# Autecology of Creeping Juniper on the Northern Mixed Grass Prairie

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The autecology of Creeping Juniper, *Juniperus horizontalis*, 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).

Creeping juniper, *Juniperus horizontalis* Moench., is a member of the cypress family, Cupressaceae, and is a native, long lived perennial (to 140 years), slow growing, evergreen, gymnosperm shrub. Aerial growth has numerous prostrate stems with long, trailing or creeping branches forming mats 10-20 feet (3-5 m) across with several short erect stems less than 10 inches (30 cm) tall. The root system is shallow with several major and minor roots from the prostrate stems that are mostly 5-14 inches (13-35 cm) deep. Most ecotypes have a large treesized taproot at the center of the plant; a few ecotypes are without a main taproot. Regeneration is by weak vegetative and sexual reproduction. Vegetative growth is from prostrate stems that touch soil and develop adventitious roots and then develop aerial stems resulting in the ability of plant parts to survive separated from the main plant and to expand the colony. Sexual reproduction is from male and female strobili (cones) that are mostly dioecious and grow on different plants, develop during May to June, and are pollinated by wind. The fleshy female berrylike cones mature during the second growing season in August to September. Seed production is usually poor, seed germination rate is very low, and seedling survival is rare. Fire usually consumes the entire plant including the large taproot because the resinous foliage is highly combustible. Some partially unburned plants could survive after a low severity fire. This summary information on growth development and regeneration of creeping juniper was based on the works of Stevens 1963, Great Plains Flora Association 1986, Gucker 2006, and Larson and Johnson 2007.

**Procedures**

**The 1983-2012 Study**

A long-term study on change in abundance of Creeping Juniper was conducted during active plant growth of July and August each growing season of 1983 to 2012 (30 years) on native rangeland pastures at the Dickinson Research Extension Center ranch located near Manning, North Dakota. Effects from three management treatments were evaluated: 1) long-term nongrazing, 2) traditional seasonlong grazing, and 3) twice-over rotation grazing. Each treatment had two replications, each with data collection sites on sandy, shallow, and silty ecological sites. Each ecological site of the two grazed treatments had matching paired plots, one grazed and the other with an ungrazed exclosure. The sandy, shallow, and silty ecological sites were each replicated two times on the nongrazed treatment, three times on the seasonlong treatment, and six times on the twice-over treatment.

During the initial phase of this study, 1983 to 1986, the long-term nongrazed and seasonlong treatments were at different locations and moved to the permanent study locations in 1987. The data collected on those two treatments during 1983 to 1986 were not included in this report.

Abundance of Creeping Juniper was determined with plant species stem density by 0.1 $m^2$ frame density method and with plant species basal cover by the ten-pin point frame method (Cook and Stubbendieck 1986).

The stem density method was used to count individual stems of each plant species rooted inside twenty five 0.1 $m^2$ quadrats placed along permanent transect lines at each sample site both inside (ungrazed) and outside (grazed) each exclosure. Stem density per 0.1 $m^2$ quadrat, relative stem density, percent frequency, relative percent frequency, and importance value were determined from the stem density data. Plant species stem density data collection was 1984, 1986 to 2012 on the twice-over treatment and was 1987 to 2012 on the long-term nongrazed and seasonlong treatments. However, stem density data was not collected during 1991, 1993 to 1997 on the sandy, shallow, and silty

ecological sites of all three management treatments, stem density data was not collected during 1992 on the sandy ecological site of all three management treatments, and stem density data was not collected during 1999 on the sandy and silty ecological sites of the long-term nongrazed treatment.

The point frame method was used to collect data at 2000 points along permanent transect lines at each sample site both inside (ungrazed) and outside (grazed) each exclosure. Basal cover, relative basal cover, percent frequency, relative percent frequency, and importance value were determined from the ten-pin point frame data. Point frame data collection period was 1983 to 2012 on the twice-over treatment and was 1987 to 2012 on the long-term nongrazed and seasonlong treatments. However, point frame data was not collected during 1992 on the sandy ecological sites of all three treatments.

During some growing seasons, the point frame method or the stem density method did not document the presence of a particular plant species which will be reflected in the data summary tables as an 0.00 or as a blank spot.

