RECONSTRUCTION OF VEGETATION ON RANGE LANDS IN

THE KLAMATH BASIN OF OREGON

by

Morley Stanton Moran

A RESEARCH PAPER

submitted to

THE DEPARTMENT OF GEOGRAPHY

OREGON STATE UNIVERSITY

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

August 1967
ACKNOWLEDGMENT

The writer wishes to express his gratitude to Professors Robert E. Frenkel and Richard M. Highsmith, Jr., for their assistance and guidance in the preparation of this paper. Acknowledgment is also given to Peter Markgraf, formerly of the Bureau of Land Management, Lakeview, Oregon, and other staff members and individuals who provided information and assistance. Sincere appreciation is also extended to Dr. Maurice P. Holsinger and to Dr. R.W. Smith for their encouragement and help in preparing the historical background.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOCATION AND HISTORICAL BACKGROUND OF STUDY AREA</td>
<td>1</td>
</tr>
<tr>
<td>PURPOSE AND OBJECTIVES OF CHOOSING THE STUDY AREA</td>
<td>3</td>
</tr>
<tr>
<td>CONSTRUCTION OF THE MAP OF PRESENT DAY VEGETATION</td>
<td>4</td>
</tr>
<tr>
<td>Physical Sites Supporting Vegetative Types</td>
<td>6</td>
</tr>
<tr>
<td>Dry Prairie Type</td>
<td>6</td>
</tr>
<tr>
<td>Wet Prairie Type</td>
<td>6</td>
</tr>
<tr>
<td>Juniper Opening and Juniper Forest Types</td>
<td>7</td>
</tr>
<tr>
<td>Pine-Juniper Type</td>
<td>7</td>
</tr>
<tr>
<td>HISTORICAL SOURCES UTILIZED TO DETERMINE PRE-SETTLEMENT VEGETATIVE PATTERN</td>
<td>8</td>
</tr>
<tr>
<td>Vegetative Patterns Documented by Journals of Explorers</td>
<td>8</td>
</tr>
<tr>
<td>Fremont's Expedition</td>
<td>9</td>
</tr>
<tr>
<td>Expedition of Williamson and Abbot</td>
<td>12</td>
</tr>
<tr>
<td>Drew's Owyhee Expedition</td>
<td>14</td>
</tr>
<tr>
<td>Vegetative Patterns Documented by General Land Office Survey Records</td>
<td>16</td>
</tr>
<tr>
<td>METHODS OF RECONSTRUCTING PRE-SETTLEMENT VEGETATION USING LAND SURVEY RECORDS</td>
<td>19</td>
</tr>
<tr>
<td>Interpretation of Field Notes</td>
<td>19</td>
</tr>
<tr>
<td>Boundary Delineation</td>
<td>21</td>
</tr>
<tr>
<td>Boundary Delineation Utilizing Original Plat of 1872</td>
<td>22</td>
</tr>
<tr>
<td>1st Order Prairies</td>
<td>22</td>
</tr>
<tr>
<td>Boundary Delineation Utilizing Field Note Data, Topographic and Surface Material Evidence, and Presently Existing Vegetative Boundaries</td>
<td>22</td>
</tr>
<tr>
<td>2nd Order Prairies</td>
<td>23</td>
</tr>
<tr>
<td>3rd Order Prairies</td>
<td>26</td>
</tr>
<tr>
<td>Pine-Juniper Type</td>
<td>26</td>
</tr>
<tr>
<td>Juniper Forest and Juniper Opening</td>
<td>27</td>
</tr>
<tr>
<td>Special Cases of Boundary Delineation</td>
<td>28</td>
</tr>
<tr>
<td>CHANGES DEMONSTRATED BY THE PRESENT DAY AND PRE-SETTLEMENT VEGETATIVE MAPS</td>
<td>32</td>
</tr>
</tbody>
</table>
**LIST OF FIGURES**

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Map of Bonanza Administrative Unit, Township 40 South, Range 14 1/2 East.</td>
<td>envelope back cover</td>
</tr>
<tr>
<td>2.</td>
<td>Map of present day vegetation.</td>
<td>envelope back cover</td>
</tr>
<tr>
<td>3.</td>
<td>Vegetative types as they appear on aerial photographs.</td>
<td>5</td>
</tr>
<tr>
<td>4.</td>
<td>Routes of early explorations by Fremont and Williamson and Abbot.</td>
<td>10</td>
</tr>
<tr>
<td>5.</td>
<td>Colonel Drew's exploration route.</td>
<td>11</td>
</tr>
<tr>
<td>6.</td>
<td>Map of pre-settlement vegetation 1872.</td>
<td>envelope back cover</td>
</tr>
<tr>
<td>7.</td>
<td>Vegetative pattern and profile of sections ten, eleven, and twelve.</td>
<td>25</td>
</tr>
</tbody>
</table>
RECONSTRUCTION OF VEGETATION ON RANGE LANDS
IN THE Klamath Basin of Oregon

ABSTRACT: Township 40 South, Range 14 1/2 East, within the Klamath Basin in south central Oregon has been chosen for analysis in reconstructing vegetation. Both the present and the pre-settlement vegetative cover are depicted on maps, and the methods and sources utilized to reconstruct pre-settlement vegetation are reviewed. The term "pre-settlement" is used by the author to denote primitive, but it does not exclude the effects of primitive man. The study also points out the most significant changes in the vegetative cover, demonstrated by the two maps.

LOCATION AND HISTORICAL BACKGROUND OF STUDY AREA

The study area is situated in the northeast portion of the Klamath Basin, and is within the 119,000 acre Bonanza Administrative Unit of the Bureau of Land Management (see Fig. 1. in enclosed envelope-back cover). It is bordered on the north and east by the Fremont National Forest, on the south by the Modoc National Forest of California, and on the west by Langell Valley and Bryant Mountain.

