

OBSERVATIONS ON RAPTORIAL BIRDS IN THE LAVA BEDS—  
TULE LAKE REGION OF NORTHERN CALIFORNIA

WITH ONE ILLUSTRATION

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A previous article on the raptorial birds of the area indicated in the above title, by Joseph S. Dixon and the present writer (Condor, vol. 39, 1937, pp. 97-102), told of conditions in December, 1935, and April, May, June and September, 1936. Meadow mice and birds of prey were both then extremely abundant. On and near the cliff areas in the spring we found 5 pairs of Red-tails, a pair of Duck Hawks, 6 pairs of Prairie Falcons, a pair of Sparrow Hawks, about 300 Barn Owls old enough to fly, 25 or 30 adult Short-eared Owls, 4 pairs of Horned Owls (with at least 4 young out of the nest), and a pair of Burrowing Owls. On the main body of the Lava Beds National Monument we found 8 pairs of Red-tails, a pair of Bald Eagles (with 1 young), 2 pairs of Prairie Falcons, a dozen or more pairs of Sparrow Hawks and several Barn and Horned owls. Somewhere between 9 and 12 pairs of Marsh Hawks were nesting within 3 or 4 miles of the monument in the Tule Lake Refuge.

Further observations, while I was employed by the United States National Park Service, were made by me in this area, January 2-7, February 25-26, June 1-12, July 15-16, August 12, October 31-November 11, 1937, and March 28, 1938, or a total of 36 days. In the first week in January of 1937, meadow mice and hawks were abundant, but owls were somewhat rarer than during the previous winter. The greatest number of each species counted on any day of this period were: Goshawk 1, Red-tail 4, American Rough-leg 18, Ferruginous Rough-leg 1, Bald Eagle (adult) 5, Marsh Hawk 16, Prairie Falcon 3, Sparrow Hawk 1, Barn Owl (on cliffs) about a dozen, Horned Owl 2, Short-eared Owl 3. Not only were most of these birds concentrated in areas of *Microtus* abundance, but 34 Great Blue Herons were also observed mousing in a dry stubble field.

The night of January 5 about five inches of snow fell, and that and the following nights the temperature reached  $-10^{\circ}$  F, and on January 7 it fell still farther, to  $-18^{\circ}$  at monument headquarters. When I returned to the area February 25, I found that the cold weather had continued and that there had been a real blizzard a week or so before my arrival. Birds of nearly all kinds were rare. Meadow mice, still enormously abundant eight weeks before, were almost absent. Fresh workings of only one were found in several miles of walking, where on January 3 there had been many hundreds. Raptors had become much scarcer. Only 4 Red-tails, 2 American Rough-legs, 3 Ferruginous Rough-legs, 2 unidentified Rough-legs, 3 Bald Eagles and 2 Marsh Hawks were seen; 5 Barn Owls were scared from the east and west Petroglyph Cliffs; no Short-eared owls were seen.

It seems certain that the reduction in numbers of hawks and owls was largely caused by the dearth of mice (though 17 hawks and an adult Bald Eagle had been killed by members of the Biological Survey, the former for molesting quail at feeding stations, and the latter as a specimen); but it is not certain if the mouse reduction was caused by disease only, as seems often to be the case, or if enemies and inclement weather played important parts in the catastrophe. Water birds were beginning to return from the south at this time, and at least 10,000 snow geese arrived in one flock on February 25.

In June, meadow mice and raptorial birds were both extremely rare. On the monument proper there were 2 pairs of Red-tails instead of 8; one pair did not lay and the other raised only 1 young; the Bald Eagles' nest had blown down, and though a new one had been built, the eggs had been destroyed by an unknown agent; there were no Prairie Falcons, instead of 2 pairs, and 1 pair of Sparrow Hawks in place of a dozen

or more. (An Osprey, not previously reported, was seen over the monument by Mr. Elmer Aldrich.) Conditions on the cliff areas are shown in the following table.

	1936	1937
Red-tailed Hawk	5 pairs	3 pairs
Duck Hawk	1 pair	1 pair (not nesting)
Prairie Falcon	6 pairs	3 pairs
Sparrow Hawk	1 pair	none
Barn Owl	about 300 individuals	about 60-70 individuals
Short-eared Owl	25-30 individual adults	none
Horned Owl	4 pairs	3 pairs
Burrowing Owl	1 pair	2 pairs
Marsh Hawk (on refuge)	9-12 pairs	2 pairs
Totals:	about 380 birds	about 95 birds, a reduction of about 75 per cent

A cliff northwest of the monument (not mentioned in the previous article) had, in 1936, 5 nests of Red-tail, 1 of Prairie Falcon, and 2 of Horned Owl; in 1937, only 2 nests of Red-tail and 1 of Horned Owl.