The 1983-2012 study attempted to quantify the increasing or decreasing changes in individual plant species abundance during 30 growing seasons by comparing differences in the importance values of individual species during multiple year periods. Importance value is an old technique that combines relative density or relative basal cover with relative frequency producing a scale of 0 to 200 that ranks individual species abundance within a plant community relative to the individual abundance of the other species in that community during a growing season. Density importance value ranks the forbs and shrubs and basal cover importance value ranks the grasses, upland sedges, forbs, and shrubs in a community. The quantity of change in the importance values of an individual species across time indicates the magnitude of the increases or decreases in abundance of that species relative to the changes in abundance of the other species.

**Results**

Creeping Juniper resumed growth during early April. Terminal twig ends of the prostrate branches grow slowly all growing season until late September or early October and usually increase total twig length less than 3.8 cm (1.5 in). These branches have the potential to grow 1.1 m (45 in) over a 30 year period. Gymnosperms do not have flowers, they reproduce sexually by strobili. Male cones start development on male shrubs at the same time as twigs resumed growth. Pollen from the male cones is released after 2 to 3 weeks and moved by the wind. Green fleshy berrylike female cones appear 1 to 2 weeks later on female shrubs. The female cones turn blue or purple in mid November and fully mature during late summer of the second growing season (Miller 1978). Seedling establishment is extremely rare. Most “new” plants develop by rooting of disconnected branches from mature shrubs.

Plant species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. Relative stem abundance of creeping juniper, as measured by density and basal cover importance values, was low and documented only on the shallow sites of the twice-over treatment. All of the plants were rooted in multiple ungrazed exclosures with some branches spreading into the grazed areas. The mean density and basal cover importance values were low at 1.37 and 1.76 on the ungrazed shallow sites and were lower at 0.17 and 0.67 on the grazed shallow sites of the twice-over treatment, respectively. The importance values were greater on the ungrazed site than that on the grazed site and the basal cover importance values were greater than the density importance values (tables 1 and 2).

On the shallow sites of the twice-over treatment, Creeping juniper was present on the ungrazed sites during 50.0% and 56.7% of the years that density and basal cover data were collected, with a mean 0.31 stems/$m^2$ density and a mean 0.28% basal cover, respectively. Creeping Juniper stems were present on the grazed sites during 9.1% and 6.7% of the years that density and basal cover date were collected, with a mean 0.036 stems/$m^2$ density and a mean 0.30% basal cover, respectively. Creeping juniper was present on the ungrazed sites during 30.0% and 50.0% of the early years (1983-1993), with a mean 0.23 stems/$m^2$ density and a mean 0.19% basal cover, and was present during 53.3% and 80.0% of the later years (1998-2012), with a mean 0.35 stems/$m^2$ density and a mean 0.43% basal cover, respectively. Creeping juniper was present on the grazed sites during 10.0% and 20.0% of the early years, with a mean 0.04 stems/$m^2$ density and a mean 0.91% basal cover, and was present during 6.7% and 0.0% of the later years, with a mean 0.027 stems/$m^2$ density, respectively (tables 1 and 2).

The creeping juniper branches that had spread into the grazed area during the early years were reduced by water deficiency during the low precipitation period of 1988 to 1992. The branches had not reexpanded back into the grazed areas for sixteen years between 1989 and 2006. During the 1983-2012 study, creeping juniper branches decreased a mean 0.32 stems/$m^2$ density and decreased a mean 0.91% basal cover from the early years to the later years on the grazed shallow sites of

the twice-over treatment.

The creeping juniper branches on the ungrazed site maintained the same stem density before and after the drought year, 1988. These branches on the ungrazed site were physically closer to the mean taproot and did not experience a density decrease as a result of the low precipitation period during the early years (1983-1993). During the 1983-2012 study, creeping juniper branches increased a mean 0.12 stems/$m^2$ density from a mean 0.23 stems/$m^2$ density during the early years to a mean 0.35% stems/$m^2$ density during the later years, and increased 0.24% basal cover from a mean 0.19% basal cover during the early years to a mean 0.43% basal cover during the later years on the ungrazed shallow sites of the twice-over treatment. Even though creeping juniper is known to grow slow, these changes in stem density and basal cover are minute in relation to its potential growth capability. Creeping juniper growth was greatly restricted on the ungrazed shallow sites and growth was prohibited on the grazed shallow sites of the twice-over treatment.

Creeping juniper has long been believed to increase under traditional grazing management practices (Butler 1983, Gucker 2006). However, the traditional seasonlong treatment of the 1983-2012 study did not cause an increase in creeping juniper abundance; nor did the twice-over grazing treatment and the long-term nongrazed treatment.

