related to sage grouse populations. Other problems included predation, reduction of fire, changes from sagebrush to areas of grasses, and current drought conditions.

Currently the ODFW district is cooperating with the Prineville district of BLM on a telemetry study to determine habitat use and nesting success. They believe all active leks within the county have been identified.

The Deschutes County data indicated a non-significant increase in grouse/10 miles (b = 0.11) since 1979 and a non-significant decline in males/lek (b = -0.26) since 1949.

Harney County

(Figures 11–14)

Data collected by ODFW on sage grouse in Harney County from 1938 to 1980 did not always note the composition of adults. Therefore, chicks/hen were only reported back to 1980. Otherwise the intensity and quality of data collection by ODFW biologist was maintained since the mid-1950s and has contributed to a more complete and consistent data set from Harney County.

The number of leks counted increased over time. Searches during the last 10 years by ODFW and BLM have located many new leks. No significant changes in the four variables over time (males/lek b = -0.22, grouse/10 miles b = 0.19, chicks/adult b = -0.02, chicks/hen b = -0.02) were detected.

Hart Mountain National Antelope Refuge

(Figures 15–17)

Consistent records at HMNAR began in 1954 although an early record was found for 1938. Production routes were initiated in 1987. The number of adults seen during production routes were not recorded, so we could not calculate chicks/adult. Refuge personnel replicated routes until a minimum sample size for hens was reached. We did not separate data using sample size criteria at HMNAR.

Due to differences in sampling procedures between HMNAR and ODFW districts, we could not pool the HMNAR data with the remainder of Lake County or statewide.

Males/lek showed a nonsignificant increase (b = 0.74) since 1980, while grouse/10 miles and chicks/hen showed no trend over time.

Lake County

(Figures 18-21)

Sage grouse sampling was inconsistent in Lake County from the earliest records. The wildlife district was originally two districts split North and South, but was combined in 1979 with the district biologist stationed in Lakeview and the assistant in Summer Lake. Turnover in personnel was high for

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North Lake County which affected continuity. Data between north and south segments were pooled as described in **Methods**.

In 1983, North Lake County used a helicopter for lek counts, resulting in a reduction of classification of adults.

The ODFW wildlife biologist expressed concern over the development of waterholes in playas. The hardpan may sometimes be breached, thus lowering water tables and reducing the herbaceous vegetation on the playa area. In addition, playas and developed water holes concentrate livestock use at these locations.

The assistant wildlife biologist for North Lake County noted that brood routes in Christmas Valley changed in the early 1980s with the development of alfalfa fields and the visibility of birds there during mid-summer. Much of the production inventory was conducted in alfalfa fields after haying. In 1990, additional miles through the fields were added. Habitat in the Chewaucan Marsh was diminished through conversion and draining in the late 1940s. Most of the best habitat and therefore production routes are located in South Lake County.

Chicks/hen and grouse/10 miles decreased significantly over time (b = -0.07 and -0.89) for the county since the mid-1950s. There was no relationship detected in males/lek or chicks/adult through time.

Malheur County

(Figures 22–25)

Collection of brood data by ODFW began in 1951, but the number of miles covered, and type of habitat inventoried varied over the years. For example, starting in 1963, number of miles traveled decreased with a corresponding increase in number of birds observed/10 miles (i.e., 200 grouse/10 miles in 1971, n = -100 miles), probably as a result of counting only the most productive areas such as particular alfalfa fields. This large increase in abundance was not detected in any other county (i.e., Lake = 7.5 grouse/10 miles, Harney = 6.0 for 1971) during that time period and we believe distorts the trend in Malheur County and the rest of the state (statewide = 47.5 grouse/10 miles for 1971) when these data were pooled.

Lek counts for Malheur County were mostly conducted by Vale District BLM. The majority were counted from a helicopter, hence most leks had only the total number of birds recorded.

Chicks/adult and chicks/hen declined slightly but significantly (b = -0.05 and -0.08) since the 1950s. There was no pattern detected in grouse/10 miles, and insufficient information for males/lek.

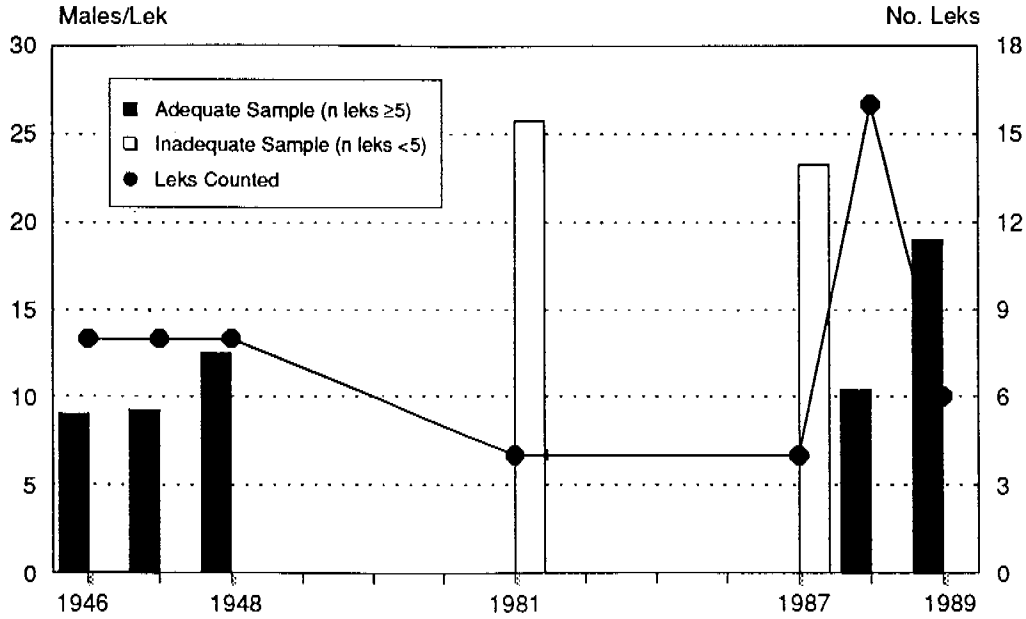

Figure 2. Males/Lek in Baker County, Oregon, 1946-89.

GSG Administrative Record 2010
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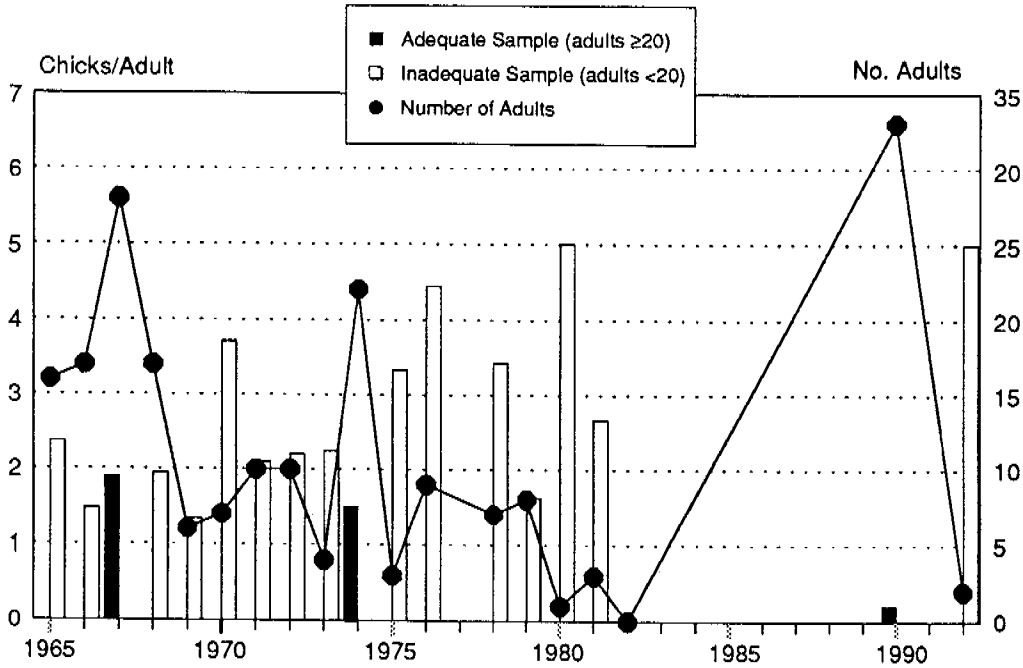

Figure 3. Chicks/Adult Sage Grouse in Crook County, Oregon, 1965-92.

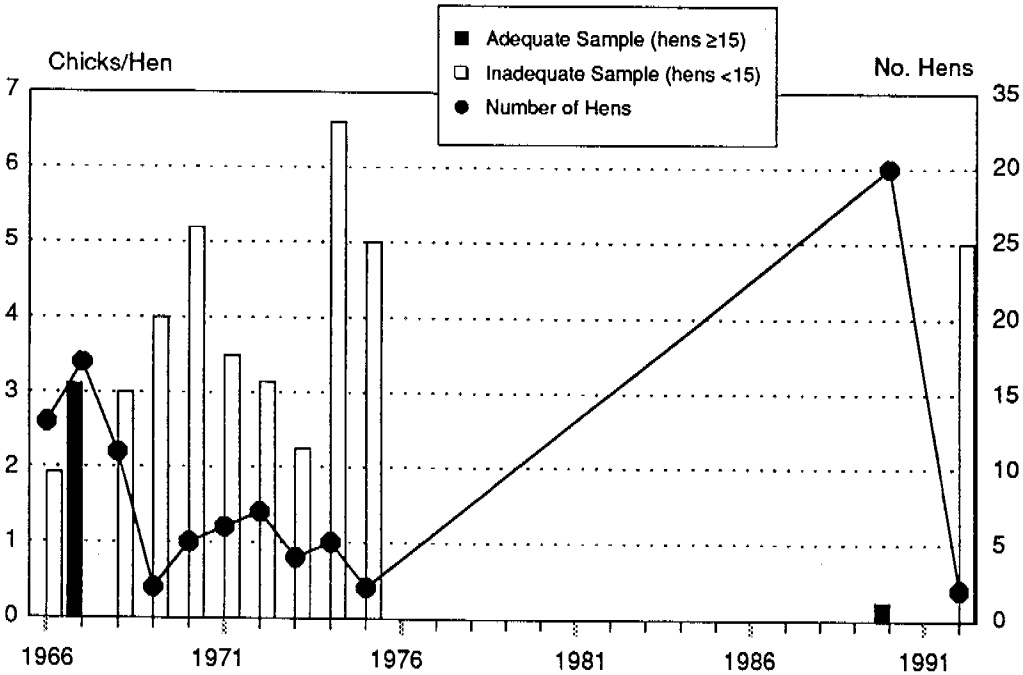

Figure 4. Chick/Hen Sage Grouse in Crook County, Oregon, 1966-92.

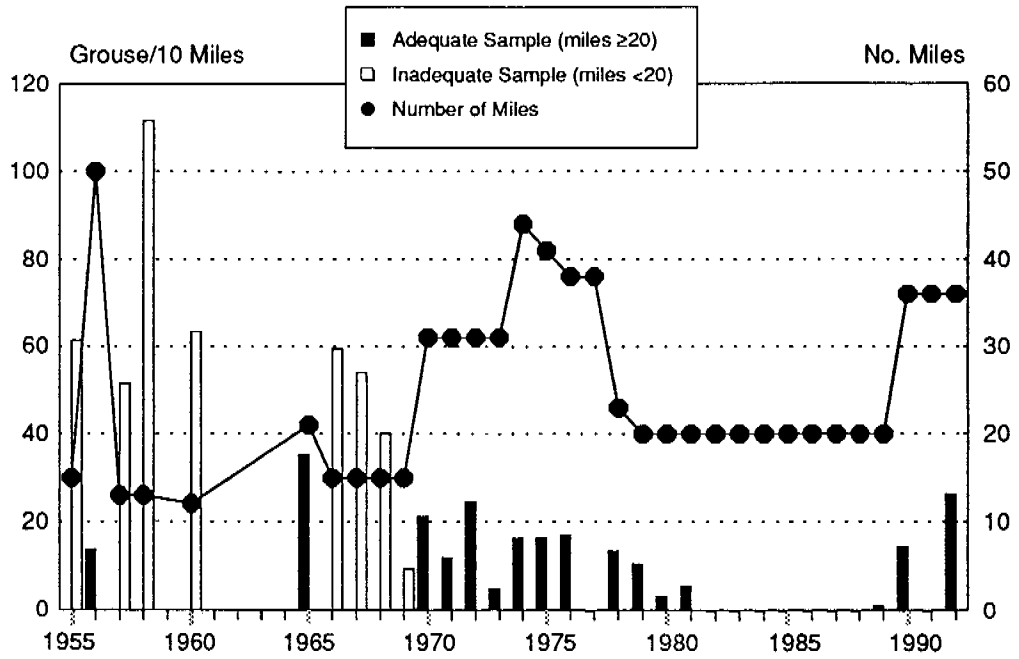

Figure 5. Sage Grouse/10 Miles in Crook County, Oregon, 1955-92.

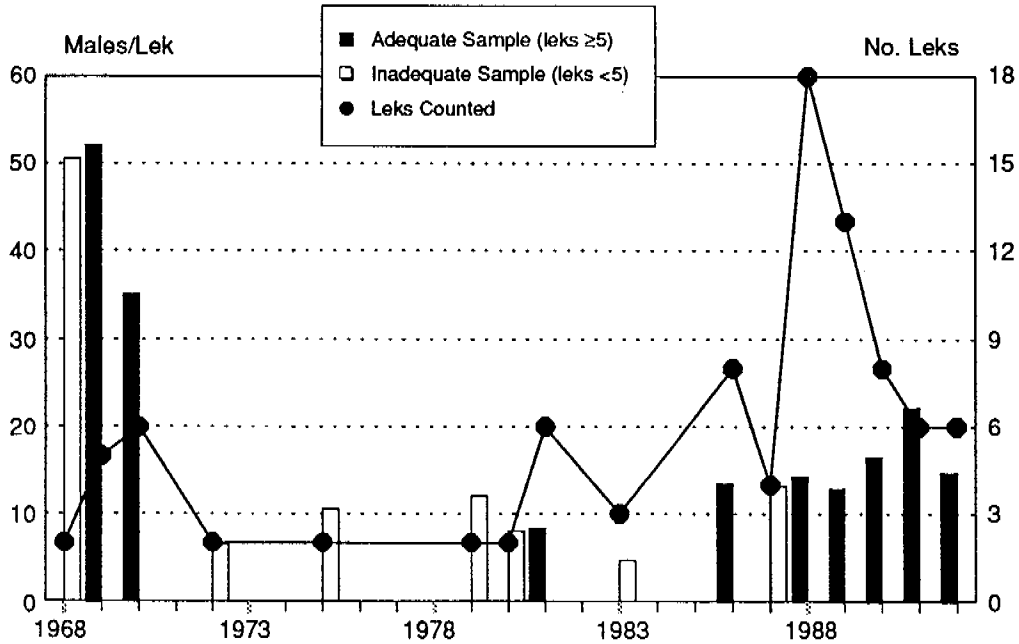

Figure 6. Males/Lek in Crook County, Oregon, 1968-92.

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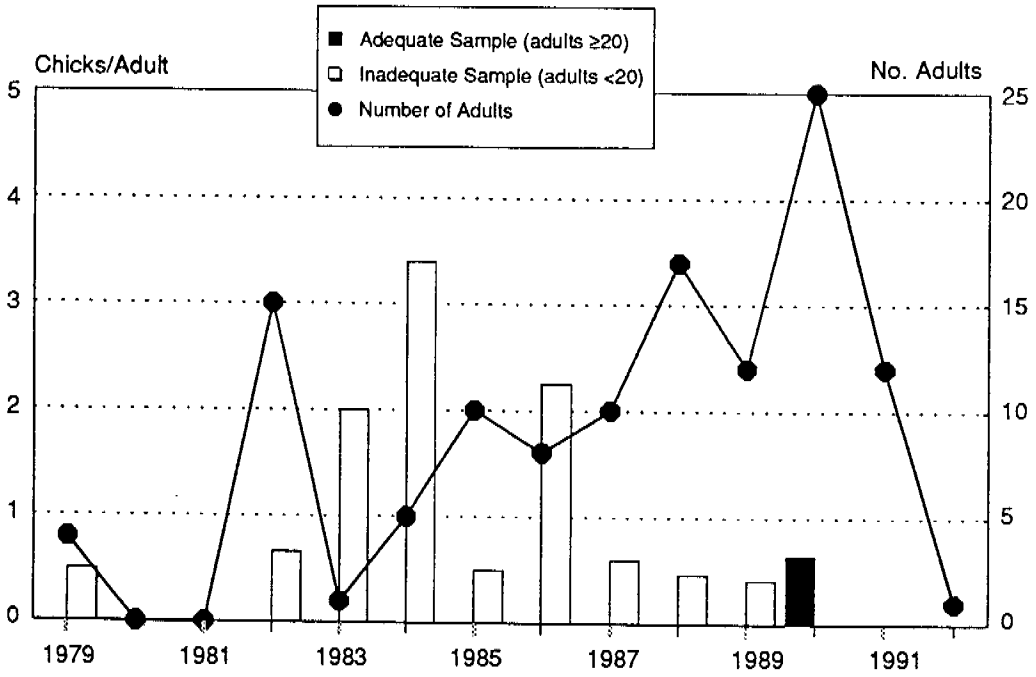

Figure 7. Chicks/Adults Sage Grouse in Deschutes County, Oregon, 1979-92.

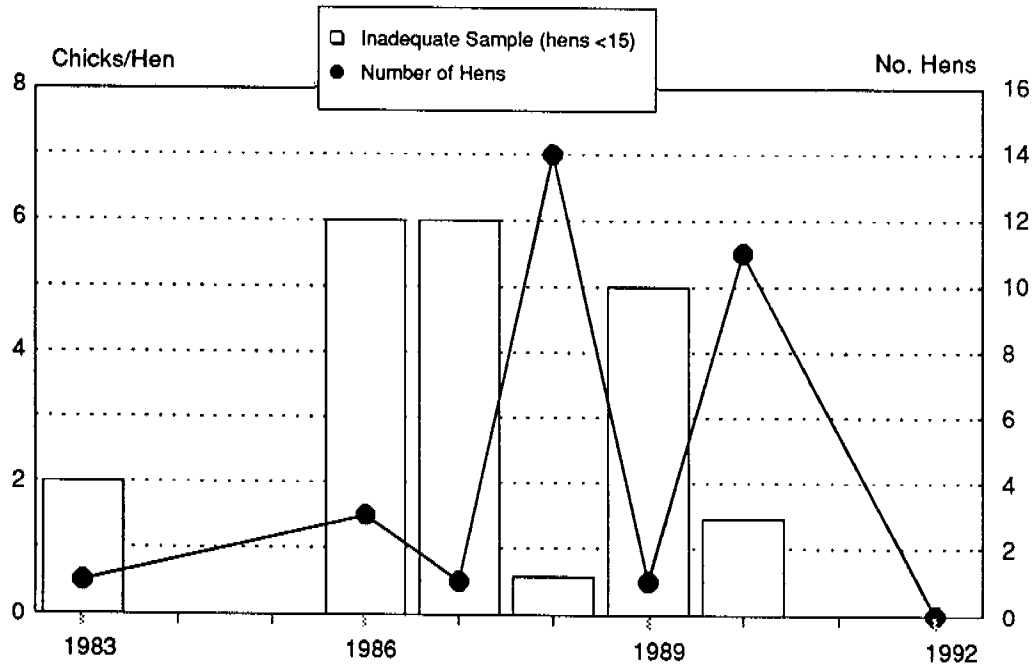

Figure 8. Chicks/Hen Sage Grouse in Deschutes County, Oregon, 1983-92.

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039342

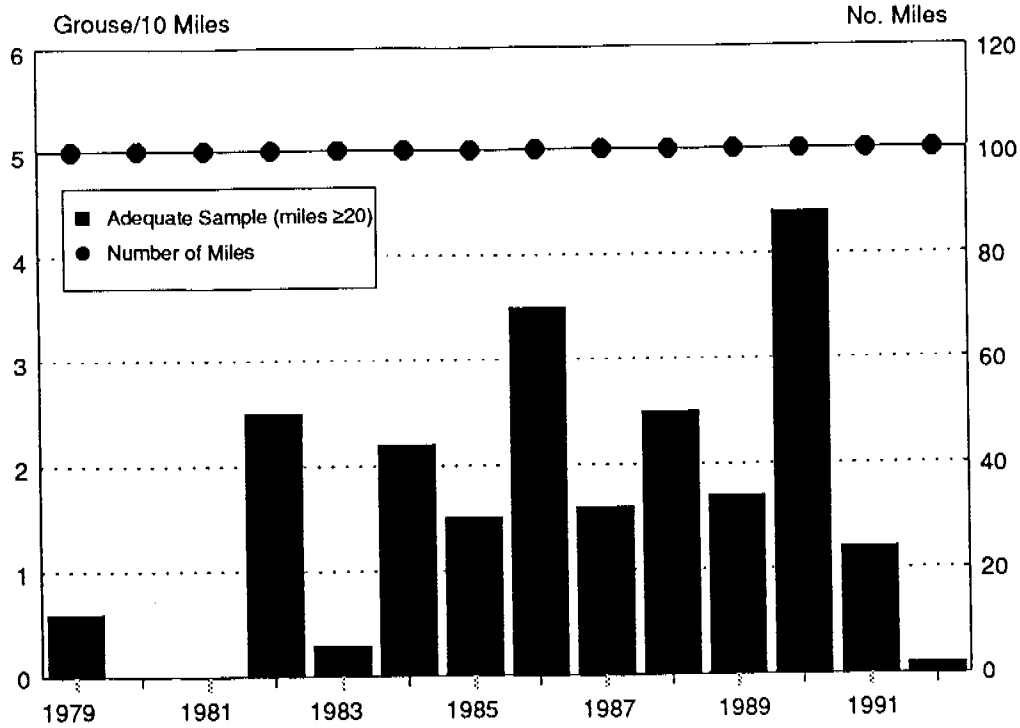

Figure 9. Sage Grouse/10 Miles in Deschutes County, Oregon, 1979-92.

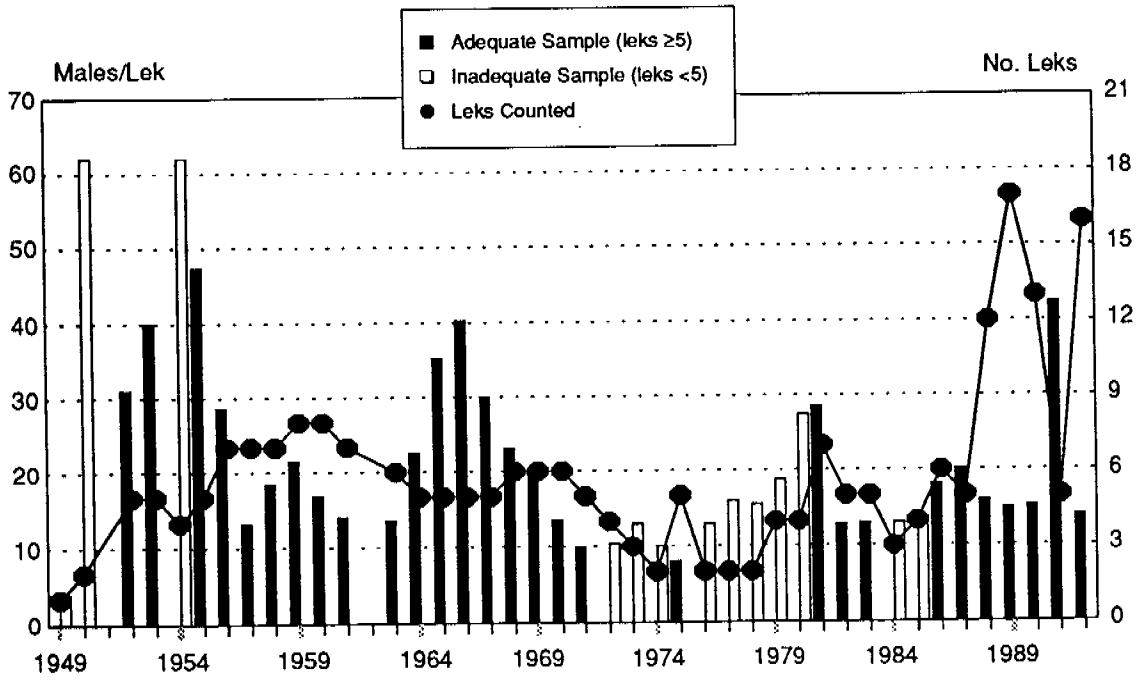

Figure 10. Males/Lek in Deschutes County, Oregon, 1949-92.

