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Finally, to my parents, who taught me that one's greatest gift is one's mind, I give a son's love and appreciation.

James W. Grimes
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ABSTRACT

The flora of Leslie Gulch
Malheur County, Oregon

by

James W. Grimes, Master of Science
Utah State University, 1979

Major Professor: Arthur H. Holmgren
Department: Biology

A study of the flora of Leslie Gulch Malheur County, Oregon was undertaken to elucidate the relationships of the flora and of the endemic species in the flora, and to determine if these endemic species are restricted to their present distribution by chemical factors of their substrates.

A checklist of native plants and a description of the major communities was made and floristic relationships were studied.

Chemical and mineralogical tests such as emission spectrography, x-ray diffraction and cation-exchange capacity as well as physical tests such as particle-size distribution and gravimetric water content were performed.

The results of the tests gave no indication of any chemical factor which may restrict the distribution of plants. A zeolite, heulandite, is present in the ash-tuff which is the substrate for the endemic species Mentzelia packardiae Glad and Senecio erttareae Barkley. However, this would not restrict plant growth.

It was concluded that the distribution of the endemics Senecio
ertterae Barkley, Mentzelia packardiae Glad, Ivesia rhypara Ertter & Reveal, Eriogonum novonudum Peck, and to some extent Astragalus sterilis Barneby and Trifolium owyheense Gilkey is determined primarily by physical factors of their substrates, and that they are pioneer species which may be competitively excluded from more normal sites.

Artemisia packardiae Grimes & Ertter ined. is a species which is restricted by a diminishing relic habitat.

The flora of Leslie Gulch has been complicated by interaction of a northern mesic association and a southern xeric association.

The endemic species Mentzelia packardiae and Senecio ertterae are recent species which evolved from a southern Great Basin flora which has moved north with the retreat of the last ice sheets.

Ivesia rhypara and Artemisia packardiae are recent species which evolved from a northern flora which followed the retreat of the ice sheets north.

(54 pages)
INTRODUCTION

The Owyhee Uplift of southeastern Oregon and southwestern Idaho is an area which includes all of the Owyhee River and parts of the Snake and Malheur River drainage basins. The geology of the region is marked by extensive Miocene volcanics with islands of pre-Miocene formations (the Silver City Mountains and South Mountain).

Kittleman et al. (1965) consider the Owyhee Uplift to be the northern edge of the Basin and Range Province which has been complicated by interaction with other provinces. Fenneman (1931), on the other hand, points out that while the Owyhee Uplift resembles the basin ranges it is too isolated to be counted among them. Roughly the area is bordered by the Malheur drainage to the north, the Basin and Range Province (represented by Steen's Mountain and the Pueblo and Santa Rosa Mountains) to the west and south, and the Snake River Plains to the east.

There are two stations near Leslie Gulch which record climatic data for this region. They are located at Owyhee Dam at 43° 39' N, 117° 15' W at an elevation of 730 m, and at Rockville at 43° 22' N, 117° 07' W at an elevation of 1110 m.

The average annual precipitation in the area is about 28.5 cm per year, and the average annual temperature is around 10°C. Tables of average annual precipitation and average annual temperature are included in Table 1. There is a large difference in the amount of precipitation received at Rockville as opposed to Owyhee Dam. Rockville receives about 7 cm more per year. Also, the average annual temperature at Rockville is about two degrees lower than at Owyhee Dam.
Table 1. Average annual precipitation and temperature

<table>
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<th>Precipitation in centimeters</th>
<th>Temperature in °C</th>
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<td>Rockville</td>
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<td>37.00</td>
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The differences in precipitation and temperature are apparently due to the differences in elevation.

Floristically the region belongs to the Great Basin (Noel Holmgren in Cronquist et al. 1972). The common plant communities are formed by species of *Artemisia* with various grasses such as desert species of *Poa* and *Agropyron*. In suitable areas communities may be formed by *Juniperus occidentalis* or *Cercocarpus ledifolius*. In the drier, more poorly drained basins *Atriplex* and *Sarcobatus* communities occur.

I have followed the nomenclature of Hitchcock et al. (1973) for the dicots, and Cronquist et al. (1972, 1977) for the gymnosperms and monocots throughout this paper.

The Owyhee Region (Fig. 1) of the Owyhee Uplift as outlined by Kittleman et al. (1965) includes most of northern Malheur County, Oregon east and west of Owyhee Reservoir. This region has a complicated stratigraphy of volcanic rocks and volcanic sediments.

Leslie Gulch (Fig. 2), the area involved in this study, is a small drainage of about 576 square kilometers which empties into Owyhee
Figure 1. The Owyhee Uplift. The Owyhee Region extends west from the Oregon-Idaho state line to just west of the Owyhee Reservoir (map from Glad 1975).
Figure 2. Leslie Gulch
Reservoir and drains T 25 S, R 44, 45 and 46 E and parts of surrounding townships. The gulch lies on the west side of the Sucker Creek Formation\(^1\) that extends North-South along the southern end of the Owyhee Region.

The ash-tuff typical of the gulch is composed of sparse phenoclasts of quartz and sanidine in a vitroclastic matrix and has been named the Leslie Gulch Ash-Flow Tuff Member of the Sucker Creek Formation (Kittleman et al. 1965). The Leslie Gulch Ash-Flow Tuff Member is shown in Figure 3. The lower end of Leslie Gulch and part of the north side of Spring Creek Gulch to the south are composed of a peculiar ash-tuff which is different from the ash-tuff typical of the Leslie Gulch Member.

The flora of Leslie Gulch was not well known before this study was undertaken, but within the gulch seven endemic species were known to occur. Four of the endemics, *Astragalus sterilis* Barneby, *Eriogonum novonudum* Peck, *Trifolium owyheense* Gilkey and *Artemisia packardiae* Grimes & Ertter \(\text{em} \) occur in suitable habitats throughout the Owyhee Region.

The other three endemics, *Ivesia rhypara* Ertter & Reveal, *Senecio ertererae* Barkley and *Mentzelia packardiae* Glad are found only in Leslie Gulch (including the upper part of Leslie Gulch known as Runaway Gulch), in Dago Gulch, a tributary of Leslie Gulch, or in Spring Creek Gulch. All three grow on peculiar edaphic sites.

\(^1\)The original spelling Succor Creek was changed to Sucker Creek in the first revision of the Mitchell Butte Quadrangle in 1921 (Axelrod 1964). Kittleman et al. (1965) named the Sucker Creek Formation from the spelling on this map. Currently the Board of Geographic Names lists the correct spelling as Succor Creek. However, the name of a stratigraphic formation cannot be changed. Unless referring to the formation I will use the name Succor Creek.
Figure 3. Typical formations of the Leslie Culch Ash-Flow Tuff.

Figure 4. Slopes of the talus-tuff.
Senecio everttiae and Mentzelia packardiae grow in talus slopes of a greenish-yellow ash-tuff confined to lower Leslie Gulch and adjacent Spring Creek Gulch. There is no color on the Munsell Soil Color Charts which matches this color exactly. The closest in one of the pale olives (5Y 6/3, 6/4) wet, and light gray or gray (5Y 6/1) dry. Very few other species grow with these endemics.

Kittleman et al. (1965) made no particular mention of the greenish-yellow ash-tuff in the description of the Leslie Gulch Ash-Flow Tuff Member. I will refer to the greenish-yellow tuff as talus-tuff since it commonly forms large talus slopes. Figure 4 shows one of these talus slopes. It has been suggested (Glad 1975) that chemical properties of the talus-tuff may be responsible for the distribution of the Mentzelia packardiae.

Along with the endemic species, the flora of Leslie Gulch is interesting from a biogeographical aspect. Reveal (pers. comm.) and Packard (pers. comm.) have both noted that the flora of Leslie Gulch has a southern aspect, meaning that it seems to resemble floras of the Great Basin. The flora does appear to have been complicated by interaction of a southern, more xeric and northern mesic elements.

This study was undertaken to elucidate the relationships of the flora, and to determine if the distribution of the endemics is indeed related to chemical properties of the various substrates.