The Bonanza Administrative Unit has been utilized for grazing cattle and sheep from the time that white settlement began in the area. In 1868, Joseph Langell, a cattle rancher, settled in the valley which now bears his name.

There was a small increase in population each year during the 1870's, and most of the new settlers were stockmen. It was not until
1873, when Modoc hostility ceased to be a problem, that increasing numbers of settlers came to the area and the livestock industry began to crystallize.

A steady increase of cattle and a phenomenal increase in the number of sheep took place between 1900 and 1930. However, range and livestock management practiced since initial settlement changed little until the Taylor Grazing Act came into being in 1934.

Prior to the time of the Taylor Grazing Act, public land was open to all and its use was entirely without supervision. Quite often large herds were turned out too early in the spring, and year-around use of the range was a common practice. With the coming of Federal supervision of the public domain, most ranches received permits to use moderate sized areas of range land. There were also regulations governing the time and length of use, and the number of cattle permitted to graze in a given area.

The Bureau of Land Management of the Department of the Interior was created on July 16, 1946. The primary concern of the Bureau is the management and improvement of Federal range lands. A multiple-use management policy is employed with a philosophy of obtaining the greatest use and value from the land. Provisions are made for proper grazing, range improvement, conservation of soil and moisture, weed control, fire control, management of forests and woodlands, wildlife and recreation.
Thus, a new concept of sound management and conservation practices by both the ranchers and the Federal Government began.

PURPOSE AND OBJECTIVES OF CHOOSING THE STUDY AREA

The author has chosen Township 40 South, Range 14 1/2 East, as the location for a problem in the reconstruction of pre-settlement vegetation. This choice was based on the author's previous research here, the excellent quality of the federal land survey records utilized to reconstruct pre-settlement vegetation, and speculation that the composition and condition of the vegetation has been altered. It is hypothesized that the aerial extent of perennial grasses was greater before initiation of livestock grazing, and many of these grasses have been replaced by weeds and annuals. It is also hypothesized that sagebrush has increased or invaded sites which did not support it before.

It is the author's opinion that this study and the accompanying maps will provide insight and information which is pertinent to this speculation. The maps may also aid workers interested in investigating physical and cultural processes which have taken place between the two distinct time horizons of the pre-settlement era and the present decade. The maps may also prove useful to those who may attempt to evaluate past and present conditions of the vegetation on a given range site. If a given vegetative type is believed to have
undergone deterioration and is thought to have been replaced by less desirable forage types, the pre-settlement vegetative map may help establish factual evidence of this or disprove it. In addition to evaluating the potentials of range sites, analysis such as this would also make it possible to plan for restoration and management of the range in a given area.

CONSTRUCTION OF THE MAP OF PRESENT DAY VEGETATION

The current map (Figure 2 in envelope) of the vegetation of Township 40 South, Range 14 1/2 East, is based upon the interpretation of a set of 1958 aerial photographs with a scale of 1:20,000. The photographs were mosaicked and the boundaries for the following vegetative types were delineated on the aerial photographs:

1) Prairies - Dry and Wet

2) Juniper Opening (Low Density)

3) Juniper Forest (High Density)

4) Pine and Juniper

Figure 3 depicts these vegetative types as they appear on aerial photographs. In viewing Figure 3, note the difference in density between Juniper Opening in the top photo and Juniper Forest in the middle photo. Also note the visual appearance of the Pine-Juniper type in the top photo, and the Dry and Wet Prairies in the middle, and bottom photographs.
Figure 3. Vegetative types as they appear on aerial photographs.

Top: From left to right - Pine-Juniper Type grades into Juniper Opening approximately at right one-third of photo.
Middle: From left to right - Juniper Forest grades into Dry Prairie.
Bottom: Wet Prairie.
Appendix I contains a summary of the dominant plant species within the township today. Appendix II contains the species which make up the given vegetative types. These types are based on the Bureau of Land Management range survey for the township.

Physical Sites Supporting Vegetative Types

Dry Prairie Type

Dry prairies usually occur along channels of intermittent streams, and in depressions of valley floors and basalt plateaus. Many of the prairies collect seasonal runoff from the highlands. Quite often the site is poorly drained due to clay subsoils and hardpan layers which restrict the downward movement of roots and water. Plants must be adapted to seasonal flooding or wet soil conditions for short periods, and they must also tolerate dry conditions during the summer.

Wet Prairie Type

Wet prairies are often found in basins, and they occur in areas which are fed by seepage from perennial streams or springs which maintain a permanent high water table. The soils usually contain layers restrictive to the downward movement of roots and water, and thus they support a variety of water-loving plants.

Neither the dry prairie nor the wet prairie can support a forest
cover such as pine or juniper because these species cannot tolerate high soil moisture for long periods, and they require good drainage. Howell makes the statement that:

Western yellow pine cannot endure any excess of moisture, (and) will not survive in saturated soil.  

Juniper Opening and Juniper Forest Types

Western juniper is the dominant tree species of the area. It exists in a wide variety of habitat conditions, with its upper and lower limits being set by soil moisture excess or deficiency. Eckert showed that juniper did not exist on sites below a given unit of soil moisture, although other environmental factors were similar. He also pointed out that juniper makes its maximum growth on rocky outcrops, and steep slopes where moisture conditions are most favorable. Juniper is occasionally present in intermittent drainages if moisture is sufficient at least for a portion of the growing season. It often grades into ponderosa pine where moisture is more effective, and to dry grassland sites where moisture is less effective.

