# Autecology of Hairy Goldenaster on the Northern Mixed Grass Prairie

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The autecology of Hairy goldenaster, *Heterotheca villosa*, 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).

Hairy goldenaster, *Heterotheca villosa* (Pursh) Shinners, is a member of the aster (sunflower) family, Asteraceae, syn.: *Chrysopsis villosa* (Pursh) Nutt., *Amellus villosus* Pursh, and is a native perennial, warm season, dicot, herb that is drought resistant. The first North Dakota record is Bergman 1911. Annual aerial growth has numerous simple, reddish brown stems arising from a perennating woody crown (caudex) with center stems erect, middle ring of stems ascending, and outer ring of stems somewhat decumbent. Stem (cauline) leaves are alternate, simple, entire, oblong or oblanceolate 2-4 cm (0.8-1.6 in) long, lower petioled, upper sessile, decreasing upward. Stems and leaves are densely covered with soft, long, white hairs and with stiff flattened hairs. The root system has a main woody taproot that develops from the woody crown, descending to 91 cm (3 ft) before forming branches that can descend to 3.1 m or 4.0 m (10-13 ft) deep. A great quantity of branched lateral roots with a radial spread of 76 cm (2.5 ft) fill the maximum space in the top 61 cm (2 ft) of soil. Two to three primary roots develop just below the numerous lateral roots, spread horizontally for about 61 cm (2 ft) then descend to the depths of the main taproot; below 61 cm (2 ft) soil depth, taproot and primary roots have few to no lateral roots. This root system provides much absorption capacity for the plant. A few short stout rhizomes develop as branches from the woody caudex. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranian crown and by sprouts from the short rhizome branches. Inflorescence has numerous solitary heads terminal on pedicels arising from leaf axils forming open corymbs atop each stem. Flower corollas of ray and disk florets are yellow to golden appearing during early July to early September. Pollination is by insects. Fruit is a hairy achene with long pappus of off white to light brown bristles. Aerial parts are not usually eaten by livestock and are top killed by fire. Damage to aerial stems activates sprouts from the short rhizome branches. This summary information on growth development and regeneration of hairy goldenaster was based on works of Weaver 1958, Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, Larson and Johnson 2007, and Stubbendieck et al. 2011.

## Procedures

### The 1955-1962 Study

Hairy goldenaster plant growth in height was determined by measuring ungrazed stems from ground level to top of leaf or to the tip of the inflorescence of an average of 10 plants of each species at approximately 7 to 10 day intervals during the growing seasons of 1955 to 1962 from early May until early September. Dates of first flower (anthesis) were recorded as observed. These growth in height and flower data were reported in Goetz 1963.

### The 1969-1971 Study

The range of flowering time of Hairy goldenaster 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 1983-2012 Study

A long-term study on change in abundance of Hairy goldenaster 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 Hairy goldenaster 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 the 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 value 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**

Hairy goldenaster resumes annual aerial growth with numerous simple stems arising from a perennating woody caudex. Central stems are erect becoming more decumbent outward. Stems and leaves are densely covered with two types of hairs. A main woody taproot descends to 91 cm (3 ft), forms branches and continues to descend to 3.1 to 4.0 m (10-13 ft) deep. A huge quantity of branched lateral roots spread radially to 76 cm (2.5 ft) completely filling the top 61 cm (2 ft) of soil. A few primary roots develop just below the numerous lateral roots, spread horizontally to 61 cm (2 ft), turn downward and descend to 91 cm (3 ft) deep. This extensive root system provides huge absorption capability. A stout rhizome system developed as branches from an enlarged caudex. Numerous solitary composite heads with yellow to golden ray and disk florets develop on terminal ends of pedicels that arise from axils forming open corymbs. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared on 28 June, the mean first flowers occurred on 6 July, and a long 8 week flower period extended from the second week of July through August to the first week of September (table 1) (Goetz 1963, Zaczkowski 1972). The combined flower period is 10 weeks from late June to early September. A mean mature stem height of 23.5 cm (9.3 in) with an annual variance in height from 20.0 cm (7.9 in) to 27.0 cm (10.6 in) was reached during August (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 20 cm to 60 cm (7.9-23.6 in) tall. The stem heights measured during the 1955-1962 study were within the normal stem heights for the Northern Plains.

Plant species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. Hairy goldenaster was found to have low abundance on sandy and silty ecological sites. Patterns in the changes in individual plant species abundance was followed for 30 growing seasons during the 1983-2012 study on the shallow ecological sites of the long-term nongrazed, traditional seasonlong, and twice-over rotation management treatments (tables 3, 4, and 5).

On the shallow site of the nongrazed treatment, Hairy goldenaster was present during 94.7% and 26.9% of the years that density and basal cover data were collected with a mean 0.92 stems/$m^2$ density and a mean 0.03% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hairy goldenaster was present during 80.0% and 16.7% of the years with a mean 1.32 stems/$m^2$ density and a mean 0.06% basal cover, respectively. During the later period (1998-2012), Hairy goldenaster was present during 100.0% and 33.3% of the years with a mean 0.77 stems/$m^2$ density and a mean 0.02% basal cover, respectively. The percent present for density data and percent present for basal cover data increased and stem density and basal cover decreased on the shallow site of the nongrazed treatment over time (tables 3, 4, and 5).

