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Seasonal diet and food selection of California quail (Callipepla californica) were studied at E.E. Wilson Wildlife Area, Oregon, during 1985 to 1987. Analysis of diets of 105 quail, along with information from 117 quail taken during 1976 to 1978 revealed 14 key plant foods. Collectively, the key foods composed 87% of the diet by dry weight during 1985-87; 6 species of legumes constituted 63% of the diet. The most frequently consumed foods included wild carrot, vetch, Scot's broom, dandelions, teasel, and grasses; the bulk of the diet was composed of deervetch, peavine, Scot's broom, vetch, and grasses. Legumes composed the bulk of the diet, were among the most frequently consumed, and were highly preferred. Invertebrate matter (primarily ants, beetles, bugs, and grasshoppers) was present seasonally (51% annual frequency) and composed 0.5% of the diet by dry weight. Frequencies of invertebrate matter were higher in spring and summer (71% and 80%, respectively) than in fall and winter (37% and 43%, respectively). Male and female quail consumed invertebrates with similar frequency. The seasonal response of key foods to disking and burning was evaluated from spring 1986 to spring 1989. Treatments produced increased percent cover and frequencies of occurrence for 7 key foods (6 key foods did not occur with sufficient frequency to evaluate response). Wild carrot and dandelions showed the greatest response with immediate and sustained increases in cover and frequency. Vetch and clover also responded positively. Reduced

cover of grasses persisted for only a few seasons. Disking consistently afforded the most immediate increases and maintenance of key foods compared with burning, although treatment effects persisted for only 1-2 years. Management for quail foods should include the establishment and maintenance of legumes and other early seral plant foods. Manipulations should be conducted every 2-3 years in western Oregon and other mesic ranges.

FORAGING ECOLOGY OF CALIFORNIA QUAIL AND RESPONSE OF KEY FOODS TO HABITAT MANIPULATIONS IN WESTERN OREGON

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Upon the completion of this thesis I realize the multitude of people who contributed to the success of the research and my personal growth; to these individuals I am sincerely grateful.

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CHAPTER I

INTRODUCTION

The goal of this research was to provide information for the effective and efficient management of habitat for California quail in western Oregon by examination of the foraging ecology and evaluation of the long-term responses of plant foods to habitat manipulations. Previous work at E.E. Wilson Wildlife Area (Wilson WA) included descriptions of foraging habitats of California quail, dietary components, and comparisons of annual disking and food plots to produce quail foods (Crawford 1978, Oates 1979, Oates and Crawford 1983). As a result, the Oregon Department of Fish and Wildlife, beginning in 1980, reinstituted several habitat manipulations to create early seral areas and increase the abundance of quail foods. Information on the long-term dietary changes of California quail and comparisons of disking and burning to produce quail plant foods is unavailable.

The objectives were to compare invertebrate and key plant foods consumed by California quail with information collected during 1976-78 (Oates 1979) and to dietary analyses from other areas of the quail range. Key foods included plant taxa that were most frequently consumed, or were highly preferred, or made up the bulk of the diet. Further, the effects of disking and burning on key plant foods were evaluated. Additional information about diets, plant availabilities, and plant response to manipulations was collected and summarized in Appendices 1, 2, 3, and 4 for those interested in specific plants for other wildlife species or to evaluate plant community response to the manipulations.

Chapter II

INVERTEBRATE MATTER IN THE DIET OF CALIFORNIA QUAIL IN WESTERN OREGON

Studies of California quail (Callipepla californica) revealed that plant foods composed more than 95% of the annual diet (Sumner 1935, Glading et al. 1940, Crispens et al. 1960, Shields and Duncan 1966, Duncan 1968, Anthony 1970, Browning in Leopold 1977:229, Knight et al. 1979, Oates and Crawford 1983). Invertebrates constituted little of the diet but may be an important source of nutrients (Leopold 1977). Additionally, some invertebrates may serve as intermediate hosts of parasites of California quail (Moore et al. 1988). Highest frequencies of invertebrate matter (chiefly ants, beetles, bugs, and grasshoppers) were reported during the spring, summer, and early fall (Sumner 1935, Glading et al. 1940, Crispens et al. 1960, Browning in Leopold 1977). Glading et al. (1940) reported that the highest consumption of invertebrates was by breeding females and chicks during the first few weeks after hatching. Rarely were invertebrates reported in the diet during winter.

Environmental conditions, notably precipitation, may affect consumption of invertebrate matter by California quail (Shields and Duncan 1966, Browning in Leopold 1977). Leopold (1977:173) stated that more insects are consumed in wet than in dry years. However, most diet studies were conducted in the arid portion of their range. Little information is available about the diet, particularly the invertebrate component, of California quail in mesic areas of the species' range (from northwestern California through western Oregon, western Washington, and Vancouver Island, British Columbia). Hence, the objectives of this study were to estimate the frequency of animal matter in the diet of California quail from western Oregon and to determine if frequencies of invertebrate matter were related to sex, age, or season.

STUDY AREA AND METHODS

The study was conducted on the 650 ha E.E. Wilson Wildlife Area (Wilson WA), located 16 km north of Corvallis, Oregon. Grasses (predominantly Festuca spp.) and forbs such as wild carrot (Daucus carota), peavine (Lathyrus spp.), vetch (Vicia spp.), and lotus (Lotus spp.), interspersed with blackberries (Rubus spp.), Scot's broom (Cytisus scoparius), roses (Rosa spp.), and small stands of Oregon white oak (Quercus garryana), Oregon ash (Fraxinus latifolia), black cottonwood (Populus trichocarpa), and hawthorne (Crataegus spp.) characterized the vegetation on Wilson WA. Plant taxonomy follows that of Hitchcock and Cronquist (1973).

California quail were collected seasonally (fall, 15 September-20 November; winter, 7 December-28 February; spring, 4 March-26 April; and summer, 18 June-6 August) by shooting and obtained from hunters at Wilson WA from 1976 to 1978 and 1985 to 1987. A total of 256 quail was taken, of which 28 had damaged or empty crops and were unusable for this study. From 1976 to 1978, 117 quail with intact crops were obtained: 50 in fall, 30 in winter, 12 in spring, and 25 in summer. From 1985 to 1987, 111 quail with intact crops were collected: 56 in fall, 17 in winter, and 19 in each of the spring and summer periods. Preliminary analysis with Chi-square tests (Snedecor and Cochran 1980:75) revealed no significant differences in frequency distributions of invertebrate matter in the annual diet of quail collected during 1976-1978 compared with 1985-1987, except for Homoptera. The rank of Homoptera, however, in the diet was not different between the two sample periods; therefore, data from all crops were combined for analysis. Age (adult or immature) of birds was based on the appearance of primary coverts and sex was based on plumage differences (Raitt 1961). Immature quail collected during this study ranged from 9 weeks of age to approximately 12 months; adults were >12 months old. Crops were removed intact and frozen until contents were sorted and identified. Invertebrate identification and classification were from Borror et al. (1981). Crop contents were weighed after drying for 24 hours in a 50°C oven.

Frequencies of invertebrate groups were calculated from all 228 quail, but weights of invertebrate matter were available only from the 111 birds collected in 1985-1987. Differences in the frequency of invertebrate matter between age, sex, and season of collection were tested with loglinear analysis (Fienberg 1983).

RESULTS AND DISCUSSION

Hymenopterans (predominantly ants) occurred with the highest annual frequency (34%) and were the most frequently consumed invertebrate in the diet of California quail during 3 of 4 seasons; frequencies ranged from 11% in winter to 68% during summer (Table II.1). Ants were the most frequent animal component of the diet reported in other studies throughout the range of the species (Sumner 1935, Glading et al. 1940, Yadon 1954, Anthony 1970). Two other groups of invertebrates, Coleoptera (beetles) and Homoptera (leafhoppers and aphids), were present at annual frequencies of $\geq$ 10%. Beetles ranged in frequencies from 6% in fall to 43% in summer (annual frequency of 20%). Homopterans occurred at an annual frequency of 10%, ranging from 2% in winter to 27% during summer. Twelve other invertebrate groups were represented, including 6 additional orders of Insecta, Pulmonata (snails), Isopoda (sow bugs), Diplopoda (millipedes), Geophilomorpha (centipedes), Araneae (spiders), and Opiliones (harvestmen). Ants, beetles, bugs (Hemiptera), moths and butterflies (Lepidoptera), leafhoppers and aphids, spiders, and snails were present in the diet during all seasons. Most invertebrates consumed were adult or late instars, but beetles, moths, and butterflies were often eaten as larvae. Sumner (1935) reported that all lepidopterans consumed by quail in his study in California were larvae. Dry weights of invertebrate matter from crops collected from 1985 to 1987 revealed that 87% of all invertebrate matter was composed of ants (27%), grasshoppers (Orthoptera) (22%), moths and butterflies (20%), and beetles (18%). The remaining invertebrate groups each accounted for 1-4% of the total invertebrate dry weight. Invertebrate matter composed approximately 0.5% of the annual diet based on dry weight.

There were differences in the seasonal and annual frequencies of invertebrate matter in the diets among adult and immature, male and female California quail (Table II.2). An interaction test between age and sex of birds and season of year with the frequency of invertebrate matter revealed that only age and season of year were significant ($p=0.05$ and $p<0.01$, respectively). Frequency of invertebrate matter was not related to sex and no higher order interactions (3- or 4-way) were significant (Fienberg 1983). Immature quail consumed invertebrate matter more frequently than adults, particularly in fall and winter, which may represent a continuation of juvenile foraging behavior. The diet of juvenile quail reportedly becomes similar to that of older birds after 6-16 weeks of age (Glading et al. 1940, Edminster 1954, Browning in Leopold 1977). Anthony (1970) reported that chicks consumed 3 times more invertebrate matter (by volume) than adult quail during the spring and summer months in eastern Washington. However, in this study, there was no apparent trend in the frequency of invertebrates consumed and the age (in weeks) of immature California quail. Invertebrate matter was present in the crops of California quail in all seasons and increased in frequency from fall through summer. Overall frequency of animal matter was 51%, which was higher than the annual frequencies reported from other studies. Frequencies of invertebrate matter were higher in spring and summer (71% and 80%, respectively) than in fall and winter (37% and 43%, respectively). In contrast to the results of Glading et al. (1940), we found that both male and female California quail consumed animal matter at high frequencies during the breeding season.