Pine-Juniper Type

The Pine-Juniper type is often found on gradual and steep slopes, or along escarpments which separate one plateau from another. Munger mentions several site requirements of western yellow pine:

Western yellow pine thrives on almost soilless steep talus slopes.... It seems to prefer well drained, loose
soils; but an increase in moisture, provided the soil is well drained, makes for rapid growth. It is uncommon on flats and bottom land, and is distinctly a tree of the slopes. 7

HISTORICAL SOURCES UTILIZED TO DETERMINE PRE-SETTLEMENT VEGETATIVE PATTERNS

Vegetative Patterns Documented by Journals of Explorers

Diaries and journals of early expeditions may be helpful in determining the quality and kinds of plants which existed in a given area before initial white settlement. All expeditions which passed through the Klamath Basin were reviewed to determine whether any of the expeditions traversed the study area. The author was interested in any notations regarding the quality and kinds of plants observed by the explorers prior to settlement in the area.

The following expeditions traveled through the Klamath Basin between 1826 and 1864:

1) Peter Skene Ogden, 1826
2) Lieutenant John Charles Fremont, 1843
3) Scott-Applegate Party, 1846
4) Lieutenants Williamson and Abbot, 1855
5) Drew's Owyhee Expedition, 1864.

None of these expeditions traversed the study area. However, the journals of Fremont, Williamson and Abbot, and Drew were all helpful in providing general information pertaining to the existence of
certain plants over a large geographic area. The routes of Fremont and Williamson and Abbot are shown in Figure 4. Drew's Owyhee Expedition is shown in Figure 5.

Fremont's Expedition

John Charles Fremont, on his second western expedition for the United States government, reached Klamath Marsh on December 10, 1843. On the 12th of December, Fremont's course took him east of Klamath Marsh to a point on the Upper Williamson River about five miles from Yamsay Mountain. Proceeding east he reached Long Creek, a northern tributary of the Sycan River, and followed it to a point near Sycan Marsh. Fremont comments:

Our road was over a broad mountain... always through pine forests, when we came down upon the headwaters of another stream on which there was grass.

Riding continually through pine forests, and on an eastward course, Fremont writes of discovering Winter Ridge and Summer Lake.

The forest looked clear ahead appearing suddenly to terminate; and beyond a certain point we could see no trees. Riding rapidly ahead to this spot, we found ourselves on the verge of a vertical and rocky wall of the mountain. At our feet - more than a thousand feet below - we looked into a green prairie country, in which a beautiful lake, some twenty miles in length was spread along the foot of the mountains...scarcely a tree was to be seen...(and) the face of the country exhibited only rocks and grass, and presented a region in which the Artemisia became the principal wood.
Figure 4. Routes of early explorations by Fremont and Williamson and Abbot.

Study area

Colonel Drew's exploration route.
Expedition of Williamson and Abbot

In 1855 Lieutenants Williamson and Abbot explored for a railroad route from the Sacramento Valley to the Columbia River as a phase of the Pacific Railroad explorations by the U.S. Army Corps of Topographic Engineers. Their expedition covered a large portion of the Klamath Basin, and it is through their records that we learn more of the character of the country.

Exploring north from the Pit River in California, but still a few miles south of Clear Lake, Lieutenant Abbot writes:

After travelling several miles on nearly level ground through the (pine) forest, we emerged from it, and found ourselves on a rocky plain covered with sage bushes. This we crossed in about six miles, and, on reaching the summit of a line of low sandstone hills capped with trap, saw below us Wright lake (Clear Lake). It was a fine sheet of water, about eleven miles long and four miles wide, bordered by tule... We encamped in the edge of the tule, near some green willow bushes which supplied us with our only fuel, as even sage bushes had disappeared after crossing the hills.12

The following day the party continued and

After crossing the low hills which border the lake, we travelled through a gently undulating region, dotted with sage bushes, for about seven miles. We then found ourselves on the edge of an abrupt descent of 200 feet, which conducted to the shores of Rhett lake (Tule Lake). On the bluff the trail joined an emigrant road, which followed down a narrow ravine to the level of the lake. The line of hills which borders the lake on the northeastern side, is separated from the tule by a narrow strip of land, elevated but little above the water. This was covered with grass, the rich green of which presented a refreshing contrast to the sickly blue of the sage plain over which we had been travelling. The clouds of dust ceased, and
we journeyed on through a much more pleasing region. After riding a few miles from the bluff, we left the road, and encamped on Lost river near where it discharges itself into the lake by several mouths. It was a deep, unfordable stream, flowing with a very sluggish current. The banks were abrupt like the sides of a canal. A few sage bushes and 'bois des vaches' supplied the only fuel. 13

On the next day, which was August 13th, the party split, each taking different routes. Lt. Williamson explored along the western side of Lower Klamath Lake, while Lt. Abbot continues north along Lost River. Abbot writes:

My party left camp first. We followed up the eastern bank of Lost river, through a dusty sage plain almost destitute of grass, to the Natural Bridge.... There is no ford for a considerable distance above, and none below. We passed over without difficulty, and followed a well marked Indian trail towards the north, through a level valley dotted with sage bushes and a few clumps of bunch grass.... The valley was about three miles wide, and bordered by high hills; those on the east being well timbered with pine, and those on the west nearly bare. The bunch grass became more abundant as we advanced, and the sage bushes fewer in number. 14

Travelling north, Abbot reached Upper Klamath Lake the next day where he was to meet Lieutenant Williamson at the south end of the lake.

It was a fine sheet of water, thirty miles long and twelve miles wide, bordered by timbered ridges with an occasional narrow belt of tule.... Following along the eastern side, we crossed a grassy meadow, and encamped at the extremity of a hilly promontory which projected into the lake. Excellent bunch grass with bushes and small trees for fuel, abounded in the vicinity. 15

Three days later Lieutenant Williamson joined Lt. Abbot and they
continued on their journey toward the Deschutes River Valley by way of the Klamath Marsh.

**Drew's Owyhee Expedition**

In the summer of 1864, Colonel C.S. Drew explored a route across southern Oregon from the Klamath Lakes to the Owyhee country. Leaving from Fort Klamath, he proceeded to the Williamson and Sprague Rivers, and Goose Lake Valley. A.H. Miller kept a journal of the expedition and gives us a vivid description of the country which they passed through.

