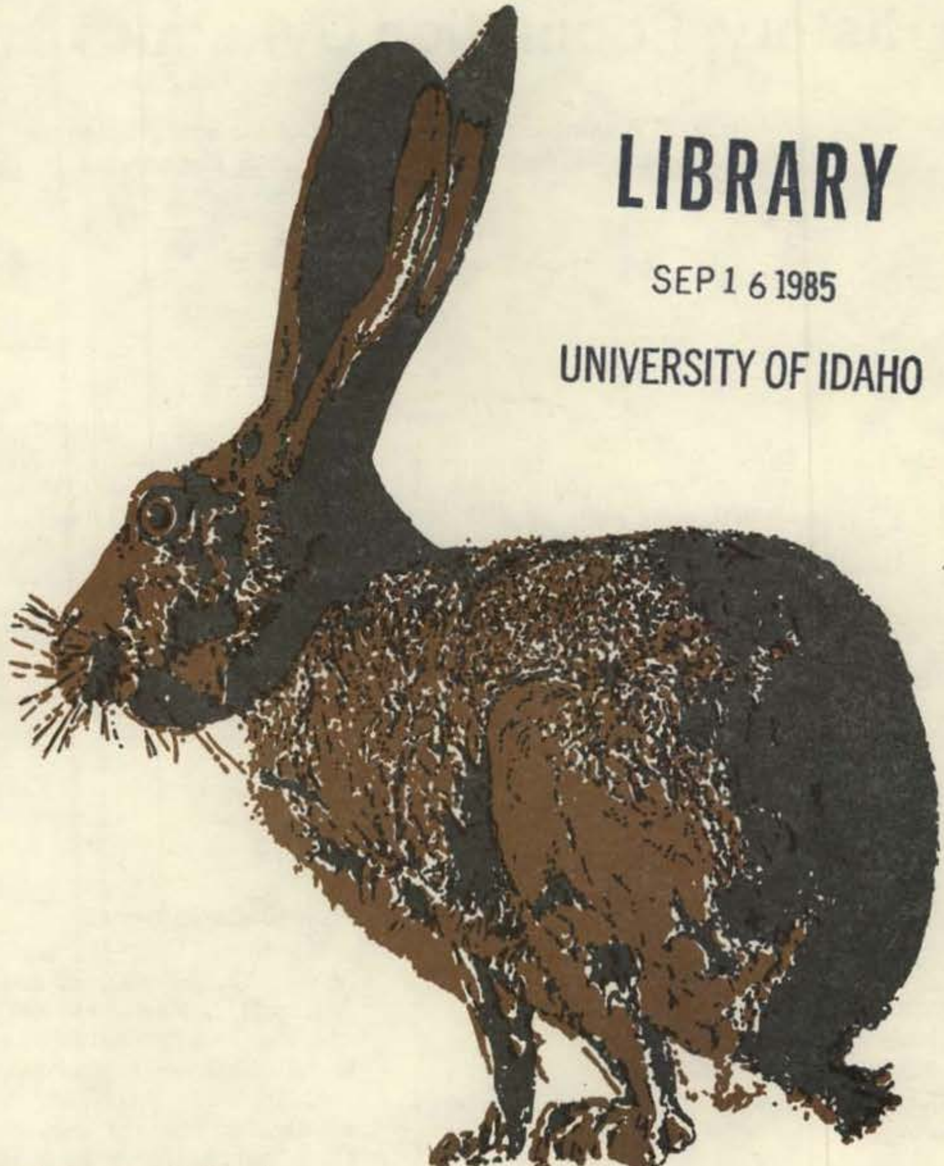
The Black-tailed Jackrabbit in Idaho

Life History, Population Dynamics and Control



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The Black-tailed Jackrabbit in Idaho: Life History, Population Dynamics and Control

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"For several years we had good crops of winter wheat...but then came the dry years and with them the jackrabbits and gophers. The jackrabbits came to the green wheat fields about sundown. They came from the lavas and the uncleared sagebrush fields where they 'shaded up' during the daytime. They came in hordes so thick that it looked as though the ground was moving. Guns were useless against them for although you could drop what you hit, the rest kept right on coming."

Arid Acres, A History of the Kimama-Minidoka Homesteaders, 1912-1932

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Acknowledgments

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Introduction

At the time of European colonization rabbits and hares were found on all continents except Australia and southern South America where they have since been introduced. Mammalogists have identified 49 living species as well as a number which are now extinct.

Those species with young that are born hairless and immobile are termed rabbits while those that give birth to fully haired, active young are considered hares. Thus, the European or domestic rabbit and all cottontails are indeed rabbits while the snowshoe "rabbit" and all jackrabbits are in fact hares.

The large hares inhabiting the grasslands and deserts of western North America were first called jackass rabbits because of their large ears. Although technically hares, the term jackrabbit is an accepted common name.

The three species of hares in Idaho are separated both morphologically and ecologically. The snowshoe hare (*Lepus americanus*) is widely distributed across the boreal region of North America. In Idaho, its range extends throughout the forested parts of the northern, central and southeastern parts of the state (Fig. 1). It is apparently absent from southern and western Idaho south of the Snake River. This species molts to a white winter pelage, hence the name varying hare. Although the summer coat is a dark brown, it retains white markings on the lower parts of the legs.

Cyclic fluctuations in the density of snowshoe hares in Canada are characterized by changes in both natality and juvenile survival. A scarcity of food during the winter is the principal cause of marked changes in natality rates and juvenile survival (121). As hare density decreases, predation exerts a greater influence on adult survival, further depressing the population (73). The fragmented distribution of snowshoe hare habitat on the periphery of its range likely prevents the development of cycles (29), which have not been confirmed for this species in Idaho.

The white-tailed jackrabbit (*Lepus townsendi*) has a broad distribution throughout the interior parts of western North America from southern Canada to northern New Mexico and from the Mississippi River west to the Sierra Nevada Mountains. This is primarily a grassland species as its earlier name, the prairie hare, suggests. Its range has been much reduced since settlement, in part because much of the grassland has been converted to agricultural crops. The species, however, remains locally common in the foothills and parks of the Rocky Mountains as well as wide stretches of Wyoming's "cold desert."

In Idaho the white-tailed jackrabbit is found in the high valleys in the central portion of the state and in the mountainous parts of eastern and southern Idaho south of the Snake River (Fig. 1). Its occurrence in northern Idaho is based on specimens from Rathdrum Prairie (1937), Kootenai County, and from Paradise Ridge (1949), Latah County. This species may no longer occur in northern Idaho.

The white-tailed jackrabbit develops a white winter coat and often moves to lower elevations during the winter months. In white pelage it is sometimes confused with the snowshoe hare but it is larger and is more likely to be associated with open habitats rather than forest or riparian vegetation. Although sometimes causing damage to stored hay, this species seldom produces widespread economic loss.