**Discussion**

Creeping juniper, *Juniperus horizontalis*, is a native, mat-forming, evergreen prostrate gymnosperm shrub that has numerous horizontal branches capable of 10 to 20 foot (3-6 m) lengths with a multitude of short erect stems 4 to 10 inches (10 to 25 cm) tall. Creeping juniper has a high frost resistance and tolerant of drought and cold, however, it has low shade tolerance (Gucker 2006), it is extremely sensitive to competition, and is usually consumed by fire (Curtis 1959) because of the highly combustible resinous foliage. Creeping juniper is dioecious with separate male and female shrubs that are slow growing, long lived plants that have poor seed production, low germination rates, high seedling mortality, and rare seedling establishment (Gucker 2006). Branch segments broken from mature plants can root and develop into separate plants.

Creeping juniper grows in Wisconsin in cedar glades which are eastern red cedar savanna communities on steep hillsides of thin loess over limestone, or of gravelly glacial moraine with a major species component of common juniper, little bluestem, hairy grama, and sand dropseed, and also grows in upper lake dune communities with no true soil but not directly affected by wave action with a major species component of common juniper, sandbar willow, northern wheatgrass, intermediate wheatgrass, prairie sandreed, and canada wildrye (Curtis 1959).

Creeping juniper grows in North Dakota Badlands in little bluestem communities on steep upland slopes with very shallow soils containing exposed scoria outcrops with a major species component of shrubby cinquefoil, skunkbush, woods rose, plains muhly, and threadleaf sedge (Hirsch 1985).

Creeping juniper can grow in deep sands, sandy, sandy loam, loamy, silty, and clay loam soils that are also described as poorly developed or shallow (Curtis 1959, Hirsch 1985, Gucker 2006) and in open communities with low plant density and little interspecies competition (Curtis 1959, Hirsch 1985).

The sandy, shallow, and silty ecological sites of the 1983-2012 study had well developed soils; the shallow soils were well developed sandy loam that were relatively thin. The plant communities were dense with grass tillers of normal height and with very little open spaces and almost no bare ground. These study sites have very different characteristics from the described plant communities where creeping juniper prefers to grow. The well developed soils of the study ecological sites permitted a healthy grass population to flourish. The tall dense grass tillers caused shading and strong aboveground competition for sunlight. The healthy grass root systems caused strong resource uptake competition for belowground nutrients and soil water. Such debilitating conditions would cause severe stresses on creeping juniper plants resulting in little resources for survival and fewer available resources for new growth. The creeping juniper plants were able to exist but unable to produce substantial new growth.

Acknowledgment

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| Table 1. Autecology of Juniperus horizontalis, Creeping juniper, with growing season changes in density importance value, 1983-2012. | | | | | |
|---|---|---|---|---|---|
| Ecological Site Year Period | Nongrazed | Seasonlong | | Twice-over | |
| | | Ungrazed | Grazed | Ungrazed | Grazed |
| Sandy | | | | | |
| 1983-1987 | Few Plants Present | | | | |
| 1988-1992 | | | | | |
| 1993-1998 | | | | | |
| 1999-2003 | | | | | |
| 2004-2009 | | | | | |
| 2010-2012 | | | | | |
| Shallow | | | | | |
| 1983-1987 | 0.00 | 0.00 | 0.00 | 0.48 | 0.55 |
| 1988-1992 | 0.00 | 0.00 | 0.00 | 2.78 | 0.00 |
| 1993-1998 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1999-2003 | 0.00 | 0.00 | 0.00 | 1.41 | 0.00 |
| 2004-2009 | 0.00 | 0.00 | 0.00 | 1.00 | 0.35 |
| 2010-2012 | 0.00 | 0.00 | 0.00 | 1.55 | 0.00 |
| Silty | | | | | |
| 1983-1987 | Few Plants Present | | | | |
| 1988-1992 | | | | | |
| 1993-1998 | | | | | |
| 1999-2003 | | | | | |
| 2004-2009 | | | | | |
| 2010-2012 | | | | | |

