Autecology of Silver Sagebrush on the Northern Mixed Grass Prairie

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The autecology of Silver Sagebrush, *Artemisia cana*, is one of the prairie plant species included in a long ecological study conducted at the NDSU Dickinson Research Extension Center during 67 growing seasons from 1946 to 2012 that quantitatively describes the changes in growth and development during the annual growing season life history and the changes in abundance through time as affected by management treatments for the intended purpose of the development and establishment of scientific standards for proper management of native rangelands of the Northern Plains. The introduction to this study can be found in report DREC 16-1093 (Manske 2016).

Plains silver sagebrush, *Artemisia cana* Pursh, is a member of the aster (sunflower) family, Asteraceae, and is a native, long lived perennial, late deciduous with a few leaves remaining through winter, warm season shrub that is flood tolerant. Aerial growth has several decumbent to ascending twisted stems arising from a large stem base; stems have numerous twisted branches forming an irregular rounded crown 1.3-3.3 feet (0.4-1 m) tall, and with a diameter about the same size. Current years twigs and leaves are tomentose, covered with dense white hairs that have a silvery reflectance in sunlight. The root system has a deep taproot that can descend to 7-10 feet (2-4 m) deep, and has extensive lateral roots. Stout shallow rhizomes extend outward to 3.4 feet (1 m) from the stem base; the rhizomes have numerous buds with the potential to produce about 52 sprouts. Regeneration is by vegetative and sexual reproduction. Vegetative growth is sprouts from vertical stem bases and from horizontal rhizomes. A rhizome network interconnects the stem bases; aggressive development can form large clonal colonies. Segments of decumbent stems that touch soil can develop adventitious roots followed by the development of aerial sprouts that can result in a greatly enlarged colony. Sexual reproduction is from numerous small inconspicuous yellowish flowers clustered on small heads that emerge during August-September. The plants strong odor sometimes reaches irritating levels. Outcross pollination is by wind. The fruit is single seeded; the seed is a small achene that is dispersed by wind and can be transported great distances along with drifting snow. Plants produce large quantities of seed that have high germination rates, however, seedling establishment and survival are low. Fire, mowing, and browsing damage the aerial stems that removes the hormone controlled apical dominance and causes activation of sprout growth from buds on the stem bases, rhizomes, and roots. This summary information on growth development and regeneration of plains silver sagebrush was based on the works of Stevens 1963, Great Plains Flora Association 1986, Mozingo 1987, Howard 2002, Manske 2006b, Johnson and Larson 2007, Stubbendieck et al. 2011, and Shultz 2012.

Procedures

The 1969-1971 Study

The range of flowering time of Silver sagebrush was determined by recording daily observations of plants at anthesis on several prairie habitat type collection locations distributed throughout 4,569 square miles of southwestern North Dakota. The daily observed flowering plant data collected during the growing seasons of 1969 to 1971 from April to August were reported as flower sample periods with 7 to 8 day duration in Zaczkowski 1972.

The 1983-2004 Study

A long-term study on the effects of tebuthiuron (Spike 20P) on silver sagebrush growing on badlands loamy overflow ecological site was conducted during 1983 to 2004 (22 years) (Manske 2006). Each plant on all treatment plots was permanently identified with an unique numbered tag. Silver sagebrush plants were evaluated for changes in density, canopy cover, and live and dead dimensions in height and crown diameter in two directions. Twigs and branches of silver sagebrush die first at the outer layer and move towards the center. Two sets of measurements were collected for the height and crown diameters for each plant. One set of measurements included both the live and dead branches, and the other set included only live branches; the differences between the two sets of measurements equaled the length of the dead branches. The elliptical crown area per square meter of ground was determined from the N-S and E-W diameter measurements, and the crown volume per cubic meter was determined from the crown area and height measurements for both the live and dead branches. Canopy cover was determined from the percentage of mean crown area covering a square meter of ground. The data collected during 1983

consisted of only mature plant measurements and the data collected during 2004 consisted of measurements from three distinctly different growth types: 1) mature plants, 2) vegetative sucker spouts that developed from surviving belowground stem bases and horizontal rhizomes, and 3) young seedling plants. Only the data from the four replicated plots of the control treatments were used to describe the changes in growth and development through time. The large plot size was 61.33 m^2 (660 ft^2).