It is difficult to explain the reduction of Prairie Falcon numbers, unless these birds in this region are more dependent upon meadow mice than is generally supposed, or unless it was simply a coincidence.

In mid-July birds of prey were still rare, and in mid-August the only ones that showed any increase were Turkey Vultures and Sparrow Hawks. At the latter time under the east Petroglyph Cliff I found dead, 1 adult and 1 nestling Prairie Falcon, 1 post-nestling Red-tail, and 2 adult and 2 nestling Barn Owls. All were too old to determine the cause of death, though some fresh .22 shells may have been connected with some of them.

Just after my August visit botulism became epidemic on the Tule Lake Refuge. By the middle of November some 7000 ducks and other water birds had died. The resident Biological Survey Biologist, Mr. Herbert H. Dill, informed me that large numbers of Turkey Vultures fed on the carcasses, along with Bald Eagles and Marsh Hawks. None of these was seen to be affected, but the young of a family of Duck Hawks apparently were attacked, and two were so weak that they were caught by hand and preserved as specimens; although *Clostridium botulinum*, type C, was not recovered from the carcasses, the symptoms were entirely typical. It is not known if the parents of this brood were the Petroglyph pair that had found a new nesting site, as seems quite possible, or a pair nesting at a distance that had been attracted by the food supply.

By the first part of November, there were many more raptors present than in June. There were about 25 Barn Owls and 4 Horned Owls on the Petroglyph Cliffs as well as 1 adult Duck Hawk (one day only) and a resident Prairie Falcon. Dead under the cliffs were 6 more Barn Owls, 2 young Prairie Falcons and a Horned Owl, all dead a month or more. From a dyke on the refuge I saw, all at the same time, 9 Marsh Hawks, 3 American Rough-legs, 2 Red-tails and 2 Prairie Falcons. A new record for the monument was a Pigeon Hawk (*Falco columbarius*) on November 8. Two immature Golden Eagles were also seen on the monument. One of these, or another, was subsequently killed by a trapper and nailed to his cabin under the east Petroglyph Cliff.

On my last visit to the Lava Beds, March 27, 1938, a pair of Prairie Falcons was seen on the Petroglyph Cliffs, and a pair of Red-tails.

#### BANDING

During the first part of June Mr. Elmer Aldrich, Student Assistant for the National Park Service, and I together banded all the nestling hawks that could be reached.

(Mr. Aldrich did the climbing and I gave him encouragement and supplied the rope.) Thirteen Red-tails in 5 nests, and 11 Prairie Falcons in 3 nests were banded. Of these, one Prairie Falcon and one Red-tail were later found dead under their respective nests. A Red-tail banded June 5, 1937, was shot near Merced, California, September 28 the same year. A Prairie Falcon banded June 6 was killed 81 days later, on August 26, at Horizon, Saskatchewan, and a couple of weeks later another was picked up dead about 100 miles away. These birds had traveled more than 900 miles northeast! Neither bird showed evidence of having been in captivity, and the extreme inaccessibility of the nesting sites, and the stringency of Canadian law, make it seem almost impossible that human agency could have been involved.

Two nests of Prairie Falcon were banded on that day, June 6, and our records unfortunately fail to show whether or not both the young were from the same nest. The adults at one of these nests were both remarkable. The female was the darkest of the species I have ever seen and was at first mistaken for a Duck Hawk. The male was the best and boldest flyer I have ever had the delight of watching. Over and over again he swooped, from a height of about 100 yards, within a foot or two of Mr. Aldrich's justifiably nervous head. The usual male will leave the defense of the young entirely to his mate and will often not come within a quarter of a mile of an intruder. This nest was about 5 miles from the monument.

#### FOOD HABITS OF HAWKS

Data for hawks in and near the Lava Beds, given herewith, are too few to permit of drawing very many conclusions as to species food habits. They simply show a few of the captures certain birds were able to make under the conditions of food and cover existing in the region under discussion, between December, 1935, and March, 1938. The term "Nest" as used below includes nesting sites that have become roosts for the adults after the dispersal of the young. Some of the food items recorded were picked up long before or after the actual nesting season. Further: (c)=seen capturing; (e)=seen eating or carrying; (n)=in nest; (u)=under nest.