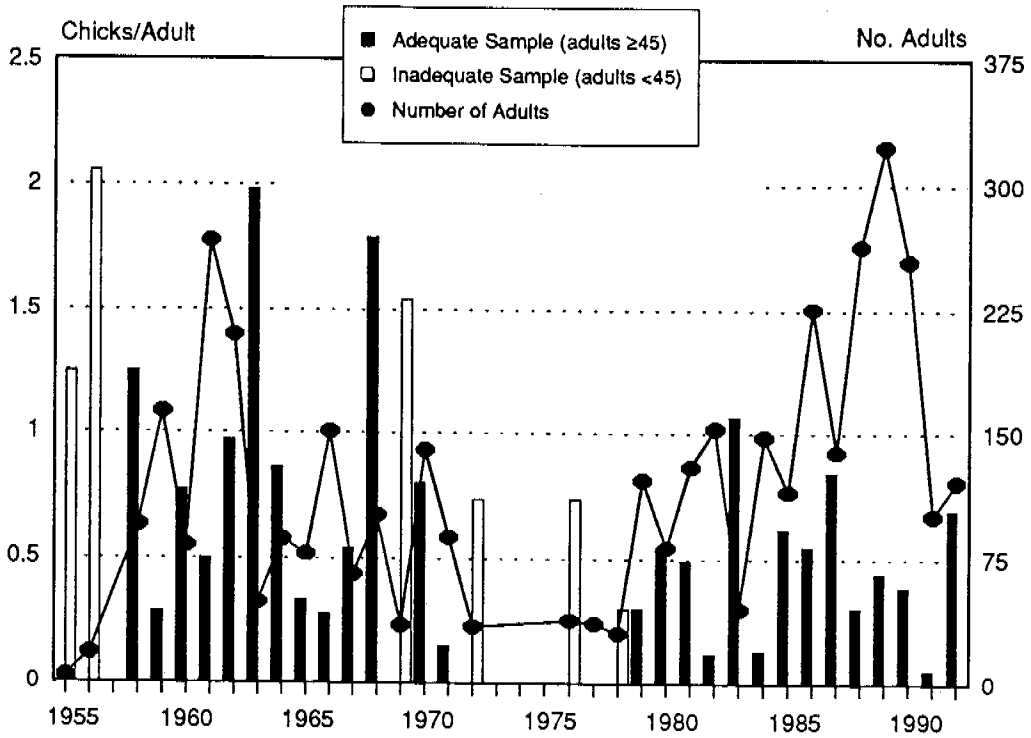

Figure 11. Chicks/Adult Sage Grouse in Harney County, Oregon, 1955-92.

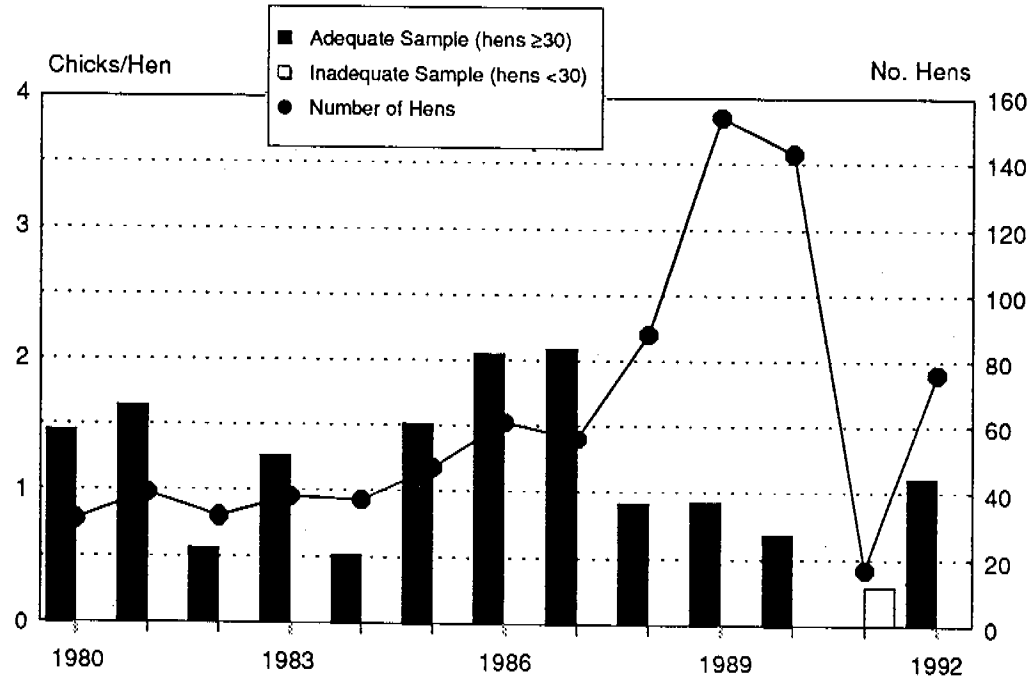

Figure 12. Chicks/Hen Sage Grouse in Harney County, Oregon, 1980-92.

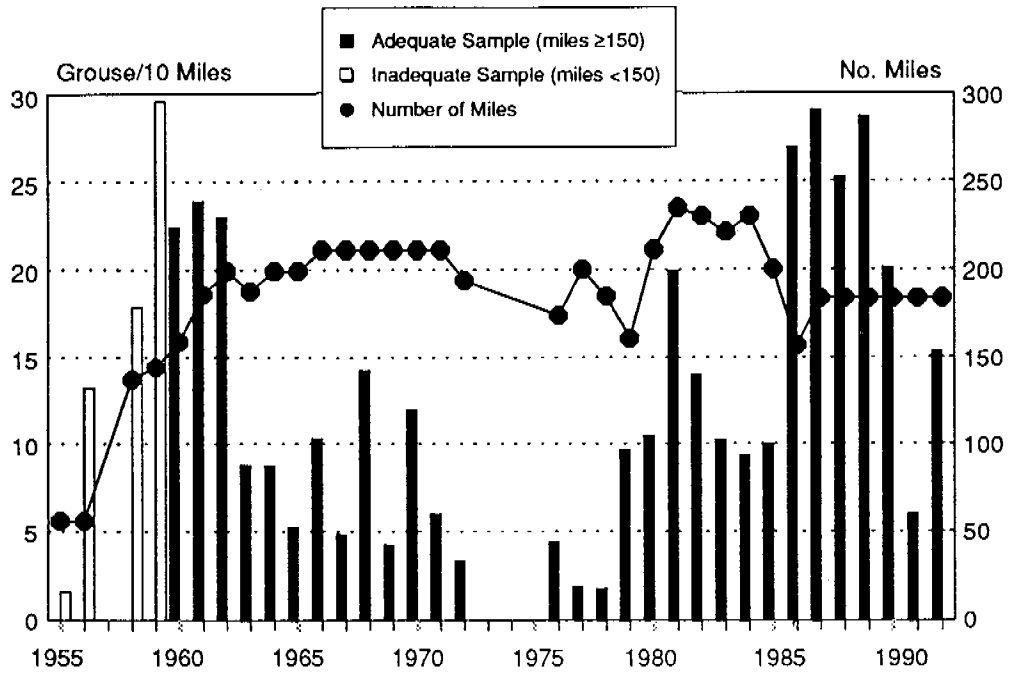

Figure 13. Sage Grouse/10 Miles in Harney County, Oregon, 1955-92.

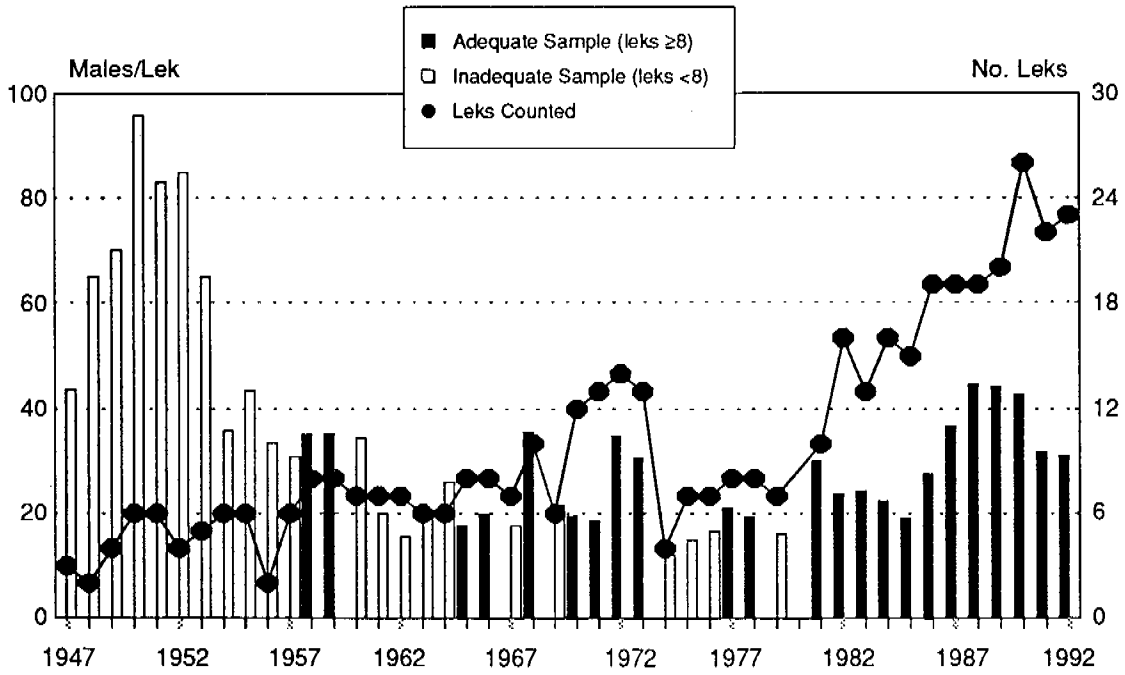

Figure 14. Males/Lek in Harney County, Oregon, 1947-92.

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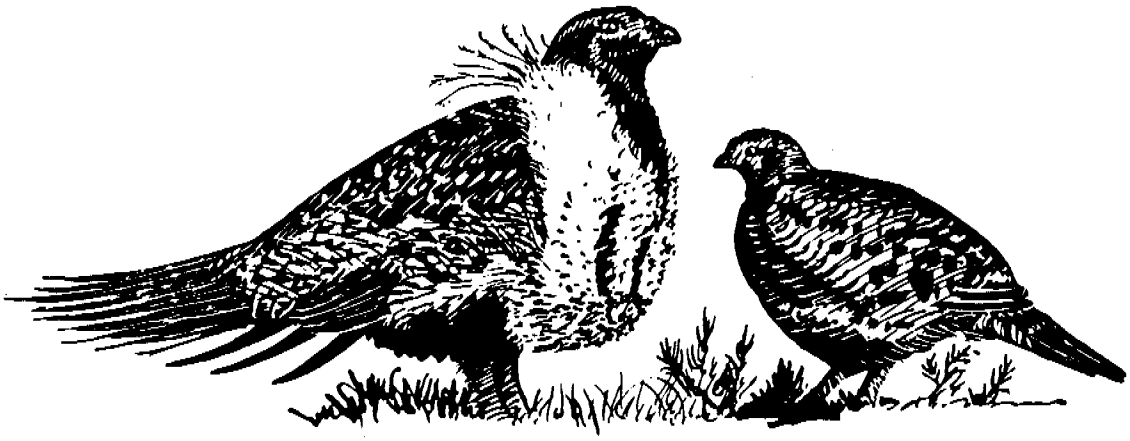


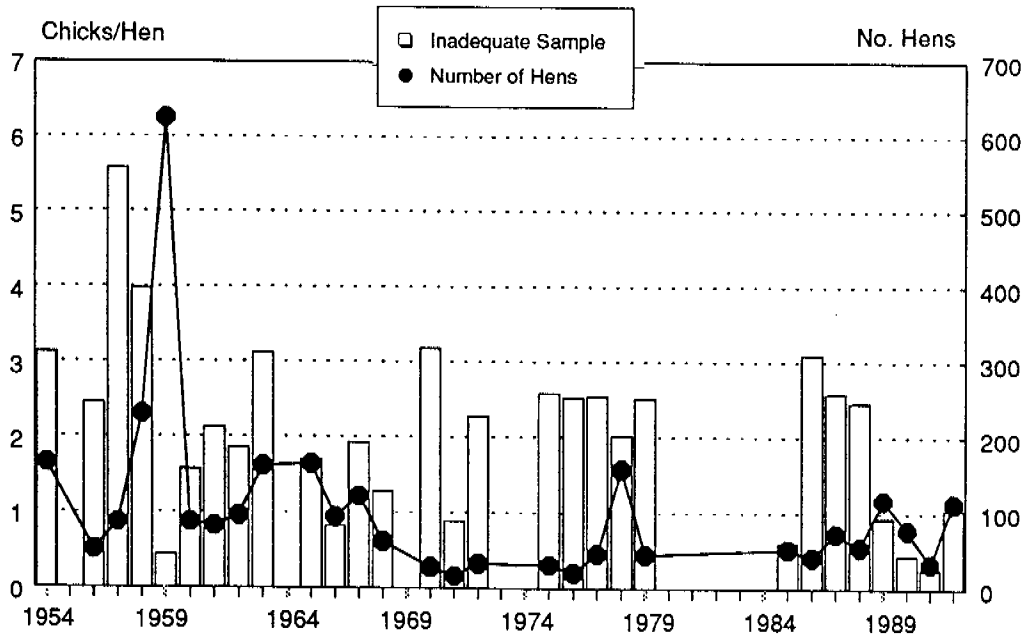


Figure 15. Chicks/Hen Sage Grouse on Hart Mountain National Antelope Refuge, Oregon, 1954-92.

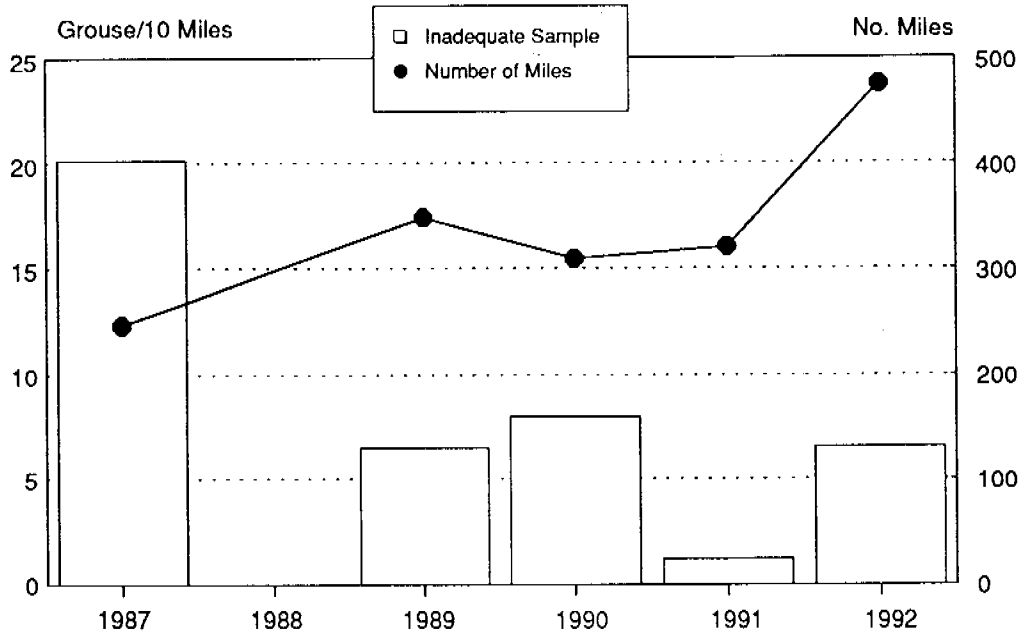


Figure 16. Sage Grouse/10 Miles on Hart Mountain National Antelope Refuge, Oregon, 1987-92.

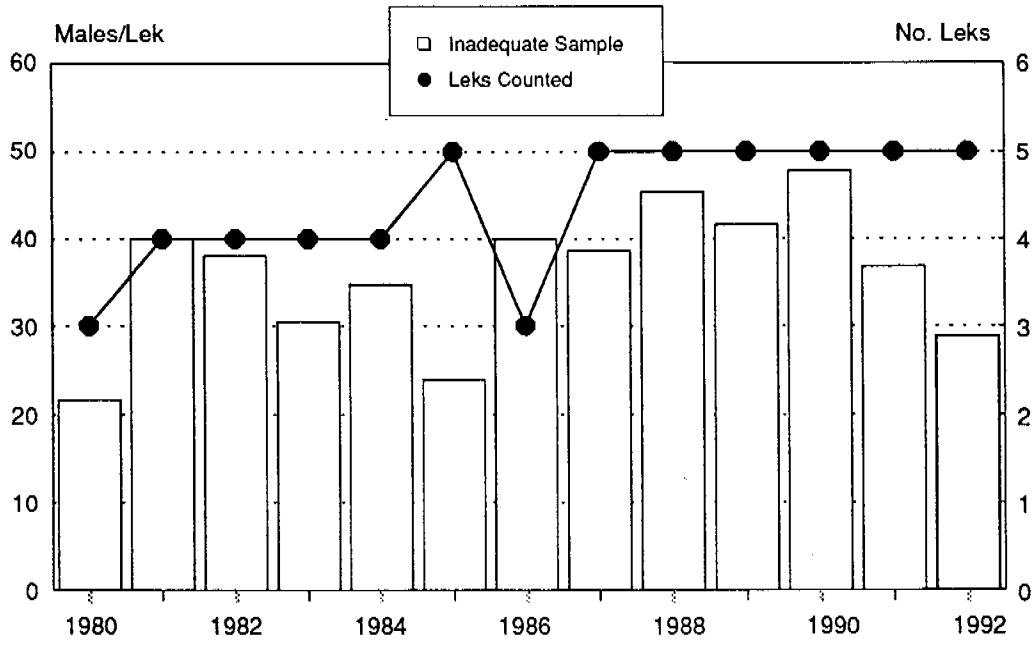


Figure 17. Males/Lek on Hart Mountain National Antelope Refuge, Oregon, 1980-92.

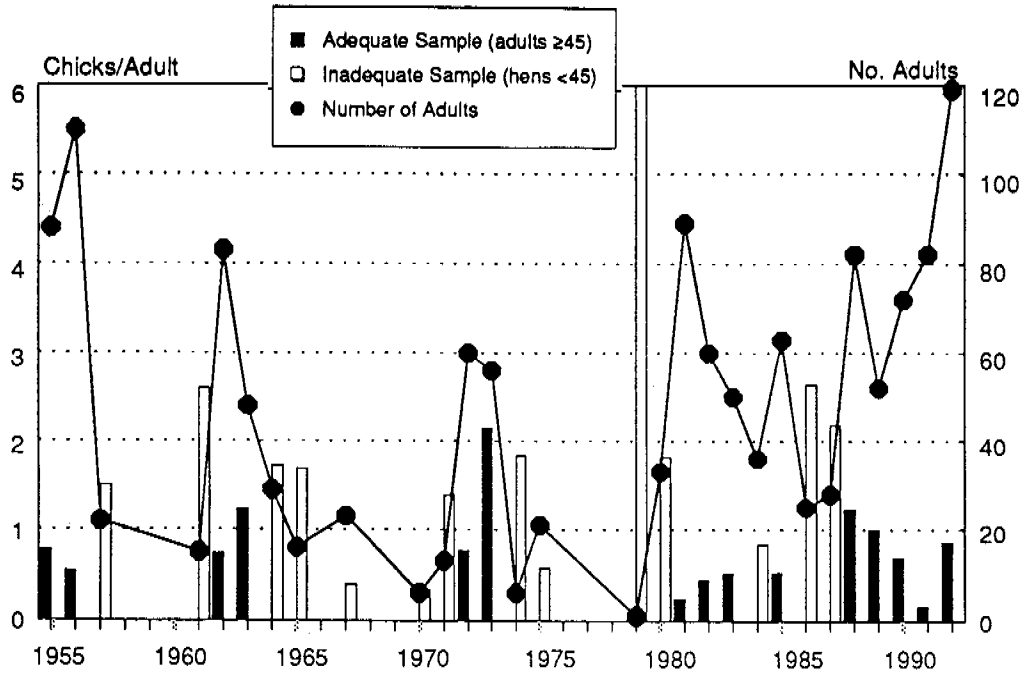


Figure 18. Chicks/Adult Sage Grouse in Lake County, Oregon, 1955-92.

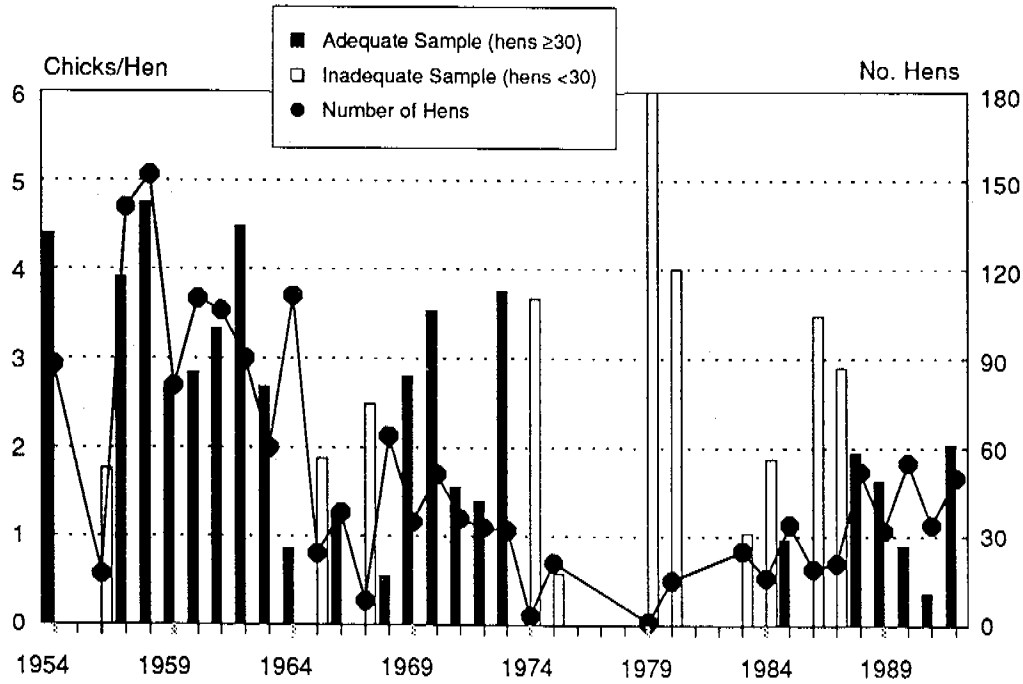


Figure 19. Chicks/Hen Sage Grouse in Lake County, Oregon, 1954-92.

