Range 14 - Vegetation Change

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INTRODUCTION

Increases in sagebrush density and cover are continuous problems faced by land managers. As density and cover of sagebrush increases, associated herbaceous vegetation cover and density declines. This process is inevitable and if not checked will result in a near monoculture of woody plants. Prior to European settlement fire was the mechanism that reduced the sagebrush and permitted understory vegetation to reassert itself. Since the settlement of the sagebrush steppe, aggressive fire suppression for the protection of natural resources and man-made structures has altered the historic fire regime. Introduction of domestic livestock grazing has also helped to alter the fire regime through removal of fine fuels that help carry fire once it is ignited.

With the removal of fire, other means of sagebrush control had to be implemented. Mechanical and chemical control methods were developed to remove sagebrush from rangelands, but control is only temporary. Sagebrush will immediately begin to encroach after a control method is implemented. This establishment and increase in density of sagebrush occurs regardless of the land management strategy in the absence of natural wildfire (Sneva *et. al.* 1984, West *et. al.* 1984). This poses an interesting question. What conditions favor sagebrush establishment? In the desert southwest plant establishment occurs in pulses, often following rainfall events (El-Ghonemy *et. al.* 1979). Establishment of sagebrush has also been suggested to occur in pulses, but the results have been inconclusive (Romney *et. al.* 1980, West *et. al.* 1979).

The objective of this research was to determine the conditions that favor big sagebrush establishment and identify pulses of establishment based on climatic and plant community conditions over a 38-year period. We hypothesized that sagebrush establishment of sagebrush occurs in pulses and these pulses are related to climatic conditions.

Study Site

The study was conducted at the Northern Great Basin Experimental Range, 36 miles west of Burns, Oregon. The NGBER is jointly operated by the USDA-ARS and Oregon State University. Vegetation is typical of the northern Great Basin sagebrush steppe. Elevation of the experimental range varies from 4200' to 5500' in elevation at the top of the dormant Pleistocene volcano, the distinguishing feature of the NGBER.

Climate is semiarid with mean annual precipitation of 11.3 inches. Eighty percent of the annual precipitation falls as rain and snow between September and June. Mean January and July temperatures are 27°F and 67°F, respectively.

Big sagebrush, low sagebrush, and western juniper are the dominant woody plants across the experimental range. Bluebunch wheatgrass, Idaho fescue, Thurber's needlegrass and Sandberg's bluegrass are the most common grasses. A variety of perennial forbs can be found, including Prairie lupine, specklepod locoweed, western hawksbeard, bigseed lomatium, and Menzie's larkspur.

Soils are of volcanic origin and are classified as mollisols of aridisols. Depth to bedrock varies from 4 feet to less than 2 feet.

The study was located in Range 14 of the NGBER. Range 14 is a 40 acre pasture in the center of the Northern Great Basin Experimental Range. This pasture has a history of long-term monitoring following big sagebrush removal. When the Experimental Range was established in 1936, Range 14 was hand-cleared of all sagebrush. Then in 1952, other study investigators sprayed 2,4-D for sagebrush control. Since 1952, there has been no large-scale sagebrush removal from Range 14. The pasture has been periodically grazed, but the majority of the use has been in the summer when most of the grasses are dormant.

Past Information

Annual soil moisture information has been collected from Range 14 since 1965 (Table 1). A long-term NOAH weather station is located less than a mile from Range 14. At this station, daily maximum and minimum temperature and precipitation are recorded. Records go back to the 1940s. Periodically from 1959, sagebrush cover and density have been recorded. Herbaceous plant production has also been periodically measured. In the years that herbaceous plant production was not sampled, production was estimated using forage forecasting models developed for the experimental range.