The country between Fort Klamath and the ford of Williamson's River is covered with a fine forest of yellow and sugar pine, and now and then a white or red fir and occasionally a good sized cedar, cottonwood, or rather aspen, is frequent around the glades and along the smaller streams.\(^{16}\)

As they enter the Sprague Valley the journal reads:

The banks of the river, and of the numerous streams putting into it on either side are fringed with willows and cottonwood, and the entire valley is skirted with a continuous forest of yellow pine, extending back to the summit of the mountains by which it is bounded. It possesses all the natural requisites for a good stock range, its lowlands being covered with a fair growth of marsh grasses, while its uplands afford a bountiful supply of the more nutritious bunchgrass.\(^{17}\)

Leaving the Sprague River Valley, they continues in a southeasterly direction, crossed the Goose Lake Mountains, and entered what is now called Drew's Valley.

Its surroundings on the north, east, and west, are
timber-covered mountains, while a low range of grass-covered hills bound it on the southward, separating it from the basin of Goose Lake. It is well watered by several mountain streams, and by springs, fringed with willow, and in some places with the cottonwood, and is covered with a luxuriant growth of grass.\textsuperscript{18}

As the party left Drew's Valley, they descended into Goose Lake basin by way of a good pass with a low grade.

From this pass to the head of Goose Lake, the first four miles was across a sage desert that extends southward down the western border of the lake as far as the eye can see... The uplands are generally covered with a luxuriant growth of bunch grass, but in many places the outcappings of lava renders them unfit for other than grazing purposes.\textsuperscript{19}

The remaining part of their journey took them over the summit of Warner Range, through Surprise and Warner Valleys, and to the Steens Mountains and Alvord Valley which led them to the junction of the Jordan and Owyhee Rivers.

Each of these expeditions provided general information about the type of plants which existed over a large portion of the Klamath Basin during the pre-settlement period.

Fremont traveled through extensive pine forests until reaching Winter Rim. Looking east, he noted the scarcity of trees, the presence of grass, and the existence of an unknown species of sage; for he mentioned that Artemisia became the principal wood.

Williamson and Abbot noted the existence of pine and extensive areas covered with sage alternating with areas of grass. The
explorers mentioned the presence of bunch grass quite often in their journal.

Drew's Owyhee expedition noted the spatial distribution of a variety of trees, grasses, and shrubs. Again, extensive areas of sage and bunch grasses were mentioned.

These expeditions were helpful in substantiating the existence of scattered patches of sage over a large portion of the Klamath Basin prior to white settlement. It is possible that sage may have existed over a larger portion of the Klamath Basin than formerly believed. Therefore, the hypothesis which suggests that sage has increased and invaded sites which did not previously support it, due to extensive grazing by sheep and cattle, should be studied further.

Vegetative Patterns Documented by General Land Office Survey Records

Land survey records are a common source of historic evidence used to reconstruct pre-settlement vegetation. A number of authors have utilized land survey records for this purpose: Lutz (1930) determined the original composition of the forest in northwestern Pennsylvania; Howell and Kucera (1956) determined the composition of pre-settlement forests in three countries of Missouri; Potzger et al. (1956) reconstructed the vegetation for the state of Indiana; and Habeck (1961) reconstructed pre-settlement vegetation in the Willamette Valley, Oregon. A review and evaluation of the instructions
and methods utilized by the surveyors, and the qualitative and quantitative use of land survey records in recent studies, is provided by Bourdo (1956).

The author has chosen to use Federal land survey records as the primary source of evidence for reconstructing pre-settlement vegetation in Township 40 South, Range 14 1/2 East. The survey was made in August of 1872.

The rectangular system of survey was adopted shortly after the Revolutionary War. Between 1782 and 1802 the states ceded their Trans-Appalachian Territories, granted to them by charters from the crown, to the United States. Congress passed the Ordinance of May 20, 1785, which provided the United States with a technique for surveying and disposing of the new public lands. These lands were to be divided into townships six miles square, containing 36 sections, each of which was to be one mile square. This ordinance was later modified by subsequent acts. The Act of February 11, 1805, concerning the mode of surveying the public land of the United States, was the last important amendment to the original act of 1785. It specified all the lines and corners we know today.

Before the reorganization of the General Land Office in 1836, each surveyor general was an independent officer and issued surveying instructions for his own district. An official set of instructions was adopted in 1855 and was published by the Commissioner of the
General Land Office for the guidance of all deputy surveyors. A number of revisions of this manual took place, but until the issue of 1881, there were no changes.

The pre-determined instructions for sub-dividing the assigned areas into townships and sections, and the very nature of the surveyor's method makes it possible to objectively reconstruct the pre-settlement vegetation along the survey lines. The original manual issued in 1855, and again in 1871, specified that four trees called "witness trees" or "bearing trees" were to be selected to establish township and range corners. The vernacular name of each tree, its diameter, and its distance and direction from the corner were recorded by the surveyor. At each section corner four trees were also selected and described in a similar manner. At quarter-section corners, only two trees were similarly selected to mark the corner. When sub-dividing areas which were treeless, a charred stake, a mound of earth, or several large rocks were used to mark the corner. Along a section line at the boundary between two contrasting vegetation types, such as where prairie was adjacent to a scattered juniper forest, the surveyor would often record a definite point along a section line where the change between the two types occurred. At the end of each mile, the surveyor provided a summary of the landscape features, mentioning the type of vegetation, soil, and geologic characteristics of the previous mile of surveyed line. When a
towship was completely divided into thirty-six sections, an over-all
detailed description was also written.

