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THE GREAT BASIN NATURALIST

DISPERSAL AND DISPERSION OF AN INTRODUCED POPULATION
OF *SYLVILAGUS FLORIDANUS*

B. J. Verts[1] and Leslie N. Carraway[1]

Abstract.— Eastern cottontail rabbits, *Sylvilagus floridanus*, introduced into Linn County, Oregon, in 1941, occupied 378.1 km^2 in 1953, 637.7 km^2 in 1970, and 1501.9 km^2 in 1980. Hiatuses within the range were related to absence of adequate coverts on conifer-dominated ridge tops and in intensively cultivated areas. Flooding of riparian zones seven times during the first 12 years after introduction and three times during the 17-year interval between the first and second surveys (especially the devastating floods of December 1964 and January 1965) was believed to have retarded dispersal or periodically reduced the area occupied. Flood-control dams constructed between 1941 and 1968 on drainage systems that affect the area limited floods to two winters since 1965 and were believed responsible for cottontails extending their range within the county nearly two and one-half fold since 1970. The absence of burrow-constructing associated species was believed relatively insignificant in retarding dispersal. Removal of brushy coverts, particularly by agricultural practices, tended to increase the size of unoccupied areas within the 1970 range of the species.

Eastern cottontail rabbits (*Sylvilagus floridanus*, indigenous to most of the United States east of the Rocky Mountains (Hall and Kelson 1959) were introduced into Linn County, Oregon, near the community of Oakville in May 1941 (Graf 1955). Graf (1955) documented the unsanctioned introduction, reported on a survey of cottontail distribution in Linn County in 1953, and speculated on avenues they used for dispersal. Although the late Professor Graf did not publish his range map in the original article, he gave the map to Verts, who, with a student, repeated the survey of distribution in 1970 and published both maps with suggestions for possible mechanisms of expansion and contraction of the cottontail range during the 17 intervening years (Verts et al. 1972). We wished to reexamine the dispersion of cottontails after 10 additional years and to evaluate the vegetation at all

sites at which cottontails were observed during earlier surveys to ascertain the effect of alterations on current distribution. Also, we wished to evaluate avenues for dispersal, or lack thereof, on distribution of cottontails.

Study Area

Linn County, Oregon, is roughly rectangular (59 x 114 km) and lies near the center of the Willamette Valley (44°12'–44°47'N, 121°48'–123°15'W). It is bounded by the Willamette River on the west, North Santiam River on the north, and the crest of the Cascade Range on the east; the southern border, although largely irregular, is artificial. Elevations range from about 60 m above mean sea level at the confluence of the Willamette and Santiam rivers to nearly 3200 m at the summit of Mt. Jefferson in the Cascade Range; eastward from the Willamette River, relief is

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negligible to the foothills of the Cascades (about 35 km) except for a few scattered buttes near the foothills.

The portion of Linn County in the Willamette Valley is largely agricultural, with production of grass seed (mostly rye grasses, *Lolium perenne* and *L. multiflorum*), wheat, and vegetable crops predominant. Oregon white oak (*Quercus garryana*), Oregon ash (*Fraxinus latifolia*), Douglas fir (*Pseudotsuga menziesii*), and black cottonwood (*Populus trichocarpa*) are typical trees of the riparian zone along major streams. Brambles, particularly blackberries (*Rubus discolor* and *R. laciniatus*), are common along small streams, edges of woodlots, railroad rights-of-way, fencerows, and field borders. Scattered buttes and low foothills are vegetated mostly by deciduous trees, especially oaks, but ridge tops and the west slope of the Cascade Range are covered mostly by subclimax Douglas fir (Johannessen et al. 1970, Franklin and Dyrness 1969).

The climate of the Willamette Valley is moderate; at Corvallis (at the west edge of the study area) January temperatures average 3.8 C, whereas July temperatures average 18.8 C. Precipitation averages 100.8 cm annually, with 82 percent falling between November and May (U.S. Department of Commerce 1978). Temperatures decline and precipitation increases (and the proportion falling as snow increases) with increasing elevation in the Cascade Range.

METHODS

Initially, to establish the current range of cottontails, we traversed all roads in western Linn County surveyed by Graf (1955) or Verts et al. (1972). We made 14 automobile trips from 1 to 18 July 1980 totaling 1390.5 km between 1900 and 2200 h Pacific Daylight Time (PDT). Roads traversed and cottontails observed during each trip were recorded on separate county road maps.

To determine the location and extent of vegetative changes affecting current dispersion of cottontails, we classified all sites at which cottontails were observed during 1953 and 1970 surveys as occupiable or unoccupiable coverts on the basis of the physiognomy of vegetative communities where

we saw cottontails in 1980. Because established populations of cottontails in Oregon seem to require an interspersion of grassy and brushy vegetation, similar to that described for the species in its native range (Schwartz and Schwartz 1959, Atzenhofer and Leedy 1947), we defined an unoccupiable site as one without brushy vegetation within 200 m. This analysis required six trips (20–27 July 1980 between 0430 h and 0745 h PDT) totaling 621.1 km; we recorded roads traversed and cottontails observed as before.

On the basis of the physiognomy of vegetative communities at sites occupied by cottontails, we extended our survey to similar roadside communities from the eastern limit of the 1970 cottontail range to the foothills of the Cascades. From 28 July to 3 August 1980, we made seven trips totaling 1035.6 km between 0445 and 0815 h PDT. We limited our survey at the foothills because we saw no cottontails in coniferous forests and such areas did not support the requisite grassy and brushy vegetation.

We considered the range occupied by cottontails as that area east of the Willamette River that extended 0.8 km beyond the furthermost points at which cottontails were seen, the same criterion used by Verts et al. (1972). Areas of ranges were estimated by use of a compensating polar planimeter.

RESULTS

In 1980, 96 eastern cottontail rabbits were seen in an area of about 1501.9 km²; thus, the range of the cottontail in Linn County increased nearly two and one-half fold from the estimated 637.7 km² in 1970, which, in turn, was about 40.7 percent larger than the 378.1 km² estimated for 1953 (Fig. 1). However, cottontails were not observed in all areas searched; relatively large areas in the vicinity of Scio, Sweet Home, and Harrisburg seemingly did not contain rabbits (Fig. 1). Also, within the region seemingly invaded within the last decade, distribution was not uniform, and, within the 1970 range, unoccupied areas that were occupied formerly (Verts et al. 1972) continued to increase in size. Nevertheless, approximately three times as many cottontails were observed per 100 km traveled within the 1970 range as in the area

searched in 1970 but in which no cottontails were seen (Table 1).

We judged that only 61 of 111 sites at which cottontails were observed in 1953 by Graf (Verts et al. 1972) supported coverts occupiable by cottontails, whereas 40 of 48 sites at which cottontails were seen in 1970 were judged to continue to support occupiable vegetative communities (Fig. 2). Current differences in numbers of occupiable

Table 1. Distances traveled, cottontails seen, and cottontails seen per 100 km traveled within and outside the 1970 cottontail range in Linn County, Oregon, 1 July–3 August 1980.

Area	Distance traveled		Cottontails seen		Cottontails/100 km	
	Morning	Evening	Morning	Evening	Morning	Evening
Within 1970 range	460.9	820.9	41	18	8.9	2.2
Outside 1970 range	1195.8	569.6	33	4	2.8	0.7

Fig. 1. Distribution of 96 eastern cottontail rabbits observed during roadside surveys conducted 1 July–3 August 1980 and ranges of cottontails in western Linn County, Oregon, in 1953, 1970, and 1980. Roads within stippled areas were searched but no cottontails were observed. Inset depicts location of study area in Oregon. Ranges of cottontails in 1953 and 1970 after Verts et al. (1972).

and unoccupiable sites between the two ear-
lier surveys were significantly different ($X^2 =$
11.624, df $= 1, P < 0.01$).

Most cottontails observed in the area seem-
ingly invaded since 1970 occurred in close
proximity to water courses (Fig. 3); large
hiatuses in the newly occupied range oc-
curred primarily in areas without drainage by
permanent streams.

DISCUSSION

Changes in the Range

In the 12 years between introduction and
the first survey in 1953, cottontails extended
their range about 25 km southward but only
about 6 km eastward (Graf 1955). The conti-
nuity of suitable coverts along north-south
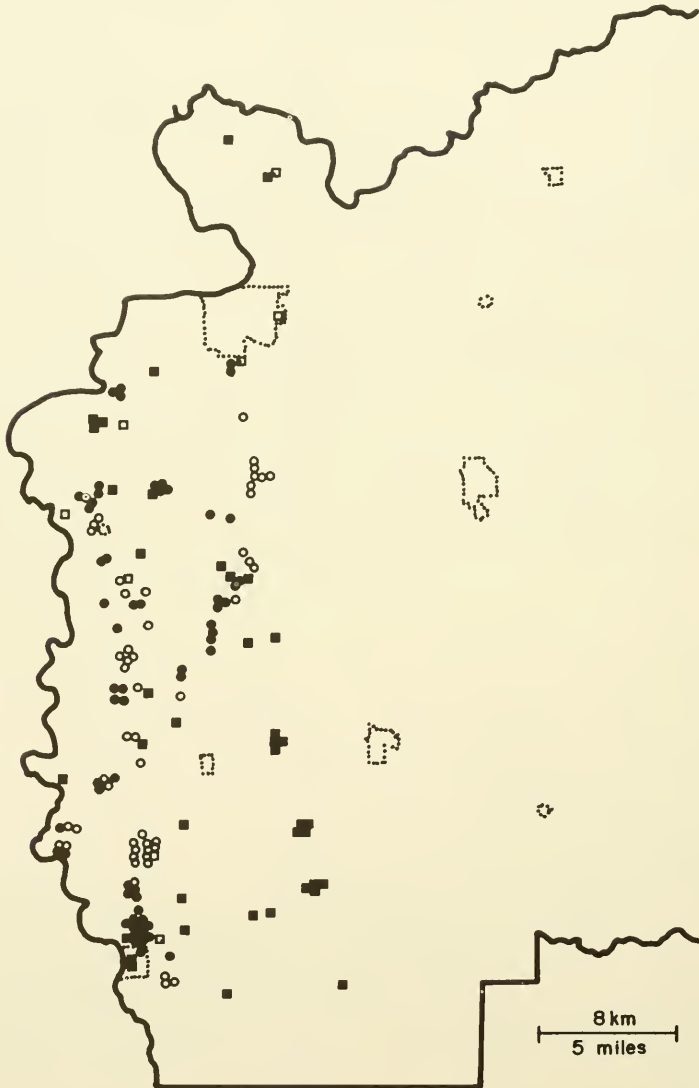
Fig. 2. Sites at which eastern cottontail rabbits were observed in western Linn County, Oregon, in 1953 (circles)
and 1970 (squares) (after Verts et al. 1972). Open symbols indicate sites at which no brushy vegetation occurred
within 200 m in 1980, thus were judged to be unoccupiable by cottontails.

railroad rights-of-way and the paucity of similar continuous suitable cover eastward from the point of release were offered as possible explanations for directional differences in range expansion (Graf 1955). Destruction of coverts as a result of agricultural practices and winter flooding of riparian zones were offered as explanations for cottontails failing to extend their range to areas beyond the limits of the 1970 range during the 17 years between the first and second surveys (Verts et al. 1972). Because the rate of occupation of new range during the first 29 years after introduction was comparatively modest, the

relatively rapid two and one-half fold expansion in range during the last decade requires explanation.

We cannot discount entirely the possibility that cottontails actually occupied much larger ranges in 1953 and 1970 than described (Verts et al. 1972), and that the rapid increase in range expansion in the last decade was an artifact of survey methods used earlier. However, the three-fold greater numbers of cottontails seen during the 1980 survey in the area occupied by cottontails before 1970 than in the area seemingly invaded during the last decade (Table 1) and the large
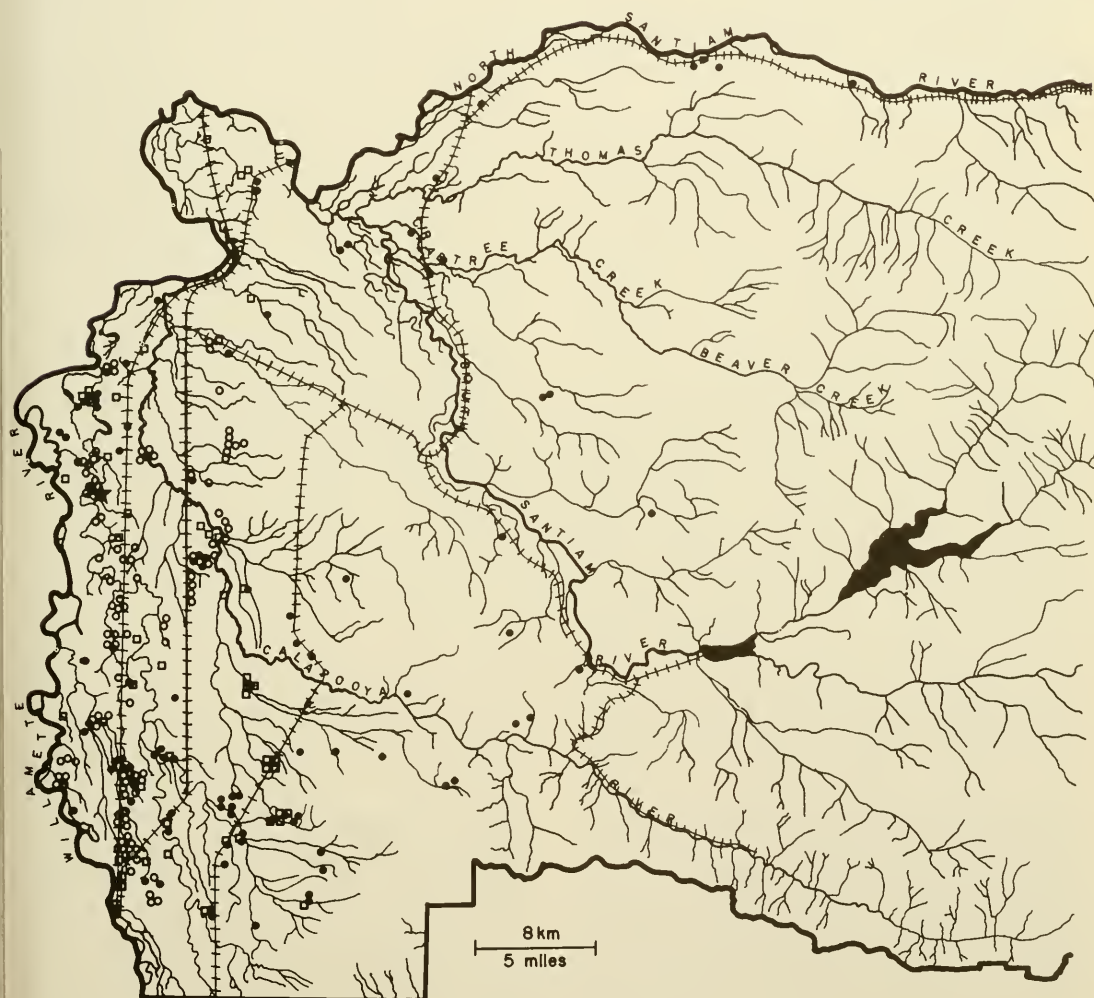

Fig. 3. Distribution of eastern cottontail rabbits observed during roadside surveys conducted in western Linn County, Oregon, in 1953 (open circles), 1970 (open squares), and 1980 (solid circles) in relation to water courses and railroad rights-of-way. Data for 1953 and 1970 from Verts et al. (1972).

hiatuses in distribution within the range occupied since 1970 (Fig. 1) indicate that invasion east of the 1970 range was likely of relatively recent occurrence.

The proximity of sightings of cottontails to streams in areas recently occupied (Fig. 3) indicates that coverts in riparian zones likely were important avenues for cottontail dispersal. Also, in newly invaded range, the relative infrequency that cottontails were seen in areas remote from permanent streams suggests that upland coverts were occupied more slowly than riparian zones. Therefore, we suspect that winter flooding of riparian areas had a significant deleterious impact on cottontail dispersal, and that the frequency and magnitude of floods was responsible for differences in observed rates that new range was invaded.

Since introduction of cottontails, winter flooding was reduced significantly by 10 flood-control dams constructed between 1941 and 1968 (International Commission on Large Dams 1973) on streams or tributaries to streams that drain the study area (Fig. 4). In the 12-year interval between introduction of cottontails and the first survey of distribution in 1953, flooding of riparian zones occurred seven times, possibly explaining the relatively limited dispersal of cottontails during that period (Graf 1955). Although riparian zones were flooded only three times during the 17-year period between the first and second surveys, the floods of December 1964 and January 1965 were of such magnitude that populations not occupying coverts remote from streams likely were eliminated or severely reduced in numbers. Thus, the 1970 survey (Verts et al. 1972) possibly was conducted after a major reduction in the cottontail range and before cottontails redispersed from coverts unaffected by the 1964–65 floods. Since 1970, however, flooding of riparian zones occurred only twice; no flooding occurred since January 1974 (Fig. 4). Although dispersal of cottontails likely was retarded and the range possibly reduced by floods during the early part of the decade between the second and third surveys, we believe that the 6 years since the last flood were adequate for cottontails to extend their range two and one-half fold (Fig. 1). High ground, not subject to flooding, and the

nearly continuous suitable cover provided along the railroad right-of-way adjacent to the North Santiam River (Fig. 3) may explain the extent of cottontail dispersal along the north boundary of our study area (Fig. 1).

Unoccupied Areas within the Range

Treatment of cottontail dispersion on the study area must include explanation of several relatively large areas seemingly unoccupied in 1980 that were occupied during earlier surveys (Fig. 1). The increase in size of the unoccupied area south of Albany since 1970 (Fig. 1) and the appearance of unoccupied areas south of Oakville and north of Harrisburg (Fig. 1) likely were related to loss of brushy coverts (Fig. 2). We found one or more coverts occupied by cottontails in 1953 or 1970 replaced by industrial complexes, warehouses, or condominiums. However, modification of most sites judged no longer occupiable by cottontails (Fig. 2) was related to agricultural practices, particularly removal of brushy fencerows.

Within the newly occupied range, cottontails were not found on ridge tops or in agricultural areas between major stream systems. We suspect that coniferous forests that exclude understories of brushy and grassy species make many ridge tops unsuitable for occupancy by cottontails. Disjunct brushy coverts in agricultural areas, although sufficiently large and of adequate quality to support cottontails, may not be occupied because intervening crops do not serve as suitable cover at seasons that juveniles disperse. These coverts may become occupied by cottontails in the future.

Also, a large area in the vicinity of Scio, searched, but seemingly not occupied by cottontails (Fig. 1), may be invaded in the future. We are unable to offer a plausible explanation for the absence of cottontails in the area, because Thomas Creek and Crabtree Creek (Fig. 3) should provide avenues for dispersal, and brushy fencerows interconnecting with riparian zones to support cottontails were relatively abundant. A small unoccupied area near Sweet Home (Fig. 1) seemed to support vegetative communities adequate for cottontails, but coverts suitable for cottontails were absent in much of the
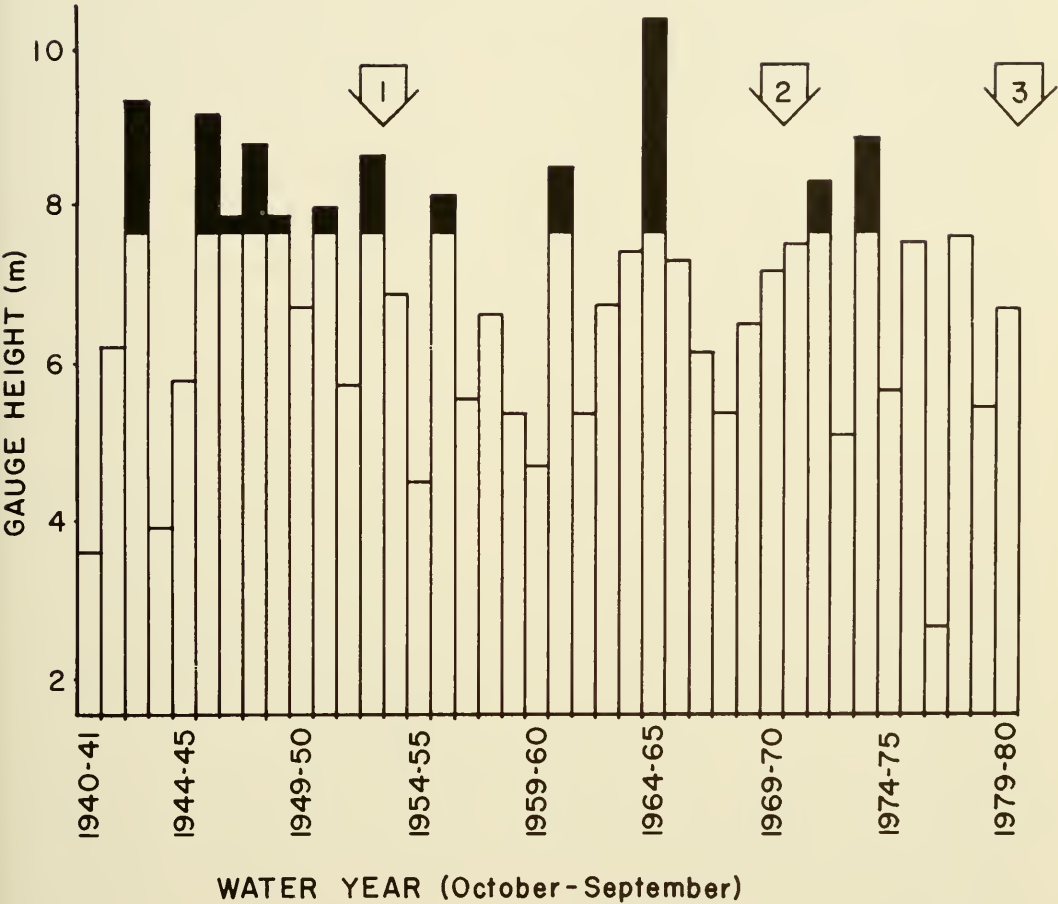
Fig. 4. Maximum gauge height for the Willamette River at Albany, Oregon, each water year, 1940–41 to 1979–80. Datum of gauge is 52.48 m above mean sea level. Solid portions of bars indicate height above flood stage (7.62 m) established by the U.S. Weather Bureau. Arrows indicate years that the three surveys of cottontail distribution were conducted. Hydrologic data are from Hulsing and Kallio (1964), U.S. Department of the Interior (1958–1978), and L. Hubbard, U.S. Geological Survey (pers. comm.).

unoccupied area south of Harrisburg, except for the narrow riparian zone along the Willamette River (Fig. 1).

Comparative Rates of Dispersal

The rate of dispersal of cottontails on our Linn County study area was infinitesimally slow in comparison with the more than 113 km per year that introduced European

rabbits (*Oryctolagus cuniculus*) averaged in New South Wales, Australia (Keast 1966). The disparity was especially great in view of differences in productivity reported for introduced populations of the two species; female European rabbits in Australia produced about 26 young in four or five litters during the annual breeding season (Myers and Poole 1962), whereas female cottontails in Oregon produced about 39 young in eight litters

(Trethewey and Verts 1971). Also, juvenile female cottontails older than 3.5 months commonly bred and some produced at least two litters during the breeding season in which they were born (Trethewey and Verts 1971), but confined populations of European rabbits were not reported to produce offspring in the season of their birth (Myers and Poole 1962), and, among wild populations, 95 percent of the productivity was by females more than six months old (Dunsmore 1971). In addition to having lower natality than cottontails, dispersing European rabbits in Australia were subjected to intensive control measures (Troughton 1943), whereas cottontails in Oregon have not become pests (Verts and Carraway 1980) and hunting of introduced cottontails has not become a popular sport (M. Henjum, pers. comm.).

Myers and Parker (1965) suggested that unoccupied burrow systems of the boodie (*Bettongia lesueuri*) preconditioned the habitat for warren-dwelling European rabbits and contributed to their rapid dispersal. Grizzell (1955), Linduska (1947), Hamilton (1934) and others documented the use of woodchuck (*Marmota monax*) burrows by cottontails and believed that burrows were important to survival of cottontails in the northern portion of their native range. The absence of a burrow-constructing ecological equivalent to *Bettongia* or *Marmota* west of the Cascade Range in Oregon possibly contributed to the slow rate of cottontail dispersal. However, use of burrows by cottontails in their native range usually was limited to inclement weather (Linduska 1947) more severe than occurs commonly in the Willamette Valley, Oregon.

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THE 1900 INVASION OF ALIEN PLANTS INTO SOUTHERN IDAHO

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Abstract.— The European annual plants *Salsola iberica, Sisymbrium altissimum, Descurainia sophia,* and *Bromus tectorum* invaded southern Idaho about 1900 and spread very rapidly into native plant communities damaged or eliminated by burning, abusive grazing, and agricultural clearing. Historic photographs reveal that the sites of initial invasion were waterway margins, railroad rights-of-way, road shoulders, city streets, agricultural areas, and construction sites. By 1915, these plants were widespread and abundant. Burning and grazing fostered their spread and dominance on millions of acres in southern Idaho.

Several European annual plants invaded southern Idaho during the few years preceding and following the turn of the century. The spread of these alien plants, especially cheatgrass, was so rapid that it often escaped recording (Leopold 1941). Four important plants—*Salsola iberica* Sennen and Pau, *Sisymbrium altissimum* L., *Descurainia sophia* (L.) Webb., and *Bromus tectorum* L.— changed the ecology and the very appearance of southern Idaho. This paper presents some new information on documenting the invasion of these plants into southern Idaho, and the means by which they came to dominate millions of acres of desert rangeland.

Presettlement Vegetation

The presettlement vegetation of southern Idaho consisted largely of open-canopied communities of low-growing shrubs, especially big sagebrush (*Artemisia tridentata*), as well as winterfat (*Ceratoides lanata*), bitterbrush (*Purshia tridentata*), rabbit brushes (*Chrysothamnus* sp.), and shadscale (*Atriplex confertifolia*) and other salt-desert shrubs. Most of the Snake River Plain was dominated by communities of big sagebrush with a rich understory of perennial bunch grasses (*Stipa, Elymus, Agropyron, Oryzopsis, Poa,* and *Festuca*) and herbs (*Balsamorhiza, Hydrophyllum, Tragopogon,* and *Agoseris*), or by winterfat or other salt-desert communities (Townsend 1839, Fremont 1845, Irving 1907, Elliot 1913, Ferrin 1935, Keith 1938, Stover 1940, Vahlberry 1940, Platt and Jackman 1946, Blaisdell 1953, Root 1955, Shirk 1956, Fulton 1965, Ellison 1960, Vale 1975, Gibbs 1976, Hironaka and Fosberg 1979, Meacham 1979, Young et al. 1979). The perennial grasses and several of the shrubs, notably winterfat, saltbushes, and bitterbrush, are highly palatable and nutritious to grazing animals (Kennedy 1903, Hodgeson 1948, Hutchings and Stewart 1953, Ellison 1960).

Originally, if sagebrush grasslands were burned, trampled, or otherwise severely disturbed and left wholly or partially bare of vegetation, snakeweed (*Gutierrezia sarothrae*) would appear on the disturbed areas within a year or two (Stewart and Hull 1949). Establishment of snakeweed was followed by the appearance of the short-lived perennial grasses bottlebrush squirreltail (*Sitanion hystrix*) and Sandberg's bluegrass (*Poa sandbergii*), along with big sagebrush seedlings. Finally, the large-culmed perennial grasses and the perennial broadleaved herbs would appear (Ellison 1960, Young et al. 1972). Revegetation occupied about a decade, and only occurred if the area was not significantly disturbed. In southern Idaho at the turn of the century, however, continual disturbance by fire, abusive grazing, agricultural practices, and construction (railroads, roads, towns, canals) created an environment in which presettlement patterns of secondary succession could not persist unchanged (Kennedy 1903, Piemeisel 1938, 1951). The stage was set for the invasion of alien plants (Young et al. 1979).

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CONDITIONS LEADING TO THE INVASION
OF EXOTIC PLANTS

By 1900, native plant communities had been severely damaged by overgrazing (Hodgeson 1948, Piemeisel 1938). Pickford (1932) wrote that in the 30 years after 1880, burning and abusive grazing had resulted in an 85 percent reduction in native perennial grasses and a 40 to 50 percent reduction in the carrying capacity of the range. By this time, stands of native perennial grasses had been virtually eliminated from southern Idaho desert lands (Hodgeson 1948). Burning also caused serious and widespread damage to the vegetation. Many stockmen, erroneously believing that burning the shrublands produced good stands of grasses even when grazing pressure following burning was not reduced, deliberately set range fires (Griffiths 1902, Pechanec and Hull 1945, Vale 1975). Griffiths (1902), who traveled southwestern Oregon ranges in 1901, reported that such range fires were very common, and that many of the fires were set by sheepmen. The fact that sheepmen used to set many range fires is common southern Idaho lore (Hicks pers. comm., C. L. Stewart pers. comm.).

From 1900 until the end of World War I, large numbers of prospective farmers settled in southern Idaho (Rinehart 1932, Gibbs 1976). In the words of Hultz (1934), the country was "wheat mad." Railroads offered cheap one-way home seeker fares, and many settlers took advantage of them (Stewart and Hull 1949, Gibbs 1976). Large acreages of sagebrush lands were settled and cleared for planting row crops and orchards. However, during the 1920s, an agricultural depression began in Idaho. Many farmers went bankrupt and abandoned their homestead claims (Stewart and Hull 1949, Gibbs 1976). Thousands of acres of plowed farmland, many acres of which had been dry-farm wheatfields, were left unattended (Warg 1938, Piemeisel 1938, Stewart and Hull 1949, Young et al. 1979).

Several decades of burning, trampling, overstocking, and abusive grazing not only severely damaged the perennial grass and herb understory of the big sagebrush lands, but also greatly reduced the acreage dominated by the most valuable forage shrub, winterfat. By 1900 many hundreds of thousands of acres of big sagebrush remained, virtually bare of understory (Sweetser 1935, Chapline 1936, Stewart 1936, Taylor 1940, Hodgeson 1948, Reidl et al. 1964, Young et al. 1979). Erosion of the soil became a critical problem, both on the open range and on abandoned cropland (Clapp 1936, USDI-BLM 1974). And, with no easing of grazing pressure, rehabilitation of the weakened native plant communities was not possible (Young et al. 1979).

HISTORY AND ECOLOGY OF INVASION

RUSSIAN THISTLE.— Russian thistle, *Salsola iberica* Sennen and Pau (Beatley 1973), was probably the first important invading plant (Hutchings and Stewart 1953). This spiny and compact annual herb is a native of the desert-steppe region of Russia. Russian thistle germinates in late spring or early summer, grows during the summer, and dies in the fall. The aboveground part of the plant then breaks off and is tumbled along the ground by the wind, scattering seeds (Piemeisel 1938). These ball-shaped dead plants are the "tumbleweeds" of western cowboy lore. Russian thistle was commonly called "tumbleweed" in southern Idaho, but was not present during the heyday of the cowboy (Piemeisel 1938, Hicks pers. comm.). Russian thistle does not tolerate crowding of stands, and will not continue to grow on an area unless the area is continually disturbed. Therefore, the presence of Russian thistle indicates lands which have been severely or continually disturbed within the past one to three years (Piemeisel 1938).

Russian thistle invaded the western United States just before 1900 (Hutchings and Stewart 1953). In Idaho, the seeds of Russian thistle were probably distributed via the Snake River and were further disseminated by irrigation canals and field ditches, the bare margins of the newly constructed waterways being excellent sites for colonization (Dewey 1896). Also, seeds of Russian thistle may have been distributed in alfalfa and other crop seeds (Piemeisel 1938).

Because of its large size and distinctive appearance, Russian thistle is easily identified in photographs. Photographs on file in the collection of the Idaho Historical Society

(Boise, Idaho), document the early establishment of Russian thistle in southern Idaho. Figure 1 is an example. The earliest photographs of Russian thistle in Idaho are IHS 64044.3, showing the plants growing on a railroad embankment in southeastern Idaho in 1890; IHS 73-230.23, an 1897 photograph showing plants growing in Nampa at the foot of a speaking platform on which William Jennings Bryan was standing; and IHS 74-194.4a, taken in Roswell in 1898, showing Russian thistle growing near a newly constructed farmhouse. Other Idaho Historical Society photographs reveal that Russian thistle first became established on railroad rights-of-way; on the edges of (dirt) city streets and in vacant city lots; at construction sites of buildings, bridges, and roads; in agricultural waste places and on field margins; and near waterways. At least 50 early photographs taken in southern Idaho show that Russian thistle was well established and widely distributed in southern Idaho by 1905, and was abundant by 1915. The fact that Russian thistle rapidly invaded severely disturbed big

sagebrush lands is illustrated by IHS photograph 73-221.810, taken in 1909 near Twin Falls, which shows a newly constructed church surrounded by a big sagebrush community with only a small cleared space in front of the building. The cleared area supports hundreds of Russian thistle plants, and the photograph is labeled "Three months from sagebrush."

In addition to mechanical disturbance (construction, grazing), fire also helped to establish Russian thistle in southern Idaho. Following burning, Russian thistle became the first plant to colonize newly burned lands, rapidly invading burned big sagebrush-perennial grass areas before snakeweed or other native plants could gain a foothold (Piemeisel 1938, Stewart and Hull 1949).

Russian thistle, though inferior in palatability and nutritional value to native grasses, can be used as forage by livestock. When it first appeared in abundance on the southern Idaho range, it was hailed by stockmen as a valuable new forage plant (Leopold 1941). Russian thistle can only be used by

Fig. 1. *Salsola iberica* and *Sisymbrium altissimum* (foreground). "Green's ranch," 24 August 1909, near Nampa, Canyon County, Idaho. Photograph courtesy of the Idaho Historical Society.

livestock, however, in the summer, before it dries into a spiny skeleton (Murray and Klemmedson 1968).

MUSTARDS.— Several European members of the mustard family also invaded disturbed southern Idaho lands. The most important of these were tansymustard (*Descurainia sophia* (L.) Webb.) (Detling 1939) and tumblemustard (*Sisymbrium altissimum* L.). These annual mustards bloom from early spring to early summer, after which they dry and die. Like Russian thistle, they have short taproots and do not protect the soil from erosion (Hull and Pechanec 1947). Tumblemustard may also break off and scatter seeds in the fall. Tumblemustard was also called "tumbleweed" in southern Idaho, but not as commonly as was Russian thistle (Hicks, pers. comm.). Mustards can tolerate more crowded conditions than Russian thistle and can persist in very dense stands for a few years, but not indefinitely. Peak demands by these plants on upper soil moisture occur before Russian thistle begins to grow. These characteristics enable the mustards to invade Russian thistle stands and replace the Russian thistle within one to three years, if not severely disturbed. However, if a mustard stand is heavily trampled or otherwise disturbed, Russian thistle will replace the mustards. Mustard stands become extremely crowded in a few years and cannot persist. If not disturbed, mustards will soon be invaded and replaced by other plants (usually cheatgrass) (Piemeisel 1951, Hironaka and Tisdale 1963).

The mustards, less distinctive in habit than Russian thistle, are much more difficult to identify with certainty in photographs. The first evidence of tumblemustard growing in Idaho is Idaho Historical Society photograph IHS 73-230.23, showing tumblemustard (with Russian thistle) in Nampa in 1897. Four 1906 Idaho Historical Society photographs show tumblemustard present along man-made waterways near Jerome and Twin Falls (IHS 73-221.781c, IHS 60-176.103, IHS 60-176.104, IHS 60-176.106). Tumblemustard also appeared between 1900 and 1917 along railroad tracks, on roadsides, at construction sites, and in agricultural areas (Fig. 1). Tansymustard is even more difficult to recognize in photographs; it probably became established at about the same times and in the

same places as did tumblemustard. The first reliable photograph evidence of tansymustard in southern Idaho is IHS photograph 68-05.45, taken at Massacre Rocks State Park along the Snake River in 1916. The mustards were widespread in Idaho by 1915. Weaver (1917:110) wrote that at that time tumblemustard or "Jim Hill mustard," as it was then called, was "present to a degree almost unbelievable." He stated that it has been introduced into the Pacific Northwest along railroad rights-of-way. Piemeisel (1938) reported that seeds of pinnate tansymustard and tumblemustard were distributed in alfalfa seed. These mustards also invaded depleted rangeland. They are unpalatable to livestock, a fact that favored their establishment and spread (Kennedy and Doten 1901).