A checklist of native plants and a description of the major communities was made and floristic relationships were studied.

Chemical and mineralogical tests such as cation-exchange capacity, emission spectrography and x-ray diffraction, as well as physical tests such as particle-size distribution and gravimetric water content were performed.
During the drought of 1977 while making a collection of Mentzelia packardiae a peculiar, almost mucilaginous sheath was found on the roots. Cross-sections were made to determine if special mucilage producing cells are present on the root epidermis.
LITERATURE REVIEW

Geology

The Sucker Creek Formation is the oldest formation exposed in the Owyhee Region. It is dated at $16.7 \times 10^6$ years by potassium-argon dating methods (Evernden & James 1964) and is of Middle Miocene Age (Axelrod 1964). Together with an unnamed igneous complex at Owyhee Dam and the Owyhee Basalt it forms the basal sequence of formations in the Owyhee Region (Kittleman 1973).

The Leslie Gulch Ash-Flow Tuff Member of the Sucker Creek Formation is the extensive ash-tuff present in the southern part of the formation. It is exposed along lower Succor Creek, in Leslie Gulch, and in the Honeycombs region. The Leslie Gulch Ash-Flow Tuff Member was deposited simultaneously with the Sucker Creek Formation and is under- and overlain by this formation. The Leslie Gulch Ash-Flow Tuff Member has a different source from the Sucker Creek Formation which has not been discovered (Kittleman 1973). In certain places the Leslie Gulch Ash-Flow Tuff Member may be overlain by Jump Creek Rhyolite or the Deer Butte Formation. Figure 5 illustrates the sequence of volcanics in the region.

During the Late Miocene-Early Pliocene, after the Owyhee Basalt had been deposited, the Owyhee Region was uplifted, starting an erosion cycle. This eroded material filled the basins and started them sinking. Following this erosion cycle the Jump Creek Rhyolite was deposited on top of parts of the Sucker Creek Formation and the Leslie Gulch Ash-Flow Tuff Member (Kittleman 1973). Dikes of this rhyolite can be found in Leslie Gulch, and the two known locations
Figure 5. Sequenc of volcanics in the Owyhee Region (from Kittleman et al. 1973).
of the Artemisia packardiae in Leslie Gulch are on dikes of the Jump Creek Rhyolite. Volcanic activity in the area has continued nearly into historical times (Cow Lakes Basalt) and the Owyhee Region has continued to be uplifted.

**Edaphic Endemism**

It has been established that edaphic factors can be important in determining patterns of plant distribution and rates of evolution. Rapid changes in the environment and the actions of geologic processes may promote rapid evolution rates (Flint 1971). Furthermore, in arid areas local diversity in topography and edaphic factors may have a pronounced effect on vegetation (Stebbins 1952).

Limited distribution of plant species is related to environmental influences, which act through physiological and genetic processes (Mason 1946). In other words, a plant species must have the physiological capability and hence the genetic background to deal with peculiar conditions imposed by the environment. Anderson (1948) argues that in this way the habitat, including edaphic factors, is important because it will maintain segregation for physiological differences between taxa, and hence can maintain separate species. According to Axelrod (1972) in arid areas, such as southeastern Oregon, the importance of edaphic factors is emphasized and thus is more likely to influence plant distribution.

There are many reports of edaphic factors controlling plant distribution. In most cases some peculiar chemical aspect of the soil limits plant distribution. Soil pH may be either so high (Kruckeberg 1969) or so low (Billings 1950) that plant growth is severely limited.
The occurrence of plants may also be limited by toxic amounts of elements (Walker 1954).

Kruckeberg (1951, 1954, 1957, 1969), Whittaker (1954a, 1954b) and Walker (1954) have shown that plants which live on serpentine outcrops must be adapted to very low levels of calcium. Furthermore, the endemics would do as well on substrates without these calcium deficiencies, but seem to be excluded because they cannot compete with other species on more normal sites.

Paleobotany

The pre-Tertiary flora of the western United States was rather uniform and contiguous. During the Tertiary the present Great Basin Floristic Province took shape (Cronquist 1978) although the roots of this flora go back to the Cretaceous (Tidwell et al. 1972).

Antevs (1952) recognizes three major trends during the Cenozoic Era which had a pronounced effect on plant biogeography. First, there was a general, though not constant cooling trend during the Tertiary and Quaternary. From the Miocene to the Pleistocene the climate grew progressively drier, a trend which Axelrod (1957) and Wolfe (1964) associate with the gradual uplift of the Sierra Nevada and Cascade Ranges. Then, during the Pleistocene, there were alternating cool periods associated with advances of the ice sheets, and warm, moist periods associated with the retreats of these sheets.

During the Tertiary the floras in western North America segregated into a northern mesic flora dominated by trees (the Arcto-Tertiary Geoflora of some authors, e.g., Axelrod) and a southern more xeric flora with fewer trees (the Neotropical-Tertiary Geoflora). These
two floristic associations are recognized as being diverse, dynamic entities although the original rigid interpretation of geoflora has fallen into disrepute. Each floristic association had its own generic composition which changed in response to changing environmental conditions, as did the boundaries of the associations.

The northern association was adapted to more temperate boreal habitats and consisted of a widespread forest which lived under uniform climatic and topographic conditions (Axelrod 1940). The southern flora had its relationships with plants now found some 20° latitude to the south (Chaney 1947).

A dryland flora (the Madro-Tertiary Geoflora) arose between the northern and southern associations as climatic conditions changed and as the environment became warmer and drier. Members of the dryland flora evolved from both floras although Axelrod (1958) suggests it evolved chiefly from members of the more southern flora which adapted to the increasing aridity. Stebbins and Major (1965) suggest that this dryland flora had its roots with the southern more tropical flora, but that instead of evolving from mesic members of the flora, it evolved from small pockets of semi-xerophytic vegetation which had always been present, and which had coalesced and spread as the climate became drier.

Out of the dryland flora two other associations segregated. A more northern part adapted to cold winters, and a more southern part adapted to a warmer climate. The northern association developed fully during the Miocene, and became what is known today as the Great Basin Floristic Province (Cronquist 1978). Cronquist points out that this association was influenced by immigrants from adjacent floras.
This Great Basin Province is well enough developed and old enough that it has also evolved certain groups (such as the genera *Eriogonum*, *Penstemon* and *Chrysothamnus*) which are of Great Basin origin.

The events during the Tertiary which led to the development of the dryland flora and the contraction of the northern and southern associations also led to a complicated pattern of forest zonation by altitude and latitude. This zonation was to become much more pronounced and complicated by the Pleistocene ice sheets (Axelrod 1966).

An analysis of the fossil floras in the region and the epochs in which they were preserved give some idea of how the vegetation changed. By the Eocene many genera which are still present in the Great Basin had evolved. Axelrod (1968) shows that there was already an altitudinal differentiation of forests by this epoch. The Comstock Flora (Sanborn 1935) and the Goshen Flora (Chaney & Sanborn 1933) show a warm-temperate to subtropical forest in regions that are now desert. As elevation increased, however, a mixed deciduous-hardwood forest became dominant. Above this elevation a conifer-hardwood forest occurred as is found in the Copper Basin Flora and consequently where a pure montane forest is associated at the higher elevations with a cold temperate climate (Axelrod 1966). The continued uplift of mountains in the Great Basin would create relic habitats for the boreal forest which was pushed farther north when a drying trend started in the Miocene and continued through the Pliocene.

During the Oligocene the tropical flora continued to recede southward and be replaced by a more temperate boreal flora as the climate became cooler and less humid (Tidwell et al. 1972). Axelrod (1966)
suggests that the conifer-hardwood forests of the Oligocene contained species which make up similar conifer-hardwood forests today.

There was increasing climatic diversity during the Miocene. By this time a temperate forest had totally replaced the subtropical forest in Oregon and the Great Basin (Chaney 1947). Wolfe (1964) believes that the southern Great Basin and the Northwest were in the same floristic province during the Middle Miocene, although by the Late Miocene the southern Great Basin floras were different, with the northern flora retaining a mesophytic aspect.