On the shallow site of the ungrazed seasonlong treatment, Hairy goldenaster was present during 25.0% and 11.5% of the years that density and basal cover data were collected with a mean 0.14 stems/$m^2$ density and a mean 0.003% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hairy goldenaster was not present on the shallow site of the ungrazed seasonlong treatment. During the later period (1998-2012), Hairy goldenaster was present during 33.3% and 20.0% of the years with a mean 0.18 stems/$m^2$ density and a mean 0.006% basal cover, respectively. Hairy goldenaster was not present during the early period and all observations were made during the later period that indicated low abundance.

On the shallow site of the grazed seasonlong treatment, Hairy goldenaster was present during 70.0% and 11.5% of the years that density and basal cover data were collected with a mean 0.19 stems/$m^2$ density and a mean 0.008% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hairy goldenaster was present during 60.0% and 33.3% of the years with a mean 0.34 stems/$m^2$ density and a mean 0.03% basal cover, respectively. During the later period (1998-2012), Hairy goldenaster was present during 73.3% and 6.7% of the years with a mean 0.14 stems/$m^2$ density and a mean 0.001% basal cover, respectively. The percent present for density data increased, and percent present for basal cover data, stem density and basal cover decreased on the shallow site of the grazed seasonlong treatment over time (tables 3, 4, and 5). The percent present for density data were greater on the shallow site of the grazed seasonlong treatment and, percent present for basal cover data, stem density, and basal cover were similar on the ungrazed and grazed seasonlong treatments.

On the shallow site of the ungrazed twice-over treatment, Hairy goldenaster was present during 90.9% and 65.5% of the years that density and basal cover data were collected with a mean 0.28 stems/$m^2$ density and a mean 0.04% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hairy goldenaster was present during 71.4% and 66.7% of the years with a mean 0.44 stems/$m^2$ density and a mean 0.09% basal cover, respectively. During the later period (1998-2012), Hairy goldenaster was present during 100.0% and 73.3% of the years with a mean 0.20 stems/$m^2$ density and a mean 0.03% basal cover, respectively. The percent present for density data and percent present for basal cover data increased slightly and stem density and basal cover decreased slightly on the shallow site of the ungrazed twice-over treatment over time (tables 3, 4, and 5).

On the shallow site of the grazed twice-over treatment, Hairy goldenaster was present during 81.8% and 46.7% of the years that density and basal cover data were collected with a mean 0.14 stems/$m^2$ density and a mean 0.019% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Hairy goldenaster was present during 71.4% and 50.0% of the years with a mean 0.13 stems/$m^2$ density and a mean 0.04% basal cover, respectively. During the later period (1998-2012), Hairy goldenaster was present during 86.7% and 46.7% of the years with a mean 0.14 stems/$m^2$ density and a mean 0.009% basal cover, respectively. The percent present for density data and stem density increased slightly and percent present for basal cover data and basal cover decreased slightly on the shallow site of the grazed twice-over treatment over time (tables 3, 4, and 5). The percent present, stem density, and basal cover were slightly greater on the shallow site of the ungrazed twice-over than those on the shallow site of the grazed twice-over treatment.

On the shallow sites, Hairy goldenaster was present during 72.5% and 32.4% of the years with a mean 0.33 stems/m$^2$ density and a mean 0.02% basal cover that indicated a relatively low abundance.

Hairy goldenaster on the shallow site of the nongrazed treatment was present during 94.7% and 26.9% of the years with a mean 0.92 stems/m$^2$ density and a mean 0.028% basal cover. Hairy goldenaster on the shallow site of the seasonlong treatment was present during 47.5% and 11.5% of the years with a mean 0.16 stems/m$^2$ density and a mean 0.006% basal cover. Hairy goldenaster on the shallow site of the twice-over treatment was present during 86.4% and 50.1% of the years with a mean 0.21 stems/m$^2$ density and a mean 0.03% basal cover. The percent present for density data, and stem density were greater on the shallow site of the nongrazed treatment. The percent present for basal cover data and basal cover were slightly greater on the shallow site of the twice-over treatment.

During the drought growing season of 1988; Hairy goldenaster was present on the nongrazed treatment 2 times out of a possible 2 for an index of 100.0%; Hairy goldenaster was present on the seasonlong treatment 2 times out of a possible 4 for an index of 50.0%; and Hairy goldenaster was present on the twice-over treatment 3 times out of a possible 4 for an index of 75.0%. Hairy goldenaster has fairly high drought tolerance on the nongrazed and twice-over treatments.