The black-tailed jackrabbit (*Lepus californicus*) is found at lower elevations of the Great Plains and Great Basin, southward into central and western Mexico. Its range has expanded northward since settlement as it seems well adapted to agricultural development. In Idaho this species occurs on the sagebrush steppe throughout the southern portion of the state, including the Pahsimeroi and Lemhi Valleys (Fig. 1). Because of dramatic changes in density and the crop depredations associated with population highs, this species periodically exerts a significant economic impact on stored hay during the winter months and on new grain crops during the spring.

Observers have reported local populations in southern Idaho at peak densities during almost every decade since 1832 (Table 1). Populations which have been censused systematically over a period of years demonstrate an alternate pattern of high and low density. Some local populations maintain a high density for several years before decline while others "crash" soon after reaching a peak. Thus, the pattern of density change is complex with respect to periodicity, amplitude and synchrony.

The factors that produce these changes are of theoretical interest to population ecologists and of practical interest to range managers, ranchers and farmers throughout southern Idaho. This publication discusses the life history, population dynamics, economic impact and methods of controlling this species with special reference to its occurrence in southern Idaho.

Reproduction and Development

The mating behavior of this species consists of circling, sparring, biting and extended chases. The male and female sometimes engage in alternate leaps over one another during which the male may emit a stream of urine. Once the chase begins, other jackrabbits may join the pair, running about in a zig-zag pattern (78). After copulation, the male falls to the ground, emits a hissing squeal and renews the chase. There may be successive copulations involving several mates (8).

Black-tailed jackrabbit populations show considerable variation in the length of the breeding season, in the frequency of pregnancy among mature females and in the size of the litter. The breeding season may extend at least 300 days in Arizona (122) and may be as short as 128 days in eastern Idaho (47). Lechleitner (80) suggested that the onset of breeding in a California population was related to the annual cycle of rainfall and subsequent availability of green forage. Gross et al. (54) have concluded that weather has no effect on the commencement of breeding of jackrabbits in the Curlew Valley of Utah and Idaho.

As with other lagomorphs, ovulation in this species is induced by copulation. Since females enter estrus soon after giving birth, several successive litters are produced during a single breeding season. The gestation period in this species ranges from 41 to 47 days (59). A captive female, however, produced successive litters at 38- and 40-day intervals (48). Feldhamer (38) estimated that

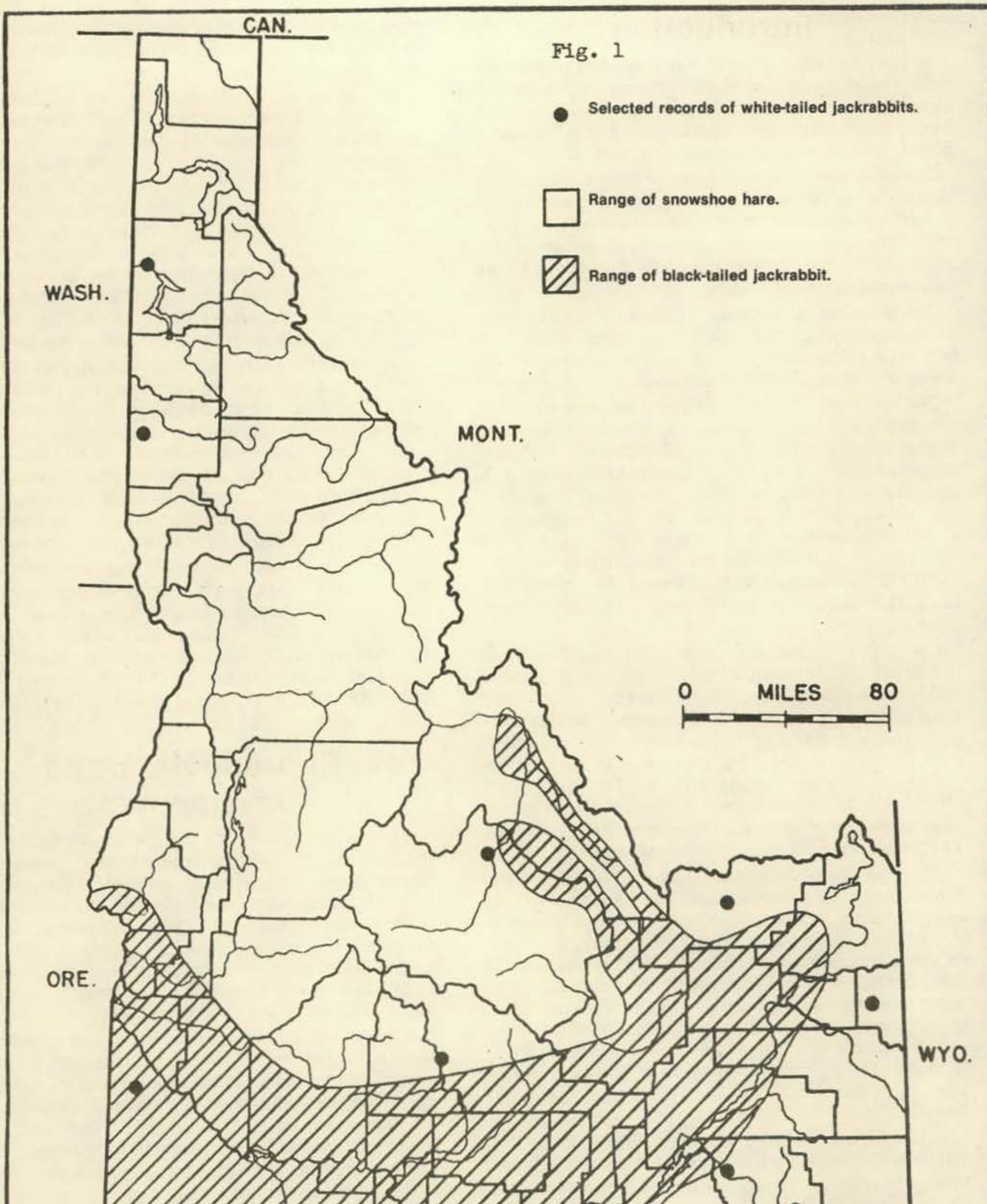

Fig. 1. Map showing jackrabbit habits in Idaho.

mature females in eastern Idaho could produce an average of 2.5 litters annually. A few juveniles produced in the first litter of the season may breed later that year (54). A rather close synchrony in litter production occurs which becomes evident when one investigates the seasonal pattern of conception dates (54).

The frequency of pregnancy in mature females varies seasonally, increasing to a peak in the spring and then decreasing as the breeding season comes to a close (54). Pregnancy rates varied inversely with density in an eastern Idaho population, decreasing from 77 to 49 percent between 1956 and 1959 as the density increased (47), although this has not been observed in the Curlew Valley population (Wagner, personal communication).

Litter size is usually determined by averaging counts of visible embryos. The mean litter size increases progressively to a peak and then decreases so that litters of a single embryo are common both at the beginning and at the end of the breeding season. Litter size also varies geographically with larger litters produced by northern populations (54).