Results

Silver sagebrush resumed growth during early spring as numerous stems from buds on several twisted aerial woody branches growing from a large woody stem base attached to stout woody rhizomes. Silver sagebrush grows best in soils developed from alluvial deposits on floodplain terraces along streams and it can grow in soils developed from sedimentary deposits in the unglaciated regions of the Northern Plains. Silver sagebrush is not known to grow in soils that developed from glacial till, however, it occasionally can be found to grow in glaciated regions of the Northern Plains in areas where the overlaying glacial till has been eroded away exposing the underlaying sedimentary deposits (Stevens 1950, Cosby 1964). Silver sagebrush is tolerant of alkali conditions (Johnson and Larson 2007).

White and Currie (1984) described the annual growing season phenological development of silver sage in eastern Montana by evaluation of morphological characteristics of fifteen plants growing at three locations that had different degrees of silver sagebrush infestation with data collected biweekly during early April to late October 1981. Their results (table 1) show that buds swell in early April, leaf expansion occurs during late April and May, rapid twig growth occurs from mid May to late June, floral development occurs during mid to late July and August, flowering (anthesis) occurs during August and September, and seed development occurs during mid to late September and October. Seed dispersal is by wind during late fall and winter.

The flowering period occurred from late August through early September during the 1969-1971 study (table 2) (Zaczkowski 1972). The normal height can grow to 1.3-3.3 feet (0.4-1 m) tall and the irregular elliptical crown diameter can develop to about the same size (Great Plains Flora Association 1986, Mozingo 1987).

Changes in plant size and growth type during the 22 year period 1983 to 2004 are summarized on table 3. Six tebuthiuron treatments, three rates at two concentrations, were evaluated against no treatment controls. After four years, 96.7% of the aboveground crowns were dead on the treated plants. Tebuthiuron affects the photosynthetic processes in the leaves, reducing the production of carbohydrates and causing leaves to be shed. This action causes a drawdown of the nonstructural carbohydrate reserves and when the stores are depleted, the plant dies. The nonstructural carbohydrate reserves of silver sagebrush plants were not totally depleted after four years of drawdown from one application of the herbicide permitting the belowground parts to survive on 16.3% of the treated plants. Some of the shed leaves from the treated plants contained small amounts of chemical and were moved to the control plots. Absorption of the herbicide by the control plants caused total or partial death of the aboveground crowns in 68.7% of the plants. The chemical action of the herbicide treatment stopped sometime during 6 to 8 years after application. Silver sagebrush can reproduce vegetatively from buds located on surviving aerial branches, from buds located belowground on surviving vertical stem bases and on horizontal rhizomes and can reproduce from seed.

In 1983 (table 3), the mature plants had a density of 1.13 plants/m^2 (69.3 Plants/Plot) with 91.7% of the aboveground plant stems living, they had a height of 76.5 cm, a N-S diameter of 64.3 cm, an E-W diameter of 62.6 cm, with a crown area or canopy cover of 35.3% plus a dead crown area that covered 2.9% of the ground. After 22 years, in 2004 (table 3), the surviving mature plants with vegetative growth from aerial branches had a density of 0.38 plants/m^2 (23.3 Plants/Plot), with 83.8% of the aboveground stems alive, they had a height of 85.2 cm, a N-S diameter of 92.8 cm, an E-W diameter of 88.7 cm, with a crown area or canopy cover of 21.1% plus a dead crown area that covered 3.3% of the ground. The surviving stem bases and rhizomes produced sucker sprouts that had a density of 0.25 suckers/m^2 (15.3 Plants/Plot), with 97.1% living stems, they had a height of 70.2 cm, a N-S diameter of 68.4 cm, an E-W diameter of 63.5 cm, with a crown area or canopy cover of 8.6% plus a dead crown area of 2.7%. Several seedlings had developed that had a density of 0.17 seedlings/m^2 (10.4 Plants/Plot), with 100.0% living stems, they had a height of 45.9 cm, a N-S diameter of 41.5 cm, an E-W diameter of 39.9 cm, with a crown area that covered 1.5% of the ground. In 2004, the combined silver sagebrush growth consisted of surviving mature plants, sucker sprouts, and seedlings that had a density of 0.80 plants/m^2 (49.1 Plants/Plot), with 86.6% of the aboveground stems alive, they had a mean height of 54.9 cm, a mean N-S diameter of 54.6 cm, a mean E-W diameter of 50.6 cm, with a crown area that covered a mean 31.1% plus a dead crown area that covered 3.6% of the ground. The recovered silver sagebrush plants had regained 70.8% of the

previous plant density and 88.3% of the canopy cover on the control treatments in 22 years after shed leaves with small quantities of the herbicide tebuthiuron had moved from treated plots.