**Discussion**

Hairy goldenaster, *Heterotheca villosa*, is a native, late succession, perennial, warm season, dicot, forb of the aster family that is commonly present on healthy mixed grass prairie plant communities. Hairy goldenaster grows better on the shallow ecological sites. Annual aerial growth resumes with several simple stems arising from an enlarged woody caudex. An extensive deep absorbent root system consists of a main woody taproot, numerous branching lateral roots, and a few descending primary roots. A stout rhizome system extends horizontally from caudex branches. Numerous composite heads with yellow to golden florets develop on pedicels from leaf axils forming open corymbs. The mean first flowers occurred on 6 July (1955-1962 study), with an observed flower period of 8 weeks from the second week of July to the first week of September (1969-1971 study), and the combined flower period of 10 weeks from late June to early September. The mean mature stem height of 23.5 cm (9.3 in) that was reached during August (1955-1962 study). Hairy goldenaster has a relatively low abundance on the shallow sites of all three management treatments. Hairy goldenaster has fairly good drought tolerance mechanisms.

The enlarged woody caudex, stout rhizomes, and the extensive, deep, and highly absorbent root system help Hairy goldenaster to persist through the harsh conditions on the Northern Mixed Grass Prairie.

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Table 1. First flower and flower period of Heterotheca villosa, Hairy goldenaster.

| | Apr | May | Jun | Jul | Aug | Sep |
|---|---|---|---|---|---|---|
| First Flower | | | | | | |
| 1955-1962 | | | | | | |
| Earliest | | | 28 | | | |
| Mean | | | | 6 | | |
| Flower Period | | | | | | |
| 1969-1971 | | | | X XX | XX XX | X |

First Flower data from Goetz 1963.
Flower Period Data from Zaczkowski 1972.

Table 2. Autecology of Heterotheca villosa, Hairy goldenaster, with growing season changes in mature height.

| | | | | Percent of Mature Height Attained | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Data Period | Minimum Annual Mature Height cm | Maximum Annual Mature Height cm | Mean Mature Height cm | Apr % | May % | Jun % | Jul % | Aug % | Sep % |
| 1955-1962 | 20.0 | 27.0 | 23.5 | 8.6 | 29.0 | 70.3 | 95.8 | 100.0 | |

Data from Goetz 1963.

| Table 3. Autecology of Heterotheca villosa, Hairy goldenaster, with growing season changes in density importance value, 1983-2012. | | | | | |
|---|---|---|---|---|---|
| Ecological Site<br>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 | 1.99 | 0.00 | 4.41 | 3.46 | 0.87 |
| 1988-1992 | 14.54 | 0.00 | 3.00 | 1.28 | 2.15 |
| 1993-1998 | 0.93 | 0.00 | 0.00 | 2.01 | 1.02 |
| 1999-2003 | 1.26 | 0.00 | 2.31 | 0.60 | 0.84 |
| 2004-2009 | 4.42 | 0.56 | 0.73 | 1.30 | 0.73 |
| 2010-2012 | 8.58 | 3.78 | 1.24 | 0.68 | 1.12 |
| Silty | | | | | |
| 1983-1987 | Few Plants Present | | | | |
| 1988-1992 | | | | | |
| 1993-1998 | | | | | |
| 1999-2003 | | | | | |
| 2004-2009 | | | | | |
| 2010-2012 | | | | | |

| Table 4. Autecology of Heterotheca villosa, Hairy golden aster, with growing season changes in basal cover importance value, 1983-2012. | | | | | |
|---|---|---|---|---|---|
| Ecological Site<br>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 | 0.93 | 0.09 |
| 1988-1992 | 0.61 | 0.00 | 0.32 | 0.63 | 0.45 |
| 1993-1998 | 0.07 | 0.00 | 0.00 | 0.06 | 0.10 |
| 1999-2003 | 0.09 | 0.00 | 0.02 | 0.40 | 0.06 |
| 2004-2009 | 0.44 | 0.09 | 0.00 | 0.29 | 0.10 |
| 2010-2012 | 0.00 | 0.06 | 0.00 | 0.04 | 0.02 |
| Silty | | | | | |
| 1983-1987 | Few Plants Present | | | | |
| 1988-1992 | | | | | |
| 1993-1998 | | | | | |
| 1999-2003 | | | | | |
| 2004-2009 | | | | | |
| 2010-2012 | | | | | |

| Table 5. Autecology of Heterotheca villosa, Hairy goldenaster, with growing season changes in density, 1983-2012. | | | | | |
|---|---|---|---|---|---|
| Ecological Site<br>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 | 0.01 | 0.00 | 0.07 | 0.09 | 0.01 |
| 1988-1992 | 0.16 | 0.00 | 0.03 | 0.01 | 0.02 |
| 1993-1998 | 0.02 | 0.00 | 0.00 | 0.01 | 0.01 |
| 1999-2003 | 0.02 | 0.00 | 0.03 | 0.01 | 0.01 |
| 2004-2009 | 0.05 | 0.01 | 0.01 | 0.03 | 0.01 |
| 2010-2012 | 0.21 | 0.07 | 0.01 | 0.01 | 0.02 |
| Silty | | | | | |
| 1983-1987 | Few Plants Present | | | | |
| 1988-1992 | | | | | |
| 1993-1998 | | | | | |
| 1999-2003 | | | | | |
| 2004-2009 | | | | | |
| 2010-2012 | | | | | |

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