This northern mesophytic flora (the Arcto-Tertiary Geoflora) reached its greatest extent during the Miocene (Axelrod 1950). However, this mesophytic forest was more diverse than any which has survived in western North America (Chaney & Axelrod 1959). Certain elements, such as the Eastern North American, Asian and Western North American could be recognized. These 'elements' represent some of the diversity of the northern flora and species with affinities to each of them may be found in the fossil floras of the area.

The Upper Miocene Sucker Creek and Trout Creek Floras of south-eastern Oregon show that the northern mesophytic forest was still dominant but that elements of both the southern, more tropical and Great Basin dryland flora could be found (Graham 1965). Taggart (1973) recognizes two major vegetational units in the Sucker Creek Flora. This illustrates the diversity of the northern mesic flora. The Trapper Creek Flora of southern Idaho is similar to the Trout Creek Flora and is an example of the northern flora.

The Cascades and Sierra Nevadas were being uplifted during the Miocene, creating numerous rain shadows on the eastern side. As a result the area was becoming distinctly drier (Axelrod 1957, Wolfe 1964).
This drying trend continued during the Early Pliocene, and this epoch became the driest part of the Tertiary (Axelrod 1948, 1964). At higher elevations in the northwestern Great Basin impoverished floras of the northern association could still be found, while members of the dryland association extended northward into drier areas (Axelrod 1950). By this time the dryland flora had divided into different communities such as chaparral, woodland and scrub-oak forest (Axelrod 1958) and it made significant contributions to the flora at its northern boundary (Detling 1968).

The Alvord Creek Flora of Oregon (Axelrod 1944) and the Verdi Flora of Nevada (Axelrod 1958), which are Early Pliocene, and the Deschutes Flora (Chaney 1938), which is of Middle Pliocene illustrates the altitudinal zonation caused by the drying trends. Elements of both the northern flora and the dryland flora are present. The elements of the northern flora were becoming restricted to the highlands, with more xeric dryland elements moving up into the lowlands (Axelrod 1948). Axelrod also suggests that the environmental changes which took place at this time were subcontinental in effect, and that ancestral species were eliminated or restricted to relic environments as more genetically variable groups (herbs and semi-woody perennials) expanded. The diversification of habitat continued from the Middle Pliocene through the Pleistocene as mountain building continued and as glaciation created a fluctuating Pleistocene environment. These factors have continued the differentiation of plant species from their Pliocene ancestors.

By the Late Pliocene the rain shadows created by the uplifting Cascades and Sierra Nevadas caused greater aridity although true
deserts still did not exist. The Late Pliocene may have been more mesic than the Middle Pliocene (Axelrod 1950).

The Pleistocene was marked by alternating glacial and interglacial periods. The spread of the ice sheets indicates a great change in climatic conditions. During the great glaciations the westerly windbelt over the Northern Hemisphere moved southward. This led to a migration of life zones because of moving ice sheets and mountain building (Charlesworth 1957, Flint 1971).

The duration of the last glacial period was about 70,000 years (Flint 1963) although it did not reach its maximum until about 18,000 B. P. (Frye, Willman & Black 1965 in Tidwell et al. 1972).

The most notable feature of the glacial periods is that they forced the migration of life zones hundreds of miles north and south and thousands of feet up and down in elevation (Morrison 1965). Madsen (1976) in a study of woodrat middens in Nevada shows that regional vegetational zones were depressed up to 1500 meters during the last glacial, while other evidence shows that the snowline in the Sierra Nevada was depressed by 800 meters (Embleton & King 1968). At the same time the Mohave Desert was occupied by a pygmy conifer forest (Wells & Berger 1967). A coniferous forest was probably present at the edge of the Snake River Plain (Butler 1976) and post-Pleistocene pollen studies in southeastern Oregon show that a forest occurred in areas that are now desert or border desert.

The post-glacial period started about 12,000 years ago (Martin & Mehringer 1965) and it culminated in a warming trend about 7,000 years ago (Butler 1976). This climax led to a vegetational distribution much the same as that of today. This warming trend may have
climaxed up to 1500 years later in the northern Great Basin than in the southern (Bryan & Gruhn 1964), and has been followed by a general cooling trend (Kukla et al. 1972, Baumhoff & Heizer 1965).

The northwestern part of the Great Basin had much uplifting and faulting during the Pleistocene (Morrison 1965). This orogenic period created north-south axes of mountains which had two effects on the vegetation in the western United States. First of all, the tops of these mountain chains served as relic islands for boreal species during the glacial periods and again after the life zones moved north. Second, these mountains intercepted rainfall from the westerly winds, and as the glaciers receded, there developed a series of rain shadows with extreme differences in precipitation and temperature. Great local differences in elevation, precipitation and climatic shifts have kept species in constant turmoil (Cronquist 1978). The cooling trend of the Late Cenozoic has brought about an overall impoverishment of mid-latitude floras, but many new species have evolved as new habitats have been formed (Leopold 1967).

Stebbins and Major (1965) point out that the present diversity of the flora in the western United States is caused not only by recent active speciation as a result of the creation of new and diverse habitats, but also by the presence of large numbers of relic species.
METHODS

The plant list of Leslie Gulch was made by covering the area on foot over the course of two field seasons. A partial list of species had been started a few years ago by Dr. Patricia L. Packard and her students at the College of Idaho. Herbarium collections were made for most of the species and specimens are on deposit at the Intermountain Herbarium, Utah State University; the Harold M. Tucker Herbarium, the College of Idaho; and the New York Botanical Garden. Some duplicates have been distributed to other herbaria.

The flora included one previously undescribed species. The description of this new species, *Artemisia packardiae*, is included in Appendix 2.

Various chemical, mineralogical, and physical tests were performed on samples of the Leslie Gulch Ash-Flow Tuff and the talus-tuff from various locations in Leslie Gulch. Emission spectrography tests were performed on the substrates to determine if any unusual ion were present, or if any were present in unusual amounts; and on samples of some of the endemics to see if they were accumulating any ion which might be present.

Cation-exchange capacity tests were done to determine the amount of exchangeable ions in the substrates. Percent nitrogen was also determined. The results of these tests gave an idea of the relative fertility of the sample sites.

Particle-size distribution was determined for the talus-tuff and the rubble on top of bare outcrops of Leslie Gulch Ash-Flow Tuff to get an idea of relative porosity and the size of spaces between the rubble
and tuff pieces. Larger pieces would indicate larger pores in the talus, and hence more area in which the roots could be exposed to air.

Gravimetric water content was determined to get a relative idea of the amount of water available to the plants.

Three sample sites were chosen for the various tests. The first sample site is in upper Runaway Gulch about .1 mile past the gate at the head of Leslie Gulch at T 25 S, R 46 E, Sec.19. This is the type locality of *Ivesia rhypara*. It is a barren outcrop of Leslie Gulch Ash-Flow Tuff with two to three inches of rubble on top.

Another sample location was on the large talus slope directly across the road from Mud Spring. Samples were taken at the upper 3 cm and the next 20 cm, or the bedrock if the talus was less than 20 cm deep. Gravimetric water content was done on samples taken at the lower 20 cm from three sites chosen at random at the base of the talus slope. Samples were taken twice during the summer: once in June and once in July since the endemics on the slope are either finished or well along in their life cycle by July.

The last site was at the base of Timber Gulch, a tributary to Leslie Gulch, at the bottom of a wash. Talus accumulates here as a small alluvial fan. The same tests were performed and gravimetric water content was taken from one location in the second 20 cm of talus.

Three other miscellaneous samples were also examined. A piece of rubble was taken from the bottom of a large talus slope in Dago Gulch after it had been determined that a zeolite was present in the talus-tuff to see if it was also present here. Emission spectrography and CEC were done on a piece of Leslie Gulch Ash-Flow Tuff to see how
it compared to the talus-tuff, and some soil was taken from below the Mud Spring talus slope to see if the zeolite from the talus-tuff was present in the soil.

The emission spectrography was done at the Utah Engineering Experiment Station at the University of Utah. X-ray diffraction was done by the Geology Department at Utah State University, and the cation-exchange capacity determinations were made at the Soil, Plant and Water Analysis Laboratory at Utah State.
RESULTS

The results are listed in the following tables.

