Autecology of Goatsbeard on the Northern Mixed Grass Prairie

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The autecology of Goatsbeard, *Tragopogon dubius,* 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).

Goatsbeard, *Tragopogon dubius* Scopoli, is a member of the aster (sunflower) family, Asteraceae, syn.: *Tragopogon major* Jacq., and is a naturalized nonnative introduced from Eurasia, biennial or vegetative monocarpic perennial, dicot, herb that is somewhat shade tolerant. The first North Dakota record is Potter 1958. First year aerial growth consists of a rosette of very long grass like leaves along with the early development of the crown and taproot. This plant has the ability to annually produce vegetative rosette leaves for up to 10 years before developing a flower stem one time then dying. Aerial growth has a single, erect, simple, slender, hollow, sparsely branched stem 40-80 cm (16-32 in) tall arising from the rosette crown, becoming widely branched with favorable conditions. Stem leaves are alternate, elongate tapered from base to tip, linear to lanceolate 10-30 cm (3.9-11.8 in) long, grasslike forming a sheath around the stem. Stems and leaves contain a bitter white milky latex. The roots system has a taproot that starts development with the crown and first set of rosette leaves and continues to develop into a long, stout, thick, fleshy taproot with unknown size and depth. Regeneration of descendant offspring plants, can only occur by seed from sexual reproduction, however, limited vegetative growth can occur from an existing crown. Vegetative growth is annual leaf development from an existing subterranian crown, for up to 10 years, until a reproductive stem with flowers is produced one time, after which the plant dies (monocarpic). Inflorescence is a large solitary head 5.6 cm (2.2 in) across terminal on a long inflated peduncle. The number of inflorescence per plant is determined by the extent of stem branches. Flowers are only yellow ray florets appearing during early June to mid August. Fruits are achene attached to large feathery, umbrella like, pappus that travels by wind. Aerial parts are usually not eaten by livestock, however, it has been found to be seasonally a part of wildlife ungulate diets of elk, deer, bighorn sheep, pronghorn, and feral horses. Damages or removal of flower heads before seed production activates the development of additional flower heads when leaf axils remain on the stem. Damage to more then 25% of the total leaf quantity causes mortality of more htan 80% of the plants. Plants are killed by fire. This summary information on growth development and regeneration of goatsbeard was based on works of Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, Larson and Johnson 2007, and Gucker 2008.

Procedures

The 1955-1962 Study

Goatsbeard 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 Goatsbeard 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 Goatsbeard 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 Goatsbeard 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

Goatsbeard begins the first year aerial growth with a rosette of very long grass like leaves and the early development of a crown and taproot. Second year aerial growth produces a single erect hallow stem with branches increasing with favorable conditions. Stems and leaves contain a bitter white milky latex. A fleshy taproot continues to develop in size with an unknown depth. Flowers are large solitary composite head with yellow ray florets terminal on a long inflated peduncle. The number of flower heads are determined by the amount of stem branches. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 18 June, the mean first flowers occurred on 2 July, with a long 12 week flower period extending from early

June through July to the end of August (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 34.4 cm (13.5 in) with an annual variance in height from 27.0 cm (10.6 in) to 45.0 cm (17.7 in) was reached during August (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 40.0 cm to 80.0 cm (15.7-31.5 in). The mature stem heights measured during the 1955-1962 study were shorter than the normal stem heights for the Northern Plains.

Goatsbeard also has a unique type of growth as a vegetative monocarpic perennial. If for any reason, mowing, herbicides, or water stress, the plant does not produce a flower during a growing season, vegetative growth of annual leaves arise from the subterranian caudex each growing season for up to 10 years or until a reproductive stem with a flower is produced one time, after which the plant dies that growing season (monocarpic).

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

On the sandy site of the nongrazed treatment, Goatsbeard was present during 55.6% and 36.0% of the years that density and basal cover data were collected with a mean 0.15 stems/m^2 density and a mean 0.03% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Goatsbeard was present during 50.0% and 20.0% of the years with a mean 0.50 stems/m^2 density and a mean 0.01% basal cover, respectively. During the later period (1998-2012), Goatsbeard was present during 57.1% and 26.7% of the years with a mean 0.17 stems/m^2 density and a mean 0.012% basal cover, respectively. The percent present increased, stem density decreased, and basal cover was fairly similar on the sandy site of the nongrazed treatment over time (tables 3, 4, and 5).

On the sandy site of the ungrazed seasonlong treatment, Goatsbeard was not present where basal cover data were collected and was present during 5.3% of the years that density data were collected with a mean 0.02 stems/m^2 density during the total 30 year period. During the early period (1983-1992), Goatsbeard was not present on the sandy site of the ungrazed seasonlong treatment. During the later period (1998-2012), Goatsbeard was present during 6.7% of the years with a mean 0.02 stems/m^2 density. Goatsbeard was not present during the early period and all density observations were made during the later period that indicated low abundance.