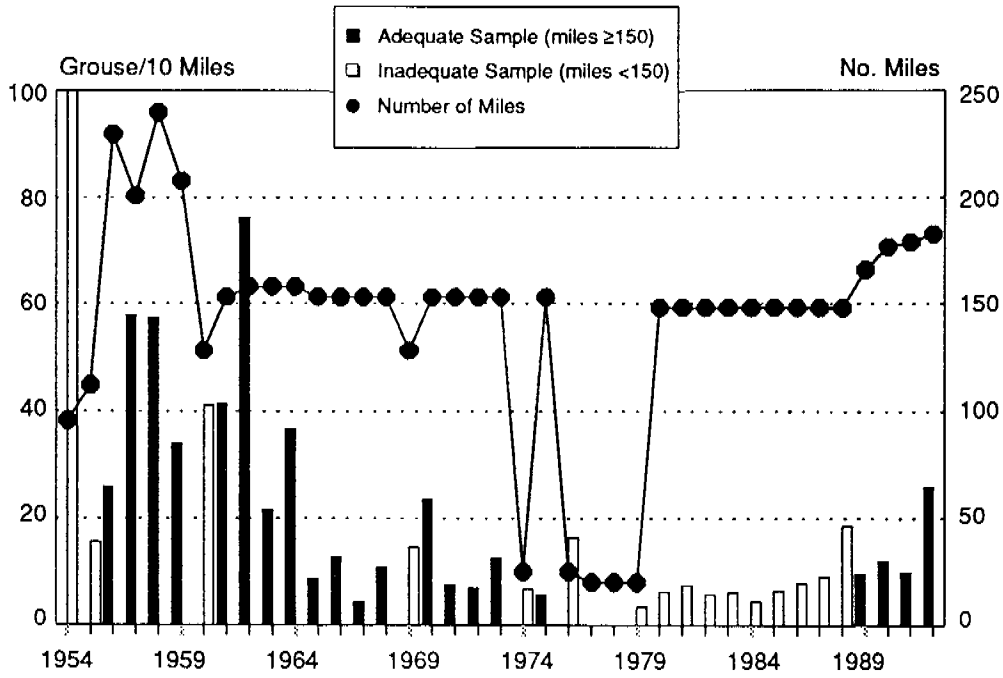


Figure 20. Sage Grouse /10 Miles in Lake County, Oregon, 1954-92.

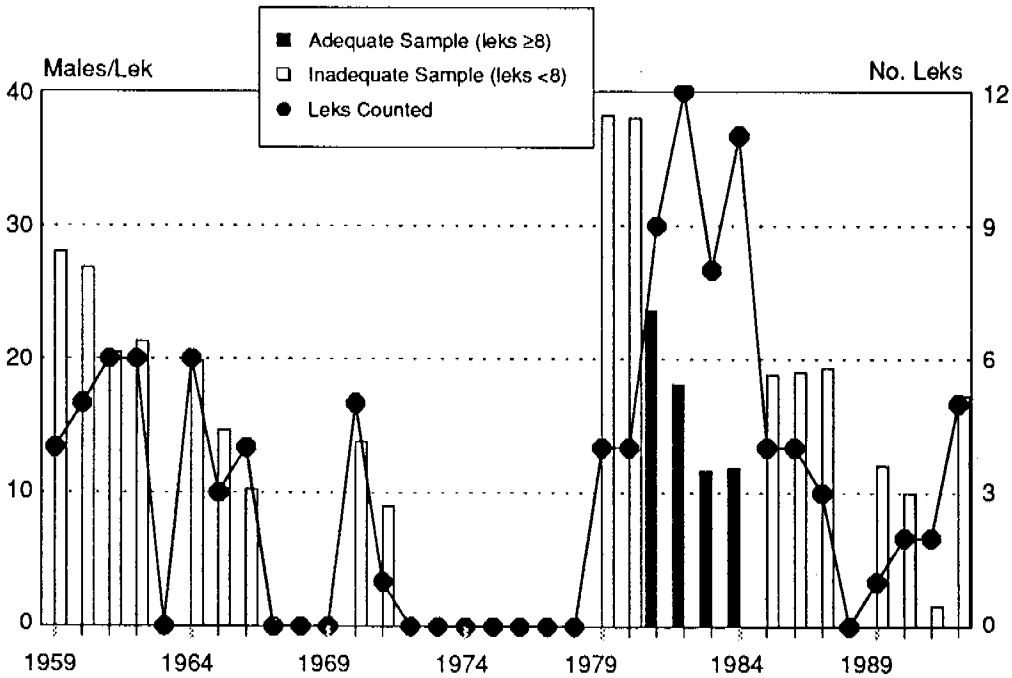


Figure 21. Males/Lek in Lake County, Oregon, 1959-92.

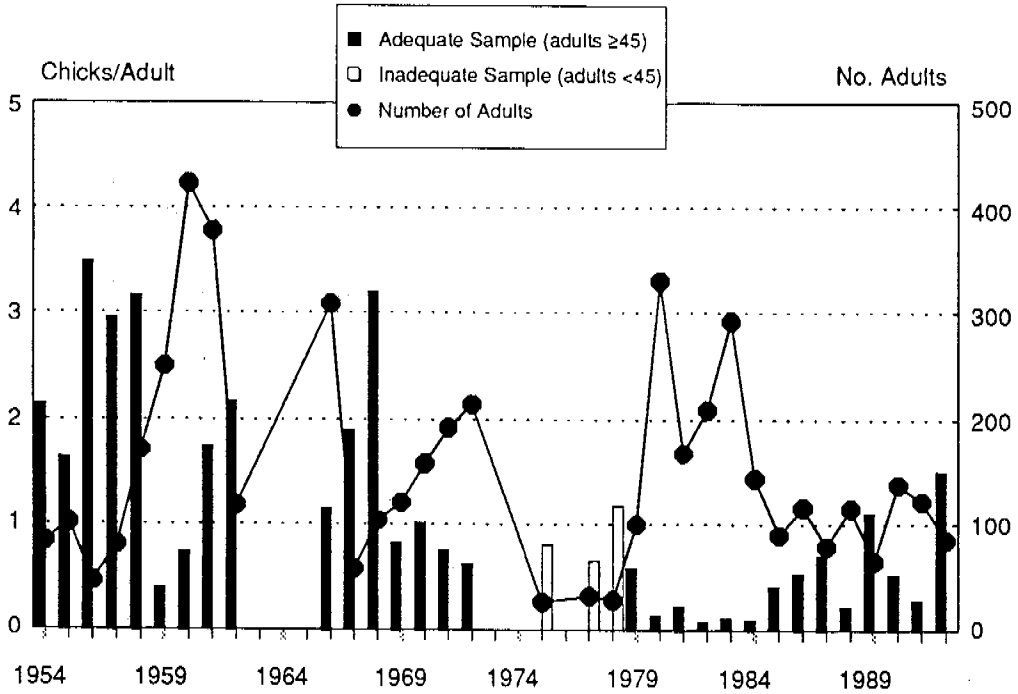


Figure 22. Chicks/Adult Sage Grouse in Malheur County, Oregon, 1954-92.

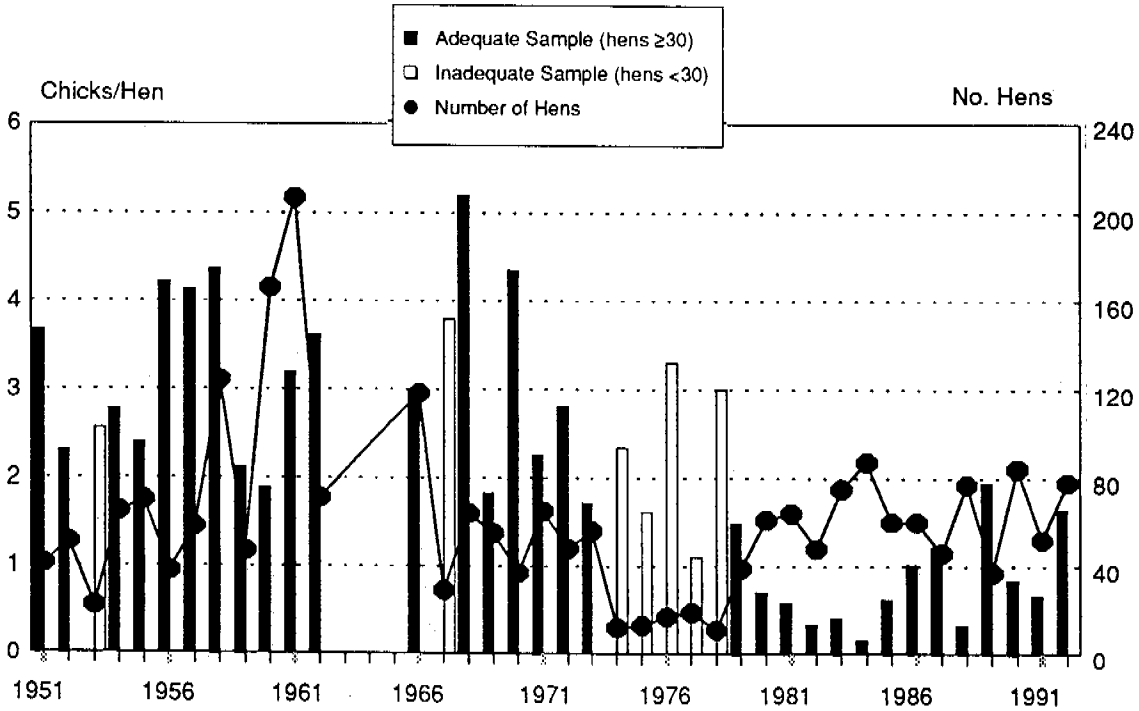


Figure 23. Chicks/Hen Sage Grouse in Malheur County, Oregon, 1951-92.

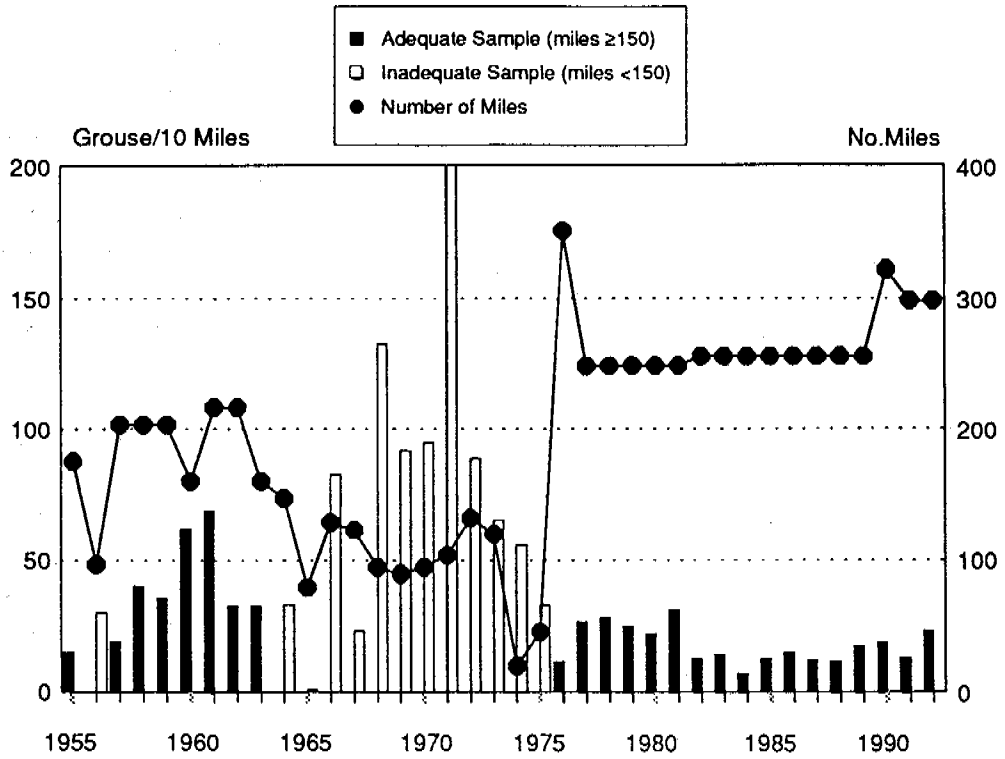


Figure 24. Sage Grouse/10 Miles in Malheur County, Oregon, 1955-92.

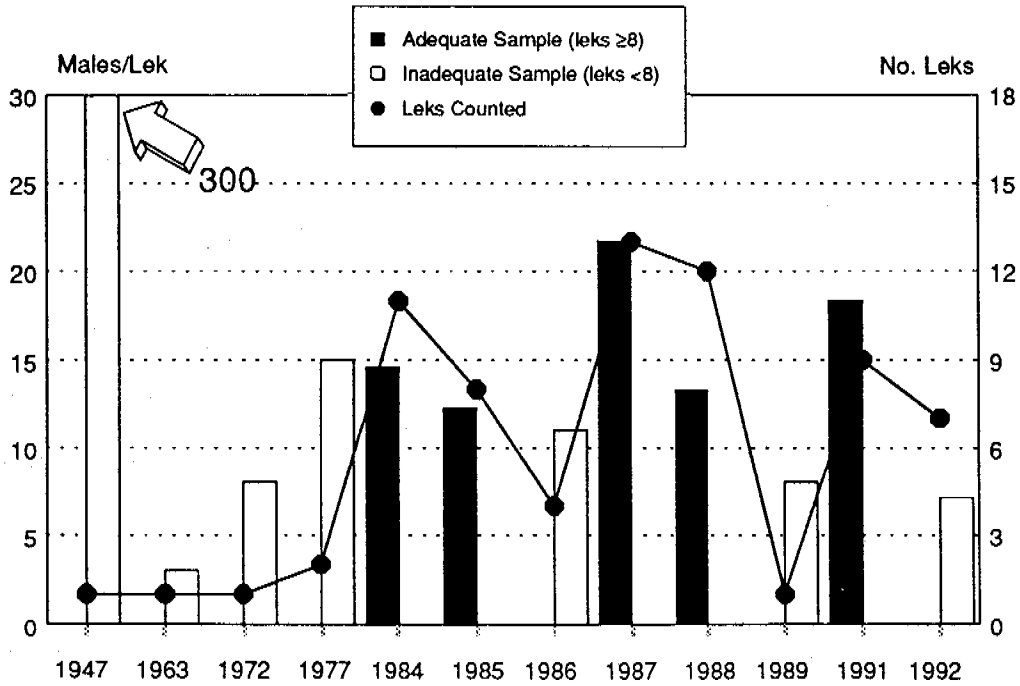


Figure 25. Males/Lek in Malheur County, Oregon, 1947-92.

Peripheral Counties

(Figures 26–29)

Baker, Crook, and Deschutes counties were included in the graphs as data were available. Although data from production routes seldom met sample size criteria, there was a good history of lek counts since the 1940s. Grouse/10 miles and chicks/adult declined slightly yet significantly (b = -0.07 and -0.07). Sample size was insufficient for chicks/hen. No significant relationship was found for males/lek and time since 1946.

Other peripheral counties were surveyed in addition to those reported above. Union County has two known leks with fairly stable numbers estimated at about 125 birds. Aerial spraying of habitat and grazing were believed to be the limiting factors by the ODFW wildlife biologist.

No census work was conducted in Grant County, although three populations were reported by the former ODFW biologist. The current ODFW wildlife biologist reported stable numbers in two sage grouse areas in his district. The Bear Valley population was estimated at about 60 birds.

The Wheeler County ODFW biologist reported the occurrence of sage grouse in one area.

There are apparently no sage grouse in Wasco County, according to the ODFW wildlife biologist. Long-term residents reported sage grouse were found at the southern edge of the county at the turn of the century.

The Klamath county ODFW biologist reported 77 documented sightings of sage grouse since 1979. Seven historic leks were described; no birds were observed in 1992.

Core Counties

(Figures 30–33)

Data were available that met sample size criteria since the early 1950s. Significant declines were observed in grouse/10 miles (b = -0.60), chicks/adult (b = -0.04), and chicks/hen (b = -0.071). No decline (b = 0.08) in males/lek was detected over time.

Statewide

(Figures 34–37)

Data from all counties were pooled to develop statewide trends. A number of years did not meet adequate sample size criteria, particularly during the early 1950s (when the number of leks counted statewide were often < 10) and the mid 1970s (when the number of miles for production routes declined). These data are called statewide, even though production routes were not conducted in some areas and lek counts were not conducted in others. Chicks/adult (b = -0.03), chicks/hen (b = -0.07), and grouse/10 miles (b = -0.77) declined significantly since the late 1950s. There was no significant relationship between males/lek and time.

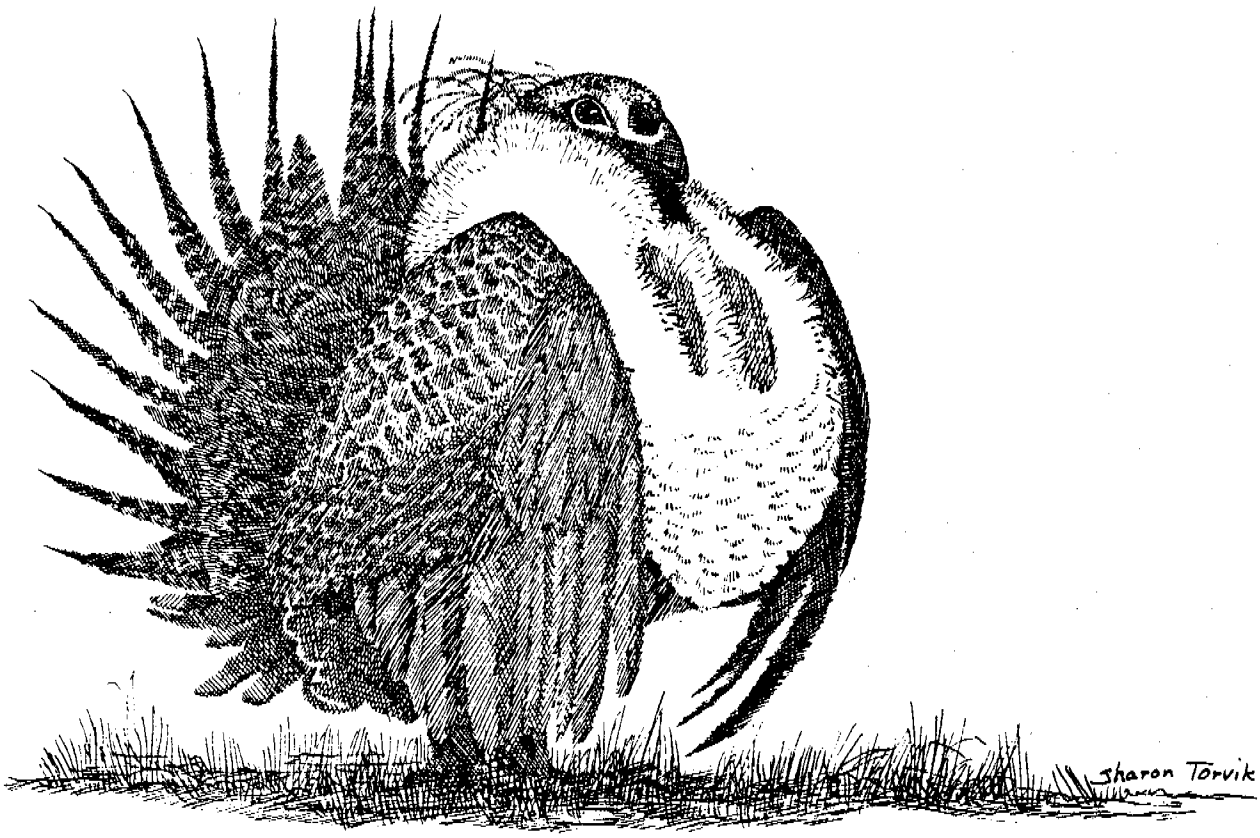
For a more in depth analysis, data were grouped by early and late periods which were the two distinct time intervals when data met minimum sample size criteria (Figures 34-37) The early period was generally from the mid-1950s through the early 1970s and the late period was generally from the mid-1970s through 1992. No significant relationships were found for any index and time for either the early or late time periods. However, chicks/hen, chicks/adult, and grouse/10 miles were significantly greater during the early period than during the later period (Table 2). There was no difference found for males/lek between periods. This analysis indicated that reductions in productivity (i.e., chicks/hen, chicks/adult) did not occur gradually but occurred sometime between the early and mid-1970s.

It is important to note the peak in sage grouse/10 miles observed during the late 1960s and early 1970s (Figure 36) may be an artifact of the data caused by sampling methods and/or possibly better conditions for sage grouse in Malheur County (Figure 24). The number of miles inventoried in Malheur County dropped to less than 100, and grouse per 10 miles increased to between 80 and 200. This was probably due to counting only the best habitat and counting large concentrations of birds. While a large number of birds were counted in Malheur County, the other

Table 2. Comparison of Sage Grouse Indices Between Early and Late Data Collection Periods in Oregon.

	Early Period		Late Period		Comparisons	
Index	Year	Mean	Year	Mean	t Value	P
Chicks/Hen	1954-73	2.87	1980-92	1.06	6.24	0.0001
Chicks/Adult	1955-72	1.29	1979-92	0.48	4.04	0.0004
Gouse/10 Miles	1956-72	31.42	1976-92	13.11	6.09	0.0001
Males/Lek	1958-73	24.56	1979-92	22.10	1.43	0.1643

core counties (Lake and Harney) generally counted less than 20 grouse /10 miles for the same period. When data were combined between counties, a peak of 30-40 grouse /10 miles was calculated statewide. This peak, however, was driven by the large number seen per 10 miles in Malheur County.



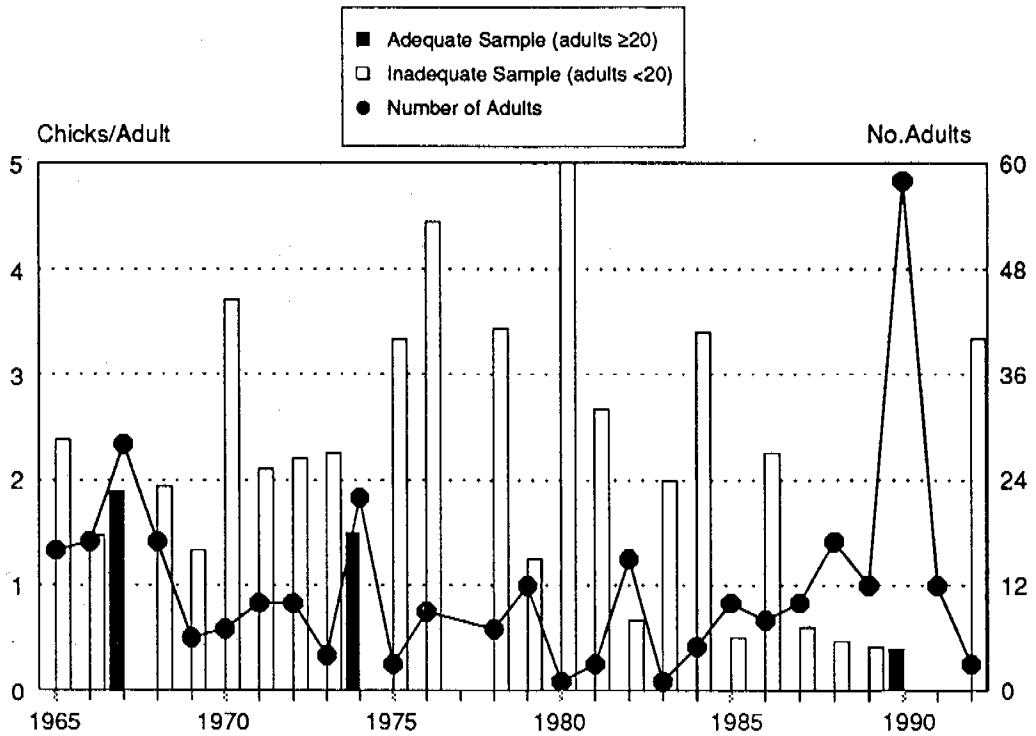


Figure 26. Chicks/Adult Sage Grouse in Peripheral Counties, Oregon, 1965-92.