Silver sagebrush is a difficult plant to kill. It has a deep taproot and an extensive system of lateral roots that can store huge quantities of nonstructural carbohydrates. Killing the top growth with fire, mowing, or foliar application of herbicides activates vegetative growth processes that, in time, replace the removed aboveground stems and branches. Tebuthiuron (Spike 20P) applied at 0.50 lb ai/ac with a second application of 0.25 lb ai/ac in about 6 years after the first can deplete silver sagebrush of its large stores of carbohydrates and actually kill the plant. Rates of 0.80 lb ai/ac kill the grass, more herbicide does not give a faster kill time and is not better for the ecosystem.

Discussion

Silver sagebrush, *Artemisia cana*, is a shrub that is widely distributed throughout most of west central North America. Its growth is generally limited to soils developed from alluvial deposits on floodplain terraces along streams and to soils developed from sedimentary deposits. It is tolerant of alkali conditions. Each year silver sagebrush resumes aerial stem growth from buds on twisted aerial woody branches. If portions of the aerial woody branches have been broken off through livestock or wildlife activity, vegetative sucker sprouts can develop from stem bases and rhizomes. Vegetative growth in height continues during April, May, June, and July. Flower buds appear from mid July to August. Flowers appear during August and September. Seeds develop during September and October. Seed dispersal occurs during late fall and winter. Normal height can grow to about 1 m (39.4 in). Mature stem height averaged 76.5 cm (30.1 in) in 1983 and averaged 85.2 cm (33.5 in) in 2004. Stems growing in the loamy overflow ecological site were shorter than the normal height of 100 cm (39.4 in) because the soils of the study plots had quantities of mineral nitrogen available at much less than the threshold quantity of 100 lbs/ac which resulted from the detrimental effects caused by the deferred grazing management practices on the biogeochemcial processes of the prairie plant community.

Silver sagebrush was variously affected by ecosystem type, and growth and development were negetively affected by traditional management practices. Silver sagebrush has several mechanisms that it can use for recovery from numerous types of reduction treatments.

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Table 1. Phenological development of Artemisia cana, Silver sagebrush.

Phenological Stages	Time Period
Bud Swell	early April
Leaf Expansion	late April to May
Rapid Twig Growth	mid May to late June
Floral Development	mid to late July and August
Flowering (Anthesis)	August and September
Seed Dvelopment	mid to late September and October
Seed Dispersal	late fall and winter

Data from White and Currie 1984.

Table 2. Flower period of Artemisia cana, Plains silver sagebrush.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period 1969-1971					X	X

Flower Period Data from Zaczkowski 1972.

Table 3. Silver sagebrush, Artemisia cana, plant dimensions of elliptical crown for live and dead branches and changes in dimensions after 22 years in southwestern North Dakota, 1983 and 2004.

Live and Dead Dimensions		1983	2004	2004	2004	2004
		Mature Shrubs	Surviving Mature Shrubs	Vegetative Sucker Sprouts	Seedlings	Total Plant Population
Plant Density	#/m^2	1.13	0.38	0.25	0.17	0.80
Canopy Cover	%	35.25	21.07	8.59	1.46	31.12
Live	%	91.69	83.80	97.10	100.00	86.62
Height	cm	76.46	85.19	70.24	45.85	54.94
N-S Diameter	cm	64.31	92.75	68.42	41.49	54.64
E-W Diameter	cm	62.57	88.67	63.46	39.85	50.62
Crown Area	cm^2/m^2	3,524.88	2,106.77	859.27	145.53	3,111.57
Crown Volume	cm^3/m^3	271,062.76	186,725.43	48,439.00	7,929.54	243,093.95
Dead	%	8.31	16.20	2.90	0.00	13.38
Height	cm	0.69	7.18	26.00	0.00	3.60
N-S Diameter	cm	2.84	6.34	19.93	0.00	3.86
E-W Diameter	cm	2.16	11.62	12.35	0.00	4.48
Crown Area	cm^2/m^2	287.36	330.09	27.46	0.00	357.55
Crown Volume	cm^3/m^3	24,554.35	36,088.51	1,446.38	0.00	37,534.89

Data of Control Plants from Manske 2006.

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