CHEATGRASS.— The most important exotic annual to invade Idaho was the Mediterranean winter annual grass *Bromus tectorum* L., which in the West has been called cheatgrass, cheatgrass brome, downy brome, downy chess, Junegrass, bronco grass, and Mormon oats. Cheatgrass now occurs in every state except Alabama, Georgia, South Carolina, and Florida. In the eastern states it is a roadside weed, but in the West it has invaded millions of acres of rangeland and cropland (Hull and Pechanec 1947, Stewart and Hull 1949, Klemmedson and Smith 1964).

Cheatgrass germinates during fall rains and maintains small, dormant leaves during the winter. In spring, it grows rapidly and begins to form seed heads in April. In May, the seeds mature, and the plants turn purplish as they dry in the early summer heat. In June and July the seeds mature and fall to the ground, and the plants die. The dry plants, by then straw colored, persist upright in place for months (Stewart and Hull 1949, Klemmedson and Smith 1964).

Stewart and Young (1949) noted that cheatgrass was collected in Pennsylvania in 1861, in Washington in 1893, in Utah in 1894, in Colorado in 1895, in Wyoming in 1900, and was present in nearly all of its current range by 1900, though it was not as abundant as it was later to become. Stewart and Young implied that the spread of cheatgrass was from east to west. However, there is a strong possibility that the first cheatgrass

to arrive in Idaho came from awns carried in the coats of sheep trailed from California through Nevada to southern Idaho.

Cheatgrass awns catch in the coats of livestock and may be carried for miles before dropping out (Piemeisel 1938). The first instances of cheatgrass invasion in Nevada were in areas where California sheep had grazed (Kennedy 1903). Since bands of California sheep were trailed through Nevada and into Idaho (Wentworth 1948, Hanley and Lucia 1973), it seems reasonable to assume that cheatgrass awns could have been carried into Idaho by these sheep. Piemeisel (1938) notes that, as with other exotic annuals, cheatgrass seeds were often present in alfalfa seeds, and cheatgrass was also distributed in that way. An Idaho Historical Society photograph (IHS 503-F), taken at the mouth of Kuna Cave in southern Ada County in 1898, shows a dense stand of cheatgrass growing under a sparse cover of big sagebrush. This is the earliest photographic evidence of cheatgrass occurrence in Idaho, and even at the time of the photograph it appears to have been well established. Klemmedson and Smith (1964) note that cheatgrass is included in Piper and Beattie's 1907 *Flora of the Palouse*, Howell's 1903 *Flora of Northwest America*, and Piper's 1906 *Flora of Washington*. Cheatgrass, however, is not mentioned in Weaver's (1917) *Flora of Southeastern Washington and Adjacent Idaho*.

O. R. Hicks (pers. comm.) remembered that, just prior to 1906, cheatgrass occurred in south central Idaho between the towns of Glenns Ferry and King Hill in what was called a "railroad line"—a line of cheatgrass invasion originating on the railroad right-of-way and extending about 300 yards into the native vegetation on either side of the railroad tracks. Hicks believed that cheatgrass was fed to the sheep in the stock cars and that seed heads fell from the cars to ground along the tracks.

In the first few years after 1900, cheatgrass gained a foothold on disturbed areas such as railroad rights-of-way, road shoulders, orchards, fallow fields, and especially in dryland alfalfa fields which were grazed after having been harvested (Stewart and Hull 1949). In photographs, cheatgrass is not distinctive in appearance at a distance and can

be positively identified only in uncommon instances. It is undoubtably present in many photographs where reliable identification is not possible. (Cheatgrass is a relatively small, fine-textured plant, and its delicate heads are stirred by a slight breeze, often blurring the photographic image.) Idaho Historical Society photographs in which cheatgrass can be positively identified show cheatgrass to have been present in southern Idaho by 1910 in areas along railroad rights-of-way, on roadsides, and in vacant, disturbed areas within towns. Severely damaged rangeland was also invaded about this time (Stewart and Hull 1949).

Cheatgrass has been called an aggressive invader of big sagebrush lands (Platt and Jackman 1946), but Piemeisel (1938), who did classic successional studies in southern Idaho beginning in the 1920s, concluded that invasions of big sagebrush lands by cheatgrass were largely limited to voids in native vegetation. Warg (1938) concluded that cheatgrass could not invade pristine native vegetation and that invasion by cheatgrass was an indication of disturbed range. Young et al. (1979) also felt that exotic annuals, including cheatgrass, did not invade stands of healthy native vegetation.

Many stockmen were enthusiastic about the appearance of the abundant new grass, and erroneously believed it to be superior to the native perennials it had replaced (Stablein 1940, Platt and Jackman 1946). Even though cheatgrass was a poor substitute for the native grasses, at the time of its rapid establishment and spread it was a blessing for the range because it did afford quantities of forage for livestock held on depleted ranges, and afforded some protection from soil erosion when much of the range was overgrazed and denuded of soil cover (Platt and Jackman 1946).

Cheatgrass burns. Because cheatgrass is the most inflammable of the range forage plants, range fires in southern Idaho became more frequent. Cheatgrass range is 500 times more likely to burn than any other rangeland type (Platt and Jackman 1946, Stewart and Hull 1949). Leopold (1941) wrote that it is in fact impossible to protect cheatgrass ranges from fire. Burning is very damaging to big sagebrush-grass communities (Pechanec et al.

1954, Vale 1974). The presence of cheatgrass in these communities can carry fires into areas that would normally not burn (Stewart and Hull 1949, Hull 1965, Pechanec et al. 1954).

Many early stockmen believed that fire did not damage cheatgrass stands (Stablein 1940, Pechanec and Hull 1945), since, once established on an area, cheatgrass will be present the year after it has been burned because cheatgrass seeds are not usually all destroyed by fire (Warg 1938, Leopold 1941). Many southern Idaho stockmen regularly set range fires, because the following year the burned areas were not camouflaged by shrubs or by the previous year's dried growth and so appeared greener (Hicks pers. comm.). Cheatgrass on the range increased very rapidly when fire was combined with overgrazing, which was often the case (Stewart and Young 1939, Leopold 1941, Ellison 1960, Hironaka and Fosberg 1979). Cheatgrass replaced much vegetation on burned areas and came to dominate millions of acres, aided by its own flammability (Stewart and Hull 1949, Klemmedson and Smith 1964, Hironaka and Fosberg 1979).

After cheatgrass became well established in southern Idaho, the pattern of secondary succession was changed. No longer was an initial disturbance necessarily followed by the eventual appearance of native shrubs and grasses. After the invasion of the exotic annuals, the secondary succession pattern became Russian thistle invasion initially, followed by mustard invasion, and finally by cheatgrass establishment. Russian thistle dominated for a year or two, mustards for two or three years, and then cheatgrass became the dominant species (Piemeisel 1951, Hironaka and Tisdale 1963). If undisturbed, cheatgrass stands were in turn invaded by bottlebrush squirreltail and subsequently by other native plants (Hironaka and Tisdale 1963). However, if cheatgrass were burned or grazed, it was able to maintain itself indefinitely (Piemeisel 1938, 1951). Overgrazing combined with burning helped to insure a continuous stand of cheatgrass and to prevent reestablishment of native plants (Piemeisel 1938, 1951, Leopold 1941, Stewart and Hull 1949).

In the years immediately following World War I, cheatgrass made its most rapid advances, colonizing millions of acres of abandoned farmland and disturbed range (Piemeisel 1938, Wentworth 1948, Stewart and Hull 1949). By the late 1920s cheatgrass was abundant in southern Idaho. An *Idaho Statesman* article dated 1 May 1928 reported that the desert bunchgrass had been replaced by grass that "grows in a day, ripens in a day, and blows away in a day." By 1932, the most important plant on Idaho desert ranges was cheatgrass (Rinehart 1932). By 1949, about 4,000,000 acres in Idaho were dominated by cheatgrass, and cheatgrass was an important component of the vegetation on 10,000,000 to 15,000,000 additional Idaho acres (Stewart and Hull 1949). This plant is now the most important forage plant in Idaho (Klemmedson and Smith 1964). The impact of cheatgrass is difficult to comprehend, for it has literally changed the appearance of southern Idaho (Young et al. 1979).

SUMMARY

At the turn of the century, the alien annual plants Russian thistle, tansymustard, tumblemustard, and cheatgrass invaded the native plant communities of southern Idaho after having first become established on canal banks, city streets, construction sites, road shoulders, abandoned farmlands, and railroad rights-of-way. Abusive grazing and burning weakened the native plant communities and opened the vegetation to invasion by these plants. The alien plants changed the patterns of secondary succession in southern Idaho and also altered the carrying capacity of the range, the amount of soil erosion, and the frequency of fires. Continued burning and excessive grazing allowed these annuals to become dominant on millions of acres of land in southern Idaho. The face of southern Idaho has been changed by the invasion of these exotic plants.

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A SAGEBRUSH WILT DISEASE OF UNKNOWN CAUSE

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ABSTRACT.— A sagebrush wilt disease is causing severe damage to Forest Service uniform shrub garden plantings in Utah. Plants within most species of the section Tridentatae express disease symptoms and may die within several months. Varying degrees of susceptibility are evident within and between species. Modification of the soil environment through past agricultural use may dispose these wildland shrubs to associated potentially pathogenic fungi.

A sagebrush (*Artemisia* L.) disease of unknown cause is severely damaging USDA-Forest Service uniform shrub garden plantings at the Utah State University Snow Field Station at Ephraim, Utah. Although the disease is not known to occur in the wildland situation, it is important from at least two aspects. First, it renders growing and maintaining the uniform shrub gardens almost impossible. Second, decimation of selected population accessions greatly depletes the genetic base. Evaluation and selection of plants for desirable characteristics such as productivity, nutritional value, drought tolerance, winter hardiness, disease resistance, and so forth are thus on a less firm basis. Assemblage of plant materials in uniform plantings is the initial step in the Forest Service's wildland shrub improvement program. The program is a cooperative effort of the USDA-Forest Service, Utah State Division of Wildlife Resources, and Utah State University.

Artemisia is a major component of the vast western United States shrublands (Beetle 1960, McArthur and Plummer 1978). Among the members of this aggressive, diverse, and adaptable genus are species useful for restoring depleted ranges and disturbed landscapes (McArthur et al. 1974, Monsen 1975), for providing nutritious and palatable browse on western big game and livestock ranges (Plummer et al. 1968, Welch and McArthur 1979), and for habitat of numerous other forms of wildlife (McKell et al. 1972).

MATERIALS AND METHODS

Assemblage of plants at the Snow Field Station began in the late 1960s and has continued to the present. The *Artemisia* selections were collected primarily from the Great Basin. Others were obtained from surrounding areas in Arizona, Colorado, Idaho, Utah, and Wyoming. Accession sources for the same species or subspecies, with few exceptions, were from different origins in each of the different years of planting. All entries of the same year were placed in the same section of the garden with those of subsequent years in adjoining sections. Entries were made as young wildling transplants. After initial watering to encourage establishment, no supplementary water was given. The plantings were cultivated to control weeds.

The number of plants established following transplant was determined at the end of the first season. Thereafter annual observations were made on plant development. The number of plants within each accession was highly variable because of transplant loss and the number available at the collection sites. Observations on disease development were not begun until 1974. The accession entries made from 1968 through 1971 appeared to be the most comparable and were selected for a disease survey in the fall of 1978. The number of plants surviving without advanced wilt symptoms was determined for each accession.

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The range in percentage survival was calculated from individual accessions within years and the mean percentage from a total of all accessions within species for each year. The total percentage survival representing accession totals for all years was totaled for each species. The more or less miscellaneous array of differing sources and numbers within and between species each year allowed only a general statistical comparison.

RESULTS

Observations revealed the following general pattern of disease development. First symptoms of the disease usually occurred in late fall or early spring as wilted leaves and shoot tips (Fig. 1). By midsummer, portions (Fig. 2A) or entire plants (Fig. 2B) collapsed and died. The disease occurred in young well-established plants during their first season of growth and in plants one or more years old. In one planting, there was a high incidence of wilt and death of plants during

Fig. 1. Wilt disease symptoms on *Artemisia tridentata*. Note wilted leaves and shoot tips (arrow).

the second season that subsided but continued to occur at a reduced rate in following years. Plants died out in patches (Fig. 3A), but more commonly there was a scattered pattern of dying (Fig. 3B).

A pronounced bluish green vascular discoloration, symptomatic of a *Verticillium*-induced disease of woody plants (Bedwell and Childs 1938, Caroselli 1957), was associated with some dying plants; however, the discoloration also occurred with non-wilted plants. Portions of the root systems of some wilt-diseased plants were necrotic, but death of plants did not seem to be associated with earlier advanced root rot or decay. It was not obvious where and how the disease was initiated in the plants. Usually, for example, when half the crown wilted and died, the corresponding portion of the root system was also found dead. Death from a vascular wilt pathogen rather than from winter injury appeared more probable because of the lack of a marked increase in rate or intensity of kill immediately following colder and drier winters and the typical wilt disease symptoms expressed by some plants during the first season planted.

All members of the section Tridentatae (see taxonomy in Beetle 1960, Beetle and Young 1965) exhibited symptoms except *A. pygmaea*, *A. longiloba*, *A. rigida*, and *A. spinescens* (Table 1). The latter three species were represented by only a few plants and therefore were not listed in Table 1. Species representing other sections of *Artemisia* did not express wilt symptoms and, except for *A. filifolia*, which was represented by only a small number of plants, survived to a relatively high degree compared to the Tridentatae in general. *Artemisia ludoviciana* and especially *A. abrotanum* seem to have suffered the least loss. Within the remaining Tridentatae, survival appeared to be the highest with *A. arbuscula* and *A. nova*, intermediate with *A. tridentata*, and lower with *A. bigelovii*, *A. cana*, and *A. tripartita*; the most severely affected was *A. rothrockii*. Within *A. tridentata*, which is of special interest to the project, ssp. *tridentata* (valley or basin big sagebrush) appeared to be somewhat less affected than ssp. *vaseyana* (mountain big sagebrush). The other subspecies, *wyomingensis* (Wyoming big sagebrush), probably cannot
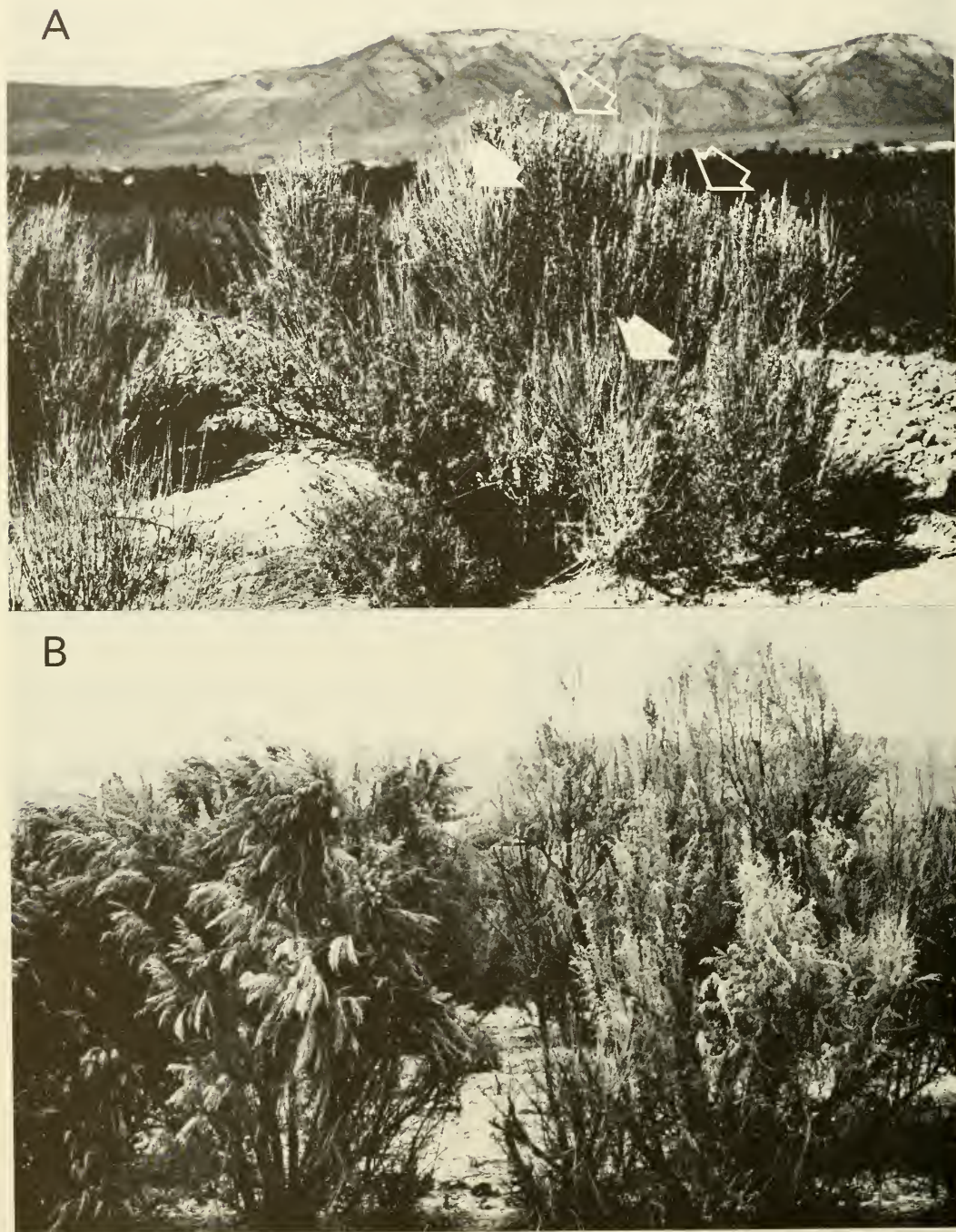
Fig. 2. Pattern of dying from wilt disease in individual plants. A, Partial death of A. *tridentata* ssp. *caseyana*, Spring City, Utah, source. Open arrows mark living portions, closed arrows mark dead portions of plant. B, Death of entire plant on right occurred by midsummer. Dove Creek, Colorado, source of A. *tridentata* ssp. *tridentata*. Plants are about 2.5 m tall. Drooping appearance of plant on left is from heavy floral heads.

Fig. 3. Pattern of dying from wilt disease in shrub garden plantings. A, A patch of dying plants. Photo taken during third season of planting, Snow Field Station. B, Scattered death of plants of various accessions. Photo was taken during fourth season of planting, Snow Field Station.

be compared reliably because of the small number of plants. Accessions within most species appeared to vary markedly in survival rates (see "percent survival" ranges, Table 1), and there tended to be a continuous death with time (see survival amounts of plants established, 1969–1972, Table 1).

The annual loss of *A. tridentata* was followed in another planting established in 1975 in a different area of the Snow Field Station. Plants grew vigorously throughout the observation period. Starting from one-year-old seedling transplants, at the end of the first season ssp. *tridentata* averaged 55 cm (Dove Creek source 60 cm) and ssp. *wyomingensis* and ssp. *vaseyana* 34 cm in height. Readings were made each fall through 1978 on the number of plants expressing wilt symptoms and dying from the disease. The results are summarized in Table 2. Loss of plants through midsummer of the first season was attributed to transplant injury. September through November, plants began developing wilt symptoms, and most of these died early in spring 1976. After the second season, little additional death of the *A. tridentata* ssp.

tridentata accessions occurred. With the other subspecies additional deaths occurred but in somewhat lesser amounts each year. By the end of the 1978 season only 58.8 percent of the three *A. tridentata* ssp. *vaseyana* accessions survived. Survival in *A. tridentata* ssp. *wyomingensis* and *A. tridentata* ssp. *tridentata* was 75.3 percent and 90.1 percent, respectively.

Discussion

Wilt disease symptoms were associated with most of the severe loss of plants recorded in Table 1. This loss cannot be attributed entirely to the disease since observations of the disease were not documented during early years of the plantings. In some accessions, especially with larger plant species, the spacing turned out to be too close and competition for water, light, and nutrients likely contributed directly to their death.

In its virgin state, the Snow Field Station area was a big sagebrush (*Artemisia tridentata*), black greasewood (*Sarcobatus vermiculatus* (Hook.) Torr.), and bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn.

Table 1. Loss of *Artemisia* plants at the Ephraim shrub garden.

Artemisia species	Year established	No. of accessions	Number established	No. without wilt in 1978	Range and mean[a] survival (%)		
Section Tridentatae							
A. arbuscula Nutt.	1969	4	50	2	0.0 (4.0)	9.1	
	1970	1	106	15	(14.2)		
	1971	2	87	9	8.8 (10.3)	11.9	
	1972	3	165	161	62.5 (97.6)	100.0	
			408	187	45.8		
A. bigelovii Gray	1970	5	203	9	0.0 (4.4)	7.7	
	1971	4	54	2	0.0 (3.7)	18.2	
	1972	4	82	29	0.0 (35.4)	52.8	
			339	40	11.8		
A. cana Pursh	1969	2	4	0	(0.0)		
	1970	1	34	5	(14.7)		
	1971	3	138	15	5.5 (10.9)	19.1	
	1972	1	20	0	(0.0)		
			196	20	10.2		
A. nova Nelson	1969	6	120	16	0.0 (13.3)	37.5	
	1970	4	76	19	15.2 (25.0)	28.6	
	1971	9	171	100	0.0 (58.5)	100.0	
	1972	4	238	121	0.0 (50.8)	80.8	
			605	256	42.3		
A. pygmaea Gray	1969	1	46	0	(0.0)		
	1970	1	36	6	(16.7)		
			82	6	7.3		

[a]The three figures represent the range and mean (center) percentage survival of the individual accessions for each year. The "total" percentage survival is of the total number of plants for all years sampled.

Table 1 continued.

Artemisia species	Year established	No. of accessions	Number established	No. without wilt in 1978	Range and mean[a] survival (%)		
A. rothrockii Gray	1969	2	196	12	1.5	(6.1)	15.9
			196	12		6.1	
A. tridentata Nutt. ssp.	1969	13	283	35	0.0	(12.4)	53.3
tridentata	1970	3	50	11	0.0	(22.0)	25.6
	1971	9	352	155	0.0	(44.0)	64.0
	1972	2	17	2	0.0	(11.8)	20.0
			702	203		28.9	
A. tridentata Nutt. ssp.	1969	1	18	0		(0.0)	
vaseyana (Rydb.) Beetle	1970	3	146	39	3.6	(26.7)	36.8
	1971	13	420	54	0.0	(12.9)	28.6
	1972	15	992	324	8.3	(32.7)	80.7
			1576	417		26.5	
A. tridentata Nutt. ssp.	1969	3	27	1	0.0	(3.7)	20.0
wyomingensis Beetle & Young	1970	2	51	1	0.0	(2.0)	2.0
	1971	4	66	17	0.0	(25.8)	39.5
	1972	2	16	11	0.0	(68.8)	73.3
			160	30		18.8	
A. tripartita Rydb.	1969	2	55	5	7.3	(9.1)	14.3
	1972	2	23	5	0.0	(21.7)	31.3
			78	10		12.8	
OTHER SECTIONS							
A. abrotanum (Bess) Rydb.	1972	1	161	154		(95.7)	
			161	154		95.7	
A. filifolia Torr.	1971	2	9	1	0.0	(11.1)	16.7
	1972	1	8	3		(37.5)	
			17	4		23.5	
A. frigida Willd.	1969	1	6	0		(0.0)	
	1970	2	73	6	3.2	(8.2)	36.4
	1971	4	128	80	0.0	(62.5)	89.9
	1972	1	32	17		(53.1)	
			239	103		43.1	
A. ludoviciana Nutt.	1970	2	64	31	44.4	(48.4)	51.4
	1971	2	49	48	83.3	(98.0)	100.0
			113	79		69.9	

and Smith) site. The soil is a heavy alluvial clay derived from limestone parent material. Although the physical and mineral nutrient characteristics have probably been altered to some extent by agricultural use, these factors do not appear to be a major or direct cause of the disease. The majority of plant accessions in the gardens were made as wildling transplants and, after establishment, their growth in general was vigorous to exceptional.

Artemisia spp. are known to form vesicular-arbuscular mycorrhizal associations (Williams and Aldon 1976, Williams et al. 1974) and may also form ectomycorrhizae. Interference with or lack of their formation in the uniform shrub gardens could lead to a nutritional deficiency from lack of proper nutrient adsorption (Voigt 1969). Some soil factors thought to influence formation of mycorrhizae include temperature, moisture, aeration, pH, organic and inorganic nutrients, fungal and plant exudates, and the rhizosphere biota (Slankis 1974). How the past agriculture may have altered these factors relative to Artemisia mycorrhizae is unknown.

Table 2. Death of *Artemisia tridentata* subspecies from the sagebrush wilt disease[a].

Subspecies	Accession source	No. planted spring 1975	No. surviving[b] 1975	1976	1977	1978	Survival[c] (%)
A. tridentata tridentata	Dove Creek, Colorado	100	87	82	80	78	89.7
A. tridentata tridentata	Bonanza, Utah	25	24	24	22	22	91.7
A. tridentata wyomingensis	Trough Springs, Nevada	75	73	68	60	55	75.3
A. tridentata vaseyana	Excel Canyon, Utah	132	131	84	80	79	60.3
A. tridentata vaseyana	South of Brigham Canyon, Utah	100	100	80	75	68	68.0
A. tridentata vaseyana	Hobble Creek, Utah	100	99	79	66	47	47.5

[a]Planting located at Snow Field Station.
[b]Number of plants surviving in the fall of each year.
[c]Percentage survival is of those plants surviving transplant in fall 1975.

The presence of mycorrhizae on sagebrush in the shrub gardens has not been determined, but growth of affected sagebrush was vigorous on the site prior to the disease, indicating a mycorrhizal presence or adequate nutrition in its absence. Even though nutrition and other growth factors appear to be adequate, lack of mycorrhizal formation may dispose the plants to disease through the lack of protection it may provide against pathogenic microorganisms (Zak 1964).

Sagebrush has a loose exfoliating outer bark, and older stems split easily, commonly separating at annual growth junctures. Sagebrush also has a low branching habit, with main branches commonly originating just above the root-stem transition zone. The lower branches split readily, adaxially, from the main stem. The bases of some lower branches die, apparently from shade suppression, and their decay extends to the heart of the main stem. These characteristics possibly dispose the plant to pathogens. During approximately 100 years of agricultural use, which was primarily for forage and grain crop production, the composition of soil microorganisms has undoubtedly changed and is artificial to the native *Artemisia* rhizosphere. Any soil-borne plant pathogens and resulting diseases confronting *Artemisia* in the plantings could very well be artifacts of the previous agriculture.

Exploratory isolation trials have yielded a multitude of microorganisms, including bacteria, fungi, and nematodes. Because surface sterilants do not contact saprophytic-type organisms within outer bark and other dead tissue, distinction of parasitic pathogens and saprophytes is confused during isolation attempts. Fungal species of the genus *Fusarium*

and a verticillate *Gliocladium* were commonly isolated from living root and stem segments of diseased plants. *Sclerotinia* and *Rhizoctonia* were occasionally isolated from the upper root zone and the latter also was isolated from higher in the stems. Many soil-borne saprophytes and important parasitic plant pathogens exist within these genera (Walker 1969). Species of ordinarily saprophytic fungi such as *Alternaria*, *Ulocladium*, and *Cylindrocarpon* were commonly encountered. Isolation and inoculation studies are being made in an effort to establish the cause of the disease.

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A NEW VARIETY OF *CENTAURIUM NAMOPHILUM* (GENTIANACEAE) FROM THE GREAT BASIN[1]

C. Rose Broome[2]

ABSTRACT.— An expression of *Centaurium namophilum* (Gentianaceae), long confused with *C. exaltatum* in the Great Basin of the western United States, is described and designated as var. *nevadense*. It may be separated from the Death Valley region endemic, var. *namophilum*, by its broader leaves, its diffuse corymbose cyme, the ultimate peduncles that are longer than the flowers, its medium to deep rose pink corolla, and its stamens that equal or exceed the style and are only slightly exserted from the corolla-tube. The var. *nevadense* occurs from eastern California to western Utah, and from southeastern Oregon and adjacent Idaho south to the northern Mojave Desert of southeastern California. *Centaurium exaltatum* may be distinguished from the new variety by its broader, more elliptical leaves, dichotomous peduncles, paler pink or bluish and generally four-merous flowers, shorter and more blunt corolla lobes, and a thicker, more included style and stigma.

A phase of the Death Valley region endemic, *Centaurium namophilum* Reveal, Broome & Beatley (Gentianaceae), has been found growing around various desert springs and seeps in the Great Basin of east central California, Nevada, western Utah, southwestern Idaho, and southeastern Oregon. This variety often occurs in close sympatry with *C. exaltatum* (Griseb.) W. F. Wight ex Piper and has been confused with that species.

Centaurium namophilum Reveal, Broome & Beatley var. nevadense Broome, var. nov. A var. *namophilo* caulibus gracilioribus, ramificatione corymbosa diffusa ascendentiore, corollis brevioribus roseis, stylis quam staminibus vulgo brevioribus differt. Chromosomatum numerus $n = 17$ de typus. Typus: NEVADA: Esmeralda Co.: Gap Springs, 2.8 miles southeast of intersection of Nevada Highway 3A and U.S. Highway 6, T.1N., R.36E., sec. 6, ca 4600 ft elev., 22 Aug 1978, *Broome 2388*. Holotype, CAS; isotypes, 18 duplicates to be distributed from MARY.

Margins of alkaline springs and seeps or graminoid meadows from Inyo and Mono Counties, California, eastward across central and northern Nevada to western Utah, and northward into southwestern Idaho and southeastern Oregon, mostly from 2200 to 6000 ft elevation. Flowering from late June to September (Figs. 1, 2).

ADDITIONAL COLLECTIONS SEEN.— CALIFORNIA: Inyo Co.: 4 mi N of Lone Pine along U.S. Hwy. 395 at alkali spring on E side of rd at S entrance to Alabama Hills Scenic Route just N of Alabama Gate, 15 Jul 1978, *Broome et al. 2281* (CAS and 19 duplicates); Owens Valley, N of Lone Pine, just above Alabama Gates, 3700 ft, 22 Jul 1973, *DeDecker 3300* (CAS, RSA); E side of Fish Slough, T.6S., R.33E., sec. 6, 4185 ft, 15 Jul 1976, *DeDecker 4103* (DEDECKER); alkaline meadow between Mono Co. line and Laws, 19 Jul 1952, *Ferris 12552* (CAS, DS, US); Teck (Texas?) Springs, Funeral Mts., Death Valley, 27 Apr 1935, *Gilman 1416* (US); shores of Owens Lake, 3600 ft, 5 Jun 1906, *Hall & Chandler 7326* (UC); alkali marsh, Fish Slough, 8.5 mi N of Bishop, 2 Sep 1949, *Nobs & Smith 1789* (UC); Furnace Creek, 17 May 1915, *Parish 10035* (UC); E side of Fish Slough, T.6S., R.33E., sec 6, ca 4150 ft, 23 Jul 1976, *Reveal 4580* (MARY and 4 duplicates). Mono Co.: Fish Slough, T.5N., R.33E., sec. 31, 15 Jul 1978, *Broome et al. 2282* (MARY and 6 duplicates); Fish Slough, 1.9 mi N of BLM Springs, T.5N., R.33E., sec. 19, 15 Jul 1978, *Broome et al. 2283* (CAS and 5 duplicates); E side of Fish Slough, T.5S., R.33E., sec. 31, 17 Jul 1978, *Broome & Reveal 2284* (CAS and 17 duplicates); Fish Slough, BLM Springs, T.5S., R.33E., sec. 30, 4200 ft, 30 Sep 1974, *DeDecker 3697* (CAS); Fish Slough,

Fig. 1. *Centaurium namophilum* var. *nevadense*. a,b, habits of two typical mature plants; c, top view of five-merous flower; d, mature capsule with persistent style; e, one valve of fruit showing the degree of placental intrusion into locule and mature seeds within; f, four-merous flower in side view. (Illustration by Peggy K. Duke of the University of Maryland.)
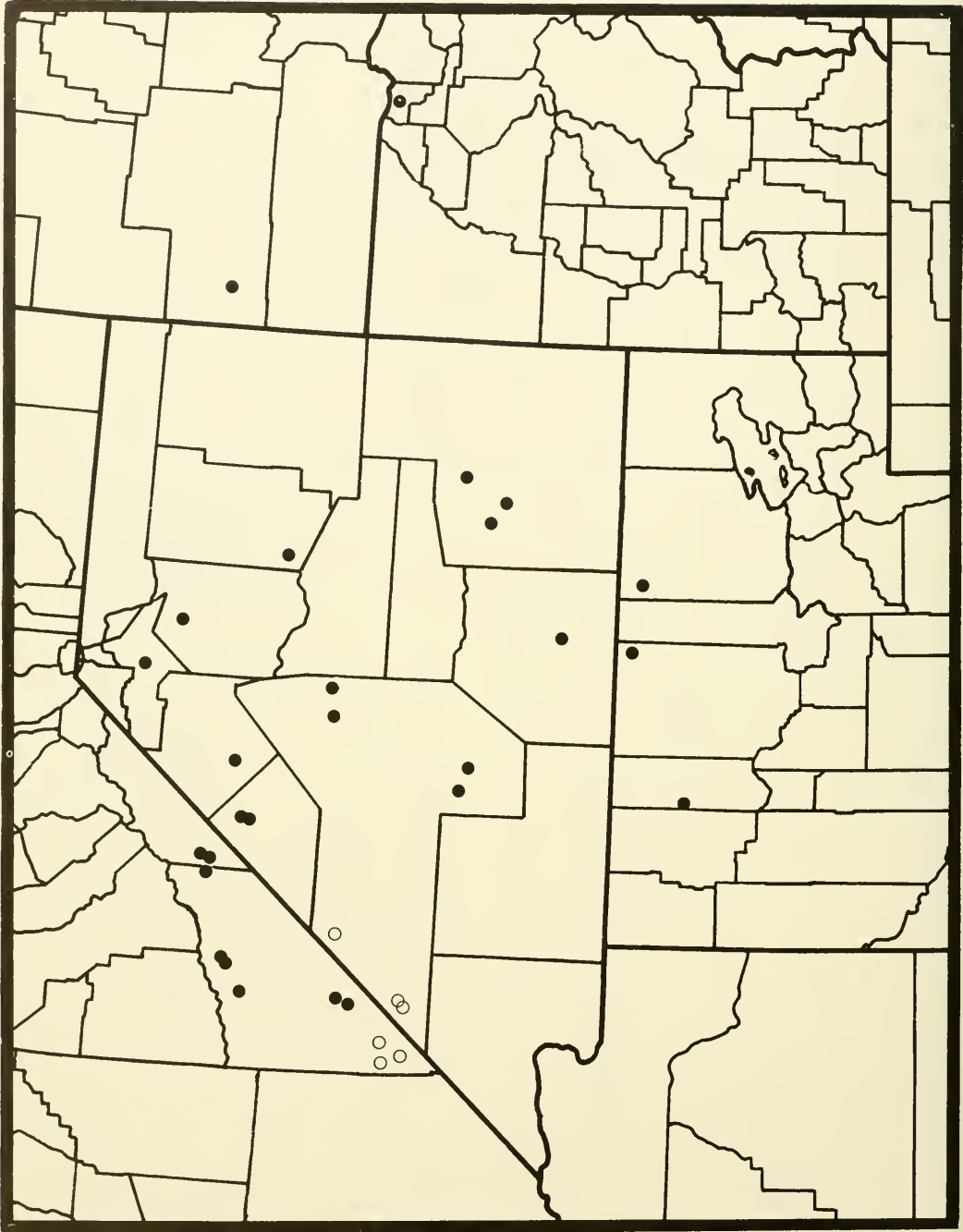
Fig. 2. Distribution of *Centaurium namophilum* var. *namophilum* (open circle) and var. *nevadense* (closed circle) in the western United States.