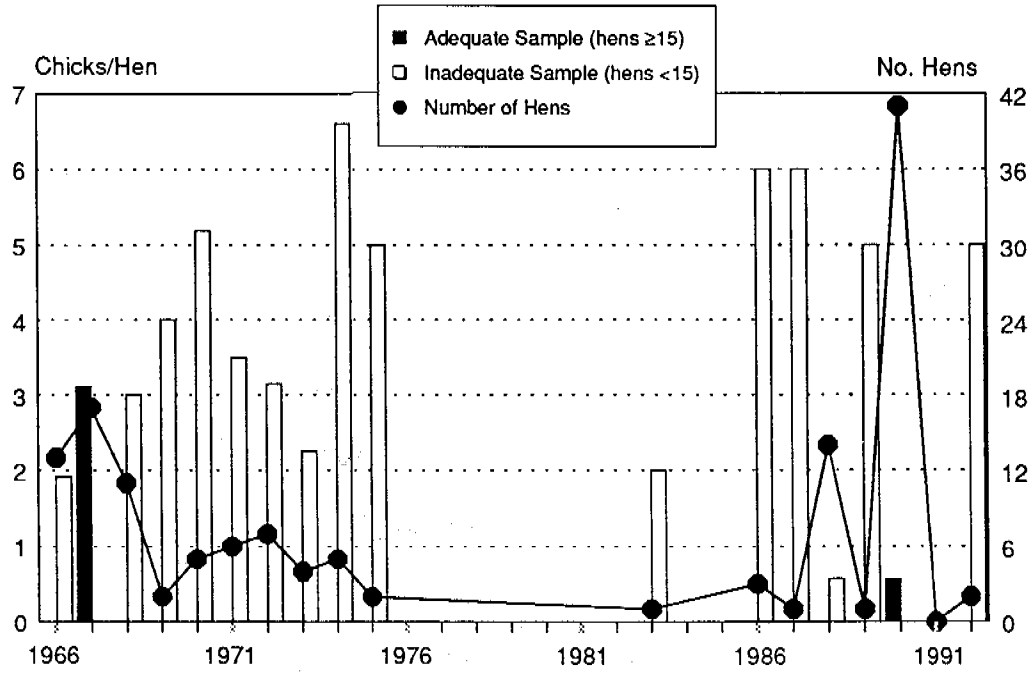


Figure 27. Chicks/Hen Sage Grouse in Peripheral Counties, Oregon, 1966-92.

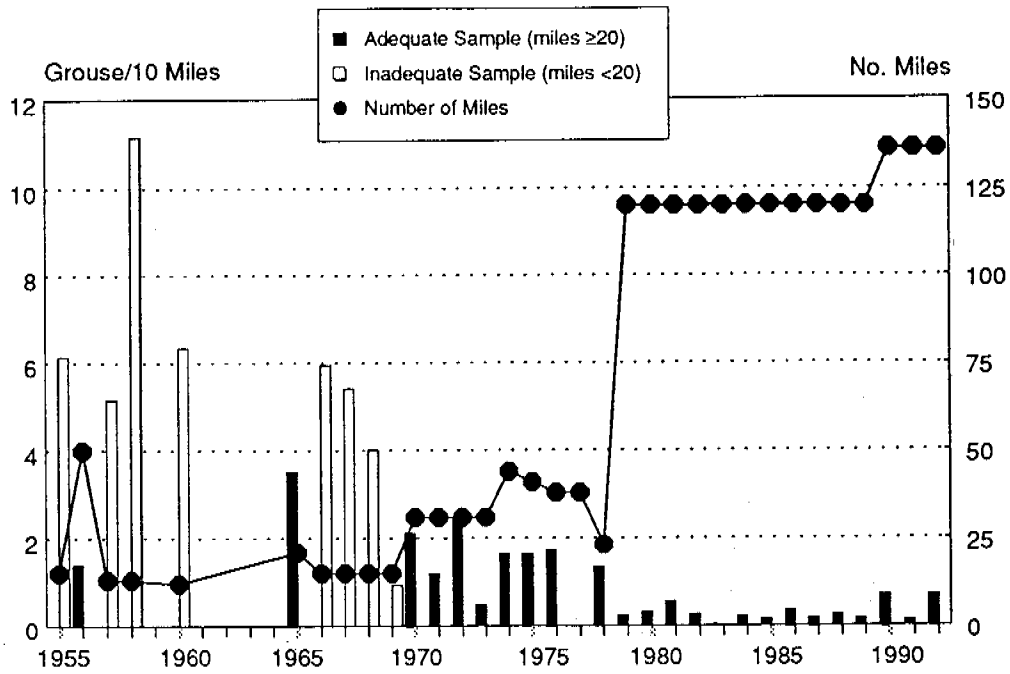


Figure 28. Sage Grouse/10 Miles in Peripheral Counties, Oregon, 1955-92.

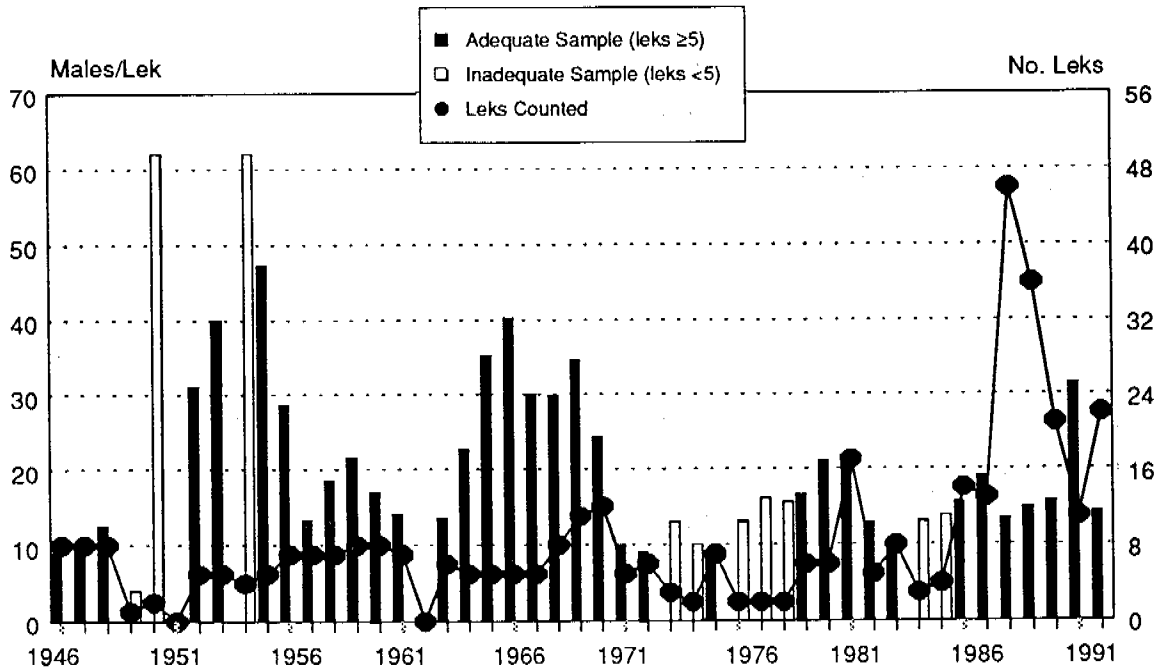


Figure 29. Males/Lek in Peripheral Counties, Oregon, 1946-92.

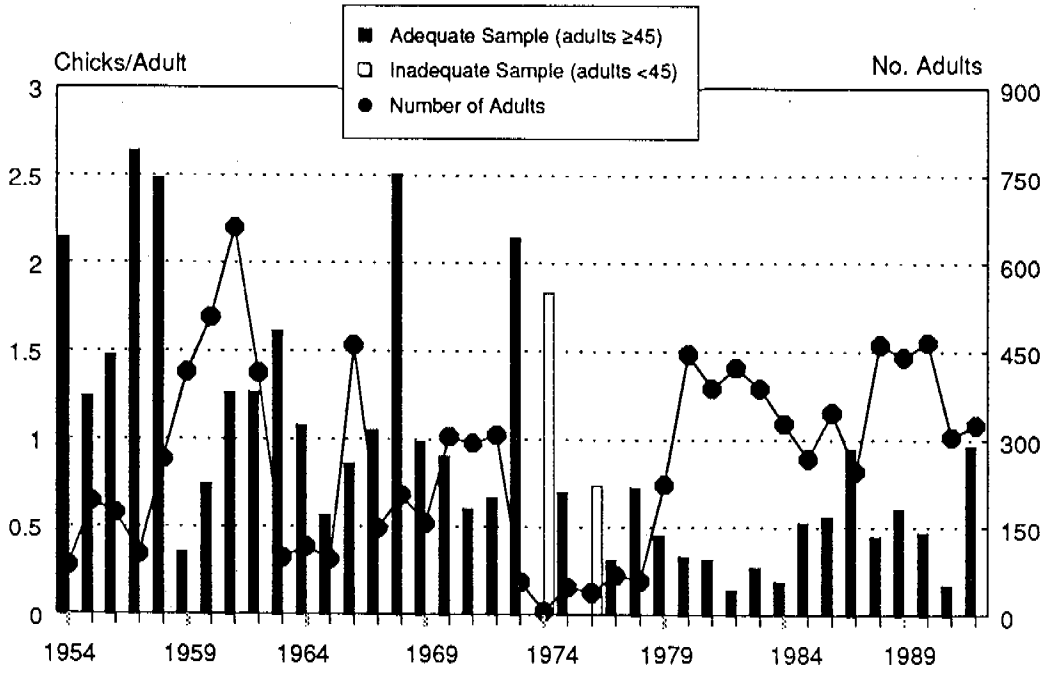


Figure 30. Chicks/Adult Sage Grouse in Core Counties, Oregon, 1954-92.

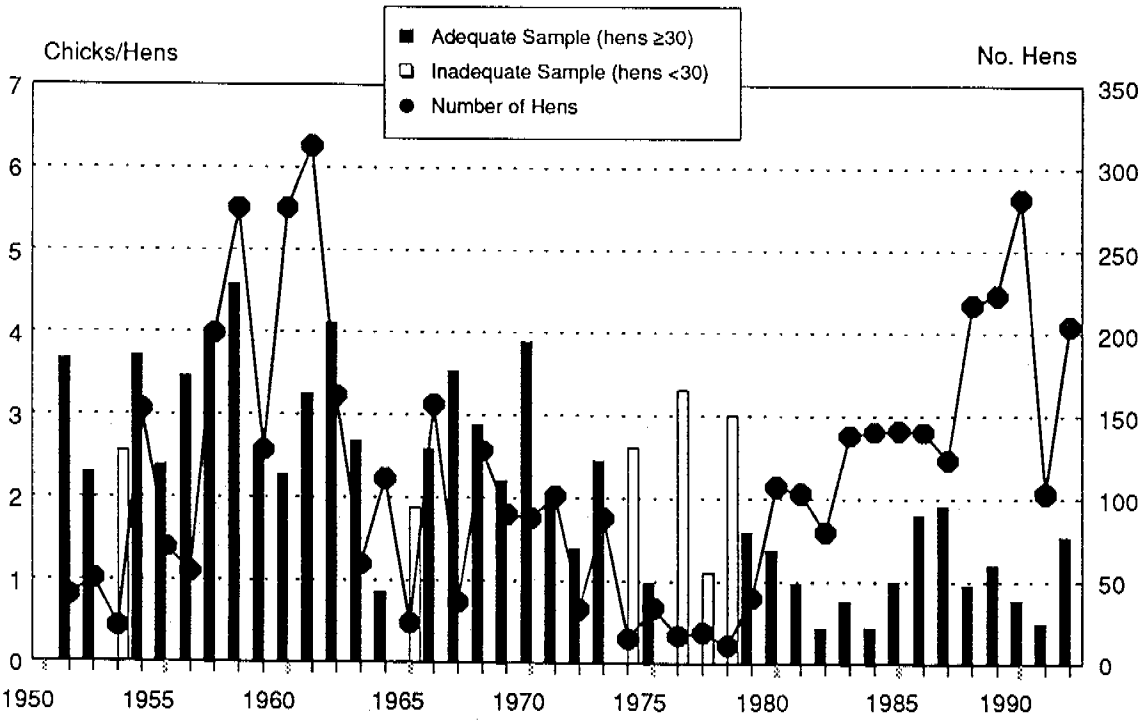


Figure 31. Chicks/Adult Sage Grouse in Core Counties, Oregon, 1950-92.

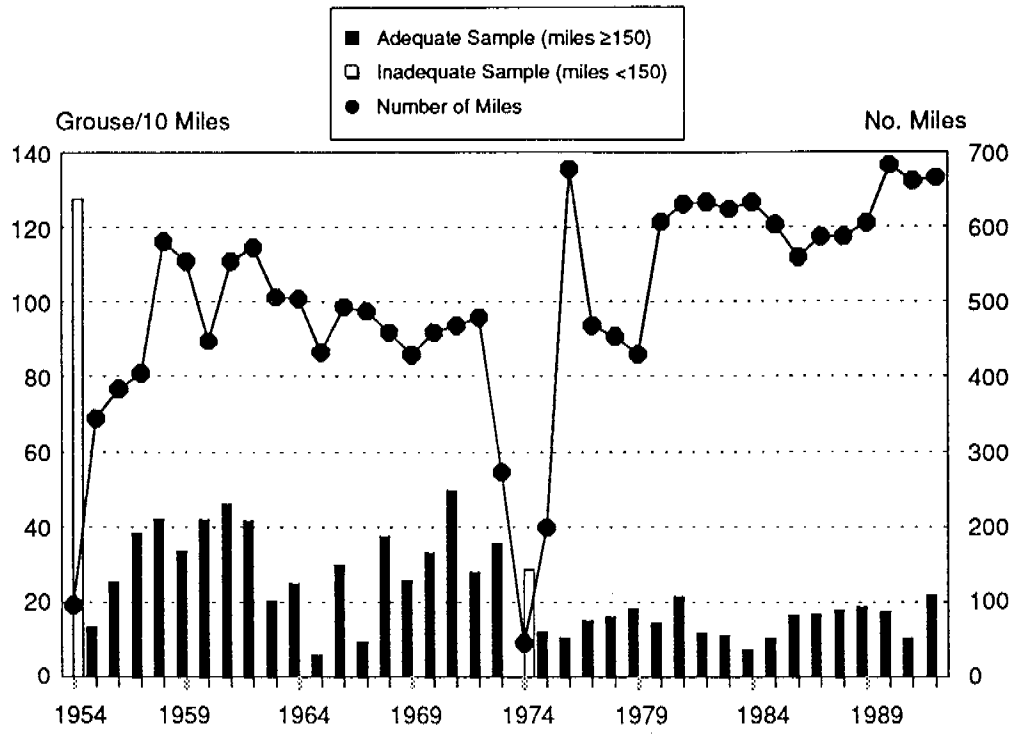


Figure 32. Sage Grouse/10 Miles in Core Counties, Oregon, 1954-92.

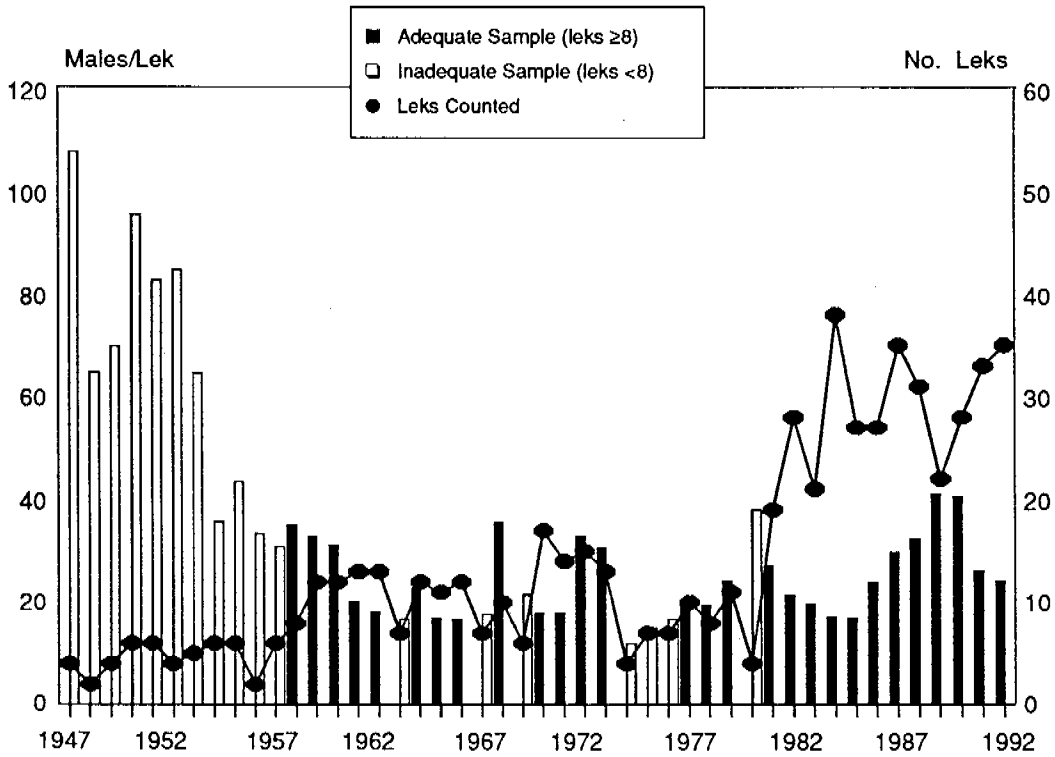


Figure 33. Males/Lek in Core Counties, Oregon, 1947-91.

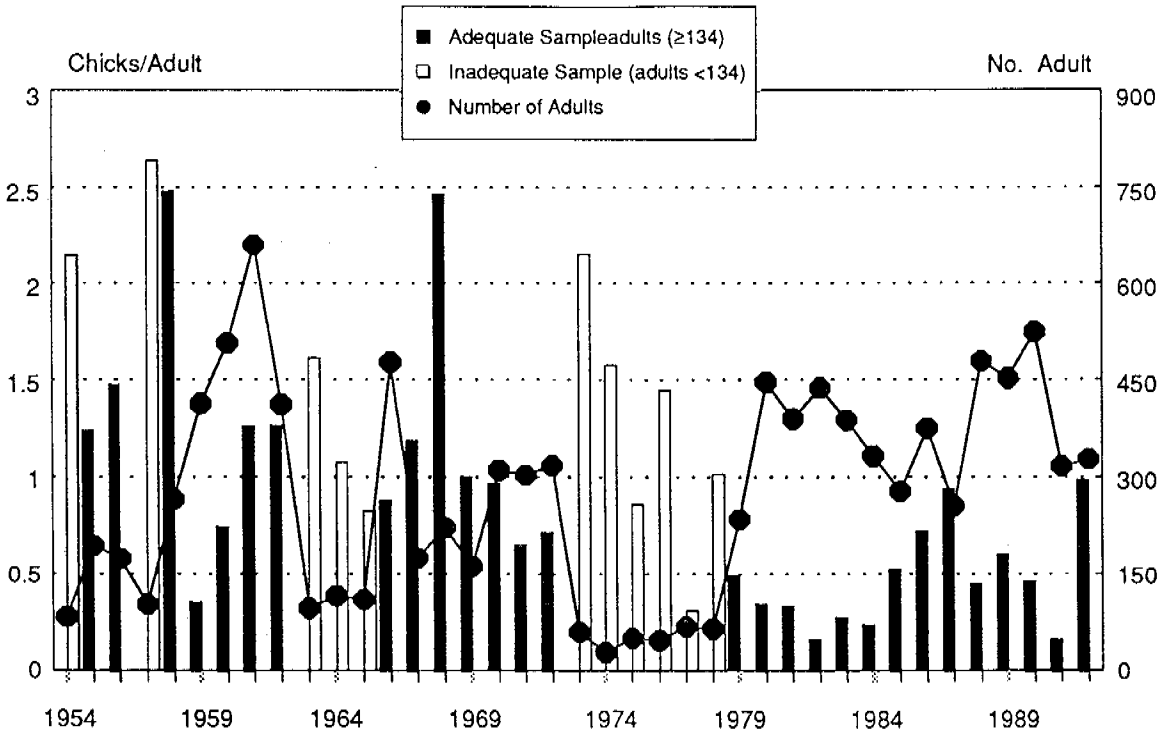


Figure 34. Chicks/Adult Sage Grouse Statewide in Oregon, 1954-92.

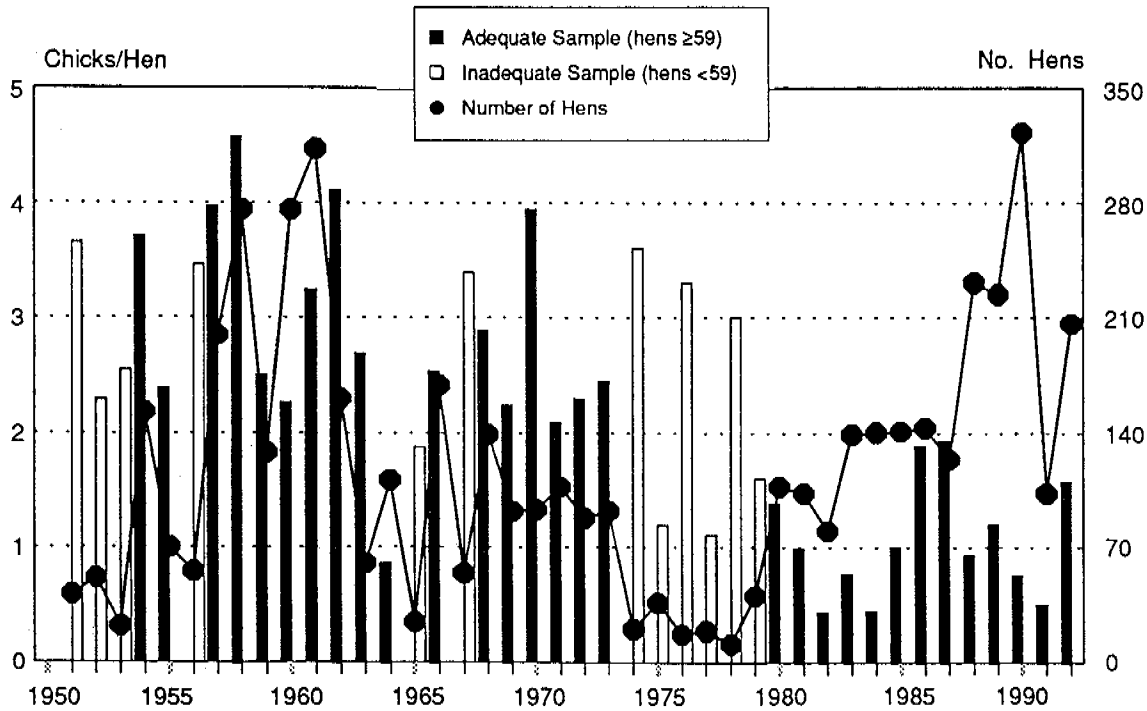


Figure 35. Chicks/Hen Sage Grouse Statewide in Oregon, 1951-92.

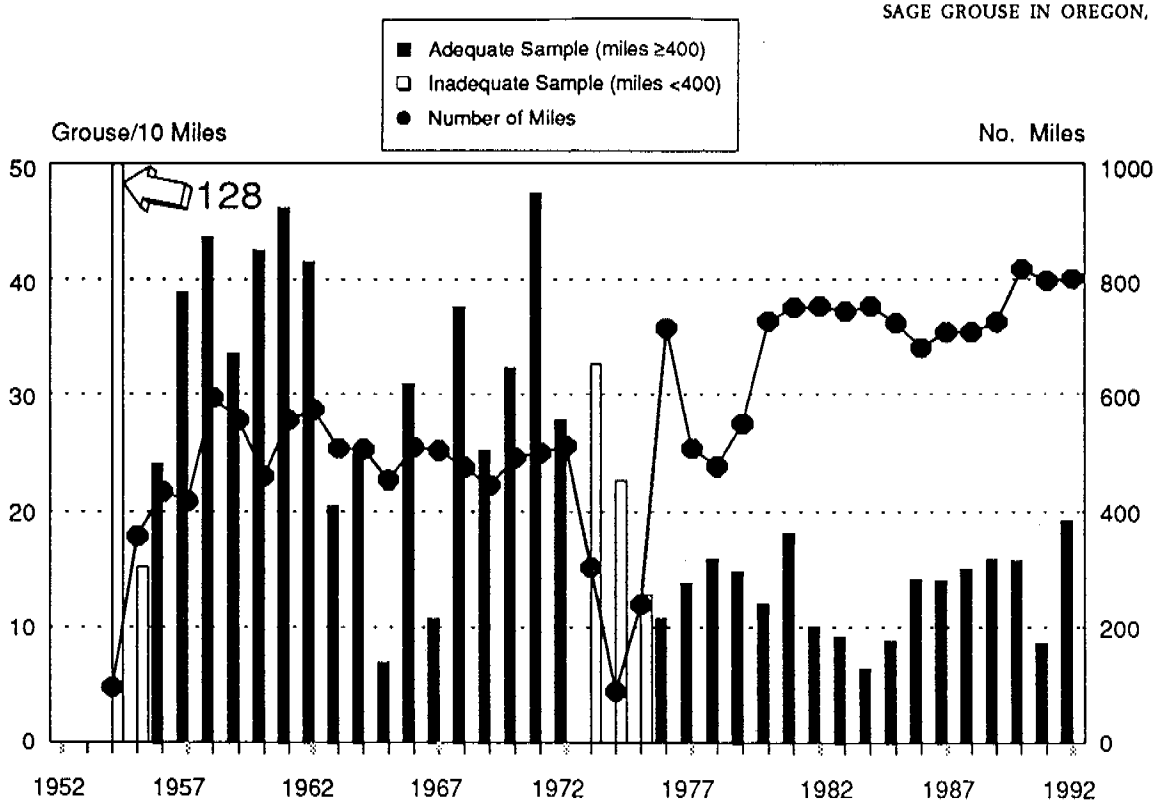


Figure 36. Sage Grouse/10 Miles Statewide in Oregon, 1954-92.