Current Study

All Wyoming big sagebrush were harvested from five, 300 ft^2 plots located randomly throughout the pasture. Larger Wyoming big sagebrush plants were cut slightly below ground level and the ground level marked. Smaller plants were removed by shovel, roots clipped and canopies removed with clippers. Canopies were removed from the main stem. Stems were numbered and returned to the lab where they were re-cut using a carbide tip circular saw. This type of saw provided a clean, smooth surface for ring counts and measurements. Samples that were too small to cut with the circular saw were cut at the ground level mark with pruning shears. Once in the lab, sections to be measured were polished with emery cloth. Rings were counted using a binocular dissecting microscope. An in-line Vernier scale was used to measure the ring widths. Ring widths from two radii were measured and then averaged to account for the irregular shape of the stem. A ring width index was then calculated to isolate the effects of climate on growth from other factors such as, plant size, age, site productivity and density (Frauds 1976; Monserud 1986). Age was determined by counting the number of rings from the center out to the current year's growth on each radii. Date of establishment for each sagebrush was decided to be the date, (1990) minus the age of the individual. Density for each year was calculated by adding the number of plants established within a given year from the plot.

Because a large percentage of the precipitation to the experimental range falls between September and June, the climatic data was based on a crop year, September through August.

Data Analysis

All sagebrush, plant community variables, and climatic data were run through a correlation analysis (PROC CORR in SAS 1986) to find significant relationships between variables. Correlation coefficients, a measure of the relationship of variables, rarely exceeded 0.30, although many were highly significant ($p < 0.001$). These numbers indicated that there was a weak, but significant relationship between sage establishment and some climatic and plant community variables.

We then used a canonical correlation analysis (PROC CANCORR in SAS 1986). A canonical correlation is a technique to test the relationship between two sets of variables. This type of analysis is useful because many environmental variables may work together, or interact, to cause a response in the organism being studied. Most of these factors could be controlled if the study was conducted in the laboratory, but this is impossible in the field. The canonical correlation analysis will find variables within the groups that respond similarly and combine them into one variable. These new variables may contain one or many of the original variables. Once the new variables are formed they are then correlated with the new variables for the other group. We group average maximum and minimum daily temperature, monthly precipitation, total precipitation, soil moisture and herbaceous plant biomass into an environmental set of variables. The ring index, total big sagebrush density, big sagebrush seedling density and big sagebrush basal area were group into the other set of variables for canonical correlation.

Results and Discussion

Ages of sagebrush found ranged from 4 to 38 years old. The age of the oldest plant, 38 years, corresponds to the date of the last herbicide treatment. This individual may have established following the herbicide treatment. We found no plants younger than 4 years. Germination of sagebrush probably did occur in the years 1987-1990, but conditions following germination may not have been conducive to survival.

We did find two peaks in establishment (Figure 1). The first peak occurred from 1966 thru 1971. The second peak occurred from 1976 thru 1981, with a dip in establishment in 1979. Pulses in establishment are common in desert communities of the southwestern U.S. (El-Ghonemy *et.al.* 1980 Romney *et. al.* 1988, Wallace and Romney 1980). Romney and associates (1980) suggested that big sagebrush established in pulses at the Nevada Test Site. However, a study at the U. S. Sheep Experiment Station near Dubois, Idaho, found that establishment of threetip sagebrush (*Artemisia tripartita* Rydb.) did not occur in pulses (West *et. al.* 1979). They concluded that the pattern of winter precipitation common in the northern sagebrush steppe provides a more reliable source of soil moisture than the summer thunderstorm pattern in the southwest.

Results of the canonical correlation analysis indicated that 89 percent of the variation in the data could be accounted for in the first two plant community and environmental variables. The first plant community variable was represented by the calculated ring index and the second community variable was a combination of new sagebrush density and to a lesser degree actual ring width (Table 1). The greater the "r" value the stronger the relationship between the variables. Environmental variable 1 was a combination of soil moisture and maximum daily temperatures for October and April (Table 1). An increase in environmental variable 1 was caused by a increase in soil moisture and a decrease in maximum daily temperatures in October and April.

Environmental variable 2 was a combination of herbaceous plant biomass, January precipitation, November maximum daily temperature, and minimum daily temperatures for March and April (Table 1). When herbaceous plant biomass, January precipitation, and November decreased and March and April minimum daily temperatures increase, environmental variable 2 increases.

Correlation of the first community and environmental variables found that community variable 1 (dominated by ring index) was positively correlated with environmental variable 1 (r = 0.74)(Figure 2). The relationship between sagebrush and environmental variable 1 indicate that ring growth of sagebrush will be greatest in years of high soil moisture in the surface 0-8 inches and when October and April have below average daily maximum temperatures. Big sagebrush has some active leaves on its stems throughout the year. This enables it to grow very early and late in the season when the other plants have become dormant. Years with higher soil moisture and cooler October to April temperatures may enable sagebrush to use less soil moisture in the fall before plants become dormant. The cooler April conditions may also save moisture for the warmer weather in May and June.