#### Red-tailed Hawk (*Buteo borealis*):

- Nest 1
  - Citellus beecheyi douglasii (e) 1
- Nest 2
  - Dipodomys heermanni californicus (n) 1
  - Microtus montanus montanus (n) 3
  - Sylvilagus nuttallii nuttallii (n) 2
- Nest 3
  - Mustela frenata nevadensis (n) 1
  - Marmota flaviventer flaviventer (n) 1
  - Citellus beldingi oregonus (n) 1
  - Microtus montanus montanus (n) 1
  - Larus californicus (u) 1
  - Fulica americana americana (n) 1
  - Icterus bullockii (n) 1
  - Pituophis catenifer heermanni (n) 1
- Nest 4
  - Marmota flaviventer flaviventer (u) 1
  - Citellus beldingi oregonus (n) 1
  - Dipodomys heermanni californicus (n) 1
  - Pituophis catenifer heermanni (n) 1
- Nest 5
  - Lepus californicus wallawalla (n) 1
  - Sylvilagus nuttallii nuttallii (n) 1

#### Nest 6

- Citellus beldingi oregonus (n) 1, (u) 1
  - Lepus californicus wallawalla (n) 1
  - Sylvilagus nuttallii nuttallii (n) 1, (u) 2
- #### Nest 7
- Marmota flaviventer flaviventer (n) 1
  - Domestic fowl (n) 2, (u) 3
  - Phasianus torquatus (u) 7
- #### American Rough-leg (*Buteo lagopus s. johannis*):
- Microtus montanus montanus (c) 1
  - Lepus californicus wallawalla (c) 1, (e) 1 (carrion)
  - Phasianus torquatus (e) 1
- #### Ferruginous Rough-leg (*Buteo regalis*):
- Microtus montanus montanus (c) 5
  - Lepus californicus wallawalla (e) 1
- #### Bald Eagle (*Haliaeetus leucocephalus*):
- Colymbus nigricollis californicus (u) 1
  - Larus californicus (u)
  - Dafila acuta tzitzihua (u) 2
  - Fish (apparently Catostomidae or Cyprinidae) (e) 2
- #### Marsh Hawk (*Circus hudsonius*):
- Microtus montanus montanus (e and c) 7
  - Lepus californicus wallawalla (carrion) (e) 2

Lophortyx californica vallicola (stomach) 1	Otocoris alpestris merrilli (u) 1
Zonotrichia leucophrys ssp. (c) 1	Sialia currucoides (u) 2
Prairie Falcon ( <i>Falco mexicanus</i> ):	Sturnella neglecta (u) 1
Nest 1	Euphagus cyanocephalus (u) 2
Citellus beecheyi douglasii (u) 1	Nest 5
Citellus beldingi oregonus (u) 1	Marmota flaviventer flaviventer (u) 1
Anas platyrhynchos platyrhynchos (u) 1	Phasianus torquatus (u) 1
Aphelocoma californica immanis (u) 1	Anthus spinoletta rubescens (u) 2
Salpinctes obsoletus obsoletus (u) 1	Duck Hawk ( <i>Falco peregrinus anatum</i> ):
Sialia currucoides (u) 2	Anas platyrhynchos platyrhynchos (u) 1
Vireo sp. (u) 1	Phasianus torquatus (u) 1
Sturnella neglecta (u) 2	Larus californicus (u) 1
Pipilo maculatus ssp. (u) 1	Zenaidura macroura marginella (u) 1
Nest 2	Colaptes cafer collaris (u) 1
Otocoris alpestris merrilli (u) 5	Salpinctes obsoletus obsoletus (u) 2
Sturnella neglecta (u) 2	Sialia currucoides (u) 20 (approximately)
Carpodacus sp. (u) 1	Sturnella neglecta (u) 2
Nest 3	Agelaius phoeniceus ssp. (u) 2
Citellus beldingi oregonus (u) 7	Xanthocephalus xanthocephalus (u) 1
Oxyechus vociferus vociferus (u) 1	Euphagus cyanocephalus (u) 8
Nest 4	Bombycilla cedrorum (u) 1
Microtus montanus montanus (c) 1	Carpodacus mexicanus frontalis (u) 1
Dafila acuta tzitzioha (u) 2	Sparrow Hawk ( <i>Falco sparverius sparverius</i> ):
Fulica americana americana (u) 2	Microtus montanus montanus (c) 2, (e) 3
Mareca americana (u) 1	Sceloporus sp. (e) 1
Colaptes cafer collaris (u) 1	Grasshoppers (c) many

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A few comments on the above are in order. It will be noted that only one pair of Red-tails (nest 7) indulged in chickens and pheasants. Their nest was a few hundred feet from an inhabited dwelling, and was also close to the town of Tulelake where chickens are not rare. It seems possible that this pair of birds was so familiar with man and his works that they fearlessly turned to the slow and defenseless fowl in preference to perfectly available normal prey. Perhaps having learned to master the Rhode Island Red, they applied the same technique to the abundant pheasants, for which their neighbors have never acquired a taste.