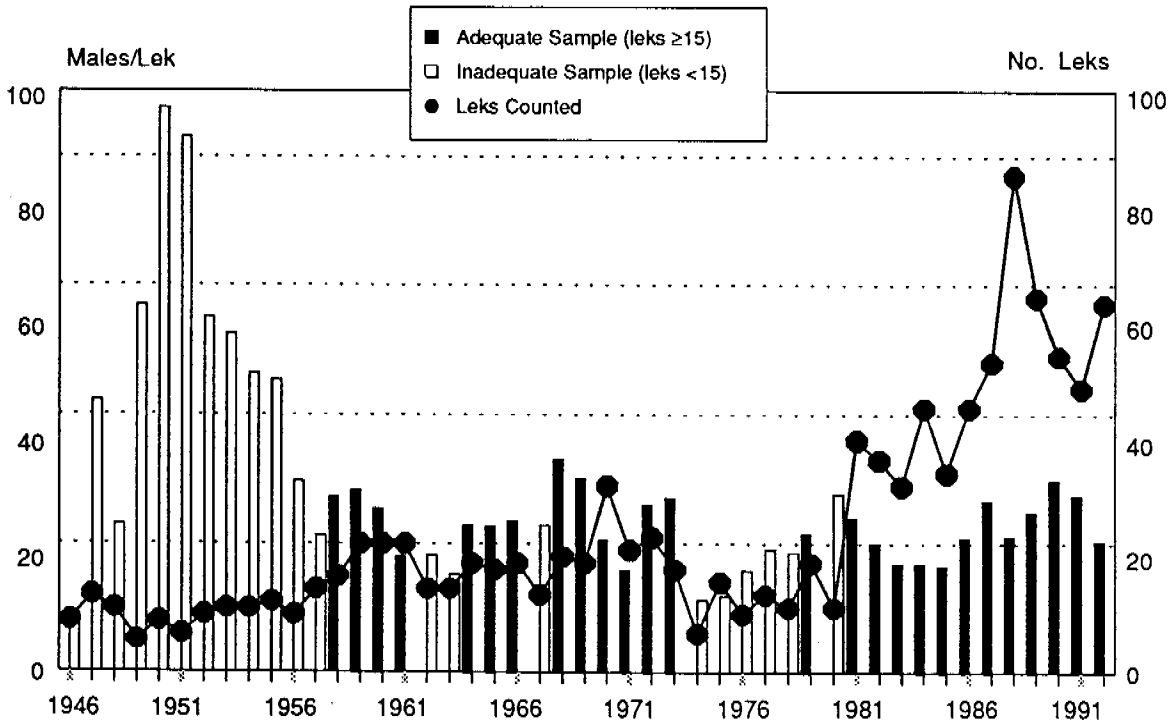


Figure 37. Males/Lek Statewide in Oregon, 1946-92.

Summary

Analysis of these data was difficult and challenging because of inconsistencies in methods and sampling intensity among counties and years. Production data were particularly inconsistent and many times of low reliability due to the above differences, the short time frame for data collection, poor counting conditions some years, and the large areas sampled. As can be seen (Figures 34-37), data collected during the last approximately 13 years were of higher quality due to larger sample sizes and more consistent collection.

Results of these analyses and statistical significance of the data were dependent on the range of years analyzed. Data were only available back to the late 1940s and early 1950s. Our analyses, therefore, covered the period that began during the last period of high sage grouse abundance which effectively increased the slope and significance of regressions and our interpretation of trends. For example, trends in productivity and grouse/10 miles were significant and declining because data which met sample size criteria began in the mid- to late 1950s during the last period of high abundance (Figures 34-36). However, trend in males/lek was not significant (Figure 37). Number of leks sampled was not high enough to meet sample size criteria until 1958. If quantitative data were available back to 1900, we believe there would have been few if any significant correlations; instead, we would likely have seen high variability in abundance and productivity due to oscillations over time. Therefore, an understanding of sage grouse trends in Oregon should consider all information, including historical accounts and data collected since the 1940s. We concluded that the early 1900s were characterized by low sage grouse abundance, followed by a large peak in 1918, a quick decline and low populations until the late 1940s. Thereafter, data and reports by ODFW biologists indicate large populations through the 1950s with a decline by the early 1960s (Figure 37). Since then, populations have fluctuated with no clear pattern evident. Productivity also fluctuated greatly since the early 1950s, but has shown a decline from what was indicated during the 1950s and 1960s. That decline apparently occurred during the early to mid-1970s.

Our conclusions are similar but slightly different than those of Crawford and Lutz (1985). Data used by Crawford and Lutz (1985) covered the period from the late 1940s through the population low of 1983; however, we used data through 1992 which included a more productive period during the mid-1980s. Data used by Crawford and Lutz (1985) came from ODFW statewide summary reports, whereas we compiled original data from ODFW and BLM district files and monthly reports. Although the general trends were similar between the two analyses, there were a number of differences in county and statewide averages due to errors in statewide summaries, revisions in mileage of production routes, and differences in calculation of productivity and males/lek (see Methods section). Crawford and Lutz (1985) found a 58% decline in males/lek and a 63% decline in grouse/10 miles between the peak of the late 1950s and the low of the early 1980s. Similar calculations made with the updated data set showed that during the late period (mid-1970s–1992) males/lek were not significantly lower while grouse/10 miles were 58% lower than during the early period (mid-1950s–early 1970s)(Table 2, page 23). Productivity indices declined by 63% for both chicks/adult and chicks/hen during the same period. Our analysis indicated the decline in productivity was not gradual but occurred during the early–mid-1970s and productivity has not declined since that time.

The declines in productivity since the 1950s and 1960s were reflected in the number of grouse/10 miles counted. This is not surprising because the number of chicks seen on production routes were commonly 33% to 100% the number of adults counted and during the 1950s and 1960s were sometimes over 200%. A decline in chick survival would obviously have a large affect on total numbers of birds counted. However, the only measure of strictly the adult population, males/lek, showed neither an increasing or decreasing trend over time. Declining nest and brood survival may have been offset by increased adult survival.

Population Estimation

While an exact count of sage grouse in Oregon is impossible, it is important to estimate the order of magnitude of that population. This can be done in several ways. We made a minimum estimate of the Oregon population for 1992 of between 27,505 and 66,012 adults. This estimate was made (Table 3) by multiplying the number of known leks by the average number of males per lek and assuming a 60:40 female:male sex ratio (Johnsgard 1973:87). Average number of males/lek was used in those areas for which it was known. For areas where leks are not regularly surveyed, averages for core and peripheral areas were used as appropriate. For example, in Malheur and Lake counties, the core average of 24.3 males per lek was used and for Klamath, Baker, and Union counties, the peripheral average of 14.2 males per lek was used.

Crawford (letter of 21 May 1992) felt that this population estimate may be high. In addition, Jan Hanf (Prineville BLM), believed that due to their extensive effort at locating leks in that district, most leks have been found and that this method of population estimation may overestimate adult numbers there. However, we believe this method underestimates the statewide adult population. Braun (letter of 26 May 1992) felt this population estimate was exceedingly conservative, because of under-estimation of both male and female components of the population. He believed a more realistic approach was to assume that only 50% of the males are represented on single lek counts and that females outnumber males by 2:1. Using Braun's adjustments a minimum estimate of 66,012 adults was calculated. Braun believed even with these adjustments the estimate was further minimized by lack of knowledge of all leks in the state. There are probably many leks that have yet to be discovered. More leks are being found each year due primarily to aerial search efforts by the BLM. This is especially true in southern Malheur County where little time has been spent searching for leks. Malheur District Biologist, Bill Olson, believes that when this is taken into ac-

Table 3. Minimum Population Estimate of Adult Sage Grouse in Oregon, 1992.

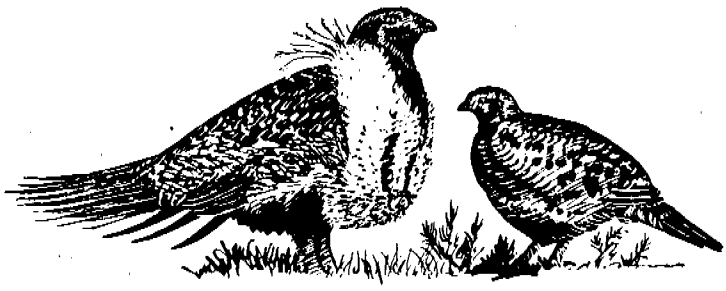
County	Known Leks	Mean Number of Males/Lek	Total No. of Males	Total Adult Estimate*
Malheur	112	24.3	2,722	6,805
Harney	119	31.0	3,689	9,223
Lake	108	24.3	2,624	6,560
Hart Refuge	22	28.8	634	1,585
Klamath	8	14.2	114	285
Deschutes	22	14.1	310	775
Crook	28	14.7	412	1,030
Baker	33	14.2	469	1,172
Union	2	14.2	28	70
Total	461		11,002	27,505

*Assumes a 60:40 female:male sex ratio to calculate totals.

count, at least 15,000 adults are present in Malheur County. This agrees with the fact that over the years, the highest numbers of sage grouse were counted in Malheur County and that county has about 32% of the state's sage grouse habitat. When this adjustment was made, the minimum estimate was increased to 35,700 adults. Therefore, we can be relatively sure the actual adult population for 1992 was between the low estimate of 27,505 and the high of 66,012.

Another way to estimate the sage grouse population in Oregon is to determine lek density in those areas where all leks are known such as Hart Mountain, the Jackass Creek area, and some areas that were intensively searched by the BLM. Lek density can be determined by the convex polygon method normally used for home range estimation (Mohr 1947). Lek density determined at Jackass Creek could then be projected to all mid-elevation (4,000 - 6,000 feet) low sagebrush and low/big sagebrush mosaic habitats. Lek density at Hart Mountain could be projected for the Trout Creek, Steens, and Pueblo mountains. Average number of males/lek for the respective areas and the appropriate sex ratio could then be used to calculate a total adult population. For this approach to work, an accurate map showing sagebrush vegetation types throughout the range of sage grouse in Oregon must be obtained; such a map is not currently available. Total area of low sagebrush, low/big sagebrush mosaics, and high mountain habitat would be measured and used to project lek densities throughout the range of the bird.

An example of grouse density calculations from 1991 data follows and could be used in this method. A lek density of 1/9 mi^2 was calculated at Hart Mountain for 1991 (Pyle, Witt and Brown 1991, unpublished report of sage grouse census). If 46 males/lek (mean for leks counted at Hart Refuge in 1991) and a 60:40 female:male ratio is used, a density of 12.7 adult grouse/mi^2 is indicated during the mating season. If 25 males/lek is used, as suggested in the report, 6.9 grouse/mi^2 is calculated. Therefore, a sage grouse density of 6.9 to 12.7 adults/mi^2 is likely. For Jackass Creek, we calculated a lek density of 1/8.3 mi^2 for 1991. Average number of males/lek for that year was 24.1. Therefore, grouse density was 7.1 adult/mi^2 during the mating season.



Sage Grouse Use of Habitat

We described habitat use by sage grouse in southeastern Oregon based on radio-telemetry studies, extensive observation of sage grouse during brood and lek counts, and literature review.

The most widely used vegetation types by sage grouse throughout the year in Oregon are normally forb rich types with low stature sagebrush, and mosaics of low and high stature sagebrush (Gill 1965, Keister and Willis 1986, Gregg 1991, Willis 1991, Drut 1992). Big sagebrush types, however, are essential in many wintering areas to provide a food source above snow (Beck 1977, Autenrieth 1981, Hupp and Braun 1989, Willis 1991). Vegetation types of low stature primarily include low sagebrush species (*A. arbuscula* and *A. longiloba*), although black sagebrush (*A. nova*), stiff sagebrush (*A. rigida*), and three-tipped sagebrush (*A. tripartita*) (Klebenow 1969) occur less frequently in Oregon and may be used. Wyoming big sagebrush (*A. t. ssp. wyomingensis*) and mountain big sagebrush (*A. t. ssp. vaseyana*) are the primary species of high stature used in mosaic form with low sagebrush in Oregon.

During the mating season (February-May), leks may be on bare areas or areas of low cover and stature of sagebrush and are more often within vegetation types of low sagebrush or low/big sagebrush mosaics (Batterson and Morse 1948, Patterson 1952, Gill 1965, Autenrieth 1981). Males spend early mornings and late evenings at strutting grounds, and remain nearby the rest of the time (Batterson and Morse 1948, Wallestad and Schladweiler 1974). Females attend leks for 1 to 3 days (Peterson 1970; Hein et al. 1980) and then move to nesting areas, which are primarily in stands of big sagebrush or mosaics of big and low sagebrush, although low sagebrush habitat is also used at lower frequencies (Nelson 1955, Klebenow 1969, Schoenberg 1982, Keister and Willis 1986, Gregg 1991). The largest sagebrush plant in the immediate area is often chosen for nesting and nests are built beneath overhanging sagebrush (Patterson 1952, Wallestad and Pyrah 1974, Hein et al. 1980, Autenrieth 1981, Keister and Willis 1986). In addition, sagebrush is used for hiding cover year-round and also provides thermal cover during summer and winter.

Hens that successfully nest spend 2-9 weeks in upland sites near their nesting area depending on forb succulence (Gill 1965, Peterson 1970, Authenrieth 1981, Keister and Willis 1986). Insects and forbs are an important component of chick diet during this early brood rearing period (Klebenow 1969, Autenrieth 1981, Johnson and Boyce 1990). After early brood rearing, when forbs have desiccated, hens with broods leave upland sites and move to more moist areas that still have succulent forbs, where they spend the mid- and late summer period with other hen and brood groups (Gill 1965, Peterson 1970, Autenrieth 1981). Unsuccessful hens may leave their nesting area immediately upon losing their nest or brood and move to summering areas to join other unsuccessful hens (Gill 1965, Peterson 1970, Keister and Willis 1986). After the breeding period (late May and early June), flocks of males have been observed at summering areas.

Habitat used by summering groups generally takes three forms: mid-elevation playas and waterholes, high mountain areas, and alfalfa developments. Although not widely reported in the literature, in much of southeastern Oregon, sage grouse have been observed during summer near playas and water holes in low sagebrush and low/big sagebrush mosaic habitats, which normally occur at mid elevation (4,000-6,000 feet). Under normal precipitation conditions, playas retain water after winter snow melts. As playa water recedes, forbs begin to grow and provide a food source after forbs on upland sites have dried out (Keister and Willis 1986). Sage grouse go to water early morning and late evening during the mid- to late summer period (Klebenow 1969, Autenrieth 1981). After drinking, they feed on available forbs then move into surrounding sagebrush areas to loaf and roost. Meadows, where available, are used in the same way as playas but provide a greater variety of forb species.

Habitat on high mountain areas (i.e., Trout Creek, Pueblo, Steens, and Hart mountains) can be

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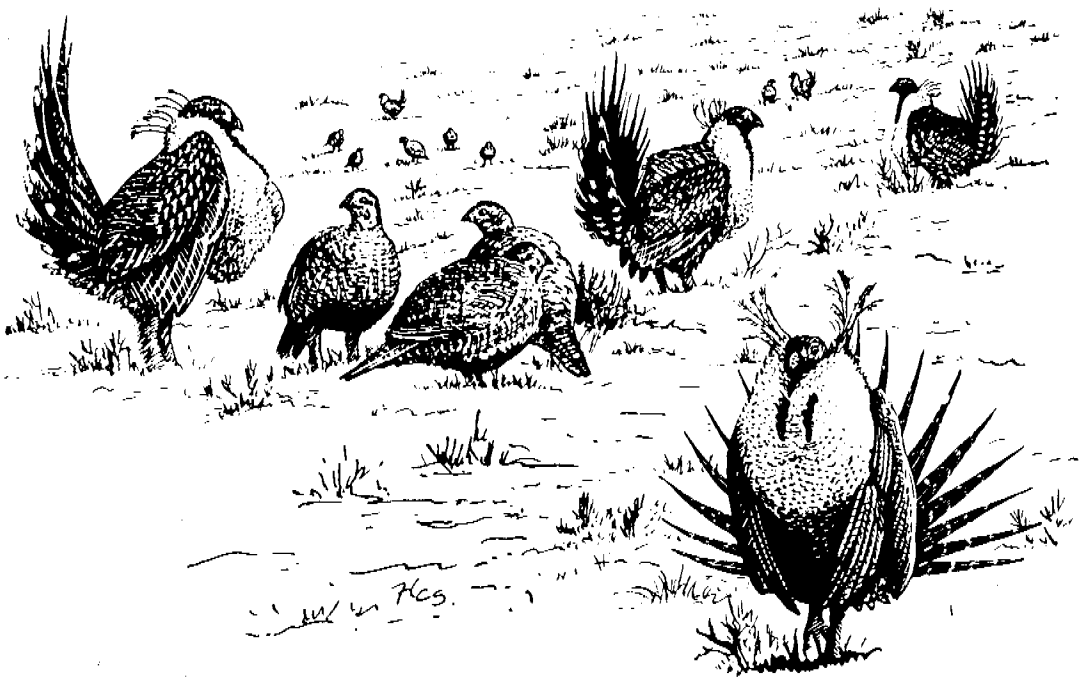
generally characterized by numerous meadows, creeks, and ponds, surrounded by low sagebrush and mosaics of low sagebrush/mountain big sagebrush. Sage grouse from such areas generally follow the moisture gradient up the mountain during the summer as snow melts (Batterson and Morse 1948, Nelson 1955, Klebenow 1969). These areas provide a source of succulent forbs and free water throughout the summer.

Sage grouse sometimes congregate during summer near irrigated alfalfa (Batterson and Morse 1948, Gill 1965, Klebenow 1969, Browers 1981, Gates 1981). As with playa areas, sage grouse fly into alfalfa fields in early morning and late evening to feed, then return to surrounding sagebrush covered hillsides to loaf and roost. Sage grouse continue to use these areas throughout the late summer and early fall as long as forbs are present. Hard frosts generally cause cessation of this activity (Willis 1991).

After forbs desiccate, sage grouse slowly disperse from summering areas and change to a diet consisting almost entirely of sagebrush (Patterson 1952, Gill 1965, Wallestad 1975, Autenrieth 1981, Remington 1981, Remington and Braun 1985). In areas where sage grouse summer in high mountain habitats, winter migration may be to lower elevations and may be to specific wintering areas (Batterson and Morse 1948, Autenrieth 1981). In mid-elevation summering areas in Oregon, sage grouse movements are more random (Keister and Willis 1986). Vegetation types used for wintering in Oregon include primarily low sagebrush, big sagebrush, and mosaics of low and big sagebrush (Willis 1991), where they often prefer wind swept areas free of snow (Batterson and Morse 1948, Beck 1977). During years with high snow accumulation, habitat may be severely limited and high stature sagebrush is essential (Wallestad 1975, Beck 1977, Autenrieth 1981, Hupp and Braun 1989). Sagebrush makes up almost the entire diet of sage grouse during winter months and dominates their diet most of the year (Batterson and Morse 1948, Nelson 1955, Gill 1965, Autenrieth 1981, Hupp and Braun 1989). Wyoming big sagebrush has been shown to be the preferred sagebrush species in sage grouse diets in Colorado (Remington 1981, Remington and Braun 1985).



Factors Affecting Sage Grouse

The present range of sage grouse in Oregon generally coincides with the northern extension of the Great Basin (see attached map) and has not changed since the 1950s (see Nelson 1955:14; Masson and Mace 1974:34). Annual precipitation during the last 100 years averaged about 10-12 inches in the north and as low as 6-8 inches in parts of the southeastern corner of the bird's range in Oregon, although precipitation varies with elevation. For example, Steens Mountain averaged 28.7 inches at 6,000 feet and 47.4 inches at 7,900 feet for 1961-90 (personal communication; Soil Conservation Service, Snow Survey Data Collection Office, Portland, Oregon). Habitat in the region is dominated by sagebrush steppe communities and varies in plant composition and productivity with elevation.

Short growing seasons, low moisture, and low site potential make many commercial uses of Oregon's sage grouse habitat unfeasible. For this reason, habitat structure and plant species composition in southeast Oregon probably changed less than in other areas of the state and less than in many other parts of the United States. However, changes in plant community structure and composition have occurred due to changes in climate, periodic drought, decline in fire frequencies, the introduction of exotic plant species, over stocking by livestock, and cultivation.

Climatic changes have occurred since the last ice age (10,000 years ago) consisting of fluctuating wet and dry cycles (Miller et al. 1991). Dry cycles probably resulted in a reduction of total plant cover and density favoring sagebrush and the salt desert species (West et al. 1979, Mehringer 1986, Merhinger and Wigand 1990). Plant cover and density increased during wet cycles and grass species were favored. From 1850-1917, precipitation was generally above normal throughout the northern half of the Great Basin which caused higher lake levels (Antevs 1938). However, this period ended in the 1920s with the most severe drought in 150 to 650 years in the Great Basin (Miller et al. 1991). By the mid-1940s, another period of above average precipitation began and lake levels were again elevated (Phillips and VanDenburgh 1971). Such extremes in climate undoubtedly had major impacts on plant communities within the shrub steppe habitats of Oregon (Pechanec et al. 1937, West et al. 1979). Other changes occurred since European settlement and are discussed in the following section.

Habitat Conversion

We believe the most important factor causing declines in sage grouse populations throughout their range was the removal of sagebrush from large areas of shrub-steppe habitat (Patterson 1952, Braun et al. 1977, Hein et al. 1980, and Autenrieth 1981). Within this region extensive habitat conversion occurred in the Columbia basin, north central Oregon (total ~10,000 mi^2), and eastern Washington for agricultural purposes and resulted in elimination of sage grouse from large areas.

Within the present sage grouse range in Oregon (~30,000 mi^2), sagebrush steppe habitats were also converted, but to a far lesser extent than in the Columbia Basin and Washington. Sage grouse habitat in peripheral areas (Klamath, Deschutes, Crook, Grant, Baker, and Union counties) tends to be more naturally fragmented by other habitats, such as juniper and coniferous forests, than in the core areas (Lake, Harney, and Malheur counties). Throughout their Oregon range, areas of mostly Wyoming big sagebrush were converted primarily to increase grass production for livestock or by wildfire. Approximately 2,760 mi^2 of primarily BLM land were devoid of sagebrush and much was seeded to crested wheatgrass by 1991 (enclosed map, Table 4). Some of these areas were not seeded, but left ungrazed immediately after the burn and now support native bunchgrass communities. In some areas, particularly Malheur County, burned habitats are dominated by cheatgrass (*Bromus tectorum*) and exotic forbs such as halogeton (*Halogeton glomeratus*). Sage grouse use of such habitats appears limited to foraging for succulent forbs around the edges dur-

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ing spring, particularly in the case of recent burns, and perhaps the establishment of leks near the edge. Low sagebrush vegetation types were also converted to crested wheatgrass, but to a much lesser extent; site potential was lower, thus the suitability for crop production was minimal. In addition, between 1961 and 1975, approximately 792 mi^2 of sagebrush habitat was converted as part of the Vale Project in Malheur County (Heady and Bartolome 1977). Many of these conversions, have been re-established with sagebrush (B. Olson [ODFW] and J. Sadowski [BLM], personal communication) and now provide habitat of varying suitability for sage grouse (Willis 1991). Although 2,760 mi^2 were converted from sagebrush vegetation types, all of that area probably was not used by sage grouse prior to conversion due to the lack of other habitat components (i.e., forbs or water).