Table 2 lists the results of the emission spectrography tests. Test 1 and Test 2 (T-1, T-2) are from the site in Runaway Gulch. Test 1 is the Ash-Flow Tuff and Test 2 is a ground sample of *Ivesia rhypara*. Tests 3 and 4 are from the talus slope across from Mud Spring. Test 3 is from the upper 3 cm and Test 4 is from the lower 20 cm. Test 5 is from a very large piece of talus at the base of the slope. Tests 6, 7, 8 and 9 are from the wash at Timber Gulch. Test 6 is from bedrock exposed along the wash and Test 7 is from the lower 20 cm of the alluvium. Test 8 and Test 9 are ground samples of *Mentzelia packardiae* and *Eriogonum novonudum* respectively.

The results of the emission spectrography tests indicate that there are no elements present in unusual amounts in any of the samples examined. Likewise none of the plants are accumulating any element of ion.

The results of the x-ray diffraction are listed in Table 3. It was determined that at least one zeolite, heulandite, is present in the talus-tuff. The chemical formula of heulandite is:

\[(\text{Na, Ca})_4\cdot 6\text{Al}_6(\text{Al, Si})_4\text{Si}_{26}0_{72}\cdot 24\text{H}_2\text{O}\]

Zeolites are minerals which characteristically have a very high cation-exchange capacity. Samples of the talus were examined for their CEC, and a sample of the Leslie Gulch Ash-Flow Tuff was examined for comparison. The results, listed in Table 4, show that the talus with the zeolites do indeed have a high CEC, while that of the Leslie Gulch has a very low CEC. The percent nitrogen was also very low.
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</table>

PC=Principal constituent  Ca=Approximately  Percentages are listed under each sample
Table 3. X-ray mineralogy determination

<table>
<thead>
<tr>
<th>Sample description</th>
<th>Mineralogy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dago Gulch – large talus rubble</td>
<td>Heulandite with some mordenite</td>
</tr>
<tr>
<td>Soil in Leslie Gulch below talus slope</td>
<td>Montmorillonite with quartz and feldspars</td>
</tr>
<tr>
<td>Upper 20 cm, Mud Spring talus</td>
<td>Heulandite with some mordenite?</td>
</tr>
<tr>
<td>Mud Spring – bedrock</td>
<td>Heulandite with some illite and mordenite</td>
</tr>
<tr>
<td>Runaway Gulch – bedrock</td>
<td>Quartz and feldspars with some illite and montmorillonite</td>
</tr>
<tr>
<td>Runaway Gulch – rubble</td>
<td>Quartz and feldspars with some illite and montmorillonite</td>
</tr>
</tbody>
</table>

The feldspars are mostly albite and orthoclase.

Heulandite is a zeolite of composition \((\text{Na, Ca})_4 \text{Al}_6 (\text{Al, Si})_4 \text{Si}_{26}^0 \cdot 72 \cdot 24\text{H}_2\text{O}\).

Mordenite is a zeolite of composition \((\text{Ca, Na}_2, \text{K}_2) (\text{Al}_2 \text{Si}_{10})^0 \cdot 24 \cdot 7\text{H}_2\text{O}\).

Table 4. Cation-exchange capacity determinations

<table>
<thead>
<tr>
<th>Sample</th>
<th>CEC</th>
<th>%N</th>
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</thead>
<tbody>
<tr>
<td>Mud Spring talus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>coarse</td>
<td>60.3 meq/100g</td>
<td>.03</td>
</tr>
<tr>
<td>60-mesh</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td>Runaway Gulch (Leslie Gulch Ash-Flow Tuff)</td>
<td>5.6</td>
<td>.01</td>
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<tr>
<td>Leslie Gulch Ash-Flow Tuff (random sample)</td>
<td>3.3</td>
<td></td>
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</tbody>
</table>

Since zeolites characteristically have a high CEC it is likely that the zeolites present in the talus-tuff are what caused the high measurements in these samples. This is supported by the fact that the typical Leslie Gulch Ash-Flow Tuff did not have a zeolite present, and had a very low CEC.
Tables 5 and 6 show the results of the tests on gravimetric water content and particle-size distribution.

Table 5. Gravimetric water content

<table>
<thead>
<tr>
<th>Location</th>
<th>Percent water by weight</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>June 30</td>
<td>July 30</td>
</tr>
<tr>
<td>Mud Springs</td>
<td>17</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Mud Springs</td>
<td>19</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Mud Springs</td>
<td>18</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Timber Gulch</td>
<td>19</td>
<td>14</td>
<td></td>
</tr>
</tbody>
</table>

The results indicate that there are adequate amounts of water present in the talus during the growing season. Tests on 1/3 and 15 bar moisture release curves would show how much of the water might be available to plants. These tests will be done as research is continuing on the talus-tuff.

The particle-size distribution shows that most of the talus-tuff material will not pass through a number 10 screen. This in effect represents a porous environment. The larger the pieces of substrate, the larger the area between pieces (though total volume of free space is less). Since these large spaces are harder to saturate with water, the root system of any plant growing on this substrate is exposing more of its root system to air and possible dessication.
Table 6. Particle-size distribution

<table>
<thead>
<tr>
<th>Screen size</th>
<th>1 1/2</th>
<th>4</th>
<th>8</th>
<th>10</th>
<th>16</th>
<th>50</th>
<th>remainder</th>
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<tbody>
<tr>
<td>Wt. Retained</td>
<td>0</td>
<td>139.33</td>
<td>249.63</td>
<td>76.17</td>
<td>85.22</td>
<td>90.82</td>
<td>22.98</td>
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<tr>
<td>% Retained</td>
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<td>21</td>
<td>38</td>
<td>11</td>
<td>13</td>
<td>14</td>
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<td>Wt. Retained</td>
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<td>580.31</td>
<td>110.38</td>
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<td>% Retained</td>
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<td>84</td>
<td>16</td>
<td>.4</td>
<td>.1</td>
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<td>T</td>
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<tr>
<td>Wt. Retained</td>
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<tr>
<td>% Retained</td>
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<td>77</td>
<td>20</td>
<td>1</td>
<td>1</td>
<td>.2</td>
<td>1</td>
</tr>
</tbody>
</table>

1 Runaway Gulch rubble
2 Mud Spring talus - upper 3 cm
3 Mud Spring talus - lower 20 cm
4 Timber Gulch alluvium - lower 20 cm
DISCUSSION

The results of the chemical and mineralogical tests give no indication of any chemical factor in either the talus-tuff or the Leslie Gulch Ash-Flow Tuff which would limit plant growth. There is a zeolite present in the talus-tuff and in some respects this is an unusual factor. Instead of limiting plant growth though, the zeolite with its high CEC would probably encourage plant growth.

There is little doubt in my mind that the distribution of the endemics in Leslie Gulch is determined by edaphic factors but it is probable that physical factors are more important than chemical in determining the distributions. Certain chemical factors such as low fertility may also be important but none of the tests indicate that the presence or abundance of a particular ion plays any role in limiting the distribution of plants on the edaphic sites. The talus slope habitat where *Senecio erterae* and *Mentzelia packardiae* grow represents a habitat different from that of the other species so they will be discussed separately.

The measurements of gravimetric water content on the talus-tuff show that water is probably not a limiting factor. The lower talus slopes where *Senecio erterae* and *Mentzelia packardiae* grow collect runoff from the slope above, and even on dry days in middle and late summer one does not have to dig far to find cool moist talus.

There are a couple of features of the talus which must be considered. The talus-tuff represents a very porous environment. Microscopic examination of the individual fragments also shows them to be quite porous; much of the water in the samples measured had soaked
into these fragments. Because of the porosity of the talus and the individual fragments themselves, it may be that roots in the talus are exposed to more air and are more prone to dessication than would be roots in a more typical soil with the same amount of water. On the other hand, with the amounts of water that are present in the talus it could be that even the large spaces between fragments are saturated with water vapor. This could explain the fact that the talus feels cool and moist even when free water is not evident. I do not think that water is a limiting factor on these talus slopes.