T.5S., R.33E., sec. 19, ca 4200 ft, 23 Jul 1976, *Reveal 4584* (MARY and 9 duplicates). IDAHO: County Unknown: Lewis' River (=Snake R.), 1834, *Nuttall s.n.* (BM, GH). Payette Co.: New Plymouth, 2200 ft, 1 Jul 1910, *MacBride 321* (UC). NEVADA: Churchill Co.: 6 mi N of Fallon, 6 Jul 1937, *Allen 284* (UC). Elko Co.: 0.2 mi W of Elko Poor Farm along Humboldt R., 9 Jun 1941, *Holmgren 1000* (UC); Ruby Valley, Sulphur Hot Springs, T.31N., R.59E., sec. 11, 6050 ft, 7 Jul 1969, *Holmgren & Kern 3663* (BRY, C, CAS, NY, RENO, WTU); Ruby Valley, 6000 ft, Aug 1865, *Watson 945* (GH); Ruby Valley, 12.9 mi SW of U.S. Hwy. 93 on Nev. Hwy. 11, T.32N., R60E., sec. 20, 31 Jul 1978, *Williams & Tiehm 78-267* (MARY); "Point," at edge of Ruby Lake Nat. Wildlife Ref., T.27N., R.58E., sec. 2, 18 Aug 1978, *Williams & Williams 78-318* (MARY). Esmeralda Co.: NE branch of Fish Lake Valley nr. Gap Springs, 5000 ft, 26 Sep 1938, *Archer 7251* (RENO, UC); nr. Gap Springs, T.1N., R.36E., sec. 5, 13 Aug 1978, *Reveal 4830* (MARY and 21 duplicates); Gap Springs, T.1N., R.36E., sec. 5, 13 Aug 1978, *Reveal 4831* (MARY and 23 duplicates); Gap Springs, T.1N., R.36E., sec. 5, 13 Aug 1978, *Reveal 4833* (MARY and 6 duplicates); Gap (Gap Springs?), 4000 ft, Jul 1886, *Shockley 531* (UC, W); Gap Springs, T.2N., R.36E., sec. 20, 3 Aug 1978, *Williams & Tiehm 78-301* (MARY). Lyon Co.: Wabuska Hot Springs, 0.5 mi N of Wabuska, T.15N., R.25E., sec. 16, 19 Aug 1978, *Broome 2375* (CAS and 23 duplicates); "boiling spring, Bent of Walker R." (=Wabuska Hot Spring), 1859, *H. Engelmann s.n.* (GH). Mineral Co.: Sodaville, 3 mi S of Mina along U.S. Hwy. 95, 22 Aug 1978, *Broome 2385* (CAS and 14 duplicates); Sodaville, 23 Aug 1978, *Broome 2386* (CAS and 4 duplicates); Sodaville, 4650 ft, 12 Aug 1978, *Reveal 4828* (MARY and 21 duplicates); Sodaville, 3 Aug 1978, *Williams & Tiehm 78-302* (MARY). Nye Co.: Smokey Valley, Darroughs Hot Springs, T.11N., R.43E., sec. 7, 24 Jul 1978, *Goodrich 11909* and *11910* (MARY); Smokey Valley, T.14N., R.43E., sec. 34, 5450 ft, 7 Aug 1978, *Goodrich 12147* (MARY); Railroad Valley, Blue Eagle Spring, T.8N., R.57E., sec. 11, 4760 ft, 23 Jul 1980, *Tiehm & Williams 6193* (MARY); Hot Creek Springs, 8 mi WSW of Sunnyside, T.6N., R.61E., sec. 17, 5220 ft, 29 Aug 1980, *Welsh & Thorne 558* (MARY); Darroughs Hot Springs, T.11N., R.43E., sec. 29, 24 Jul 1978, *Williams & Williams 78-235* (MARY). Pershing Co.: Dixie Valley, Sou Hot Springs, T.26N., R.38E., sec. 29, 19 Jun 1978, *Broome et al. 2172* (CAS and 4 duplicates). White Pine Co.: Steptoe Valley, Monte Neva Hot Springs, T.21N., R.63E., sec. 24, 6050 ft, 28 Jun 1978, *Pinzl & Williams 1927* (MARY); Steptoe Valley, Monte Neva Hot Springs, T.21N., R.64E., sec. 22, 17 Jul 1979, *Thorne & Harrison 660* (BRY, MARY). OREGON: Harney Co.: shores of Borax (=Hot) Lake, T.37S., R.33E., sec. 14, 16 Aug 1978, *Broome 2366* (CAS and 15 duplicates); margin of Borax Lake, 28 Jun 1936, *Peck 19087* (WILLU, WTU). UTAH: Beaver Co.: Escalante Valley, 3 mi S of Thermo Siding, 14.5 mi WSW of Minersville, T.31S., R.12W., sec. 21, 5050 ft, 27 Aug 1980, *Welsh et al. 20136* (MARY); Millard Co.: 6.5 mi E of Gandy, S of Salt Marsh Lake, T.16S., R.18W., sec. 6, 4788 ft, 5 Sep 1976, *Welsh et al. 14512* (BRY). Tooele Co.: Six Mile Spring, 5 mi NW of Callao, T.10S., R.17W., sec. 9, 4800 ft, 20 Jul 1978, *Welsh et al. 17701* (BRY). County unknown: nr. Salt Lake City, 1901, *McVicker s.n.* (UC).

The new variety differs from var. *namophilum* (Reveal et al., 1974) chiefly in the more ascending, corymbose branching, and the smaller, darker rose pink corollas that are mostly less than 17 mm long, and by having styles shorter than or scarcely exceeding the stamens at anthesis. The following key will serve to differentiate the varieties most of the time.

A.   Principal leaves usually linear and sharply recurved; inflorescence a paniculate cyme with a definite central axis, the main branches diverging at a 45 degree or greater angle; ultimate peduncles generally shorter than the flowers and thus the flowers congested at tips of the branches; corolla pale to medium pink, the corolla-lobes equaling or more than half as long as corolla-tube, the stamens well exserted from the corolla-tube and these exceeded by the style .... *C. namophilum* var. *namophilum*

AA. Principal leaves lanceolate or narrowly oblong, ascending or merely outcurved; inflorescence a diffuse corymbose cyme with the main branches ascending at less than a 45 degree angle from the axis; ultimate peduncles usually longer than the flowers and thus the flowers not appearing congested at tips of the branches; corolla medium to deep rose pink, the corolla-lobes less than half as long as corolla-tube, the stamens only slightly exserted from corolla-tube and equaling or exceeding the style ....
.... C. namophilum var. nevadense

Centaurium namophilum var. *namophilum* is endemic to a narrow desert valley about 45 miles long situated between the Greenwater Mountains on the west and the Resting Spring Range on the east (Fig. 2). The plant occurs from the vicinity of Beatty (*Ripley & Barneby 3994*, CAS) in southern Nye Co., Nevada, southward along the Amargosa River drainage to near Tecopa, Inyo Co., California. The California collections of this variety (*Coville & Funston 275*, US, from Resting Springs Valley in 1891; *Kerr s.n.*, CAS, UC, from Shoshone in 1934; and *Roos & Roos 4927*, RSA, UC, US, from Tecopa in 1950) represent populations that may no longer be extant. The variety could not be located in 1978 despite a careful search of these sites.

About 33 miles west and slightly north of the type locality of var. *namophilum* (in Ash Meadows, Nye Co., Nevada) and across the Funeral-Greenwater mountain system, is the Furnace Creek area in Death Valley, Inyo Co., California. This is now the site of the Death Valley Museum and visitor's center. *Centaurium* apparently exists no longer in this site, but was formerly collected at Furnace Creek in 1915 (*S. B. Parish 10035*, UC) and at nearby Texas Spring in 1935 (*Gilman 1416*, US). These collections quite closely resemble the plants from Shoshone and Tecopa referred above to var. *namophilum*. However, they are of the short-styled form with shorter corolla-lobes, and are considered, somewhat arbitrarily, to belong to var. *nevadense*. They more closely resemble the populations of var. *nevadense* that occur some 60 miles west in Owens Valley, at elevations of 3500 ft and above, and other populations scattered through Nevada and adjacent states (Fig. 2), than they do var. *namophilum*.

The var. *nevadense* is the same as *Erythraea nuttallii* sensu Gray (1876) and Coville (1893). Gray accurately distinguished *E. nuttallii* from *E. douglasii* A. Gray (a superfluous name for *Centaurium exaltatum*)

and gave its range as "Nevada, as near as Ruby Valley, and in adjacent parts of Idaho and Utah."

Erythraea nuttallii S. Wats. (1871a) was based on several different elements. Watson referred Nuttall's manuscript names "*E. longiflora*," "*E. elata*," and "*E. tenella*" to this species. However, plate 29 that accompanied the protologue clearly is based on a collection from Carson City, Nevada, gathered by Charles L. Anderson (29), and is the only *specimen* cited by Watson other than his own 945. Watson did refer to his own Nevada locations (Unionville, Huntington, and Ruby Valley). I have examined the Anderson collection (GH) and the Nuttall specimens upon which the three unpublished names were based (BM, GH, PH). The Anderson specimen is nearly identical to the published figure (t. 29), whereas none of the Nuttall material bears much resemblance to the plate, nor does *Watson 945*. The Anderson collection, however, is clearly representative of *Centaurium exaltatum*. Because it served as model for the plate and is not excluded by Watson's description, *Anderson 29* (GH!) is hereby designated the lectotype of *E. nuttallii*, and thus that name becomes a taxonomic synonym of *C. exaltatum*.

As for the three Nuttall names mentioned by Watson (1871a), the collections on which they were based represent three discordant elements. Nuttall's "*E. longiflora*" is *Centaurium namophilum* var. *nevadense*; his "*E. elata*" is typical *C. exaltatum*; and his "*E. tenella*" is *C. floribundum* (Benth.) B. L. Robinson. These specimens were gathered by Nuttall on a trip across the Rocky Mountains with Nathaniel J. Wyeth in 1834 (Graustein 1967). "*Erythraea longiflora*" and "*E. elata*" were gathered along the "Lewis' River, R. Mts.," which now refers to the Snake River of southern Idaho and Oregon. His specimen of "*E. tenella*" was gathered from "Port Neff, Columbia River," which is a reference to the

Portneuf River, a tributary of the Snake River in eastern Idaho. Nuttall and Wyeth were there for several weeks in July 1834 while Wyeth was constructing Fort Hall, a trading post along the Snake River near the mouth of the Portneuf (Robertson 1963). Unfortunately, there is no direct information as to where, along the Lewis' River, Nuttall may have gathered his specimens. Wyeth's party was along the Snake River only near Fort Hall and on the Idaho-Oregon border near the mouth of the Boise River where the party crossed into Malheur Co., Oregon, on 24 August. They stayed along the Snake River until reaching the Burnt River 27 August (McKelvey, 1955). Because both *C. exaltatum* and *C. namophilum* var. *nevadense* are known from western Idaho, it is possible Nuttall gathered his material in this area.

Asa Gray (1876) correctly excluded Nuttall's "*Erythraea tenella*" and "*E. elata*" from the concept of *Erythraea nuttallii*, leaving "*E. longiflora*," *Anderson 29*, a collection by Henry Engelmann (GH), and the Watson collection (*Watson 945*, GH) from Ruby Valley, Nevada. Unfortunately, only the Ruby Valley collection seems to be extant, and this is var. *nevadense*. It is the only location for the collection number cited by Watson (1871b) himself, and thus it is likely that the plants from Unionville and Huntington, Pershing Co., Nevada, either were not preserved or were incorporated all together into a single collection. As for the Engelmann collection, this too is var. *nevadense*, collected during the 1857–1859 wagon road survey of James Simpson (Jackson 1964) at Wabuska, Lyon Co., Nevada.

George Engelmann, the famed St. Louis botanist and brother of Henry (Reveal 1972), stated in 1878, "This plant [*Erythraea douglasii*] has been confounded by Mr. Watson with his *E. nuttallii*, which, however, is a smaller and more leafy plant, with larger flowers and much larger seeds (0.65 mm long), but much smaller stigmas." Still, Engelmann failed to lectotypify Watson's species, or to circumscribe it correctly.

The incomplete distinctions made in the past between *Centaurium namophilum* var. *nevadense* and *C. exaltatum* are understandable because, in a manner that is typical of sympatric species of *Centaurium*, these two entities converge greatly when found together. It is sometimes with only the greatest of difficulty that poorly prepared herbarium material can be separated. The main characters by which *C. exaltatum* may be distinguished from var. *nevadense* are its broader, more elliptical leaves, the dichotomous (vs. trichotomous) peduncles, the paler pink or bluish, generally four-merous flowers, the shorter and more blunt corolla lobes, and the generally thicker, more included style and stigma.

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ON THE TYPIFICATION OF *SALVIA DORRII* (LAMIACEAE)[1]

Jeffrey L. Strachan[2] and James L. Reveal[2]

ABSTRACT.— The type of *Salvia dorrii* is shown to represent the Great Basin phase of the species (currently called subsp. *argentea*) rather than the Mojave Desert expression as implied by Epling and others. The Mojave Desert phase is hereby renamed S. *dorrii* var. *pilosa* (A. Gray) Strachan & Reveal.

In the Intermountain Region, three phases of *Salvia dorrii* (Kellogg) Abrams (Lamiaceae) are reported. The northern var. *carnosa* (Dougl. ex Greene) Cronq. of Washington and Oregon barely enters the Region along the Snake River on the Oregon-Idaho border. The widespread Great Basin plant has been called subsp. *argentea* (Rydb.) Munz, but the Mojave Desert element, long referred to as subsp. *dorrii*, was not considered to be in the Region even though the type was collected in west central Nevada. An examination of the variation in the S. *dorrii* complex throughout its range (by Strachan), and specifically that in the Intermountain Region (by Reveal), has shown some minor problems that can be resolved at this time.

When *Salvia dorrii* was originally proposed, it was placed in the genus *Audibertia* Benth. in Lindl., a homonym of *Audibertia* Benth., a synonym of *Mentha* L., and apparently was based on a C. Herbert Dorr collection supposedly gathered near Virginia City, Nevada (Epling 1938, Ewan 1967). This original collection has been lost (Epling 1938). Kellogg (1863) mentioned Dorr collections for three new species. Under *Lilium parvum* he thanked "Mr. C. H. Dorr for specimens from Nevada Territory." The type of *Viola aurea* was found by "Mr. C. W.[sic] Dorr from Nevada Territory," but in his description of *Spraguea paniculata* Kellogg wrote that the type was found by Dorr "in a ravine extending to the west, about six miles from Virginia City, Nevada Territory, at an altitude of 3,000 feet." It was this latter informa-

tion that probably led to the assumption that the type of *A. dorrii* came from near Virginia City. In his description of *A. dorrii*, Kellogg gives no indication at all as to the collector or the place of collection. The specific epithet is our only link with Dorr.

Interestingly, there is a series of subsequent species found in western Nevada and along the eastern slope of the Sierra Nevada in California proposed by Kellogg (1863) without any reference to collector or exact location (except one). These are *Lupinus confertus* (p. 192), *L. calcaratus* (p. 195), *L. caudatus* (p. 197), *Oenothera nevadensis* (p. 224—his next paper), *O. cruciformis* (p. 227), and *Viola chrysantha* var. *nevadensis* (p. 229). Only *O. cruciformis* has a location cited for it, this being "Steamboat Springs, Nevada Territory." Raven (1962) did not find a type specimen of *O. cruciformis* and proposed a neotype for this narrowly endemic species. Only a fragment of a specimen, without any information, was found for *O. nevadensis* (Raven 1969). This specimen was taken by Raven to represent Kellogg's original material. As for the three lupines, we can find recently published information on two. Hess and Dunn (1970) cite a Carson Valley collection of Kellogg's as the type of *L. caudatus*. Although Greene (1887) indicated that Kellogg did some collecting and illustrating of plants, both Ewan (1955) and Greene insist that Kellogg did not begin active botanizing until his Alaskan trip in 1867. Neither Reifschneider (1964) nor Ewan (1967) report Kellogg as a Nevada collector. There is no indication on

the specimen of *L. caudatus*, now deposited at the California Academy of Sciences, when it was collected or who made the collection. According to Curran (1885), this species was originally gathered by Dorr near Virginia City, but she gives no evidence to support this conclusion. It is probable that Kellogg was not the collector of this specimen as suggested by Hess and Dunn. It should be noted that John Allen Veatch, an associate of Kellogg's then living in Virginia City, did collect in Carson Valley. We suggest that the lupine could just as well have been gathered by Veatch as it may have been gathered by Dorr.

Dunn (1957) reports no type specimen for *L. calcaratus*, but Curran (1885) states the plant was collected "by H. C. [sic] Dorr, near Virginia City," indicating that perhaps a specimen must have been extant at one time, although it is possible she just assumed it was gathered by Dorr near Virginia City. Day (pers. comm.) says there is no type for *L. confertus*, and Cox (1972) suggests the need for a neotype. As for the *Viola*, no specimen is extant (Day, pers. comm.), and there is some question as to the exact meaning of the name "*nevadensis*." J. T. Howell and A. Day (pers. comm.) have called to our attention that *V. douglasii* (as *V. chrysantha* is now called) is a Sierra Nevada species, and is not found in the state of Nevada. Perhaps the plant came from the mountains of California rather than Nevada. We cannot tell. Curran (1885), in her review of the early names proposed by Kellogg, states the variant was hardly different from typical *V. douglasii*, but there is no indication that she actually saw a specimen.

In reviewing the distribution of the plants attributed to Dorr, two occur in the Virginia City area of west central Nevada. These are *Viola aurea* and *Spraguea umbellata* Torr., the correct name for *S. paniculata*. However, we have no record of *Lilium parvum* from the Intermountain Region of Nevada (Cronquist et al. 1977), although it is found on the eastern slope of the Sierra Nevada in Nevada. We now suspect that Dorr collected several specimens that were used by Kellogg to propose new species. For unknown reasons Kellogg failed to record who made the collections. One possible reason is that Kellogg was unable to retain Dorr's specimens for the California Academy of Sciences' collection and decided not to cite them. We have found no Dorr or Kellogg specimen of *S. dorrii* among the several hundred specimens we have observed of the complex, and, thus, we too must conclude that the type is lost.

The only indication as to the original intent of the type is that represented by the illustration published by Kellogg (1863). Epling (1938) referred *Audibertia dorrii* to synonymy under his *Salvia carnosa* Dougl. ex Greene subsp. *pilosa* (A. Gray) Epling without comment, although his range map specifically excluded the Virginia City area of western Nevada. The Kellogg illustration is not critical enough to fully distinguish his species from either the Great Basin phase, subsp. *argentea*, or the Mojave Desert plant, subsp. *dorrii*, which would later (Abrams 1951) include what Epling termed *S. carnosa* subsp. *pilosa*. The Kellogg illustration shows a rather congested inflorescence. This is similar to the condition found in the Mojave Desert phase. The short hairs on the ciliated bracts, however, are more similar to what is found on the bracts of the Great Basin phase. In reading the description additional characters can be noted. The verticillasters are given as "proliferous or condensed whorls, the whorls often remote or separated, of about three or more." The bracts are stated to be "externally somewhat strigose," a distinctive feature that clearly indicates the original material was not the southern phase characterized by long, pilose hairs on the bracts. Finally, an examination of other collections from the Virginia City area reveal only plants of "subsp. *argentea*." We believe the epithet *dorrii*, which must be typified with the Kellogg illustration according to Art. 9.3 of the International Code (Stafleu et al. 1978), applies to the Great Basin phase of the species rather than the southern desert expression as proposed by Epling and followed by Abrams (1951), Munz and Keck (1959), and others.

As a result, we propose to place *Audibertiella argentea* Rydb. in synonymy under *Salvia dorrii* var. *dorrii*, and recognize *S. dorrii* var. *pilosa* (A. Gray) Strachan & Reveal, comb. nov., based on *Audibertia incana* var. *pilosa* A. Gray, Syn. Fl. N. Amer. ed. 2, 2(1): 461. 1886 as typified by *Parish & Parish 1309*.

Actually, var. *pilosa* is found in the Great Basin. Specimens have been found in the La-hontan Basin system of central and northern Washoe County and the Black Rock Desert area of Humboldt County, Nevada, westward into eastern Lassen County, California. These isolated populations differ from the southern plants in having narrower bracts and somewhat shorter, but still pilose hairs on the outer surface and margin of the bracts. The typical form of var. *pilosa* is found as far north as the northern end of Owens Valley in extreme southern Mono County, California.

Additional variation is known to exist in *Salvia dorrii* as now defined. As these variants are found outside the boundaries of the Inter-mountain Region, they will be discussed later.

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PARASITES OF INDOCHINESE REFUGEES ENTERING UTAH COUNTY, UTAH: A TWO-YEAR SURVEY

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ABSTRACT.— A survey of parasites from 39 stool specimens taken from 36 Indochinese refugees who are now living in Utah County, Utah, indicated representative intestinal helminths (worms), and protozoans upon clinical examination. Approximately 75% of the stools contained nematodes, and 55.5% had protozoans. Parasites found were *Entamoeba coli*, *Chilomastix mesnili*, *Endolimax nana*, *Giardia lamblia*, *Iodamoeba buetschlii*, *Clonorchis sinensis*, *Trichuris trichiura*, *Ascaris lumbricoides*, and *Plasmodium vivax*. The most common protozoan observed was *Entamoeba coli* (1979 and 1980) while the most common helminths were *Ascaris lumbricoides* (1979) and *Clonorchis sinensis* (1980). These data were comparable to studies of refugees at two other laboratories in Utah and one at Washington, D.C.

Since May 1975, approximately 150,000 Indochinese refugees have entered the United States, a small percent of whom now live in Utah. More are expected. A majority of the refugees arrive directly from camps in Malaysia, Indonesia, Thailand, etc., with only preliminary screening for tuberculosis, leprosy, venereal disease, and mental defects and disorders, which is done by the Center for Disease Control (CDC) of the United States Public Health Service [Morbidity and Mortality Weekly Report (MMWR) 1979]. According to the cited article, the CDC does not consider it necessary to routinely screen all Indochinese refugees for intestinal or blood parasites. This is not regarded by the CDC as being critical because adequate sewage disposal and improved hygienic practices maintained in the USA will decrease the risk posed by intestinal helminths and protozoa by interrupting life cycles and minimizing direct fecal contamination. The possibility of malaria transmission is small, especially in the winter months, due to the limited number of anopheline mosquitoes in Utah.

In 1979 President Carter announced that 14,000 Indochinese refugees would be accepted monthly for resettlement in the United States. The CDC at Atlanta, Georgia, is responsible for the medical screening of refugees while they are still abroad and for the inspection of refugees upon arrival at USA ports of entry.

United States Public Health Service teams have recently visited areas in California, Oregon, Washington, and Hawaii that have already received large numbers of refugees, as well as refugee camps and embarkation areas in Southeast Asian countries. From these visits, as well as from limited surveillance data and the experience gained in the resettlement of over 150,000 Vietnamese refugees in the United States since May 1975, the following may be expected:

1. "The majority of refugees will be free of major contagious diseases;
2. Where an illness is present, it will likely represent a personal rather than a public health problem; and
3. The main health problems, perhaps exceeded only by the stress of resettlement itself, will include tuberculosis and parasitic diseases" (MMWR 1979).

The CDC continues to survey resettlement areas in the U.S. for parasitic diseases. One survey in Illinois (February 1979) found hookworms to be the most common intestinal parasite in the group (64 percent), followed by *Giardia lamblia* (18 percent), *Trichuris* (12 percent), and *Ascaris* (9 percent) (MMWR 1979). The purpose of our investigation was to determine the presence of intestinal and blood parasite infections of refugees in Utah County, Utah, by performing direct examinations of blood and fecal samples and to

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compare these data with results for other areas in Utah and for Washington, D.C.

MATERIALS AND METHODS

During 1979, a series of fecal samples taken three times weekly were obtained from each patient in plastic specimen cups into which 60 ml of 10 percent formalin was added for preservation. The sampling was varied in 1980 in that specimens were obtained from the Utah County Public Health Office following visits by refugees. Samples were then stored in a refrigerator at 5 C for 1 to 36 hours until concentration and staining procedures were performed. Samples were concentrated by the formalin-ether concentration technique (Richie 1948), and preliminary examinations were made by mixing one drop of fecal concentrate with one drop iodine, covering with a coverslip and examining under various powers with a microscope. Permanent slides were prepared with the trichrome stain technique (Garcia and Ash 1979) and iron hematoxylin stain technique (Spencer and Monroe 1975). The zinc flotation helminth egg isolation technique (Spencer and Monroe 1975) was also used on several samples.

Blood samples were drawn from a median cubital puncture into heparinized vacutubes from the majority of the patients. A finger prick was used for some, with the blood being collected in a heparinized capillary tube, care being taken not to "milk" the tissue to avoid diluting the blood with interstitial tissue fluid. From these blood samples, thick and thin smears were prepared from the Giemsa stain technique (Shute 1966, Shute and Maryon 1966) and examined microscopically.

RESULTS

Examination of fecal samples from 6 refugees in 1979 (Table 1a) and 30 refugees in 1980 (Table 1b) revealed the presence of five protozoan parasites (*Entamoeba coli*, *Chilomastix mesnili*, *Endolimax nana*, *Iodamoeba buetschlii*, and *Giardia lamblia*) and five helminth parasites (*Ascaris lumbricoides*, *Trichuris trichiura*, hookworms, *Clonorchis sinensis*, *Strongyloides stercoralis*) (larvae) (Tables 2a and 2b). Of the helminths observed four were roundworms and one (*C. sinensis*) was a fluke. Thick and thin blood smears from 66 percent (2/3) of the 1979 refugees and 48 percent (11/23) of the 1980 group were positive for malaria (*Plasmodium vivax*) (Table 3).

For the 1979 sample, one of the two refugees from whom both blood and fecal samples were taken was found to be free of pathogenic parasites, but the other had both blood and intestinal infections. One of the three refugees who gave stool samples was found to have a multiple infection, another an infection by a single pathogenic species, and the third was found to be pathogen-free. One Indochinese refugee, who submitted blood only, was found to harbor malarial parasites.

Data from the stool and blood samples examined during 1980 included individuals with no parasite infections and those with intestinal parasites, blood parasites, or both. Four refugees had four different species of intestinal parasites. The combined results of 1979 and 1980 show a high incidence of parasitism among the refugees entering Utah County. There were variations in percent infections for the two years, which would be expected due to the limited number of

TABLE 1a. Status for 6 of the 9 refugees checked in Utah County, Utah, for parasites, 1979.

Patient No.	Age	Sex	Height	Weight	Time in U.S.	Place of origin	Refugee camp	Time in camp
1	19	M	5'5"	102 lbs.	6½ months	Saigon	Malaysia	7 months
2	11	M	4'6"	70 lbs.	3 weeks	Saigon	Indonesia	8 months
3	54	M	5'5"	100 lbs.	3 weeks	Saigon	Indonesia	8 months
4	14	M	5'2"	90 lbs.	6½ months	Saigon	Malaysia	7 months
5	20	M	5'9"	110 lbs.	5 months	Saigon	Malaysia	8 months
6	17	F	5'2"	110 lbs.	6½ months	Saigon	Malaysia	7 months

TABLE 1b. Status for 28 of the 30 refugees checked in Utah County, Utah, for parasites, 1980.

Patient No.	Age	Sex	Arrival date, Utah Day/Month/Year	Refugee camp	Origin	Blood sample	Fecal sample
1	37	M	28-II-80	Chieng Khong, Thailand	Laos	1	0
2	16	M	28-II-80	Chieng Khong, Thailand	Laos	1	0
3	14	M	28-II-80	Chieng Khong, Thailand	Laos	1	0
4	7	F	28-II-80	Chieng Khong, Thailand	Laos	1	0
5	10	M	28-II-80	Chieng Khong, Thailand	Laos	1	0
6	5	M	28-II-80	Chieng Khong, Thailand	Laos	1	0
7	34	F	28-II-80	Chieng Khong, Thailand	Laos	1	0
8	55	M	1-III-80	Ubon, Thailand	Laos	1	1
9	50	F	1-III-80	Ubon, Thailand	Laos	1	1
10	29	M	1-III-80	Ubon, Thailand	Laos	1	1
11	19	M	1-III-80	Ubon, Thailand	Laos	1	1
12	12	M	1-III-80	Ubon, Thailand	Laos	1	1
13	21	M	1-III-80	Ubon, Thailand	Laos	1	1
14	9	M	1-III-80	Ubon, Thailand	Laos	1	1
15	13	M	1-III-80	Ubon, Thailand	Laos	1	1
16	17	F	1-III-80	Ubon, Thailand	Laos	1	1
17	26	F	1-III-80	Ubon, Thailand	Laos	1	1
18	28	M	1-III-80	Ubon, Thailand	Laos	1	1
19	71	F	1-III-80	Ubon, Thailand	Laos	1	1
20	42	F	14-III-80	Nong Khai, Thailand	Laos	1	1
21	47	M	14-III-80	Nong Khai, Thailand	Laos	1	1
22	4	F	14-III-80	Nong Khai, Thailand	Laos	1	1
23	20	M	14-III-80	Nong Khai, Thailand	Laos	0	1
24	7	M	14-III-80	Nong Khai, Thailand	Laos	0	1
25	18	M	14-III-80	Nong Khai, Thailand	Laos	0	1
26	12	M	14-III-80	Nong Khai, Thailand	Laos	0	1
27	9	M	14-III-80	Nong Khai, Thailand	Laos	0	1
28	28	M	12-VIII-80	Nong Khai, Thailand	Laos	1	0

TABLE 2a. Results of 9 stool specimens examined from 6 refugees entering Utah County (1979).

Parasite	No. of infected stools	% Infected stools
Entamoeba coli	2	22
Chilomastix mesnili	1	11
Endolimax nana	1	11
Giardia lamblia	1	11
Entamoeba histolytica	0	0
Hookworms	0	0
Ascaris lumbricoides	5	56
Trichuris trichiura	2	22

TABLE 2b. Results of 30 stool specimens examined from 30 refugees entering Utah County (1980).

Parasite	No. of infected stools	% Infected stools
Entamoeba coli	11	37
Chilomastix mesnili	1	3
Endolimax nana	0	0
Giardia lamblia	3	10
Entamoeba histolytica	0	0
Iodamoeba buetschlii	4	13
Hookworms	6	20
Clonorchis sinensis	12	40
Trichuris trichiura	7	23
Ascaris lumbricoides	4	13
Strongyloides stercoralis (larvae)	1	3

samples in 1979. For both years *Entamoeba coli*, a commensal, was the common protozoan parasite (22 percent, 37 percent) followed by *Giardia lamblia*, an intestinal parasite (11 percent, 10 percent) Table 2a, 2b. The most common intestinal parasite for 1979 was *Ascaris lumbricoides* (60 percent) followed by *Trichuris trichiura* (20 percent). For 1980 the fluke *Clonorchis sinensis* was first (40 percent), followed by *Trichuris trichuria* (23 percent), hookworms (*Necator americanus*

or *Ancylostoma duodenale*) (27 percent), and *Ascaris lumbricoides* (14 percent). For both years the only blood parasite encountered was *Plasmodium vivax* (malaria).

Fertilized helminth eggs of *Ascaris lumbricoides* and *Trichuris trichiura* were present both years, as well as unfertilized *Ascaris lumbricoides* eggs. There were no cestode

TABLE 3. Blood parasites (*Plasmodium vivax*) observed from refugees entering Utah County, 1979 and 1980.

Year	No. of samples	No. with parasites	% Infected
1979	4	3	75
1980	23	11	48

eggs in any of the fecal specimens. The nematodes or roundworms were the most common group of endoparasites.

The protozoan parasites were found in both cyst and trophozoite stages. *Entamoeba* *coli* was only found in the trophozoite stage, and *Chilomaxtis mesnili*, *Endolimax nana*, and *Giardia lamblia* were observed only in the cyst stage. *Plasmodium vivax* was the blood parasite found in some of the blood samples (Table 3).

Data from the samples we checked were compared with results from concurrent parasite studies of refugees in Salt Lake and Utah Counties, Utah, and Washington, D.C. (Tables 4,5,6).

DISCUSSION

Although more than 100,000 Indochinese refugees have been admitted to the United

TABLE 4a. Intestinal parasitism in Indochinese refugees, by age group, Salt Lake County, Utah, July–December 1979 (MMWR 1979).

	Age 0–4	Age 5–15	Age 16–24	Age 25–44	Age 45	All ages
Number examined	38	98	93	98	29	356
Helminths						
Ascaris lumbricoides	4 (11)[*]	7 (7)	7 (8)	5 (5)	1 (3)	44 (12)
Clonorchis sinensis	0	0	5 (5)	1 (1)	0	6 (2)
Hookworms	1 (3)	4 (4)	10 (11)	8 (8)	2 (7)	25 (7)
Strongyloides stercoralis	2 (5)	0	0	0	0	2 (1)
Trichuris trichiura	0	6 (6)	8 (9)	16 (16)	1 (3)	31 (9)
Protozoans						
Endolimax nana	0	5 (5)	5 (5)	1 (1)	2 (7)	13 (4)
Entamoeba coli	0	4 (4)	2 (2)	7 (7)	0	13 (4)
Entamoeba histolytica	0	0	2 (2)	0	1 (3)	3 (1)
Giardia lamblia	3 (8)	6 (6)	6 (6)	1 (1)	0	16 (4)

[*]Number of persons infected (percent infected).

TABLE 4b. Intestinal parasites in Indochinese refugees, by age group, Utah County, Utah, 1980.

	Age 0–4	Age 5–15	Age 16–24	Age 25–44	Age 45	All ages[**]
Number examined	53	120	102	170	49	494
Helminths						
Ascaris lumbricoides	6 (12)[*]	26 (22)	17 (17)	19 (11)	6 (12)	74 (15)
Clonorchis sinensis	7 (13)	38 (32)	31 (31)	42 (25)	6 (12)	124 (25)
Hookworms	11 (21)	40 (34)	25 (25)	40 (24)	18 (37)	134 (27)
Strongyloides stercoralis (larvae)	1 (2)	5 (4)	3 (3)	3 (2)	2 (4)	14 (3)
Trichuris trichiura	7 (13)	34 (28)	16 (16)	20 (12)	9 (18)	86 (18)
Taenia sp.	0	3 (3)	3 (3)	1 (1)	0	7 (1)
Protozoans						
Endolimax nana	1 (2)	6 (5)	4 (4)	6 (4)	3 (6)	19 (4)
Entamoeba coli	8 (15)	17 (14)	12 (12)	13 (8)	6 (12)	56 (11)
Entamoeba histolytica	1 (2)	7 (6)	2 (2)	6 (4)	2 (4)	18 (4)
Giardia lamblia	7 (13)	18 (15)	15 (15)	12 (7)	2 (4)	54 (11)
Entamoeba hartmani	1 (2)	2 (2)	2 (2)	1 (1)	1 (2)	7 (2)

[*]Percent infection in parentheses
[**]254 males; 35 percent infected
240 females; 30 percent infected

States in the past year, very few population-based data have been published on their health conditions other than intestinal parasitism and tuberculosis (MMWR 1979). Representative data are essential for realistic planning of initial health-care delivery for this population. Health departments, clinics, or other agencies that have collected or are collecting data on the health status of representative samples of the arriving refugee population (not simply clinic samples of the ill) are encouraged to share their findings with local and state health departments and CDC (MMWR 1979).

Investigations of parasite incidence among incoming refugees show generally the same organisms being encountered, but not necessarily in the same proportion. This is evident with malaria. A CDC report concerning the health status of Vietnamese refugees arriving in the U.S. (MMWR 1975:158) reported that, of 77,526 refugees seen, only two cases of malaria were reported. More recent reports indicate a higher incidence of malaria, however, with malaria being the number one cause of death among the Cambodian

refugees in Thailand, followed by malnutrition (MMWR 28:545–546, 1979; MMWR 28:388–398, 1979). A random survey of one camp revealed *P. falciparum* malaria in 30 of 80 people (38 percent) screened (MMWR 28:545–546, 1979).