I concluded that many of the key invertebrates consumed by California quail in the arid portion of the range (ants, beetles, bugs, and grasshoppers) also were the primary invertebrates in the diet of quail in western Oregon. Invertebrates constituted a relatively small proportion of the total diet of California quail in western Oregon but were consumed in higher frequencies and more

consistently throughout the year than in other areas of the range of the species.

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Table II.1. Seasonal and annual frequencies of invertebrate groups in the diet of California quail, E.E. Wilson Wildlife Area, Oregon, 1976-1978 and 1985-1987.

Invertebrate group	Frequency (%)				
	Fall (n=106)	Winter (n=47)	Spring (n=31)	Summer (n=44)	Annual (n=228)
Hymenoptera	25	11	55	68	34
Coleoptera	6	26	29	43	20
Homoptera	6	2	10	27	10
Araneae	2	6	16	11	7
Lepidoptera	3	11	13	2	6
Orthoptera	8	2		9	6
Hemiptera	5	2	3	2	4
Isopoda		6		11	4
Pulmonata	1	4	3	7	3
Unidentified Insecta					
adult	2	9	3		3
larvae	2	2			1
Neuroptera				2	1
Dermaptera	2			2	1
Diptera		2		2	1
Opiliones				2	1
Geophilomorpha		2	3		1
Diplopoda		2			1
All invertebrate matter combined	37	43	71	80	51

Table II.2. Seasonal and annual frequencies of invertebrate matter in the diet of adult and immature, male and female California quail, E.E. Wilson Wildlife Area, Oregon, 1976-1978 and 1985-1987.

Age and sex	Frequency (%)				
	Fall	Winter	Spring	Summer	Annual
Adult male	15 (20)[1]	36 (14)	80 (5)	64 (11)	38 (50)
Adult female	30 (10)	38 (8)	75 (4)	100 (3)	48 (25)
Immature male	41 (29)	53 (15)	67 (15)	88 (16)	59 (75)
Immature female	37 (30)	40 (10)	71 (7)	79 (14)	51 (61)
Total	33 (89)[2]	43 (47)	71 (31)	80 (44)	50(211)

[1] Number of crops examined.

[2] Age and sex information was not recorded for 17 of 106 birds taken during fall collections; consequently, fall and annual sample sizes and frequencies of occurrence differ from Table II.1.

CHAPTER III

DIETARY CHANGES OF CALIFORNIA QUAIL IN WESTERN OREGON

ABSTRACT

Analysis of diets of 222 California quail (Callipepla californica) from western Oregon taken in 1976-78 and 1985-87 revealed 14 key plant foods (annual frequency >15%) among 53 taxa consumed; 10 of 14 key foods were similar between time periods. Collectively the key foods composed 87% of the diet by dry weight during 1985-87 and 6 species of legumes composed 63% of diet. Foraging apparently was less selective and more opportunistic within the key group because 9 of the 14 foods were consumed in different frequencies between the 2 periods. Relative availabilities of key foods were similar between 1976-78 and 1985-87. Legumes composed the bulk of the diet, were among the most frequently consumed, and were among the most highly preferred food items. Management for quail should focus on establishment and maintenance of an array of legumes.

Management of quail habitat often includes manipulations designed to increase production of important foods. Availability of food influences diet, may cause fluctuations in population levels, and is a key element in sustaining high populations of California quail (Sumner 1935, Emlen and Glading 1945, Leopold 1977:170). Gullion (1966) stated that year-round, long-term diet information on game birds, including population status, was critical to understanding habitat management and population dynamics of these birds. Yet, few such studies have been performed, especially on quail of the western United States.

Browning (in Leopold 1977:229) summarized diet studies of California quail from California and noted that a variety of annual plants, particularly filarees (Erodium spp.), legumes, and grasses, furnished the bulk of the diet. Johnsgard (1973:398) concluded that legumes were the most preferred foods of California quail in their native range but probably were less important in extralimital populations. In western Oregon, initial dietary work indicated that several species of Cichorieae (milky-juiced composites), legumes, sorrel (Rumex spp.), and bittercress (Cardamine spp.) were important foods (Oates and Crawford 1983). The purpose of this project was to provide long-term information on the foods and dietary preferences of California quail in western Oregon. Specific objectives were to determine annual and seasonal diets by frequency and weight, to test for changes in use (frequency of occurrence in crops) of key plant foods between 1976-78 and 1985-87, and examine changes in food preferences between 1976-78 and 1985-87.

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STUDY AREA

The study was conducted on the 650-ha E.E. Wilson Wildlife Area (Wilson WA), located 16 km north of Corvallis, Benton County, Oregon. Wilson WA is the site of a decommissioned military base; secondary succession began on the area after abandonment in 1950. Grasses (predominantly Festuca spp.) interspersed with blackberries (Rubus spp.), Scot's broom (Cytisus scoparius), roses (Rosa spp.); and small stands of Oregon white oak (Quercus garryana), Oregon ash (Fraxinus latifolia), black cottonwood (Populus trichocarpa), hawthornes (Crataegus spp.), and apple (Pyrus malus) characterized the vegetation on Wilson WA. Plant taxonomy followed Hitchcock and Cronquist (1973). Annual rainfall averaged 106 cm from 1976 to 1987.

Numerous management practices were conducted on the Wilson WA since 1950, including food plantings, burning, and water development. From 1979 to 1987, the period between the initial study by Oates and Crawford (1983) and the completion of this study, 100-ha of the Wilson WA were burned, 85-ha were sprayed with herbicides (spraying often preceded a burn to increase the fuel load), and 7-ha were disked. The number of food plots was decreased from 21 to 5. Mowing of roadsides, bulldozing, and selective cutting of black cottonwood and Douglas fir (Pseudotsuga menziesii) also were conducted. The number of gallinaceous guzzlers was increased from 4 to 12. Agricultural fields on and adjacent to Wilson WA were used primarily for commercial grass seed production.

Fall quail populations on Wilson WA averaged 250 to 300 birds during 1976-78 (Crawford and Oates 1986) and approximately 400 birds during 1985-87 (unpubl. data) based on counts of coveys and birds/covey. Fall harvests contained 55% males and 66% immatures from 1976-78 (n=58) and 49% males and 67% immatures from 1985-87 (n=57) (unpubl. data).

METHODS

To address changes in the diet between the 2 time periods, comparisons were made between 1) key plant foods consumed, 2) plant parts taken by the birds, 3) frequency of occurrence in the diet, and 4) preference. Diet was determined from 105 California quail collected seasonally (fall, Sep-Nov; winter, Dec-Feb; spring, Mar-May; and summer, Jun-Aug) from fall 1985 to fall 1987 by shooting and obtained from hunters at Wilson WA. Crops were removed intact and frozen until contents could be sorted and identified. Sorted crop contents were weighed after drying for 24 h in a 50 C oven. These data were compared with results of diet analyses conducted at Wilson WA from fall 1976 to fall 1978 (Oates 1979 and unpubl. data) in which frequencies of occurrence of food items were recorded for 117 quail examined, but no estimate of weights was made. Key foods of the California quail were defined as those items that occurred at an annual frequency >15% during either period (preliminary analysis revealed that only those foods with an annual frequency >15% constituted $\geq$1% of the diet by weight from 1985-1987). Although invertebrates were reported in 51% of all crops, they composed only 0.5% of diet by weight (Blakely et al. 1988). Chi-square analysis was used to test for seasonal and annual differences ($p \leq 0.05$) in the use (frequency of occurrence in crops) of key foods between 1976-78 and 1985-87 (Snedecor and Cochran 1980).

Concurrent with quail collections, availability of vegetation was measured seasonally from winter 1985 to fall 1987. To ensure representative sampling, Wilson WA was divided into quarters and 5 random 20-m transects were placed in each quarter within shrub/grassland areas, the habitat used almost exclusively for foraging by California quail. Hence, randomly placed transects were relocated: 1) if the transect had more than 50% coverage in forested stands or continuous shrub cover; or 2) if the transect fell entirely upon a road, parking lot, building, or pond, or 3) if 2 transects had already been located within agricultural fields during any one season for the entire area. The line-intercept method (Canfield 1941) was

used to estimate frequency of occurrence of shrubs and trees on the transects. Frequencies of occurrence of herbaceous species were averaged from 10 0.5-m^2 circular plots spaced at 2-m intervals along each transect. Availability data for 1976-78 were obtained from Oates (1979).

Dietary use and availability data were employed to determine the relative preference index of food items (RPI= frequency of food item in the diet/frequency of food item in the habitat). Occasionally, uncommon plants were not recorded on transects or in plots during some seasons; in such instances, a value of 1% was assigned for availability to calculate the RPI of that food item. Preference values for 1976-78 were computed from Oates (1979) and unpublished data; some values differed from those in Oates and Crawford (1983) because the data were averaged by season, additional diet data were included, and availability data were rounded to whole numbers.

RESULTS

Diet

Fifty-three of approximately 90 plant taxa present on Wilson WA were consumed by California quail (39 taxa during 1976-78 and 44 taxa during 1985-87); 30 of the 53 foods were consumed during both time periods. Fourteen key plant foods were identified: 11 during 1976-78 and 13 in 1985-87 (Table III.1). Key foods included 10 taxa associated with early successional areas, 2 shrub species, 1 tree, and grasses; 12 of the key foods were exotic to western Oregon. Quail consumed 10 of the same key foods during both periods. Bittercress was a key food only during 1976-78 and Scot's broom, deervetch (Lotus spp.), and sweet-clover (Melilotus spp.) were key foods only during 1985-87. Three of the 5 most frequently consumed foods were the same during both decades (vetch [Vicia spp.], wild carrot [Daucus carota], and grasses).

The majority of these foods was consumed as seeds although foliage and flower parts also were taken throughout the year. Dry weights (%) of seeds and mature fruit pulp in the diet from 1985-87

during spring, summer, fall, and winter were 49%, 95%, 97%, and 83%, respectively; the remainder was foliage and flower parts. Plant parts consumed during the 2 time periods were similar.