Prairie Falcon nests 2 and 3 were on the same cliff, within about a quarter-mile of each other, facing in the same direction over identical terrain, yet the food habits of the two pairs were different, one pair going in for birds and the other mainly for squirrels. The Baldpate shown for Nest 4 was brought in during the duck epidemic and may have been a sick bird.

Marsh Hawks and Rough-legs were seen many times to make captures of small dark-colored prey in *Microtus*-infested territory, but it was rarely possible to identify the prey with certainty, even with glasses.

#### FOOD HABITS OF OWLS

Data about the owls are much more extensive than for the hawks. On August 12, 1937, I collected a gunny-sack full of owl pellet material under the east and west Petroglyph Cliffs. One hundred whole pellets taken at random were weighed, and the collection was computed to have comprised a total of 1382 pellets. Most of the mammals were iden-

tified and counted by means of the lower jaws only, though a goodly number of the skulls were saved as checks. Lower jaws of *Peromyscus crinitus* and *P. maniculatus gambelii* are not certainly distinguishable in most cases, so the skulls that contained cheek teeth were separated, and the jaws assigned in proportion. Most of the birds were identified by means of skulls, though humeri and tarsometatarsi were also used; in three or four cases other parts of the skeleton had to be relied on. The following 3391 items were identified:

	Number	Per cent of total items
<b>Mammals:</b>		
<i>Sorex vagrans amoenus</i> . . . . .	1	.03
<i>Sorex merriami</i> (2nd and 3rd from California) . . . . .	2	.06
<i>Mustela frenata nevadensis</i> . . . . .	1	.03
<i>Perognathus parvus mollipilosus</i> . . . . .	38	1.12
<i>Dipodomys heermanni californicus</i> . . . . .	25	.74
<i>Reithrodontomys megalotis</i> ssp. . . . .	22	1.62
<i>Peromyscus crinitus</i> ssp. . . . .	17	.50
<i>Peromyscus maniculatus gambelii</i> . . . . .	330	9.83
<i>Neotoma cinerea</i> ssp. . . . .	3	.09
<i>Microtus montanus montanus</i> . . . . .	2796	82.45
<i>Lagurus curtatus</i> ssp. (probably <i>L. c. artemisiae</i> , and if so the 2nd from California) . . . . .	1	.03
<i>Mus musculus</i> ssp. . . . .	26	.77
<i>Lepus californicus wallawalla</i> (young) . . . . .	3	.09
<i>Sylvilagus nuttallii nuttallii</i> (young) . . . . .	3	.09
Totals . . . . .	3301	97.34
<b>Birds:</b>		
<i>Podilymbus podiceps podiceps</i> . . . . .	1	.03
<i>Erismatura jamaicensis rubida</i> . . . . .	1	.03
<i>Phasianus torquatus</i> ssp. . . . .	3	.09
<i>Rallus limicola limicola</i> (first record for Tule Lake basin) . . . . .	1	.03
<i>Porzana carolina</i> . . . . .	1	.03
<i>Fulica americana americana</i> . . . . .	6	.18
<i>Oxyechus vociferus vociferus</i> . . . . .	1	.03
<i>Tyto alba pratincola</i> (young) . . . . .	1	.03
<i>Otocoris alpestris merrilli</i> . . . . .	9	.27
<i>Petrochelidon albifrons albifrons</i> . . . . .	1	.03
<i>Telmatodytes palustris plesius</i> . . . . .	6	.18
<i>Sialia currucoides</i> . . . . .	6	.18
<i>Passer domesticus domesticus</i> . . . . .	1	.03
Icterid ( <i>Xanthocephalus xanthocephalus</i> ?) . . . . .	1	.03
Icterid ( <i>Agelaius phoeniceus</i> ssp.?) . . . . .	1	.03
<i>Icterus bullockii</i> . . . . .	1	.03
<i>Euphagus cyanocephalus</i> . . . . .	12	.35
<i>Molothrus ater</i> ssp. . . . .	4	.12
<i>Passerculus sandwichensis</i> ssp. . . . .	2	.06
<i>Spizella breweri breweri</i> . . . . .	1	.03
<i>Spizella</i> sp. . . . .	2	.06
Totals . . . . .	62	1.83
<b>Reptiles:</b>		
<i>Pituophis catenifer heermannii</i> . . . . .	1	.03
<i>Sceloporus</i> sp. . . . .	2	.06
Totals . . . . .	3	.09
<b>Insects:</b>		
Grasshoppers . . . . .	20-30	
Total (for purposes of calculation) . . . . .	25	.74
Totals . . . . .	3391	100.00