METHODS OF RECONSTRUCTING PRE-SETTLEMENT
VEGETATION USING LAND SURVEY RECORDS

Interpretation of Field Notes

Field notes and plats were utilized to construct the map of 1872
shown in Figure 6 in the envelope. The field notes were also helpful
in identifying a number of plant species, and in determining the exist-
ence of vegetative types. The writer's interpretation of the names of
these plants used by the surveyor, and the plants which make up the
given vegetative types are listed in Appendices III and IV.

To construct the map, graph paper was divided into thirty-six
sections, and the following data were plotted along all north-south
and east-west section lines:

1) The position and vernacular name of all witness trees at
each corner

If no witness trees were recorded by the surveyor this was
indicated on the graph paper.

2) All points where a change between two types of vegetation
has been indicated by the surveyor

3) The type of vegetative cover which was indicated by the sur-
veyor at the end of the surveyed mile
The following excerpt from the field notes will illustrate how the surveyor recorded this data:

Begin at a stone, the established Corner to Townships 39 and 40 South, Ranges 14 1/2 and 15 East, and run thence South on a true line along the East boundary of Sec. 1.
5.00 Enter open pine timber bears E and W
10.00 Leave timber and enter rocky prairie bears NW and SE
40.00 Set Sandstone 16 x 14 x 12 for 1/4 sec. Corner
52.00 Leave prairie and enter pine timber
56.50 A Yellow Pine 36 in.
70.00 A low ridge
75.00 Leave timber and enter rocky prairie bears SE and NW
80.00 Set Stone 30 x 14 x 7 in. for cor to secs 1, 12, 6, 7 from which
A Juniper 12 in. dia. bears 51° W 39 links
No other trees near
Land nearly level - 2d rate - Prairie rocky with some bunch grass, Timber Pine and Scattering Juniper.

The surveyors began this particular mile at the northeast corner of Township 40 South, Range 14 1/2 East. Their course ran south along section one of the east boundary of the township. The surveyors entered open pine timber five chains (1 chain equals 66 feet) south of the corner. At ten chains, the surveyors left the open pine timber and entered a rocky prairie. Upon reaching the half mile point, the quarter section corner was established with a stone. Since the surveyor makes no mention of witness trees, the author has assumed that there were no trees near by to serve this purpose. This is a reasonable assumption since the surveyors were in a prairie at this point. Fifty-two chains south of the corner, the surveyors left the prairie and entered pine timber. At fifty-six and one-half chains,
a yellow pine 36 inches in diameter was found on the survey line. Seventy chains south of the corner a low ridge was crossed, and at seventy-five chains the surveyors left the pine timber and entered another prairie. Upon reaching the section corner only one tree instead of four could be used as a witness tree. The description of the tree, including its name, diameter, angle, and distance from the corner is recorded. At the end of the surveyed mile, the surveyor comments on the physical condition of the prairie site, and also points out that juniper was scattered among the pine timber.

**Boundary Delineation**

After plotting all field note data, the same vegetative types delineated on the map of present day vegetation were evident on the 1872 map.

The vegetative boundaries established on Figure 6 were constructed by utilizing from one to four of the following sources of information:

1) Vegetative boundaries delineated on the original plat of 1872
2) The surveyor's field notes
3) Topographic and surface material evidence at a given site
4) Presently existing vegetative boundaries
5) Field checking

(Soil surveys would have been helpful, but they were not available.)
Boundary Delineation Utilizing Original Plat of 1872

1st Order Prairies. Six dry prairies and three wet prairies were delineated on the plat made in 1872. These prairies are distinguished from other prairies in Figure 6 in the following way: Dry and Wet Prairies are shown on the map in white, and their boundary lines are delineated with a solid black line. These are typed as 1st Order Prairies. The Wet Prairies, however, are designated by the letter W. In all cases, the prairie boundaries which cross the section lines on the original plat of 1872 correspond exactly with the field note data.

Boundary Delineation Utilizing Field Note Data, Topographic and Surface Material Evidence, and Presently Existing Vegetative Boundaries

Before any of the boundaries were constructed, the possible area for delineation was carefully studied with the aid of aerial photographs, topographic maps, and the surveyor's field note data. An examination of topography and presently existing vegetative boundaries was found to be helpful in determining where the boundary may have existed in the past. In some cases presently existing vegetative boundaries were utilized as inferred boundaries on the map of 1872. This practice was not carried out, however, unless a definite physical difference between the two sites coincided with the present boundary which separated one vegetative type from another. Frequently a
change in surface expression coincided with the present vegetative boundary between a Prairie type and a Juniper or Pine-Juniper type.

Some boundaries were delineated where a difference in soil moisture occurred. For example, Wet Prairies could often be distinguished from Dry Prairies by a perceptible difference in black and white tones on the aerial photographs. Wet Prairies vary from dark gray tones to black, and Dry Prairies vary from light gray tones to white (see Figure 3, middle and bottom photos).

Differences in surface material were also helpful in determining the location of boundaries. An extremely rocky area or the exposure of bed-rock, for example, could be distinguished from sites free from rock, by a perceptible difference of texture evident on the aerial photographs.

**2nd Order Prairies.** A number of prairies were indicated by the surveyor's field notes, but their boundaries were not delineated on the original plat of 1872. Certain segments of their boundaries are, therefore, based on the evidence discussed above. In Figure 6 these prairies may be distinguished from others by a light dot pattern within broken lines. Wet Prairies within this category are also designated with the letter W. The prairies in this category are types as 2nd Order Prairies. An example of the criteria utilized to determine the boundaries for the prairie in sections twelve and one will illustrate
the above points. In these sections (twelve and one), two precise points were indicated in the field notes which established the north and south boundaries between prairie and forest on the eastern boundary of the township. A segment of the western boundary was established by field note data on the section line between sections one and twelve. Several excerpts from the field notes will illustrate the point. The surveyor's course ran south along sections one and twelve of the east boundary of the township. Seventy-five chains south of the NE corner of the township the field note entry reads:

75.00 Leave timber and enter rocky prairie

Continuing on a south course along the east boundary of section twelve, and at 60 chains, the notes read:

60.00 Leave prairie and enter pine timber

These two points mark the north and south boundaries of the prairie. Surveying on a true line running west between sections one and twelve and at 20 chains west from the eastern boundary of the township, the entry in the field notes reads:

20.00 Enter pine timber bears N and S

This point established a segment of the western boundary on the section line between one and twelve. Except for these three points, the boundary of the prairie is based on topography and presently existing vegetative boundaries.