The 14 key foods collectively composed 87% of the dry weight of all crop contents; the top 4 foods, all legumes, made up 63% of the diet (Table III.2). Deervetch, consumed only as seeds during each season except spring, made up the largest percentage (20%) of the total diet. Seeds of peavine (Lathyrus spp.) were eaten every season except summer and composed 16% of the total crop contents dry weight. Both the seeds and foliage (including flower parts) of Scot's broom, a leguminous shrub, and vetch were consumed during each season of the year and constituted 16% and 11% of the crop contents by dry weight, respectively. Other legumes in the diet (including clover [Trifolium spp.], sweet-clover, lupine [Lupinus sp.], and locust [Robinia pseudo-acacia]) collectively composed an additional 4% of the diet. The foliage of clover was consumed during all seasons and the seeds of clover and sweet-clover were eaten seasonally except during spring. Grasses (Family Gramineae), which were consumed seasonally as seeds and foliage, included 9 taxa but were primarily Festuca spp. and Poa spp. Grasses composed 8% of the total crop contents by dry weight, were present in the diet during each season, had the highest annual frequency of occurrence in the diet (84%), and were the most available food on the study area. The remaining key foods composed 1-4% of the diet by weight. Wild carrot was consumed only as foliage during the summer, whereas both seeds and foliage were taken during the other seasons. Pulp of apple was consumed during fall and winter. Seeds of teasel (Dipsacus sylvestris) were present in the diet during each season. The mature fruit of blackberries, the most abundant shrub on the area, was present in the diet during each season except spring; blackberry flower parts and foliage were consumed during winter and spring. Foliage and flower parts of Cichorieae were present seasonally in approximately 1/3 of all crops. Sorrel was consumed seasonally as seeds (except spring) and foliage (except summer).

Changes in Use

Annual dietary frequencies of 9 key plant foods of California quail differed between 1976-78 and 1985-87 (Table III.1). Deervetch, Scot's broom, sweet-clover, grasses, teasel, and blackberry increased in frequency of occurrence in the diet of quail. Annual frequencies of use were unchanged for vetch, clover, peavine, apple, and sorrel. Use of wild carrot, Cichorieae, and bittercress decreased. Most significant differences in seasonal frequencies of use occurred during fall and winter (7 and 9, respectively) compared with spring and summer (3 and 4, respectively). These differences possibly reflected greater opportunity for selection of foods by quail because plant foods (both seeds and vegetative parts) typically are most abundant during fall and winter (Gullion 1966, Leopold 1977:170). Grasses, wild carrot, and vetch were present in >1/3 of all crops during both collection periods, but Cichorieae and sorrel were replaced by deervetch, Scot's broom, and teasel among high frequency foods during 1985-87.

Availability

The methods by which Oates and Crawford (1983) collected availability data differed from this study; consequently, we were unable to make statistical comparisons of frequencies of occurrence of key foods available on the Wilson WA between 1976-78 and 1985-87. The relative availabilities, however, of the most common key foods during 1985-87 (grasses, blackberry, vetch, and wild carrot) were the same as those reported by Oates (1979) (Table III.3). Likewise, the relative availabilities of the least common key foods (peavine, deervetch, clover, and sweet-clover) were similar between periods.

Preference

Because relative availabilities were similar between periods, trends in food preferences of most taxa paralleled changes in use. Seasonal preference values of key foods revealed that legumes were the most highly preferred item during each season of both periods (Table III.4). Six foods were highly preferred during $\geq$1 season

during both 1976-78 and 1985-87, including peavine, clover, deervetch, Scot's broom, sorrel, and apple. Bittercress and Cichorieae were highly preferred only during 1976-78 and sweet-clover was highly preferred only during 1985-87. Vetch, blackberry, teasel, wild carrot, and grasses were relatively common in the diet and habitat during both periods and, consequently, had proportionately lower RPI values.

DISCUSSION

California quail used more than 1/2 of the plant species on Wilson WA for food. Although 53 plant taxa were consumed, the bulk of the diet was composed of a few key foods, 10 of which were similar between 1976-78 and 1985-87. Use and preferences differed, however, for most foods within this key group between 1976-78 and 1985-87. Within the preferred group of key foods (primarily legumes), quail apparently were less selective and seemingly more opportunistic. We concluded that California quail displayed strong preferences for a particular group of foods but were somewhat less selective within that group. The most preferred foods also composed a substantial proportion of the diet by weight (deervetch, peavine, and Scot's broom collectively amounted to 47%), which indicated adequate supplies of key foods at the Wilson WA. Productivity of California quail at Wilson WA, as reflected in fall age ratios, was similar between times, although the birds were slightly more abundant during 1985-87. Apparently, food was not a critical limiting factor to quail populations during the time of study.

Manipulations conducted on Wilson WA seemingly were inadequate to alter secondary plant succession at least in regard to key foods because relative availabilities were similar between periods. Manipulations from 1980 to 1987 affected only a small part of the area; further, the beneficial effects of disking and burning on key foods are ephemeral, persisting for only 1-2 years after treatment (Blakely 1989).

Legumes had moderate to high frequencies of use, were among the most preferred foods during both decades, and composed 63% of the

annual diet by weight during 1985-87. Browning (in Leopold 1977:230) stated that availability of legume seeds was a primary factor in high production during wet years in arid ranges in California. Oates and Crawford (1983) reported that legumes (except vetch) were related to the distribution and productivity of quail in western Oregon. In arid portions of the range of California quail, filarees, cultivated grains, legumes, grasses, and a variety of fruits from trees and shrubs were reported as staple foods (Sumner 1935, Glading et al. 1940, Crispens et al. 1960, Shields and Duncan 1966, Anthony 1970, Leopold 1977:172, Browning [in Leopold 1977:229]), but in western Oregon, a mesic extension of the range of California quail, legumes were substantially more preferred over other foods and, as a group, were the most important foods.

Habitat management for California quail in western Oregon and other mesic portions of the range should include establishment of an array of legumes (especially deervetch, peavine, vetch, and clover) as key forage items. These legumes and the other important foods characteristic of early seral areas may be planted or increased naturally by treatments such as disking and burning if adequate seed sources in the soil are available (Sumner 1935, Emlen and Glading 1945, Leopold 1977:170, Oates and Crawford 1983, Chapter IV this thesis).

Table III.1. Annual and seasonal use (% frequency of occurrence in crops) of key plant foods of California quail, E.E. Wilson Wildlife Area, Oregon, 1976-78[a] and 1985-87.

Food	Annual		Fall		Winter		Spring		Summer	
	76-78 (n=117)	85-87 (n=105)	76-78 (n=50)	85-87 (n=56)	76-78 (n=30)	85-87 (n=17)	76-78 (n=12)	85-87 (n=19)	76-78 (n=25)	85-87 (n=13)
Wild carrot	**72**	**44**[b]	**56**	**25**	100	100	100	68	48	15
Vetch	69	65	50	50	83	100	83	79	72	62
Cichorieae	**53**	**18**	**38**	**4**	50	29	42	37	84	38
Grasses	**38**	**84**	**35**	**77**	**27**	**100**	**33**	**79**	**56**	**100**
Sorrel	34	21	24	11	30	29	58	42	40	23
Peavine	31	20	26	25	53	24	33	16	8	0
Teasel	**31**	**45**	**21**	**52**	60	71	42	21	4	15
Bittercress	**27**	**3**	3	0	**47**	**6**	**92**	**11**	4	0
Apple	22	23	**9**	**39**	**63**	**12**	0	0	0	0
Clover	19	22	0	4	**13**	**59**	42	47	40	15
Blackberry	**17**	**31**	38	36	**0**	**24**	0	11	**16**	**54**
Deervetch	**14**	**40**	**6**	**41**	**7**	**71**	8	0	36	54
Scot's broom	**6**	**45**	**12**	**34**	**0**	**41**	**8**	**74**	**4**	**54**
Sweet-clover	**0**	**17**	0	13	**0**	**35**	0	0	**0**	**38**

[a]Data from 1976-78 were from Oates (1979) and unpublished data.
[b]Pairs of numbers in **boldface** type were significantly different ($P \leq 0.05$).

Table III.2. Annual relative dry weight and plant parts consumed of key foods in crops of 105 California quail, E.E. Wilson Wildlife Area, Oregon, 1985-87.

Food	Annual relative weight (%)	Plant parts consumed[a]			
		Fall	Winter	Spring	Summer
Deervetch	20	S	S		S
Peavine	16	S	S	S	
Scot's broom	16	S,L	S,L	S,L,Fl	S,FL
Vetch	11	S,L	S,L	S,L	S,L
Grasses	8	S,L	S,L	S,L	S,L
Wild carrot	4	S,L	S,L	S,L	L
Apple	3	Fr	Fr		
Clover	2	S,L	S,L	L	S,L
Blackberry	2	Fr	L,Fr	L,Fl	Fr
Teasel	2	S	S	S	S
Sweet-clover	1	S	S		S
Cichorieae	1	L,Fl	L	L,Fl	Fl
Sorrel	1	S,L	S,L	L	S
Other plant foods	13				

[a]S=seeds, L=leaves, Fl=flower parts, Fr=mature fruit or berry

Table III.3. Annual and seasonal availability (% frequency of occurence in habitat) of key plant foods of California quail, E.E. Wilson Wildlife Area, Oregon, 1976-78[a] and 1985-87.

	Annual		Fall		Winter		Spring		Summer	
Food	76-78	85-85	76-78	85-87	76-78	85-87	76-78	85-87	76-78	85-87
Grasses	92	92	90	94	91	90	93	91	96	92
Blackberry	53	60	55	60	53	62	51	60	51	57
Vetch	53	40	61	34	48	52	53	59	58	17
Wild carrot	27	35	28	26	15	34	33	44	42	36
Teasel	9	20	10	21	8	15	10	26	9	20
Apple	7	4	5	3	6	0	7	8	10	5
Cichorieae	6	11	9	10	5	16	5	10	4	9
Scot's broom	4	6	1	13	5	8	5	3	4	3
Sorrel	3	5	3	5	4	8	4	3	3	4
Bittercress	3	2	1	1	5	5	4	3	1	0
Clover	2	2	1	3	1	2	2	3	2	1
Peavine	1	3	1	2	1	3	1	3	1	3
Deervetch	1	2	1	2	1	1	2	4	1	3
Sweet-clover	1	1	1	1	0	0	0	0	0	0

[a]Data from 1976-78 were from Oates (1979).

Table III.4. Annual and seasonal relative preference indices of key plant foods of California quail, E.E. Wilson Wildlife Area, Oregon, 1976-78[a] and 1985-87.