| Table 2. Autecology of Juniperus horizontalis, Creeping juniper, with growing season changes in basal cover importance value, 1983-2012. | | | | | |
|---|---|---|---|---|---|
| Ecological Site Year Period | Nongrazed | Seasonlong | | Twice-over | |
| | | Ungrazed | Grazed | Ungrazed | Grazed |
| Sandy | | | | | |
| 1983-1987 | Few Plants Present | | | | |
| 1988-1992 | | | | | |
| 1993-1998 | | | | | |
| 1999-2003 | | | | | |
| 2004-2009 | | | | | |
| 2010-2012 | | | | | |
| Shallow | | | | | |
| 1983-1987 | 0.00 | 0.00 | 0.00 | 1.32 | 3.62 |
| 1988-1992 | 0.00 | 0.00 | 0.00 | 1.07 | 0.42 |
| 1993-1998 | 0.00 | 0.00 | 0.00 | 0.72 | 0.00 |
| 1999-2003 | 0.00 | 0.00 | 0.00 | 2.48 | 0.00 |
| 2004-2009 | 0.00 | 0.00 | 0.00 | 3.02 | 0.00 |
| 2010-2012 | 0.00 | 0.00 | 0.00 | 2.44 | 0.00 |
| Silty | | | | | |
| 1983-1987 | Few Plants Present | | | | |
| 1988-1992 | | | | | |
| 1993-1998 | | | | | |
| 1999-2003 | | | | | |
| 2004-2009 | | | | | |
| 2010-2012 | | | | | |

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# Appendix
# Autecology Data
# of Creeping Juniper