Figures 7A and 7B show this prairie in section twelve as well
Vegetative pattern and profile of sections ten, eleven, and twelve.
as the prairie in section eleven. Boundary segments of the latter prairie were also established by the surveyor's field notes. Figure 7A is a duplication of the vegetative pattern for sections ten, eleven, and twelve in Figure 6. A vertical profile taken along crossections A-A' of these sections is shown in Figure 7B, and illustrates the spatial distribution of the vegetative types in association with topography. In viewing the vertical profile in Figure 7B it can be seen that both prairies are topographically low. The remaining segments of the boundaries for these prairies is based on a contour above each basin floor which separates the prairies from Pine-Juniper and Juniper types.

3rd Order Prairies. Several of the prairies' boundaries were delineated without the surveyor's field note data. Delineation was accomplished by utilizing topographic and surface material evidence and the presently existing vegetative boundaries at the given sites. These prairies are typed as 3rd Order Prairies. A second pattern and broken line boundary distinguishes these prairies from others in Figure 6.

Pine-Juniper Type. The Pine-Juniper type boundaries were established by examining the surveyor's field notes, topographic and surface material evidence, and presently existing vegetative boundaries. Examples of this type are shown in sections twelve and ten
6) Good Juniper timber

7) Considerable Juniper timber

These terms were not included in the surveyor's Manual of Instructions. Thus, the terms used by the individual surveyor were terms which he felt would best describe the variation in Juniper density.

There is only one area depicted on the map of 1872 as Juniper Forest. At this site the surveyor indicated a density difference which seemed significant; he used the term "considerable Juniper timber" in describing the area in sections nine and ten, and three and four. All other areas described by the surveyor were depicted as Juniper Opening on the 1872 map.

Special Cases of Boundary Delineation

In part of sections thirty-six and twenty-five the vegetative pattern is undifferentiated. The large prairie which centers on sections twenty-six and twenty-five, and the narrow wet prairie centering on section thirty-six were delineated by the surveyors. The prairie boundaries which cross the section lines correspond exactly with the field note data. There is a degree of confusion, however, pertaining to what vegetative types existed in the area covered by the lined pattern. The surveyor's field notes for the line between sections thirty-five and thirty-six reads:

Land nearly level soil 2d rate In prairie 1st rate with luxuriant grass
There was no notation regarding tree species along the surveyed line. A juniper witness tree was present at the 1/4 section, however.

Field notes for the line between sections twenty-five and thirty-six read:

Land hilly soil 2d rate  Good bunch grass  No timber

There were no witness trees indicated for the corners on this line.

Field notes for the line between sections twenty-five and twenty-six read:

Land nearly level, soil in prairie good  Grass good  No timber

Again, there was no indication of witness trees for the corners on this line. The last field note entry in relation to this area was made in reference to the surveyed line between sections twenty-five and twenty-four. The field notes read:

Land hilly. Soil poor and rocky Some good pine timber on 1st half mile  Undergrowth Mountain Mahogany, Manzanita, Quaking ash, and Wild Plum.

Except for the timber growth mentioned in this last entry, the surveyor indicated that there was no timber along these surveyed lines. However, the boundaries for the prairies were delineated. The question arises, what criteria were used to delineate these boundaries? The boundary would normally separate two different vegetative types, but the field notes do not indicate that another type existed.
Inspection of the site does reveal that the southern and eastern boundaries of the large prairie could have been delineated by a natural topographic boundary. This interpretation would reveal the criterion the surveyors used to delineate this part of the boundary and it would remove the necessity of having another vegetative type adjacent to the prairie. It must be realized, however, that there is some question about the absence of trees of some species in this area.

In most of section thirteen and parts of twelve and twenty-four the vegetative types are not differentiated. The area is presently a mixture of Juniper Forest, Juniper Opening, Pine and Juniper Forest, and a small Prairie. The boundaries could not be delineated by any of the criteria discussed. Therefore, this area is typed with a special symbol standing for a mixture of all of these types.

The large area on the west side of the township typed as prairie with scattered sparse juniper, is a rock flat consisting of three large prairies separated by narrow rocky ridges, supporting scattered juniper timber. The surveyor's field notes give further insight as to the character of the area. The following entries are summary remarks made by the surveyors at the end of each surveyed mile. The compass courses followed by the surveyors between the given sections are indicated. North between sections twenty-nine and thirty:

Lan. nearly level--2d rate--Good bunch grass and a little Scattering Juniper
West between sections twenty and twenty-nine:

Land open, Nearly level. Good bunch grass A little Juniper timber

East between sections nineteen and thirty:

Land mostly level, poor and rocky. Some good Juniper timber Good bunch grass

North between sections nineteen and twenty:

Land open, level, 2d rate, Scattering Juniper timber Bunch grass abundant

West between sections seventeen and twenty:

Land open slightly rolling Scattering Juniper timber and plenty of bunch grass.

East between sections eighteen and nineteen:

Land level, 2d rate. Some Juniper timber Good bunch grass.

North between sections seventeen and eighteen:

Land nearly level Very little timber Grass abundant

The most significant fact revealed by the field notes is the sparse distribution of juniper here, compared to other areas in the township. Only four witness trees were indicated, and of these, three of them were on the section line between sections twenty-nine and thirty. The field notes indicate that within this predominately flat, well-grassed area juniper was present. However, sufficient evidence for the delineation of boundaries was lacking.