The accompanying illustration (fig. 25) shows some of the jaws that were counted. All the *Microtus* jaws would not fit on the largest piece of black cardboard I could find, and the left-overs are piled on top of the others. Approximate average weights of most of the prey species are known, and from them it can be calculated that the owls had eaten about 300 pounds of rodents, including about 284 pounds of *Microtus*, and about 13½ pounds of birds.



Fig. 25. Jaws of some of the mammals from owl pellets collected August 12, 1937. The largest piece of black cardboard obtainable would not hold all 2796 jaws of *Microtus montanus*, and the excess is piled at the lower right. The large square, upper left, is jaws of 347 *Peromyscus*, and on it jaws of 26 *mus* and 3 *Neotoma*. Farther to right are *Reithrodontomys* (upper), *Dipodomys* (center), and *Perognathus* (lower). Still farther to the right are 3 jaws of young *Sylvilagus* and 3 of younger and smaller *Lepus*.

Picked up along with the pellets, and apparently dropped by the owls, were remains of: *Lasiurus cinereus* 1, *Dipodomys heermanni californicus* 1, *Lepus californicus wallawalla* 2, *Numenius americanus* 1. The bat and curlew came from under the same Horned Owl roost, though Barn Owls lived so near that they may have been the captors.

When the pellets were collected, only those were taken that seemed, on the basis of state of preservation, to have been cast later than the previous winter. The very large percentage of meadow mice found make it seem almost certain, however, that a large part of those gathered actually dated at least from the previous fall and early winter, when both owls and *Microtus* were abundant. In this case the pellets must have represented a part of the meals of about 4 to 12 Horned Owls (*Bubo virginianus occidentalis*) and 30 to 100 Barn Owls (*Tyto alba pratincola*).

On November 5, 1937, 382 pellets were collected. These were all fresh, dark-colored, and covered with a varnish-like coat of dried mucous, so that it seems certain that they were all deposited later than August 12, especially as all fresh material seen on that date had been taken. There were apparently about 4 Horned Owls and about 25 Barn Owls on the cliffs during this time, so that the pellets collected (since pellets are produced at the approximate rate of one per owl per day) account for only about one-sixth of the food eaten. The 994 items identified were:

	Number	Per cent of total items
<b>Mammals:</b>		
<i>Perognathus parvus mollipilosus</i> . . . . .	18	1.81
<i>Dipodomys heermanni californicus</i> . . . . .	3	.30
<i>Reithrodontomys megalotis</i> ssp. . . . .	27	2.72
<i>Peromyscus crinitus</i> ssp. . . . .	16	1.62
<i>Peromyscus maniculatus gambelii</i> . . . . .	201	20.22
<i>Microtus montanus montanus</i> . . . . .	676	68.01
<i>Mus musculus</i> ssp. . . . .	6	.60
<i>Lepus californicus wallawalla</i> (young) . . . . .	2	.20
<i>Sylvilagus nuttallii nuttallii</i> (adult) . . . . .	1	.10
Totals: . . . . .	950	95.57
<b>Birds:</b>		
<i>Podilymbus podiceps podiceps</i> . . . . .	1	.10
? <i>Dafla acuta tztzihoa</i> . . . . .	1	.10
? <i>Lophortyx californica vallicola</i> . . . . .	1	.10
<i>Fulica americana americana</i> . . . . .	1	.10
<i>Limnodromus griseus scolopaceus</i> . . . . .	1	.10
<i>Ereunetes mauri</i> . . . . .	2	.20
<i>Steganopus tricolor</i> . . . . .	1	.10
<i>Otocoris alpestris merrilli</i> . . . . .	3	.30
<i>Petrochelidon albifrons albifrons</i> . . . . .	1	.10
<i>Anthus spinoletta rubescens</i> . . . . .	1	.10
<i>Passer domesticus domesticus</i> . . . . .	1	.10
<i>Sturnella neglecta</i> . . . . .	1	.10
<i>Xanthocephalus xanthocephalus</i> . . . . .	3	.30
Icterid ( <i>Xanthocephalus</i> ?) . . . . .	1	.10
<i>Agelaius phoeniceus</i> ssp. . . . .	4	.40
<i>Euphagus cyanocephalus</i> . . . . .	2	.20
<i>Molothrus ater</i> ssp. . . . .	2	.20
<i>Passerculus sandwichensis</i> ssp. . . . .	16	1.62
Passerine (very young; Icterid?) . . . . .	1	.10
Totals: . . . . .	44	4.43
Combined totals: . . . . .	994	100.00