	Annual		Fall		Winter		Spring		Summer	
Food	76-78	85-85	76-78	85-87	76-78	85-87	76-78	85-87	76-78	85-87
Peavine	31	7	26	13	53	8	33	5	8	0
Clover	10	11	0	1	13	30	21	16	20	15
Deervetch	14	20	6	21	7	71	4	0	36	18
Sorrel	11	4	8	2	8	4	15	14	13	6
Cichorieae	9	2	4	<1	10	2	8	4	21	4
Bittercress	9	2	3	0	9	1	23	4	4	0
Apple	3	6	2	13	11	12	0	0	0	0
Teasel	3	2	2	3	8	5	4	1	<1	1
Wild carrot	3	1	2	1	7	3	3	2	1	<1
Scot's broom	2	8	12	3	0	5	2	25	1	18
Vetch	1	2	1	2	2	2	2	1	1	4
Blackberry	<1	1	1	1	0	<1	0	<1	<1	1
Grasses	<1	1	<1	1	<1	1	<1	1	<1	1
Sweet-clover	0	17	0	13	0	35	0	0	0	38

[a]Data for 1976-78 were from Oates (1979) and unpublished data.

Chapter IV

RESPONSE OF KEY FOODS OF CALIFORNIA QUAIL TO HABITAT MANIPULATIONS

Food supply was identified by Leopold (1977:170) as a factor that may limit California quail populations. Emlen and Glading (1945) stated that quail numbers fluctuated with the abundance of food if adequate cover were available. In the Willamette Valley, Oregon, Oates (1979) found that quail abundance and productivity were related to the availability of certain key foods, primarily annual forbs.

In mesic portions of the range of California quail (from northwestern California through western Oregon and Washington to British Columbia), early seral stage grasslands and cultivated areas are preferred habitats (Barclay and Bergerud 1975, Crawford 1978). Management of these habitats necessitates frequent manipulations because of the rapid rate of plant succession. Burning and disking have been used to increase or maintain annual plants as food for California quail (Sumner 1935, Biswell et al. 1952, Duncan 1968, Oates and Crawford 1983). On the E.E. Wilson Wildlife Area (Wilson WA) in western Oregon, controlled burns were used from 1953 to 1967 to set back plant succession and increase forb production. Approximately 1/4 of the area was burned annually and the highest populations of quail occurred during this time (Crawford 1978). Oates and Crawford (1983) found that annual disking provided greater benefits than food plantings by stimulating the growth of preferred foods and creating open areas for foraging. Since 1980, both disking and burning were used to manage quail habitat at Wilson WA. However, neither the duration of response of key foods to disking beyond 1 year nor the comparative effects of burning and disking on key foods were tested. Consequently, the objective of this study was to determine the annual and seasonal changes in percent cover and frequency of occurrence of key plant foods of California quail as a result of spring disking and summer burning.

STUDY AREA AND METHODS

The study was conducted on the 650-ha E.E. Wilson Wildlife Area located in the Willamette Valley, 16 km north of Corvallis, Oregon. Grasses (predominantly Festuca spp.) interspersed with blackberries (Rubus spp.), Scot's broom (Cytisus scoparius), roses (Rosa spp.), and small stands of Oregon white oak (Quercus garryana), Oregon ash (Fraxinus latifolia), black cottonwood (Populus trichocarpa), hawthorne (Crataegus spp.), and apple (Pyrus malus) characterized the vegetation on Wilson WA. Common annual and biennial herbaceous plants included oxeye-daisy (Chrysanthemum leucanthemum), thistle (Cirsium spp.), wild carrot (Daucus carota), Klamath weed (Hypericum perforatum), tarweed (Madia sativa), clover (Trifolium spp.), and vetch (Vicia spp.). Agricultural fields on Wilson WA were used primarily for commercial grass seed production. Plant taxonomy follows that of Hitchcock and Cronquist (1973).

To determine the response of key foods to habitat manipulations, 9 0.3-ha study plots in grassland areas that had not been manipulated for at least 20 years were randomly assigned to receive disking (3 plots) or burning (3 plots) treatments, or to serve as controls (3 plots). Disking was completed in March 1986 and consisted of pulling a bi-directional disk to a depth of 20 cm over each plot twice, the second time at a 90° angle to the first. The controlled burns took place in August 1986 because most agricultural fields in the Willamette Valley are burned during the late summer. The last measurable rain fell 45 days before the burns. Temperature maximum and minimum were approximately 29 C and 13 C, respectively, on burn days. Backfires from disked fire-lines were lit with drip-torches. Attempts were made to burn all fine-fuels and litter, but the burn treatment on 2 plots was incomplete; some small areas were not completely burned. Control plots were untreated.

Vegetational response on the disked, burned, and control plots was evaluated seasonally (winter, Dec-Feb; spring, Mar-May; summer, Jun-Aug; and fall, Sep-Nov) beginning with pre-treatment measurements in March 1986 and continuing through April 1989. Each of the 9 study

plots was divided into halves within which 1 20-m transect was placed randomly. Percent cover and frequency of occurrence of herbaceous vegetation was measured with 10 0.5-m^2 circular plots spaced at 2-m intervals along each transect. The line-intercept method (Canfield 1941) was used to measure the percent cover and frequency of occurrence of shrubs and trees along each transect.

Analysis of vegetational response focused on the key plant species consumed by California quail on Wilson WA; 14 key foods were described by Oates and Crawford (1983) and in Chapter III of this thesis. These key foods, each of which occurred in >15% of 222 quail crops collected during 1976-1978 and 1985-1987 and composed $\geq$1% dry weight of all crop contents during 1985-1987, were deervetch (Lotus spp.), peavine (Lathyrus spp.), Scot's broom, vetch, grasses (including Agrostis spp., Dactylis glomerata, Festuca spp., Holcus lanatus, Lolium sp., Panicum sp., Phalaris sp., Poa spp., and Triticum sp.), wild carrot, apple, clover, teasel (Dipsacus sylvestris), blackberry, sweet-clover (Melilotus spp.), false dandelion (Hypochaeris radicata) and other of the milky-juiced composites (Tribe Cichorieae), bittercress (Cardamine spp.), and sorrel (Rumex spp.). These 14 key foods constituted 87% of the quail diet by weight during 1985-1987.

Non-parametric one-way analysis of variance with Savage scores was used to evaluate differences in percent cover and frequency of occurrence of the key foods among all treatments and controls by season (SAS Inst. Inc. 1987) because the distributions of percent cover and frequency of occurrence values were most closely approximated by exponential Weibull functions (Lehman 1975). Pairwise multiple-comparisons of least significance difference with Savage scores were used to separate the groups when the overall test was significant at $p \leq 0.10$.

RESULTS AND DISCUSSION

Eight of the 14 key foods occurred with sufficient frequency to evaluate their responses to disking and burning. Sweet-clover and Scot's broom were not present in any of the experimental plots and

apple, peavine, deervetch, and sorrel occurred only infrequently. These species were confined largely to roadsides at Wilson WA, which were not part of the experimental plots. Disking and burning produced increased percent cover and frequencies of occurrence during at least 1 season for 7 of the other 8 key foods. No significant differences of teasel cover or frequency between the treatments and controls during any of the seasons were found (Figures IV.1 and IV.2). Seasonal average and standard error values for percent cover and frequency of occurrence are summarized in appendices 5 and 6, respectively.

Two key foods, Cichorieae and wild carrot, had an immediate and sustained response to disking and to a lesser extent burning. Cover and frequency of the Cichorieae increased significantly after disking for 4 consecutive seasons above the respective seasonal values in burned and control plots. After burning, percent cover and frequency were higher only during the first winter compared with the control plots (Figures IV.1 and IV.2). Oates and Crawford (1983) also reported a positive response of Cichorieae to disking and a positive relationship to quail numbers immediately after disking. Wild carrot had the greatest response to disking; percent cover increased significantly above control values after disking through spring 1987 and again during spring 1988 (Figure IV.1). Wild carrot cover on the burned plots was significantly higher than the controls after the plots were burned but not to the level produced by disking until winter. Thereafter, the response to burning was similar to the response to disking. Frequency of wild carrot was similar to the cover response except that no significant differences were found during summer 1986 or winter 1987 (Figure IV.2).

Blackberry and bittercress had delayed and limited responses to the manipulations. Blackberry, the only shrub that had a measurable response, increased in frequency and percent cover during the second fall after burning; frequency also increased during winter 1989. Disking had no effect on blackberry cover and frequency. However, blackberry, the most abundant and important cover species for quail

on Wilson WA (Crawford 1978), was probably not a limited food source. Bittercress did not show any significant response to the manipulations until the second spring on burned plots and the third spring on disked plots (Figures IV.1 and IV.2). Oates and Crawford (1983) reported positive response of bittercress during summer and fall after disking.

Disking and burning had contrasting effects on clover. Initially, percent cover and frequency increased during the first winter after disking, after which a positive response was evidenced on burned plots during the second spring and summer (Figures IV.1 and IV.2). Oates and Crawford (1983) reported positive responses of clover during the summer and fall after disking.

Vetch had increased percent cover after disking and burning for a short time, but later the trend was reversed (Figure IV.1). Frequency of vetch increased immediately after disking but was significantly less frequent during the next season compared with burned and control plots. Burning did not affect the frequency of vetch (Figure IV.2). Reduced vetch cover and frequency were found during spring 1988 and winter and spring 1989.

Percent cover of grasses was significantly reduced after disking and burning, but neither treatment effect remained consistently significant after fall 1986 (Figure IV.1). Frequency of grasses were not affected by either treatment (Figure IV.2). Although grasses were a common component of the diet, they were also the most available key food on Wilson WA (Blakely 1989); a sustained reduction of grass cover to promote the growth of other key quail food plants was the desired effect.

The percent cover of bare-ground also is an important element in relation to the production of key foods. Significant increases in bare-ground cover were evident immediately after both treatments and although the differences were still significant at the conclusion of the study, all mean percent cover values were <1% from spring 1988-spring 1989 (% bare-ground from summer 1986-winter 1988 ranged from 4-40% on disked plots, 2-20% on burned plots, and 1-4% on control

plots). Disking produced significantly more bare-ground for a longer time-period than burning.

Observations during the last several seasons of the study indicated apparent differences in the vegetative structure and composition on the fire-line areas (most notably increased cover and frequency of wild carrot, clover, dock, and bare-ground). These sites were disked and compacted by equipment used during the controlled burns in March 1986. The fire-lines were still visually discernable from the adjacent burn plots and bordering untreated areas; however, due to high variability within the fire-lines, the differences were not significant when measured during spring 1989.