Table 4. Estimated[a] Areas of Major Sagebrush Conversions Primarily on BLM Lands in Southeastern Oregon, 1991.

County	Area Converted (mi^2)
Malheur	730*
Harney	1,050
Lake	706
Deschutes	193
Crook	40
Baker	41
Total	2,760

[a]Calculated from approximate areas mapped by ODFW district biologists; Lakeview and Prineville BLM provided estimates for their areas north of Christmas Valley in Lake, Deschutes, and Crook counties.

* Does not include the Vale Project.

Before European settlement, a 15-25 year fire cycle in mountain big sagebrush (Houston 1973, Burkhardt and Tisdale 1976) and a 50-100 year cycle in Wyoming big sagebrush (Wright and Bailey 1982) provided a natural mosaic of big sagebrush and grass of varying ages within the big sagebrush vegetation types (Winward 1991). However, a decrease in fire frequency during the mid-1900s and overgrazing in the early 1900s may have contributed to large areas of older big sagebrush. In addition, cover and density of big sagebrush increased on big sagebrush sites and understory species (grasses and forbs) have decreased (Winward 1991). Our data indicated where large blocks occur adjacent to good lek habitat, hens used them for nesting, but leave after nesting and early brood rearing. Big sagebrush habitats were sometimes used in Oregon during winter (Willis 1991). Also as a result of fire suppression, the area dominated by western juniper (*Juniperous occidentalis*) increased, particularly in the more moist sagebrush steppe habitats of the northern and western portions of the range and may have contributed to displacement of sage grouse in those areas.

Because density of big sagebrush increased in large blocks, and highly flammable exotics (i.e., cheatgrass) invaded, large wildfires occurred in some areas (Whisenant 1990). The result today is two vegetation types that occur in large blocks that provide limited sage grouse habitat. This situation, however, may be improved for sage grouse by creation of mosaics where large blocks of monoculture grassland or big sagebrush now exist. Sagebrush will normally re-invade burn areas to a 20% cover within 12 years in mountain big sagebrush sites but may take over 40 years in Wyoming big sagebrush sites (Winward 1991). However, burned areas that are dominated by cheatgrass may not readily recover because of frequent fires in this annual grassland community. Fire frequencies on cheatgrass dominated grasslands may be as often as 3-5 years (Whisenant 1990). Crested wheatgrass seedings reinvaded by sagebrush in the Vale project of southeast Oregon were used seasonally by sage grouse (Willis 1991). Recovery of sagebrush steppe communities for sage grouse may be enhanced by efforts to re-establish sagebrush, forbs, and other grass species on cheatgrass dominated sites. In the large blocks of big sagebrush, mosaics can be created

either mechanically or with prescribed burning, whichever is most appropriate for the site.

According to some ODFW district wildlife biologists, conversions to alfalfa production in southeastern Oregon were beneficial for sage grouse in some cases. Where relatively small areas of Wyoming big sagebrush or greasewood (*Sarcobatus vermiculatus*) were converted to irrigated alfalfa, diet for sage grouse during the late brood rearing period may have improved.

Predation

While "normal" (i.e., before European settlement) levels of population, productivity, and fluctuations of sage grouse in southeastern Oregon are not known, year to year fluctuations in productivity in recent years may be highly influenced by changes in abundance of coyotes and ravens. In addition, higher values for sage grouse indices (chicks/adult, chicks/hen, grouse/10 miles) during the late 1950s and 1960s may have been primarily a result of reduced populations of coyotes and ravens due to the use of 1080 poisonous baits during those years. Declines in sage grouse productivity since then may be highly affected by increases in coyote and raven populations.

In southeastern Oregon, Littlefield and Thompson (1985) believed that raven abundance probably increased since the introduction of livestock in the late 1800s. Coyote numbers probably were similarly affected. However, the two factors that appeared to have played the largest role in influencing coyote and raven abundance since the late 1940s were the use of compound 1080 to control coyotes and the abundance of jackrabbits. A major food source for coyotes (Clark 1972, Wagner and Stoddart 1972, Witham 1977, Neff and Woolsey 1979) and ravens (Littlefield and Thompson 1985) is black-tailed jackrabbits (*Lepus californicus*). Black-tailed jackrabbit populations fluctuate by great orders of magnitude (Wagner and Stoddart 1972, McAdoo and Young 1980) and fluctuation in coyote numbers were associated with the varying abundance of black-tailed jackrabbits (Stoddart 1977, Clark 1972). Raven and coyote numbers in Harney County were significantly correlated with jackrabbit abundance (r [for coyotes versus jackrabbits, 1946-1991] = 0.309, r [for ravens vs. jackrabbits, 1976-1991] = 0.71) (Figure 38).

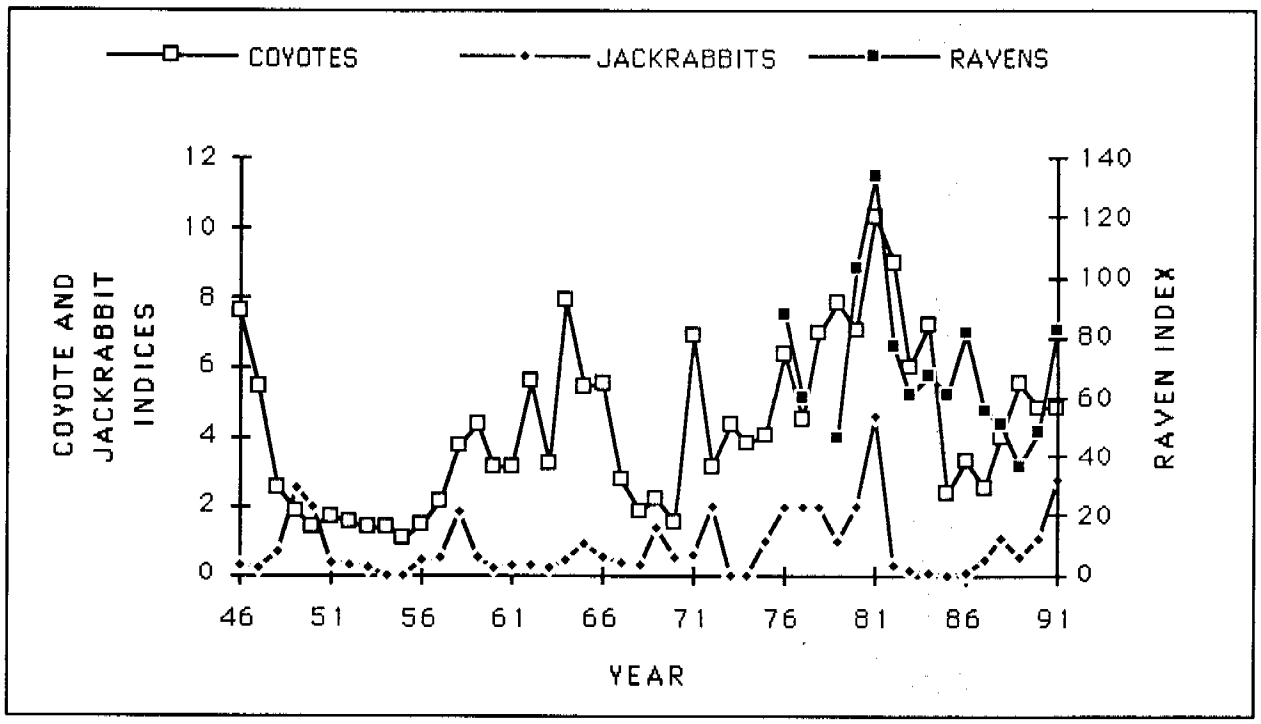

Figure 38. *Relationship Between Coyotes, Ravens, and Jackrabbits in Harney County, Oregon, 1946-1991.*

Several authors believed that predator control using 1080 was important in affecting coyote density (Arrington and Edwards 1951, Clark 1972, Neff and Woolsey 1980). There was a general decline in coyote abundance in the western states during the late 1940s due to the use of 1080 (USFWS 1978) and that decline appears to be proportionate to the number of bait stations used (Cain et al. 1972, USFWS 1978). However, since 1972 when 1080 was banned, a dramatic increase in coyote numbers was evident in some areas (Roughton 1977, USFWS 1978). In Harney County the coyote index was significantly greater ($P = 0.0001$, $t = -4.0$) after 1972 than during the 1080 period, 1948-72. Likewise, raven numbers were much reduced in southeastern Oregon during the 1080 period but have increased since 1972 (Littlefield and Thompson 1985).

There is a high likelihood that predators sometimes limit numbers of several species including big game (Cain et al. 1972, Connolly 1978, Corneli 1980). In southeastern Oregon there were several investigations supporting that conclusion. Coyotes played a major role in reducing survival of young mule deer (Trainer et al. 1981) and pronghorn (Trainer et al. 1983, Willis 1988). In addition, coyotes limited sandhill cranes (*Grus canadensis*) at Malheur National Wildlife Refuge (USFWS 1985, 1989), and were involved in nest predation on waterfowl at Summer Lake (Denney 1984); ravens were also major predators of waterfowl and sandhill cranes. In each case, predator control was employed to reduce predator numbers and increases in survival of young resulted. Particularly in the case of waterfowl and sandhill cranes at Malheur NWR, predation was identified as the limiting factor. Habitat was manipulated to improve nesting success, however survival of young did not respond until predator control was initiated. Bergerud (1988:719-22) stated that the composition of predators is greatly changed from that of 100 years ago and that humans have altered the interactions between predators and grouse. Therefore *"...predator populations can be so abundant that habitat alone will not suffice to permit a population to increase."*

Within recent years all studies of nesting sage grouse in Oregon demonstrated a high incidence of predation during nesting and early brood rearing. Batterson and Morse (1948) demonstrated increased nest success of 35% versus 3% for an avian predator control area versus a non-predator control area in Baker County during 1941-46 and concluded that *"the greatest single limiting factor for sage grouse is nest predation by ravens."* Nelson (1955) found that 41% of the nests studied in Lake County during 1954 were lost to predators. Keister and Willis (1986) found the major factor determining sage grouse levels at Jackass Creek during 1984-86 was loss of nests and chicks during the first three weeks of life (see also Batterson and Morse 1948, and Gill 1965). Coyotes and ravens were suspected as the major nest predators. During that period, sage grouse productivity increased dramatically (mean chicks/hen = 0.13 –1984, 1.09 –1985, 2.45 – 1986), while coyote abundance declined as much as 88% from 1984 to 1985 and 13% from 1985 to 1986 (Willis 1988). This decline in coyote abundance was in part due to a coyote removal project on the study area. In addition, a paired t-test showed that numbers of ravens counted weekly on the study area were 31% lower ($t = 2.251$, df = 13, $P < 0.05$) in 1986 than in 1985 ($\bar{x}$ = 5.4 ravens/100 miles vs 7.72, respectively) during the nesting and early brood rearing periods (25 March-24 June). Further studies done at Jackass Creek and at Hart Mountain during 1989-91 showed that predation was the primary cause of nest failure and ravens, coyotes, badgers, and ground squirrels were implicated (Crawford et al. 1991, Gregg 1991, Drut 1992). Elsewhere, predation was mentioned as a restraint on populations by Gill (1965) and Autenrieth (1981). Important predator species mentioned were ravens (Autenrieth 1981), ground squirrels (Patterson 1952, Gill 1965), and badgers (Nelson 1955). In addition, hawks were documented to take chicks (Carhart 1942). While predation was reported as an important factor in egg and chick survival by numerous studies, predator abundance was rarely measured, so comparisons of predator abundance between study areas and years can not be made.

Predation does not appear to be a large, direct factor affecting adult sage grouse survival. Wallestad (1975) reported a low adult mortality rate. During a

1984-86 study at Jackass Creek, a minimum estimate of average age was made at 4.3 years for hens that reached one year of age, based on survival of radio-collared hens (Keister and Willis 1986). Coyotes and bobcats killed hens and golden eagles took sage grouse males, females, and chicks. Males were especially vulnerable on leks (personal observation, Batterson and Morse 1948) to golden eagle predation. Hens were more vulnerable to predation by coyotes during nesting when they were reluctant to flush from nests (Autenrieth 1981, Keister and Willis 1986).

Coyote control was effective in limited geographic areas at reducing coyote abundance and increasing survival of several species, including pronghorn, deer, and livestock (Udy 1953, Wade 1981, Stout 1982, Neff et al. 1985, Willis 1988). However, success over large areas has not been achieved except with the use of chemicals, particularly compound 1080. We agree with Connolly and Longhurst (1975) that predator control over broad areas is neither cost effective nor practical using presently available methods.

Water: Meadows, Riparian Areas, Playas, and Water Developments

In late summer sage grouse strongly preferred areas with free water and succulent forbs (Klebenow 1969, Autenrieth 1981, Keister and Willis 1986). Historically, free water and succulent forbs were provided at mid-elevation (4,000-6,000 feet) in southeastern Oregon primarily by playas. However, some riparian areas were present along both intermittent and perennial streams and meadows were sometimes present. Free water, meadows, and perennial streams are more abundant and consistently available above 6,000 feet in elevation.

Water developments were begun in the drier, mid-elevation areas after 1940, primarily for the benefit of livestock. Some 1,260 were developed on lands administered by Burns BLM between 1940 and 1982 (F. Taylor, personal communication); 1,172 spring developments and reservoirs were created from 1940 through 1975 by the Vale District of the BLM (Heady and Bartolome 1977); and Lakeview BLM currently has about 1,191 developed reservoirs and waterholes (C. Oke, personal communication). These developments may have allowed a number of domestic and wildlife species, including sage grouse and cattle, to expand their range into less suitable habitat. Predators, such as coyotes and ravens may also have benefited from a better distribution of water throughout drier habitats (Witham 1977). Before such developments, sage grouse may have been confined to higher elevation habitats during prolonged dry periods due to lack of water and forbs associated with playas and meadows at mid-elevations. The period of the 1920s and 1930s was extremely dry as evidenced by rainfall records and the drying of large lakes such as Malheur, Harney, Abert, Summer, and Goose lakes (Phillips and VanDenburgh 1971). This dry period may have contributed to low sage grouse numbers and great concern for the survival of the species during that time (Meyers 1946).

During summer, sage grouse in northwestern Nevada preferred small meadows with succulent forbs and avoided dense stands of meadow vegetation (Oakleaf 1971, Evans 1986). Likewise, Batterson and Morse (1948) found that meadow areas that were grazed by livestock received more use by sage grouse than ungrazed meadows and concluded that *"...apparently the rank cover developed by irrigated and fenced enclosures is unattractive to sage grouse..."* Effective grazing management removes old material and maintains the integrity of the plant community as indicated by plant composition, cover, and soils. The key for providing desirable meadow habitat for sage grouse is to have enough grazing pressure to remove tall, dense stands of meadow vegetation while maintaining grazing pressure light enough to prevent changing plant composition, lowering water tables, erosion, and loss of plant cover.

Disease

Autenrieth (1981:35) listed salmonellosis, botulism, and aspergillosis as diseases that might be important to sage grouse. Coccidiosis, a one-celled animal transmitted through contaminated water, was thought to be the most prevalent disease affect-

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ing sage grouse. In addition, Autenrieth (1981) reported tapeworm infections (*Raillietina spp.*) as common but not thought to be serious. Tapeworms were documented in the intestines of Oregon sage grouse during 1954 by Nelson (1955), who reported heavy infestation, and during the 1940s by Batterson and Morse (1948), who reported one hen with 24 tapeworms, 3-6 inches long. Ellis Mason (personal communication) reported collecting sage grouse each month of the year in the late 1950s and finding tapeworms in all specimens. He found many grouse with large worms that filled the intestines.

Water developments that concentrate sage grouse during fall may facilitate disease transmission of both coccidiosis and tapeworms. Sage grouse populations have the ability to increase quickly when conditions favor chick survival. Disease is a factor that could quickly reduce sage grouse numbers from high population levels. Meyers (1946) and Batterson and Morse (1948) reported that sage grouse were plentiful in 1918. However, reports of dead and dying birds were abundant the following year and by 1920 sage grouse were scarce. Batterson and Morse (1948) believed this decline possibly resulted from an epizootic. Another period of abundance during the 1940s and 1950s was followed by a decline (Figure 36, E. Mason, personal communication). Disease and tapeworms possibly contributed to these two declines.

Use of Chemicals

Johnson and Boyce (1990) reported that nearly 35,000 mi^2 of western rangelands were sprayed for grasshopper control during the previous five years and that sage grouse commonly nest in areas sprayed for grasshoppers. They used newly hatched chicks and chicks captured in the wild to investigate the effects of eliminating insects from the diet. They concluded that chicks less than three weeks of age required insects for survival and that chicks over three weeks of age had reduced growth rates without insects in their diets. In addition Blus et al. (1989) documented sage grouse mortality in southeastern Idaho in agricultural fields sprayed with organophosphorus insecticides.

The use of chemicals in Oregon, both herbicides and insecticides, may have periodically reduced sage grouse numbers locally. In agricultural areas, annual spraying of chemicals could drastically reduce insect populations needed by chicks and directly poison adult birds. In sagebrush steppe habitats, periodic spraying for grasshopper control during May and June could significantly reduce insect populations.

Livestock Grazing

Excessive grazing by livestock in the late 1800s and early 1900s has contributed to the increase in cover and density of big sagebrush and a decrease of grasses and forbs in some big sagebrush vegetation types (Winward 1991). Overgrazing was characterized by change in plant composition which resulted in loss of cover, especially grass cover, lowering of water tables through headcutting in meadow areas, and erosion (Cottam and Stewart 1940, West 1983). Factors such as distance to water and topography influenced the level of utilization (Heady 1975, Stoddart et al. 1975) with cattle preferring areas closer to water and of moderate slope.

Grazing by livestock began in southeastern Oregon in the late 1800s with European settlement (Oliphant 1968). By the turn of the last century, Griffiths (1902) found public ranges of the region in many places badly depleted, which were, in his opinion, directly traceable to overstocking. After enactment of the Taylor Grazing Act of 1934, grazing pressure decreased and numbers of sheep and domestic horses declined while cattle increased (Trainer et al. 1983:10-11). Since 1964 there was a significant decline ($r = -0.676$) in grazing of livestock on BLM administered land throughout the sage grouse range of Oregon (Figure 39). Feral horse grazing made up an additional 4% of the forage consumption on BLM administered lands (J. Fullerton [BLM], personal communication). In addition to reductions in livestock grazing, grazing systems were implemented in the 1960s (W.F. Taylor [BLM], personal communication). Grazing systems regulated livestock class as well as time and duration of grazing to improve health and productivity of livestock

forage plants. The combined influence of water distribution, topography, seedings, and grazing systems resulted in a mosaic of different utilization patterns across the landscape with some areas virtually ungrazed and other areas overgrazed. In general, improved ecological condition resulted since the early 1900s through the use of grazing systems and a reduction in grazing pressure (animal unit

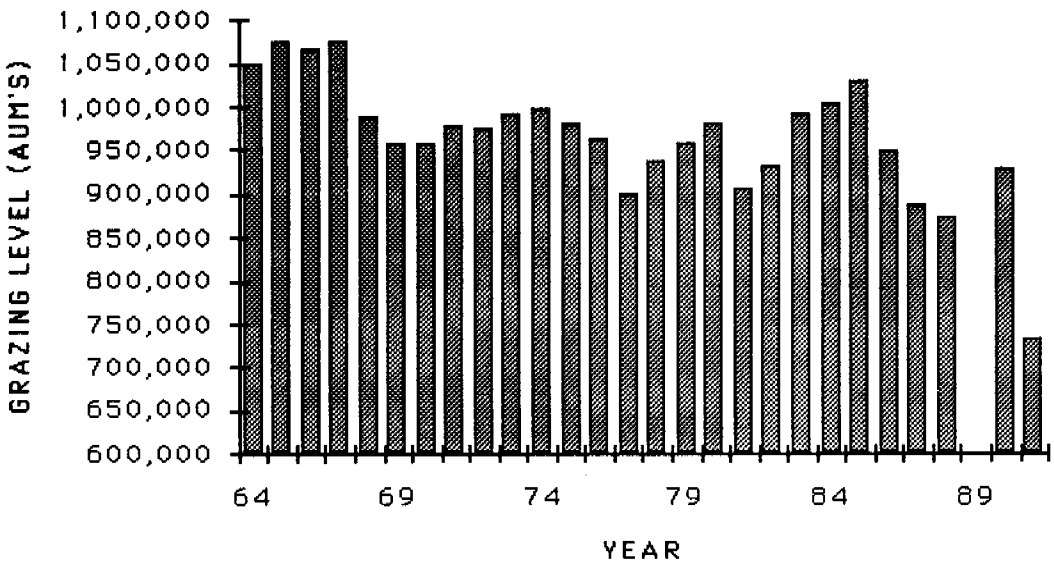

Figure 39. Grazing Level on BLM Lands (Vale, Burns, Lakeview, and Prineville districts) in Southeastern Oregon, 1964-1991. (See Appendix B for raw data: data supplied by J. Fullerton [BLM], personal communication). AUMs for 1989 are not reported due to a change in accounting procedures. Grazing increased during the early 1980s due to high precipitation and flood relief programs and decreased since due to drought conditions.

Table 5. Condition* and Trend of Lands Administered by the BLM in Southeastern Oregon, 1992 (Data provided by BLM districts).

		Condition (Number of Square Miles)					
District	Trend	PNC	LS	MS	ES	Unclass.	Total
Vale	10% Up; 6% Down	409	1,832	4,564	1,082	206	8,093
Burns	23% Up; 1% Down	115	2,047	2,390	555	145	5,252
Lakeview	45% Up; 5% Down	265	1,266	2,673	882	5,086	
Prineville	29% Up; 11% Down	73	650	1,104	434	288	2,549
Total (mi^2)	24% Up	862	5,795	10,731	2,953	639	20,980
(%)	5% Down	4	28	51	14	3	

* PNC = Potential Natural Community
LS = Late Seral ecological status
MS = Mid-Seral ecological status
ES = Early Seral ecological status

months—AUMs) (Sneva et al. 1984, Table 5).

Within the present range of the sage grouse, the BLM classifies the condition of their 20,980 mi^2 of land as 4% in potential natural community, 28% in late seral ecological status, 51% in mid-seral status, and 14% in early seral status. The trend on approximately 24% of the land is upward and 5% is downward (Table 5).

Vegetative cover has been considered important to sage grouse nesting success (Hein et al. 1980, Autenrieth 1981). On better ranges, litter and grass-forb understory was thought to contribute to successful nesting by helping to camouflage nests. Wallestad and Pyrah (1974) found sagebrush cover was the most important factor to nesting sage grouse in Montana and that successful nests were located in stands of sagebrush with a higher canopy coverage than those of unsuccessful nests. Shrub cover was also mentioned as important by Schoenberg (1982), Autenrieth (1981), and Wallestad and Pyrah (1974). Klebenow (1969) however, reported that sage grouse did not use tall, dense sagebrush with little understory. Gregg (1991) found for 1989-90 that grass cover and medium height shrub cover was greater at successful nest sites than at unsuccessful nest sites within the mountain big sagebrush vegetation type at HMNAR. However, there was no difference found at the Jackass Creek study area within the low sagebrush, big sagebrush, and mixed sagebrush types (Gregg 1991:43-45). While grass and sagebrush cover may work in conjunction with other factors, nest success during 1989-91 was only 18% at Hart Mountain and 10% at the lower elevation, drier Jackass Creek study area (Drut 1992). Even with excellent herbaceous cover provided by higher elevation, more moist habitat at HMNAR, nest success was much lower during the study than a few years earlier or during 1992. Obviously other factors played a larger role in determining nesting success during that period.

We believe that overgrazing is detrimental to sage grouse due to its adverse affect on meadows, riparian areas, and herbaceous and sagebrush cover and was particularly detrimental during the late 1800s and early 1900s (Russell 1885, Griffiths 1902, West 1983). However, controlled grazing can increase the desirability of meadows for sage grouse. The key is to manage grazing at the proper level to achieve the benefits without adverse impacts. Continued efforts to control or reduce grazing where needed to meet utilization standards and projects to improve riparian areas and meadows are steps in the right direction. Examples of such projects include a riparian improvement project at Jackass Creek and a number of projects and grazing reductions on parts of the Trout Creek Mountains. In addition, projects that actively pursue improvements in degraded habitats such as monotypic stands of grass or Wyoming big sagebrush would be beneficial.