Community variable 2 (dominated by new sagebrush density) and environmental variable 2 were also positively correlated (r = 0.68)(Figure 3). Establishment of new plants was high in years when herbaceous plant biomass and daily minimum temperatures in March and April were high. Warm spring nights and low levels of competition from herbaceous plants were obvious factors that could favor sagebrush seedling establishment. November maximum daily temperatures and January precipitation had a negative affect on establishment of new sagebrush. Cold November temperatures and greater than average January precipitation tended to reduce establishment of sagebrush. Sagebrush flowers in mid-to late summer and seeds mature on the flowering stem through the fall. Low November temperatures may damage the seeds while they are on the flowering stems thus reducing the seeds available to germinate the following spring. Greater than average precipitation is often a benefit to plants, but the majority of precipitation in January comes as snow. A study in Colorado found that mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana* (Rydb.)Beetle) seedlings under the snow were killed by a snow mold (Sturges and Nelson 1984). Looking back at Figure 1, the two periods of high sagebrush establishment occurred during periods when herbaceous plant biomass, November maximum daily temperatures and January precipitation were 1.5°F below average.

SUMMARY

Growth and establishment of big sagebrush is affected by many interacting environmental factors. Optimum conditions of any one of these factors may not be enough to benefit sagebrush growth and establishment. We found two peaks of sagebrush establishment: 1966-1971 and 1976-1982. This data indicate that the seasonality and amount of precipitation and temperature is critical to sagebrush establishment. Sagebrush establishment is inhibited by cold Novembers and heavy January snow, which promote snow mold. Establishment is enhanced by early, wet springs. The combination of all the above variables acted together to produce the positive growth and establishment. Results form this study support our initial hypothesis that sagebrush establishment occurs in pulses. We also accepted our second hypothesis, environmental factors working in concert have a larger effect on sagebrush growth and establishment than any one factor alone.

LITERATURE CITED

El-Ghonemy, A. A., A. Wallace and E. M. Romney. 1980. Frequency of numbers of perennial shrubs in the northern Mojave Desert. Great Basin Naturalist Memoirs 4:35-38.

Frauds, H. C. Tree-ring and climate. Academic Press. New York. 567p.

Monserud, R. A. 1986. Time-series analysis of tree-ring chronologies. Forest Science 32:349-372.

Romney, E. M., A. Wallace and R. B. Hunter. 1980. The role of pioneer species in revegetation of disturbed desert areas. Great Basin Naturalist Memoirs 4:31-35.

SAS. 1986. SAS/STAT Users Guide, Release 6.03. SAS Institute INC. Cary, North Carolina.

Sneva, F. A., L. R. Rittenhouse, P. T. Tueller and P. Reece. 1984. Changes in protected and grazed sagebrush-grass in Eastern Oregon, 1937-1974. Oregon State University

Agricultural Experiment Station Bulletin 663.

Sturges, D.L. and D.L. Nelson. 1984. Disease on mountain big sagebrush, p. 215-221. *In:* McArthur, E.D. and B.L. Welch (ed.), Proc. Symp. on the biology of *Artemisia* and *Chrysothamnus*.

West, N. E., K. H. Rea and R. O. Harniss 1979. Plant demographic studies in sagebrush-grass communities of southeastern Idaho. Ecology 60:37-388.

West. N. E., R. D. Provenza, P. S. Johnson and M. K. Ownes. 1984. Vegetation change after 13 years of livestock exclusion on sagebrush semidesert in west central Utah. Journal of Range Management. 37:262-264.

Table 1. Canonical Correlation variables and their correlation with community and environmental variables. "r" values close to 1 indicate a strong relationship between variables. Positive numbers indicate the variables increase and decrease together and negative numbers indicate that as one variable increase the other variable decreases. Northern Great Basin Experimental Range. 1990.