The low organic matter and frequently shifting substrates are also features of the talus-tuff which would affect plant growth. The Mentzelia packardiae and Senecio erectae appear to have evolved with several adaptations to living on the talus slopes. First of all, as annuals they can complete their life cycle in a relatively short time if necessary. During the drought of 1977 they had, for the most part, bloomed and died by late July or early August. However, during moister years the Senecio in particular may be found blooming into late September.

Secondly, for annuals they have quite extensive root systems. Roots of Mentzelia packardiae (the plant averages about 15 cm in height) have been observed growing as far as 40 cm laterally and 30 to 40 cm down into the talus. In this way they may be exposing more of their root system to dessication, but they are also better able to exploit water from a large area. Also, when the roots come into contact with large talus or bedrock, the roots branch into hundreds of rootlets which cling tightly to the surface. In this manner the roots may be utilizing water which is stored in the very porous material.
The roots are also quite fleshy and sometimes mucilaginous. Cross-sections of a *Mentzelia* root were done, and while there were no anatomical adaptations noted in the epidermis, the mucilaginous covering was evident. This may be an adaptation to protect the roots from dessication, and it may be that the mucilaginous sheath may help to imbibe water from the talus-tuff. The mucilaginous sheath is more pronounced in dry years, but it cannot be concluded that protection from dessication is its *raison d'être*.

The frequent shifting of the talus slopes represents another problem to the annual species. Shifting talus presents a problem for seed germination and seedling survival, and large movements of talus could bury adult plants.

The annual species have a few adaptations which may help overcome this problem. First, their root system is quite extensive for annuals. This not only roots the plant more firmly, and may to a small degree help stabilize the talus, but it also means that if part of the root is broken off by moving talus there is still a rather extensive system left. Both the roots and the adult plants are quite fleshy. This may make them more resilient and less likely to be broken off by moving talus.

There is not any apparent unusual chemical factor associated with the Leslie Gulch Ash-Flow Tuff and, aside from the presence of the zeolite with its high CEC, there is nothing unusual about the talus-tuff either. *The Senecio* and *Mentzelia* then had to be adapted to the harsh physical conditions of the talus slopes.

The perennial species face similar problems. None of the endemic perennials (except *Astragalus sterilis*) grow in deep talus. They occur
mostly on ridges and on the upper portions of talus slopes. Their root systems also show some adaptations.

*Astragalus sterilis* is the only endemic perennial which is commonly found growing on deep rubble. The rubble is often very fine, and then is not as porous as the talus-tuff slopes. The root system is quite extensive and tough and wiry. It goes quite deep through the rubble and often extends to bedrock. The plant has a much-branched caudex. Often times I have seen where the plant has been buried by rubble, but appears to be growing up through it with no apparent ill effects.

*Astragalus sterilis* will also grow on bare bedrock outcrops. It can be found on either the Leslie Gulch Ash-Flow Tuff Member, or on other members of formations throughout the Owyhee Region. When found on bedrock, its root system goes quite deep into cracks in the bedrock, and may extend several decimeters over the top of the bedrock, just under a thin layer of rubble, to other cracks. These roots appear to go quite deep, probably getting water which has seeped into the cracks.

*Ivesia rhypara* has a similar growth habit with respect to the roots. It too is found on barren bedrock outcrops of the Leslie Gulch Ash-Flow Tuff with a thin layer of rubble. It rarely grows in deeper material.

*Eriogonum novonudum* grows in lower Leslie Gulch on talus-tuff ridges and hillsides of the Leslie Gulch Ash-Flow Tuff. It also grows on other materials in the Owyhee Region but is always found on ridges and hillsides where talus accumulation is not great. It also sends roots quite deep into cracks in the bedrock although it has no surface root system. The caudex is elevated above the rubble layer. This allows the talus to move around the root, much like rocks moving around
a telephone pole, without burying the plant, or piling up so much talus around the caudex that it breaks the plant off.

Another endemic, *Trifolium owyheense*, is not confined to any particular habitat and is not relevant to most of this discussion. However, it does grow on tops of talus slopes and its root system shows another adaptation. The root usually lies below the zone where the talus is most active. From the top of the root many small branches come off. These grow up through the rubble and talus. If there is a sudden talus slide stems may be broken off, but the root remains intact and more stems will grow. Another species which grows on the talus, *Arenaria nuttallii* var. *fragilis*, has the same adaptation. The *Arenaria* is not endemic to Leslie Gulch, but in Leslie Gulch it is confined to the talus-tuff slopes.

Although the absolute amounts of essential elements are about the same, the Leslie Gulch Ash-Flow Tuff does not have a zeolite with a high CEC, which has more available ions. It is likely that the *Ivesia rhypara* and other endemics which grow on the Ash-Flow Tuff have physiological adaptations which aid them in exploiting the ions present, much the same as that hypothesized for some other edaphic endemics (Kruckeberg 1954, Clarkson 1965).

It is likely that all of the above endemics have a similar physiological adaptation concerning water. The absolute amounts of water available to the plants may be less than that on more normal soils but the plants are better able to exploit the water that is present.

Aside from the presence of the zeolites in the talus-tuff, the edaphic sites are sterile. The percent nitrogen that was measured
in two of the samples was very low (Table 4). The actively moving talus, or winds blowing across the bare bedrock outcrops prevent the accumulation of organic matter and nitrogen cannot build up from that source. It is likely that the endemics are pioneer species which are not able to compete on more normal sites.

Observations on *Ivesia rhypara* also lead to this conclusion. On slopes and flatlands which are either more stable, or on which soil formation has begun *I. rhypara* can be found growing among species which do not grow in the bare bedrock outcrops. As the substrate stabilizes even more, and other species increase in abundance *I. rhypara* cannot be found.

Greenhouse experiments could be performed to test the hypothesis that the endemics are competitively excluded. The endemics could be germinated in plots with their normal substrate and in plots with greenhouse soil. In some of these plots other species could also be sown. If there is a pronounced differential survival of seedlings between those plots with only the endemics and those plots with the endemics and other species, it is likely that the endemics are competitively excluded. Kruckeberg (1954) has shown that competition may limit the growth of serpentine endemics off the serpentine outcrops.

*Artemisia packardiae* is also limited in distribution. This appears to be a case where the distribution is not limited by edaphic factors per se, but by a diminishing relic habitat. *A. packardiae* has been found to date in Leslie Gulch only on two of the highest ridges on the north side of Leslie Gulch on cliff faces and among rocks in dikes of Jump Creek Rhyolite. The Jump Creek Rhyolite once overlaid most of the Leslie Gulch Ash-Flow Tuff. During the erosion
cycles which went with the glacial periods this rhyolite was eroded away, and since has been diminishing in extent.

Arthur Cronquist (pers. comm.) suggests that *Artemisia packardiae* may be a new species which has been left behind as the Pleistocene ice sheets retreated and the northern Great Basin became warmer and drier. *A. packardiae* then has evolved to a very specific habitat which may only be a remnant of its former range. Dikes of the Jump Creek Rhyolite continue across the south side of Leslie Gulch up to Mahogany Mountain. However, *A. packardiae* has not been found on any of these dikes. These dikes are higher than those on the north side of the gulch, and the presence of more mesic species (such as *Sambucus caerulea* and *Acer glabrum*) indicates they receive more precipitation. It is likely that the *Artemisia* is a recent species which has adapted to the drier sites where the more mesic species are excluded.

*Artemisia michauxiana* and other members of the section *Abrotanum*, which includes *A. packardiae*, are distributed on high mountains throughout the Great Basin. These mountains serve as relic islands for many more "northern" species, some of which have evolved into new taxa. If *Artemisia packardiae* were a true relic species, and not a recent species evolved from northern affinities, one would expect to find it on Mahogany Mountain, which supports a relic stand of *Pinus ponderosa* and a flora which Detling (1968) says represents a northern island flora.