On the sandy site of the grazed seasonlong treatment, Goatsbeard was present during 15.8% and 16.0% of the years that density data and basal cover were collected with a mean 0.03 stems/m^2 density and a mean 0.004% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Goatsbeard was not where basal cover data were collected and was present during 25.0% of the years that density data were collected with a mean 0.08 stems/m^2 density. During the later period (1998-2012), Goatsbeard was present during 13.3% and 26.7% of the years with a mean 0.01 stems/m^2 density and a mean 0.008% basal cover, respectively. Goatsbeard was not present where basal cover data was collected during the early period and all basal cover data was collected during the later period that indicated low abundance. The percent present for density data and stem density decreased on the sandy site of the grazed seasonlong treatment over time (tables 3 and 5). The percent present, stem density, and basal cover were greater on the sandy site of the grazed seasonlong treatment than those on the sandy site of the ungrazed seasonlong treatment.

On the sandy site of the ungrazed twice-over treatment, Goatsbeard was present during 52.4% and 41.4% of the years that density and basal cover data were collected with a mean 0.08 stems/m^2 density and a mean 0.013% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Goatsbeard was not present where basal cover data were collected and was present during 50.0% of the years that density data were collected with a mean 0.07 stems/m^2 density. During the later period (1998-2012), Goatsbeard was present during 53.3% and 53.3% of the years with a mean 0.08 stems/m^2 density and a mean 0.009% basal cover, respectively. Goatsbeard was not present with basal cover data duirng the early period and all basal cover observations were made during the later period. The percent present for density data decreased and stem density increased on the sandy site of the ungrazed twice-over treatment over time (tables 3 and 5).

On the sandy site of the grazed twice-over treatment, Goatsbeard was present during 52.4% and 24.1% of the years that density and basal cover data were collected with a mean 0.06 stems/m^2 density and a mean 0.008% basal cover during the total 30 year period, respectively. During the early period (1983-

1992), Goatsbeard was present during 16.7% and 11.1% of the years with a mean 0.02 stems/m^2 density and a mean 0.002% basal cover, respectively. During the later period (1998-2012), Goatsbeard was present during 66.7% and 33.3% of the years with a mean 0.08 stems/m^2 density and a mean 0.007% basal cover, respectively. The percent present, stem density, and basal cover all increased on the sandy site of the grazed twice-over treatment over time (tables 3, 4, and 5). The percent present for density data and stem density were fairly similar, and percent present for basal cover data and basal cover were slightly greater on the sandy site of the ungrazed twice-over treatment than those on the sandy site of the grazed twice-over treatment.

On the shallow site of the nongrazed treatment, Goatsbeard was present during 42.1% and 23.1% of the years that density and basal cover data were collected with a mean 0.11 stems/m^2 density and a mean 0.014% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Goatsbeard was not present where basal cover data were collected and was present during 20.0% of the years with a mean 0.04 stems/m^2 density. During the later period (1998-2012), Goatsbeard was present during 50.0% and 26.7% of the years with a mean 0.14 stems/m^2 density and a mean 0.014% basal cover, respectively. Goatsbeard was not present with basal cover data during the early period and all basal cover observations were made during the later period. The percent present for density data and stem density increased on the shallow site of the nongrazed treatment over time (tables 3 and 5).

On the shallow site of the ungrazed seasonlong treatment, Goatsbeard was not present where basal cover data were collected and was present during 20.0% of the years that density data were collected with a mean 0.02 stems/m^2 density during the total 30 year period. During the early period (1983-1992), Goatsbeard was not present on the shallow site of the ungrazed seasonlong treatment. During the later period (1998-2012), Goatsbeard was present during 26.7% of the years with a mean 0.03 stems/m^2 density. Goatsbeard was not present with basal cover data the total 30 year period and was not present with density data during the early period and all density observations were made during the later period that indicated low abundance.

On the shallow site of the grazed seasonlong treatment, Goatsbeard was not present where basal cover data were collected and was present during 10.0% of the years that density data were collected with a mean 0.01 stems/m^2 density during the total 30 year period. During the early period (1983-1992), Goatsbeard was not present on the shallow site of the grazed seasonlong treatment. During the later period (1998-2012), Goatsbeard was present during 13.3% of the years with a mean 0.013 stems/m^2 density. Goatsbeard was not present with basal cover the total 30 year period and was not present with density data during the early period and all density observations were made during the later period that indicated low abundance. The percent present for density data and stem density were greater on the shallow site of the ungrazed seasonlong treatment than those on the shallow site of the grazed seasonlong treatment.