Canonical Correlation Variable	Input Variable	r value
Community 1	Ring Index	0.9250
Community 2	New Plant Density	0.8000
	Ring Width	0.6511
Environmental 1	Soil Moisture 0-8"	0.4370
	October Daily Maximum Temp	-0.4842
	April Daily Maximum Temp	-0.04355
Environmental 2	Herbaceous Plant Biomass	-0.4612
	January Precipitation	-0.5056
	March Daily Minimum Temp	0.4599
	April Daily Minimum Temp	0.4658
	November Maximum Daily Temp	-0.4442

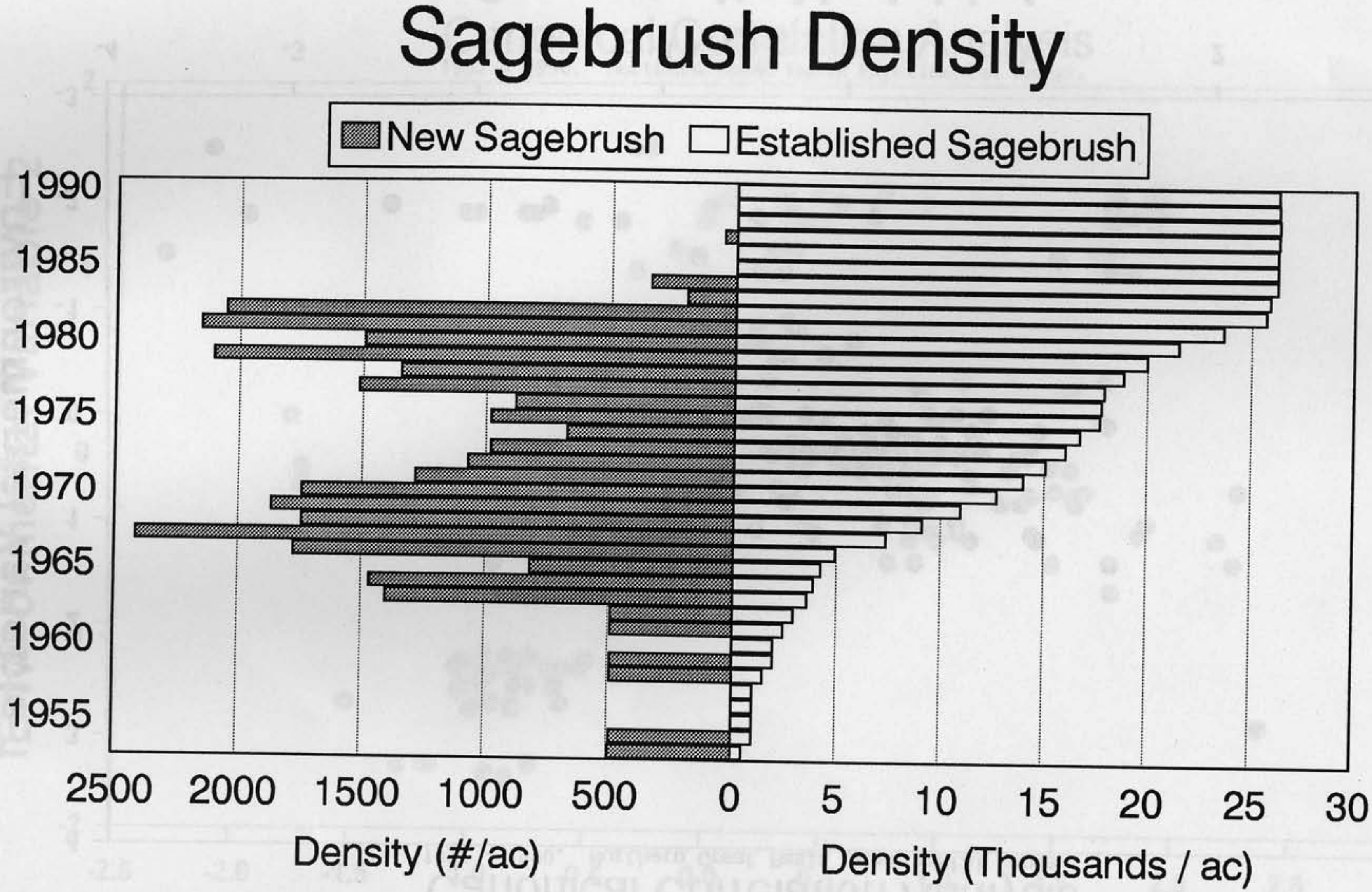

Figure 1. Density of new sagebrush seedlings and total density of all sagebrush from 1952 to 1990. Northern Great Basin Experimental Range.