Prenatal mortality, which is calculated from counts of corpora lutea and visible embryos, is difficult to measure because of the loss of entire litters either before or after implantation. Feldhamer (38) calculated an intra-uterine mortality rate of 46 percent in an eastern Idaho jackrabbit population. Gross et al. (54) found evidence of intrauterine loss of entire litters only in the first and last conception periods.

Based on field observations, Tiemeir (119) concluded that litters are sometimes dropped in a nest, which is merely a shallow depression dug on the surface of the ground. He found that newborn animals remained in the vicinity of the nest for more than a week before dispersing.

Table 1. Occurrences of peak densities in black-tailed jackrabbit populations of southern Idaho, 1832-1982.

1832 Nathaniel Wyeth, leading a small party in southcentral Idaho, reported "We found rabbits plenty on the plain" (134).

1854 George Suckley, on a government survey, reported large numbers of jackrabbits between the Boise and Snake Rivers (92).

1878 Charles Bendire, an early naturalist, found jackrabbits abundant in the Payette River valley (92). A bounty of 51 cents was offered by Ada County for each pair of jackrabbit ears (Idaho Triweekly Statesman).

1885 Ada County made bounty payments on 18,265 pairs of ears (Idaho Triweekly Statesman).

1892 Ada County paid bounty on 27,712 pairs of ears (Idaho Triweekly Statesman).

1894-95 Drives at Idaho Falls, Nampa, Marian (Cassia County), Market Lake and Rigby (92).

1895-96 Drives at Malta, Marian and Rigby (92).

1896-97 Drives at Malta (92) and Mud Lake.

1905-06 Jackrabbits abundant near Rupert in the fall with heavy mid-winter mortality (Rupert Record).

1909-10 Drives near Rupert. Lincoln County Commissioners offered a bounty of 3 cents for each rabbit scalp with the ears attached (Rupert Pioneer-Record).

1910 Photo of a drive at Mora near Kuna (Idaho Historical Society).

1912 Photo of a drive at Gooding (Idaho Historical Society).

1913 Photos of drives near Twin Falls (Idaho Historical Society).

1913-14 Several drives near Hazelton (Rupert Pioneer-Record). Strychnine-treated oats were made available to farmers at Aberdeen (Aberdeen Times). Drives near Downey and Twin Falls (Pocatello Tribune).

1918-19 Drives at Rupert (28).

1920-21 Drives at Aberdeen, Moreland and Springfield (Bingham County News).

1931 Nearly 1,000 jackrabbit carcasses per mile on the highway near Thousand Springs (49).

1932 A count of 422 jackrabbits and 176 cottontails on the highway between Boise and Mountain Home (111).

1934 Drives near Mountain Home (Mountain Home Republican), Boise (Idaho Statesman) and Paul (28).

1935-36 Peak numbers in the Cassia Creek Valley (28), at Mud Lake and Shoshone (Idaho Statesman) and at Aberdeen (Aberdeen Times).

1938 Carcasses of rabbits (both cottontails and jackrabbits) numbered 72 per mile near Thousand Springs but only 2 per mile south of Boise (131).

1940 An average of 14 carcasses per mile between Tremonton, Utah, and Boise (106).

1948-49 Jackrabbits were abundant in eastern Idaho. The Idaho State Legislature appropriated $20,000 for control (Idaho Statesman).

1957 Fifty-four carcasses on a 2-mile stretch of highway near Burley (1).

1959 Jackrabbits at peak density on the Idaho National Engineering Laboratory near Idaho Falls (47).

1970 Peak density in the Curlew Valley, Idaho and Utah (124).

1971 Peak density on the Snake River Birds of Prey Area (BLM files); Drive at Mud Lake (38).

1978 Peak density in the Raft River Valley (117).

1981 Peak density in the Snake River Birds of Prey Area (BLM files).

1981-82 Drives at Mud Lake.

Post-natal development of the black-tailed jackrabbit has been described (48, 59). The ear, foot and body length increase at a faster rate than body weight during the first 10 weeks of life, evidence that there has been strong selection for early development of the body frame.

Several authors mention the presence of a white blaze on the forehead of juvenile jackrabbits. This begins to disappear in the black-tailed jackrabbit at 10 weeks of age. The dark pelage of juvenile jackrabbits is retained for 6 to 9 months and then is replaced with a lighter coat of adult animals (59).

Home Range and Movements

The size of the home range varies depending upon the quality and quantity of the forage and cover available. Black-tailed jackrabbits in California had home ranges that ranged from 30 to 45 acres, with those smaller in size located in areas where movement was restricted by barriers such as ditches, fences and water (79). Home ranges of similar size were reported in southern Idaho (47) and in Kansas (119). In Arizona where food and cover is more widely dispersed, the home range may be 1 to 2 miles in diameter (122).

Jackrabbits aggregate in large concentrations during seasons of drought (13) or deep snow (47). These concentrations may appear to include immigrants when in fact only the local population is involved. French et al. (47) demonstrated the effect of local concentration in this way: At a density of only 0.2 jackrabbits per acre, a circular area of 79 square miles would contain 10,112 rabbits. If all of those in the outer 1-mile belt of this circle moved into the central portion, the jackrabbit population there would increase by 4,364 animals or 43 percent. Winter concentrations involving such short movements can be expected at sites where stored hay is located near sagebrush rangeland.

Food Habits

The diet of jackrabbits varies according to forage availability and palatability. Although rabbits feed on a wide range of forage plants, only a few species constitute the bulk of the diet during any season (Table 2). Plant development affects diet with the more succulent, rapidly growing items preferred during the spring (37). As grasses and forbs mature, their palatability decreases, and in some areas, cacti become important in the diet. Plants with high water content are used as a water source in arid regions.

Diets on Idaho rangeland include predominantly grasses in the spring and early summer, forbs and grasses in the late summer and fall and shrubs in the winter months. Cheatgrass (*Bromus tectorum*) is a preferred item during the spring. Indian ricegrass (*Oryzopsis hymenoides*), Sandberg bluegrass (*Poa sandbergii*), needle-and-thread (*Stipa comata*), bottlebrush squirreltail (*Sitanion hystrix*) and a variety of annual grasses are readily taken, especially in the spring (37). Crested wheatgrasses (*Agropyron cristatum* and *A. desertorum*) are preferred forages when available during the spring months (129).

A variety of forbs are taken during the summer months as well as grass. Halogeton (*Halogeton glomeratus*) is used extensively on a year-long basis. This plant serves as a water source during the dry season. Shrubs such as shadscale (*Atriplex confertifolia*) and greasewood (*Sarcobatus vermiculatus*) are also used as food sources. Kochia (*Kochia americana*), an introduced annual, is a favored year-long forage (20).

Winterfat (*Cerratoides lanata*) and perennial grasses make up 80 percent of the summer diet of black-tailed jackrabbits on the Idaho National Engineering Laboratory. Jackrabbits selected grass-dominated areas for feeding at night (68).