It is very interesting to note that the surveyors recorded the
existence of sagebrush in only three locations. These areas were between sections eight and seventeen, between seven and eighteen, and on the south boundary of section thirty-three. The recorded comment in each instance was:

Some sage undergrowth

From this entry, of course, it cannot be established what species of sage was present. The fact that it is not mentioned for any other location within the township is very surprising, however, since the entire region is densely covered with sage today.

CHANGES DEMONSTRATED BY THE PRESENT DAY AND PRE-SETTLEMENT VEGETATIVE MAPS

One of the most marked changes which has occurred since 1872 is the increase of juniper. It will be recalled that the surveyors indicated there was no timber present in the undifferentiated area in sections twenty-five and thirty-six. Today the area is covered with a dense stand of juniper. It can also be seen that the large prairie centered on the section line between sections twenty-five and twenty-six has been largely invaded by juniper. Many areas where the field notes recorded the presence of very little juniper timber in 1872 are densely covered with it today. A comparison of the two maps readily reveals the areas which have increased in juniper density.

Another significant change which has occurred since 1872 is the introduction of cheatgrass (*Bromus tectorum*) at the turn of the
century. It is believed that cheatgrass was first brought to the area by transient sheep, and was apparently transported in their fleece. Today cheatgrass is present on a number of sites within the township.

Perhaps the most significant change, and yet the most confusing, is the present existence of sagebrush on a majority of sites of every vegetative type within the township. The field notes of the 1872 survey mention the existence of sagebrush in only three locations. It is assumed, therefore, that the surveyors recognized sagebrush when they saw it, but it does not seem reasonable that it was completely absent over the remaining part of the township.

Both Artemisia tridentata (big sagebrush) and Artemisia arbuscula (low sagebrush) exist in the area today. It is possible that Artemisia tridentata was the only species which the surveyors recognized as sagebrush. While large areas are presently covered with big sagebrush, low sage covers more area within the township.

Throughout their field notes, the surveyors referred to the good bunch grass. It is possible that the bunch grass was quite high during the month of August when the township was surveyed. Very little, if any grazing would have taken place during this time since initial settlement was just beginning. In view of this, the high grass could have completely obscured the low sage, particularly if it was in scattered patches of low density.
The agent of fire may also help explain why sage brush was nearly absent in the area. Pease points out that:

local legends hold that the Modocs used fire to keep the forest floor clear of shrubs in order to make game more abundant and facilitate hunting... This practice would suggest that in pristine times understory vegetation was not only sparser than today, but it contained more grass and less shrubs.\textsuperscript{28}

This is not an established fact, but it is given here as a hypothesis which may explain why sage was not more widely noted in 1872. On the other hand, as the field notes indicate, it may not have existed within the township at that time except in the limited areas mentioned.

To be certain, there have been changes in the vegetative cover within the study area. It is the author's hope that the present day map and the reconstructed map of 1872, along with the subject material in this study, will be helpful to others who are interested in investigating changes in the vegetative pattern, and to those interested in investigating physical and cultural processes which have taken place between the two distinct time horizons of the pre-settlement era and the present decade.
FOOTNOTES


4. Vegetative types are physiognomic units based on appearance of the vegetation, with regard to the dominants in a given area. The plant species which make up the vegetative types, with the exception of some prairie types, consist of upper and lower stories. An upper story may contain ponderose pine, juniper, and mountain mahogany with an understory of bunch grass.


8. Source: (Figure 4)

9. Source: (Figure 5)


17. Miller, op. cit., p. 4.


APPENDICES
# APPENDIX I

**Species Included in Bureau of Land Management Range Survey**

<table>
<thead>
<tr>
<th>Vernacular Name</th>
<th>Botanical Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Trees</strong></td>
<td></td>
</tr>
<tr>
<td>western juniper</td>
<td>Juniperus occidentalis</td>
</tr>
<tr>
<td>western yellow pine</td>
<td>Pinus ponderosa</td>
</tr>
<tr>
<td><strong>Shrubs</strong></td>
<td></td>
</tr>
<tr>
<td>bitterbrush</td>
<td>Purshia tridentata</td>
</tr>
<tr>
<td>green manzanita</td>
<td>Arctostaphylos patula</td>
</tr>
<tr>
<td>grey rabbit brush</td>
<td>Chrysothamnus spp.</td>
</tr>
<tr>
<td>mountain mahogany</td>
<td>Cercocarpus ledifolius</td>
</tr>
<tr>
<td>big sagebrush</td>
<td>Artemisia tridentata</td>
</tr>
<tr>
<td>low sagebrush</td>
<td>Artemisia arbuscula</td>
</tr>
<tr>
<td><strong>Grasses</strong></td>
<td></td>
</tr>
<tr>
<td>big bluegrass</td>
<td>Poa ampla</td>
</tr>
<tr>
<td>cheatgrass</td>
<td>Bromus tectorum</td>
</tr>
<tr>
<td>Idaho fescue</td>
<td>Festuca idahoensis</td>
</tr>
<tr>
<td>Nevada bluegrass</td>
<td>Poa nevadensis</td>
</tr>
<tr>
<td>Sandbergs bluegrass</td>
<td>Poa secunda</td>
</tr>
<tr>
<td>squirreltail grass</td>
<td>Sitanion Hystrix</td>
</tr>
<tr>
<td>thurber needle grass</td>
<td>Stipa Thurberiana</td>
</tr>
<tr>
<td>rushes</td>
<td>Juncus spp.</td>
</tr>
<tr>
<td>sedges</td>
<td>Carex spp.</td>
</tr>
</tbody>
</table>
APPENDIX II