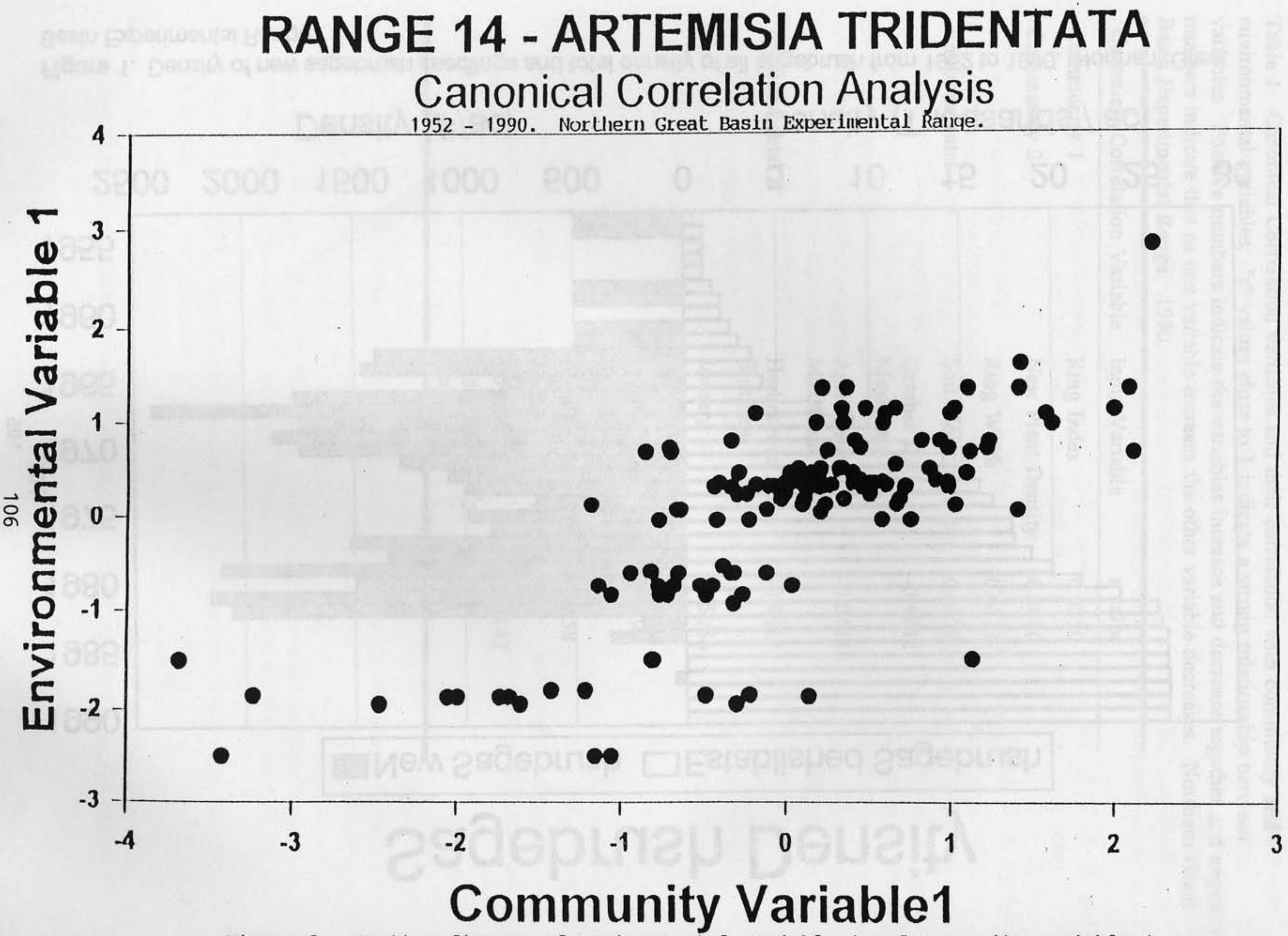

Figure 2. Scatter diagram of Environmental variable 1 and Community variable 1.