Harvest

Harvest of sage grouse in Oregon was highly variable over time. Early warden reports and Game Commission Biennial Reports routinely commented on the opening or closing of sage grouse seasons based on the projected imminent demise or bumper crop of the species. Records since 1949 were compiled for statewide harvest (Table 6). Harvest by wildlife district or county was not available.

Season length and bag limits were generally more liberal during periods of greater sage grouse productivity and abundance. However, hunting seasons during the last decade were designed to collect information on sage grouse from analysis of wings (Table 7) while providing limited hunting recreation. Hunting probably did not limit sage grouse populations in Oregon (Crawford 1982). Using the current minimum population estimate of 27,505 adult birds and the average chick/adult ratio (1982-91) of 0.45, annual harvest over the last decade has been less than 7% of the annual production and less than 3% of the population. Braun (1975:1) reported up to 25% of fall populations of sage grouse were harvested in other areas with no noticeable effect on spring populations.

Analysis of wing data indicated that male:female ratios during 1982-91 were near the 40:60 level used in the population estimate calculation (Table 7). Higher proportions of chicks were seen in the wings than on production routes ($t = 2.68$, $P < 0.05$), possibly due to hunter bias and/or differential suscepti-

Table 6. Oregon Sage Grouse Harvest Summary, 1949-91.

Year	Season Length (Days)	Daily Bag Limit	Total Bag Limit	No. of Hunters	Total Kill	Birds Per Hunter
1949	5	2	2			
1950	7	3	3	133	241	1.8
1951	9	4	8	2,273	5,000	2.2
1952	13	4	8	7,229	18,788	2.6
1953	6	2	4	8,147	11,406	1.4
1954		no season				
1955		no season				
1956		no season				
1957		no season				
1958	9	2	4	7,374	21,284	2.9
1959	9	2	4	7,127	17,304	2.4
1960		no season				
1961	2	2	2	2,725	6,659	2.4
1962	9	2	4	3,541	10,571	3.0
1963	9	2	2	1,913	4,117	2.2
1964	9	2	2	3,718	8,669	2.3
1965		no season				
1966	2	2	2	2,234	3,731	1.7
1967		no season				
1968	2	2	2	1,231	2,010	1.6
1969	2	2	2	2,774	4,758	1.7
1970	3	2	4	5,430	10,250	1.9
1971	3	2	4	2,068	3,102	1.5
1972	2	2	2	4,226	6,794	1.6
1973	2	2	2	4,046	7,483	1.9
1974	2	2	2	1,774	1,947	1.1
1975	2	2	2	1,310	2,121	1.6
1976		no season				
1977		no season				
1978		no season				
1979		no season				
1980		no season				
1981		no season				
1982	2	2	2	228	117	0.5
1983	2	2	2	297	353	1.2
1984	2	2	2	114	144	1.3
1985		no season				
1986		no season				
1987		no season				
1988		no season				
1989	2	2	2	827	711	0.9
1990	2	2	2	780	1,034	1.3
1991	2	2	2	223	260	1.2

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Table 7. Information Determined from Wings Collected from Sage Grouse, 1982-1991 (Crawford 1992).

Category	1982	1983	1984	1989	1990	1991
Number	73	291	144	326	437	295
Male:Female	39:61	43:57	38:62	41:59	44:56	42:58
Adults:Immature	47:53	62:38	60:40	59:41	66:34	69:31
(Chicks/Adult)	(1.13)	(0.61)	(0.67)	(0.69)	(0.52)	(0.45)
Adult, M:F	53:47	37:63	37:63	37:63	46:54	45:55
Immature, M:F	26:74	53:47	42:58	46:54	39:61	37:63
Male, A:I	64:36	54:46	56:44	54:46	70:30	73:27
Female, A:I	36:64	67:33	61:39	63:37	63:37	65:35
Mean Hatching	6/3	6/14	6/12		5/24	6/15
Range, Hatching	5/9–7/7	5/11–7/14	5/13–7/7	7/18	5/4–7/13	5/7–7/23

bility of chicks to hunting. There was no significant correlation between productivity (chicks/adult) calculated from wing data and that determined from production routes and no trend was detected between productivity and time. While the range of hatching dates calculated from wing analysis encompassed dates found in studies in Oregon, mean dates were as much as one month later (Nelson 1955, unpubl. ODFW data). This may indicate that nest success and chick survival were greater for renesting grouse (incubating in May and early June) than for those during the first attempts of the year (incubating in April and early May). This would be consistent with the fact that more alternate prey are usually available for potential predators during May and June.

Analysis of Potential Factors Affecting Sage Grouse

We employed forward stepwise multiple regression to investigate possible relationships between several variables that might affect sage grouse productivity or population level. Data collected in Harney County was used for this purpose because that data set was more complete and consistent, and it was believed that Harney County represents some of the best habitat in the state. To be added to the model, the partial F-ratio for a variable had to be above the tabular value at the 0.05 level and the appropriate degrees of freedom.

Four regression equations were investigated. Dependent variables included grouse/10 mi, males/lek, chicks/female, and chicks/adult. Independent variables included the coyote index, raven index, winter temperature index, winter snowfall, grazing (AUMs), and several precipitation variables. Those variables included September-June precipitation that most affects plant growth during the growing year, May-June precipitation that most affects forb growth, and July-September precipitation that would affect fall greenup of forbs and grasses (Sneva 1982). We preferred to have a direct measurement of habitat condition through the years, however such a measurement was not available. We believed that the several precipitation variables and AUMs would provide an indirect measurement of habitat condition.

Of the four multiple regression equations evaluated, there was only one meaningful relationship found and that was the significant regression

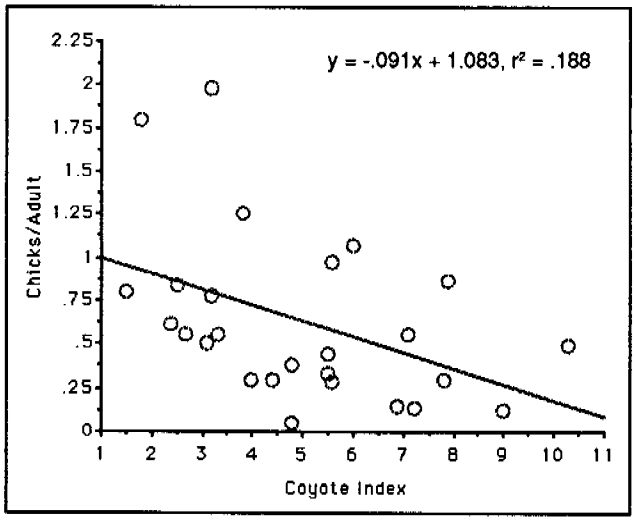

Figure 40. Sage Grouse Productivity vs. Coyote Abundance in Harney County, Oregon, 1959-1991.

(r = -0.434) between coyote abundance and chicks/adult (Figure 40). This relationship indicated coyote abundance may have been an important factor affecting survival of chicks. However, only 19% of the variability in chicks/adult was explained by coyote abundance, indicating that other factors were also important. Other important factors may have been changes in abundance of other predators, plant community changes, disease, and major weather events, in addition to those variables analyzed that may have been important only occasionally.

Discussion and Conclusions

Throughout sage grouse range, the most detrimental factor to sage grouse populations was the complete conversion of large areas of sagebrush steppe habitat, primarily for intensive agriculture, and has been the primary factor in the Columbia Basin. In southeastern Oregon, conversion occurred to a much lesser extent because of the limited ability thus far to make commercial use of the land except for livestock grazing and some cultivation of alfalfa.

Although the population dynamics of sage grouse in southeastern Oregon before European settlement is unknown, populations since the turn of the century were characterized by fluctuations in numbers and productivity. Data collected since the 1950s indicate a decline in productivity which occurred around the early 1970s and has not declined since then. Several studies, particularly in the last 10 years, documented low nest success and chick survival during the first few weeks of life which caused low sage grouse productivity some years. In each case predation was the cause of low nest success and chick survival. Fluctuations in productivity, with a decline since the early 1970s is probably the result of the complicated interaction of a number of factors. However in general, fluctuations in predator abundance in southeastern Oregon has probably been the most important single factor affecting annual productivity of sage grouse in that region. A general increase in predator abundance was indicated through most of Oregon's sage grouse range since the ban of 1080 in 1972 and generally coincides with a decline in sage grouse productivity. Other contributing factors include:

1. Habitat fragmentation caused by sagebrush-to-crested wheatgrass conversion projects and wildfire since the 1950s.
2. Overgrazing by livestock, particularly in the late 1800s and early 1900s which caused reduction of forb and grass cover, increases in shrub cover, degraded riparian areas, and changes in species composition in some areas.
3. Use of chemicals for intensive agriculture and grasshopper control.
4. Changes in fire frequency.
5. Long and short term climatic fluctuations.
6. Significant weather events (e.g., large snowfall during the peak of nesting season).
7. Water developments since the 1940s which may have benefited sage grouse by allowing them to utilize drier habitats during drought periods but may also have contributed to the increase and better distribution of livestock and predators and the spread of disease some years.

While productivity declined since the 1950s and 1960s, a self-sustaining sage grouse population is indicated in Oregon by the combination of the following:

1. A present range of ~30,000 mi^2 in Oregon, contiguous with sage grouse ranges in Idaho, Nevada, and California and which has not changed substantially since intensive agriculture removed most of the shrub steppe habitats in the northern part of the state.
2. Relatively secure habitat conditions within its present range which includes ~17,000 mi^2 of productive sage grouse habitat.
3. No significant change in the adult population as indicated by the trend in males/lek since the late 1950s.
4. No decline in productivity in the last 15 years.
5. A relatively abundant population as indicated by a population estimate of between ~28,000 and 66,000 adults and 19.3 grouse/10 miles counted on production routes in 1992.
6. Continued fluctuations in population indices that have apparently been characteristic since the turn of the century.

Although a general decline in productivity has not been noted over the last 15 years, long term increases in average productivity and population levels of sage grouse are desirable and can best be realized by improvements in habitat conditions on a landscape basis. Large scale, intensive predator

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control would probably increase sage grouse productivity and populations in a relatively short time, however this is unfeasible with methods currently available.

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Recommendations

To insure continued self-sustaining populations of sage grouse and improve productivity in Oregon, actions should be taken to maintain and enhance habitat conditions. Research and experimentation should be a part of this effort. The following actions should be avoided to prevent degradation of current habitat conditions:

1. Complete conversion of large blocks of sagebrush habitat to grassland.
2. Retreatment of old conversions to remove reestablishing sagebrush.
3. Spraying of pesticides to control grasshoppers before mid-July in sagebrush steppe lands inhabited by sage grouse.

The following recommendations address the long-term objective of improving sage grouse habitat in quantity (i.e., to make more suitable habitat available and to increase grouse numbers as they expand their use of habitat) and quality (to increase grouse productivity and density):

1. Create sagebrush/grassland mosaics by the reestablishment of sagebrush within large areas that were converted to grasslands. Re-establish forbs and grasses on depleted ranges (Autenrieth 1981).
2. Create sagebrush/grassland mosaics within large stands of big sagebrush. Priority should be given to those dense big sagebrush stands which have water available and are adjacent to known sage grouse lek habitat and adjacent to areas of low sagebrush and low/big sagebrush mosaics. Created mosaics should include juxtaposition of the two types. We recommend irregular shapes and conversion methods which favor forbs. Autenrieth (1981) favored spot burns of 2.5-5 acres and chaining, which are good for maximizing edge and retaining forbs. Managers should err on the side of leaving plenty of sagebrush. We recommend leaving between 60% and 70% of the area in big sagebrush so that ample sagebrush cover remains for nesting and wintering use.
3. Develop and maintain systems that improve riparian, playa and meadow habitats, and increase forb and grass cover in uplands. Priority should be given to those areas of known sage grouse habitat. In many cases this may necessitate a change or reduction in grazing which may be accomplished through close scrutiny of forage use, fewer annual AUMs, different seasonal use patterns, or the creation of more fenced pastures. Rangeland ecologists in coordination with wildlife biologists are best qualified to determine the most appropriate ways to accomplish this objective.

Several studies and experiments may be necessary to best achieve the habitat objectives defined above and to continue to learn more about the species. We recommend that efforts be directed as follows:

1. Determine the best and most practical method to reestablish sagebrush in converted areas.
2. Determine the best and most practical method to create mosaics in large big sagebrush stands. Because of the need to proceed with caution at removing sagebrush in sage grouse winter range, we believe the effects should be closely monitored.
3. A research project should be developed to:
   a. determine the effects of creating mosaics in dense stands of big sagebrush on sage grouse and other species, and
   b. determine the optimum shape and amount of sagebrush cover to remove.
4. Continue to search for leks.
5. Develop a project to place transmitters on sage grouse in several locations to locate more nesting, summering, and wintering areas so that these areas can be managed with consideration for the welfare of sage grouse.
6. Develop an accurate vegetation type map within sage grouse range in order to identify and prioritize areas to be treated and to facilitate population estimation.

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Table 8. Recommended Minimum Sample Sizes for Four Indices of Sage Grouse in Oregon.

County	Sage Grouse Habitat (Sq.Mile)	% of Total	SAMPLE SIZE			
			Leks	No. of Miles	Adults	Hens
Wheeler	30	0.2				
Union	39	0.2				
Grant	119	0.7				
Klamath	398	2.3	1	20	3	2
Deschutes	470	2.8	1	20	4	2
Crook	750	4.4	2	40	6	3
Baker	1,062	6.3	2	60	8	4
Lake	3,540	20.8	6	164	27	12
Harney	5,019	29.5	9	233	39	17
Malheur	5,495	32.3	10	255	47	19
Core Counties	14,054	82.7	25	652	113	48
Peripheral Counties	2,868	16.9	6	140	21	11
Total	16,992	99.5	31	792	134	59

Monitoring of sage grouse populations through lek counts and production routes should continue. ODFW staff and district biologists should make collection of quality data a high priority. Sampling areas, indices to be monitored, and procedures should be standardized between districts.

Sample sizes should be stratified among counties according to the proportion of total sage grouse habitat occurring in each county and as calculated in **Methods** (page 4) and presented in Table 8. These sample sizes represent the recommended minimum samples for each county in order to have 80% confidence that the statewide sample means for males/lek, chicks/hen, and chicks/adult are within ± 20% of the true means. To have that same confidence in county data, sample sizes must meet statewide criteria (i.e., 30 leks: 85 hens and chicks, and 165 adults and chicks must be classified).

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Appendices

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Sage Grouse Data Collected in **Baker County**, Oregon, 1946-92.

YEAR	No. Males	Leks Counted	Males per Lek	Chicks	Hens	Adults	Chicks per Hen	Chicks per Adult	Total Grouse	No. Miles	Grouse per 10 mi
1946	72	8	9.0								
1947	74	8	9.3								
1948	100	8	12.5								
1949											
1950											
1951											
1952											
1953											
1954											
1955											
1956											
1957											
1958											
1959											
1960											
1961											
1962											
1963											
1964											
1965											
1966											
1967											
1968											
1969											
1970											
1971											
1972											
1973											
1974											
1975											
1976											
1977											
1978											
1979											
1980											
1981	103	4	25.8								
1982											
1983											
1984											
1985											
1986											
1987	93	4	23.3								
1988	166	16	10.4								
1989	114	6	19.0								
1990											
1991											
1992											

Sage Grouse Data Collected in **Crook County**, Oregon, 1946-92.

YEAR	No. Males	Leks Counted	Males per Lek	Chicks	Hens	Adults	Chicks per Hen	Chicks per Adult	Total Grouse	No. Miles	Grouse per 10 mi
1946											
1947											
1948											
1949											
1950											
1951											
1952											
1953											
1954											
1955									92	15	61.3
1956									69	50	13.8
1957									67	13	51.5
1958									145	13	111.5
1959											
1960									76	12	63.3
1961											
1962											
1963											
1964											
1965				38		16		2.4	74	21	35.2
1966				25	13	17	1.9	1.5	89	15	59.3
1967				53	17	28	3.1	1.9	81	15	54.0
1968	101	2	50.5	33	11	17	3.0	1.9	60	15	40.0
1969	260	5	52.0	8	2	6	4.0	1.3	14	15	9.3
1970	210	6	35.0	26	5	7	5.2	3.7	66	31	21.3
1971				21	6	10	3.5	2.1	37	31	11.9
1972	13	2	6.5	22	7	10	3.1	2.2	76	31	24.5
1973				9	4	4	2.3	2.3	15	31	4.8
1974				33	5	22	6.6	1.5	72	44	16.4
1975	21	2	10.5	10	2	3	5.0	3.3	67	41	16.3
1976				40		9		4.4	65	38	17.1
1977									0	38	0.0
1978				24		7		3.4	31	23	13.5
1979	24	2	12.0	13		8		1.6	21	20	10.5
1980	16	2	8.0	5		1		5.0	6	20	3.0
1981	50	6	8.3	8		3		2.7	11	20	5.5
1982				0		0			0	20	0.0
1983	14	3	4.7						0	20	0.0
1984									0	20	0.0
1985									0	20	0.0
1986	108	8	13.5						0	20	0.0
1987	53	4	13.3						0	20	0.0
1988	258	18	14.3						0	20	0.0
1989	167	13	12.8						2	20	1.0
1990	132	8	16.5	7	30	33	0.2	0.2	52	36	14.4
1991	133	6	22.2						0	36	0.0
1992	88	6	14.7	10	2	2	5.0	5.0	95	36	26.4

Sage Grouse Data Collected in **Deschutes County**, Oregon, 1946-92.

YEAR	No. Males	Leks Counted	Males per Lek	Chicks	Hens	Adults	Chicks per Hen	Chicks per Adult	Total Grouse	No. Miles	Grouse per 10 mi
1946											
1947											
1948											
1949	4	1	4.0								
1950	124	2	62.0								
1951											
1952	155	5	31.0								
1953	200	5	40.0								
1954	248	4	62.0								
1955	237	5	47.4								
1956	201	7	28.7								
1957	92	7	13.1								
1958	129	7	18.4								
1959	172	8	21.5								
1960	135	8	16.9								
1961	98	7	14.0								
1962											
1963	81	6	13.5								
1964	113	5	22.6								
1965	176	5	35.2								
1966	201	5	40.2								
1967	150	5	30.0								
1968	138	6	23.0								
1969	121	6	20.2								
1970	81	6	13.5								
1971	50	5	10.0								
1972	41	4	10.3								
1973	39	3	13.0								
1974	20	2	10.0								
1975	40	5	8.0								
1976	26	2	13.0								
1977	32	2	16.0								
1978	31	2	15.5								
1979	75	4	18.8	2		4		0.5	6	100	0.6
1980	110	4	27.5	0		0			0	100	0.0
1981	200	7	28.6	0		0			0	100	0.0
1982	64	5	12.8	10		15		0.7	25	100	2.5
1983	65	5	13.0	2	1	1	2.0	2.0	3	100	0.3
1984	39	3	13.0	17		5		3.4	22	100	2.2
1985	55	4	13.8	5		10		0.5	15	100	1.5
1986	109	6	18.2	18	3	8	6.0	2.3	35	100	3.5
1987	101	5	20.2	6	1	10	6.0	0.6	16	100	1.6
1988	192	12	16.0	8	14	17	0.6	0.5	25	100	2.5
1989	255	17	15.0	5	1	12	5.0	0.4	17	100	1.7
1990	198	13	15.2	16	11	25	1.5	0.6	44	100	4.4
1991	212	5	42.4	0		12		0.0	12	100	1.2
1992	225	16	14.1	0	0	1		0.0	1	100	0.1

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Sage Grouse Data Collected in **Harney County**, Oregon, 1946-92.

YEAR	No. Males	Leks Counted	Males per Lek	Chicks	Hens	Adults	Chicks per Hen	Chicks per Adult	Total Grouse	No. Miles	Grouse per 10 mi
1946											
1947	131	3	43.7								
1948	130	2	65.0								
1949	280	4	70.0								
1950	575	6	95.8								
1951	498	6	83.0								
1952	340	4	85.0								
1953	324	5	64.8								
1954	215	6	35.8								
1955	261	6	43.5	5		4		1.3	9	56	1.6
1956	67	2	33.5	37		18		2.1	74	56	13.2
1957	185	6	30.8								
1958	281	8	35.1	119		95		1.3	245	137	17.9
1959	282	8	35.3	47		163		0.3	426	144	29.6
1960	241	7	34.4	64		83		0.8	356	159	22.4
1961	140	7	20.0	134		267		0.5	444	186	23.9
1962	109	7	15.6	204		210		1.0	457	199	23.0
1963	115	6	19.2	97		49		2.0	165	188	8.8
1964	156	6	26.0	75		87		0.9	174	199	8.7
1965	142	8	17.8	26		78		0.3	104	199	5.2
1966	159	8	19.9	42		151		0.3	217	211	10.3
1967	124	7	17.7	36		66		0.5	102	211	4.8
1968	356	10	35.6	181		101		1.8	300	211	14.2
1969	129	6	21.5	54		35		1.5	89	211	4.2
1970	235	12	19.6	112		140		0.8	252	211	11.9
1971	242	13	18.6	13		88		0.1	126	211	6.0
1972	487	14	34.8	25		34		0.7	65	194	3.4
1973	397	13	30.5								
1974	48	4	12.0								
1975	105	7	15.0								
1976	117	7	16.7	28		38		0.7	77	174	4.4
1977	168	8	21.0	0		36		0.0	38	200	1.9
1978	156	8	19.5	9		30		0.3	33	185	1.8
1979	113	7	16.1	37		122		0.3	156	161	9.7
1980				45	31	82	1.5	0.5	221	211	10.5
1981	302	10	30.2	64	39	130	1.6	0.5	467	235	19.9
1982	380	16	23.8	18	32	153	0.6	0.1	322	230	14.0
1983	317	13	24.4	48	38	45	1.3	1.1	226	221	10.2
1984	360	16	22.5	19	37	148	0.5	0.1	215	230	9.3
1985	287	15	19.1	71	47	115	1.5	0.6	200	200	10.0
1986	522	19	27.5	125	61	226	2.0	0.6	422	157	26.9
1987	698	19	36.7	117	56	139	2.1	0.8	535	184	29.1
1988	849	19	44.7	80	88	264	0.9	0.3	464	184	25.2
1989	885	20	44.3	142	154	323	0.9	0.4	528	184	28.7
1990	1112	26	42.8	98	143	255	0.7	0.4	370	184	20.1
1991	696	22	31.6	5	17	101	0.3	0.0	110	184	6.0
1992	714	23	31.0	84	76	121	1.1	0.7	282	184	15.3

Sage Grouse Data Collected on **Hart Mountain National Wildlife Refuge**, 1946-92.

YEAR	No. Males	Leks Counted	Males per Lek	Chicks	Hens	Adults	Chicks per Hen	Chicks per Adult	Total Grouse	No. Miles	Grouse per 10 mi
1946											
1947											
1948											
1949											
1950											
1951											
1952											
1953											
1954				515	165		3.1				
1955											
1956				125	51		2.5				
1957				485	87		5.6				
1958				912	230		4.0				
1959				274	625		0.4				
1960				136	87		1.6				
1961				174	82		2.1				
1962				178	96		1.9				
1963				502	161		3.1				
1964											
1965				276	164		1.7				
1966				77	94		0.8				
1967				235	122		1.9				
1968				79	62		1.3				
1969											
1970				89	28		3.2				
1971				15	17		0.9				
1972				75	33		2.3				
1973											
1974											
1975				80	31		2.6				
1976				53	21		2.5				
1977				117	46		2.5				
1978				317	157		2.0				
1979				113	45		2.5				
1980	65	3	21.7								
1981	160	4	40.0								
1982	152	4	38.0								
1983	122	4	30.5								
1984	139	4	34.8								
1985	120	5	24.0	31	52		0.6				
1986	120	3	40.0	130	42		3.1				
1987	193	5	38.6	188	73		2.6		497	247	20.1
1988	227	5	45.4	135	55		2.5				
1989	208	5	41.6	109	117		0.9		226	348	6.5
1990	239	5	47.8	35	78		0.4		247	309	8.0
1991	184	5	36.8	9	34	36	0.3	0.3	48	320	1.5
1992	144	5	28.8	117	113	173	1.0	0.7	311	475	6.5

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Sage Grouse Data Collected in **North Lake County**, Oregon, 1946-92.