Increased production of key quail foods in western Oregon was accomplished by disking and burning grassland habitats, although the increases were not maintained for more than 2 years. Disking consistently afforded the most immediate increases and maintenance of the key foods compared with burning. Leopold (1977:179) reported that in solid stands of grass in arid regions of California, disking and burning, usually encouraged the growth of forbs. The difference between the methods possibly resulted from the varied effect on the root mass of grasses, differences in seedbed characteristics for windborne seeds, and a more efficient seed scarification process by disking than burning. In this study, disking also was less expensive than burning (5 man-hours/ha for disking and 24 man-hours/ha for burning); however burning becomes less expensive when applied to larger areas and disking costs/ha remain constant regardless of area size.

Of the 6 leguminous key foods identified by Blakely (1989), only vetch and clover were found consistently enough in the study plots to evaluate the response to disking and burning. Clover and vetch responded positively to the manipulations although the response of vetch sometimes was negatively affected by the manipulations after the second year perhaps because its growth form enables it to grow in dense stands of grass as well as in early seral areas. Oates and Crawford (1983) found that disking also increased the frequencies of

peavine and deervetch. Their study areas were much larger (2.4 ha) and included shrub cover and associated edge species within disturbed areas along roadsides whereas the plots in this study were restricted to grass stands and rarely had any associated shrubs or roadsides.

The vegetation sampling methods used in this study could be improved to reduce the high variability in cover and frequency values. The same number of circular plots could have been more efficiently used by randomly placing 4 transects/experimental plot with 5 plots/transect, which would yield a larger n-size and perhaps reduce the within group variance. The large plot size was used to adequately sample uncommon plants but the cover values of those plants within the plot were small, resulting in testing for statistical differences between fractions of a percent. The scale of the differences found may not seem biologically significant, but the quail on Wilson WA forage selectively within the group of key foods tested (Chapter III).

MANAGEMENT IMPLICATIONS

Disking, compared with burning, promoted greater production of key foods of California quail in western Oregon. Key food production should be targeted for habitats that will be readily used by foraging quail. The importance of roadsides and areas adjacent to adequate cover (roosting and escape) was reported in several studies (Sumner 1935, Emlen and Glading 1945, Stinnett and Klebenow 1986) and these areas often produce the best variety of key quail foods (perhaps due to a more diverse seed pool). Management for increased production of key quail foods should be conducted by disking strips or meandering paths adjacent to patches of cover. Disking large, contiguous areas should be avoided because quail typically forage only in areas adjacent to cover (Sumner 1935, Emlen and Glading 1945). Disking in combination with compaction may be a viable management method. Burning is recommended when disking is not feasible. In mesic zones, the manipulations should be conducted approximately every 2-3 years to maintain increased production of key foods.

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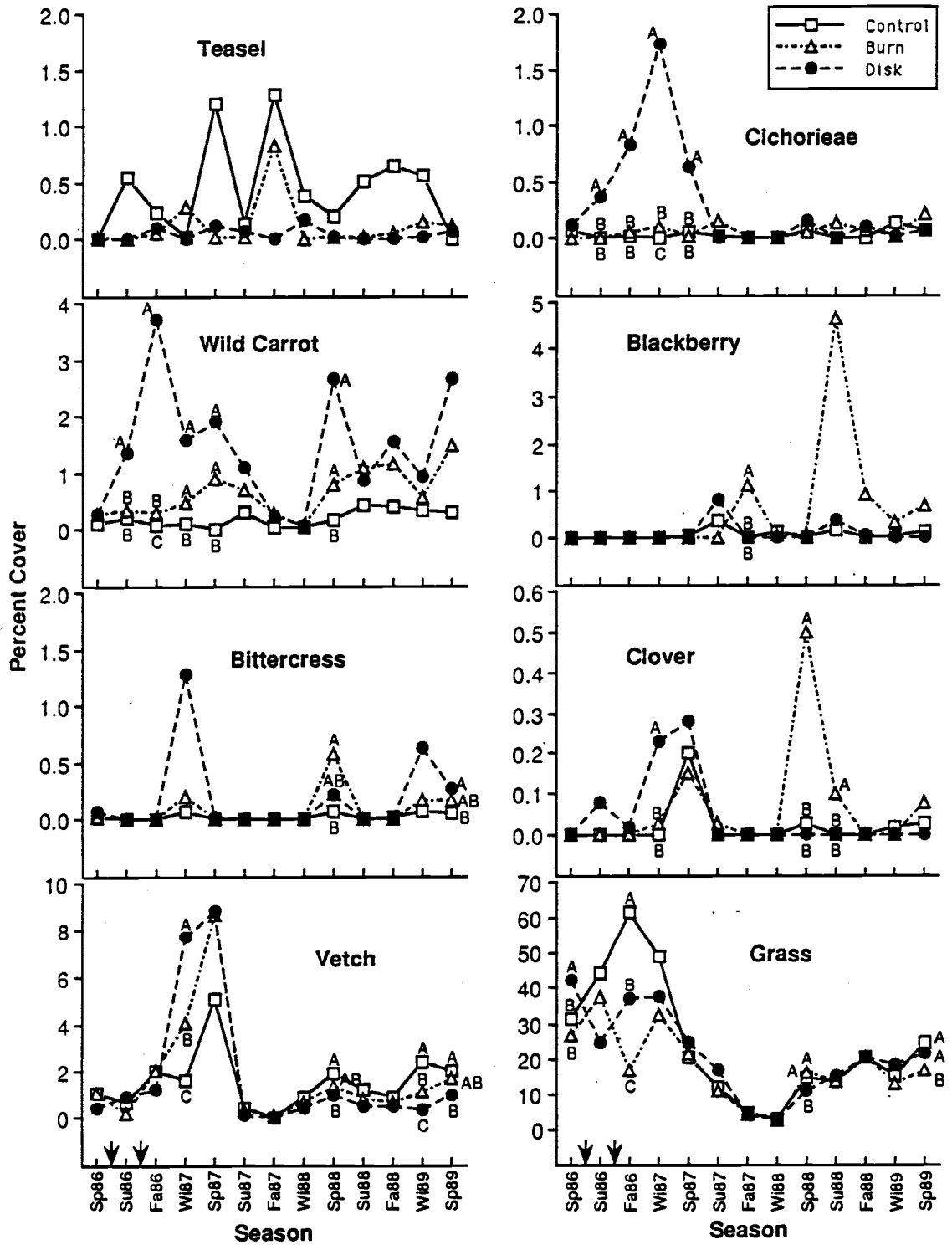

Figure IV.1. Seasonal response (% cover) of 8 key foods of California quail to burning and disking, E.E. Wilson Wildlife Area, Oregon, 1986-89. Arrows indicate when disking and burning, respectively, were conducted. Letters indicate significant differences ($p \leq 0.10$) within seasons; treatments with same letter were not different.

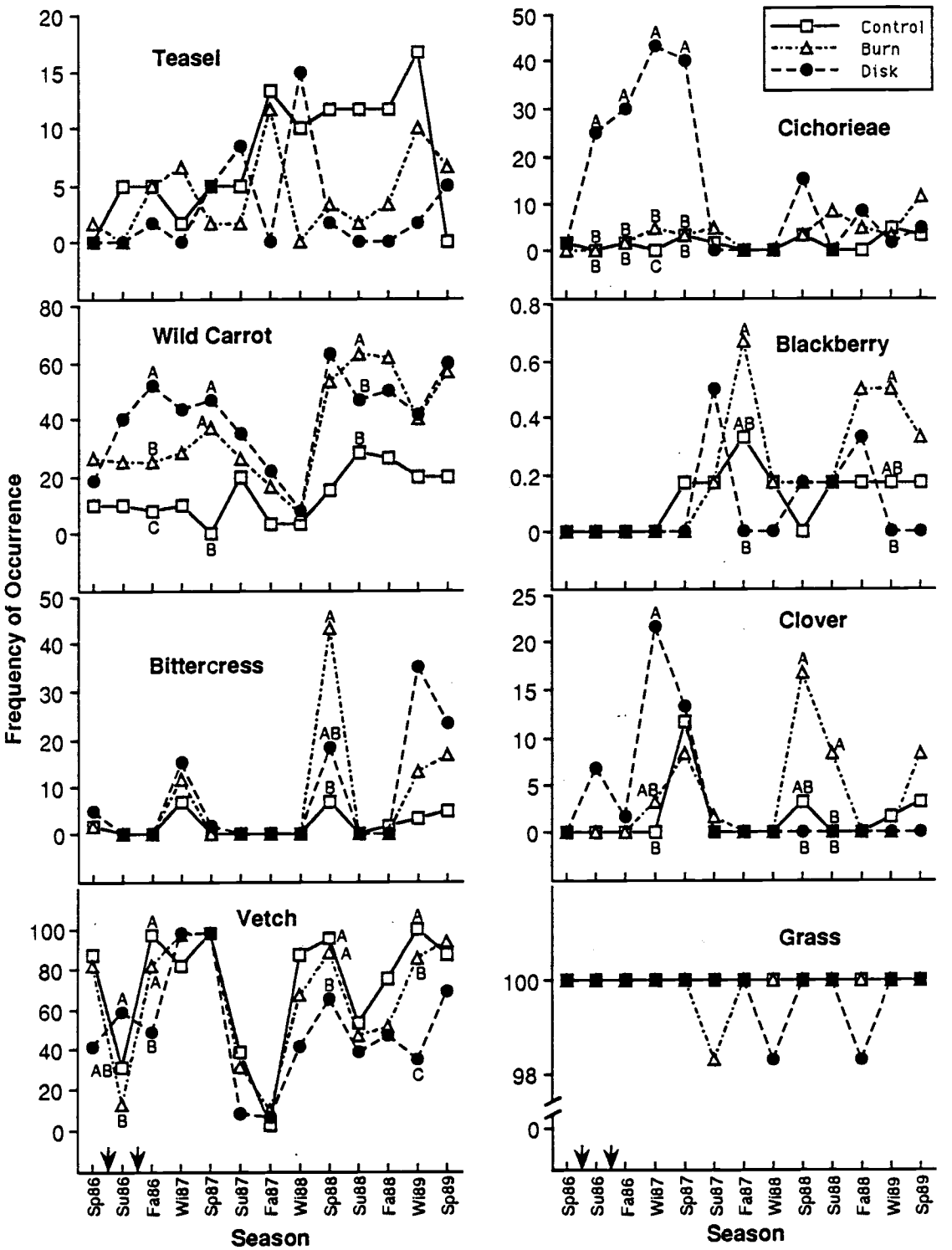

Figure IV.2. Seasonal response (% frequency of occurrence) of 8 key foods of California quail to burning and disking, E.E. Wilson Wildlife Area, Oregon, 1986-89. Arrows indicate when disking and burning, respectively, were conducted. Letters indicate significant differences ($p \leq 0.10$) within seasons; treatments with same letter were not different.