Malaria (*Plasmodium*) can be definitively diagnosed only through the careful microscopic examination of blood films. For our study, both thick and thin blood films were made and the slides were stained with the Giemsa stain.

The films were carefully dried, then examined with oil immersion for any malarial stage. The number of malarial stages per 100 red blood cells (RBC) was noted on all thick film slides.

A national comparison from CDC states that, as of 18 August 1979, there were 19 new cases of malaria reported, with a cumulative total of 408. In September of 1979, 10 new cases were reported, with a cumulative total of 519 (MMRW 1979).

TABLE 5a. Parasites of 13 refugees checked by the Utah County Public Health Department, 1979.

Parasite	No. infected refugees	% Infected
Entamoeba coli	4	31
Entamoeba histolytica	1	7
Endolimax nana	1	7
Chilomastix mesnili	1	7
Giardia lamblia	2	15
Hookworms	11	85
Strongyloides stercoralis (larvae)	2	23
Ascaris lumbricoides	4	31
Trichuris trichiura	1	7

TABLE 5b. Parasites of 494 refugees checked by the Utah County Public Health Department, 1980.

Parasite	No. infected refugees	% Infected
Entamoeba coli	48	8
Entamoeba histolytica	18	4
Entamoeba hartmani	9	2
Endolimax nana	21	5
Chilomastix mesnili	0	0
Giardia lamblia	52	11
Hookworms	132	27
Strongyloides stercoralis (larvae)	12	3
Ascaris lumbricoides	68	14
Trichuris trichiura	88	18
Clonorchis sinensis	125	26
Taenia sp.	5	1

TABLE 6. Intestinal parasitism in Indochinese refugee children, by age group, Washington, D.C., September–November 1979 (MMWR 1979).

	Age 0–4	Age 5–9	Age 10–18	All ages
Number examined	6	16	9	31
Ascaris lumbricoides	2 (33)[a]	9 (56)	3 (33)	14 (45)
Clonorchis sinensis	0	0	1 (11)	1 (3)
Giardia lamblia	1 (17)	4 (25)	1 (11)	6 (19)
Hymenolepis nana	0	1 (6)	1 (11)	2 (6)
Strongyloides stercoralis	0	2 (13)	3 (33)	6 (16)
Trichuris trichiura	0	3 (19)	0	3 (10)

[a] Number positive (percent positive).
All *Strongyloides* infections were in children from one family.

In a typical three-month period in Utah
(1979), the Utah Bureau of Laboratories ex-
amined approximately 800 stool specimens,
of which 76 (9.5 percent) were positive, with
Giardia lamblia being the most commonly
identified organism (4.8 percent), followed by
Trichuris (0.5 percent), *Entamoeba histolytica*
(0.13 percent), *Ascaris* (0.13 percent), and
hookworms (0.13 percent) (Olsen and Fuku-
shima 1977). Refugee screening is an efficient
means of gaining information about parasites.

*Giardia lamblia, Chilomastix mesnili, Enta-
moeba coli*, and *Endolimax nana* are relative-
ly nonpathogenic intestinal protozoans with a
worldwide geographic distribution. They oc-
cupy different locations in the intestinal tract
of humans, being asymptomatic or causing
mild diarrhea (Spencer and Monroe 1977).
The infective stage is the cyst that is passed
out of the intestine with fecal material. Stud-
ies of these protozoans have shown that wa-
ter can be contaminated with host fecal
material.

Refugees infected with intestinal helminths
and protozoa should not create a problem to
the public. Adequate sewage disposal inter-
rupts the transmission of the helminths,
which require several days of incubation in
soil to become infective.

In conclusion, because of present sanitary
conditions in Utah County, no serious prob-
lems should occur due to refugees in this
area. Further investigation, as well as host
treatment and follow up of diagnosed cases,
would be appropriate.

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THE INVERTEBRATE FAUNA OF THE CAVES
OF THE UINTA MOUNTAINS, NORTHEASTERN UTAH

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Abstract.— Seven large caves in the Uinta Mountains, Utah, were surveyed for their invertebrate faunas. Thirty-eight species were found, and 30 of these are typical cave inhabitants. Diptera are the predominant group. Cave-restricted species are an amphipod, two diplurans, and possibly a *Rhagidia* mite. The caves were probably uninhabitable in the past glacial because of severe periglacial environmental conditions, and the faunas have moved into the present cave sites since deglaciation of the Uintas.

Since the helpful checklist of Nicholas (1960), much additional survey work has been completed on the cavernicolous invertebrate faunas of the United States (see review in Peck and Lewis 1978). However, gaps still exist in certain western states, and these should be filled in an attempt to achieve a comprehensive understanding and a unified general theory of the evolution and distribution of North American cave invertebrates (Peck 1978, 1981).

The Uinta Mountains of northeastern Utah are ringed by limestone and contain many caves, but no effort seems to have been made to characterize their fauna. Field work was conducted in August 1979 to remedy this.

Extensive information is available on the caves of Utah, although much of it exists in obscure publications. A general overview of Utah speleology is given by Green (1963a), and White (1979) discusses karst landforms in the Uinta Mountains. Brief information on the caves studied follows. These are the largest known in the Uintas and are the most likely to have a variety of microhabitats, and thus to support the greatest diversity of invertebrate fauna.

Cave locations are shown in Figure 1. They are indicated on USGS topographic maps and on U.S. Forest Service maps of the Ashley and Uinta Forests. All the caves are formed in the Madison and Deseret lime-

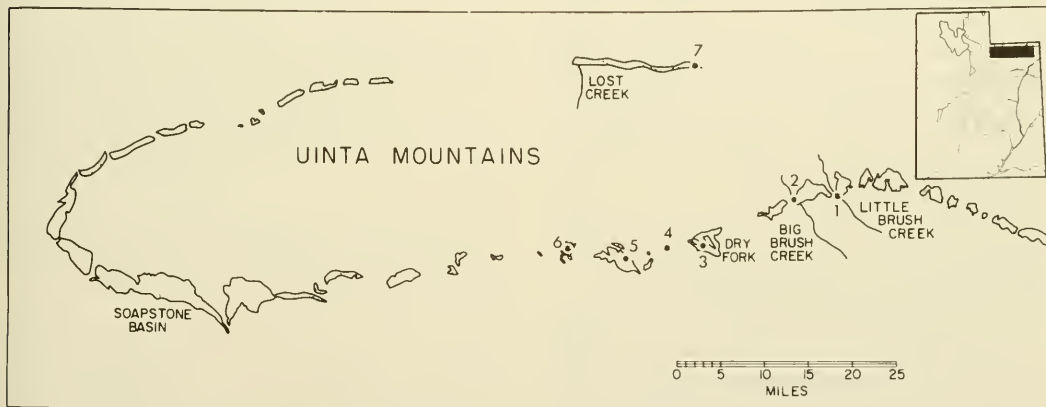Fig. 1. Pattern of outcrop of Mississippian limestones ringing the Uinta Mountain uplift (adapted from White 1979). Caves surveyed for invertebrate faunas are: 1, Little Brush Creek Cave; 2, Big Brush Creek Cave; 3, Dry Fork Cave; 4, Ice Cave; 5, White Rocks Cave; 6, Pole Creek Cave; 7, Sheep Creek Cave. Inset shows location of Uinta Mountains in Utah.

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stones of Mississippian age. Because caves are fragile environments, excessive and careless visitation to them should not be encouraged.

Big Brush Creek Cave, Uintah County, Sec. 29, T 1 S, R 21 E, on Red Cloud Loop forest road 018, about 9000 ft elev., about 17 mi N of Vernal.

This cave lies in a large stream sink and has a very large entrance arch. Up and to the left of the entrance is an upper and irregular series of passages called the ice cave section. The main passage narrows somewhat before entering a huge room containing much wood debris, indicating that this and deeper areas of the cave fill completely with flood waters. The cave continues down through a series of crawls and chambers into a maze of water-scoured passages with pools. At 26,000 ft in length, and an 800 ft depth (White 1978, Green 1963b), it is the largest cave in Utah. Temperatures were 1 C in the first big room, and 6 C in the second (RH 93 percent).

Little Brush Creek Cave, Uintah County, Sec. 25, T 1 S, R 21 E, about 8000 ft elev., near route 44, about 18 mi N of Vernal.

The cave has a large arched entrance in a large sink into which flows a wet weather stream. In time of flood, water ponds in the sink and log jams occur in narrow passages. The cave is 15,000 ft long and 500 ft deep (White 1979, Green 1963a, 1963c). Fauna was found on rotting wood, flood debris, and sand. The temperature was 10 C (RH 88 percent). The local environment is boreal forest, with the north-facing hillside above the cave covered by spruce and fir.

Dry Fork Cave, Uintah County, Sec. 21, T 3 S, R 19 E, in Dry Fork Canyon, at about 8000 ft elev., about 18 mi NW of Vernal.

The entrance is a stoopway in a rock outcrop on a hillside. The cave is an ascending walking-crawling passage with about 100 ft of main passage (Green 1957), which is mostly dry but with some moist and wet areas. The cave floor is of dust, clay, sand, and small to large, rounded stream boulders. The temperature was 9 C (RH 94 percent). The sparse fauna was concentrated near moist areas and at moist *Neotoma* packrat droppings and decaying nest debris.

Ice Cave, Uintah County, Sec. 5, T 2 W, R 1 E, near the top of Ice Cave Peak, off forest road 104, about 9700 ft elev., about 15 mi NNW of Lapoint.

The cave's slotlike entrance is at the bottom of an aspen-lined sink. The cave consists solely of a low chamber 30 feet wide and 60 feet long, floored with dirt and much ice. The fauna is concentrated on the cave ceiling and uses the cave as a daytime retreat or as an aestivation site. When insects die they fall to the ice and may be preserved there. Other arthropods are in litter and decaying debris at the base of the entrance slope. The air temperature was 4 C (RH 85 percent) 3 ft above the ice.

Whiterocks Cave, Duchesne County, Sec. 1, T 2 N, R 1 W, about 8000 ft elev., high on cliffs above Whiterocks River Canyon, about 10 mi N of Whiterocks, or 15 mi NNW of Lapoint.

The gated cave entrance is reached by an arduous climb. Entry is allowed only with forestry personnel and arrangements must be made with the Vernal office several weeks in advance. This is a large cave of irregular dimensions, and it is certainly in need of protection to conserve it. Much of this cave, about 3000 ft long, is generally moist but lifeless, and fauna was found associated with moist rat dung only near the entrance. Many dripstone pools are present but are also barren of life. The temperature was 7.5 C (RH 94 percent). The abundant packrat middens may contain a valuable record of past climatic and floristic changes in the area of the cave (see Van Devender and Spaulding 1979).

Pole Creek Cave, Duchesne County, Sec. 24, T 3 N, R 2 W, off forest road 117, around 7000 ft elev., about 12 mi NW of Whiterocks or 23 mi NNW of Roosevelt.

The cave entrance is a flood-water stream resurgence at the base of a limestone slope. The sink of Pole Creek is a broad area about ½ mi north. The low entrance leads to a large ascending stream passage floored with sand, mud, and water-sculptured rock. About 600 ft of passage exists before a deep pool floods the cave from wall to wall. The air temperature was 8.5 C (RH 87 percent) and the water was 8 C. The fauna was on damp soil near scarce bits of organic debris, or on the ceiling at the entrance.

Sheep Creek Cave, Daggett County, Sec. 16, T 2 N, R 19 E, at 7040 ft elev., about 7 mi SW of Manila.

The cave is formed in vertical limestones on the west wall of Sheep Creek Canyon where this intersects the Uinta Crest fault. The Forest Service has protected the cave entrance, some 30 m above the cave stream resurgence, by a gate, but this has been vandalized. The main cave passage is the abandoned upper level of the stream that now resurges at a lower level. I judge the ashy nature of much of the cave floor, the "burnt" smell in the cave, and the soot-darkened ceiling to indicate that large accumulations of organic matter, such as packrat nests, formerly existed here but have been burned. This likely happened in or before 1950, and is regrettable because a valuable paleoenvironmental record (see Van Devender and Spaulding 1979) has been mostly lost. A few isolated middens still exist near the entrance. The "burned" part of the cave is barren. Lower levels near the stream had a sparse fauna on mud banks. The stream seems to carry only finely divided organic matter. The air temperature was 9.5 C (RH 94 percent) at the stream and the stream was 9 C.

Annotated Faunal List

The following contains the standard terminology for cavernicolous animals (see Barr 1968, Peck and Lewis 1978).

PHYLUM ANNELIDA
Class Oligochaeta
Family Lumbricidae
Aporrectodea tuberculata (Eisen), D. Schwert det., troglophile-edaphobite.
Little Brush Creek Cave, 3. Big Brush Creek Cave, 5.
Allolobophora sp., D. Schwert det., troglophile-edaphobite.
Big Brush Creek Cave, 1 immature.
Family Enchytraeidae
Genus and species undetermined, troglophile-edaphobite.
Big Brush Creek Cave.
PHYLUM ARTHROPODA
Class Crustacea
Order Amphipoda
Family Crangonyctidae
Stygobromus sp., J. Holsinger det., troglobite.

Pole Creek Cave, abundant in flooded passage. These are an undescribed species, very similar to several others in the western *hubbsi* group (Holsinger 1974). This is the first collection of subterranean amphipods from Utah.
Class Arachnida
Order Aranea
Family Erigonidae
Anacornia proceps Chamberlin, W.J. Gertsch det., troglophile.
Big Brush Creek, 1 female and 1 immature. Dry Forks Cave, 1 male, 11 females, 8 immatures.
Order Acarina
Family Rhagidiidae
Rhagidia sp., cf. *grahami* Elliott, troglophile or troglobite.
Little Brush Creek Cave (type locality), Sheep Creek Cave, Ice Cave, Big Brush Creek Cave, and Dry Forks Cave. The species was previously reported only from the type locality (Elliott 1976), but the above abundant records may represent other species as well in this poorly known genus.
Family Oribatidae
Genus and species undetermined, troglophile.
Big Brush Creek Cave, abundant on flood debris.
Class Chilopoda
Order Scolopendromorpha
Family Scolopendridae
Genus and species undetermined, accidental?
Big Brush Creek Cave, one in flood debris.
Class diplopoda
Order Polydesmoidea
Family, genus, and species undetermined, troglophiles?
Dry Forks Cave. A small eyeless species abundant on damp debris.
Class Insecta
Order Collembola
Family Onychiuridae
Onychiurus decus Christiansen, K. Christiansen det., troglophile.
Big Brush Creek Cave. The species was previously known only from a snowfield in Montana (Christiansen and Bellinger 1980:431).
Onychiurus similis Folsom, K. Christiansen det., troglophile.
Pole Creek Cave. The species is widespread across the United States, with only

one cave record from Texas (Christiansen and Bellinger 1980:437).

Onychiurus ramosus Folsom, K. Christiansen det., troglophile.

Whiterocks Cave, on moist rat dung. The species is widespread across the United States, with only two cave records from Virginia (Christiansen and Bellinger 1980:453).

Family Tomoceridae

Tomocerus flavescens (Tullberg), K. Christiansen det., troglophile.

Big Brush Creek Cave, Little Brush Creek Cave, Pole Creek Cave. Christiansen (1964) notes that the species is spread across the continent and is known from caves in 14 states.

Order Diplura

Family Campodeidae

Haplocampa sp., L. M. Ferguson det., troglobite.

Pole Creek Cave. This is a new species with an unusual morphology. The genus contains cavernicolous species in Illinois, Missouri, California, and Washington; and epigean species in California, Montana, Oregon, Washington, and Alberta.

Haplocampa sp., L.M. Ferguson det., troglobite.

Sheep Creek Cave, Little Brush Creek Cave, Big Brush Creek Cave. This is a new species and may represent a new genus.

Order Coleoptera

Family Carabidae

Bembidion sp., accidental.

Big Brush Creek Cave, on flood debris.

Rhadine sp., troglophile.

Dry Forks Cave, one dead on sand bank.

Family Staphylinidae

Quedius spelaeus Horn, troglophile.

Dry Forks Cave, many in *Neotoma* dung and nest debris. The species occurs across the continent, frequently in caves (Smetana 1971).

Genus and species undetermined, troglophile?

Ice Cave, two in entrance debris. These are in the subfamily Aleocharinae, which is frequently found in caves.

Family Scarabaeidae

Aphodius sp., accidental.

Ice Cave, three in entrance debris.

Order Lepidoptera

Family Noctuidae

Euxoa auxiliaris (Grote), D. LaFontaine det., trogloxene.

Ice Cave. This and the following species of fairly widespread moths often retreat to caves to aestivate or to seek a daytime retreat.

Euxoa idahoensis (Grote), D. LaFontaine det., trogloxene.

Ice Cave.

Apamea amputatrix (Fitch), D. LaFontaine det., trogloxene.

Ice Cave.

Scoliopteryx libatrix (Linnaeus), trogloxene.

Pole Creek Cave. The species is worldwide, and commonly uses caves as overwintering sites.

Order Siphonaptera

Family Ceratophyllidae

Orchopeas sexdentatus (Baker), G. Holland det., ectoparasite.

This is a widespread flea on *Neotoma* wood rats, and these specimens were abundant in a *Neotoma* nest in Dry Forks Cave.

Order Diptera

Family Tipulidae

Pterelachisus sp., H. Teskey det., trogloxene.

Ice Cave, on ceiling.

Yamatipula sp., H. Teskey det., trogloxene.

Ice Cave, on ceiling.

Family Mycetophilidae

Rymosia sp., R. Vockeroth det., trogloxene.

White Rocks Cave, Ice Cave.

Bolitophila sp., R. Vockeroth det., trogloxene.

Ice Cave.

Bolitina sp., R. Vockeroth det., trogloxene.

Ice Cave.

Exechia sp., R. Vockeroth, trogloxene.

Ice Cave.

Exechiopsis sp., R. Vockeroth det., trogloxene.

Pole Creek Cave, abundant 'on ceiling at entrance; Ice Cave.

Mycetophila sp., R. Vockeroth det., trogloxene.

Ice Cave.

Family Sciaridae

Lycoriella sp., R. Vockeroth det., trogloxene or troglophile.

White Rocks Cave, Dry Forks Cave.

Family Spheroceridae
Leptocera sp., R. Vockeroth det., trogloxene or troglophile.
     Ice Cave, Dry Forks Cave.
Family Phoridae
Megascelia sp., R. Vockeroth det., trogloxene or troglophile.
     Ice Cave.
Family Heleomyzidae
Genus and species undetermined, trogloxene or troglphile.
     Ice Cave.
Family Anthomyidae
Genus and species undetermined, accidental.
     Ice Cave.

Discussion

A total of 38 species were found in caves in the Uinta Mountains. Of these, 30 species are in taxa that are typical of caves and cave-like habitats in North America in their behavioral, ecological, and evolutionary characteristics. The only true cave-limited species are the amphipod, 2 diplurans, and possibly the *Rhadidia* mite.

As habitats, the caves themselves are probably preglacial in time of origin, especially White Rocks Cave. The caves may not have been overridden by the Pleistocene piedmont and valley glaciers coming from the Uinta Mountain uplands (Atwood 1904, Hansen 1975), but they would have suffered extreme and prolonged flooding and scouring by meltwater streams. The caves were probably uninhabited during glacials because they were colder, there was less food input due to periglacial climatic conditions, and because of meltwater scouring. Thus, the fauna probably represents an occupation of caves sometime in the past 10,000 years since the last glacial. In this respect the fauna is very similar to that of Ontario, Canada, caves which have been occupied since the last glacial, and have an abundance of trogloxenic diptera (Peck, unpubl. ms.).

The amphipod may be an exception to this generalization. Holsinger (1980) thinks that some groundwater amphipods may have existed under glacial ice masses, but I am inclined to keep open the alternative of movement from unglaciated peripheral refugia, through interstices in groundwater, into the

area after deglaciation (Peck and Lewis 1978). A large fauna is known to live in the west in the interstices of gravels and coarse streamside sediments (Stanford and Gaufin 1974), which knowledge supports the possibility of such faunal movements.

Future research can contribute by surveying cave faunas in the western Uintas. The area of greatest present ignorance of cave faunas is in the details of their life cycles and seasonal dynamics. Most rewarding would be careful ecological study of the troglobites or of the trogloxenic Diptera.

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EVALUATING THE RELATIONSHIP BETWEEN MULE DEER PELLET-GROUP DATA AND AVAILABLE WINTER RANGE, USING LANDSAT IMAGERY

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ABSTRACT.— In this study, mule deer population trend data (deer-days-use/hectare) were statistically analyzed with range area data that were extracted from LANDSAT satellite imagery. The remote sensing techniques developed use multidate, winter images of an area in central Utah. Snow-covered areas and vegetational areas mapped from the imagery were composited into 26 maps representing the approximate winter range available to mule deer on 26 dates over a five-year period (1972–1977). Utah State Division of Wildlife Resources pellet-group transect data were statistically analyzed with range data measured from the satellite imagery. Range area accounted for a fairly large proportion of the variation in deer-days-use/hectare (r = –.83). This result seems reasonable since deer population density should increase as available range decreases.

In this study the relationship between vegetational area defined by the extent of snow cover and mule deer pellet-group transect data are examined. LANDSAT satellite imagery was used as a means of measuring the distribution of snow cover and vegetation in an area of central Utah between 1972 and 1977.

Researchers studying deer population dynamics agree that snow cover and winter range are critical limiting factors of deer populations (Aldous 1945, Anderson et al. 1974, Dasmann and Hjersman 1958, Gilbert et al. 1970, Leopold et al. 1951, Levaas 1958, Richens 1967, Wallmo et al. 1977). Use of remote sensing techniques for analyzing wildlife populations and wildlife habitat is not a recent development. Low altitude aerial photograph interpretation has been a commonly employed technique since the mid-1930s for vegetational analysis (Dalke 1937, 1941, Leedy 1948) and for direct censusing of wildlife populations (Heyland 1975, Meier 1975).

In the past 20 years, development of new sensing systems has generated an intense interest among wildlife biologists in the application of new remote sensing techniques. Many standard field procedures used to study wildlife are laborious and time consuming, and the prospect of gaining data more rapidly has prompted much of the current interest in remote sensing. Among the more recently developed sensors that augment conventional aerial photography in wildlife investigations are radar, thermal infrared scanners, and multispectral scanners. Platforms that contain these sensor packages are midaltitude commercial aircraft, high altitude U-2 and RB-57, and NASA's LANDSAT satellites. NASA's LANDSAT program began in the summer of 1972 with the launching of LANDSAT 1 (formerly called ERTS 1) and has continued with the launching of two subsequent satellites (LANDSAT 2 and 3) (U.S. Geological Survey 1979). Because these satellites retrieve data from the same geographic area every 18 days, this new technology provides wildlife managers with the potential of repeated monitoring of wildlife habitat.

In addition to wildlife and vegetation studies, the LANDSAT satellites are a useful data source for numerous other resource studies. One approach important to the present research was initially developed to monitor the variable of winter snow cover in montane hydrologic cycles (Aul and Ffolliott 1975, Barnes 1974, Evans 1974, Meier 1975, Rango 1975). In these LANDSAT snow surveys, visual interpretation of enlarged imagery (scale = 1:250,000) was an accurate means of mapping the areal extent of snow cover. Snow cover and winter range are agreed to be important to deer population dynamics, and it has been demonstrated that LANDSAT is capable of detecting changes in snow cover. With these two factors taken into consideration, this project was undertaken to refine

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a remote sensing technique that would utilize snow measurements made from satellite imagery for predicting regional deer population trends.

STUDY AREA

The study area (Fig. 1), which lies mainly along the Wasatch Plateau in central Utah, is
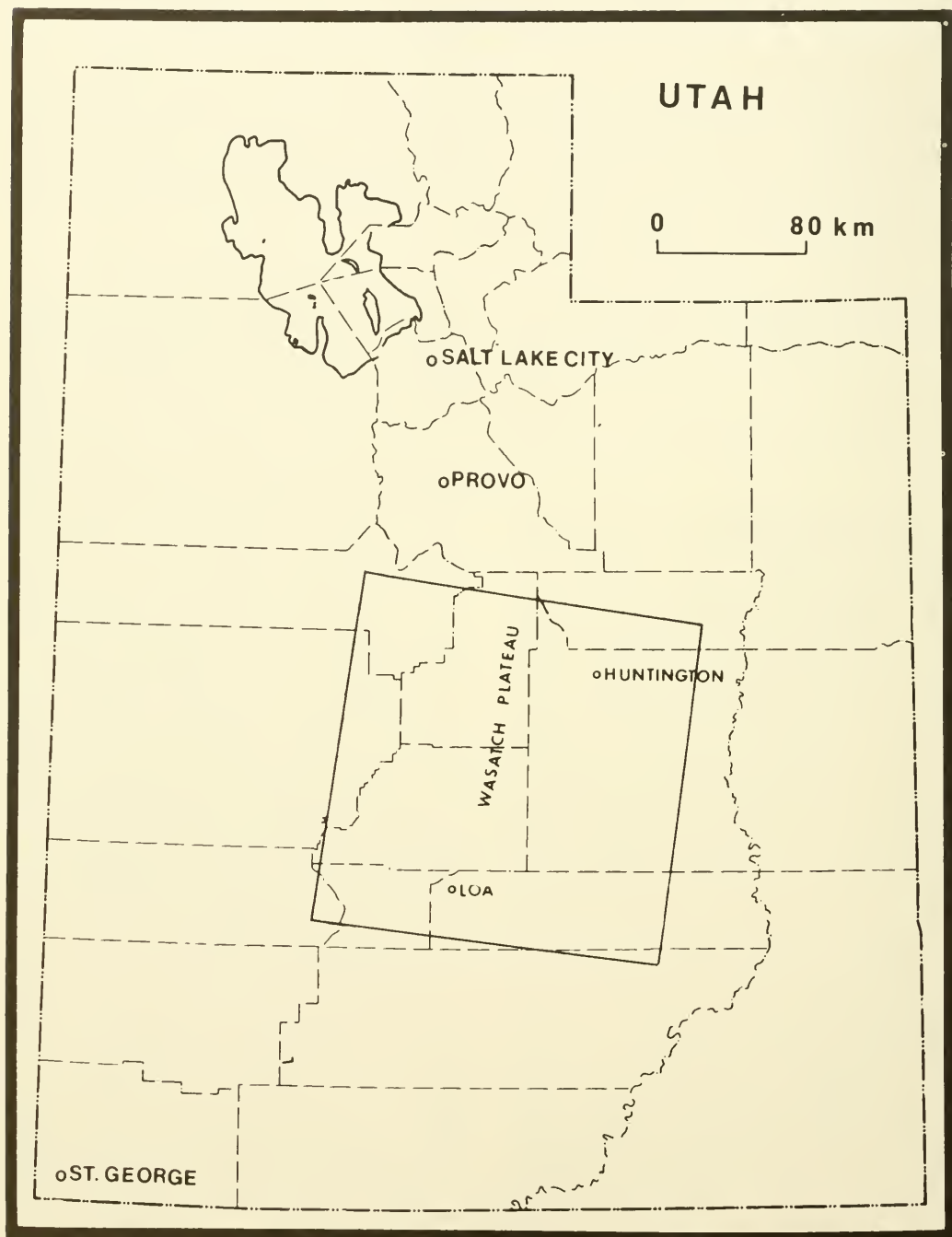

Fig. 1. Location of the study area within Utah. Boundaries are not aligned directly north and south because of the orbital paths of the LANDSAT satellites.

physically complex and consists of dominant, north-south-oriented mountain ranges dissected by low valleys. Physiographic features included in the study area include the Wasatch Plateau, the Sevier Plateau, and the southern tip of the Wasatch Mountains. Vegetation of this area reflects both the complexity of the physical environmental patterns and their apparent modifications by man. Areas modified by man support a combination of agricultural land uses including dry farming (nonirrigated) of winter wheat, irrigated farming of alfalfa, and pasturage of livestock (mainly sheep and cattle). Less disturbed areas of the valleys are dominated by desert shrub species relatively common throughout the cold desert. They include big sage (*Artemisia tridentata*), rabbit brush (*Chrysothamnus nauseosus*), Mormon tea (*Ephedra viridis*), bromegrass (*Bromus* spp.), wheatgrass (*Agropyron* spp.), and grama (*Bouteloua* spp.). Along a hypothetical transect from the low valleys to the mountain crest, the undisturbed vegetation communities above the valley floors form four plant zones that vary according to environmental gradients of temperature and moisture. The first communities to be encountered above the previously described desert shrub communities are either deciduous shrub (*Acer grandidentatum-Quercus gambelii*) or juniper-pinyon (*Juniperus* spp.-*Pinus edulis*). These two communities occur in approximately the same elevational range and are segregated primarily by differences in available moisture, with deciduous shrub communities occurring in the more mesic sites. The second elevational zone comprises a combination of forested plant communities, but the dominant community in the study area is aspen (*Populus tremuloides*). Scattered among this dominant community are relatively homogenous stands of the Douglas fir-white fir community type (*Pseudotsuga menziesii-Abies concolor*); these localized stands are also apparently controlled by local site factors. At higher elevations the communities in the third elevational zone make a gradual transition to spruce-fir (*Picea englemanii-Abies lasiocarpa*). The uppermost community or fourth elevational zone encountered in this transect is alpine tundra (various mat-forming species), which reflects the combination

of dessication (frost and wind) and poor soil formation at the highest elevations of this area (Allred 1975, Arnow and Wyckoff 1977, Buchanan and Nebeker 1971). Within the study area (Fig. 1) are 15 deer herd management units, whose boundaries are defined by the Utah State Division of Wildlife Resources (DWR). These herd units (Fig. 2) are the basis for the state's retrieval of deer population data and the implementation of deer management regulations. They are also the areas from which deer population data are analyzed in this study.

Methods

Data for this study were extracted from two primary sources. The first source was a report published by the Utah State Division of Wildlife Resources (1978) that provided detailed data from pellet-group transects within the study area. The second major data source for this study consisted of imagery from the NASA LANDSAT satellites. Satellite imagery was used for mapping of vegetation distribution and seasonal distribution of snow cover. Vegetation interpretation and mapping was carried out on a false-color composite LANDSAT image at a scale of 1:250,000, dated 25 August 1977 and processed to a positive print. Because of the small scale of the image, detailed vegetation interpretation was not carried out. Instead, the vegetational boundaries mapped consisted of the interface between oak-maple or pinyon-juniper communities and desert shrub communities. This boundary is significant because it approximates the lower elevational limits of vegetation types considered suitable for deer wintering (Leopold 1951, Richens 1967). So, per se, the map discussed was not a map of vegetational species, but rather a map showing the lower elevational extent of all vegetation types considered by many as suitable winter range for mule deer. As this vegetational boundary was interpreted on the image it was traced directly onto an acetate (stable drafting film) overlay. After this map was completed it was photographically reduced to a scale of 1:500,000 (50 percent reduction) and processed to a film positive print. Snow cover was mapped using 70 mm black and white LANDSAT band 5 transparencies (1:3,000,000) and a color additive

viewer that enlarged the 70 mm trans-
parencies to a mappable scale (1:500,000).
Mapping of snow cover consisted of delineat-
ing a boundary along which snow was pres-
ent on one side and absent on the other. No
attempt was made in this study to differen-
tiate snow depths from satellite imagery. Al-
though it is well known that snow depth and
snow condition (ice crusts, etc.) both have a
strong influence on deer distribution (Gilbert

et al. 1970) these parameters were not detec-
table on the LANDSAT imagery used in this
research. The rationale for using simply pres-
ence or absence as a measure was that, as
snow accumulates and extends to lower ele-
vations or ablates and recedes to higher ele-
vations, the areal extent of snow in itself
should represent a general shrinking or en-
larging of available winter areas for deer. Af-
ter the individual images were enlarged into
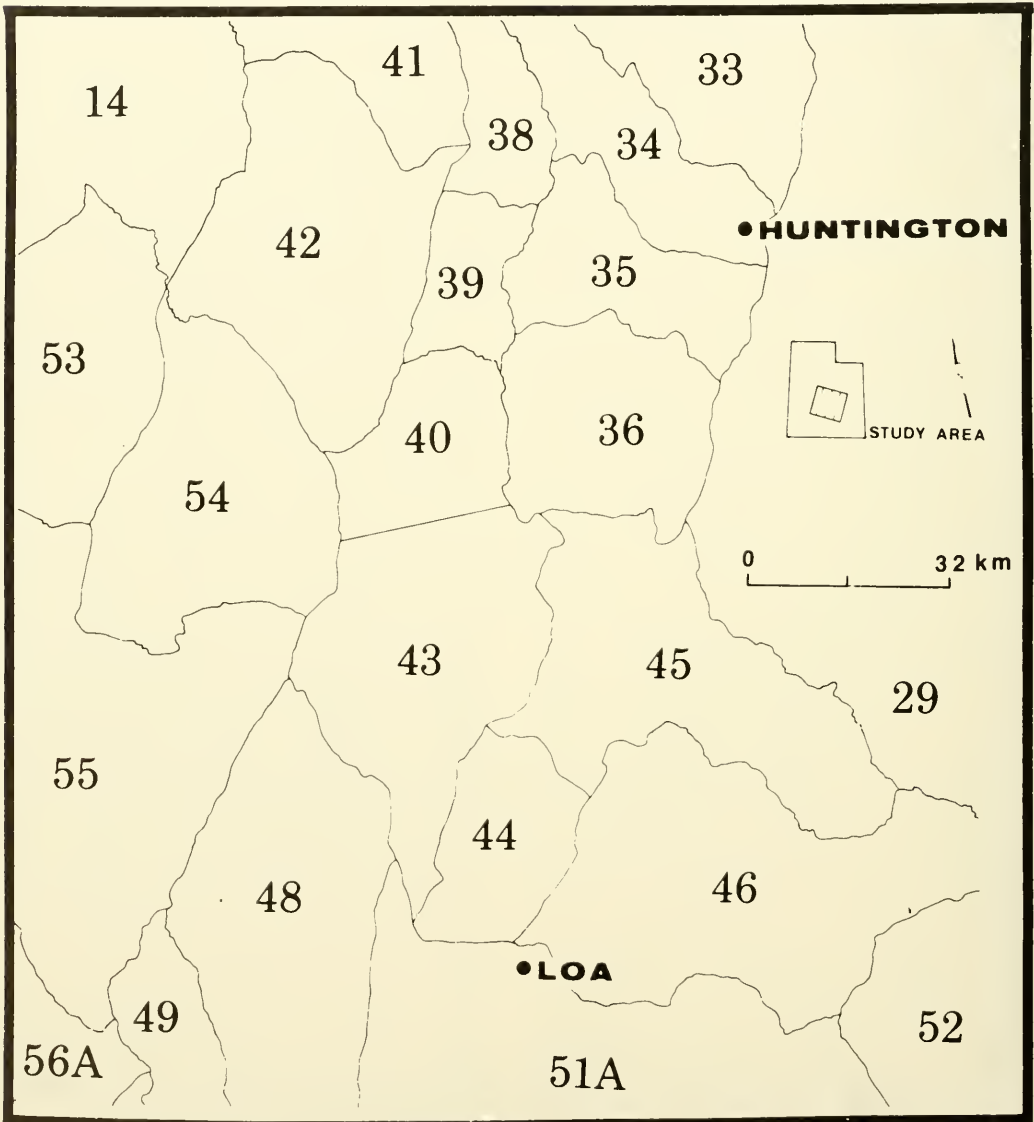
Fig. 2. Locations of the Utah State Division of Wildlife Resources deer herd management units in the study area.

the drafting surface of the color additive viewer, the snow boundary was traced manually onto an acetate overlay. Snow cover was mapped for a period extending from the winter of 1972–73 to the winter of 1976–77. In all, 30 LANDSAT images of different dates were interpreted and mapped for snow cover (Table 1). Although the satellites each cover the same ground scene every 18 days, cloud cover during the winter period limited the acquisition of 18-day repetitive coverage of the study area.