Table 2. Summary of seven investigations of black-tailed jackrabbit diets.

Location	Season	Principal forage species
Colorado, shortgrass (42)	September-October	western wheatgrass, alfalfa, summer cypress
	December-February	smooth brome, wheat, fringed sage, alfalfa
	April-May	crested wheatgrass, wheat, fringed sage, alfalfa
	June-August	western wheatgrass, bluegrass, summer cypress
Utah, salt desert (26)	March	salt sage, shadscale, big sage
	April	grasses, shadscale
	May	squirreltail, Indian ricegrass
	September	grasses
	October	rabbitbrush, granite gilia
	November-December	big sage, rubber rabbitbrush
Utah, salt desert and sagebrush (19; 128)	Fall-winter	big sage greasewood, shadscale, summer cypress
	spring	squirreltail, crested wheatgrass, cheatgrass
Washington, sagebrush (120)	Yearlong	squirreltail, crested wheatgrass, forbs including yarrow, turpentine cymopterus, hoary aster, needle and thread grass, big sage, rabbitbrush
Idaho, sagebrush (37)	April	cheatgrass, Sandberg bluegrass, barley, big sage
	June	cheatgrass, big sage, squirreltail, cryptantha
	August	mustards, big sage, wild rye
Arizona, desert-grass (122)	Year long	mesquite, grasses
Nevada, desert-grass (61)	Late summer-winter	shrubs, especially creosote bush, winterfat, krameria
	Spring, early summer	ricegrass, cheatgrass, needle and thread grass

Fall diets include sagebrush, rabbitbrush and grasses. Late-maturing plants such as pigweed (*Amaranthus graecizans*), Russian thistle (*Salsola kali*) and tansymustard (*Descurainia pinnata*) are taken in the early fall. The use of shrubs progressively increases as the season advances. Shrubs represent the major food source during the winter.

Jackrabbits feed on lawn grasses and ornamental shrubs at sites near native rangeland. They also damage windbreaks, orchards and grape vines. Alfalfa and seedling grain crops have been devastated during population highs. Potato plants, although eaten, are not a preferred food. The extensive damage to stored hay is well known.

Jackrabbits re-ingest soft fecal pellets as do other lagomorphs (77). These soft pellets are produced within the caecum and represent a rich source of nutrients. In Australia, wild rabbits increased the rate of re-ingestion during drought periods when only low-quality forage was available. Soft fecal pellets are also rich in protein since they contain microorganisms harbored in the caecum.

A mature jackrabbit may consume forage amounting to 6.6 percent of its body weight (122) or about 390 grams per day (56), of which about 45 percent is assimilated. Succulent forages are better assimilated than dry, woody foods used during the winter months.

Habitat Relationships

Based on fecal pellet accumulation, black-tailed jackrabbits use sites with greater biomass of grasses on the Idaho National Engineering Laboratory (85). The presence of thickspike wheatgrass (*Agropyron dasystachyum*), needle-and-thread grass and bottlebrush squirreltail characterize most areas frequented by jackrabbits during the winter and spring months. Shrub cover is common at winter feeding sites as well. A diverse vegetation with respect to height, form and species representation provides abundant cover and forage. These observations agree with those of Flinders and Hansen (42) in northeastern Colorado where the feeding sites of black-tailed jackrabbits supported a herbaceous vegetation of high diversity and biomass.

Early investigations by Vorhies and Taylor (122) and by Taylor et al. (116) in southern Arizona suggested that jackrabbits preferred rangelands that had been heavily grazed by livestock. They concluded that jackrabbit use of heavily grazed range was not the cause of its deterioration but rather the result of its heavy use by domestic stock. Others, working in tall grass prairie, have attributed the increase of jackrabbits on deteriorated range to the removal of taller grasses, which both improved the opportunity to detect predators and permitted the invasion of weedy species that are preferred forage (9, 13).

The subsequent work of Flinders and Hansen (44) has shown that the relationship of jackrabbits to range condition is not as simple as was once thought. Grazing by domestic stock can either reduce cover below that which is preferred by jackrabbits or induce a dense growth of shrubs which is also marginal habitat for jackrabbits. These observations suggest that range condition can influence jackrabbit use, but that this relationship can vary locally depending on the composition and density of the range plants present. Further, a grazing intensity that might have no effect on jackrabbit distribution and density in one region may be significant in another.

In southern Idaho, rangelands in good condition provide excellent jackrabbit habitat. With range deterioration through overgrazing, shrubby species such as big sagebrush increase at the expense of grasses and forbs. In extreme cases, the sagebrush stand becomes so dense that it virtually excludes other vegetation. Such habitats receive only light use by jackrabbits.

The destruction of a dense shrub cover by wildfire does not improve jackrabbit habitat if it favors the development of large areas of weedy annuals such as cheatgrass. Burns that both reduce shrub density and enhance the production of perennial grasses improve these sites for jackrabbits. Thus, jackrabbit populations respond to habitat alteration rather than serving as a first cause, as Fichter (40) has emphasized.

The effects of grazing by jackrabbits on rangeland vegetation is a source of concern. When the jackrabbit population is low, evidence of their foraging is difficult to detail, but during population highs the effect may be dramatic. Jackrabbits have removed 94 percent of the current growth of Indian ricegrass and 80 percent of the rubber rabbitbrush (*Chrysothamnus nauseosus*) in the Curlew Valley of Utah during a population high (26). Vegetation protected from jackrabbits and domestic sheep for periods of 5 to 15 years, however, revealed little change other than some increase in the coverage of winterfat and a small reduction in the amount of bare ground (100).

Further investigation by Clark (20) indicated that jackrabbits at high density removed 30 to 40 percent of the individual plants of kochia, a highly preferred species, but only 5 to 11 percent of the remaining kochia plants were browsed, confirming that kochia can withstand heavy grazing by jackrabbits. Under the heaviest grazing pressure observed by Westoby and Wagner (129) in the Curlew Valley, jackrabbits removed less than 10 percent of the production of crested wheatgrass in all but the driest years.

Using exclosures as controls, Anderson (2) found that heavy winter browsing by black-tailed jackrabbits in eastern Idaho did not reduce the productivity of winterfat or green rabbitbrush (*Chrysothamnus nauseous*), although spiny hopsage (*Atriplex spinosa*) appeared to be more susceptible to damage. No evidence could be found that foraging had a significant impact on perennial grass production since two rhizomatous species, thickspike wheatgrass and a ryegrass (*Elymus triticoides*), both important forage plants, are well adapted to heavy grazing.

Competition with Other Species

The diet of the black-tailed jackrabbit overlaps that of other mammalian grazers since this species uses the important forage species at one time or another during the year. Competition for the food resource occurs only if the forage base deteriorates as a result of the combined effects of all grazing species. Thus, competition is not confirmed by simply showing concurrent use of the same forages. Since responses of vegetation to grazing pressure are often confounded with that due to the changes in the pattern and amount of precipitation, the authors are unable to quantify the effects of competition between grazing species.