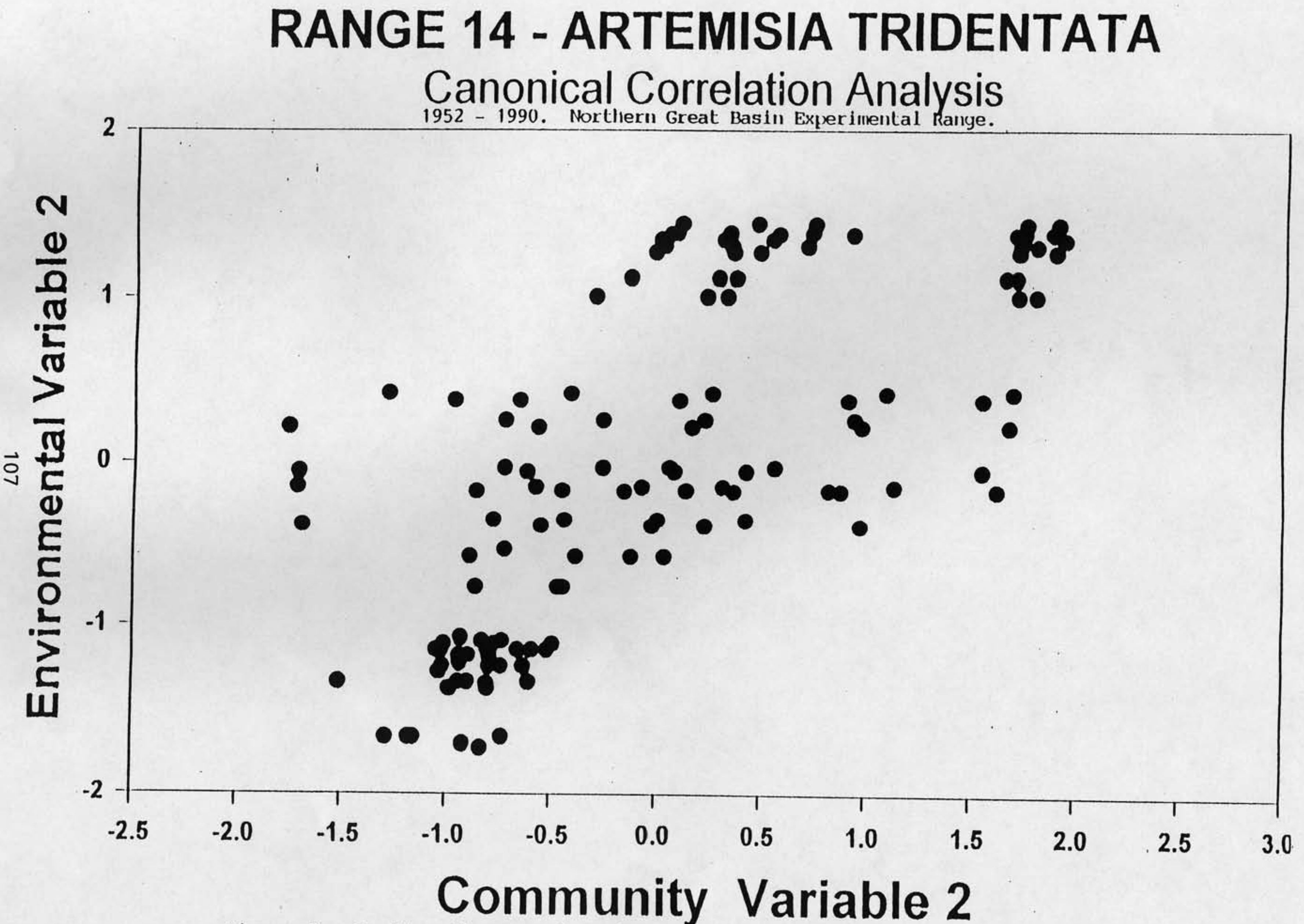

Figure 3. Scatter diagram of Environmental variable 2 and Community variable 2.