In the last phase of the mapping procedure, the snow cover maps were composited with the vegetation map to form the final maps, which portray the distribution of vegetation assumed to be suitable for deer winter range at given points in time. After the composite maps were produced, the winter range areas were measured with a Hewlett-Packard Model 9866A microcomputer that was interfaced with a map board and cursor. The microcomputer was programmed as an electronic planimeter to automatically

compute area from the map scale. As a result of the composite mapping, 26 maps (four images indicated total snow cover and were therefore not mapped) were produced, which illustrate the annual variation, in the mapped winter range, over a five-year period (Fig. 3). Data from both sources were compiled into two separate sets of observations. This compilation was accomplished by dividing the study area into two distinct geographic units (Fig. 4). DWR pellet-group transect data were placed in the observations of the first or second geographic unit and analyzed with vegetational area data from that same area. This summarization of herd unit data from the 15 DWR-designated units was carried out because of a lack of any real barriers to deer migration between most of the DWR units. The boundary that separated the herd units into two distinct geographic units was placed along the center of a broad, low-elevation valley with heavy agricultural use. Because of sparse vegetation this may be a more realistic barrier to deer migration and, therefore, a reasonable separation of populations. After compiling the data in this fashion (Table 2), the vegetational data extracted from satellite imagery and the DWR transect data were analyzed by regression (Nie et al. 1975).

Table 1. Dates of LANDSAT satellite imagery acquired for analysis of snow cover and vegetation.

2 February 1973
15 April 1973
3 May 1973
8 June 1973
30 October 1973
15 February 1974
28 April 1974
16 May 1974
26 June 1974
19 September 1974
25 October 1974
30 November 1974
5 January 1975
28 February 1975
5 April 1975
11 May 1975
25 June 1975
20 October 1975
4 December 1975
18 January 1976
27 January 1976
21 March 1976
30 March 1976
14 May 1976
26 June 1976
5 October 1976
14 October 1976
28 November 1976
16 December 1976
9 April 1977

Results and Discussion

Regression analysis of the data (Fig. 5) supports the assumption of a relationship between range area measured with the remote

Table 2. Data for deer population with observations based on areas corresponding to Figure 4.

Area	Year	Mean deer-days-use/ hectare	Mean square kilometers of winter range
1	1973	61.0	1538.5
	1974	56.2	1834.2
	1975	69.3	2110.3
	1976	40.1	2892.5
	1977	29.7	4133.9
2	1973	128.0	1154.1
	1974	99.0	1533.0
	1975	94.1	1427.6
	1976	72.5	1915.0
	1977	44.6	3014.0

Area 1 corresponds to DWR herd units 34, 35, 36, 45, 46, 51A, 38, 39, 40, 43, and 44.
Area 2 corresponds to DWR herd units 42, 54, 48, 53, and 59.

sensing technique and the DWR pellet-group transect measure of deer-days-use/hectare ($r = -.83$, $P < .003$). These results seem logical, even though in this research there was no direct consideration of the important snow parameters mentioned earlier (i.e., snow depth and snow condition), since it would be ex-

pected that seasonal shifts in snow elevation through accumulation and ablation would, perhaps, influence these parameters. The negative relationship demonstrated by these analyses would seem reasonable because, as snow cover increased over the suitable vegetation types, causing a shrinkage of winter
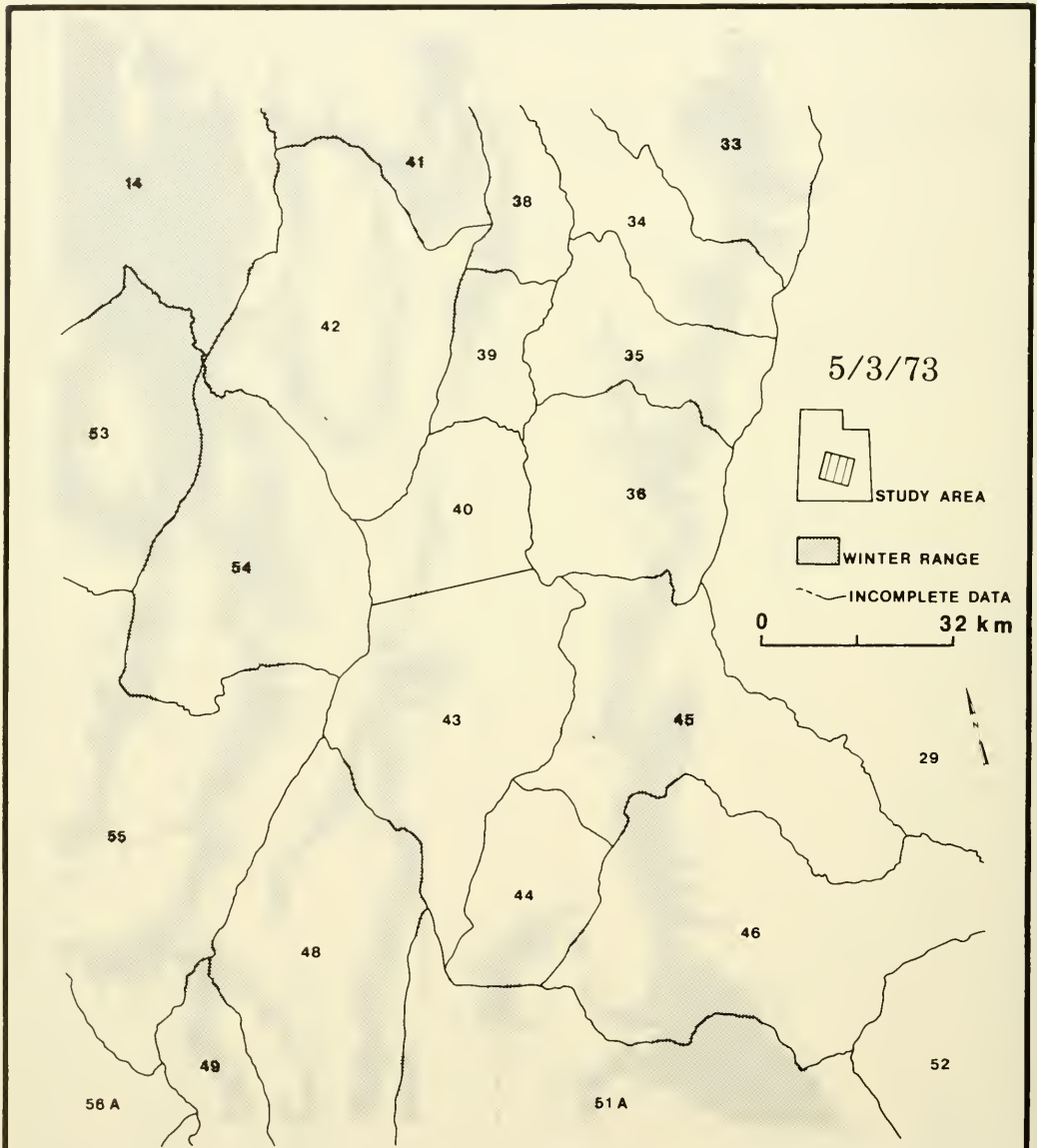
Fig. 3. Sample composite map (1 of 26) that is the result of combining a snow cover map (generated from the interpretation of satellite imagery), a map of the lower boundary of deer habitat (interpreted from satellite imagery), and a map of the state defined herd unit boundaries (delimited by legal description onto a 1:250,000 U.S.G.S. quadrangle). Each of the maps that were developed represent deer winter range available on the date the satellite imagery was acquired.

range, deer use would tend to increase per unit area of available range. This finding may have several important management implications: as a new technique for assessing winter ranges over large areas in a relatively short time, for evaluating land areas for acquisition by the state for winter range preservation, and for analyzing the effects of winter cloud seeding on deer ranges.

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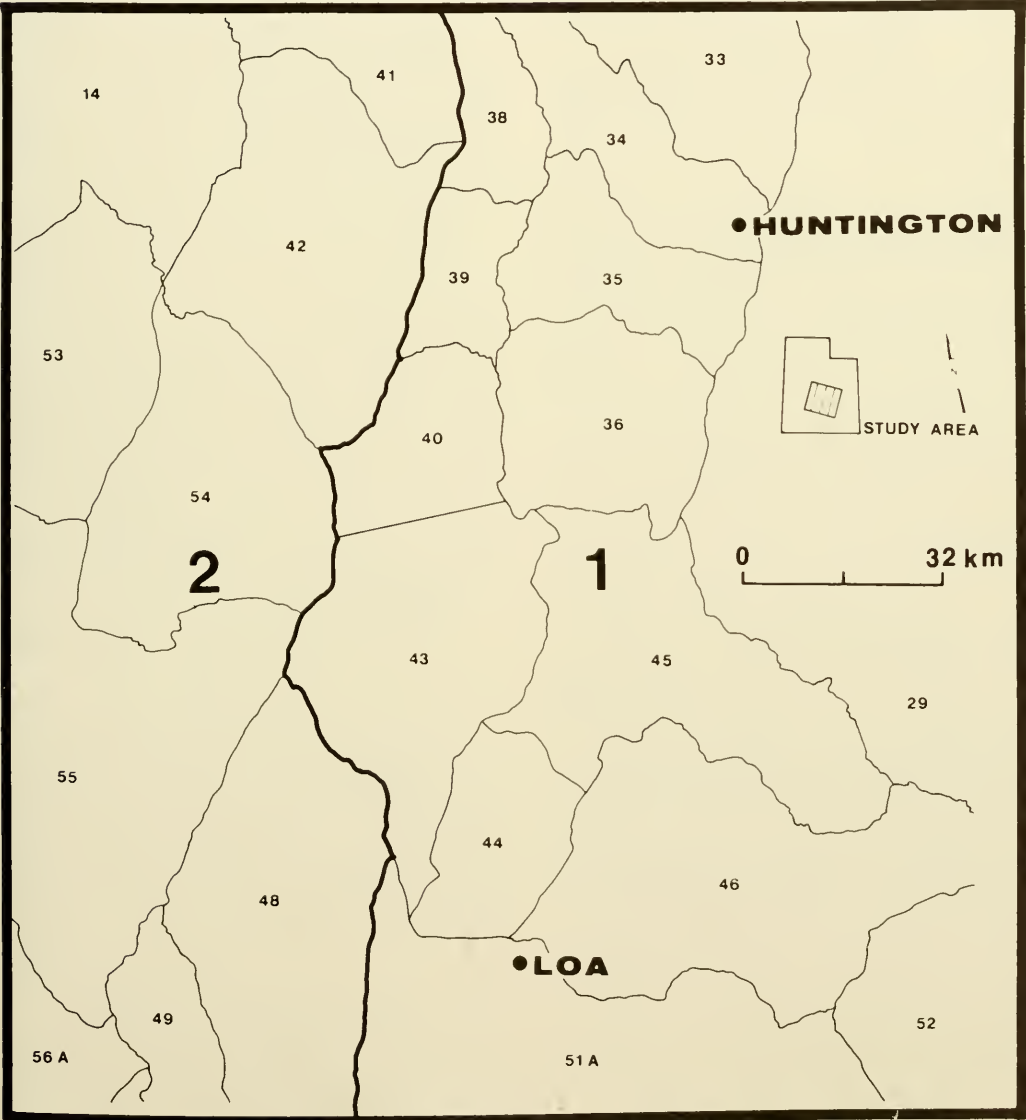
Fig. 4. Study area showing the boundary that was used to divide the herd units into more biologically appropriate samples.
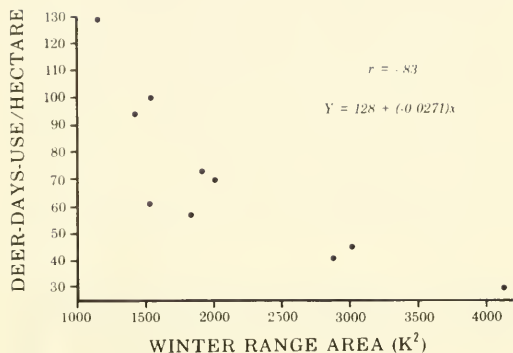
Fig. 5. Regression of the variable deer-days-use/hectare with winter range area using the data compiled within the two more biologically appropriate sub-samples (n = 10).

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TIME BUDGETS OF WYOMING GROUND SQUIRRELS, *SPERMOPHILUS ELEGANS*

David A. Zegers[1]

ABSTRACT.— Time budget of free-living adult *Spermophilus elegans* differed significantly from that of juveniles in the Front Range of the Rockies during 1974–1975. No differences were found between males and females. Hour of day, day since emergence, air temperature, cloud cover, and presence of predators all correlated with the frequency of various components of the time budget.

Study of time budgets is important in comprehending the roles of animals in ecosystems as well as understanding their basic patterns of behavior. Time budgets constructed for a few ground squirrels [the Columbian ground squirrel, *Spermophilus columbianus* (Betts 1976); the thirteen-lined ground squirrel, *S. tridecemlineatus*, and the spotted ground squirrel, *S. spilosoma* (Streubel 1975); and Belding ground squirrel, *S. belding* (Morton 1975)] illustrate the significant effects exogenous and endogenous factors have on the time allotted to various activities. My objectives were (1) to produce time budgets for the Wyoming ground squirrel, *Spermophilus elegans* (*sensu* Nadler, Hoffmann, and Greer 1971; (2) to document differences in time budgets due to age and sex; (3) to correlate variation in time budget with several environmental factors: weather, day since emergence, hour of day, and presence of predators; and (4) to assess the ecological and evolutionary correlates of these variations in time budget.

METHODS

A colony of free-ranging Wyoming ground squirrels was observed from 18 May 1974 to 24 August 1974 and from 20 April 1975 to 20 August 1975 in a montane meadow (2440 m elevation) in the Front Range of the Rocky Mountains approximately 16 km southwest of Boulder, Colorado (Zegers and Williams 1979).

Using the technique of Wiens et al. (1970), I employed an electronic metronome,

binocular, and a 20X telescope to observe the squirrels from a blind. The animals were marked for individual recognition from a distance using a unique combination of freeze brands (Hadow 1972) located at one or two of the spots on the animal's body.

The behavior of these ground squirrels was divided into 13 categories (i.e., activities) (Zegers 1977). This classification scheme is similar to those previously used for this squirrel (Clark and Denniston 1970) and for the closely related Richardson's ground squirrel, *S. richardsonii* (Quanstrom 1968 and 1971). These 13 activities and their definitions are as follows:

1. The basic posture is a resting and observation position with all four paws on the ground.
2. Semi-alert posture is a resting and observation position in which the forepaws are off the ground and the back is arched.
3. The alert position is a resting and observation position in which the forepaws are off the ground and the back is straight, not arched.
4. The down feeding posture is a variation of the basic posture in which the squirrel is eating. Food is manipulated using the teeth and lips without the aid of the forepaws.
5. The upright feeding posture is a variation of either the semi-alert or alert postures in which food is handled with the forepaws.
6. Running is a rapid locomotor activity in which the animal is moving ≥ 1.0 m/s and is not involved in a chase.
7. Chasing is running in which the individual is chasing another.
8. Chased is running in which the individual is being chased.
9. Walking is relatively slow (compared to running) locomotion of < 1.0 m/s.
10. Hay-gathering involves stuffing herbaceous stems and leaves into the mouth without chewing and

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swallowing. These materials are cut or pulled up by use of the forepaws and teeth and placed in the mouth perpendicular to the sagittal line and then deposited somewhere underground.

11. Grooming includes self- and allogrooming as well as dusting, in which a squirrel rolls from side to side while prostrate in the dirt of an entrance mound.

12. Digging is the behavior in which a squirrel removes soil from a tunnel entrance by using either or both hind limbs and forelimbs.

13. Fighting is similar to fighting among other rodents, and involves rolling, biting, clawing, and yelping.

Other data were collected for each of 1125 observation periods, which lasted from 5 to 15 minutes. These data included date, time of observations, animal identification number, information about predators (i.e., whether or not a predator was visible, and, if so, its species), and weather conditions. Air temperature was measured at 0.5 m above ground every half hour. Sky cover was divided into four cloud categories: clear (no clouds), partly cloudy (less than 50 percent of sky covered), mostly cloudy (more than 50 percent of sky covered) and overcast (complete cloud cover).

Differences in time budget due to age and sex were tested via chi-square analysis. The relationship between five environmental factors and the components of time budget were analyzed by multiple regression. Air temperature, day since emergence, hours of day, sky conditions, and presence of predators served as independent variables, and the frequencies of each of the 13 activities for each of the observation periods were the dependent variables.

Results and Discussion

Although the behavior of S. *elegans* has been studied (Clark 1970a, Clark and Denniston 1970, Pfeifer 1980), a time budget has never before been constructed. Aboveground time budget for all individuals is shown in Figure 1. Note that the two feeding activities were the most protracted, combining to consume 39.3 percent of all time spent above ground. The three sedentary but watchful positions (basic, semi-alert, and alert) were the next most frequent, followed by the five postures labeled "individual maintenance." Note that the three agonistic activities were the least frequent.

Few time budgets of other sciurids are available for comparison. Betts (1976) found that feeding consumed from 49 to 86 percent, and "alertness" occupied from 6 to 26 percent of the total time above ground of *Spermophilus columbianus*. *Tamiasciurus*, the red squirrel, spent approximately 35 percent of its total time above ground feeding, although this percentage ranged from 9 to 60 percent (Smith 1968). Streubel (1975) found *Spermophilus tridecemlineatus* spent 42.4 percent and S. *spilosoma* spent 45.6 percent of its time feeding, but only 11.6 percent and 15 percent, respectively, in some alert postures. Sexual and agonistic behavior com prised less than 5 percent of the total budget for these species. When above ground, Wyoming ground squirrels spent a smaller proportion of their time feeding, and more time in sedentary observation than these other species. This may be due to a greater threat from predators, or to prevailing habitat conditions resulting in differences in social system or foraging strategy.

These differences in time budget also reflect differences in territorial maintenance strategy. For example, *Tamiasciurus*, a squirrel that defends a food supply, uses a strategy that spends little time on actual territorial defense (0.25 to 1.85 percent of active time, Smith 1968). Complete defense is probably difficult if not impossible in the spatial complexity of the coniferous forest. It appears to be energetically adaptive to use warning calls and to tolerate some intrusion rather than to spend considerable time and energy chasing other squirrels. *Spermophilus spilosoma* and S. *tridecemlineatus* do not defend food supplies. Their territoriality can be described as core monopolization (Streubel 1975), in which individual distance and the tendency to remain near the home burrow spaces individuals. No cooperative or extended familiar behavior and little agonistic behavior occur (Streubel 1975). In contrast, S. *richardsonii* and S. *elegans* do not defend food territories but do defend reproductive territories. During mating individual males occupy territories that contain the home ranges of several females (Yeaton 1972). These are succeeded by female territories during gestation and lactation (Quanstrom 1968, Yeaton 1972). My observation of female territories for S.
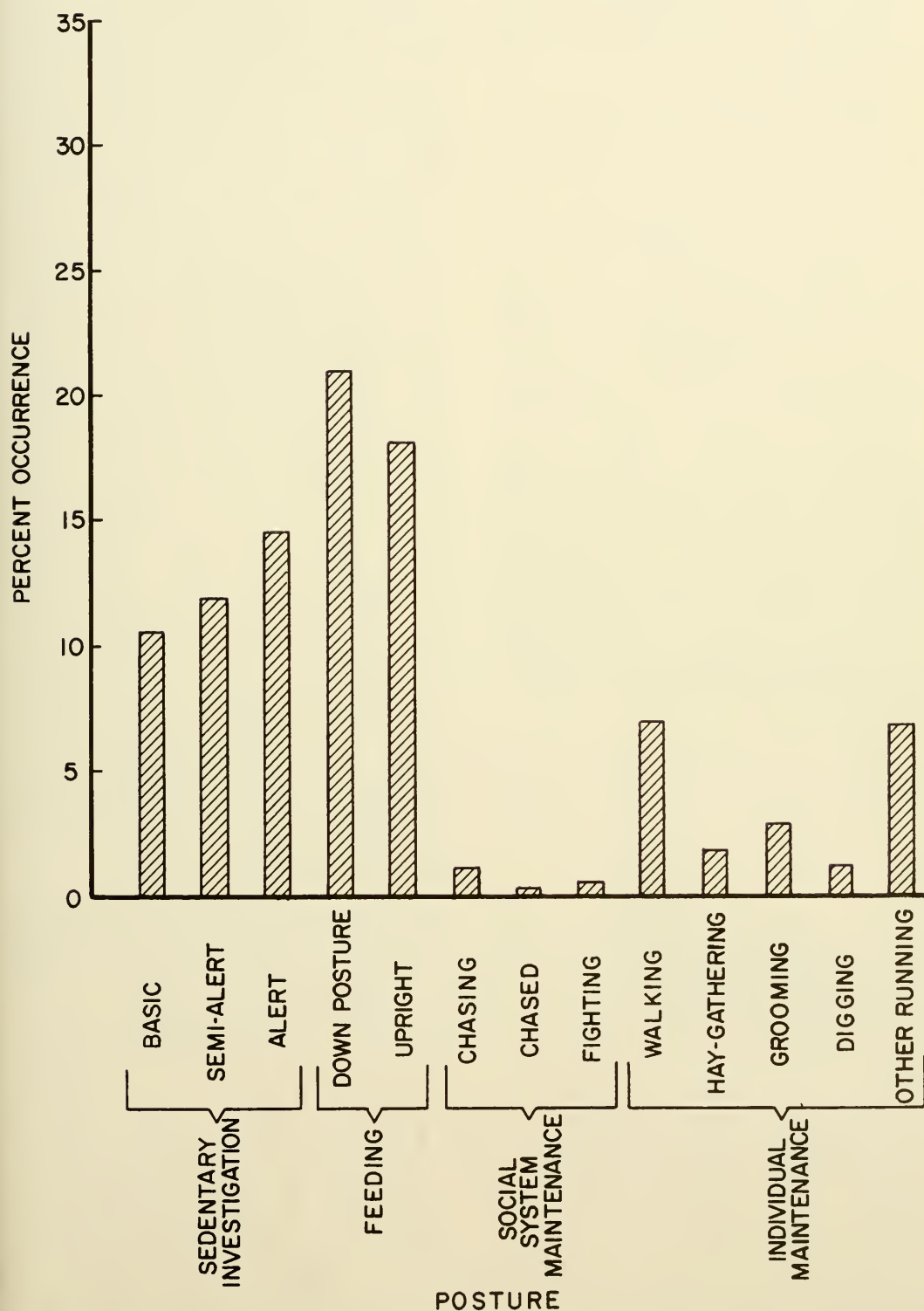
Fig. 1. Time budget of a population of Wyoming ground squirrels during the summers of 1974 and 1975.

elegans revealed them to be essentially used to protect the burrow entrance, (and therefore the young) against intrusion by conspecifics rather than for defending an area of open ground.

The differences in time budget between sexes for adults and between age groups are shown in Figures 2 and 3. Time budgets of adults differed significantly from those of juveniles ($X^2 = 38.67$; df = 12; p < 0.05) but sex did not have a significant effect on time budget ($X^2 = 0.73$; df = 12; p > 0.05). The effects of age and sex on time budgets have not been studied extensively for sciurids. I know of only one other study of sciurids that presents time budget data by age and sex groups. Although the data were not statistically analyzed, the time budgets of adult and yearling *S. columbianus* appear to be substantially different from those of juveniles (Betts 1976). Moreover, differences between adults and yearlings and between males and females existed. Likewise, my data indicate a significant difference between age groups, although the difference between sexes was not significant. The apparent time budget differences between sexes of the Columbian ground squirrel suggest that that species has a more pronounced division of labor than *S. elegans*.

Differences in time budget between adults and juveniles are important and obvious. Feeding to support growth is not as important to adults as to juveniles. Adults come out of hibernation essentially full grown and must only consume sufficient energy to reproduce successfully and to deposit enough fat to survive hibernation. Juveniles, however, grow at a rate of 11.4 percent per day during the first weeks after birth until full length is achieved at about 63 days of age (Clark 1970a). In addition, the juveniles must then put on enough fat to survive hibernation. Moreover, for both *S. richardsonii* and *S. elegans* a temporal difference exists between adults and juveniles in their activities. Adults are finished with aboveground activities before juveniles start prehibernatory fattening (Clark 1970b, Dorrance 1974, Michener 1972 and 1974, Quanstrom 1968, and Zegers 1977). This removes adults from the area when the juveniles are preparing for hibernation and, by reducing intraspecific competition, probably increases survival of juveniles (Yeaton 1969). Likewise, early immergence of adults into hibernacula may increase adult survivorship by reducing predation pressure (Morton 1975).

Several sciurids are known to modify activity periods in response to environmental factors (Yeaton 1969, Clark 1970b, Quanstrom 1971, Baudinette 1972, G. R. Michener 1973). Multiple regression of environmental factors on the 13 components of the time budget of Wyoming ground squirrels revealed some interesting relationships to that budget (Table 1). None of the independent variables correlated with frequency of

TABLE 1. Independent variables which were significant predictors of the frequency of 13 activities of *Spermophilus elegans*. Presence of predator (Pred), hour of day, day since emergence, air temperature, and sky conditions were analyzed for their effect on the frequency of each activity. Direction of the correlation is indicated by the sign (+ or -). n.s. = not significant

Activity	Independent variables (p<0.05 for beta)				
	Pred	Hour	Day	Temp	Cloudiness
Basic	n.s.	+	n.s.	−	n.s.
Semi-alert	+	n.s.	−	−	n.s.
Alert	+	n.s.	n.s.	+	n.s.
Feeding down	−	+	n.s.	−	n.s.
Feeding upright	−	−	+	+	n.s.
Chasing	−	n.s.	+	n.s.	n.s.
Chased	−	n.s.	+	n.s.	−
Other running	−	n.s.	−	n.s.	+
Walking	−	−	−	−	n.s.
Hay gathering	−	−	n.s.	n.s.	n.s.
Grooming	−	n.s.	+	n.s.	n.s.
Digging	−	+	n.s.	−	−.
Fighting	n.s.	n.s.	n.s.	n.s.	n.s.
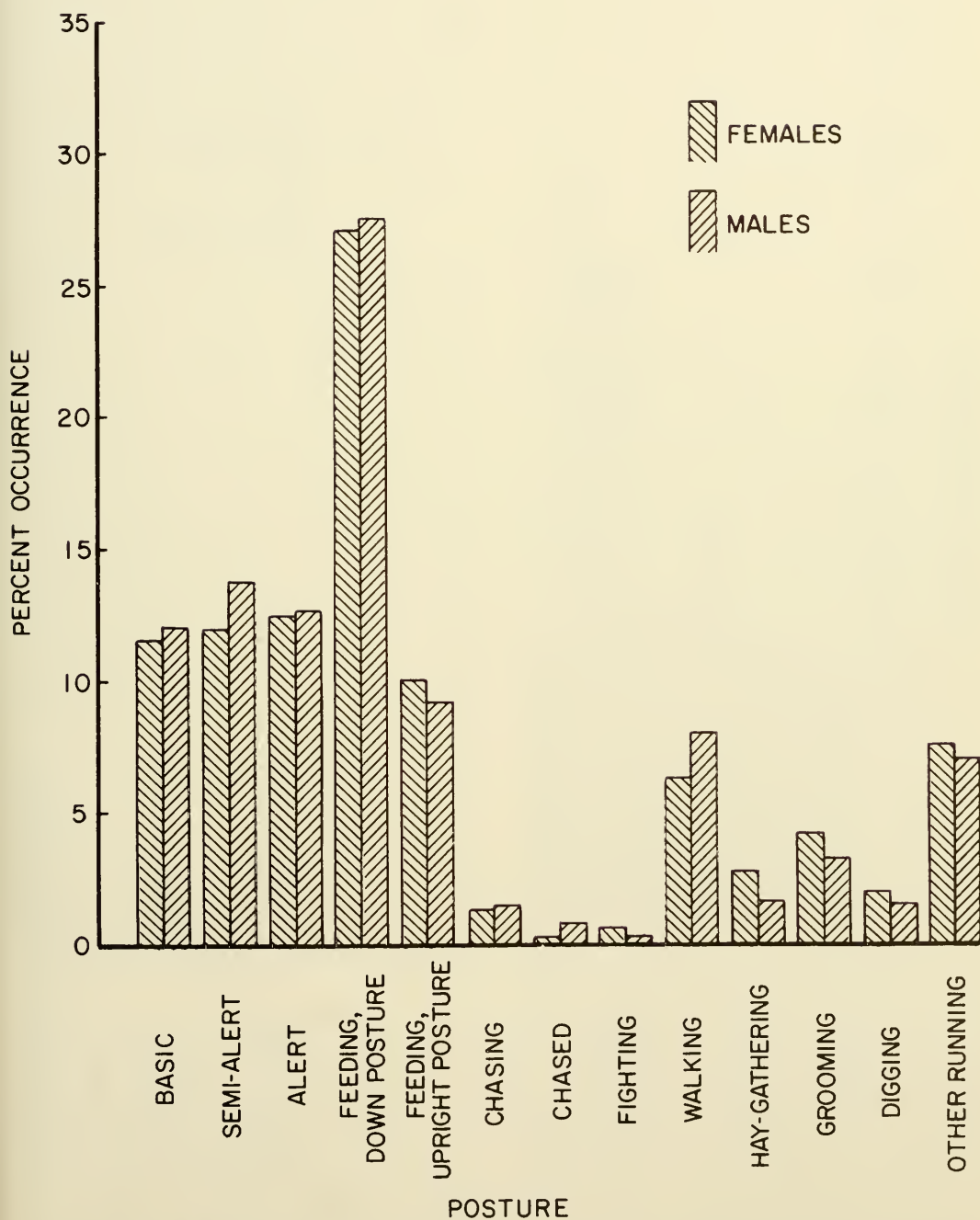
Fig. 2. Comparison of time budgets of adult male and adult female Wyoming ground squirrels during the summers of 1974 and 1975.
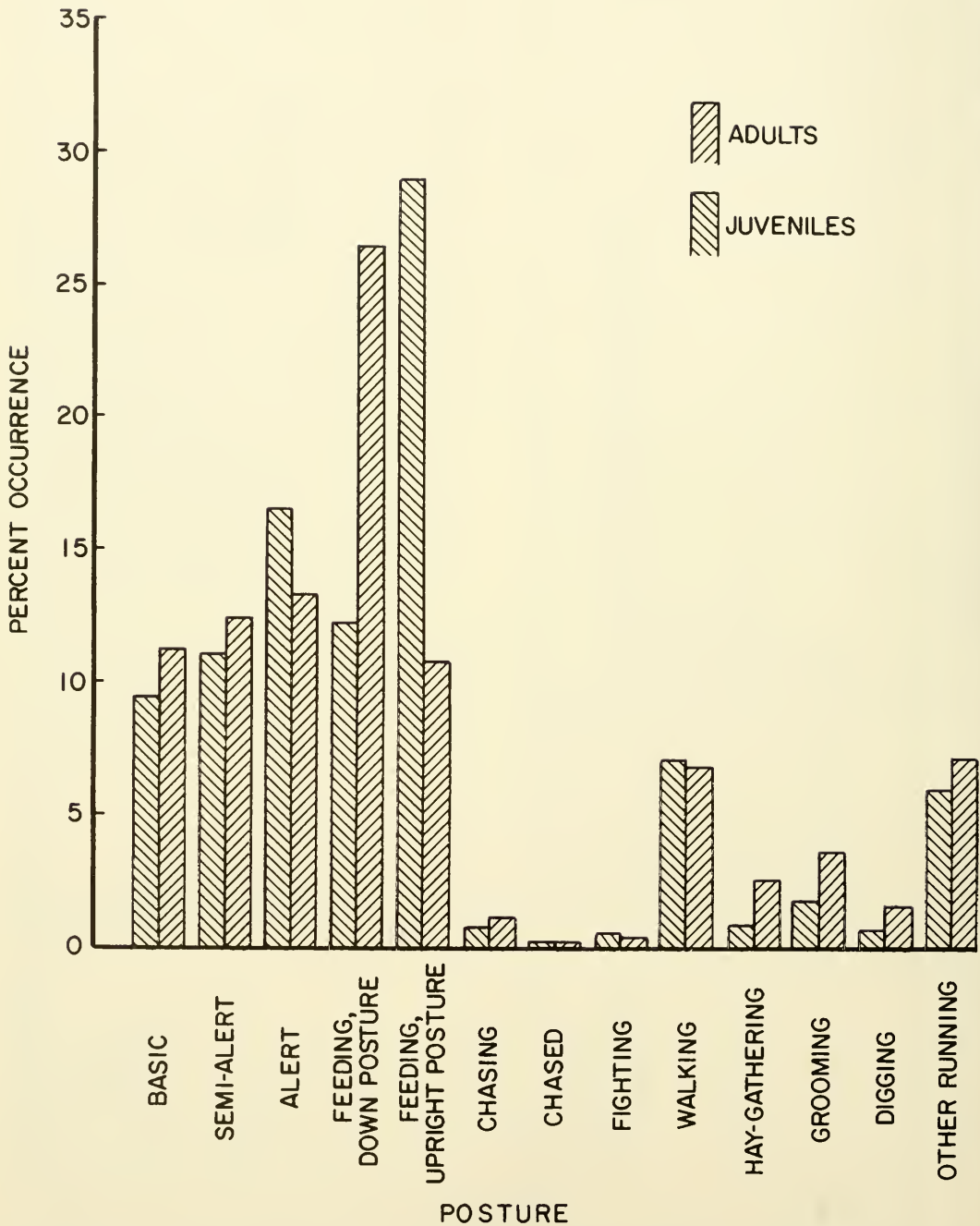
Fig. 3. Comparison of time budgets of all adult and juvenile Wyoming ground squirrels during the summers of 1974 and 1975.

fighting. This reflects the obvious social nature of fighting; social situation was obviously the most important factor in initiating fighting, which went on regardless of the hour, date, or weather.

The presence of a predator was the most recurring significant variable (Table 1), correlating with the frequency of 11 activities. The most casual observer of these squirrels would agree that behavior is greatly modified once a predator is detected by the squirrels. All feeding, social activity, grooming, etc., stopped as the squirrels, using either the basic, semi-alert, or alert postures, intently observed the predator.

Day since emergence correlated with feeding postures, chasing, chased, walking, and grooming activities. This indicates chronological changes in the time budget (Zegers 1977). As the season proceeded, adults became progressively more sedentary and spent less time feeding, although they continued to gain weight (Zegers and Williams 1977). This quiescence could be due to diminished metabolic rate during prehibernatory fattening (Armitage and Schulenberger 1972). In addition, the squirrels might have been able to spend less time feeding and still gain weight because the energy drain of reproduction and territorial defense was no longer present. Regardless of the cause of their quiescence, the alertness of these individuals probably aided in predator detection and thereby contributed to the survival of juveniles. This interpretation is supported by the fact that in the last two weeks before disappearing into hibernacula these adults stopped gaining weight and on the average actually lost weight (Zegers and Williams 1977). Some factor other than insufficient body fat was preventing these adults from hibernating two weeks earlier. Perhaps this factor was parental care.

The effects of ambient temperature, cloud cover, and hour of the day on sciurid time budgets are generally interpreted as thermoregulatory and water balance mechanisms. Michener (1968) demonstrated that S. richardsonii modified overall activity in response to air temperature and light intensity (i.e., cloudiness) in ways that promoted overall maintenance of body temperature and water balance. My data show that air temperature

and cloudiness also affect specific behaviors, although this conclusion must be qualified. Many behaviors were not influenced by weather conditions (Table 1). Although running decreased on sunny days, digging increased. As air temperature increased squirrels walked and dug less. This may reflect generally lower activity when temperatures are high. Although this could be a thermoregulatory response, the data in Table 1 generally support the idea that specific behaviors of ground squirrels tend not to be greatly influenced by weather conditions. These squirrels were above ground apparently for a purpose (e.g., feeding, territorial defense, predator detection). If weather conditions were unfavorable enough to seriously interfere with these activities, the animals returned to their burrows. If, however, conditions were less than ideal but not sufficient to force them into burrows, the squirrels may have responded with slight modifications of (1) the frequency of some behaviors or (2) posture. For example, on cold, sunny days the squirrels used postures that maximized their heat gain from the sun, whereas on hot, sunny days they used postures that minimized heat gain from the sun (Zegers 1977). In general, activity level (i.e., number of individuals above ground at any one time) decreased during cool and cloudy periods and during hot and sunny periods. Likewise Baudinette (1972) found that the California ground squirrel, S. beecheyi, avoided the warmest periods of summer days by remaining in the favorable environment of the burrow. The blacktail prairie dog, Cynomys ludovicianus, (Althen 1975) also showed peak activity above ground synchronous with times of optimal microenvironmental thermal conditions.