During population highs, jackrabbits are capable of removing extensive quantities of forage even if this cannot be demonstrated to have a long-term effect on the rangeland. Under such conditions, temporary competition with livestock for forage will almost certainly occur. The impact of forage loss is most evident during drought years. Those wildlife species dependent on the forage base will adjust to forage loss by changing diet, patterns of feeding or areas utilized. There is no evidence of an effect of heavy jackrabbit grazing pressure on the reproductive success of any wildlife species. While there will inevitably be the exception, competition for range forage does not appear to be a widespread or continuing problem as far as jackrabbits are concerned (44, 100).

Clark and Innis (21) used a simulation model to estimate energy demand and density changes, testing the hypothesis that dense populations of black-tailed jackrabbits are limited by forage resources. Using this model, populations at peak density consumed less than 1 percent of the available forage. They concluded that the sharp declines in density from peak levels are not caused by the depletion of food resources.

Populations

The black-tailed jackrabbit is notorious for its dramatic fluctuations in numbers. Densities of the Curlew Valley population have been estimated to range from 19 to 163 per square mile over an 8-year period (54). Estimates as high as 320 per square mile in Arizona (122), 250 per square mile in Kansas (119) and 700 per square mile in California (79) have been made by other investigators. Smith and Nydegger (109) report a mean density of 163 per square mile from 1977 to 1981 on sagebrush sites in the Birds of Prey Study Area of southwestern Idaho. Even greater densities undoubtedly occur periodically near food sources during the winter months.

Although the data are incomplete, peaks have been reported for localized populations of the black-tailed jackrabbit in southern Idaho in almost every decade for the last 150 years (Table 1). The interval between peaks normally ranges from 7 to 10 years (42). The magnitude of density change from a peak to low population can be as great as 40:1. Density changes in different regions are not always in synchrony due to unique conditions locally with respect to weather, habitat and predator density. The most recent increase and decline of the jackrabbit populations in the eastern and southwestern regions of Idaho was markedly different (Fig. 2).

Population changes in Kansas are related to cover and ultimately to the pattern and amount of rainfall (13). On tall grass prairie, populations build only during drought periods. Since the pattern of drought is unpredictable, no cyclic fluctuation in density is apparent. This situation may exist elsewhere on the periphery of the range of this species, explaining in part the asynchrony in density change so often observed.

Predator-Prey Relationships

Since the black-tailed jackrabbit represents a major food source for a variety of mammalian and avian predators, changes in its density can have dramatic effects on the density and productivity of its predators.

Predators can respond numerically to changes in prey density (form concentrations at food sources) or they can respond functionally (increase consumption of the prey species). Coyotes (*Canis latrans*) demonstrate a strong numerical response to an increase in jackrabbit density (124; Fig. 3) with the two species demonstrating a classical predator-prey oscillation. In addition, the proportion of females breeding and litter size were correlated with jackrabbit density on a 700-square-mile study area of northern Utah and southern Idaho (18).

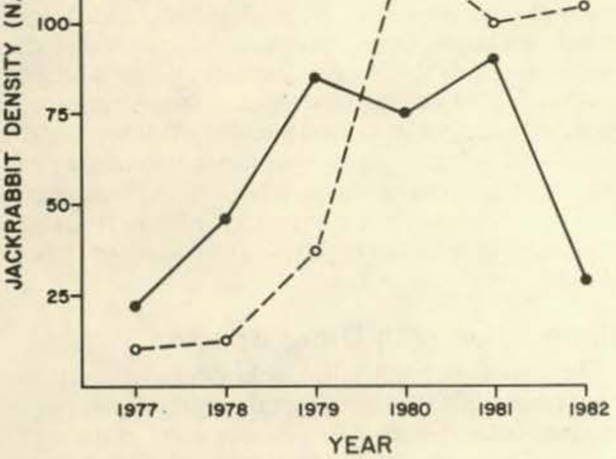

Fig. 2. This graph shows changes in jackrabbit density comparing numbers in Snake River Birds of Prey Study Area (solid line) with fall census of the Idaho National Engineering Laboratory (dash line). Unpublished data used with permission of Michael Kochert and L. Charles Stoddart.

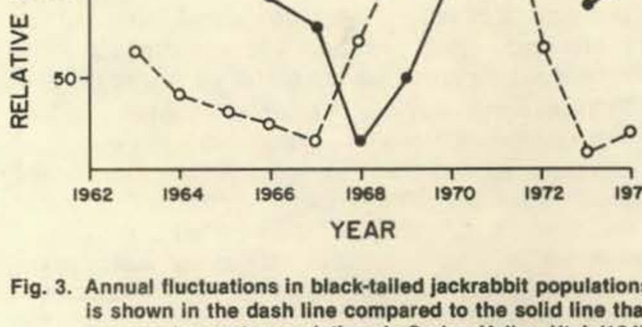

Fig. 3. Annual fluctuations in black-tailed jackrabbit populations is shown in the dash line compared to the solid line that represents coyote populations in Curlew Valley, Utah (124).

A functional (dietary) response in coyotes to an increase in jackrabbit density also occurs. Clark (18) found that the proportions of lagomorphs, primarily jackrabbits, ingested by coyotes showed a positive relationship with jackrabbit density during a 3-year period. Lagomorph remains, primarily those of jackrabbits, occurred in 89 percent of the coyote feces recovered from the Idaho National Engineering Laboratory from 1969 to 1971 when the densities of both Nuttall cottontails (*Sylvilagus nuttalli*) and jackrabbits were high (6). Cottontails alone comprised most of the diet of coyotes when jackrabbits occurred at a low density on this site (67, 84). Thus, lagomorphs remained a major prey item for coyotes on the INEL, but the proportion of jackrabbits and cottontails alternated in importance. On a statewide basis, the harvest by hunters of Nuttall cottontails (Norell, personal communication) shows a cyclic pattern which is synchronous with that of black-tailed jackrabbit density.

Other carnivores also demonstrate numerical and functional responses to changes in jackrabbit density. The pregnancy rate and litter size of kit foxes (*Vulpes velox*) increased during high jackrabbit density in west-central Utah (32). Nuttall cottontails and jackrabbits occurred in 87 percent of the bobcat (*Lynx rufus*) scats recovered from the INEL when both of these lagomorphs occurred at high densities in the 1969-1971 period.