*Ivesia rhypara* appears to be derived from *I. gordonii*, a species of higher elevations (Ertter pers. comm.). Because of its present distribution one could argue that *I. gordonii* was a member of the more northern flora which was pushed south by the ice sheets of the
Pleistocene, and which retreated north, or to higher elevations, as the last ice sheets retreated. Like the *Artemisia packardiae* it is likely that *Ivesia rhypara* is a new species which evolved from *I. gordonii* as the glaciers retreated north.

If *Ivesia rhypara* were a relic species, one would expect to find it on similar outcrops of Leslie Gulch Ash-Flow Tuff throughout the region. However, only one other population has been found, at about the same elevation, in Juniper Gulch, about three airline miles away, even though the area has been searched by helicopter several times. All similar reddish outcrops are barren of *Ivesia rhypara*.

*Senecio witterae* and *Mentzelia packardiae* also appear to be recent species, but they appear to have their affinities with a southern flora which moved north after the last glacial. These species may therefore by only a few thousand years old. The taxonomic affinities of *Mentzelia packardiae* appear to be southern, and the presence of other species confined to the same habitat also leads to this conclusion.

*Mentzelia packardiae* belongs in the section *Trachyphytum*, subsection *Trachyphyta* (Glad 1975). The genus itself appears to have southern affinities (Johnson 1968). Although species in this subsection may be found in drier areas as far north as Montana and Washington, its center of distribution is in the more dry areas of the western United States and Argentina and Chile.

*Senecio witterae* belongs to the general assemblage of annual senecios including *S. californicus* and *S. vulgare*. This group includes many widespread species whose affinities are difficult to delineate. The genus as a whole appears to be basically of northern
origins (Johnson 1968). This, however, does not argue against a southern parentage for *Senecio erterae*. Cronquist (1978) points out that many of the larger North American genera have evolved species which live in habitats or under climatic regimes that are not common for the rest of the genus. This has especially happened where species are in marginal areas and are exposed to new environmental conditions as they move up and down in elevation.

Two other species, *Arenaria nuttallii* var. *fragilis* and a xeromorphic form of *Lathyrus pauciflorus* ssp. *pauciflorus* grow only in Leslie Gulch on the talus-tuff with the two annual endemics. These species are common on talus and gravel slopes, but are more common in the Great Basin.

The endemic species are also associated with two rather distinct communities which occur in Leslie Gulch. Upper Leslie Gulch, Runaway Gulch and Dago Gulch support a flora which has a northern aspect. Not only is there a relic stand of *Pinus ponderosa*, but more mesic species such as *Sambucus caerulea*, *Scrophularia lanceolata*, *Agastache urticifolia*, *Acer glabrum* and *Lewisia rediviva* occur in this community. Also, *Silene scaposa* var. *lobata*, a species which is common on higher mountains in the Great Basin which support somewhat of a relic northern flora, and *Cercocarpus ledifolius* var. *intercedans*, the northern variety of mountain mahogany also grow in this community.

The most common communities in lower Leslie Gulch are *Artemisia tridentata*, *Atriplex confertifolia* or *Sarcobatus vermiculatus* communities. These species are common throughout the Great Basin, but the latter two are more reminiscent of the drier parts of the Great Basin. Likewise the genus *Eriogonum* evidently has its center of
distribution in the Great Basin (Cronquist 1978). *Eriogonum novonudum*, one of the endemics, is restricted to lower Leslie Gulch.

I do not mean to suggest that upper Leslie Gulch, Runaway Gulch and Dago Gulch are strictly northern communities, or that lower Leslie Gulch is strictly southern. Cronquist (1978) shows that differences in elevation may confuse boundaries between northern and southern elements as lowland taxa evolved to higher elevations and hence more mesic environments and as northern groups adapted to lower elevations and more xeric environments. Nevertheless, the taxonomic relationships of the endemics and the distribution of other taxa do suggest that the flora in upper Leslie Gulch was primarily influenced by northern groups while the flora of lower Leslie Gulch was heavily influenced by southern groups. The difference between the communities in upper and lower Leslie Gulch is probably a result of the difference in elevation, which is between 457 and 610 meters. From the climatic data it was seen that there is a large difference in temperature and precipitation between Owyhee Dam and Rockville, which have a similar difference in elevation. Upper Leslie Gulch, being higher, probably receives enough extra moisture to support a more northern flora.
CONCLUSIONS

The endemics probably are not primarily adapted to chemical factors as was suggested by Glad (1975). It is likely that Glad's conclusion was based on a typographical error in a test report she received. Results of tests on samples taken at a later date near the same location as Glad's gave results of 600 ppm potassium as opposed to 6000 ppm as Glad's tests indicated. The endemics are probably pioneer species adapted to the harsh physical conditions of the edaphic sites. Furthermore they are probably competitively excluded from more normal sites. The talus-tuff species – Senecio erterae and Mentzelia packardiae – have had to adapt to a very porous, actively moving substrate with low fertility. The heulandite increases the availability of ions but is probably not a selective force.

The endemics Ericogonum novonudum, Ivesia rhypara and to some extent Trifolium owyheense, are adapted to very shallow rubble and talus ridge tops and hillsides. Water relations are much more important with these species than with the talus-tuff endemics. Their habitat receives no runoff from slopes above, and since the rubble is so shallow, there is probably more moisture lost to evaporation. The endemics have evidently adapted to this by sending roots very deep into cracks in the bedrock.

Astragalus sterilis and Trifolium owyheense occur on a wide variety of habitats throughout the Owyhee Region. They are capable of living in some of the peculiar edaphic sites in Leslie Gulch: Astragalus sterilis in deep talus or on hillsides and ridge tops, and Trifolium owyheense on hillsides and ridge tops. These species may have a
wider ecological amplitude than the other endemics, with a greater competitive ability and hence can probably grow in a wider variety of habitats.

All of these edaphic endemics probably have some physiological adaptation to deal with the low fertility and peculiar water relations of their habitats.

In a sense *Artemisia packardiae* is limited by habitat. It has been found in three places in the Owyhee Region, always on cliff faces or high rocky areas. The species probably became adapted to this habitat as the area became warmer and drier. Its widely disjunct distribution indicates that this species was once more widespread. But still the species has probably only evolved since the end of the last glacial advance 5,200 to 7,000 years ago.

The other three species which are found only in Leslie Gulch are also recent species. *Ivesia rhypara* has evidently evolved from a northern group or species and has become adapted to the warmer and drier conditions of its habitat. The argument that this species is recent is supported not only by the fact that the dry conditions did not exist in the area more than 7,000 years ago, but also by the fact that it is found only in one area and not on similar habitats throughout the Owyhee Region.

*Ivesia rhypara* and *Artemisia packardiae* are associated with a flora which has been heavily influenced by northern species. Some of these species are *Cercocarpus ledifolius var. intercedans*, *Pinus ponderosa* and *Silene scapos var. lobata*.

The other two endemics, *Mentzelia packardiae* and *Senecio erterae*, are new species which have moved into the area from the Great Basin.
as conditions became warmer and drier. *Mentzelia packardiae* has taxonomic affinities in the Great Basin. *Senecio everttae* has no clear taxonomic affinities and the support for the argument that it is of Great Basin origin is circumstantial. It is always associated with *M. packardiae*, but it is also associated with two species which are more common on talus and gravel slopes on the Great Basin – *Arenaria nuttallii* var. *fragilis* and *Lathyrus pauciflorus* ssp. *pauciflorus*.

The 'northern' flora on the higher, eastern side of the gulch is more clearly northern than is the lower, western end. The lower communities have no clearly southern species other than the endemics, but certain taxa, such as *Atriplex confertifolia* and *Sarcobatus vermiculatus*, although having taxonomic affinities with a northern flora, (Cronquist 1978) are more reminiscent of drier Great Basin communities.
RECOMMENDATIONS FOR FURTHER RESEARCH

There are five areas in which further research could be done in Leslie Gulch and the Owyhee Region.

The taxonomic affinities of some of the endemic species could be studied further. Genome analyses could be helpful in showing the derivation of some of the endemics. *Mentzelia packardiae*, for example, is closely related to *M. mollis* Peck, a species which grows on clay hillsides in the Sucker Creek Formation. *M. packardiae* is octoploid, while *M. mollis* is tetraploid. It is not known if the species are sibling species, or if *M. mollis* is a parent of *M. packardiae*.