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A NEW PULVINATE *ERIOGONUM* (POLYGONACEAE) FROM UTAH[1]

James L. Reveal[2]

Abstract.— A new species of pulvinate wild buckwheat, *Eriogonum soredium* (Polygoneae, Eriogonoideae) is described from near-barren limestone slopes in the Grampian Hill area near Frisco, Beaver County, Utah. The new species is outwardly similar to *E. shockleyi* S. Wats. but may be readily distinguished by its glabrous (not pubescent) flowers and fruits, generally smaller leaves, more numerous involucres per head, turbinate (not campanulate) involucres with 5, rarely 4 (not 5 to 10) teeth, and the smaller flowers.

Botanical explorations in the Inter-mountain Region as part of the general survey for rare and restricted vascular plants continue to reveal new, localized species heretofore unknown. The present discovery represents one of many new species to be found by Dr. Stanley L. Welsh of Brigham Young University and those associated with his investigations of the endangered and threatened flora of Utah.

Eriogonum soredium Reveal, sp. nov. A *E. shockleyi* floribus et fructibus glabris differt.

Low, matted herbaceous perennial with numerous dense rosettes of leaves forming a dense, compact mat 1–3 dm across, the caudex with numerous branches, the upper portion densely matted with persistent leaves and petiole-bases, arising from a stout, woody taproot; *leaves* clustered, persistent, forming tight, compact rosettes of numerous leaves, the leaf-blade narrowly elliptic to narrowly oblong, (2) 2.5–4.5 (5) mm long, (0.7) 1–1.8 (2) mm wide, densely whitish-tomentose on both surfaces, the apex blunt and rounded or sometimes broadly acute, the base cuneate, the margin entire, rolled and thickened but not revolute, the petiole short, 0.5–2 (3) mm long, densely white-tomentose, the petiole-base narrowly elongated, (0.5) 1–3 mm long, 0.4–0.5 mm wide, densely white-tomentose without, glabrous and tannish within; *flowering stems* erect or nearly so, scapose, 2–8 mm long, tomentose in anthesis but becoming less so at maturity; *inflorescences* capitate, the head 4–8 mm across; *bracts* 6–8, lanceolate to narrowly triangular, 1.3–1.6 (1.8) mm long, tomentose without, glabrous within, distinct and not at all fused basally; *involuces* 4–6 per head, turbinate, 2 mm long, 1.3–1.5 mm wide, densely tomentose without with long tangled white hairs especially along the teeth and margin of the tube, glabrous within except for along the very margin, the (4) 5 erect, triangular and acute teeth 0.5–0.6 mm long, with a well-defined hyaline but pubescent membrane between each tooth, the bractlet linear-oblanceolate, 2–2.5 mm long, densely pubescent, especially apically, with long tangled hairs, less pubescent and with shorter gland-tipped hairs below, the pedicel long, 2–2.5 (3) mm long, glabrous; *flowers* white with reddish bases and midribs, (1.5) 2–2.5 mm long, glabrous without, sparsely glandular especially along the midrib within, the tepals slightly dimorphic, those of the outer whorl broadly obovate, 2.5–3 mm long and 1.6–2 mm wide when flattened, mostly spreading to recurved in anthesis and fruit, the apex broadly rounded and often emarginate, those of the inner whorl narrowly obovate, 2 mm long and 1.5 mm wide when flattened, mostly spreading in anthesis and fruit, the apex broadly rounded to truncate and often emarginate, united up to ¼ their length, the base rounded or nearly so, the lower portion of the midrib keeled in late anthesis and fruit; *stamens* slightly included, the filament 2.5–3 mm long, very sparsely pubescent basally, the anther reddish, oval, 0.4–0.5 mm long; *achenes* light brown, glabrous, 2–2.5

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mm long, the narrowly globose base tapering to a long, 3-angled beak (Fig. 1).

TYPE.— UTAH: Beaver Co., Grampian Hill, San Francisco Mts., near Frisco, on limestone hill S of rd just past turnoff to pass, sec. 23, T.27S., R.13W., 6600 ft elev., 29 Aug 1980, *Welsh, Chatterley & Anderson 20192.* Holotype, US. Isotypes, BRY, MARY, and 9 to be distributed from BRY.

ADDITIONAL SPECIMENS EXAMINED.— UTAH: Beaver Co., Frisco, sec. 23, T.27S., R.13W., 7300 ft elev., 6 Jun 1978, *Ostler & Anderson 1261* (BRY); San Francisco Mts., sec. 33, T.26S., R.13W., 14 June 1978, *Ostler & Anderson 1350* (BRY); Grampian Hill, sec. 23, T.27S, R.13W., 6740 ft elev., 25 June 1980, *Welsh & Chatterley 19653* (BRY, MARY).

Eriogonum soredium (from the Greek *soredion* meaning "small heap" alluding to the mat-forming habit of the plant) is most closely related to *E. shockleyi* S. Wats., a widespread Intermountain Region species which ranges from eastern California to western Colorado and northwestern New Mexico, and from the Snake River Plains of southern Idaho to northern Arizona. The new species differs from *E. shockleyi* most markedly in its glabrous flowers and fruits, but in addition the new species may be recognized by its smaller and generally narrower leaves (2–5 mm long in *E. soredium* versus 2–12 mm long in *E. shockleyi*), more numerous involucres (4 to 6 instead of 2 to 4) per head, its turbinate (not campanulate) involucre with 4 or 5 teeth rather than 5 to 10 as in *E. shockleyi*, and the

Fig. 1. *Eriogonum soredium*: A, habit of growth; B, involucre; C, leaves and involucre; D, flowers.

smaller flowers (up to 2.5 mm long in *E. soredium*, up to 4 mm long in *E. shockleyi*). In terms of habit the two are similar: both form rather compact mats of numerous, densely leaved rosettes. The flower color of *E. shockleyi* is more a creamy-white than the pure white of *E. soredium*, although the former may have yellowish flowers as well.

In my treatment of *Eriogonum* for Utah (Reveal, 1972), *E. soredium* will key (page 175) to *E. panguicense*. Here the dichotomy may be changed accordingly:

EE. Flowers white.
     F.   Stems glabrous, 0.2–30 cm long; involucre glabrous; mountains of Sevier Co. southward to Kane and Washington cos. ....
.... 37. *E. panguicense*
    FF.   Stems tomentose, up to 0.8 cm long; involucre tomentose; low hills near Frisco, Beaver Co. ....
.... 39a. *E. soredium*

The new species is local and rare and occurs near populations of *Eriogonum shockleyi*. The Frisco area is noted for its historic mining operations, and for this reason *E. soredium* must be regarded as a potentially threatened species of flowering plants.

ACKNOWLEDGMENTS

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A CHECKLIST OF THE ALPINE VASCULAR FLORA OF THE TETON RANGE, WYOMING, WITH NOTES ON BIOLOGY AND HABITAT PREFERENCES

John R. Spence[1,2] and Richard J. Shaw[1]

Abstract.— A checklist of the vascular flora of the alpine zone (treeless vegetation above 9500 feet or 2900 m) of the Teton Range is presented. For each of the 216 species, six attributes are listed: flower color and shape, pollination mode, life form, habitat preference, and whether each species is found in the Arctic. White and yellow flowered species are most common, and zoophilous species greatly predominate over anemophilous and apomictic species. Perennial/biennial herbs are the most common life form. Common habitats in the alpine zone include dry and wet meadows, bogs, debris accumulations, and cliffs and rock faces. Arctic species account for 25.9 percent of the flora. The 216 species are distributed among 111 genera and 36 families. The largest families, in order of size, are Asteraceae, Poaceae, Cyperaceae, Brassicaceae, Rosaceae, and Scrophulariaceae.

The Teton Range, located for the most part inside Grand Teton National Park, is a typical fault block range. The mountains are about 60 km long and average 6 to 9 km wide. The major peaks in the center of the range and to the north are composed of Precambrian gneisses, schists, and granites. The southern peaks are capped by Paleozoic sedimentary rocks, and the divide to the west of the main peaks consists of Paleozoic and Mesozoic rocks. The range has been extensively glaciated in the past, and several small cirque glaciers of the Neoglacial age exist in sheltered areas of the range (Love and Reed 1968, Reed and Zartman 1973). The climate on the floor of Jackson Hole to the east of the Tetons is continental, with long, cold winters and a short growing season. Annual mean temperature is low. Precipitation is also low, falling mostly as snow in the winter months (Reed 1952, Shaw 1958).

The vascular flora of the Tetons has been well documented over the last 30 years (Shaw 1958, 1968, 1976). Approximately 150 species were listed as occurring in the alpine zone (Shaw 1976, unpublished data). Recent intensive collecting in portions of the alpine zone (Spence 1980) and reexamination of herbarium collections (Hartman and Lichvar 1979) have added more than 50 additional species.

The purposes of this checklist are to include all the recent information on the alpine flora of the Teton Range and provide general information on floral characteristics, pollination modes, and habitats in the alpine zone. Phytogeographical relationships will also be mentioned. In this paper, the alpine zone is defined as high elevation areas of treeless vegetation, with the lower limits arbitrarily set at 9500 feet (2900 m). Although timberline (composed of *Pinus albicaulis, Picea engelmannii,* and *Abies lasiocarpa*) is generally found at elevations of 10,000 to 10,500 feet (3050 to 3200 m) in the Tetons, many areas below this support typical alpine species. Such areas include many of the cirques in the range, and the neoglacial deposits below the present glaciers.

Methods

The checklist was collected from studies by Merkle (1962, 1963), Scott (1966), Shaw (1976), Spence (1980), and Hartman and Lichvar (1979), supplemented by personal observations and herbarium materials. All species on the list can be found on deposit at the Intermountain Herbarium (UTC) at Utah State University, the Rocky Mountain Herbarium (RM) at the University of Wyoming, and the Moose Herbarium in Grand Teton National Park. Polunin (1959) and Hultén (1968) were consulted for those species found in the Arctic. For each species six characteristics are noted. An asterisk (°) before the name of the species indicates it is found in

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the Arctic; a dagger (†) indicates the species is characteristically subalpine. Flower color is listed as w = white, y = yellow, v = violet, p = pink, b = blue, r = red, br = brown, g = green, and o = orange. Only species with conspicuously colored flowers are indicated. Flower shape is listed as a = actinomorphic, z = zygomorphic, and is listed only for those species with conspicuously colored flowers. Pollination mode is listed as Z = zoophilous, A = anemophilous or apomictic. Fryxell (1957), Pojar (1974), Ostler and Harper (1978), and Swales (1979) were consulted for aid in determining pollination mode. Life form is listed as s = shrub, p = perennial/biennial herb, g = perennial/biennial graminoid, and a / annual herb or graminoid. Major habitat types are listed as 1 = dry meadows, 2 = wet meadows, 3 = bogs, 4 = debris accumulations, 5 = cliffs and rock faces, 6 = neoglacial deposits. For more information on the habitat types see the discussion and Table 3.

Results and Discussion

Table 1 lists the 216 species of vascular plants and presents for each species the biological attributes and habitat preferences by family in alphabetical order within the major categories Ferns, Fern Allies, and Gymnosperms; Dicots; and Monocots. The species are arranged in alphabetical order within each family. Table 2 is a statistical summary of the species and their attributes.

More than 50 percent of the species belong to the six largest families. In addition, 78 of the species belong to the 11 largest genera. It is interesting to note that the six families listed in Table 2 are also the six largest families in the flora of Teton County (Shaw 1976). Indeed, the genera *Carex*, *Potentilla*, *Poa*, *Salix*, and *Erigeron* are also listed as being among the largest genera in Teton County.

White and yellow flowered species predominate (64.1 percent). This result is similar to data presented by Ostler and Harper (1978) in a study of plant communities in the Wasatch Mountains of Utah and Idaho. In that study, from 65 to 75 percent of all conspicuously colored flowers in several alpine communities were white or yellow. This is a common feature of alpine floras throughout

the world (Wardle 1978). One possible reason for the commonness of white and yellow flowers in the alpine zone could be that the most common and important pollinators often are generalist fly and bee species, which frequently prefer such colors (Percival 1965, Moldenke 1976, Wardle 1978).

Some difficulty was encountered with the category Pollination Mode. Table 2 shows that 75.2 percent of the species are characteristically animal pollinated. This should be considered as a maximum value, because many of the species included in this category are probably autogamous, especially in the Brassicaceae. Not enough information on breeding systems of alpine species is available yet to state definitely whether a species outcrosses or is predominantly autogamous. The category Anemophilous/Apomictic species includes most monocots, *Artemisia*, *Oxyria digyna*, and the known apomicts *Taraxacum officinale* and *Polygonum viviparum* (Fryxell 1957, Swales 1979). Some of the grasses, particularly the *Poa* species, are probably partially or wholly apomictic also.

In the category Arctic and Alpine species 56, or 25.9 percent, are included. This can be compared with the Beartooth Range 150 km to the north. There, 47 percent of the species occur in the arctic as well (Johnson and Billings 1962). The lower value for the Tetons is possibly due to the somewhat drier conditions found there compared with typical Rocky Mountain ranges like the Beartooths or the Wind River Range to the southeast (Mahaney 1980). The value of 25.9 percent is intermediate between the Beartooths and northern Great Basin Ranges to the southwest of the Tetons (Billings 1978). The somewhat drier conditions, perhaps accentuated during the Hypsithermal, probably explain the absence of such widespread arctic species as *Koenigia islandica*, *Gentiana algida*, and *Saxifraga caespitosa* in the Tetons. All three species occur in the Beartooth and Wind River Ranges (Johnson and Billings 1962, Scott 1966).

Certain species, such as *Senecio integerrimus*, *Carex douglasii*, *Mitella pentandra*, and *Eriophyllum lanatum*, are more characteristic of the subalpine zone in the Tetons. The inclusion of the 18 subalpine

TABLE 1. A list of all species occurring in the alpine zone of the Teton Range with flower color and shape, pollination mode, life form, habitat preference, and origin noted. ° indicates an arctic species; † indicates a subalpine species. The attributes are listed as 1 = flower color (y = yellow, w = white, v = violet, p = pink, b = blue, r = red, br = brown, g = green, and o = orange), 2 = flower shape (a = actinomorphic, z = zygomorphic), 3 = pollination mode (A = anemophilous or apomictic, Z = zoophilous), 4 = life form (p = perennial/biennial herb, s = shrub, g = perennial/biennial graminoid, a/annual herb/graminoid), and 5 = habitat (1 = dry meadows, 2 = wet meadows, 3 = bogs, 4 = debris accumulations, 5 = cliffs and rock faces, 6 = neoglacial deposits). For more detail see Methods.

			Attribute		
Family	1	2	3	4	5

Ferns, fern allies, and gymnosperms

CUPRESSACEAE

°*Juniperus communis* L. var. *depressa* Pursh	–	–	A	s	6

LYCOPODIACEAE

Lycopodium selago L.	–	–	–	p	5

POLYPODIACEAE

°*Asplenium viride* Huds.	–	–	–	p	4
Athyrium filix-femina (L.) Roth	–	–	–	p	6
Cryptogramma crispa (L.) R.Br. ex Hook. var. *acrostichoides* (R.Br.) Clarke	–	–	–	p	4,6
°*Cystopteris fragilis* (L.) Bernh.	–	–	–	p	4,6

SELAGINELLACEAE

Selaginella densa Rydb.	–	–	–	p	4,5,6

Dicots

APIACEAE

°*Bupleurum americanum* Coult. & Rose	y	a	Z	p	1,4
Cymopterus hendersonii (Coult. & Rose) Cronq.	y	a	Z	p	4,6

ASTERACEAE

°*Achillea millefolium* L. ssp. *lanulosa* (Nutt.) Piper var. *alpicola* (Rydb.) Garrett	w	a	Z	p	1,4,6
†*Agoseris aurantiaca* (Hook.) Greene	o	a	Z	p	1,2
A. glauca (Pursh) Raf.	y	a	Z	p	1,6
†*Anaphalis margaritacea* (L.) Benth. & Hook.	w	a	Z	p	6
Antennaria alpina (L.) Gaertn. var. *media* (Greene) Jeps.	w	a	Z	p	1
A. microphylla Rydb.	w	a	Z	p	6
A. umbrinella Rydb.	w	a	Z	p	1.6
Arnica latifolia Bong.	y	a	Z	p	1,4,6
A. longifolia D.C. Eat.	y	a	Z	p	2,6
†*A. mollis* Hook.	y	a	Z	p	2
Artemisia campestris L. ssp. *borealis* (Pall.) Hall & Clements	–	–	A	s	1
°*A. frigida* Willd.	–	–	A	s	1
°*A. norvegica* Fries ssp. *saxatilis* (Bess.) Hall & Clements	–	–	A	s	4,6
A. scopulorum Gray	–	–	A	s	4
Aster alpigenus (T. & G.) A. Gray var. *haydenii* (Porter) Cronq.	v	a	Z	p	1
Chaenactis alpina (Gray) M. E. Jones	p	a	Z	p	4,6
Cirsium tweedyi (Rydb.) Petr.	p	a	Z	p	6
°*Erigeron compositus* Pursh	v	a	Z	p	1,4,6
E. leiomerus Gray	v	a	Z	p	1,4,6
E. peregrinus (Pursh) Greene ssp. *callianthemus* (Greene) Cronq.	p	a	Z	p	2
E. simplex Greene	v	a	Z	p	1,4
E. ursinus D.C. Eat.	v	a	Z	p	1
†*Eriophyllum lanatum* (Pursh) Forbes var. *integrifolium* (Hook.) Smiley	y	a	Z	p	6
Haplopappus acaulis (Nutt.) Gray	y	a	Z	p	4,6
H. suffruticosa (Nutt.) Gray	y	a	Z	s	1

Table 1 continued.

Family	Attribute				
	1	2	3	4	5
Hieracium gracile Hook.	y	a	Z	p	2,6
Hymenoxys grandiflora (T. & G.) Parker	y	a	Z	p	1,4,6
Senecio amplectans Gray	y	a	Z	p	1,4
S. canus Hook.	y	a	Z	p	4
S. crassulus Gray	y	a	Z	p	2
S. fremontii T. & G.	y	a	Z	p	4,6
†*S. integerrimus* Nutt.	y	a	Z	p	6
†*S. streptanthifolius* Greene	y	a	Z	p	6
†*S. triangularis* Hook.	y	a	Z	p	2
S. werneriaefolius Gray	y	a	Z	p	6
°*Solidago multiradiata* Ait.	y	a	Z	p	1,4,6
°*Taraxacum lyratum* (Ledeb.) DC.	y	a	Z	p	1,4,6
T. officinale Weber	y	a	A	p	1,2,4,6
Townsendia montana Jones	v	a	Z	p	4,6
BORAGINACEAE					
Eritrichium nanum (Vill.) Schrad. var. *elongatum* (Rydb.) Cronq.	b	a	Z	p	1,4,6
Mertensia ciliata (James) G. Don	b	a	Z	p	2
Myosotis sylvatica Hoffm. var. *alpestris* (Schmidt) Koch.	b	a	Z	p	1,4
BRASSICACEAE					
Arabis drummondii A. Gray	v	a	Z	p	1
°*A. holboellii* Hornem.	v	a	Z	p	1
A. lemmonii S. Wats.	v	a	Z	p	4,6
A. lyallii S. Wats.	v	a	Z	p	1,6
A. nuttallii Robinson	w	a	Z	p	6
Draba apiculata Hitchc.	w	a	Z	p	1
°*D. aurea* Vahl.	y	a	Z	p	4,5,6
D. crassa Rydb.	y	a	Z	p	4
°*D. crassifolia* Graham	y	a	Z	a	1
D. lonchocarpa Rydb.	w	a	Z	p	4,5,6
D. oligosperma Hook.	y	a	Z	p	4
D. ventosa Gray	w	a	Z	p	4,5
Erysimum asperum (Nutt.) DC.	y	a	Z	p	6
Physaria australis (Pays.) Rollins	y	a	Z	p	4
°*Smelowskia calycina* C. A. Meyer var. *americana* (Regal & Herd)					
Drury & Rollins	w	a	Z	p	1,6
CAMPANULACEAE					
°*Campanula rotundifolia* L.	v	a	Z	p	1,4
CARYOPHYLLACEAE					
Arenaria congesta Nutt.	w	a	Z	p	4,6
A. nuttallii Pax.	w	a	Z	p	6
°*A. obtusiloba* (Rydb.) Fern	w	a	Z	p	1,4,6
°*Cerastium arvense* L.	w	a	Z	p	2
°*C. beeringianum* Cham. & Schlecht.	w	a	Z	p	4,6
°*Sagina saginoides* (L.) Karst.	w	a	Z	p	2,6
°*Silene acaulis* L.	p	a	Z	p	1,4,6
†*S. parryi* (Wats.) Hitchc. & Mag.	w	a	Z	p	6
Stellaria umbellata Turcz.	w	a	Z	p	2
CRASSULACEAE					
Sedum debile S. Wats.	y	a	Z	p	4,6
Sedum lanceolatum J. Torr.	y	a	Z	p	1,4,6
S. rhodanthum A. Gray	p	a	Z	p	2
°*S. rosea* (L.) Scop. ssp. *integrifolium* (Raf.) Hult.	v	a	Z	p	2,3
S. stenopetalum Pursh	y	a	Z	p	4,5

Table 1 continued.

Family	Attribute				
	1	2	3	4	5
ERICACEAE					
°*Arctostaphylos uva-ursi* (L.) Spreng.	w	a	Z	s	2,4
Gaultheria humifusa (Grah.) Rydb.	w	a	Z	s	2
Kalmia microphylla (Hook.) Heller	p	a	Z	s	2,3
Phyllodoce empetriformis (Sw.) D. Don	p	a	Z	s	2
P. glanduliflora (Hook.) Cov.	w	a	Z	s	2,4
Vaccinium scoparium Leib.	w	a	Z	s	6
FABACEAE					
Astragalus kentrophyta Gray var. *implexus* (Canby) Barneby	v	z	Z	p	1,6
°*Hedysarum boreale* Nutt.	p	z	Z	p	6
H. occidentale Greene	v	z	Z	p	1,4
°*Oxytropis campestris* (L.) DC.	w	z	Z	p	1,4
O. deflexa (Pall.) DC. var. *foliosa* Hook. Barneby	v	z	Z	p	1,4,6
GENTIANACEAE					
Gentiana calycosa Griseb.	b	a	Z	p	2,6
GROSSULARIACEAE					
Ribes montigenum McClatchie	p	a	Z	s	2,6
HYDROPHYLLACEAE					
Phacelia hastata Dougl. var. *alpina* (Rydb.) Cronq.	v	a	Z	p	4,6
P. sericea (Grah.) Gray	v	a	Z	p	1,4,6
HYPERICACEAE					
†*Hypericum formosum* H.B.K. var. *nortoniae* (Jones) Hitchc.	y	a	Z	p	6
LINACEAE					
°*Linum perenne* L. var. *lewisii* (Pursh) Eat. & Wright	b	a	Z	p	1
ONAGRACEAE					
°*Epilobium alpinum* L.	p	a	Z	p	1,4,6
°*E. latifolium* L.	p	a	Z	p	2,4,6
POLEMONIACEAE					
Linanthus nuttallii Gray	w	a	Z	p	1,4
Phlox pulvinata (Wherry) Cronq.	w	a	Z	p	4
°*Polemonium pulcherrimum* Hook.	b	a	Z	p	4
P. viscosum Nutt.	b	a	Z	p	4,6
POLYGONACEAE					
Eriogonum ovalifolium Nutt. var. *depressum* Blank.	w	a	Z	p	4,6
†*E. umbellatum* Torr. var. *subalpinum* (Greene) Jones	y	a	Z	p	4
°*Oxyria digyna* (L.) Hill	g	a	A	p	2,4,5,6
Polygonum bistortoides Pursh	w	a	Z	p	2,6
°*P. viviparum* L.	w	a	A	p	2
PORTULACEAE					
Claytonia lanceolata Pursh	p	a	Z	p	2
C. megarhiza (Gray) Parry	p	a	Z	p	4
Lewisia pygmaea (Gray) Robins.	p	a	Z	p	4,6
L. triphylla (Wats.) Robins.	p	a	Z	p	4
Spraguea umbellata Torr.	w	a	Z	p	4
PRIMULACEAE					
°*Androsace septentrionalis* L.	w	a	Z	a	1,6
Dodecatheon conjugens Greene	p	a	Z	p	2
D. pulchellum (Raf.) Merrill	p	a	Z	p	2
Primula parryi A. Gray	p	a	Z	p	2,4,5

Table 1 continued.

Family	1	2	Attribute 3	4	5
PYROLACEAE					
Pyrola dentata Smith	w	a	Z	p	4
°P. minor L.	p	a	Z	p	2,3
RANUNCULACEAE					
Anemone multifida Poir. var. tetonensis (Porter) Hitchc.	y	a	Z	p	1,6
Aquilegia flavescens S. Wats.	y	a	Z	p	2,4,6
Caltha leptosepala DC.	w	a	Z	p	2
Ranunculus eschscholtzii Schlecht.	y	a	Z	p	2
var. alpinus (Wats.) C. L. Hitchc.					
var. eschscholtzii					
var. suksdorfii (Gray) Benson					
Trollius laxus Salisb.	y	a	Z	p	2
ROSACEAE					
°Dryas octopetala L. var. angustifolia C. L. Hitchc.	w	a	Z	s	4
°Geum rossii (R. Br.) Ser. var. turbinatum (Rydb.) C. L. Hitchc.	y	a	Z	p	4
Ivesia gordonii (Hook.) T. & G.	y	a	Z	p	1,4
Potentilla brevifolia Nutt. ex T. & G.	y	a	Z	p	4
P. concinna Rich. var. rubripes (Rydb.) C. L. Hitchc.	y	a	Z	p	4
P. diversifolia Lehm.	y	a	Z	p	1,4
P. flabellifolia Hook.	y	a	Z	p	2
°P. fruticosa L.	y	a	Z	s	1,4,6
P. glandulosa Lindl. var. pseudorupestris (Rydb.) Breit.	y	a	Z	p	6
P. gracilis Dougl.	y	a	Z	p	2,6
°P. nivea L.	y	a	Z	p	2,4,6
Rubus idaeus L. ssp. sachalinensis (Levl.) Focke	w	a	Z	p	4
°Sibbaldia procumbens L.	y	a	Z	s	2,4,6
RUBIACEAE					
Kellogia galioides Torr.	w	a	Z	p	5
SALICACEAE					
°Salix arctica Pall.	–	–	Z	s	1,4,6
S. cascadensis Cockerell	–	–	Z	s	1,2,4
°S. glauca L.	–	–	Z	s	1,2
°S. reticulata L. ssp. nivalis (Hook.) Love et al.	–	–	Z	s	2
°S. rotundifolia L. ssp. dodgeana (Rydb.) Argus	–	–	Z	s	1,4
SAXIFRAGACEAE					
†Mitella pentandra Hook.	g	a	Z	p	2
Parnassia palustris L. var. montanensis (Fern & Rydb.) C. L. Hitchc.	w	a	Z	p	2
Saxifraga adscendens L.	w	a	Z	p	2,5
°S. bronchialis L. var. austromontana (Wieg.) Jones	w	a	Z	p	2,4,5,6
S. debilis Engelm.	w	a	Z	p	6
°S. flagellaris Willd.	w	a	Z	p	2,4,5
°S. oppositifolia L.	v	a	Z	p	2,4
S. rhomboidea Greene	w	a	Z	p	2,6
Telesonix jamesii (Torr.) Raf. var. heucheriformis (Rydb.) Bacigalupi	w	a	Z	p	4,5,6
SCROPHULARIACEAE					
Besseya wyomingensis (A. Nels.) Rydb.	v	z	Z	p	1
†Castilleja miniata Dougl.	r	z	Z	p	2,6
C. pulchella Rydb.	r	z	Z	p	1,2
C. sulphurea Rydb.	y	z	Z	p	1
Mimulus lewisii Pursh	p	z	Z	p	2,6

Table 1 continued.

Family	1	2	Attribute 3	4	5
Pedicularis bracteosa Benth.	y	z	Z	p	4
P. contorta Benth.	w	z	Z	p	1
°*P. groenlandica* Retz.	v	z	Z	p	2,3
P. parryi Gray var. *purpurea* Parry	w	z	Z	p	1
†*Penstemon attenuatus* Dougl. ssp. *pseudoprocerus* (Rydb.) Keck.	b	z	Z	p	6
P. montanus Greene	v	z	Z	p	4
P. whippleanus Gray	y	z	Z	p	1,4,6
°*Veronica wormskjoldii* Roem. & Schult.	v	z	Z	p	2,6
VALERIANACEAE					
Valeriana acutiloba Rydb.	w	a	Z	p	1,4
VIOLACEAE					
Viola adunca J. E. Smith	v	z	Z	p	2
Monocots					
CYPERACEAE					
Carex albonigra MacKenz.	–	–	A	g	4,6
°*C. atrata* L.	–	–	A	g	1,2
†*C. douglasii* Boott.	–	–	A	g	6
C. elynoides Holm	–	–	A	g	1,4,6
†*C. geyeri* Boott.	–	–	A	g	1
C. haydeniana Olney	–	–	A	g	1,4,6
†*C. illota* Bailey	–	–	A	g	2,3
C. luzulina Olney	–	–	A	g	6
C. microptera Mack.	–	–	A	g	1,4
C. nardina Fries	–	–	A	g	1,2
C. nigricans C. A. Mey.	–	–	A	g	1,2
C. nova L. Bailey	–	–	A	g	2,6
C. paysonis Clokey	–	–	A	g	6
C. phaeocephala Piper	–	–	A	g	4,6
C. pyrenaica Wahl.	–	–	A	g	1,2,4
†*C. rossii* Boott.	–	–	A	g	1,2
JUNCACEAE					
Juncus drummondii E. Bey.	–	–	A	g	2,6
J. mertensianus Bong.	–	–	A	g	2,3,6
J. parryi Engelm.	–	–	A	g	1,2,4
Luzula piperi (Cov.) Jones	–	–	A	g	2,3,6
°*L. spicata* (L.) DC.	–	–	A	g	2,4,6
LILIACEAE					
Erythronium grandiflorum Pursh	y	a	Z	p	2
°*Lloydia serotina* (L.) Sweet.	w	a	Z	p	1,4
°*Zigadenus elegans* Pursh	w	a	Z	p	2
Tofielda glutinosa (Michx.) Pers.	w	a	Z	p	2
POACEAE					
Agropyron caninum (L.) Beauv. var. *latiglume* (Scribn. & Smith) Hitchc.	–	–	A	g	1,4,6
var. *andinum* (Scribn. & Smith) Hitchc.					
A. scribneri Vasey	–	–	A	g	1,4,6
Agrostis humilis Vasey	–	–	A	g	2
†*A. idahoensis* Nash	–	–	A	g	6
°*A. scabra* Willd.	–	–	A	g	1,2
A. thurberiana Hitchc.	–	–	A	g	2,3
A. variabilis Rydb.	–	–	A	g	1,4
°*Calamagrostis purpurascens* R. Br.	–	–	A	g	4,6

Table 1 continued.

Family	1	2	3	4	5
					Attribute
Danthonia intermedia Vasey	–	–	A	g	1,4
Deschampsia atropurpurea (Wahl.) Scheele	–	–	A	g	2
°*D. cespitosa* (L.) Beauv.	–	–	A	g	2
°*Festuca ovina* L.	–	–	A	g	1,6
Leucopoa kingii (Wats.) Weber	–	–	A	g	1,6
°*Phleum alpinum* L.	–	–	A	g	2,3,4,6
Poa alpina L.	–	–	A	g	1,4,6
P. cusickii Vasey var. *cusickii* Hitchc.	–	–	A	g	4
var. *epilis* (Scribn.) Hitchc.					
P. incurva Scribn. & Wms.	–	–	A	g	4
P. nervosa (Hook.) Vasey var. *wheeleri* (Vasey) Hitchc.	–	–	A	g	1,4
P. pattersonii Vasey	–	–	A	g	1,4,6
P. reflexa Vasey & Scribn.	–	–	A	g	2
P. rupicola Nash ex Rydb.	–	–	A	g	4
P. sandbergii Vasey	–	–	A	g	6
°*Trisetum spicatum* (L.) Richt.	–	–	A	g	1,2,4,6

species reflects their occasional appearance above timberline, generally in the glacial cirques.

The Tetons are quite high, with 55 peaks and 7 percent of the area of the park above 10,000 feet (3050 m). Despite this, probably because the range is so precipitous, extensive stretches of alpine meadow vegetation are uncommon. Nevertheless, some extensive areas of alpine meadows can be found in the northern part of the range (e.g., Moose Basin), around Schoolroom Glacier to the west of the main peaks, in Alaska Basin, and along the Skyline Trail in the southern part of the range. Taluses and other debris accumulations, on the other hand, are abundant throughout the range and are probably the most widespread and common alpine habitats.

The major habitat types in which each species is commonly found are listed in Table 1. Although many species are characteristic of a particular habitat, other species can be found in a variety of habitats. For this reason the assignment of each species to a particular habitat or habitats should be interpreted only in a broad sense. For some species, the habitat preference is only tentative. As more information becomes available on habitat preferences and vegetation ecology in the alpine zone of the Tetons, it is hoped that a more rigorous and exact classification will be produced. Table 3 presents the major habitat types in the alpine zone using physical and vegetative characteristics. A brief discussion of each habitat and some of the characteristic species of each follows.

Lakes and streams are common in the alpine zone of the Tetons, but no aquatics have been found. Since Scott (1966) listed a collection of *Ranunculus natans* from the alpine of the Beartooth Range, this species should be sought in the alpine of the Tetons.

Bogs, where found, generally occur close to the lower limits of the alpine zone at 9500 feet (2900 m). They commonly occur in cirques and local depressions in the major canyons, especially along streams. Mosses are common, and *Carex* and *Salix* species dominate the vascular flora. Other species found in bogs include *Pedicularis groenlandica*, *Pyrola minor*, *Sedum rosea*, *Kalmia microphylla*, and *Agrostis thurberiana*.

The bog habitat usually grades into wet meadow habitat, with any boundary between the two often difficult to find. The wet meadow habitat is common at lower elevations, particularly in cirques, around lakes and seeps, and along streams. Vegetation occurring below late-lying snowbanks is also included in this habitat type. Wet meadows are usually dominated by various Ranunculaceae (especially *Caltha leptosepala*), and *Polygonum bistortoides*, *Pedicularis groenlandica*, *Veronica wormskjoldii*, *Deschampsia cespitosa*, and *Carex*, *Potentilla* and *Salix* species. Along streams *Phyllodoce empetriformis* and *P. glanduliflora* are especially common, along

with *Epilobium latifolium*, and *Carex, Dodecatheon*, and *Castilleja* species. Seeps generally support a rich mixture of *Mertensia ciliata*, and *Carex, Mimulus*, and *Saxifraga* species, with many mosses. Ground which is exposed late by late melting snow usually supports species like *Claytonia lanceolata*, *Erythronium grandiflorum*, and *Ranunculus eschscholtzii*.

Dry meadows are fairly common. Areas like Alaska Basin, parts of Moose Basin, large stretches along the Skyline Trail in the southern Tetons, and slopes in the major cirques consist of this habitat type. At high elevations, this habitat is composed of scattered patches of plants with many bare areas between the patches. The top of Prospectors Mountain and Hurricane Pass are good examples of this type of vegetation. The lower elevation and more extensively vegetated dry meadows are dominated by species of the Asteraceae and Poaceae families. *Astragalus*

TABLE 2. Statistical summary of the alpine flora of the Teton Range. The families with more than 10 species and the genera with 5 or more species are also listed.