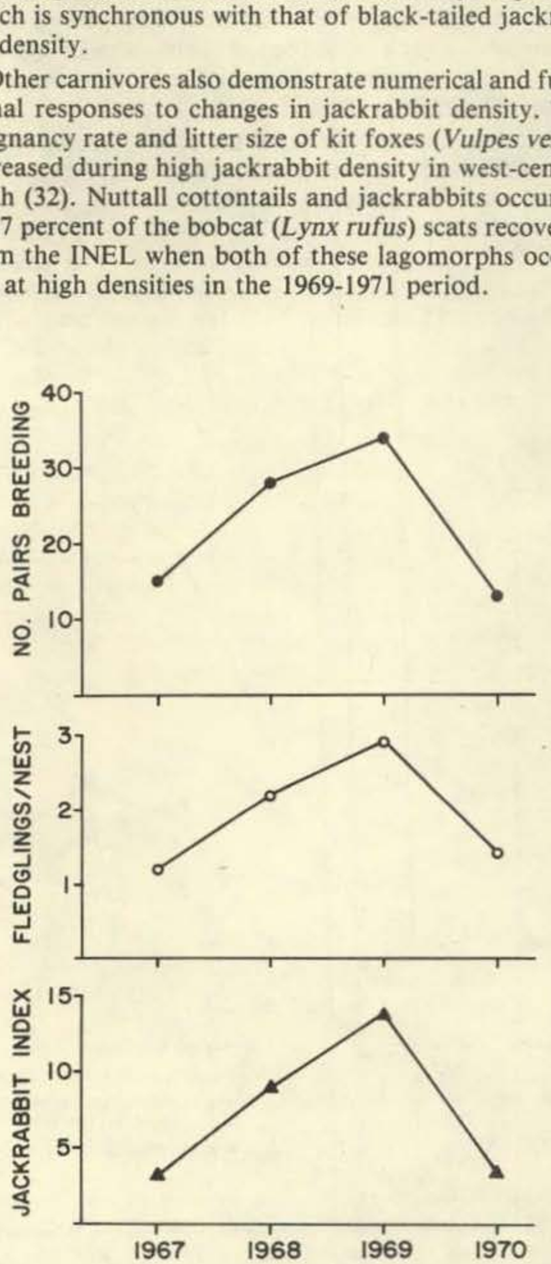

Fig. 4. This comparison shows changes in the index of jackrabbit density, fledging success and number of nesting pairs of ferruginous hawks in central Utah (108).

The availability of jackrabbits also influences the reproduction and diet of raptorial birds. The number of breeding pairs, number of eggs laid, number of young hatched and fledging success of ferruginous hawks (*Buteo regalis*) were positively related to jackrabbit density in central Utah, 1967-1974 (108: Fig. 4) and in the Raft River Valley, Idaho, 1972-1980 (117). Golden eagles (*Aquila chrysaetos*) showed both a numerical (number of pairs nesting, nestling survival and fledging success) and dietary response to changes in jackrabbit density on the Birds of Prey Study Area in southwestern Idaho in 1972-1980 (75).

Population Dynamics

Jackrabbit populations are maintained by remarkably high rates of reproduction. This productivity is countered by high mortality rates that vary between years. Changes in pregnancy rate, litter size and survival operate first to suppress and later to renew the population. The turnover rates in jackrabbit populations are relatively high. Only about 20 percent of the juveniles survive the first year of life, and very few individuals within a cohort survive to age 5 (79).

To illustrate these attributes, consider a population of 800 animals and a balanced sex ratio (Table 3). At high density, we assume that this population has a survival rate of 0.81 in February, a pregnancy rate of 0.36 and that each female produces 0.84 embryos. Because of the high mortality rate and low productivity the population falls to 746 (including 98 young of the first litter) by the end of the month. Beginning with the increase in pregnancy rate and litter size in March, the population increases through May and then begins to decrease because of a reduction in the pregnancy rate and litter size near the close of the breeding season.

Assuming a 25 percent reduction in the number of adults at the beginning of the breeding season, as might occur through a control program, the June population is reduced from 1,482 to 1,111 animals. A 50 percent reduction of adults in January produces a June population about equal in density to the pre-control level, if the reduction is distributed equally among all age classes and no other compensatory adjustments occur.

Similar control efforts later in the breeding season, when pregnancy rates and litter sizes are larger, produce similar results (Table 3, Scenario IV and V), as does a split control effort (Table 3, Scenario VI). These simulations demonstrate the remarkable resiliency of jackrabbit populations and the variation in the effectiveness of control efforts depending on the timing of their occurrence. Compensatory adjustments such as increases in pregnancy rate, survival or litter size would enhance the recovery after control (Fig. 5).

Control

Biological, mechanical and chemical methods can be employed to control jackrabbit populations. Each has inherent costs and potential for success depending upon the value of the crop threatened, jackrabbit density, local weather conditions and numerous other factors.

Biological methods include predators and disease as well as the use of habitat manipulation and chemosterilants. Most investigators agree that predators, including coyotes, are unable to control jackrabbit populations, even when predators are afforded complete protection. We agree with Evans et al. (35) that jackrabbit populations will continue to fluctuate in density regardless of predation pressure.

The introduction of a host-specific disease organism is often proposed as a ready solution to an animal pest problem. The release of the viral disease myxomatosis to control the European rabbit (*Oryctolagus cuniculus*) serves as an example of such a control attempt. While its early success was encouraging, the eventual establishment of a dynamic accommodation between the disease and the host has since diminished the effectiveness of this means of control (98, 99).

Table 3. Effects of selective levels of control on jackrabbit numbers.*

Month beginning	Density of breeding adults	Number surviving: Adults	Litter 1	Litter 2	Litter 3	Litter 4	Final density
Scenario I — No control							
February	800	648	98				746
March	648	544	82	426			1,052
April	544	456	69	358	621		1,504
May	456	384	58	301	522	429	1,694
June	384	322	49	253	438	360	1,482
Scenario II — 25% control in January							
February	600	486	74				560
March	486	408	62	320			790
April	394	342	52	269	466		1,129
May	330	258	44	226	391	321	1,270
June	258	242	37	190	328	270	1,111
Scenario III — 50% control in January							
February	400	324	49				373
March	324	272	41	214			527
April	272	228	34	180	311		753
May	228	192	29	152	260	215	848
June	192	162	24	128	218	181	742
Scenario IV — 25% control in early March before mid-March breeding							
February	800	648	98				746
March	648	408	62	348			818
April	408	342	52	292	466		1,152
May	342	288	44	245	391	322	1,290
June	288	242	37	206	328	270	1,083
Scenario V — 50% control in early March before mid-March breeding							
February	800	648	98				746
March	648	272	41	303			616
April	272	228	34	292	311		828
May	288	192	29	214	261	290	986
June	192	162	24	180	219	244	749
Scenario VI — 25% control before Feb. 1 and 25% control before mid-March breeding							
February	600	486	74				577
March	243	306	47	261			614
April	153	258	39	219	349		865
May	129	216	33	184	293	243	965
June	108	182	28	155	246	204	815

*Assume a balanced sex ratio (54), a beginning density of 800 per square mile (Stoddart, personal communication), no juvenile breeding (47), monthly pregnancy rates of 0.36, 0.70, 0.80, 0.65 and 0.25 with first breeding Feb. 1 (47), monthly survival rates of 0.81, 0.91 and 0.84 thereafter (54) and monthly mean litter sizes of 0.84, 2.07, 3.4, 3.45 and 1.47 (47).