Species in Vegetative Types Based on Bureau of Land Management Range Survey

Dry Prairie
  low sagebrush
    Sandbergs bluegrass - squirreltail grass

  low sagebrush
    big bluegrass - squirreltail grass

  low sagebrush
    Idaho fescue - squirreltail grass

  low sagebrush
    Idaho fescue - Sandbergs bluegrass

  low sagebrush
    big bluegrass - Sandbergs bluegrass

Wet Prairie
  rushes, sedges, Nevada bluegrass

Juniper Opening
  juniper - low sagebrush
    Sandbergs bluegrass - cheatgrass

  juniper - low sagebrush
    big bluegrass - squirreltail grass

  juniper - mountain mahogany
    Sandbergs bluegrass

  juniper
    squirreltail grass - Sandbergs bluegrass

  big sagebrush - juniper
    Sandbergs bluegrass - Idaho fescue

  low sagebrush - juniper - bitterbrush
    Sandbergs blue grass
low sagebrush - juniper
cheatgrass - Sandbergs bluegrass

low sagebrush - juniper
Sandbergs bluegrass - squirreltail grass

low sagebrush - juniper
big bluegrass - Sandbergs bluegrass

low sagebrush - juniper
Idaho fescue - squirreltail grass

low sagebrush
Idaho fescue - squirreltail grass

Juniper Forest
juniper - low sagebrush
squirreltail grass - Idaho fescue

juniper - low sagebrush
big bluegrass - squirreltail grass

juniper - low sagebrush
Sandbergs bluegrass - squirreltail grass

juniper - mountain mahogany
squirreltail grass - Idaho fescue

Pine-Juniper
ponderosa pine - mountain mahogany
big bluegrass - thurber needlegrass

ponderosa pine - mountain mahogany
squirreltail grass - Idaho fescue

juniper - ponderosa pine - big sagebrush - bitterbrush
Sandbergs bluegrass - cheatgrass
<table>
<thead>
<tr>
<th>Surveyor's Name for Plants Observed</th>
<th>Author's Interpretation of Species* (Vernacular Name)</th>
<th>Botanical Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trees:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cedar</td>
<td>incense-cedar</td>
<td><em>Libocedrus decurrens</em></td>
</tr>
<tr>
<td>Cherry</td>
<td>bitter cherry</td>
<td><em>Prunus emarginata</em></td>
</tr>
<tr>
<td>Fir</td>
<td>white fir</td>
<td><em>Abies concolor</em></td>
</tr>
<tr>
<td>Juniper</td>
<td>western juniper or ponderosa pine or western yellow pine</td>
<td><em>Juniperus occidentalis</em></td>
</tr>
<tr>
<td>Pine</td>
<td>quaking asp</td>
<td><em>Pinus ponderosa</em></td>
</tr>
<tr>
<td>Quaking asp</td>
<td>quaking asp</td>
<td><em>Populus tremuloides</em></td>
</tr>
<tr>
<td>Wild plum</td>
<td>western plum</td>
<td><em>Prunus subcordata</em></td>
</tr>
<tr>
<td>Shrubs:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buckbrush</td>
<td>buckbrush</td>
<td><em>Ceanothus sanguineus</em></td>
</tr>
<tr>
<td>Greasewood</td>
<td>greasewood</td>
<td><em>Sarcobatus vermiculatus</em></td>
</tr>
<tr>
<td>Manzanita</td>
<td>green manzanita</td>
<td><em>Arctostaphylos patula</em></td>
</tr>
<tr>
<td>Mountain</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mahogany</td>
<td>mountain mahogany</td>
<td><em>Cercocarpus ledifolius</em></td>
</tr>
<tr>
<td>Sagebrush</td>
<td>big sagebrush</td>
<td><em>Artemisia tridentata</em></td>
</tr>
<tr>
<td>Grasses:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunch grass</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Idaho fescue**</td>
<td></td>
<td><em>Festuca idahoensis</em></td>
</tr>
<tr>
<td>Sandbergs bluegrass**</td>
<td></td>
<td><em>Poa secunda</em></td>
</tr>
<tr>
<td>Nevada bluegrass**</td>
<td></td>
<td><em>Poa nevadensis</em></td>
</tr>
<tr>
<td>Squirreltail grass**</td>
<td></td>
<td><em>Sitanion Hystrix</em></td>
</tr>
<tr>
<td>Henry rye and possibly Wild rye</td>
<td></td>
<td></td>
</tr>
<tr>
<td>alkali rye grass</td>
<td></td>
<td><em>Elymus triticioides</em></td>
</tr>
<tr>
<td>giant rye grass</td>
<td></td>
<td><em>Elymus condensatus</em></td>
</tr>
<tr>
<td>Macoun's rye grass</td>
<td></td>
<td><em>Elymus macounii</em></td>
</tr>
<tr>
<td>Canada rye grass</td>
<td></td>
<td><em>Elymus canadensis</em></td>
</tr>
</tbody>
</table>


**Interpretation of the bunch grasses which may have existed in 1872, is based on the existence of these species on present sites within the study area. The surveyor did not mention any species except the rye grasses.
APPENDIX IV

Author's Interpretation of Possible Vegetative Types in 1872

Dry Prairie
  bunch grass

Wet Prairie
  bunch grass, sedges, rushes

Juniper Opening and Juniper Forest
  juniper - mountain mahogany
    bunch grass
  juniper - big sagebrush
    bunch grass
  juniper - low sagebrush
    bunch grass
  juniper - greasewood
    bunch grass
  juniper - mountain mahogany
    bunch grass
  juniper - bitterbrush
    bunch grass

Pine-Juniper
  ponderosa pine - juniper - mountain mahogany
    bunch grass
  ponderosa pine - juniper - mountain mahogany - manzanita
    bunch grass
  ponderosa pine - juniper - mountain mahogany - manzanita - quaking asp - wild plum
    bunch grass
  ponderosa pine - mountain mahogany - bitterbrush
    bunch grass
  ponderosa pine - mountain mahogany
    bunch grass