| Table 1. | Density analysis for native range on the twice-over rotation grazing system at the Dickinson Research Extension Center. | | | | | | |
|---|---|---|---|---|---|---|---|
| System: | West/East | | | | | | |
| Pasture: | NR-1-6 | | | | Relative | | |
| Site: | Shallow, ungrazed | | Relative | Percent | Percent | Importance | |
| Species: | Juniperus horizontalis | Density | Density | Frequency | Frequency | Value | |
| | | | | | | | |
| | | | | | | | |
| 1983 | | No Densities Collected | | | | | |
| 1984 | | | | | | | |
| 1985 | | No Densities Collected | | | | | |
| 1986 | | 0.04 | 0.52 | 4.00 | 0.92 | 1.44 | |
| 1987 | | | | | | | |
| 1988 | | 0.08 | 4.88 | 4.00 | 2.78 | 7.66 | |
| 1989 | | 0.04 | 1.11 | 4.00 | 2.33 | 3.44 | |
| 1990 | | | | | | | |
| 1991 | | No Densities Collected | | | | | |
| 1992 | | | | | | | |
| 1993 | | No Densities Collected | | | | | |
| 1994 | | No Densities Collected | | | | | |
| 1995 | | No Densities Collected | | | | | |
| 1996 | | No Densities Collected | | | | | |
| 1997 | | No Densities Collected | | | | | |
| 1998 | | | | | | | |
| 1999 | | 0.08 | 0.85 | 4.00 | 1.19 | 2.04 | |
| 2000 | | | | | | | |
| 2001 | | | | | | | |
| 2002 | | 0.08 | 1.03 | 4.00 | 1.20 | 2.24 | |
| 2003 | | 0.12 | 1.49 | 4.00 | 1.27 | 2.76 | |
| 2004 | | | | | | | |
| 2005 | | | | | | | |
| 2006 | | | | | | | |
| 2007 | | 0.08 | 0.62 | 4.00 | 1.35 | 1.97 | |
| 2008 | | 0.04 | 0.57 | 4.00 | 1.92 | 2.49 | |
| 2009 | | 0.04 | 0.40 | 4.00 | 1.11 | 1.51 | |
| 2010 | | 0.04 | 0.84 | 4.00 | 1.96 | 2.80 | |
| 2011 | | 0.04 | 0.51 | 4.00 | 1.35 | 1.86 | |
| 2012 | | | | | | | |
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| Table 2. | Density analysis for native range on the twice-over rotation grazing system at the Dickinson Research Extension Center. | | | | | | |
|---|---|---|---|---|---|---|---|
| System: | West/East | | | | | | |
| Pasture: | NR-1-6 | | | | Relative | | |
| Site: | Shallow, grazed | | Relative | Percent | Percent | Importance | |
| Species: | Juniperus horizontalis | Density | Density | Frequency | Frequency | Value | |
| | | | | | | | |
| | | | | | | | |
| 1983 | | No Densities Collected | | | | | |
| 1984 | | | | | | | |
| 1985 | | No Densities Collected | | | | | |
| 1986 | | 0.04 | 0.60 | 4.00 | 1.05 | 1.66 | |
| 1987 | | | | | | | |
| 1988 | | | | | | | |
| 1989 | | | | | | | |
| 1990 | | | | | | | |
| 1991 | | No Densities Collected | | | | | |
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| 1993 | | No Densities Collected | | | | | |
| 1994 | | No Densities Collected | | | | | |
| 1995 | | No Densities Collected | | | | | |
| 1996 | | No Densities Collected | | | | | |
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| 2004 | | | | | | | |
| 2005 | | | | | | | |
| 2006 | | 0.04 | 0.58 | 4.00 | 1.54 | 2.12 | |
| 2007 | | | | | | | |
| 2008 | | | | | | | |
| 2009 | | | | | | | |
| 2010 | | | | | | | |
| 2011 | | | | | | | |
| 2012 | | | | | | | |
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| Table 3. | Points analysis for native range on the twice-over rotation grazing system at the Dickinson Research Extension Center. | | | | | |
|---|---|---|---|---|---|---|
| System: | West/East | | | | | |
| Pasture: | NR-1-6 | | Relative | | Relative | |
| Site: | Shallow, ungrazed | Basal | Basal | Percent | Percent | Importance |
| Species: | Juniperus horizontalis | Cover | Cover | Frequency | Frequency | Value |
| | | | | | | |
| | | | | | | |
| 1983 | | | | | | |
| 1984 | | | | | | |
| 1985 | | | | | | |
| 1986 | | 0.70 | 2.62 | 4.00 | 1.90 | 4.52 |
| 1987 | | 0.10 | 0.29 | 1.00 | 0.45 | 0.74 |
| 1988 | | | | | | |
| 1989 | | | | | | |
| 1990 | | | | | | |
| 1991 | | 0.50 | 1.91 | 3.00 | 1.44 | 3.35 |
| 1992 | | 0.20 | 0.87 | 2.00 | 1.13 | 2.00 |
| 1993 | | 0.40 | 0.89 | 2.00 | 0.85 | 1.75 |
| 1994 | | | | | | |
| 1995 | | | | | | |
| 1996 | | | | | | |
| 1997 | | | | | | |
| 1998 | | 0.30 | 1.83 | 1.00 | 0.75 | 2.58 |
| 1999 | | 0.30 | 0.93 | 1.50 | 0.63 | 1.56 |
| 2000 | | 0.45 | 1.80 | 1.00 | 0.57 | 2.37 |
| 2001 | | 0.90 | 3.44 | 2.00 | 1.02 | 4.46 |
| 2002 | | 0.40 | 1.37 | 2.00 | 0.89 | 2.26 |
| 2003 | | 0.30 | 1.06 | 1.50 | 0.71 | 1.77 |
| 2004 | | 1.15 | 3.84 | 4.00 | 1.78 | 5.62 |
| 2005 | | | | | | |
| 2006 | | 0.10 | 0.47 | 1.00 | 0.59 | 1.06 |
| 2007 | | 1.70 | 7.16 | 6.00 | 3.66 | 10.82 |
| 2008 | | 0.05 | 0.29 | 0.50 | 0.34 | 0.63 |
| 2009 | | | | | | |
| 2010 | | 0.75 | 3.84 | 4.50 | 3.02 | 6.86 |
| 2011 | | | | | | |
| 2012 | | 0.05 | 0.20 | 0.50 | 0.26 | 0.46 |
| | | | | | | |

| Table 4. | Points analysis for native range on the twice-over rotation grazing system at the Dickinson Research Extension Center. | | | | | |
|---|---|---|---|---|---|---|
| System: | West/East | | | | | |
| Pasture: | NR-1-6 | | Relative | | Relative | |
| Site: | Shallow, grazed | Basal | Basal | Percent | Percent | Importance |
| Species: | Juniperus horizontalis | Cover | Cover | Frequency | Frequency | Value |
| | | | | | | |
| | | | | | | |
| 1983 | | 8.70 | 13.97 | 13.00 | 4.11 | 18.08 |
| 1984 | | | | | | |
| 1985 | | | | | | |
| 1986 | | | | | | |
| 1987 | | | | | | |
| 1988 | | | | | | |
| 1989 | | 0.40 | 1.25 | 2.00 | 0.85 | 2.10 |
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