Control by means of habitat manipulation also appears to have limited potential primarily because of the costs involved. While development of large areas of intensive agriculture has reduced the distribution and abundance of the black-tailed jackrabbit in southern Idaho, the species continues to impact grain crops and stored hay several miles within the perimeter of cultivated ground. Fagerstone et al. (37) suggested that planting edge strips of less palatable crops such as potatoes might reduce damage to preferred forages such as crested wheatgrass and barley. While the elimination of sagebrush near crops reduces resting cover for jackrabbits, it can have unfavorable impacts on game birds such as sage grouse (35). Overall, habitat manipulation to control jackrabbits must be evaluated on an site-specific basis.

The use of chemosterilants to inhibit reproduction is impractical because (1) jackrabbits are widely distributed during the breeding season, (2) the reproduction of nontarget species such as cottontail rabbits can be affected and (3) the recurrence of estrus after induced litter loss requires multiple treatments (35).

Mechanical control includes the use of fencing to prevent access to forage as well as direct methods such as drives, shooting or trapping. Evans et al. (36) have described a variety of fencing techniques to exclude jackrabbits. Despite the expense and inconvenience, they conclude that fencing is often a wise investment. Using estimates of $1 per linear foot for fencing and alfalfa

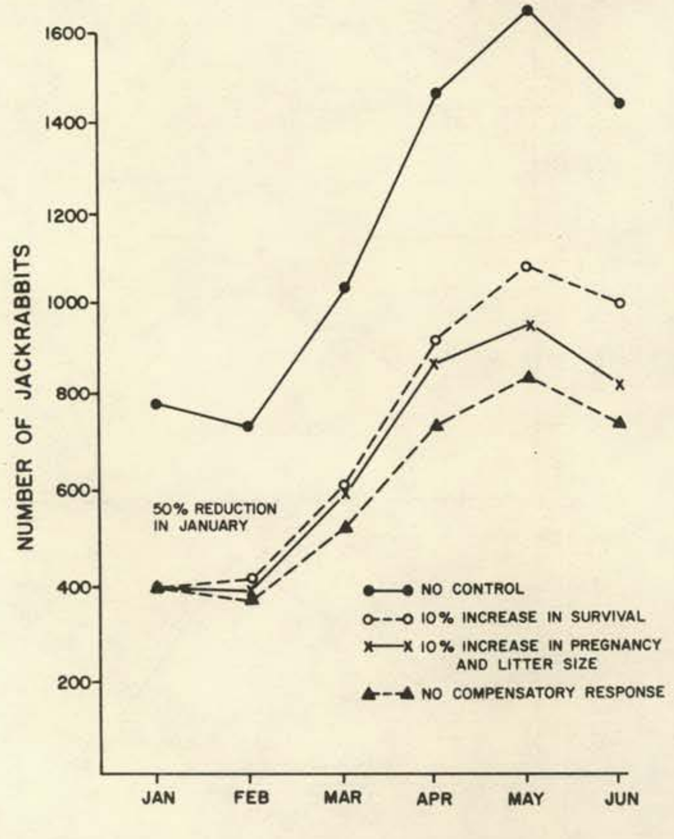

Fig. 5. This shows the effect of compensatory responses on a jackrabbit population that is reduced by 50 percent before the breeding season.

valued at $33.50 per ton, Bickler and Shoemaker (7) concluded that fencing was cost-effective only if the fields are small in size or the jackrabbit population is at peak density.

Jackrabbit drives remain a popular if ineffective method of jackrabbit control, at least in southern Idaho where there is a long tradition associated with this activity (Table 1; 83). Drives conducted near Mud Lake in 1981-82 attracted international attention and generated much adverse public comment. While some of the participants acted irresponsibly, the fact remains that death by clubbing is no less "humane" than that exercised by predators.

While drives may temporarily reduce a local population, we doubt that they have any significant effect in reducing peak densities. Shooting is even less effective unless it is employed as a means of harassing a localized population, such as that congregated at stored hay.

The use of chemicals to control jackrabbits, while summarily rejected by some, merits continued evaluation. Of the toxicants currently available, sodium fluoroacetate (Compound 1080) is undoubtedly the most controversial. This pesticide has been extensively studied to evaluate bait placement and acceptance (102, 103), formulation (97) and the loss of toxicity through weathering (130) when used against the European rabbit in Australia. Less in-