Along the same lines it would be helpful to learn more about the origin of the floras which surround Leslie Gulch. The region has many interesting areas with many endemic species. The Leslie Gulch flora must have developed from many of the species in surrounding floras, and to understand their origin would help to understand the origin of the Leslie Gulch flora.

Wood rat middens have been seen in various parts of Leslie Gulch. It would be helpful to study some of these middens since they can give a more immediate botanical history of the gulch.

The greenhouse experiments on seed germination and survival of the endemics in competition with other species should be performed.

Finally, further research should be done on the heulanditic talus-tuff. A better idea of how much water is actually available to the plants could be gained if 1/3 and 15 bar water release curves were done. Also soil research could be done below the talus-tuff slopes to see if the zeolite is present in the soil below.


'Northern" Community - upper Leslie, Dago and Runaway Gulches. The following species occur in miscellaneous shrub-grass steppe and adjacent rock outcrop communities.

**POLYPODIACEAE**
Cystopteris fragils (L.) Bernh.

**CUPRESSACEAE**
Juniperus occidentalis Hook.

**POACEAE**
Bromus carinatus Hook. & Arn.
Festuca idahoensis Elmer
Vulpia octoflora (Walter) Rydb.
Melica spectabilis Scribn.
Poa ampla Merr.
P. sandbergii Vasey
Agropyron trachycaulum (Link) Malte
A. spicatun (Pursh) Scribn. & Smith
Elymus cinereus Scribn. & Smith
E. glaucus Buckl.
Hordeum brachyantherum Nevski
H. depressum (Scribn. & Smith) Rydb.
H. jubatun Smith
Deschampsia danthonioides (Trin.) Munro
D. elongata (Hook.) Munro
Agrostis exerata Trin.
Oryzopsis hymenoides (Roem. & Schult.) Ricker
Stipa occidentalis Thurb.

**LILIACEAE**
Allium acuminatum Hook.
A. parvum Kellogg
Calochortus macrocarpus Dougl.
Fritillaria pudica (Pursh) Spreng.
Zigadenus paniculatus Wats.

**POLYGONACEAE**
Eriogonum microthecum Nutt.
E. strictum Benth.
E. umbellatum Torr.
Polygonum douglasii Greene

**AMARANTHACEAE**
Amaranthus albus L.
A. californicus (Moq.) Wats.

**AIZOACEAE**
Mollugo verticillata L.

**PORTULACACEAE**
Lewisia rediviva Pursh
Montia fontana L.
M. perfoliata (D. Donn) Howell
CAROPHYLLACEAE
Silene douglasii Hook.
S. scaposa Robins var. lobata Hitchc. & Maguire
Stellaria calycantha (Ledeb.) Bong.
S. longipes Goldie

RANUNCULACEAE
Clematis ligusticifolia Nutt.
Delphinium nuttallianum Pritz.

BRASSICACEAE
Arabis holboellii Hornem.
Camelina microcarpa Andrz.
Descurainia pinnata (Walt.) Britt.
Draba verna L.
Erysimum asperum (Nutt.) DC.

SAXIFRAGACEAE
Heuchera cylindrica Dougl.
Lithophragma parviflora (Hook.) Nutt.

ROSACEAE
Cercocarpus ledifolius Nutt. var. intercedans Schneid.
Geum triflorum Pursh
Holodiscus dumosus (Hook.) Heller
Potentilla glandulosa Lindl.
P. gracilic Dougl.
Prunus virginiana L.
Prunus glandulosa Curran
Rosa woodsii Lindl.

FABACEAE
Astragalus filipes Torr.
A. lentiginosus Dougl. var. platyphyllidus (Rydb.) Peck
A. purshii Dougl.
A. reventus A. Gray
Lupinus caudatus Kellogg
L. laxiflorus Dougl.
L. lepidus Dougl.
L. polyphyllus Lindl.
Trifolium owyheense Gilkey

GERANIACEAE
Geranium viscosissimum Fisch.

CELASTRACEAE
Glossopetalon nevadense Gray

MALVACEAE
Sphaeralcea munroana (Dougl.) Spach.

VIOLACEAE
Viola beckwithii T. & G.

LOASACEAE
Mentzelia albicaulis Dougl.

ONAGRACEAE
Epilobium paniculatum Nutt.
Oenothera caespitosa Nutt.

APIACEAE
Lomatium dissectum (Nutt.) Math. & Const.
L. triternatum (Pursh) Coult. & Rose
GENTIANACEAE
Fraserera albicaulis Dougl.

ASCLEPIADACEAE
Asclepias cryptoceras Wats.

POLEMONIACEAE
Collomia grandiflora Dougl.
Gilia aggregata (Pursh) Spreng.
G. sinuata Dougl.
Leptodactylon pungens (Torr.) Nutt.
Microsteris gracilis (Hook.) Greene
Phlox hoodii Rich

HYDROPHYLLACEAE
Hydrophyllum capitatum Dougl.
Phacelia hastata Dougl.
P. linearis (Pursh) Holz.

BORAGINACEAE
Amsinkia tesselata Gray
Cryptantha intermedia (Gray) Greene
Lappula redowskii (Hornem.) Greene
Lithospermum ruderale Dougl.
Plagiobothrys scouleri (Hook. & Arn.) I. M. Johnst.

LAMIACEAE
Agastache urticifolia (Benth.) Kuntze
Salvia dorrii (Kellogg) Abrams

SOLANACEAE
Nicotiana attenuata Torr.

SCOPHULARIACEAE
Castilleja angustifolia (Nutt.) G. Don
C. chromosa A. Nels.
C. inverta (Nels. & Macbr.) Pennell & Ownbey
C. linariaefolia Benth.
Collinsia parviflora Dougl.
Orthocarpus hispidus Benth.
Penstemon deustus Dougl.
P. speciosus Dougl.

RUBIACEAE
Galium aparine L.
G. multiflorum Kellogg

CAPRIFOLIACEAE
Symphoricarpos oreophilus Gray

VALERIANACEAE
Plectritis macrocera Torr. & Gray

ASTERACEAE
Achillea millefolium L.
Agoseris glauca (Pursh) Raf.
Antennaria dimorpha (Nutt.) Torr. & Gray
A. luzuloides Torr. & Gray
Artemisia arbuscula Nutt.
A. packardiae Grimes & Ertter ined.
A. tridentata Nutt.
Aster frondosus (Nutt.) Torr. & Gray
Balsamorhiza sagittata (Pursh) Nutt.
Blepharipappus scaber Hook.
Chaenactis douglasii (Hook.) Hook. & Arn.
ASTERACEAE (con't.)
Chrysothamnus nauseosus (Pall.) Britt.
C. viscidiflorus (Hook.) Nutt.
Cirsium utahense Petrak
Crepis accuminata Nutt.
Erigeron bloomeri Gray
E. corymbosus Nutt.
E. pumilus Nutt.
Eriophyllum lanatum (Pursh) Forbes
Gutierrezia sarothrae (Pursh) Britt.
Haplopappus nanus (Nutt.) D. C. Eat.
Lagophylla ramosissima Nutt.
Machaeranthera canescens (Pursh) Gray
Microseris troximoides Gray
Senecio canus Hook.
Tetradymia canescens DC.
Townsendia florifer (Hook.) Gray

The following species occur in more mesic areas in the shrub-steppes or along streams, springs and bottomlands.

CYPERACEAE
Carex microptera Mkze.
Eleocharis palustris (L.) R. & S.

LEMNACEAE
Spirodela polyrhiza (L.) Schleid

JUNCACEAE
Juncus bufonius L.
J. ensifolius Wikstr.

LILIACEAE
Smilacina stellata (L.) Desf.
S. racemosa (L.) Desf.

SALICACEAE
Populus tremuloides Michx.
Salix lasiolepis Benth.

BETULACEAE
Betula occidentalis Hook.

ULMACEAE
Celtis reticulata Torr.

