THE ROOT SYSTEM OF *ARTEMISIA TRIDENTATA* AT 9,500 FEET IN WYOMING

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Abstract. Three plants of big sagebrush (*Artemisia tridentata* Nutt.) were excavated on each of four sites at 9,500 ft elevation in northwestern Wyoming. All plants studied were characterized by a woody taproot which rapidly tapered to a diameter of 2 or 3 mm within the first 6 dm of soil and a dense well-developed system of lateral roots. About 62% of the total root length was concentrated in the upper 6 dm of the soil profile. Depth of maximum penetration varied from 12.2 to 18.3 dm, and maximum radial spread from the stem ranged from 9.1 to 15.2 dm. Root penetration and depths of concentration were slightly greater on the drier ridge and west-exposure sites as compared to the more moist valley bottom and east exposure locations. Radial root spread was greatest on plants growing on sidehill sites. The general root configuration of big sagebrush would appear to allow utilization of both surface and subsurface moisture and nutrients.

INTRODUCTION

Root characteristics of big sagebrush (*Artemisia tridentata Nutt.*) were studied in northwestern Wyoming to determine the length, depth, and configuration of the root system and to determine how these characteristics varied among four sites. The results will aid in evaluating the watershed value of this important shrub.

The root form of big sagebrush was first described by Pool (1908) as ". . . usually composed of 3 to 6 or more

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main branches which subdivide soon, thus forming a rather narrow root system." Van Dersal (1938) further described the root configuration as ". . . two-storied with shallow fibrous, and deep spreading roots . . ." Big sagebrush studied in the Tooele Valley in Utah exhibited a well-developed system of laterals in the upper soil and a deeply penetrating taproot (Kearney et al. 1914). Kearney's article contained a photograph of a big sagebrush plant exposed in an arroyo near Nephi, Utah, that had a taproot extending downwards for 15 ft.

Shantz and Zon (1924) noted that the roots of big sagebrush are well developed at the surface and extend to depths of 4 to 18 ft. Robertson (1943) indicated that the species had a well-developed system of lateral roots that tended to concentrate in the upper 15 in. of soil. Robertson (1947), as a result of other studies, concluded that big sagebrush dominates the adjacent area within a radius of roughly 1 m about the trunk. According to Goodwin (1956):

> the roots of big sagebrush are so variable that it appeared impossible to describe them with a simple term or phrase. It is apparent that the habitat in which the root develops has considerable influence upon its morphology. Two additional characteristics are noteworthy. One is the apparent ability of the root to penetrate indurate layers by slow vertical extension. The second is extensiveness, which allows the plant to draw upon a large volume of soil.

Although generalized descriptions of the root system of big sagebrush are numerous, detailed information on variation and site response is needed.

Methods

The study area, located about 15 air-miles northeast of Dubois, Wyoming, on the Shoshone National Forest, lies in the headwaters of Wayne's Creek in the drainage of the East Fork of the Wind River. Soils are of glaciofluvial origin initially derived from the Tepee Trail formation, a volcanic conglomerate.

Vegetation is composed of big sagebrush at a density of about 10,000 mature plants per acre, and an understory of grasses and forbs. Idaho fescue (*Festuca idahoensis* Elmer), the dominant grass species, accounts for about 25% of the total herbage production. Three species of bluegrass, *Poa secunda* Presl., *P. ampla* Merr., and *P. cusickii* Vasey, and two species of wheatgrass, *Agropyron subsecundum* (Link) Hitchc. and *A. dasystachyum* (Hook.) Scribn., compose the remainder of the major grasses on the study sites. Major forbs include *Lupinus sericeus* Pursh, *Geum triflorum* Pursh, and *Agoseris glauca* (Pursh) D. Dietr.

The big sagebrush community now present on the area has apparently resulted from a fire that removed most of the original forest cover. Islands of mixed lodgepole pine (*Pinus contorta* Dougl.), Engelmann spruce (*Picea engelmannii* Parry), and subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) occur throughout and appear to be invading the sagebrush grasslands that now surround them.

Four sites were selected: east- and west-facing slopes (of about 8%), a ridge top, and a valley bottom. All locations were within a 3-acre area. At each of these sites a trench was excavated approximately 1.2 m wide, 4.6 m long, and as deep as necessary to determine the maximum depth of root penetration. This work was done with a tractor-mounted backhoe. Each trench was located to represent average conditions for its respective site and was oriented so as to pass about 15 cm from the stems of at least three sagebrush plants. Excavations on the east and west slopes were aligned at right angles to contours.

The method employed was essentially that described by Weaver (1919) and was based on a study of one-half of the plant's root system. When each trench was completed and smoothed vertically in a plane flush with the root crowns, hand tools were used to remove the remaining portions of the root system from the soil. Roots smaller than about 0.1 mm in diameter were too small to be traced in the soil for distances greater than a few millimeters from the larger roots from which they originated, but these small roots generally were confined to the ends of the larger roots and appeared to comprise only a small percentage of the total length of the root system. Root and soil features were recorded by means of scale drawings and photographs as they were exposed.

In addition, ring counts were made of stem cross sections at ground level to estimate the age of each plant (Ferguson 1960). Vertical crown projection area was recorded by estimating the area bounded by the crown perimeter, and total height was measured. Descriptions of the soil profiles were made in the field and supplemented with laboratory analyses of samples obtained during the study.

Results and Discussion

Soil characteristics were very similar among the four sites. In all cases the A horizon (0-3.6 dm) had a clay-loam texture with a pH of about 5.65. Organic matter

Table I. Descriptions of big sagebrush plants excavated

Site	Plant number	Age (years)	Height (dm)	Vertical crown projection area (m^2)	Maximum root depth (dm)	Maximum radial root spread (dm)
East exposure	E1	31	6.6	0.36	16.8	13.7
	E2	25	5.8	0.36	16.8	15.2
	E3	27	5.3	0.13	15.2	15.2
West exposure	W1	30	3.8	0.10	15.9	13.7
	W2	25	4.3	0.10	15.2	15.2
	W3	32	4.6	0.51	18.3	10.7
Ridge	R1	21	3.6	0.15	18.3	12.2
	R2	27	5.3	0.18	18.3	9.1
	R3	21	3.8	0.05	18.3	10.7
Bottom	B1	56	8.4	1.35	16.8	10.7
	B2	28	6.4	0.13	15.2	12.2
	B3	26	6.4	0.64	12.2	9.1

ture plane, roots characteristically ended in a fan-shaped arrangement. Similar observations were made by Goodwin (1956).

All plants studied were characterized by a woody taproot that tapered to a diameter of 2 or 3 mm within the upper 6 dm of soil. The fine portion of the taproot continued downward, and in all cases accounted for the maximum depth of penetration. Extensive lateral root development originated from the thicker portion of the taproot; about 62% of the total root length was concentrated in the upper 6 dm of soil. An exceptionally heavy concentration of short, fine roots occupied the surface 1.5 dm of soil under the crown. The laterals that originated from the upper 3.0 dm of taproot achieved maximum horizontal spread. The overall root configuration of big sagebrush would appear to allow utilization of both surface and subsurface moisture and nutrients.

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