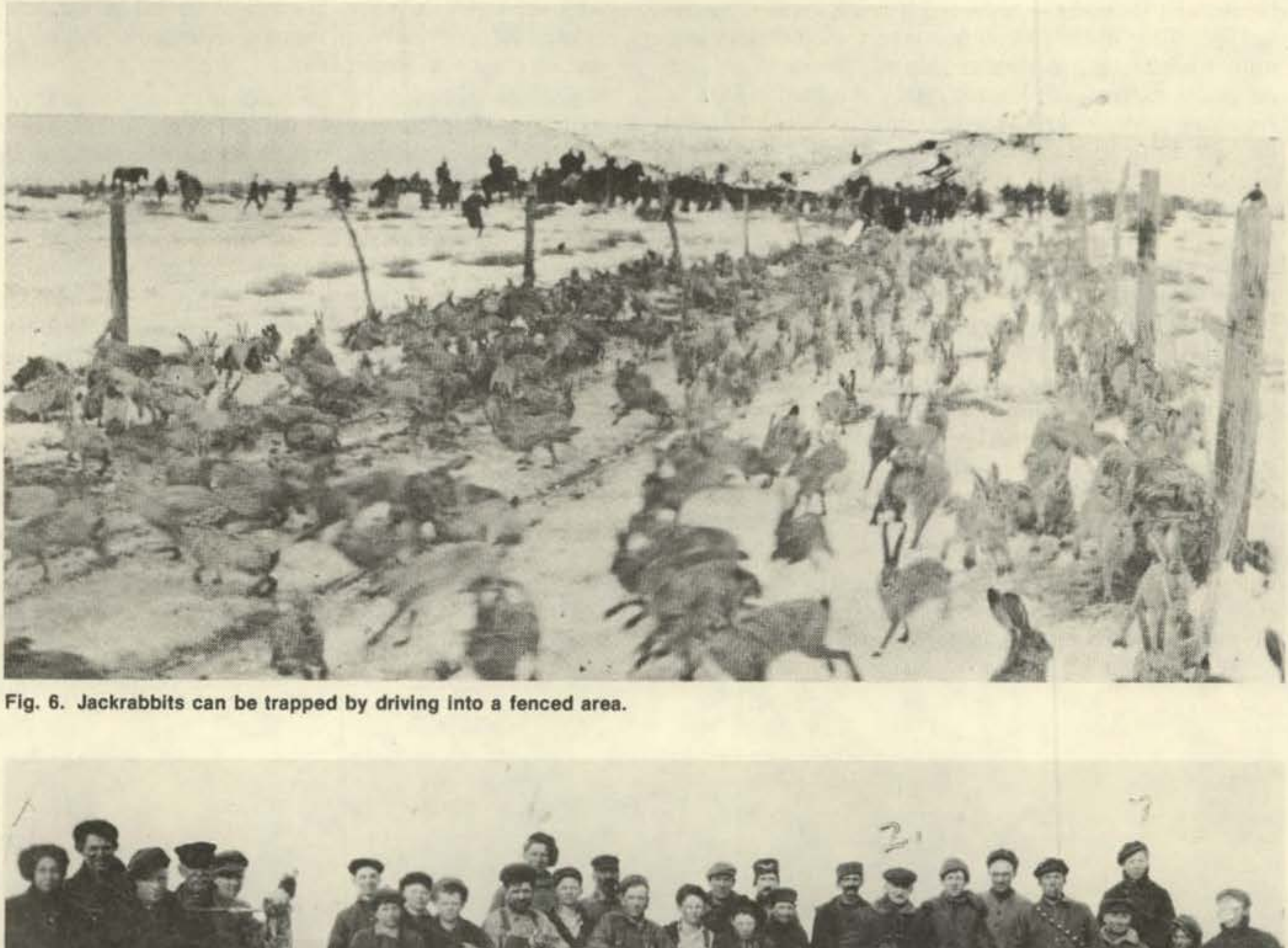

Fig. 6. Jackrabbits can be trapped by driving into a fenced area.

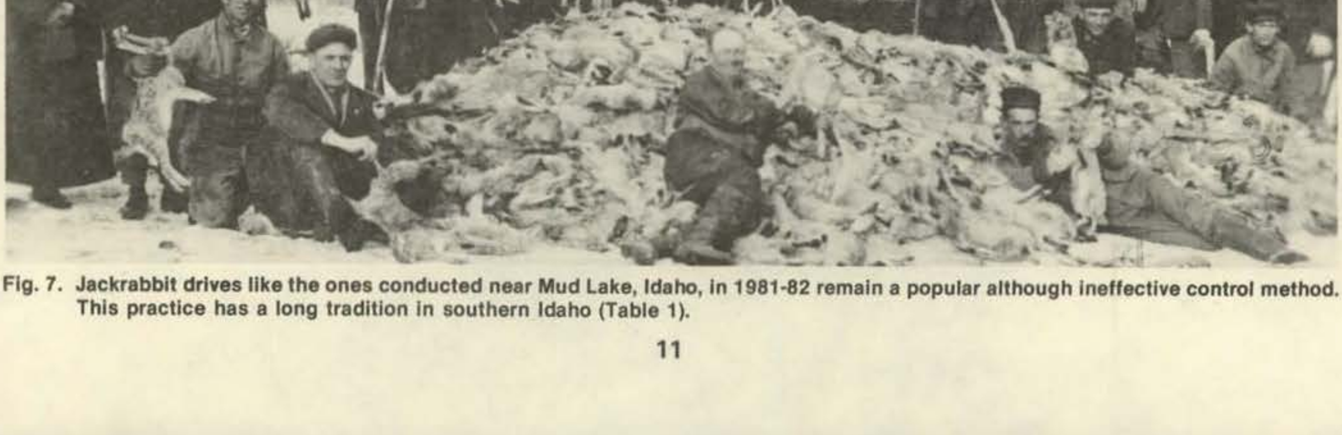

Fig. 7. Jackrabbit drives like the ones conducted near Mud Lake, Idaho, in 1981-82 remain a popular although ineffective control method. This practice has a long tradition in southern Idaho (Table 1).

formation is available on the field use of this toxicant to control jackrabbits (35).

The use of 1080 on federal lands was banned in 1972 although some experimental investigation of its effectiveness in animal damage control continues. Hegdal et al. (62) found evidence of secondary poisoning of coyotes, bobcats and striped skunks (*Mephitis mephitis*) after aerial application of 1080 bait to control ground squirrels in California. Detecting 1080 residues in animals killed by secondary poisoning is difficult since (1) the animal often vomits the toxic material before death, and (2) most of the poison ingested secondarily is fluoroacetate, an unstable byproduct of 1080 metabolism difficult to detect at low concentrations (62). The threat of secondary poisoning must be thoroughly assessed before 1080 can again be registered for field use.

Strychnine remains an important method of chemically controlling jackrabbits although it has a greater potential for killing livestock and non-target wildlife than any other toxicant (86). A formulation of 0.3 to 0.35 percent on grain, carrots, apples or freshly chopped alfalfa is recommended. Coating vegetable or fruit baits with corn oil extends the time that they remain acceptable in warm weather (35).

As with other toxicants, prebaiting enhances acceptance. The use of bait stations is essential when non-target species are present. Otherwise, strychnine baits can be distributed in furrows where they are more easily located by rabbits and the unused portion an be recovered after treatment. Griffith and Evans (50) describe a vehicle-mounted dispenser useful in placing bait into furrows. Strychnine kills rapidly so that efforts to recover carcasses are minimized (102). Experiments conducted by the U.S. Fish and Wildlife Service indicate that strychnine-killed jackrabbits are lethal to coyotes and sometimes to raptors, but only if the stomach contents are ingested (35).

Zinc phosphide is a gray-black, crystalline powder that reacts with dilute acids in the gastrointestinal tract to produce phosphine, a toxic, colorless gas with a garlic odor (65). A formulation of 0.75 percent zinc phosphide using carrots as bait was effective against jackrabbits in both field and cage tests (35). Sandvol and Finnigan (personal communication) found that zinc phosphide on alfalfa pellets using corn oil as a sticker produced erratic results. Acceptance was best during cold weather.

Because it is slow-acting, rabbits ingesting zinc phosphide baits can move several miles before death ensues, a circumstance which precludes the recovery of carcasses. Zinc phosphide is probably the least dangerous of the commonly used toxicants because of its emetic properties and its detoxification in the digestive tract of the target species (62).

Anticoagulants have not been recommended for rabbit control because of the high potential of secondary poisoning of mustelids (weasels, skunks, badgers, mink) (34). Most anticoagulants require ingestion over a period of days and the use of feeders which intensifies the labor associated with their use. The availability of an antidote, vitamin K1, provides a means of reviving most non-target species poisoned secondarily.

An organophosphate insecticide used as a foliar spray showed promise in controlling jackrabbits with minimal threat to non-target species in experiments conducted by Evans et al. (35). Further study is necessary to determine residue levels in food crops and the effects of this toxicant on ruminant physiology before a recommendation can be made regarding its future use in jackrabbit control.

In summary, we recommend fencing and persistent harassment as the primary means of protecting stored hay from damage by jackrabbits. When these methods of control are ineffective, the judicious use of pesticides may be necessary in some instances to reduce economic loss. Protecting grain crops at sites adjoining uncultivated ground is more difficult. In this case fencing and harassment are often impractical and the use of chemicals is probably the only feasible means of control. Regrettably, all toxicants currently available possess one or more attributes which limit or preclude their safe use under most field conditions. The search for safer and more effective toxicants should continue.

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