Under the roosts were found remains of *Neotoma cinerea* ssp. 1, *Lepus californicus wallawalla* 4, and *Sylvilagus nuttallii nuttallii* 1.

## EFFECT OF PREDATION BY HAWKS AND OWLS

Unfortunately, results of the predation by the raptorial birds are by no means so clear as would at first sight appear. The birds oftenest killed by hawks are apparently *Sialia currucoides*, 24 (out of 93 bird records in the food); *Phasianus torquatus*, 10; *Euphagus cyanocephalus*, 10; *Sturnella neglecta*, 7; and *Otocoris alpestris merrilli*, 6. Other species occur as less than 5 per cent of the food items. Birds occurring as more than 5 per cent of the 106 items from owl pellets are *Passerculus sandwichensis* ssp., 18; *Euphagus cyanocephalus*, 14; *Otocoris alpestris merrilli*, 12; *Fulica americana americana*, 7; *Telmatodytes palustris plesius*, *Sialia currucoides*, and *Molothrus ater* ssp., each 6. The Cowbird is not particularly common, and the abundance of the Marsh Wren is not known, but all the others vary from common (Coot, Meadowlark, Mountain Bluebird) to exceedingly abundant (Brewer Blackbird), and it is quite clear that none of the species is endangered, or probably appreciably reduced in numbers, by either the hawks or owls. Resident people reported seeing hawks kill many pheasants during the cold spell of January-February 1937; but later in the year the pheasants seemed about as abundant as ever, which is a strong statement, since the pheasant population in the Tule Lake basin appears to be denser than in many of the famous pheasant areas of Oregon and Washington.

The effect on the mammals, especially the meadow mice, may be considerable, or it may be very slight. In the fall of 1936, hunting over the 100 square miles of the old lake bed, there must have been not far from 1000 hawks and 1000 owls, and it seems likely that about 2000 meadow mice a day were killed by the birds. Assuming (as is not unreasonable from various observations) that a pair of adult *Microtus* produce 5 young every 45 days, or .11 young per day, we should need a breeding population of only 36,364 adult mice to supply the 2000 eaten daily by the hawks and owls. On the other hand, late fall seems to be a very low point in the breeding cycle of meadow mice, so that the assumed rate of reproduction is probably much too high. Perhaps 363,640 adults would be needed. Moreover, several non-raptorial birds, such as shrikes, gulls, herons, ravens, and predatory mammals from shrews to coyotes, are also at work, and perhaps eat as many mice as the raptors. Thus there would be required 727,280 adult *Microtus*, which amounts to a population of only about 12 mice per acre, including the young not yet eaten. There were actually many more than this on some acres, but I have no idea what the average for the whole basin was, nor what is the actual net reproductive rate of the mice, nor the actual age composition of the population, nor the amount of predation by other microtophagous creatures. Indeed, even the guesses for numbers of raptors present and number of mice eaten daily may easily be 50 per cent in error.

Such arithmetical juggling as the above shows, I think, quite clearly that it would be easy on the basis of quite reasonable assumptions, to "prove" that the raptorial birds were having no appreciable effect on the rodents, and equally easy, by varying the assumptions a little, to "prove" that the birds are saviours of the local agricultural populace. Far more important, it seems to me, such figuring shows how woefully little we know of prey-predator relationships in general, and what they mean to the predators and to the various categories of prey.

Until such knowledge is obtained, and probably afterward, I will continue to contemplate with much spiritual pleasure the continuing process of a large number of noble hawks and owls (to which I am greatly attached) busily consuming an even larger number of meadow mice (to which I am relatively indifferent), on and about the Lava Beds National Monument.

*Santa Barbara, California, January 15, 1939.*