CHAPTER V

CONCLUSION

The plant component of the diet of California quail on the E.E. Wilson Wildlife Area during 1976-78 and 1985-87 was composed of a large number of taxa of which a few key plant foods (primarily legumes) were consistently preferred and provided the bulk (% dry weight) of the quail diet. Annual and seasonal frequencies of use of a few taxa within this preferred group differed between 1976-78 and 1985-87. The relative abundance of the early seral plant foods was similar between the time periods despite management on the Wilson WA to encourage their growth. Information reported from other portions of the species' range (Sumner 1935, Glading et al. 1940, Crispens et al 1960, Leopold 1977:172) also indicated the importance of early seral plant foods; however, quail in extralimital areas were thought to rely more on agricultural crops (Johnsguard 1973:398) than weedy legumes as found in this study. The most fequently consumed foods included wild carrot, vetch, Scot's broom, dandelions, teasel, and grasses; the bulk of the diet was composed of deervetch, peavine, Scot's broom, vetch, and grasses. Invertebrates (primarily ants, beetles, bugs, and grasshoppers) were consumed more frequently and consistently on Wilson WA than in more arid portions of the range, although they composed only 0.5% of the total diet during 1985-87. Frequencies of invertebrate matter were higher in spring and summer than in fall and winter. Male and female quail consumed invertebrates with similar frequency.

Disking resulted in an increased percent cover of more key foods over a longer period than did burning. Neither treatment effect was significant after 2 years. Burning was previously used on Wilson WA to maintain early seral areas (approximately 1/4 of the area was burned annually during 1953 to 1967), however this study indicates that disking would provide more persistent results and therefore be more efficient.

This study demonstrated that although >50% of the available foods were taken by quail, only a relatively small number of foods provided most of the diet. Invertebrates constituted a small proportion of the diet but likely were an important source of nutrients, especially among immatures. Of the plant foods, legumes were the most frequently consumed, were highly preferred, and composed the bulk of the diet. In western Oregon and other mesic parts of the California quail range, habitat management (particularly by disking) should focus on providing an adequate distribution of a variety of legumes (especially deervetch, peavine, and vetch).

CHAPTER VI

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APPENDICES

Appendix 1. Annual and seasonal availability (% frequency of occurrence in habitat) of plant species other than key foods of California quail, E.E. Wilson Wildlife Area, Oregon, 1985 to 1987.

Plant taxa	Annual	Fall	Winter	Spring	Summer
Chrysanthemum leucanthemum	45	39	43	52	46
Moss	42	26	67	57	17
Hypericum perforatum	29	35	7	30	45
Cirsium spp.	23	14	25	29	25
Cerastium spp.	10			38	<1
Centaurium umbellatum	9	6	25	1	6
Galium spp.	6		3	17	3
Madia spp.	5	4		5	10
Epilobium spp.	4	1	7	6	3
Geranium spp.	4	3	7	4	1
Plantago spp.	4	2	4	7	5
Myosotis bicolor	3	<1	1	10	1
Prunus spp.	3			10	3
Senecio spp.	2	<1	1	5	1
Anthemis cotula	1	<1		2	3
Carex spp.	1		1	2	<1
Juncus spp.	1	2	<1		1
Lupinus spp.	1	<1		2	1
Oenanthe sarmentosa	1		5		
Polygonum spp.	1		3		
Pseudotsuga menzesii	1			3	
Sanicula spp.	1		1	2	
Solidago spp.	1		2		2
Vinca major	1			2	<1
Ferns	1		1	2	1
Achillea millefolium	<1				<1
Alnus rubra	<1	<1			
Amelanchier spp.	<1			<1	<1
Anaphalis margaritacea	<1				1
Aster spp.	<1	1			
Brassica spp.	<1				1
Celtis reticulata	<1	<1			<1
Chenopodium album	<1			1	
Convolvulus spp.	<1				1
Crataegus spp.	<1	<1	<1	<1	<1
Delphinium spp.	<1			1	
Eschscholzia californica	<1	1			
Fraxinus latifolia	<1		<1		
Geum spp.	<1			<1	
Gnaphalium spp.	<1			1	
Parentucellia viscosa	<1			1	
Populus trichocarpa	<1	<1		<1	
Quercus garryana	<1	<1	<1		<1
Ranunculus spp.	<1			<1	
Rhus diversiloba	<1				<1
Salix spp.	<1		<1	<1	<1
Solanum spp.	<1				1
Symphoricarpos albus	<1	<1		<1	
Tanacetum vulgare	<1				1

Appendix 2. Annual and seasonal use (% frequency of occurrence in crops) of plant species other than key foods of California quail, E.E. Wilson Wildlife Area, Oregon, 1985 to 1987.

Plant taxa	Annual (n=105)	Fall (n=56)	Winter (n=17)	Spring (n=19)	Summer (n=13)
Polygonum spp.	14	4	41	16	23
Cirsium spp.	12	18	12		8
Madia spp.	11	13	6		31
Moss	11	5	24	21	8
Cerastium spp.	10		6	53	
Chenopodium album	8	4		5	38
Galium spp.	7	4		11	23
Geranium spp.	5		18		15
Myosotis bicolor	5			21	8
Hypericum perforatum	3	2	12		
Robinia pseudo-acacia	3		18		
Spergularia spp.	3			11	8
Brassica spp.	2	2			8
Epilobium spp.	2	4			
Stellaria spp.	2		6	5	
Anthemis cotula	1	2			
Carex spp.	1	2			
Geum spp.	1		6		
Lupinus spp.	1				8
Plantago spp.	1		6		
Pseudotsuga menziesii	1	2			
Unknown Caryophyllaceae		1			5
Unknown Cruciferae	1		6		

Appendix 3. Seasonal response (% cover) of plant species other than key foods of California quail to habitat manipulations, spring 1986 to spring 1989.

	Spring 86			Summer 86			Fall 86			Winter 87			Spring 87		
Plant taxa	Cont	Burn	Disk	Cont	Burn	Disk	Cont	Burn	Disk	Cont	Burn	Disk	Cont	Burn	Disk
Achillea millefolium						0.1									
Anthemis cotula									0.1						
Aster spp.															
Carex spp.															
Centaurium umbellatum	+[a]			0.5	0.8	+		+	0.1	0.2	0.5	1.9			
Cerastium spp.	0.4	1.9	0.4			0.1			+			+	0.4	3.7	2.4
Chrysanthemum leucanthemum	9.4	14.7	3.8	14.4	13.7	3.7	12.5	2.8	4.6	6.4	6.3	6.6	7.6	5.3	5.2
Cirsium spp.	1.2	2.5	0.3	2.2	2.4	5.8	0.5	0.7	6.7	0.1	0.2	1.3	0.1	2.0	4.1
Convolvulus spp.		1.1			2.4										
Delphinium spp.															
Epilobium spp.			+		+				0.1						0.1
Galium spp.		0.3		0.1	0.7	0.6			0.3	+	0.1	0.9	0.4	1.7	1.5
Geranium spp.	0.4	+		0.3			0.2	+	0.1	0.1	0.1	0.2	0.1	0.1	
Hypericum perforatum	0.2	0.7	0.6	1.2	3.0	1.5	0.8	0.1	1.5	0.2	0.8	0.8	0.2	0.7	0.8
Juncus spp.				0.1	0.1										
Lupinus spp.														0.1	0.1
Madia spp.				0.2					0.2			0.6			
Moss	5.1	2.6	5.3	1.6	1.1	1.05	1.15	2.7		15.0	20.9	2.3	1.2	0.4	1.2
Myosotis bicolor				0.1	0.3	0.8			0.4	0.4	10.5	0.2		+	
Plantago spp.	0.1	0.1	+	0.1	0.1		0.1	0.2	0.1		+		0.2	0.1	0.2
Ranunculus spp.														0.1	0.1
Sanicula spp.															
Solanum spp.															
Solidago spp.	0.1	0.5		0.2	0.8			0.1			0.6			1.2	0.1
Vinca major														3.8	
Viola spp.															
Tellima grandiflora	0.1														
Senecio spp.															
Parentucellia viscosa				0.1										0.1	
Hemizonia pungens									+						
Acer spp.								+							
Crataegus spp.															
Rosa spp.															
Rhus diversiloba															
Fraxinus latifolia	+														
Prunus spp.	+														

APPENDIX 3 (continued)

Plant taxa	Summer 87			Fall 87			Winter 88			Spring 88			Summer 88		
	Cont	Burn	Disk	Cont	Burn	Oisk	Cont	Burn	Oisk	Cont	Burn	Oisk	Cont	Burn	Oisk
Achillea millefolium															
Anthemis cotula															
Aster spp.				+	0.1										
Carex spp.	+												0.7		
Centaurium umbellatum	0.7	0.6	0.1	0.1	0.1		0.7	0.3	+	0.3	0.4	+	0.7	0.9	0.2
Cerastium spp.										+	0.2	0.9	0.1	0.2	
Chrysanthemum leucanthemum	7.4	9.1	2.3	2.5	1.7	1.4	1.1	3.1	2.0	9.9	5.9	8.7	6.1	5.9	1.4
Cirsium spp.	1.5	2.0	3.0	0.2	0.4	1.1		0.2	0.6	0.4	0.9	1.7	1.2	0.8	2.4
Convolvulus spp.														0.5	
Delphinium spp.													+		
Epilobium spp.			+									0.1			
Galium spp.	+									0.4	0.9	1.4	0.2	0.3	0.4
Geranium spp.	0.4						0.1	0.5	0.3	+	0.1	0.1	0.2	+	
Hypericum perforatum	2.0	1.4	1.1	0.2	0.5	0.6	0.1	0.9	1.0	0.3	0.3	0.8	0.7	0.7	1.0
Juncus spp.											0.1				
Lupinus spp.												+			
Madia spp.	0.7	0.2	0.3			+	0.1	1.0	0.7	1.0	0.6	0.7	0.1		0.3
Moss	0.5	0.2	0.7				1.3	1.5	0.9	0.7	0.3	0.1	0.2	0.1	0.1
Myosotis bicolor															
Plantago spp.	+	0.2	+				+				0.1	0.1	0.1	0.1	
Ranunculus spp.															
Sanicula spp.											0.2	+			
Solanum spp.															
Solidago spp.	0.1	0.3	+	+	0.4					0.1	0.2	0.2	+	0.4	0.2
Vinca major															
Viola spp.											0.1				
Tellima grandiflora															
Senecio spp.	+	+													
Parentucellia viscosa															
Hemizonia pungens															
Acer spp.				+											
Crataegus spp.										+					
Rosa spp.		+		+		0.3				0.7		0.3	0.1		1.7
Rhus diversiloba				+									+		
Fraxinus latifolia															
Prunus spp.															