YEAR	No. Males	Leks Counted	Males per Lek	Chicks	Hens	Adults	Chicks per Hen	Chicks per Adult	Total Grouse	No. Miles	Grouse per 10 mi
1946											
1947											
1948											
1949											
1950											
1951											
1952											
1953											
1954				8	1		8.0				
1955											
1956				30	17	51	1.8	0.6	115	118	9.7
1957				33	9	22	3.7	1.5	55	40	13.8
1958				162	38		4.3		237	80	29.6
1959	112	4	28.0	46	16		2.9		124	80	15.5
1960	134	5	26.8								
1961	123	6	20.5	39	11	15	3.5	2.6	115	25	46.0
1962	128	6	21.3	61		83		0.7	291	30	97.0
1963				59	10	48	5.9	1.2	184	30	61.3
1964	119	6	19.8	50		29		1.7	153	30	51.0
1965	44	3	14.7	27		16		1.7	43	25	17.2
1966	41	4	10.3						52	25	20.8
1967				9		23		0.4	32	25	12.8
1968									43	25	17.2
1969											
1970	69	5	13.8	2		6		0.3	8	25	3.2
1971	9	1	9.0	18	13	13	1.4	1.4	31	25	12.4
1972				12	11	25	1.1	0.5	37	25	14.8
1973				21	8	23	2.6	0.9	44	25	17.6
1974				11	3	6	3.7	1.8	17	25	6.8
1975				5					54	25	21.6
1976									41	25	16.4
1977									0	20	0.0
1978									0	20	0.0
1979				6	1	1	6.0	6.0	7	20	3.5
1980				30	7	25	4.3	1.2	55	20	27.5
1981	78	5	15.6	11		37		0.3	48	20	24.0
1982	102	8	12.8	19		17		1.1	36	20	18.0
1983	93	8	11.6	13	4	13	3.3	1.0	35	20	17.5
1984	130	11	11.8	9	2	11	4.5	0.8	20	20	10.0
1985	75	4	18.8	8	2	7	4.0	1.1	15	20	7.5
1986	76	4	19.0	7	2	4	3.5	1.8	21	20	10.5
1987	58	3	19.3	1	1	6	1.0	0.2	22	20	11.0
1988				16	10	22	1.6	0.7	39	20	19.5
1989	12	1	12.0	7	16	24	0.4	0.3	31	38	8.2
1990	20	2	10.0	15	17	25	0.9	0.6	44	49	9.0
1991	3	2	1.5	0	8	12	0.0	0.0	24	51	4.7
1992	86	5	17.2	20	18	23	1.1	0.9	64	55	11.6

Sage Grouse Data Collected in **South Lake County**, Oregon, 1946-92.

YEAR	No. Males	Leks Counted	Males per Lek	Chicks	Hens	Adults	Chicks per Hen	Chicks per Adult	Total Grouse	No. Miles	Grouse per 10 mi
1946											
1947											
1948											
1949											
1950											
1951											
1952											
1953											
1954				379	87		4.4		961	96	100.1
1955				68		88		0.8	175	112	15.6
1956				29		59		0.5	483	112	43.1
1957				517	132		3.9		1107	161	68.8
1958				560	114		4.9		1144	161	71.1
1959				175	65		2.7		582	128	45.5
1960				313	110		2.8		527	128	41.2
1961				314	95		3.3		519	128	40.5
1962				404	90		4.5		915	128	71.5
1963				102	50		2.0		158	128	12.3
1964				95	111		0.9		428	128	33.4
1965				45	24		1.9		89	128	7.0
1966				49	38		1.3		143	128	11.2
1967				20	8		2.5		34	128	2.7
1968				35	64		0.5		121	128	9.5
1969				98	35		2.8		187	128	14.6
1970				180	51		3.5		353	128	27.6
1971				38	23		1.7		84	128	6.6
1972				34	22	35	1.5	1.0	69	128	5.4
1973				99	24	33	4.1	3.0	148	128	11.6
1974											
1975				12	21	21	0.6	0.6	33	128	2.6
1976					65	42	0.0	0.0	179	128	14.0
1977											
1978											
1979	153	4	38.3								
1980	152	4	38.0	30	8	8	3.8	3.8	38	128	3.0
1981	135	4	33.8	10		52		0.2	62	128	4.8
1982	115	4	28.8	7		43		0.2	50	128	3.9
1983				13	21	37	0.6	0.4	55	128	4.3
1984				21	14	25	1.5	0.8	46	128	3.6
1985				25	32	56	0.8	0.4	81	128	6.3
1986				59	17	21	3.5	2.8	95	128	7.4
1987				60	20	22	3.0	2.7	112	128	8.8
1988				85	42	60	2.0	1.4	237	128	18.5
1989				45	16	28	2.8	1.6	130	128	10.2
1990				34	38	47	0.9	0.7	168	128	13.1
1991				12	26	70	0.5	0.2	154	128	12.0
1992				82	32	96	2.6	0.9	411	128	32.1

Sage Grouse Data Collected in **Lake County**, Oregon, 1946-92.

YEAR	No. Males	Leks Counted	Males per Lek	Chicks (/Hen)	Hens	Chicks (/Adults)	Adults	Chicks per Hen	Chicks per Adult	No. Grouse	No. Miles	Grouse per 10 mi
1946												
1947												
1948												
1949												
1950												
1951												
1952												
1953												
1954				387	88			4.4		961	96	100.1
1955						68	88		0.8	175	112	15.6
1956				30	17	59	110	1.8	0.5	598	230	26.0
1957				550	141	33	22	3.9	1.5	1162	201	57.8
1958				722	152			4.8		1381	241	57.3
1959	112	4	28.0	221	81			2.7		706	208	33.9
1960	134	5	26.8	313	110			2.8		527	128	41.2
1961	123	6	20.5	353	106	39	15	3.3	2.6	634	153	41.4
1962	128	6	21.3	404	90	61	83	4.5	0.7	1206	158	76.3
1963				161	60	59	48	2.7	1.2	342	158	21.6
1964	119	6	19.8	95	111	50	29	0.9	1.7	581	158	36.8
1965	44	3	14.7	45	24	27	16	1.9	1.7	132	153	8.6
1966	41	4	10.3	49	38			1.3		195	153	12.7
1967				20	8	9	23	2.5	0.4	66	153	4.3
1968				35	64			0.5		164	153	10.7
1969				98	35			2.8		187	128	14.6
1970	69	5	13.8	180	51	2	6	3.5	0.3	361	153	23.6
1971	9	1	9.0	56	36	18	13	1.6	1.4	115	153	7.5
1972				46	33	46	60	1.4	0.8	106	153	6.9
1973				120	32	120	56	3.8	2.1	192	153	12.5
1974				11	3	11	6	3.7	1.8	17	25	6.8
1975				12	21	12	21	0.6	0.6	87	153	5.7
1976										41	25	16.4
1977										0	20	
1978										0	20	
1979	153	4	38.3	6	1	6	1	6.0	6.0	7	20	3.5
1980	152	4	38.0	60	15	60	33	4.0	1.8	93	148	6.3
1981	213	9	23.7			21	89		0.2	110	148	7.4
1982	217	12	18.1			26	60		0.4	86	148	5.8
1983	93	8	11.6	26	25	26	50	1.0	0.5	90	148	6.1
1984	130	11	11.8	30	16	30	36	1.9	0.8	66	148	4.5
1985	75	4	18.8	33	34	33	63	1.0	0.5	96	148	6.5
1986	76	4	19.0	66	19	66	25	3.5	2.6	116	148	7.8
1987	58	3	19.3	61	21	61	28	2.9	2.2	134	148	9.1
1988				101	52	101	82	1.9	1.2	276	148	18.6
1989	12	1	12.0	52	32	52	52	1.6	1.0	161	166	9.7
1990	20	2	10.0	49	55	49	72	0.9	0.7	212	177	12.0
1991	3	2	1.5	12	34	12	82	0.4	0.1	178	179	9.9
1992	86	5	17.2	102	50	102	119	2.0	0.9	475	183	26.0

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Sage Grouse Data Collected in **Malheur County**, Oregon, 1946-92.

YEAR	No. Males	Leks Counted	Males per Lek	Chicks	Hens	Adults	Chicks per Hen	Chicks per Adult	Total Grouse	No. Miles	Grouse per 10 mi
1946											
1947	300	1	300.0								
1948											
1949											
1950											
1951				150	41		3.7				
1952				117	51		2.3			165	
1953				56	22		2.5			190	
1954				180	65	84	2.8	2.1	264		
1955				167	70	102	2.4	1.6	269	175	15.4
1956				160	38	46	4.2	3.5	294	97	30.3
1957				239	58	81	4.1	3.0	391	203	19.3
1958				541	124	171	4.4	3.2	822	203	40.5
1959				99	47	250	2.1	0.4	729	203	35.9
1960				312	166	423	1.9	0.7	992	160	62.0
1961				660	207	378	3.2	1.7	1487	216	68.8
1962				257	71	119	3.6	2.2	717	216	33.2
1963	3	1	3.0						525	160	32.8
1964									495	147	33.7
1965									7	80	0.9
1966				353	118	308	3.0	1.1	1066	129	82.6
1967				110	29	58	3.8	1.9	289	123	23.5
1968				333	64	104	5.2	3.2	1257	95	132.3
1969				100	55	121	1.8	0.8	825	90	91.7
1970				161	37	158	4.4	1.0	900	95	94.7
1971				146	65	192	2.2	0.8	2091	104	201.1
1972	8	1	8.0	134	48	214	2.8	0.6	1169	132	88.6
1973				96	56		1.7		784	120	65.3
1974				28	12		2.3		112	20	56.0
1975				21	13	26	1.6	0.8	154	46	33.5
1976				56	17		3.3		409	350	11.7
1977	30	2	15.0	21	19	32	1.1	0.7	663	248	26.7
1978				33	11	28	3.0	1.2	695	248	28.0
1979				58	39	100	1.5	0.6	623	248	25.1
1980				43	61	330	0.7	0.1	553	248	22.3
1981				37	64	168	0.6	0.2	776	248	31.3
1982				16	48	209	0.3	0.1	325	255	12.7
1983				31	75	292	0.4	0.1	365	255	14.3
1984	161	11	14.6	13	87	144	0.1	0.1	181	255	7.1
1985	98	8	12.3	37	60	90	0.6	0.4	324	255	12.7
1986	44	4	11.0	61	60	116	1.0	0.5	387	255	15.2
1987	282	13	21.7	56	46	79	1.2	0.7	311	255	12.2
1988	159	12	13.3	25	77	115	0.3	0.2	300	255	11.8
1989	8	1	8.0	72	37	65	1.9	1.1	444	255	17.4
1990				71	84	138	0.8	0.5	613	321	19.1
1991	166	9	18.4	34	52	122	0.7	0.3	391	298	13.1
1992	50	7	7.1	128	78	85	1.6	1.5	691	298	23.2

Sage Grouse Data Collected in **Peripheral Counties***, Oregon, 1946-92.

YEAR	No. Males	Leks Counted	Males per Lek	Chicks (/Hen)	Hens	Chicks (/Adults)	Adults	Chicks per Hen	Chicks per Adult	No. Grouse	No. Miles	Grouse per 10 mi
1946	72	8	9.0									
1947	74	8	9.3									
1948	100	8	12.5									
1949	4	1	4.0									
1950	124	2	62.0									
1951												
1952	155	5	31.0									
1953	200	5	40.0									
1954	248	4	62.0									
1955	237	5	47.4							92	15	6.1
1956	201	7	28.7							69	50	1.4
1957	92	7	13.1							67	13	5.2
1958	129	7	18.4							145	13	11.2
1959	172	8	21.5									
1960	135	8	16.9							76	12	6.3
1961	98	7	14.0									
1962												
1963	81	6	13.5									
1964	113	5	22.6									
1965	176	5	35.2			38	16		2.4	74	21	3.5
1966	201	5	40.2	25	13	25	17	1.9	1.5	89	15	5.9
1967	150	5	30.0	53	17	53	28	3.1	1.9	81	15	5.4
1968	239	8	29.9	33	11	33	17	3.0	1.9	60	15	4.0
1969	381	11	34.6	8	2	8	6	4.0	1.3	14	15	0.9
1970	291	12	24.3	26	5	26	7	5.2	3.7	66	31	2.1
1971	50	5	10.0	21	6	21	10	3.5	2.1	37	31	1.2
1972	54	6	9.0	22	7	22	10	3.1	2.2	76	31	2.5
1973	39	3	13.0	9	4	9	4	2.3	2.3	15	31	0.5
1974	20	2	10.0	33	5	33	22	6.6	1.5	72	44	1.6
1975	61	7	8.7	10	2	10	3	5.0	3.3	67	41	1.6
1976	26	2	13.0			40	9		4.4	65	38	1.7
1977	32	2	16.0							0	38	
1978	31	2	15.5			24	7		3.4	31	23	1.3
1979	99	6	16.5			15	12		1.3	27	120	0.2
1980	126	6	21.0			5	1		5.0	6	120	0.1
1981	353	17	20.8			8	3		2.7	11	120	0.1
1982	64	5	12.8			10	15		0.7	25	120	0.2
1983	79	8	9.9	2	1	2	1	2.0	2.0	3	120	0.0
1984	39	3	13.0			17	5		3.4	22	120	0.2
1985	55	4	13.8			5	10		0.5	15	120	0.1
1986	217	14	15.5	18	3	18	8	6.0	2.3	35	120	0.3
1987	247	13	19.0	6	1	6	10	6.0	0.6	16	120	0.1
1988	616	46	13.4	8	14	8	17	0.6	0.5	25	120	0.2
1989	536	36	14.9	5	1	5	12	5.0	0.4	19	120	0.2
1990	330	21	15.7	23	41	23	58	0.6	0.4	96	136	0.7
1991	345	11	31.4	0	0	0	12		0.0	12	136	0.1
1992	313	22	14.2	10	2	10	3	5.0	3.3	96	136	0.7

* Pheripheral counties include Crook, Deschutes, and Baker.

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Sage Grouse Data Collected in **Core Counties***, Oregon, 1946-92.

YEAR	No. Males	Leks Counted	Males per Lek	Chicks (/Hen)	Hens	Chicks (/Adults)	Adults	Chicks per Hen	Chicks per Adult	No. Grouse	No. Miles	Grouse per 10 mi
1946												
1947	431	4	107.8									
1948	130	2	65.0									
1949	280	4	70.0									
1950	575	6	95.8									
1951	498	6	83.0	150	41			3.7				
1952	340	4	85.0	117	51			2.3				
1953	324	5	64.8	56	22			2.5				
1954	215	6	35.8	567	153	180	84	3.7	2.1	1225	96	127.6
1955	261	6	43.5	167	70	240	194	2.4	1.2	453	343	13.2
1956	67	2	33.5	190	55	256	174	3.5	1.5	966	383	25.2
1957	185	6	30.8	789	199	272	103	4.0	2.6	1553	404	38.4
1958	281	8	35.1	1263	276	660	266	4.6	2.5	2448	581	42.1
1959	394	12	32.8	320	128	146	413	2.5	0.4	1861	555	33.5
1960	375	12	31.3	625	276	376	506	2.3	0.7	1875	447	41.9
1961	263	13	20.2	1013	313	833	660	3.2	1.3	2565	555	46.2
1962	237	13	18.2	661	161	522	412	4.1	1.3	2380	573	41.5
1963	118	7	16.9	161	60	156	97	2.7	1.6	1032	506	20.4
1964	275	12	22.9	95	111	125	116	0.9	1.1	1250	504	24.8
1965	186	11	16.9	45	24	53	94	1.9	0.6	243	432	5.6
1966	200	12	16.7	402	156	395	459	2.6	0.9	1478	493	30.0
1967	124	7	17.7	130	37	155	147	3.5	1.1	457	487	9.4
1968	356	10	35.6	368	128	514	205	2.9	2.5	1721	459	37.5
1969	129	6	21.5	198	90	154	156	2.2	1.0	1101	429	25.7
1970	304	17	17.9	341	88	275	304	3.9	0.9	1513	459	33.0
1971	251	14	17.9	202	101	177	293	2.0	0.6	2332	468	49.8
1972	495	15	33.0	46	33	205	308	1.4	0.7	1340	479	28.0
1973	397	13	30.5	216	88	120	56	2.5	2.1	976	273	35.8
1974	48	4	12.0	39	15	11	6	2.6	1.8	129	45	28.7
1975	105	7	15.0	33	34	33	47	1.0	0.7	241	199	12.1
1976	117	7	16.7	56	17	28	38	3.3	0.7	706	677	10.4
1977	198	10	19.8	21	19	21	68	1.1	0.3	701	468	15.0
1978	156	8	19.5	33	11	42	58	3.0	0.7	728	453	16.1
1979	266	11	24.2	64	40	101	223	1.6	0.5	786	429	18.3
1980	152	4	38.0	148	107	148	445	1.4	0.3	867	607	14.3
1981	515	19	27.1	101	103	122	387	1.0	0.3	1353	631	21.4
1982	597	28	21.3	34	80	60	422	0.4	0.1	733	633	11.6
1983	410	21	19.5	105	138	105	387	0.8	0.3	681	624	10.9
1984	651	38	17.1	62	140	62	328	0.4	0.2	462	633	7.3
1985	460	27	17.0	141	141	141	268	1.0	0.5	620	603	10.3
1986	642	27	23.8	252	140	193	346	1.8	0.6	925	560	16.5
1987	1038	35	29.7	234	123	234	246	1.9	1.0	980	587	16.7
1988	1008	31	32.5	206	217	206	461	0.9	0.4	1040	587	17.7
1989	905	22	41.1	266	223	266	440	1.2	0.6	1133	605	18.7
1990	1132	28	40.4	218	282	218	465	0.8	0.5	1195	682	17.5
1991	865	33	26.2	51	103	51	305	0.5	0.2	679	661	10.3
1992	850	35	24.3	314	204	314	325	1.5	1.0	1448	665	21.8

* Core counties include Harney, Lake, and Malheur.

Sage Grouse Data Collected **Statewide** in Oregon, 1946-92.

YEAR	No. Males	Leks Counted	Males per Lek	Chicks (/Hen)	Hens	Chicks (/Adults)	Adults	Chicks per Hen	Chicks per Adult	No. Grouse	No. Miles	Grouse per 10 mi
1946	72	8	9.0									
1947	505	12	42.1									
1948	230	10	23.0									
1949	284	5	56.8									
1950	699	8	87.4									
1951	498	6	83.0	150	41			3.7				
1952	495	9	55.0	117	51			2.3				
1953	524	10	52.4	56	22			2.5				
1954	463	10	46.3	567	153	180	84	3.7	2.1	1225	96	127.6
1955	498	11	45.3	167	70	240	194	2.4	1.2	545	358	15.2
1956	268	9	29.8	190	55	256	174	3.5	1.5	1035	433	23.9
1957	277	13	21.3	789	199	272	103	4.0	2.6	1620	417	38.8
1958	410	15	27.3	1263	276	660	266	4.6	2.5	2593	594	43.7
1959	566	20	28.3	320	128	146	413	2.5	0.4	1861	555	33.5
1960	510	20	25.5	625	276	376	506	2.3	0.7	1951	459	42.5
1961	361	20	18.1	1013	313	833	660	3.2	1.3	2565	555	46.2
1962	237	13	18.2	661	161	522	412	4.1	1.3	2380	573	41.5
1963	199	13	15.3	161	60	156	97	2.7	1.6	1032	506	20.4
1964	388	17	22.8	95	111	125	116	0.9	1.1	1250	504	24.8
1965	362	16	22.6	45	24	91	110	1.9	0.8	317	453	7.0
1966	401	17	23.6	427	169	420	476	2.5	0.9	1567	508	30.8
1967	274	12	22.8	183	54	208	175	3.4	1.2	538	502	10.7
1968	595	18	33.1	401	139	547	222	2.9	2.5	1781	474	37.6
1969	510	17	30.0	206	92	162	162	2.2	1.0	1115	444	25.1
1970	595	29	20.5	367	93	301	311	3.9	1.0	1579	490	32.2
1971	301	19	15.8	223	107	198	303	2.1	0.7	2369	499	47.5
1972	549	21	26.1	202	88	227	318	2.3	0.7	1416	510	27.8
1973	436	16	27.3	225	92	129	60	2.4	2.2	991	304	32.6
1974	68	6	11.3	72	20	44	28	3.6	1.6	201	89	22.6
1975	166	14	11.9	43	36	43	50	1.2	0.9	308	240	12.8
1976	143	9	15.9	56	17	68	47	3.3	1.4	771	715	10.8
1977	230	12	19.2	21	19	21	68	1.1	0.3	701	506	13.9
1978	187	10	18.7	33	11	66	65	3.0	1.0	759	476	15.9
1979	365	17	21.5	64	40	116	235	1.6	0.5	813	549	14.8
1980	278	10	27.8	148	107	153	446	1.4	0.3	873	727	12.0
1981	868	36	24.1	101	103	130	390	1.0	0.3	1364	751	18.2
1982	661	33	20.0	34	80	70	437	0.4	0.2	758	753	10.1
1983	489	29	16.9	107	139	107	388	0.8	0.3	684	744	9.2
1984	690	41	16.8	62	140	79	333	0.4	0.2	484	753	6.4
1985	515	31	16.6	141	141	146	278	1.0	0.5	635	723	8.8
1986	859	41	21.0	270	143	270	375	1.9	0.7	960	680	14.1
1987	1285	48	26.8	240	124	240	256	1.9	0.9	996	707	14.1
1988	1624	77	21.1	214	231	214	478	0.9	0.4	1065	707	15.1
1989	1441	58	24.8	271	224	271	452	1.2	0.6	1152	725	15.9
1990	1462	49	29.8	241	323	241	523	0.7	0.5	1291	818	15.8
1991	1210	44	27.5	51	103	51	317	0.5	0.2	691	797	8.7
1992	1163	57	20.4	324	206	324	328	1.6	1.0	1544	801	19.3

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Appendix B. Grazing Level on Four BLM Districts in Southeastern Oregon, 1964-91.*

Year	Prineville	Vale	Baker**	Burns	Lakeview	Total
1964	105,313	409,726	93,723	296,447	144,639	1,049,848
1965	112,488	411,285	93,723	313,997	144,639	1,076,132
1966	83,426	419,567	84,908	315,930	161,942	1,065,773
1967	102,482	421,052	76,653	333,704	141,552	1,075,443
1968	99,815	422,414	64,081	275,845	127,987	990,142
1969	89,046	426,024	52,811	245,277	142,800	955,958
1970	94,945	407,152	53,651	250,969	148,968	955,685
1971	92,170	418,010	52,659	252,703	163,021	978,563
1972	98,157	416,248	52,200	249,834	157,801	974,240
1973	96,052	419,472	55,235	265,008	157,127	992,894
1974	103,435	432,394	55,929	260,328	145,188	997,274
1975	92,400	415,383	54,983	260,328	155,682	978,776
1976	86,765	424,646	55,463	253,395	141,869	962,138
1977	83,102	369,334	50,857	253,195	143,194	899,682
1978	84,227	406,637	51,531	241,500	154,064	937,959
1979	85,951	414,274	52,168	247,619	156,778	956,790
1980	82,594	420,342	55,317	246,956	176,258	981,467
1981	78,853	431,141	56,123	202,304	138,020	906,441
1982	78,853	474,430		213,162	165,074	931,519
1983	78,988	488,904		246,778	177,092	991,762
1984	99,004	464,960		273,392	166,878	1,004,234
1985	111,139	464,300		291,529	162,372	1,029,340
1986	103,544	421,265		263,327	161,035	949,171
1987	103,582	432,643		228,718	123,999	888,942
1988	101,331	405,316		230,062	135,828	872,537
1989***						
1990	111,022	461,694		231,944	125,000	929,660
1991	104,588	366,124		166,385	94,633	731,730

* Data from J. Fullerton (BLM)(personal communication).

** Baker District data included in Vale District after 1982.

*** AUM's for 1989 are not reported due to a change in accounting procedures.

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