URTICACEAE
Urtica dioica L.

RANUNCULACEAE
Aconitum columbianum Nutt.
Aquilegia formosa Fisch.
Clematis ligusticifolia Nutt.
Ranunculus scleratus LA

PAEONIACEAE
Paeonia brownii Doug.

BRASSICACEAE
Arabis holboellii Hornem.
Barbarea orthoceras Ledeb.
Descurainia pinnata (Walt.) Britt.
Draba verna L.
The following species are associated with *Ivesia rhypara* on barren outcrops of Leslie Gulch Ash-Flow Tuff in Runaway Gulch.

*also occur along the stream bed in lower Leslie Gulch*

The following species is known from only one location in Juniper Gulch.

*POLYPODIACEAE*

*Polystichum scopulinum* (D. C. Eat.) Maxon
Lower Leslie Gulch – on dry bottomlands and dry hillsides

POACEAE
Bromus brizaeformis Fisch. & Meyer
Poa sandbergii Vasey
Agropyron spicatum (Pursh) Scribn. & Smith

CHENOPODIACEAE
Atriplex confertifolia (Torr. & Frem.) Wats.
A. spinosa (Hook.) Colotzi
Chenopodium leptophyllum Nutt.
Sarcobatus vermiculatus (Hook.) Torr.

AMARANTHACEAE
Amaranthus albus L.
A. californicus (Moq.) Wats.

BRASSICACEAE
Descurainia pinnata (Walt.) Britt.

FABACEAE
Astragalus purshii Doug.

MALVACEAE
Sphaeralcea munroana (Dougl.) Spach.

LOASACEAE
Mentzelia albicaulis Doug.

ONAGRACEAE
Epilobium paniculatum Nutt.

POLEMONIACEAE
Gilia sinuata Doug.
Microsteris gracilis (Hook.) Greene

HYDROPHYLLACEAE
Phacelia hastata Doug.

BORAGINACEAE
Amsinkia lycopsoides Lehm.
A. tessellata Gray
Lappula redowskii (Hornem.) Greene
Plagiobothrys scouleri (Hook. & Arn.) I. M. Johnst.

SOLANACEAE
Nicotiana attenuata Torr.

SCROPHULARIACEAE
Orthocarpus hispidus Benth.

ASTERACEAE
Achillea millifolium L.
Artemisia spinescens D. C. Eat.
A. tridentata Nutt.
Chaenactis douglasii (Hook.) Hook. & Arn.
Chrysothamnus nauseosus (Pall.) Britt.
C. viscidiflorus (Hook.) Nutt.
Cirsium utahense Petrak
Grindelia squarrosa (Pursh) Dunal
Gutierrezia sarothrae (Pursh) Britt.
Iva axillaris Pursh
Lagophylla ramosissima Nutt.
Machaeranthera canescens (Pursh) Gray
Stephanomeria tenuifolia (Torr.) Hall
Tetradymia canescens DC.
On rock outcrops and nearby dry hillside in lower Leslie Gulch

BRASSICACEAE
Thelypodium lacinatum (Hook.) Endl.

CHENOPODIACEAE
Atriplex spinosa (Hook.) Collotzi

ROSACEAE
Holodiscus dumosus (Hook.) Heller

POLEMONIACEAE
Leptodactylon pungens (Torr.) Nutt.

ASTERACEAE
Brickelia microphylla (Nutt.) Gray

On talus-tuff slopes in lower Leslie Gulch

POLYGONACEAE
Eriogonum vimineum Dougl.

CARYOPHYLLACEAE
Arenaria nuttallii Pax. var. fragilis Maguire & Holmgren

FABACEAE
Astragalus sterilis Barneby
Lathyrus pauciflorus Fern. var. pauciflorus

LOASACEAE
Mentzelia packardiae Glad

HYDROPHYLLACEAE
Phacelia lutea (Hook. & Arn.) J. T. Howell var. lutea

SCOPHULARIACEAE
Mimulus cusickii (Greene) Piper

ASTERACEAE
Senecio erterae Barkley
Stephanomeria tenuifolia (Torr.) Hall

On talus ridge tops and upper slopes of talus-tuff

Lower Leslie Gulch

POLYGONACEAE
Eriogonum novonudum Peck

SCROPHULARIACEAE
Mimulus cusickii (Greene) Piper
M. nanus H. & A.

Upper Leslie Gulch

FABACEAE
Trifolium owyheense Gilkey

SCROPHULARIACEAE
Mimulus cusickii (Greene) Piper
M. nanus H. & A.

ASTERACEAE
Dimeresia howelli Gray
A new species of Artemisia (Asteraceae:Anthemidae) from southeastern Oregon

*Artemisia packardiae* Grimes & Ertter, sp. nov.

*Ab A. michauxiana et affinis omnibus partibus glaberrima nec tomentosa simulque dense glandulosa diversa.*

Fragrant erect perennial herbs 2-5 (6) dm tall, generously provided with sessile glands, otherwise glabrous; stems many, with or without several distinct branches, arising from an extensive woody branched caudex, often surmounting a taproot, remains of old stems present; leaves cauline, alternate, sometimes fascicled, the lower reduced, quickly withering or brown and scalelike, the upper bright green and bipinnatifid, 1.5-5 cm long, 1-2.5 cm wide, the 5-7 (9) primary segments 0.4-1.5 cm long, linear, widely spreading, narrowed at the base and joined along the rachis by decurrent leaf tissue, at least some of the secondary segments toothed, the apices acute and indurate, the margins slightly revolute, the petiole indistinct or lacking with the veins decurrent on the stem, the leaves in the inflorescence reduced, pinnatifid to entire; inflorescences narrowly paniculiform or occasionally racemiform, 5-20 cm long, 1.5-4 cm wide, the lower branches arising from the axils of the uppermost leaves; peduncles lacking or up to 1 mm long, subtended by a singes linear-lanceolate bract 1-2 mm long; involucres campanulate to hemispherical, 2.5-3.5 mm long, 2-4.5 mm wide (pressed), the 9-11 phyllaries 1-3 mm long, 1-2 mm wide, broadly ovate, obtuse to rounded, keeled, sometimes saccate, glandular at least at the base, the margins broadly scarious and erose, subtended by 2-4 lanceolate bracts 1-1.5 mm

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This description was coauthored with Barbara Ertter at the New York Botanical Garden and is being published in *Brittonia*, a publication of the New York Botanical Garden.
long, the receptacle flat to hemispherical, naked; flowers (15) 20-35, perfect except for the 3-8 pistillate ones, all fertile or the central ones aborted, bright yellow, glandular externally, the tube 0.3-0.8 mm long, the limb 1-1.5 mm long; stamens 1.5 mm long, the filaments 0.5 mm long, the anthers 0.8-1 mm long, acute, bright yellow; style branches papillate and truncate in the perfect flowers, smooth and sounded in the pistillate flowers; achenes light brown, ellipsoid, ± arcuate, 1 mm long, 0.5 mm wide, epappose, the pericarp translucent, resinous, quickly swelling when moistened, with 4 prominent ribs at the base reduced to nerves near the minute crown.

Restricted to volcanics in Malheur County, Oregon, from 1200 to 1500 meters elevation. Flowering from May to July.

TYPE: UNITED STATES. OREGON. Malheur Co.: W side of Juniper Gulch in the Leslie Gulch State Recreation Area, at the base and on cliff faces of a dike of Jump Creek Rhyolite, T 26 S, R 45 E, SE ¼ of Sec. 12, 1430 m elev., associated with Haplopappus nanus, 12 Jun 1977, Grimes & Ertter 1088 (HOLOTYPE: NY; ISOTYPES: UTC, CIC, MO, US, and to be distributed).

ADDITIONAL SPECIMENS EXAMINED: OREGON: Malheur Co.: Owyhee River, 29 Jun 1957, Dean 115 (NY); Three Forks Canyon, 14 Jul 1958, Dean 282 (NY); Succor Creek Canyon, 14 May 1974, Packard 74-15 (NY); Leslie Gulch, 12 Sep 1977, Grimes 1094 (UTC).