APPENDIX 3 (continued)

Plant taxa	Fall 88			Winter 89			Spring 89		
	Cont	Burn	Disk	Cont	Burn	Disk	Cont	Burn	Disk
Achillea millefolium									+
Anthemis cotula									
Aster spp.	0.2	+							
Carex spp.									
Centaurium umbellatum	0.7	0.4	0.4	0.7	1.3	0.5	0.3	0.6	0.2
Cerastium spp.	+	0.2	0.4	0.4	0.6	1.2	1.2	1.5	2.1
Chrysanthemum leucanthemum	7.2	6.0	3.5	5.4	6.8	3.1	6.5	8.5	2.8
Cirsium spp.	0.9	0.8	0.9	0.2	0.2	0.7	0.6	0.5	0.6
Convolvulus spp.									
Delphinium spp.							0.1		+
Epilobium spp.	0.1				+		0.1		0.1
Galium spp.							0.5	0.4	0.5
Geranium spp.				0.3	0.1	+	+	+	0.1
Hypericum perforatum	0.4	0.7	0.7	0.1	0.1	0.1	0.3	0.2	0.2
Juncus spp.									
Lupinus spp.									
Madia spp.	0.2		+	0.1	0.6	0.4	0.1		0.2
Moss	0.5	0.2	0.1	7.6	5.3	2.2	2.5	5.4	2.3
Myosotis bicolor									
Plantago spp.	0.2	0.1	+	0.1	0.1		0.2	0.3	
Ranunculus spp.									
Sanicula spp.						+	0.3		
Solanum spp.		0.2							
Solidago spp.		0.2		+			+	0.7	
Vinca major									
Viola spp.									
Tellima grandiflora									
Senecio spp.	0.1	+		+					
Parentucellia viscosa									
Hemizonia pungens									
Acer spp.									
Crataegus spp.		+		1.3			+		
Rosa spp.	0.1	+		0.4			0.1		0.1
Rhus diversiloba	+	+							
Fraxinus latifolia									
Prunus spp.									

[a] + = % cover value <0.05

Appendix 4. Seasonal response (frequency of occurrence) of plant species other than key foods of California quail to habitat manipulations, spring 1986 to spring 1989.

	Spring 86			Summer 86			Fall 86			Winter 87			Spring 87		
Plant taxa	Cont	Burn	Disk	Cont	Burn	Disk	Cont	Burn	Disk	Cont	Burn	Disk	Cont	Burn	Disk
Achillea millefolium						1.7									
Anthemis cotula									3.3						
Aster spp.															
Carex spp.															
Centaurium umbellatum	1.7			25.0	30.0	1.7		1.7	3.3	10.0	26.7	53.3			
Cerastium spp.	36.7	78.3	33.3			3.3			3.3			3.3	28.3	91.7	95.0
Chrysanthemum leucanthemum	60.0	60.0	51.7	60.0	61.7	43.3	61.7	41.7	55.0	61.7	51.7	40.0	65.0	60.0	45.0
Cirsium spp.	20.0	38.3	21.7	26.7	36.7	78.3	21.7	25.0	70.0	6.7	11.7	15.0	1.7	61.7	86.7
Convolvulus spp.		15.0			25.0										
Delphinium spp.															8.3
Epilobium spp.			1.7		3.3				6.7						
Galium spp.		21.7		8.3	35.0	30.0			16.7	3.3	6.7	23.3	30.0	55.0	48.3
Geranium spp.	13.3	1.7		8.3			8.3	1.7	1.7	6.7	6.7	8.3	3.3	3.3	
Hypericum perforatum	13.3	51.7	41.7	41.7	58.3	68.3	40.0	6.7	46.7	8.3	30.0	35.0	13.3	35.0	40.0
Juncus spp.				1.7	1.7										
Lupinus spp.														3.3	3.3
Madia spp.				3.3					11.7			36.7			
Moss	60.0	46.7	55.0	21.7	21.7	25.0	21.7	20.0		75.0	88.3	53.3	33.3	30.0	73.3
Myosotis bicolor				13.3	21.7	56.7			33.3	21.7	63.3	11.7		1.7	
Plantago spp.	3.3	3.3	1.7	3.3	1.7		1.7	10.0	5.0		1.7		6.7	5.0	8.3
Ranunculus spp.														1.7	1.7
Sanicula spp.															
Solanum spp.															
Solidago spp.	3.3	11.7		6.7	13.3			5.0			15.0			21.7	6.7
Vinca major														26.7	
Viola spp.															
Tellima grandiflora	3.3														
Senecio spp.															
Parentucellia viscosa				5.0										6.7	
Hemizonia pungens									1.7						
Acer spp.								16.7							
Crataegus spp.															
Rosa spp.															
Rhus diversiloba															
Fraxinus latifolia	16.7														
Prunus spp.	16.7														

APPENDIX 4 (continued)

Plant taxa	Summer 87			Fall 87			Winter 88			Spring 88			Summer 88		
	Cont	Burn	Disk	Cont	Burn	Disk	Cont	Burn	Disk	Cont	Burn	Disk	Cont	Burn	Disk
Achillea millefolium													15.0		
Anthemis cotula				1.7	3.3								41.7	60.0	13.3
Aster spp.	1.7												5.0	15.0	
Carex spp.	38.3	28.3	8.3	8.3	11.7		40.0	21.7	3.3	20.0	25.0	3.3	66.7	66.7	51.7
Centaurium umbellatum										3.3	20.0	58.3	33.3	28.3	71.7
Cerastium spp.	61.7	65.0	45.0	58.3	55.0	50.0	48.3	66.7	71.7	65.0	61.7	85.0		11.7	
Chrysanthemum leucanthemum	31.7	53.3	66.7	11.7	25.0	38.3		16.7	38.3	20.0	46.7	81.7	3.3		
Cirsium spp.												6.7			
Convolvulus spp.			1.7										20.0	23.3	31.7
Delphinium spp.										35.0	51.7	81.7	13.3	1.7	
Epilobium spp.	1.7						8.3	35.0	23.3	3.3	6.7	5.0	53.3	61.7	75.0
Galium spp.	18.3														
Geranium spp.	55.0	61.7	63.3	13.3	38.3	51.7	11.7	83.3	86.7	28.3	23.3	60.0			
Hypericum perforatum											1.7				
Juncus spp.												1.7			
Lupinus spp.	20.0	6.7	8.3			1.7	11.7	65.0	56.7	78.3	53.3	56.7	6.7		15.0
Madia spp.	21.7	11.7	31.7				68.3	71.7	76.7	46.7	13.3	5.0	13.3	11.7	6.7
Moss															
Myosotis bicolor															
Plantago spp.	3.3	10.0	3.3				1.7				1.7	5.0	6.7	6.7	
Ranunculus spp.															
Sanicula spp.											10.0	1.7			
Solanum spp.															
Solidago spp.	5.0	3.3	3.3	1.7	8.3					5.0	10.0	11.7	1.7	16.7	15.0
Vinca major															
Viola spp.											3.3				
Tellima grandiflora															
Senecio spp.	1.7	3.3													
Parentucellia viscosa															
Hemizonia pungens															
Acer spp.				16.7											
Crataegus spp.										16.7					
Rosa spp.		16.7		16.7		16.7				33.3		16.7	16.7		50.0
Rhus diversiloba				16.7									16.7		
Fraxinus latifolia															
Prunus spp.															

APPENDIX 4 (continued)

Plant taxa	Fall 88			Winter 89			Spring 89		
	Cont	Burn	Disk	Cont	Burn	Disk	Cont	Burn	Disk
Achillea millefolium									1.7
Anthemis cotula									
Aster spp.	8.3	3.3							
Carex spp.									
Centaurium umbellatum	45.0	36.7	28.3	40.0	63.3	30.0	21.7	41.7	13.3
Cerastium spp.	3.3	18.3	30.0	20.0	46.7	68.3	60.0	81.7	91.7
Chrysanthemum leucanthemum	66.7	66.7	70.0	66.7	68.3	68.3	60.0	66.7	60.0
Cirsium spp.	26.7	33.3	50.0	10.0	11.7	38.3	26.7	28.3	31.7
Convolvulus spp.									
Delphinium spp.							3.3		1.7
Epilobium spp.	6.7				1.7		11.7		5.0
Galium spp.							41.7	35.0	41.7
Geranium spp.				15.0	8.3	1.7	1.7	3.3	5.0
Hypericum perforatum	35.0	63.3	60.0	5.0	6.7	8.3	23.3	23.3	18.3
Juncus spp.									
Lupinus spp.									
Madia spp.	15.0		1.7	6.7	40.0	15.0	11.7		8.3
Moss	25.0	16.7	6.7	91.7	90.0	80.0	66.7	95.0	75.0
Myosotis bicolor									
Plantago spp.	15.0	6.7	1.7	10.0	3.3		8.3	13.3	
Ranunculus spp.									
Sanicula spp.						1.7	6.7		
Solanum spp.		3.3							
Solidago spp.		6.7		1.7			3.3	15.0	
Vinca major									
Viola spp.									
Tellima grandiflora									
Senecio spp.	3.3	1.7		1.7					
Parentucellia viscosa									
Hemizonia pungens									
Acer spp.									
Crataegus spp.		16.7		16.7			16.7		
Rosa spp.	33.3	16.7		16.7			33.3		16.7
Rhus diversiloba	16.7	16.7							
Fraxinus latifolia									
Prunus spp.									