Attribute		Number of species	Percent of total
LIFE FORM			
perennial/biennial herb		149	69.0
perennial/biennial graminoid		44	20.4
shrub		21	9.9
annual herb or graminoid		2	1.0
	Total	216	100.0
FLOWER COLOR			
yellow		52	33.3
white		48	30.8
violet		23	14.7
pink		20	12.8
blue		8	5.1
red		2	1.3
brown/green/orange		3	2.0
	Total	156	100.0
FLOWER SHAPE			
actinomorphic		137	87.8
zygomorphic		19	12.2
	Total	156	100.0
POLLINATION MODE			
zoophilous		158	75.2
anemophilous/apomictic		52	24.8
	Total	210	100.0
ORIGIN			
alpine but not arctic		142	65.7
arctic and alpine		56	25.9
subalpine		18	8.4
	Total	216	100.0
NUMBER OF FAMILIES		36	—
NUMBER OF GENERA		111	—
NUMBER OF SPECIES		216	—

LARGEST FAMILIES (number of species)	LARGEST GENERA (number of species)	
Asteraceae (39)	*Carex* (16)	*Agrostis* (5)
Poaceae (23)	*Poa* (8)	*Arabis* (5)
Cyperaceae (16)	*Potentilla* (8)	*Erigeron* (5)
Brassicaceae (15)	*Senecio* (8)	*Salix* (5)
Rosaceae (13)	*Draba* (7)	*Sedum* (5)
Scrophulariaceae (13)	*Saxifraga* (6)	

kentrophyta, Carex nigricans, and Juncus drummondii are also very common. At high elevations the vegetation is dominated by Hymenoxys grandiflora, Smelowskia calycina, Oxytropis campestris, Lloydia serotina, and Eritrichium nanum.

Debris accumulations include taluses, scree slopes, and boulder fellfields. These habitats are often physically disturbed by mass movements. Vegetation cover is usually very low. Many species have adapted to the disturbed and often xeric conditions of debris accumulations, generally by producing extensive root or rhizome systems. Common species include Dryas octopetala, Oxyria digyna, Cryptogramma crispa, Senecio fremontii, Phacelia hastata, Erigeron compositus, Senecio longifolia, and Epilobium alpinum.

Neoglacial deposits include the full range of debris accumulations, plus some unique minor habitat types (Spence 1980). Characteristic species include Oxyria digyna, Senecio fremontii, Poa pattersonii, Juncus drummondii, Carex phaeocephala, and Trisetum spicatum. Floristically, Neoglacial deposits

are among the richest of the habitat types in the alpine of the Tetons.

Rock faces and cliffs are abundant in the Tetons. The most common species found in this habitat type include Telesonix jamesii, Oxyria digyna, and various species of Saxifraga, Arabis, and Draba.

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TABLE 3. The major habitat types in the alpine zone of the Teton Range, with some physical and vegetative characteristics noted for each type.

Habitat type	Characteristics
Lake and stream habitat	standing or moving water present.
Bog habitat	water-saturated soil throughout the growing season, sometimes flooded in early season, vegetation cover usually 100 percent, with mosses common.
Wet meadow habitat	ground flat to gently sloping, soil generally moist, obvious boulders few and scattered, usually occurs near streams, lakes, seeps, bogs, or late lying snowbanks, vegetation cover generally high (often 100 percent), usually found below 10,500 ft (3200 m).
Dry meadow habitat	ground flat to gently sloping, soil generally dry, obvious boulders few and scattered, usually occurs away from lakes, streams, seeps, bogs, or late lying snowbanks, vegetation cover moderate to high at low elevations, low at high elevations.
Debris accumulation habitat (includes taluses, scree slopes, and boulder fellfields)	ground flat to steeply sloping, little soil, mostly accumulations of moderate- to large-sized rock fragments, vegetation cover very low, plants usually confined to crevices between rocks.
Rock face and cliff habitat	mostly bedrock, generally steep (40° +) sometimes with ephemeral streams in early season, plants usually growing on small ledges or in cracks in the rocks.
Neoglacial deposits	flat to more often steep accumulations of glacial debris, usually near existing glaciers or permanent snowbanks, vegetation cover generally low, recently formed (100–3000 years old). See Benedict 1973, Mahaney 1975.

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SOME SPATIAL AND BEHAVIORAL FEATURES
OF THE THIRTEEN-LINED GROUND SQUIRREL

Tim W. Clark[1]

ABSTRACT.— Some relationships between home range, agonistic behavior, and reproductive patterns in thirteen-lined ground squirrels were investigated in Laramie Plains, Wyoming (August 1966–April 1969). Population size and densities fluctuated seasonally and annually. Adult male (N = 7) home ranges averaged 0.24 ha and were smaller than those of the female (N = 9), which averaged 0.35 ha. Agonistic interactions were more frequent during the natal period (late May–June) than during the breeding-gestation period (mid April–May). Most squirrels (86 percent) shared capture sites and had overlapping home ranges. However, a certain degree of spacing existed because of agonistic behavior.

This study investigated the relationship between home range, agonistic behavior, and reproductive patterns in a natural population of thirteen-lined ground squirrels.

METHODS

A 10 ha grid with Sherman traps at 20 m intervals was live-trapped from August 1966 to April 1969. Captured squirrels were marked by toe clipping and dye marking with Nyanzol black fur dye. A grid of colored stakes at 30 m intervals was superimposed over the trap grid to facilitate squirrel observations. Home ranges (Dice 1952) and "centers-of-activity" (Hayne 1949) were determined. To the polygon-shaped home range, a boundary strip of one-half the distance between traps was added. Observations were made from two elevated blinds (4 m tall) and vehicles.

Reproductive patterns were estimated by examining males for testis position and females for perforated vagina, swollen vulva, and recent evidence of parturition or lactation (Packard 1968).

Agonistic data were collected in 1968 by observing marked and unmarked squirrels behaviorally interacting in a 2 ha sample area. Ten 1-hr observation sessions (0900–1000) were made five days apart. Five fell within the "breeding-gestation" period (15 April–5 May) and five in the "birth-natal" period (1–31 June). Just prior and following each session, five scans were made of the study site to determine identifications of all active squirrels, their locations, and type of activities exhibited. Social interactions were classified as "agonistic" or "sexual" after Burns (1968). The "form" and "result" of all agonistic interactions was noted. The form was either "contact" (in which some physical contact occurred), "chase" (both squirrels moving at least 1 m in the same direction at same time), or both. Even though neither contact nor chase were involved, an interaction was still called agonistic if it contained "threat" postures (Grubitz 1966). Results were classified as "dominant," "stand-off," or "subordinant" (a squirrel spatially supplanted by a second squirrel).

STUDY AREA

Squirrels were studied on Hutton Lake National Wildlife Refuge, Albany County, Wyoming. This area is montane (elev 2400 m) and consists of native short grass prairie called "Transitional Life-Zone" by Cary (1917). Predominant plants included blue grama (*Bouteloua gracilis*), western wheatgrass (*Agropyron smithii*), june grass (*Koleria cristata*), needle grass (*Stipa* spp.) and prickly pear cactus (*Opuntia polycantha*) (Clark 1971).

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RESULTS

In all, 196 squirrels were captured: 18 in 1966, 79 in 1967, 87 in 1968, and 12 in 1969. Squirrels emerged from hibernation from late March to early April and disappeared from mid-August to early October each year. Two general peaks in captured rates occurred (Fig. 1), the first during the breeding season and early gestation in late April and May and the second in early July when young squirrels made their initial appearance above ground.

By 1968, a large number of squirrels had been marked, allowing identification of age structure. Therefore, the 1968 data is felt to be most representative and is given below. Density peaks in 1968 corresponded to population peaks, when 15.2 animals per ha were present during breeding and early gestation and 12.7 when young first appeared above ground. The mean density from 31 March to 17 August 1968, was 4.0 per ha.

Age and sex structure varied seasonally. From late March to July, the population was comprised of 1+ yr olds. By mid-September the entire aboveground population consisted of young of the year. In August 1968, the population was 28.6 percent young of the year (14M:6F), 60.0 percent adults of unknown age (18M:4F), and 11.4 percent adults 2+ yrs old (4M:4F). The sex ratio was 1.0M:0.4F for young, 1.0M:1.3F for adults (age unknown), and 1.0M:1.0F for squirrels 2+ yrs old. There were nearly twice as many males as females in the young age class, but this changed in favor of females in the adult age class.

The 1968 mean trapping success per 100 trap days was 7.1 (range 1.6–20.1). Mean number of captures per squirrel was 4.0. About 36.1 percent of the squirrels captured were caught only once, 21 percent twice, 16 percent 3 or 4 times, 18 percent 5 to 10 times, and 8 percent 11 or more times.

Home range size varied between sexes. Adult females' home ranges averaged about 40 percent larger than adult males. The mean number of times each adult male (N=7) was
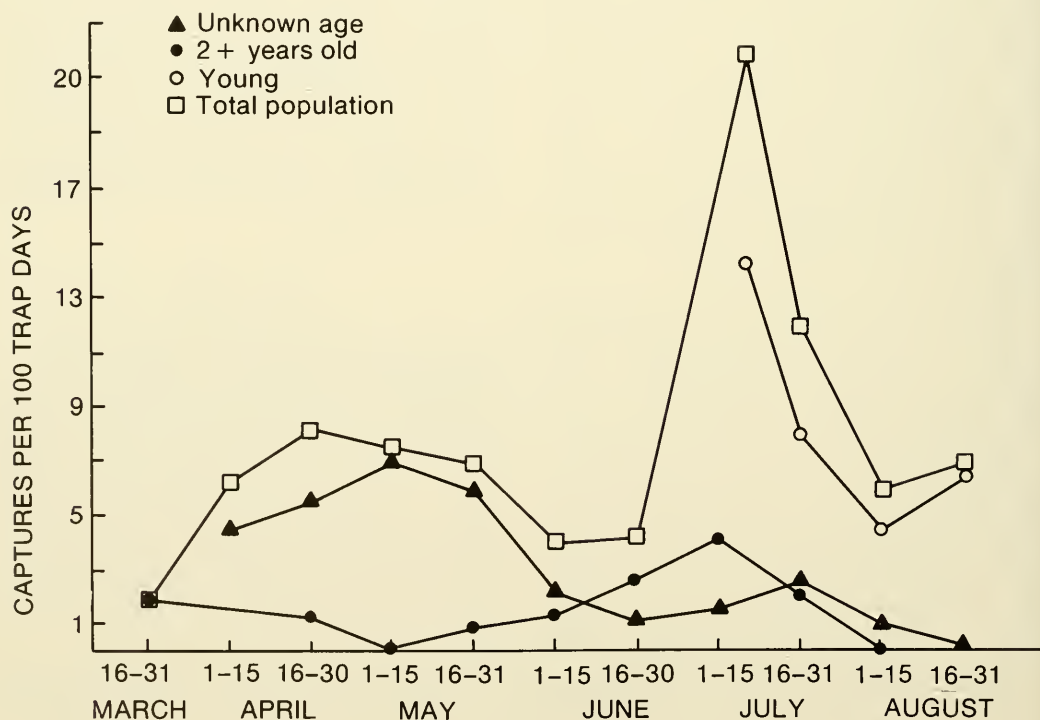

Fig. 1. Captures per 100 trap days expressed biweekly throughout the 1968 trapping period as an index of population activity.

captured or observed was 9.8 SD ± 2.1; for each adult female (N = 9) it was 16.6 ± 3.9. Mean home range for adult males was 0.24 SD ± 0.11 ha (range 0.11–0.39); for adult females it was 0.35 SD ± 0.19 (range 0.27–0.56).

Breeding occurred in April (Table 1), a fact determined by examining the sexual condition of 69 squirrels. Young squirrels first appeared above ground in early July. By first counting backwards, using known nest confinement and gestation periods (Asdell 1946), then observing breeding in the field, we estimated the duration of these life history stages.

Agonistic behavior observations were expressed for two periods: breeding-gestation (mid-April–May) and natal care (late May–June). From 28 April to 4 May 1968 there was a peak of activity. Four instances of "courtship" behavior were noted that followed descriptions given by McCarley (1966) and Wistrand (1974). No copulatory behavior was seen. During this week 14 squirrels were later recaptured in areas up to 300 m away from their original capture sites. Mean capture success for 15 April to 31 May (breeding) was 6.9 per 100 trap days, more than twice the 3.1 capture index for the natal period (1–31 June). However, differences were not significant

Of 29 agonistic interactions seen in 1968, 21 involved at least one female and 8 involved a male; the second animal in these interactions was not identified. Of agonistic interactions (N = 17) observed during the natal period, 14 involved females. Table 2 gives the form of agonistic interactions seen. No

significant differences existed in the form of the interactions between the two periods.

Parturition burrows (N = 5) were located by observing adult females carry mouthfuls of nest materials into certain burrows. These sites were taken as centers-of-activity. In males, geometric centers of home ranges were considered as centers-of-activity in 9 cases. Analyses of location and outcome of 24 agonistic interactions for these squirrels indicated that an individual tended to be dominant in interactions occurring nearest its center-of-activity (Table 3).

Discussion

According to Kummer (1971), social affinity and spatial proximity are so highly correlated that the distribution of individuals in space can be used as first reading of the social structure. A great proportion (86 percent) of all squirrels in the study shared capture sites. By itself, a large overlap in capture sites does not necessarily indicate a large overlap in home range. Existence of agonistic interactions suggests that a portion of each home range was defended against intrusion, although this may have indicated hierarchy independent of actual geography. Nevertheless, a certain degree of spacing did exist as a result of agonistic behavior.

Table 2. "Form" of 29 agonistic interactions observed in thirteen-lined ground squirrels, Laramie Plains, Wyoming (1968).

Form	Breeding–gestation	Birth–natal
	1 April–31 May	1–31 June
Contact	2	4
Chase	4	3
Both	6	10
Totals	12	17

Table 1. Sexual condition of adult thirteen-lined ground squirrels in the Laramie Plains, Wyoming.

Sexual condition	Breeding–gestation	Birth–natal
	1 April–31 May	1–31 June
Females:		
Vulvae normal	1	8
Vulvae swollen and/or open	29	1
Lactating	1	9
Nonlactating	29	0
Males:		
Testes abdominal	1	3
Testes scrotal	25	1

Table 3. Results of 24 agonistic interactions in relation to distance from "centers-of-activity" in thirteen-lined ground squirrels.

Encounter results	Meters from center-of-activity		
	0–8	9–15	16+
Dominant	12	4	2
Stand-off	4	2	0
Subordinate	0	0	0
Totals	16	6	2

In a population of ground squirrels organized into overlapping home ranges, it can be assumed that few novel encounters between adults will occur once the basic home range configuration has been well established. This may account for the relatively few agonistic interactions seen in this study (N = 29) and seen by Wistrand (1974), who saw only 19, compared to Grubitz (1966), who noted 767 in a closed area. Balph and Stokes (1963) suggested that, in Uinta ground squirrels, "territorial" behavior may be the result of an encroachment by one squirrel into the area of another squirrel's "individual distance" rather than a fixed site attachment. Wistrand (1974) considered that a similar pattern of agonistic behavior occurred in his thirteen-lined ground squirrel population.

Territorialism is suggested by squirrel's marked avoidance of certain burrows, especially during the natal period. In Richardson's ground squirrels, Yeaton (1972) noted that females possess a "territory" throughout the aboveground activity cycle. Wistrand (1974) noted that thirteen-lined ground squirrels defended burrows, but only at the time they occupied the burrow. He also noted that a burrow may be used by more than one squirrel, provided only one animal occupies it at a given time. A similar case may have existed in my study. Temporal-spatial mechanisms clearly need further elucidation before we understand thirteen-lined ground squirrel social organization.

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OVERWINTER SURVIVAL OF RING-NECKED PHEASANTS IN UTAH

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ABSTRACT.— The influence of winter weather on the survival of Utah's ring-necked pheasants was evaluated using correlation analysis. This method used published Utah State Division of Wildlife Resources population data and a calculated winter warmth index. Results show four different patterns of survival occurring in the 14 counties analyzed.

Wagner and Stokes (1968) estimated over-winter survival of ring-necked pheasants (*Phasianus colchicus*) in Wisconsin. They correlated a fall population index with an over-winter survival index and with a spring population index. Their results suggested density independent winter survival for the statewide population. Perry (1946) proposed that severe winter weather in New York affected the vigor of pheasants but did not significantly increase overwinter mortality.

Edwards et al. (1964), Gates and Woehler (1968), and Gates (1971) suggest that harsh weather, particularly in late winter and early spring, may cause increased mortality of hens in the early summer during the brood-rearing season. Gates (1971) proposed that a decrease in body weight of hens caused by harsh winter weather delayed egg laying in spring and resulted in hens entering the breeding season in suboptimal physical condition. During the nesting and brood-rearing period, hens continue to lose weight; this results in reduced production of young and may lead to the death of the hen. Other studies have shown increased mortality due directly to winter storms, with rates reaching as high as 90 percent (Kimball et al. 1956). Evidence also indicates that predation rates increase with severity of winter weather (Dumke and Pils 1973). In this paper, population dynamics of ring-necked pheasants in Utah are evaluated using indices similar to those employed by Wagner and Stokes (1968) to determine the relationship of winter weather to survival.

METHODS

Data used in this analysis were compiled from Utah Upland Game Annual Reports from 1967 through 1979 (Nish 1967–1976, Bunnell and Olsen 1977–1978, Bunnell and Leatham 1979) and from Climatological Data of Utah (Mitchell 1962–1979). Preliminary models were derived for Box Elder, Cache, Duchesne, Sevier, Uintah, and Utah Counties to select indices for use in the final analyses.

The fall population index used was birds harvested per hunter day afield. In 1973 the daily bag limit on pheasants in Utah was lowered from three to two cocks per day. However, the mean harvest rate did not show a substantial decrease in response to this change. It appeared that reducing the bag limit did not influence hunter success. No attempt was made to adjust the fall index to the change in bag limit.

The summer index used was computed by subtracting young/km from total birds/km yielding an index of adult pheasants/km. These summer population data are collected each August along established census routes. Summer population data were used because spring population data were not available in Utah. Also, by using summer data we can incorporate summer mortality due to winter weather as discussed previously.

A winter survival index was calculated by dividing the summer index by the fall index of the previous year. All population indices

were multiplied by 100 to give whole numbers.

In the preliminary models, a winter severity index utilizing temperature and precipitation variables similar to Gates' (1971) procedure was attempted, but no significant relationships were apparent between the survival index and the winter severity index. Precipitation alone showed no significant relationship to pheasant survival. There was, however, a significant positive correlation between winter (December, January, and February) temperature and the survival index. Hence, we hypothesized that for the areas of Utah studied, there was not enough precipitation during the winter months to significantly affect the pheasant numbers. Winter precipitation varied from only trace amounts in Emery County, to a high three-month total of 27.3 cm (10.75 inches) in Box Elder County. As a result of preliminary findings, a winter warmth index was used in this analysis, calculated by summing the average temperatures for December, January, and February only.

The fall population index was correlated with the log of the summer population index for the following year. The winter warmth index was correlated with the log of the appropriate survival index. Log transformations of the dependent variables were used because they yielded slightly higher correlation coefficients than analyses using raw data.

Areas analyzed were selected from throughout Utah. Counties were selected based on the completeness of their population data. Weather stations within the selected counties were selected based on their proximity to major pheasant-hunting areas and on the completeness of their climatological data (Table 1). Where monthly weather data were missing for any station, missing values were filled with appropriate monthly averages from 1962 through 1979. For stations with missing data for an entire year, values were estimated using data from a neighboring station.

RESULTS

The major pattern of population dynamics identified in this study showed a strong correlation between the fall and summer population

indices, with little or no influence of winter temperatures on survival (Table 2). This pattern was observed for Beaver, Box Elder, Juab, Salt Lake, Tooele, and Utah Counties. It implies that overwinter survival rates do not fluctuate radically from year to year, since the number of birds in the summer is influenced predominantly by the number of birds present the previous fall. Given the wide range of fall population numbers observed through the study period, the above-mentioned counties seem to exhibit survival rates that are independent of fall population size. Because overwinter survival does not seem to be influenced by population size or winter weather in these counties, factors influencing reproductive success are probably most crucial to these populations. Factors that have been shown to be influential to reproductive success include excessive hen mortality due to farming operations (Gates 1971), nest and hen predation (Dumke and Pils 1973), and variable springtime weather conditions (Besadny 1967, Stokes 1968).

Another pattern of survival was expressed in Millard and Sevier Counties. The fall and summer population indices were strongly correlated, as were the winter warmth and survival indices. This correlation implies density-independent overwinter survival as discussed for the counties previously mentioned, with winter temperatures also playing a part in population dynamics.

TABLE 1. A list of counties on which the analysis was run and weather stations used. All counties had 17 years of data except Beaver.

County	Weather station	Population data missing 1962–1979
Beaver	Beaver	1965
Box Elder	Brigham City	None
Cache	Logan	None
Duchesne	Roosevelt	None
Emery	Castle Dale	None
Juab	Nephi	None
Millard	Fillmore	None
Salt Lake	Salt Lake Airport	None
Sanpete	Moroni	None
Sevier	Richfield	None
Tooele	Tooele	None
Uintah	Vernal	None
Utah	Provo	None
Weber	Ogden	None

Table 2. Summary of the correlation analyses for each county. The table includes sample sizes used to determine fall and summer indices, correlation coefficients, and mean coefficients of determination (R^2) for groups of counties showing similar responses.

County	Hunters reporting fall harvest 95% C.I.	Km of summer pheasant routes 95% C.I.	Fall vs. summer index r =	Mean R^2	Winter warmth vs. survival index r =	Mean R^2
Beaver	34 ± 5.6	153 ± 47.2	0.67°°		0.15	
Box Elder	587 ± 65.2	248 ± 21.4	0.73°°		0.36	
Juab	79 ± 9.9	58 ± 8.2	0.80°°		0.20	
Salt Lake	548 ± 48.2	286 ± 86.8	0.70°°		-0.39	
Tooele	117 ± 17.4	103 ± 13.3	0.47°		0.25	
Utah	827 ± 77.0	569 ± 67.7	0.66°°	0.46	-0.04	0.07
Millard	220 ± 21.5	401 ± 42.9	0.67°°		0.57°°	
Sevier	185 ± 21.0	289 ± 37.1	0.66°°	0.44	0.62°°	0.35
Cache	437 ± 41.2	231 ± 58.0	0.39		0.61°°	
Sanpete	214 ± 25.7	262 ± 60.7	0.35	0.14	0.41°	0.27
Duchesne	148 ± 16.1	567 ± 28.5	-0.11		0.30	
Emery	135 ± 13.9	271 ± 46.4	0.18		0.34	
Uintah	141 ± 11.4	260 ± 42.7	-0.03	0.02	0.15	0.08
Weber	496 ± 47.8	149 ± 17.6	0.03	0.00	-0.49°	0.24

° = $P < 0.05$
°° = $P < 0.01$

Pheasants in the western plains have been shown to suffer direct storm-induced mortality during extremely harsh periods (Kimball et al. 1956, Lyon 1959). Pheasant losses in Millard and Sevier Counties may be a result of direct winter mortality, or mortality occurring during the nesting season due to winter weather, as suggested by Gates (1971). Analysis of winter mortality and vigor in these areas may help determine mechanisms of weather-induced mortality.

Significant correlations between the winter temperatures and the survival indices, with no statistically significant correlations between the fall and summer indices, were shown for Cache and Sanpete Counties. Winter temperature, although a significant factor to survival, accounted for only about 27 percent of the variability in the survival index. This fact, coupled with the lack of correlation between fall and summer indices, implies highly variable November to August survival rates for these counties, with winter temperatures playing a minor although important role.

Duchesne, Emery, and Uintah Counties showed no significant correlation in either of the correlation analyses. These results suggest only that survival rates are highly variable and winter weather has very little influence on the pheasant populations. Any pheasant studies in these counties should look closely at the influences of population size, reproductive success, habitat, and food requirements on the ecology of these populations.

Weber County was unique in expressing a significant negative correlation between winter temperatures and the survival index with no relationship between fall and summer indices. In Weber County, survival rates seem to decrease when winter temperatures increase and are highly variable from year to year. These results are presented here with no attempt at interpretation.

Through a series of indices and their interactions, we have shown several patterns of overwintering population dynamics for pheasants in Utah. We are not suggesting that county boundaries delineate unique ecological situations. By using data from individual counties, we have been able to show that variation exists between different areas of the state. The methods outlined in this paper do not propose to give definitive solutions to particular population dynamics. They are intended to yield generalizations concerning

factors that may be influential on a particular population. These techniques can be used on any wildlife species for which there are population data as a preliminary analysis to provide guidance for major studies. Once crucial factors are identified, further research can be more precisely directed to determine specific factors that may be limiting survival.

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DIETS OF SYMPATRIC RED FOXES AND COYOTES IN SOUTHEASTERN IDAHO[1]

Jeffrey S. Green[2,3] and Jerran T. Flinders[2]

Abstract.— Scats of sympatric red foxes and coyotes from the upper Snake River Plain of southeastern Idaho were analyzed for composition. Rodent remains in general and those of cricetid mice in particular occurred more frequently in scats of red foxes during all seasons of the year than any other food items identified. Scats of coyotes differed significantly in content from scats of red foxes during winter and contained primarily pygmy rabbit remains. In summer, remains of pygmy rabbits, sheep, ground squirrels, yellow-bellied marmots, arthropods, and vegetation were found more frequently in scats of coyotes and remains of cricetid mice occurred more frequently in scats of red foxes. Red foxes and coyotes generally consumed similar food items but in different proportions. Based on the location of scats that were collected, red foxes and coyotes largely used different portions of the study area. Reasons for the preferential usage of habitat are discussed.

Although over 100 studies of food habits of red foxes (*Vulpes vulpes*) (Ables 1975) and numerous studies of diets of coyotes (*Canis latrans*) (Gier 1975) have been published, there is a lack of information on the food habits of these two canids in sympatry. Both species are versatile in their eating habits and readily consume animal and plant matter depending on season and availability. Both species readily feed on livestock and poultry when available and thus have come into conflict with human interests. Here we report the diets of red foxes and coyotes on the U.S. Sheep Experiment Station (USSES), where up to 10,000 sheep graze at various times of the year.

Study Area and Methods

The USSES occupies approximately 11,000 ha of the upper Snake River Plain in Clark County, Idaho. The vegetation, described by Blaisdell (1958), is dominated by big sagebrush (*Artemisia tridentata*), with the primary understory species being thick spike wheatgrass (*Agropyron dasystachym*), bluegrass (*Poa* spp.), and mixed forbs. The area is grazed by sheep primarily in the spring and fall.

Scats from red foxes and coyotes were collected monthly from January 1976 to March 1978, primarily along dirt roads except when snow cover allowed cross-country snowmobile travel. Scat identification was made by observation of associated tracks, prey kills, and proximity to known dens and areas of preferred use. Scats were oven dried prior to storage and were later washed, separated, and prepared for analysis in a manner similar to that described by Johnson and Hansen (1979). The hair component of each scat was hand separated from the large (> 1mm) insoluble component.

Using a point frame method, 20 hair fragments from each scat were selected and identified by comparison to a reference collection of hair from prey species on the USSES. Hair was identified by medullary characters (Brunner and Coman 1974). Teeth were also used to verify the animal species consumed.

Relative abundance of small rodents on the USSES was estimated (Leslie 1952) with two parallel lines of 50 snap traps at 10 m intervals set for four consecutive nights. At least six sites per season were trapped during July 1976 and July 1977 in areas of varying sagebrush and bitterbrush cover. Fecal pellets of pygmy rabbits (*Brachylagus idahoensis*) were collected from seven permanent sites during 1977 and 1978 to monitor relative abundance of rabbits (Green and Flinders, 1980a). Rock chucks (*Marmota flaviventris*) and sage

grouse (*Centrocercus urophasianus*) were censused with spatial counts during summer 1976 and 1977.

A chi-square test was used to compare red fox and coyote diets and significance is reported at the 0.05 level.

RESULTS AND DISCUSSION

One hundred twenty-five scats from red foxes and 129 scats from coyotes were analyzed. They were grouped, according to date of collection, into one of two seasonal periods: winter (comprising inclusively the months September through February) and summer (comprising inclusively the months March through August). Small sample size precluded meaningful analyses of red fox and coyote scats between years. Therefore, the results reported reflect a biseasonal comparison of scat composition through a 27-month period (Table 1).

Sheep and yellow-bellied marmot remains occurred more frequently in red fox scats during the winter period, and Great Basin pocket mice (*Perognathus parvus*) occurred more frequently in the summer period. Rodents in general and cricetid mice in particular (primarily *Peromyscus maniculatus*), occurred more frequently in scats of red foxes in both seasonal periods than any other food items identified.

Remains of pygmy rabbits were found most frequently in the scats of coyotes during the winter period and remains of Uinta ground squirrels (*Spermophilus armatus*), yellow-bellied marmots, arthropods, and vegetation were found more frequently in scats during the summer period. This was not unexpected, since yellow-bellied marmots and ground squirrels were in hibernation from approximately August until March and the likelihood of coyotes consuming arthropods and vegetation was higher in summer than in winter.

There were significant differences in the composition of scats of red foxes and coyotes during the winter and summer periods. During winter, pygmy rabbit remains were found more frequently in scats of coyotes, and remains of cricetid mice, birds, and vegetation were found more frequently in scats of red

TABLE 1. Bi-seasonal comparisons of contents of scats from sympatric red foxes and coyotes in southeastern Idaho.

| | Winter (September–February) | | | | Summer (March–August) | | | |
| | Red fox (n = 38) | | Coyote (n = 64) | | Red fox (n = 87) | | Coyote (n = 65) | |
	% occur.[1]	% vol.	% occur.	% vol.	% occur.	% vol.	% occur.	% vol.
Rabbits (total)	(32)	(22)	(67)	(70)	(32)	(14)	(38)	(22)
Pygmy rabbit	29	22	64	69	22		38	22
(*Brachylagus idahoensis*)								
Jackrabbit	3	t	3	1				
(*Lepus townsendii*)								
Rodents (total)	(71)	(51)	(39)	(16)	(82)	(69)	(74)	(65)
Yellow-bellied marmot	5						31	
(*Marmota flaviventris*)								
Uinta ground squirrel			2		1		17	
(*Spermophilus armatus*)								
Great Basin pocket mouse	3		3		17		12	
(*Perognathus parvus*)								
Cricetid mice[2]	68		39		75		43	
Other rodents	5		6		16	5		
Domestic sheep	34	23	25	13	17	14	32	12
Birds	13	t	3	t	10	t	12	t
Arthropods	18	t	6	t	21	t	49	t
Plant matter[3]	34		17		34		66	

[1]Percent of scats that contained particular food items.
[2]Primarily *Peromyscus maniculatus*.
[3]Volume of plant matter was not estimated.

foxes. In the summer period, remains of pygmy rabbits, sheep, ground squirrels, yellow-bellied marmots, arthropods, and vegetation were found more frequently in scats of coyotes, and remains of cricetid mice occurred more frequently in scats of red foxes.

An index of similarity (SI) was calculated for scat composition of red foxes and coyotes for the winter and summer periods using the formula SI = (Σ minimum value ÷ Σ maximum value) (100). The SI for composition of scats of red foxes and coyotes during the winter period was 48.5 percent and during the summer period was 44.5 percent. An SI of 100 percent would exist when scats were identical in composition.

The density of small mammals was estimated to be 44/ha in the summer 1976 and 74/ha in the summer 1977. Deer mice were the predominant rodent during both years (59 and 90 percent, respectively). The density of yellow-bellied marmots and sage grouse were 0.075 and 0.475/ha, respectively, in 1976 and 0.57 and 0.97/ha, respectively, in 1977. Fecal pellet counts of pygmy rabbits were not significantly different during the two years of the study.

Sheep remains were found in scats of red foxes and coyotes throughout the year. In winter, the sheep remains were obtained as carrion because the sheep were kept in pens where they were not vulnerable to predation. Sheep carcasses were not removed from the range, and in winter they may have provided an important source of food for both canids. One of us (Green) observed sheep carcasses uncovered from beneath several feet of snow by red foxes and coyotes. They were frequently fed upon by both predators. During the spring, lamb remains were observed at the entrance to several fox dens. Lambs die of exposure and/or disease in the spring and may be consumed by both red foxes and coyotes. Both predators may also kill and consume sheep.

Several studies have shown that, in certain areas, coyotes relied heavily upon rabbits (*Sylvilagus* spp.) and/or hares (*Lepus* spp.) (Bond 1937, Sperry 1941, Korschgen 1957, Clark 1972). In this study area, pygmy rabbits provided a major portion of the diet of coyotes. Scats from coyotes collected during January and February were often composed entirely of remains from pygmy rabbits. During the period of this study, cottontail rabbits (*S. nuttallii*) and white-tailed jackrabbits (*L. townsendii*) were rarely observed. Although relatively small, pygmy rabbits were the largest prey species available on the USSES during the latter half of the winter period. [Adult pygmy rabbits weigh approximately 450 g (Green and Flinders 1980b); adult Nuttall's cottontail rabbits weigh approximately 800 g (Orr 1940); white-tailed jackrabbits weigh approximately 2.7 kg (Flinders and Hansen 1972).]

Scats from coyotes were collected throughout the 11,000 ha of the USSES although more (73 percent) were found in the northern half. Scats from red foxes were also found throughout the study area, but a majority (80 percent) was collected in the southern half. In addition, red foxes were rarely observed anywhere but in the southern portion of the USSES. The entire study area is sagebrush-grass type with no readily apparent differences in habitat between the northern and southern portions. Rodent trapping and other censusing of wildlife indicated that items of prey were generally found in similar concentrations in all areas sampled.

We propose that both canids in this study, and particularly red foxes, showed a preferential usage of habitat for the following reasons. For over 60 years the plan of sheep management at the USSES has been to graze the southern portion of the range with ewes and their new lambs beginning approximately May 1. The death of lambs from disease and starvation is often augmented by adverse weather conditions, thus providing carrion for carnivores. The availability of carrion corresponds closely to the time of whelping, raising, and rearing of red fox pups. Since adult red foxes are likely to remain in the same area for life (Ables 1975), it is conceivable that generations of red foxes have keyed on this area for food; both carrion and vulnerable prey (lambs). At least five active den sites of red foxes were located in the southern portion of the USSES during this study. Red foxes have not been actively hunted in this area.

Several factors have increased human killing of coyotes since the early 1970s. Fur prices escalated, causing increased sport

hunting, trapping, snowmobile chasing, and aerial gunning of coyotes. The latter two methods are extremely effective in eliminating coyotes in sagebrush-grass habitat. The use of poisons for coyote control was prohibited, perhaps intensifying the effort, particularly in sheep-producing areas, to remove coyotes at every opportunity.

Since the USSES headquarters is located in the southern portion of the range, human activity (moving sheep to and from headquarters for lambing and shearing, hauling water, and inhabiting sheep wagons) is more intense than in the northern area. Human pressure on coyotes, the concurrent relative disregard for red foxes, and the opportune pup-rearing circumstances for red foxes in the southern portion of the range may all have contributed to the differential use of habitat by red foxes and coyotes observed in this study.

Although little is known of the interspecific relationships of red foxes and coyotes, there is some indication that red foxes may readily occupy a suitable niche vacated by coyotes as a result of predator control or other reasons (Gier 1975, U.S. Fish and Wildlife Service 1978). It is not known how long red foxes and coyotes have occupied this study area, but, because both these predators often utilize similar food items and occupy similar habitat, it is doubtful that their relationship is static.

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THE EFFECT OF ELEVATED TEMPERATURE ON COPPER TOXICITY TO THE THERMOPHILIC ALGA *SYNECHOCOCCUS LIVIDUS* (CYANOPHYCEAE)

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ABSTRACT.— The hypothesis that temperature influences the toxicity of copper to thermophilic Cyanophyceae was tested in a laboratory study with *Synechococcus lividus*. This thermophile was tested at copper concentrations from 0 to 200 ug/l, and temperatures from 40.0 to 50.0 C. It was found that an interaction between increased copper and temperature significantly decreased the rate of carbon assimilation, chlorophyll content, and photosynthetic efficiency.