Appendix 5. Seasonal response (mean % cover [n=6] and standard error) of 8 key plant foods of California quail to habitat manipulation, spring 1986 to spring 1989.

			Bittercress		Blackberry		Cichorieae		Clover		Grass		Teasel		Vetch		Wild Carrot	
Year	Season	Treatment	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
1986	spring	control	0.02	0.02			0.08	0.08			31.52	1.80			1.05	0.24	0.10	0.04
		disk	0.02	0.05			0.12	0.12			42.38	3.11			0.42	0.14	0.27	0.20
		burn	0.03	0.03							26.75	3.34	0.02	0.02	1.08	0.11	0.28	0.13
1986	summer	control									44.20	4.32	0.55	0.55	0.70	0.37	0.20	0.09
		disk					0.37	0.14	0.08	0.08	24.42	3.10			0.88	0.26	1.35	0.49
		burn									37.63	6.16			0.20	0.08	0.35	0.16
1986	fall	control					0.03	0.03			61.67	3.34	0.23	0.23	1.98	0.16	0.08	0.03
		disk					0.83	0.32	0.02	0.02	36.88	3.40	0.10	0.10	1.22	0.50	3.70	2.20
		burn					0.05	0.05			16.52	1.13	0.05	0.05	2.00	0.47	0.32	0.11
1987	winter	control	0.07	0.07							49.20	6.75	0.02	0.02	1.58	0.31	0.10	0.06
		disk	1.28	1.03			1.72	0.53	0.23	0.12	37.60	4.26			7.75	1.88	1.58	0.86
		burn	0.20	0.13			0.10	0.05	0.03	0.02	32.18	3.72	0.28	0.28	4.02	0.78	0.47	0.15
1987	spring	control			0.06	0.06	0.05	0.05	0.20	0.09	20.32	3.08	1.20	1.20	5.07	1.12		
		disk	0.02	0.02			0.62	0.19	0.28	0.16	24.43	3.54	0.12	0.12	8.80	3.59	1.92	1.27
		burn					0.03	0.02	0.15	0.08	21.62	4.28	0.02	0.02	8.67	0.73	0.90	0.57
1987	summer	control			0.38	0.38	0.02	0.02			11.90	1.55	0.13	0.09	0.43	0.20	0.32	0.24
		disk			0.82	0.50					10.82	1.51	0.08	0.07	0.08	0.05	1.08	0.62
		burn			0.02	0.02	0.15	0.11	0.03	0.03	16.83	4.58	0.02	0.02	0.33	0.18	0.70	0.34
1987	fall	control			0.03	0.02					4.88	0.92	1.28	1.15	0.03	0.03	0.03	0.02
		disk									3.87	0.60			0.07	0.03	0.23	0.11
		burn			1.12	0.57					4.22	0.30	0.82	0.58	0.10	0.05	0.27	0.25
1988	winter	control			0.14	0.14					2.83	0.27	0.38	0.38	0.88	0.06	0.03	0.03
		disk									2.42	0.26	0.17	0.11	0.43	0.16	0.08	0.05
		burn			0.04	0.04					2.67	0.15			0.70	0.15	0.08	0.05
1988	spring	control	0.08	0.08			0.08	0.07	0.03	0.02	14.50	1.21	0.20	0.16	1.93	0.37	0.17	0.13
		disk	0.22	0.09	0.03	0.03	0.15	0.07			10.98	0.91	0.02	0.02	0.98	0.29	2.65	1.15
		burn	0.58	0.20	0.09	0.09	0.05	0.03	0.50	0.28	15.93	1.31	0.03	0.03	1.38	0.27	0.80	0.31
1988	summer	control			0.18	0.18					13.73	2.23	0.52	0.52	1.18	0.53	0.43	0.24
		disk			0.38	0.38					15.13	1.61			0.50	0.15	0.87	0.32
		burn			4.64	4.64	0.13	0.08	0.10	0.05	13.58	1.55	0.03	0.03	0.80	0.41	1.10	0.36
1988	fall	control	0.02	0.02	0.02	0.02					20.40	1.60	0.65	0.65	0.90	0.17	0.42	0.27
		disk			0.07	0.05	0.10	0.05			20.45	2.21			0.52	0.10	1.55	0.94
		burn			0.94	0.56	0.08	0.05			20.50	2.80	0.05	0.03	0.67	0.26	1.15	0.37
1989	winter	control	0.08	0.07	0.07	0.07	0.13	0.09	0.02	0.02	15.13	1.79	0.57	0.42	2.42	0.13	0.35	0.22
		disk	0.63	0.31			0.02	0.02			18.47	1.60	0.02	0.02	0.37	0.04	0.93	0.40
		burn	0.17	0.13	0.33	0.25	0.03	0.03			13.07	1.66	0.15	0.10	1.17	0.18	0.58	0.27
1989	spring	control	0.05	0.05	0.14	0.14	0.07	0.05	0.03	0.03	24.58	1.79			2.03	0.45	0.32	0.17
		disk	0.27	0.08			0.07	0.05			21.32	1.74	0.07	0.05	0.97	0.24	2.67	1.10
		burn	0.17	0.06	0.68	0.63	0.22	0.10	0.08	0.05	16.87	1.14	0.12	0.10	1.68	0.23	1.50	0.84

Appendix 6. Seasonal response (mean % frequency of occurrence [n=6] and standard error) of 8 key plant foods of California quail to habitat manipulation, spring 1986 to spring 1989.

			Bittercress		Blackberry		Cichorieae		Clover		Grass		Teasel		Vetch		Wild Carrot	
Year	Season	Treatment	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
1986	spring	control	1.67	1.67			1.67	1.67			100.00	0.0			81.67	6.01	10.00	3.65
		disk	5.00	3.42			1.67	1.67			100.00	0.0			41.67	14.47	18.33	12.22
		burn	1.67	1.67							100.00	0.0	1.67	1.67	86.67	6.15	26.67	12.56
1986	summer	control									100.00	0.0	5.00	5.00	31.67	9.46	10.00	3.65
		disk					25.00	8.06	6.67	6.67	100.00	0.0			58.33	11.08	40.00	12.38
		burn									100.00	0.0			13.33	4.94	25.00	11.47
1986	fall	control					1.67	1.67			100.00	0.0	5.00	5.00	96.67	3.33	8.33	3.07
		disk					30.00	9.66	1.67	1.67	100.00	0.0	1.67	1.67	48.33	13.76	51.67	14.47
		burn					1.67	1.67			100.00	0.0	5.00	5.00	81.67	16.41	25.00	9.22
1987	winter	control	6.67	6.67							100.00	0.0	1.67	1.67	81.67	7.49	10.00	6.32
		disk	15.00	8.47			43.33	8.43	21.67	10.78	100.00	0.0			96.67	2.11	43.33	14.06
		burn	11.67	8.33			5.00	2.24	3.33	2.11	100.00	0.0	6.67	6.67	98.33	1.67	28.33	11.67
1987	spring	control					3.33	3.33	11.67	5.43	100.00	0.0	5.00	5.00	98.33	1.67		
		disk	1.67	1.67	0.17	0.17	40.00	9.66	13.33	8.03	100.00	0.0	5.00	5.00	98.33	1.67	46.67	18.56
		burn					3.33	2.11	8.33	4.77	100.00	0.0	1.67	1.67	98.33	1.67	36.67	16.87
1987	summer	control			0.17	0.17	1.67	1.67			98.33	1.67	5.00	3.42	38.33	17.01	20.00	12.38
		disk			0.50	0.22					100.00	0.0	8.33	6.54	8.33	4.77	35.00	15.65
		burn			0.17	0.17	5.00	3.42	1.67	1.67	100.00	0.0	1.67	1.67	31.67	17.21	26.67	11.45
1987	fall	control			0.33	0.21					100.00	0.0	13.33	11.45	3.33	3.33	3.33	2.11
		disk									100.00	0.0			6.67	3.33	21.67	9.80
		burn			0.67	0.21					100.0	0.0	11.67	7.49	10.00	5.16	16.67	14.76
1988	winter	control			0.17	0.17					100.00	0.0	10.00	10.00	86.67	4.94	3.33	3.33
		disk									100.00	0.0	15.00	9.57	41.67	14.24	8.33	4.77
		burn			0.17	0.17					98.33	1.67			66.67	13.58	6.67	4.22
1988	spring	control	6.67	6.67			3.33	2.11	3.33	2.11	100.00	0.0	11.67	7.92	95.00	3.42	15.00	11.47
		disk	18.33	7.49	0.17	0.17	15.00	7.19			100.00	0.0	1.67	1.67	65.00	8.85	63.33	19.09
		burn	43.33	14.30	0.17	0.17	3.33	2.11	16.67	5.58	100.00	0.0	3.33	3.33	88.33	7.49	53.33	19.09
1988	summer	control			0.17	0.17					100.00	0.0	11.67	11.67	53.33	17.26	28.33	14.93
		disk			0.17	0.17					100.00	0.0			38.33	8.72	46.67	15.20
		burn			0.17	0.17	8.33	5.43	8.33	4.01	100.00	0.0	11.67	11.67	46.67	15.85	63.33	20.11
1988	fall	control	1.67	1.67	0.17	0.17					100.00	0.0	11.67	11.67	75.00	9.92	26.67	13.82
		disk			0.33	0.21	8.33	4.01			100.00	0.0			46.67	8.03	50.00	11.83
		burn			0.50	0.22	5.00	3.42			98.33	1.67	3.33	2.11	51.67	16.82	61.67	19.73
1989	winter	control	3.33	2.11	0.17	0.17	5.00	3.42	1.67	1.67	100.00	0.0	16.67	11.16	100.00	0.0	20.00	10.33
		disk	35.00	17.08			1.67	1.67			100.00	0.0	1.67	1.67	35.00	3.42	41.67	14.70
		burn	13.33	9.89	0.50	0.22	3.33	3.33			100.00	0.0	10.00	8.16	85.00	9.57	40.00	16.12
1989	spring	control	5.00	5.00	0.17	0.17	3.33	2.11	3.33	3.33	100.00	0.0			86.67	11.45	20.00	10.00
		disk	23.33	8.03			5.00	3.42			100.00	0.0	5.00	3.42	68.33	13.76	60.00	19.32
		burn	16.67	5.58	0.33	0.21	11.67	4.77	8.33	5.43	100.00	0.0	6.67	4.94	93.33	3.33	56.67	18.38