Geothermal springs represent a remarkably unique and stable environment with respect to a large number of physical and chemical parameters. The temperatures of these springs rarely vary more than 2 C throughout the seasons. A constant flow rate with laminar flow characteristics exists which, among other things, minimizes the forces of erosion. Light intensity is high. The area around hot springs is usually devoid of trees and the water column is shallow. Nutrient replenishment is continuous in the flowing water system, so that nutrient deficiencies probably do not develop (Brock 1970).

Even in these seemingly ideal conditions, only a restricted flora exists. Due to the elevated temperatures of the thermal spring environment—approximately 50 C to well above the boiling point in fumaroles—prokaryotes are usually the sole inhabitants (Brock 1967a). The Cyanophyceae present have an upper temperature limit of 73–75 C. These algae are not merely subsisting, but are actually growing and thriving at a given location (Brock 1967b). This heat tolerance seems to be due to a number of factors, including the thermal stability of their photosynthetic membrane systems, the low Q_{10} value of respiratory rates preventing acceleration to lethal catabolism, the heat stability of the algal protoplasmic structures and the capacity of their proteins to endure high temperatures without denaturation, and the lack of competition in the environment

(Brock 1974, Lewin 1962). Luxuriant growth is to be expected in these locations.

However, visible degradation of the algal mats has occurred in many thermal springs of Yellowstone National Park. This deterioration is particularly noticeable in those areas which are heavily frequented by visitors.

Changes in water temperature, nutrient concentration, flow rate, etc., may be eliminated as possible mechanisms for degradation due to the stability of the environment. An external factor exists as the remaining possibility—i.e., the introduction of copper coinage to the thermal springs (R. A. Hutchinson, Yellowstone National Park Geologist, pers. comm.).

Copper has long been widely used as an algicide. The recommended dose for algal control in alkaline water ranges from 0.2 to 2.0 mg/l (Trainor 1978), but can be as low as 50 µg/l for *Chlorella* (Bartlett et al. 1974). The chemical analysis of some of the major thermal springs of Yellowstone National Park indicates the copper concentration ranges from 1 to 9 µg/l (Brock, 1978), which appears to be much too low for the demonstrated algicidal effects. However, this does not preclude the possibility of increased toxicity at the elevated temperatures found in the thermal springs. These temperatures approach the critical maximum for life itself.

The possibility, therefore, exists that even low copper concentration in a thermal environment produce a detrimental effect on

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algal mats—i.e., an interactive effect exists between copper and heat.

METHODS

Axenic cultures of *Synecococcus lividus* (R. Castenholz, Department of Biology, University of Oregon, pers. comm.) were maintained in a general growth medium (Miller et al. 1978) with a 12-hour light:dark cycle. Cultures were frequently diluted to maintain cells in exponential growth phase.

Batch cultures were acclimated to a temperature (± 0.01 C) for one week prior to each experiment. Following this acclimation period the culture volume was subdivided, and to each aliquot an amount of copper was added as $CuSO_4 \cdot 5H_2O$. Final concentrations were 0, 50, 100, 150, and 200 μg Cu/l. Aliquots were then incubated a further 24 hours after which each treatment was dispensed into triplicate 125 ml glass bottles for measurement of carbon assimilation, and an amount was filtered for chlorophyll analysis.

To each of the replicate bottles, we added 5 u Ci of 14-C bicarbonate (New England Nuclear). Cells were incubated for three hours, then membrane filtered and washed with distilled water. Filters were dried, placed in omnifluor, and activity measured by liquid scintillation. Because each treatment was handled in the same manner, radioactive counts per minute (CPM) were directly comparable among treatments. Chlorophyll-a was estimated from the optical density of ethanol extracts.

TABLE 1. Relative carbon assimilation (counts per minute) at experimental temperatures and copper concentrations.

	$\mu g/l$ Cu				
Degrees C	0	50	100	150	200
	31409	8339	8595	7505	2922
	47990	10980	8027	4508	1259
40.0	49364	9436	7765	4059	1032
	46400	11315	11415	3382	2662
	44649	10932	9174	2421	1284
	44459	9157	11700	4087	1221
	28340	26293	9845	2294	1076
	31502	16756	8746	2468	631
42.5	39546	21045	7263	1845	463
	45936	13467	8034	2932	1399
	51584	12640	6336	1317	2477
	46953	12162	7490	3420	352
	218047	131760	53929	26266	8420
	195315	138318	53482	24028	6977
45.0	165850	126580	46425	24480	4832
	184091	113685	39251	23552	2999
	178200	131783	29053	21473	2426
	147796	137110	38914	20091	1499
	126228	46272	16153	4162	1033
	140663	29294	13862	2798	903
47.5	155604	26466	10830	2287	1459
	164761	22688	11420	1932	619
	155644	26186	11849	1257	580
	147319	22365	10548	2040	520
	53933	37702	11616	4812	521
	54506	33803	11605	6573	1762
50.0	62672	24093	12541	1846	803
	73887	21548	9130	1942	4422
	79563	17767	7518	2232	506
	62200	17893	12252	4387	826

This procedure was repeated at each of five growth temperatures: 40.0, 42.5, 45.0, 47.5, and 50.0 C. To facilitate statistical manipulation, all CPM and chlorophyll data were normalized with respect to the control treatment (0 μg/l Cu) to eliminate differences among treatments due to variations in starting population density.

RESULTS AND DISCUSSION

Carbon assimilation data in terms of CPM are shown in Table 1. At all experimental temperatures increased copper concentration led to decreased carbon assimilation so that, at 200 μg, Cu/l assimilation was less than 5 percent of the control value. Using analysis of variance for two-way classification (Mendenhall et al. 1977) we found a significant interaction ($F_{16,125} = 3.31$, $p < 0.01$) between temperature and copper concentration.

Two possible causes for decreased carbon assimilation include decreased chlorophyll content per cell and depressed photosynthetic efficiency measured as carbon assimilation per unit chlorophyll. Table 2 shows the chlorophyll concentration of aliquot cultures after only 24 hours of incubation in the presence of copper. Again, at all experimental temperatures there is a significant decrease in chlorophyll with increased copper. There was also significant interaction ($F_{16,25} = 8.56$, $p < 0.01$) between temperature and copper.

Photosynthetic efficiency as measured by carbon assimilation per unit chlorophyll similarly decreased with increasing copper concentration (Table 3). Further, there was a significant interaction ($F_{16,125} = 12.44$, $p < 0.01$) between temperature and copper.

From these data it appears that copper interacting with temperature can cause significant depression of the photosynthetic activity of *Synechococcus lividus*. This appears to be caused by a decrease in chlorophyll content of the cell, and a lowered photosynthetic efficiency. It is possible that at temperatures higher than those examined only minute concentrations of copper may prove to be toxic to *S. lividus*. If this is so, and if our results may be extended to other thermophilic cyanophytes, this is a possible mechanism to

TABLE 2. Chlorophyll-a concentrations (μg/l) of aliquot cultures following 24-hour incubation with various copper concentrations.

Degrees C	μg/l Cu				
	0	50	100	150	200
40.0	52	42	41	37	31
	49	40	37	36	29
42.5	50	38	27	31	28
	47	36	34	31	28
45.0	98	80	64	75	58
	98	69	64	77	61
47.5	87	63	59	42	34
	90	62	66	41	33
50.0	85	55	48	37	27
	83	58	51	38	26

TABLE 3. Relative photosynthetic efficiency as CPM ^{14}C assimilated per mg chlorophyll. Control treatments were normalized to 100 percent.

Degrees C	μg/l Cu				
	0	50	100	150	200
40.0	100	28	28	14	6
42.5	100	55	31	9	5
45.0	100	94	37	16	4
47.5	100	27	12	3	2
50.0	100	59	28	12	7

explain the current deterioration of algal mats in many thermal springs.

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AVIFAUNA OF THE MT. DELLENBAUGH REGION, SHIVWITS PLATEAU, ARIZONA[1]

John G. Blake[2]

ABSTRACT.— An investigation of the avifauna of Mt. Dellenbaugh, Arizona, and nearby areas on the Shivwits Plateau was conducted during fall 1974 and during spring and summer 1975. A total of 92 species of birds was recorded, of which 56 were considered resident. Species composition is discussed in relation to habitat.

From an ornithological standpoint, the Shivwits Plateau in northwestern Arizona has been neglected. In fact, bird studies in the entire region (northwestern Arizona, southwestern Utah, and adjoining parts of southeastern Nevada) have been limited. The need for work in this part of Arizona is evident from an examination of distribution maps in *Birds of Arizona* (Phillips et al. 1964) and is further emphasized by Monson and Phillips (1964:178). Despite this lack of information, virtually no work has been conducted on the Shivwits Plateau and nearby areas.

Mt. Trumbull, located approximately 50 km NE of Mt. Dellenbaugh on the Uinkaret Plateau, was visited by Huey (1939) for approximately two weeks in late July; Mt. Trumbull is the closest reported study area to that part of the Shivwits Plateau covered by the present report. Farther east, Rasmussen (1941) and Jenks (1931) have reported on bird communities of the Kaibab Plateau. Investigations on avifauna of south central and southwestern Utah have been somewhat more extensive (Presnall 1935, Hardy and Wiggins 1940, Behle 1943, Behle et al. 1958, Wauer and Carter 1965) but have not included the Shivwits Plateau region. Farther west, several authors have examined the desert avifauna of the Virgin River Valley in Nevada, Arizona, and Utah (Tanner 1927, Wauer and Russell 1967, Wauer 1969, Behle 1976, Whitmore 1977).

In 1975, a study was initiated by the U.S. National Park Service Cooperative Resources Studies Unit located at the University of Nevada, Las Vegas, to document distribution of plants and animals within the Lake Mead National Recreation Area. The northern boundary of the recreation area crosses the southern edge of the Shivwits Plateau, close to Mt. Dellenbaugh. As a consequence, several trips were made to the Shivwits Plateau by members of the NPS study team, with observations taken on occurrence and distribution of flora and fauna. The present paper presents an account of bird species observed. Distribution of birds within different habitats is discussed.

Place names and topographical information used in the present report are taken from U.S.G.S. 1:250,000 topographical maps.

STUDY AREA

The Shivwits Plateau is primarily flat tableland, with occasional lava-capped buttes and isolated mountains. Over much of the southern part of the plateau elevation is approximately 1830 m. Northward, the plateau stretches toward Utah, gradually decreasing in elevation. The southern boundary is marked by an abrupt descent to the Sanup Plateau, at 1370 m. Numerous steep-walled canyons dissect the plateau, leading eventually to the Colorado River. Mt. Dellenbaugh, the highest peak in the southern part of the plateau, reaches an elevation of 2130 m. Approximately 8 km NE is Yellow John Mountain, which reaches an elevation of 2060 m (Fig. 1).

Observations are primarily from the vicinity of Mt. Dellenbaugh and Green Springs Canyon; additional observations were made on a trip along Twin Point (Fig. 1). Various distinct habitats occur at different locations

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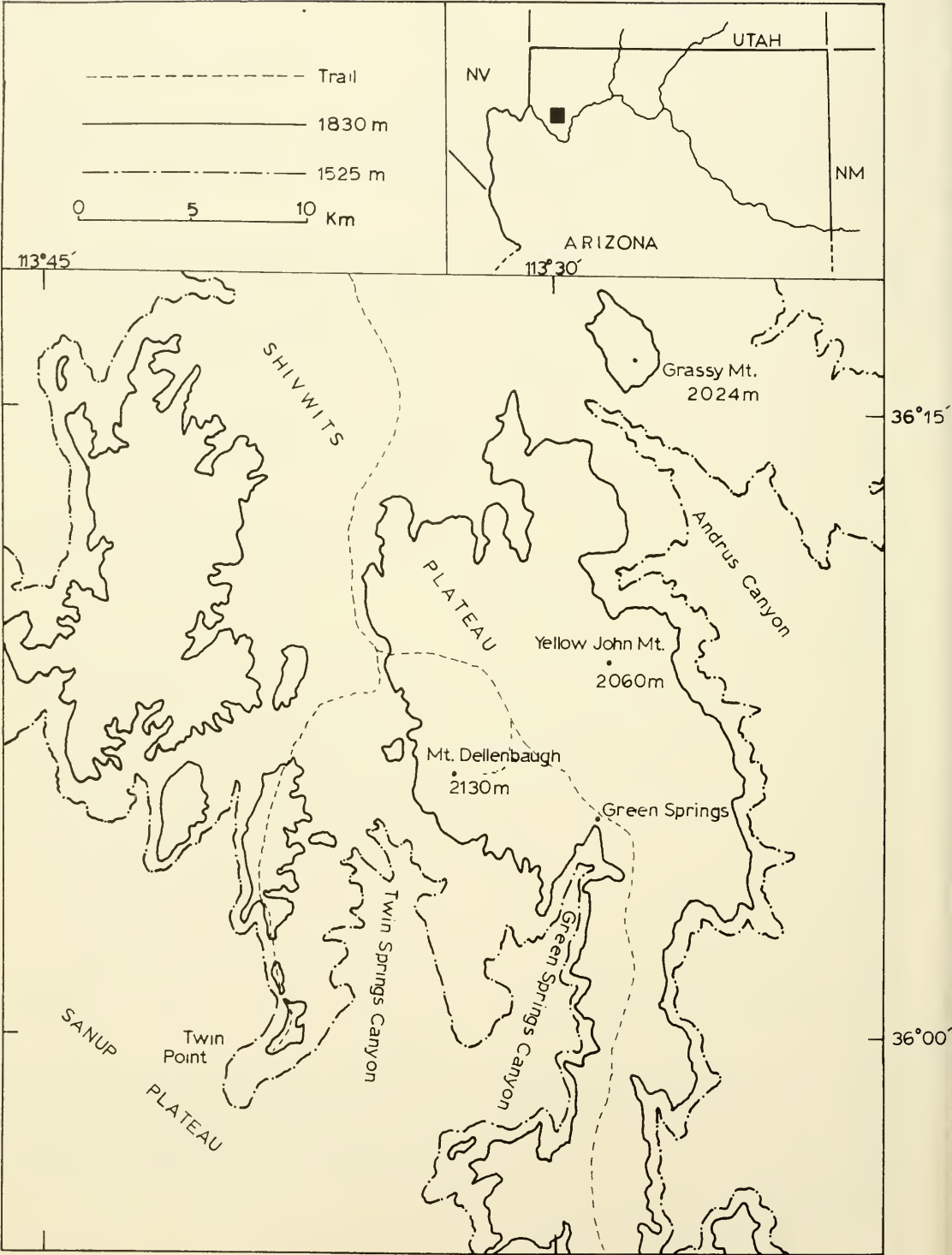
Fig. 1. The southern part of the Shivwits Plateau is shown, with sites mentioned in the report indicated. Location of the plateau within Arizona is shown in the upper right.

and are briefly described below. Plant identification was by members of the NPS study team.

Predominant vegetation over most of the Shivwits Plateau is pinyon pine (*Pinus monophyla*) – juniper (*Juniperus osteosperma*) woodland. Understory is sparse within this open, relatively xeric woodland, consisting primarily of sagebrush (*Artemisia*) and scrub oak (*Quercus*). Locally concentrated patches of oaks and sagebrush produce a more brushy appearance in certain areas (e.g., southern end of Twin Point).

Ponderosa pine (*Pinus ponderosa*) occurs in limited amounts, principally along drainages where soils are deeper and moisture conditions higher. Scattered individuals occur throughout the area. Due to drainage patterns, ponderosas occur primarily as belts interspersed in pinyon-juniper woodland and bordering open sagebrush fields. Understory and ground cover are sparse, with a mixed shrub assemblage that includes species of oak, sagebrush, mountain mahogany (*Cercocarpus montanus*), and others.

Upper slopes of Mt. Dellenbaugh and edges and slopes of various canyons are covered with a mixed assemblage of relatively brushy shrubs and trees, which produces a chaparral type habitat. Although oaks, including scrub oak (*Quercus turbinella*), Gambel oak (*Q. gambelii*), and wavyleaf oak (*Q. undulata*), are particularly abundant, numerous other shrubs also occur, including mountain mahogany and manzanita (*Arctostaphylos pungens*). Particularly on the slopes of Mt. Dellenbaugh, New Mexican locust (*Robinia neomexicana*) occurs in locally dense stands.

Large expanses of sagebrush (*Artemisia tridentata*) occur at a number of locations on the plateau. In a number of instances, juniper trees have been cleared, and large piles of dead trees add a significant component to the habitat. Additional plant species occurring with sagebrush include rabbit brush (*Chrysothamnus spp.*), snake weed (*Gutierrezia microcephala*), and others.

Several ranchers graze cattle on the plateau, and a number of ponds have been constructed to supply water. Vegetation is virtually absent around some ponds, but others are bordered by relatively dense stands of shrubs, particularly rabbit brush.

All habitat types described above occur at or near Mt. Dellenbaugh. A large sagebrush field occurs just north of the mountain and has been maintained in part for use as a landing strip. Cattle also graze over parts of the field; several ponds occur in or around the perimeter of the field. Pinyon-juniper woodland surrounds much of the mountain and extends south to the plateau edge. Pinyon-juniper extends part way up the slopes of the mountain, particularly on the northern face. Ponderosa pine occurs in belts near the base of the mountain, bordering the sagebrush at numerous points. Mixed oak scrub predominates over much of the mountain slope.

Green Springs Canyon is located approximately 6 km ESE of Mt. Dellenbaugh (Fig. 1). Pinyon-juniper woodland predominates over much of the surrounding plateau. An open ponderosa pine stand occurs at the head of the canyon. The stand was logged at some time in the past, and presently is composed of large, widely spaced trees, forming a more parklike appearance than is found elsewhere. Patches of sagebrush occur at scattered locations, but large expanses are absent from the area. Canyon slopes and edges are covered by oak scrub, with Gambel oak particularly prevalent in patches on midslopes. The canyon bottom is quite moist and supports a limited amount of riparian vegetation.

Twin Point is predominantly pinyon-juniper woodland with oak scrub along the plateau rim and at the southern end of the point. Large sagebrush fields occur at several locations along the plateau.

Methods

Mt. Dellenbaugh was visited in fall 1974 (28 September, 4–5, 12–14 October), and spring (17–18 May) and summer (7,9,27–29 June) 1975. Green Springs Canyon was visited 28–29 September 1974 and 16 May and 6,8 June 1975. A trip was made to the southern end of Twin Point 6–7 October 1974; the northern end was briefly visited again on 7 June 1975. Thus, a total of 19 days was spent in field observations.

No regular censuses were conducted during the study, but all habitats were surveyed

on a regular basis. Observations were conducted on foot and were concentrated in the morning, from approximately one-half hour prior to sunrise until approximately 4–5 hours after sunrise. Additional observations were made throughout the day with a second concentrated effort in the evening. During observation periods, a count was kept of the number of individuals of each species seen. The trip out from Twin Point involved periodic stops for observation as well as observations from the vehicle.

Several additional trips were made to the Mt. Dellenbaugh area in spring and summer 1976 by other members of the study team. Observed species new to the area are listed at the end of the Appendix.

Species were classified as resident (including those thought to be permanently resident on the plateau and those that breed in the area but depart for winter), migrant (those passing through the area in fall and/or spring as part of a regular migration), and visitors (including those that breed elsewhere, frequently at lower elevations, which appear on the Shivwits Plateau irregularly but not during normal migration periods). Most visitors were observed only once.

Relative abundance designations were determined from the number of days on which the species was observed, together with the number of individuals observed. Abundant species were designated as those seen on approximately 80 percent or more of trips, common species were observed 60–80 percent of the time, uncommon species were observed 40–60 percent of the time, and rare species were observed less than 40 percent of the time. The number of individuals observed was used to modify these categories. Thus, a species seen on all trips, but with only 1–2 individuals recorded each time was designated common. Alternatively, species seen on few trips, but seen in large numbers on each trips, were designated as common. This method is subjective, but with criteria consistently applied does provide an index of abundance.

RESULTS

A total of 92 species was recorded during visits to the Shivwits Plateau (Appendix). Of these, 13 were observed only in 1976, including one summer resident (Poor-will), 3 migrants, and 9 visitors. The failure to record additional summer residents suggests that coverage in 1975 was relatively complete. The following discussions that involve habitat preference will not include these species, due to a lack of personal observations.

Of the total observed, 56 species were considered probable breeding residents, 24 were migrants, and 12 were visitors. More species were observed in pinyon-juniper woodland than in other habitats (Table 1), although the numbers in oak scrub and ponderosa pine were comparable. Among residents, a greater number were recorded from oak scrub habitat (35) than from pinyon-juniper (34) or ponderosa pine (31). Migrants were considerably more common in pinyon-juniper and ponderosa pine stands than in oak scrub. The number of resident species observed on fields or at ponds were similar (Table 1). Heavy use of ponds by migrants (29 percent of the total observed at ponds) resulted in a higher species total from ponds than from fields.

Thirty-two species were observed in only one habitat (Table 2). Of these, 15 were resident, 14 were migrant, and 3 were visitors. Only a single resident species (Black-throated Gray Warbler) was restricted to pinyon-juniper woodland, although this habitat is predominant over the plateau. More species, 5, were restricted to oak scrub habitat than to any other habitat. More than twice as

TABLE 1. Distribution within habitats is shown for species recorded at or near Mt. Dellenbaugh, Arizona, 1974–1975.

	Pinyon-juniper	Ponderosa pine	Oak scrub	Sagebrush fields	Ponds
Residents	34	31	35	18	18
Migrants	11	7	7	3	8
Visitors	0	1	0	0	2
Total	45	39	42	21	28

many migrants were observed only at ponds (7) than in any other habitat (3 in pinyon-juniper). In contrast to residents, only one migrant was restricted to oak scrub areas. Visitors also were slightly more frequent at ponds than in other habitats.

DISCUSSION

Close proximity of several distinct habitat types may influence the species composition of an area. Habitat variability is greater at Mt. Dellenbaugh than at Green Springs Canyon, and a greater number of species were resident at Mt. Dellenbaugh (51) than at the latter area (33). Four species, including 3 owls, were recorded only from Green Springs Canyon. In addition, Canyon Wrens were present along the canyon slopes at Green Springs. Presence of large sagebrush fields and several cattle ponds accounted for 4 of 15 species recorded only from Mt. Dellenbaugh (Killdeer, Common Nighthawk, Horned Lark, Mountain Bluebird); Turkey Vultures and Red-tailed Hawks also were seen more frequently over fields or at ponds.

Species composition at Mt. Dellenbaugh and surrounding areas was similar to that reported by Huey (1939) for Mt. Trumbull. Of 51 species included by Huey in his report, 43 were from the Mt. Trumbull region, with 8 from areas farther north. Of the 43, 38 were considered resident at Mt. Trumbull, with 3 more possibly resident in the area. Of the 43 birds seen at Mt. Trumbull, 32 were considered resident at Mt. Dellenbaugh, 5 were not considered resident, and 6 were not observed at Mt. Dellenbaugh. Seven of the 8 species recorded by Huey (1939) from areas north of Mt. Trumbull were seen at Mt. Dellenbaugh; 4 were considered resident. The present report covers a greater area than did Huey (1939), which accounts in part for the higher

resident species total from Mt. Dellenbaugh (56 species). In addition, Mt. Trumbull reaches a higher elevation (2447 m) than Mt. Dellenbaugh, accounting in part for some of the species differences between the two areas.

The present report presents a preliminary species list, but considerable additional work in the area is needed. Bird communities on the more isolated Sanup Plateau have, for example, not been investigated at all. Additionally, although pinyon-juniper woodland forms a fairly continuous cover over the plateau, additional habitat types are present as more or less isolated patches of varying size. An examination of bird use of these habitat patches, with respect to area and degree of isolation, would prove interesting.

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TABLE 2. Distribution of species restricted to one habitat. Species were observed at or near Mt. Dellenbaugh, Arizona, 1974–1975.

	Pinyon-juniper	Ponderosa pine	Oak scrub	Sagebrush fields	Ponds
Residents	1	4	5	2	3
Migrants	3	2	1	1	7
Visitors	0	1	0	0	2
Total	4	7	6	3	12

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APPENDIX

Species observed on Shivwits Plateau, Arizona. Observations were made at Mt. Dellenbaugh (MD), Green Springs Canyon (GS), and Twin Point (TP). Residential status (R) is noted (M = migrant, V = visitor, PR and SR = permanent and summer residents, respectively). Relative abundances are indicated by season (F = fall, SP = spring, SU = summer). Five habitats are distinguished (PJ = pinyon-juniper woodland, PP = ponderosa pine, OS / oak scrub, F = sagebrush fields, P = ponds). Nomenclature follows AOU Check-list of North American Birds, 1957 ed., with 32nd and 33rd supplements.

Species	R	Abundance			Location			Habitat				
		F	SP	SU	MD	GS	TP	PJ	PP	OS	F	P
Green-winged Teal	M	X					+					+
Anas crecca												
Ruddy Duck	M		X		+							+
Oxyura jamaicensis												
Turkey Vulture	SR		U	C	+					+	+	+
Cathartes aura												
Sharp-shinned Hawk	SR	U	U		+	+		+	+	+		
Accipiter striatus												
Cooper's Hawk	M	U			+		+	+	+	+		+
Accipiter cooperi												
Red-tailed Hawk	PR	U	R	U	+					+	+	
Buteo jamaicensis												
Golden Eagle	PR	X					+				+	
Aquila chrysaetos												
American Kestrel	SR	U	U	C	+	+	+	+		+	+	+
Falco sparverius												
Killdeer	SR		C	C	+							+
Charadrius vociferus												
Spotted Sandpiper	M		X		+							+
Actitis macularia												
Long-billed Dowitcher	M		X		+							+
Limnodromus scolopaceus												
Black-necked Stilt	M		X		+							+
Himantopus mexicanus												
Bonaparte's Gull	M		X		+							+
Larus philadelphia												
Band-tailed Pigeon	SR	C		C	+	+		+	+	+		
Columba fasciata												

Appendix continued.

Species	R	Abundance			Location			Habitat				
		F	SP	SU	MD	GS	TP	PJ	PP	OS	F	P
Mourning Dove *Zenaida macroura*	SR	R	A	A	+	+	+	+	+	+	+	+
Screech Owl *Otus asio*	PR			X		+		+		+		
Flamulated Owl *Otus flameolus*	SR		X			+		+		+		
Great Horned Owl *Bubo virginianus*	PR		X			+		+	+			
Common Nighthawk *Chordeiles minor*	SR			C	+						+	
White-throated Swift *Aeronautes saxatalis*	SR	C	C	A	+	+	+			+		+
Broad-tailed Hummingbird *Selasphorus platycercus*	SR		U	C	+	+		+	+	+		
Common Flicker *Colaptes auratus*	SR	A	A	A	+	+	+	+	+	+		+
Williamson's Sapsucker *Sphyrapicus thryoideus*	M	X				+			+			
Hairy Woodpecker *Dendrocopos villosus*	PR	C	C	C	+	+	+	+	+	+		
Cassin's Kingbird *Tyrannus vociferans*	SR		A	A	+	+	+	+	+	+	+	+
Ash-throated Flycatcher *Myiarchus cinerascens*	M		U		+			+		+		
Black Phoebe *Sayornis nigricans*	V			X	+				+			
Say's Phoebe *Sayornis saya*	V			X	+							+
Gray Flycatcher *Empidonax wrightii*	SR		U	C	+	+		+	+	+		
Western Wood Pewee *Contopus sordidulus*	SR	R		C	+	+		+	+	+		
Horned Lark *Eremophila alpestris*	SR			R	+							+
Violet-green Swallow *Tachycineta thalassina*	SR		A	A	+	+	+		+	+	+	+
Rough-winged Swallow *Stelgidopteryx ruficollis*	V			X			+					+
Steller's Jay *Cyanocitta stelleri*	PR	U	U	U	+	+		+	+	+		
Scrub Jay *Aphelocoma coerulescens*	PR	A	U	C	+	+	+	+		+	+	
Common Raven *Corvus corax*	PR	A	U	C	+	+	+	+	+	+	+	+

Appendix continued.

Species	R	Abundance			Location			Habitat				
		F	SP	SU	MD	GS	TP	PJ	PP	OS	F	P
Pinyon Jay	PR	A	U	C	+			+	+	+		+
Gymnorhinus cyanocephalus												
Mountain Chickadee	PR	C	C	A	+	+		+	+	+		
Parus gambeli												
Plain Titmouse	PR	A	C	A	+	+	+	+	+	+		
Parus inornatus												
Common Bushtit	PR	A	U		+		+	+		+		
Psaltriparus minimus												
White-breasted Nuthatch	PR	C	U	C	+	+		+	+			
Sitta carolinensis												
Pygmy Nuthatch	PR	A	U	A	+	+			+			
Sitta pygmaea												
Brown Creeper	PR	C		R	+	+			+			
Certhia familiaris												
House Wren	SR			R	+					+		
Troglodytes aedon												
Bewick's Wren	SR	C		U	+	+	+	+		+	+	
Thryomanes bewickii												
Canyon Wren	SR	U		R		+	+			+		
Catherpes mexicanus												
Rock Wren	SR	C	R	U	+	+	+	+		+	+	
Salpinctes obsoletus												
Mockingbird	SR			U	+			+				+
Mimus polyglottos												
Sage Thrasher	M	X					+	+				
Oreoscoptes montanus												
American Robin	SR	R	R	C	+	+	+	+	+	+		+
Turdus migratorius												
Western Bluebird	SR	C	C	C	+	+	+	+	+		+	
Sialia mexicana												
Mountain Bluebird	SR	A	C	C	+						+	+
Sialia currocoides												
Townsend's Solitaire	M	C			+	+	+	+		+		
Myadestes townsendi												
Blue-gray Gnatcatcher	SR			C	+	+				+		
Polioptila caerulea												
Ruby-crowned Kinglet	M	C			+	+	+	+	+			
Regulus calendula												
Gray Vireo	M	R	R		+				+	+		
Vireo vicinior												
Solitary Vireo	SR			C	+	+		+	+			
Vireo solitarius												
Warbling Vireo	M		X		+			+				
Vireo gilvus												
Virginia's Warbler	SR		U	C	+	+				+		
Vermivora virginiae												

Appendix continued.

Species	R	Abundance			Location			Habitat				
		F	SP	SU	MD	GS	TP	PJ	PP	OS	F	P
Yellow-rumped Warbler *Dendroica coronata*	M	A	A		+	+	+	+		+	+	
Black-throated Gray Warbler *Dendroica nigrescens*	SR		A	A	+			+				
Grace's Warbler *Dendroica graciae*	SR		A	A	+	+			+			
Wilson's Warbler *Wilsonia pusilla*	M	U			+		+	+	+			
Brewer's Blackbird *Euphagus cyanocephalus*	M	R	R		+		+					+
Brown-headed Cowbird *Molothrus ater*	SR		A	C	+		+	+	+			+
Hepatic Tanager *Piranga flava*	SR			C	+	+			+			
Black-headed Grosbeak *Pheucticus melanocephalus*	SR		U	C	+	+		+	+	+		
Cassin's Finch *Carpodacus cassinii*	M	U			+	+		+	+			
House Finch *Carpodacus mexicanus*	SR	U		C	+	+	+	+	+	+		+
Lesser Goldfinch *Carduelis psaltria*	SR			C	+				+			
Green-tailed Towhee *Pipilo chlorura*	M		X		+				+			
Rufous-sided Towhee *Pipilo erythrophthalmus*	SR	C	C	A	+	+	+	+		+	+	
Savannah Sparrow *Passerculus sandwichensis*	M	X			+						+	
Lark Sparrow *Chondestes grammacus*	SR	U	A	C	+	+		+	+		+	+
Dark-eyed Junco *Junco hyemalis*	PR	A	U	R	+			+	+		+	
Chipping Sparrow *Spizella passerina*	SR	C	C	A	+	+		+	+	+	+	
Brewer's Sparrow *Spizella breweri*	SR			U			+					+
Black-chinned Sparrow *Spizella atrogularis*	SR		U	U	+	+				+		
White-crowned Sparrow *Zonotrichia leucophrys*	M	A			+	+	+	+	+	+	+	

Species observed only in 1976.

Poor-will *Phalaenoptilus nuttallii*	SR				+							
Acorn Woodpecker *Melanerpes formicivorus*	V				+							

Appendix continued.

Species	R	Abundance			Location			Habitat				
		F	SP	SU	MD	GS	TP	PJ	PP	OS	F	P
Western Kingbird	V				+							
Tyrannus verticalis												
Dusky Flycatcher	M				+							
Empidonax oberholseri												
Water Pipit	M				+							
Anthus spinoletta												
Loggerhead Shrike	V				+							
Lanius ludovicianus												
Western Meadowlark	V				+							
Sturnella neglecta												
Scott's Oriole	V				+							
Icterus parisorum												
Northern Oriole	V				+							
Icterus galbula												
Western Tanager	V				+							
Piranga ludoviciana												
Evening Grosbeak	V					+						
Hesperiphona vespertina												
Pine Siskin	M				+							
Carduelis pinus												
Black-throated Sparrow	V				+							
Amphispiza bilineata												

MONTIA LINEARIS (PORTULACACEAE): A NEW RECORD FOR UTAH

Stephen L. Clark[1] and Robert Graybosch[1]

ABSTRACT.— *Montia linearis* Dougl., a plant known from British Columbia to Montana, Nevada, and California, is reported from Utah.

A collection of *Montia linearis* Dougl. by Buchanan 2135, Weber Co., Utah North Fork Park near Cobble Cr., 5600 feet, 9 July 1973 (WSCO) and distributed as *Montia chamissoi* (Ledeb) Dur. & Jacks. has been identified by Clark and Graybosch as *Montia linearis*. Collections of this plant by Clark 4150 from the same general location July 1978 (WSCO) have further verified its existence in Utah. At present this is the only place in Utah where this plant is known to occur.

In Utah, this species should be considered rare, and endangered due to the heavy recreational use to which its habitat is subjected.

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FIRST RECORD OF THE SPOTTED BAT (*EUDERMA MACULATUM*) FROM OREGON

Ellen E. McMahon[1], Clifford C. Oakley[2], and Stephen P. Cross[3]

Abstract.— A spotted bat (*Euderma maculatum*) was taken at Mickey Springs, 28 km northeast of Andrews, Harney County, Oregon. This represents a 225 km range extension and a new record for Oregon.

An adult female spotted bat (*Euderma maculatum*) was captured at Mickey Springs (T33S, R35E, S13) on 21 July 1976 at the north end of the Alvord Basin in southeastern Oregon. Mickey Springs, elevation 1235 m, and the Alvord Basin are located approximately 15 km east of Steens Mountain, 28 km northeast of Andrews, in Harney County. The rain shadow of Steens Mountain (elevation 2947 m) creates zeric conditions, and open water sources are scarce in the northern part of the basin. Mickey Springs itself is a hot spring, but its runoff forms a shallow, 12 x 24 m, cooled pond approximately 50 m to the east. This pond attracts numerous wildlife, including many bats. Mickey Mountain, elevation 1920 m, is located 3 km to the west and appears to be the closest area with potential roosting sites. The local vegetation is Shrub-Steppe (Franklin and Dyrness 1973), predominated by greasewood (*Sarcobatus vermiculatus*). Shadscale (*Atriplex confortifolia*) and sagebrush (*Artemisia tridentata*) are also abundant.

The spotted bat was captured sometime between midnight and 0800 in a mist net that had been tended for four hours after civil sunset and then furled to prevent further captures. The bat was discovered in a weakened condition as the net was being dismantled, and it subsequently died in the process of being removed from the net. It is on deposit in the Museum of Vertebrate Natural History at Southern Oregon State College, Ashland. External measurements are: total length, 124 mm; tail length, 49 mm; hind foot, 11 mm; ear, 41 mm; tragus, 15 mm; forearm, 52 mm; weight, 16.0 g.

This capture represents the first *Euderma* from Oregon. The closest record is from 24 km southwest of Caldwell, Idaho (Tucker, 1957), approximately 225 km northeast of Mickey Springs. Another *Euderma* was collected at Reno, Nevada (Hall 1935), 362 km to the south. These two marginal records and the similarity of habitat have led several authors (Hall and Kelson 1959, Snow 1973, Watkins 1977) to infer that the species range includes southeastern Oregon. Other species of bats captured at this site during four nights of netting were *Myotis leibii*, *Myotis volans*, *Lasionycteris noctivagans* and *Pipistrellus hesperus*.

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