On the shallow site of the ungrazed twice-over treatment, Goatsbeard was present during 54.6% and 31.0% of the years that density and basal cover data were collected with a mean 0.09 stems/m^2 density and a mean 0.009% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Goatsbeard was not present on the shallow site of the ungrazed twice-over treatment. During the later period (1998-2012), Goatsbeard was present during 80.0% and 53.3% of the years with a mean 0.13 stems/m^2 density and a mean 0.02% basal cover, respectively. Goatsbeard was not present during the early period and all observations were made during the later period.

On the shallow site of the grazed twice-over treatment, Goatsbeard was present during 36.4% and 13.3% of the years that density and basal cover data were collected with a mean 0.04 stems/m^2 density and a mean 0.002% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Goatsbeard was present during 14.3% and 10.0% of the years with a mean 0.01 stems/m^2 density and a mean 0.002% basal cover, respectively. During the later period (1998-2012), Goatsbeard was present during 46.7% and 20.0% of the years with a mean 0.05 stems/m^2 density and a mean 0.003% basal cover, respectively. The percent present, stem density, and basal cover all decreased 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 all greater on the shallow site of the ungrazed twice-over treatment than those on the shallow site of the grazed twice-over treatment.

On the silty site of the nongrazed treatment, Goatsbeard was present during 57.7% and 38.5% of the years that density and basal cover data were collected with a mean 0.26 stems/m^2 density and a mean 0.05% basal cover during the total 30 year period, respectively. During the early period (1983-

1992), Goatsbeard was present during 20.0% and 16.7% of the years with a mean 0.08 stems/m^2 density and a mean 0.05% basal cover, respectively. During the later period (1998-2012), Goatsbeard was present during 71.4% and 33.3% of the years with a mean 0.26 stems/m^2 density and a mean 0.03% basal cover, respectively. The percent present for density data and stem density increased greatly, percent present for basal cover data increased, and basal cover data decreased on the silty site of the nongrazed treatment.

On the silty site of the ungrazed seasonlong treatment, Goatsbeard was present during 45.0% and 11.5% of the years that density and basal cover data were collected with a mean 0.24 stems/m^2 density and a mean 0.002% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Goatsbeard was not present on the silty site of the ungrazed seasonlong treatment. During the later period (1998-2012), Goatsbeard was present during 60.0% and 20.0% of the years with a mean 0.32 stems/m^2 density and a mean 0.004% basal cover, respectively. Goatsbeard was not present during the early period and all observations were made during the later period.

On the silty site of the grazed seasonlong treatment, Goatsbeard was present during 30.0% and 3.9% of the years that density and basal cover data were collected with a mean 0.05 stems/m^2 density and a mean 0.001% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Goatsbeard was not present where basal cover data were collected and was present during 20.0% of the years with a mean 0.06 stems/m^2 density. During the later period (1998-2012), Goatsbeard was present during 33.3% and 6.7% of the years with a mean 0.05 stems/m^2 density and a mean 0.001% basal cover, respectively. Goatsbeard was not present with basal cover data during the early period and all basal cover observations were made during the later period that indicated low abundance. The percent present for density data increased and stem density decreased on the silty site of the grazed seasonlong treatment over time (tables 3 and 5). The percent present, stem density, and basal cover were all greater on the silty site of the ungrazed seasonlong treatment than those on the silty site of the grazed seasonlong treatment.

On the silty site of the ungrazed twice-over treatment, Goatsbeard was present during 54.6% and 34.5% of the years that density and basal cover data were collected with a mean 0.12 stems/m^2 density and a mean 0.02% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Goatsbeard was present during 42.9% and 22.2% of the years with a mean 0.13 stems/m^2 density and a mean 0.02% basal cover, respectively. During the later period (1998-2012), Goatsbeard was present during 60.0% and 40.0% of the years with a mean 0.12 stems/m^2 density and a mean 0.01% basal cover, respectively. The percent present for density data and percent present for basal cover data increased, and stem density and basal cover remained about the same on the silty site of the ungrazed twice-over treatment over time (tables 3, 4, and 5).

On the silty site of the grazed twice-over treatment, Goatsbeard was present during 45.5% and 20.0% of the years that density and basal cover data were collected with a mean 0.11 stems/m^2 density and a mean 0.003% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Goatsbeard was present during 28.6% and 10.0% of the years with a mean 0.03 stems/m^2 density and a mean 0.002% basal cover, respectively. During the later period (1998-2012), Goatsbeard was present during 53.3% and 33.3% of the years with a mean 0.14 stems/m^2 density and a mean 0.005% basal cover, respectively. The percent present, stem density, and basal cover all increased on the silty site of the grazed twice-over treatment over time (tables 3, 4, and 5). The percent present, stem density, and basal cover were all greater on the silty site of the ungrazed twice-over treatment than those on the silty site of the grazed twice-over treatment.

On the sandy site, Goatsbeard was present during 36.3% and 23.5% of the years with a mean 0.07 stems/m^2 density and a mean 0.01% basal cover. On the shallow site, Goatsbeard was present during 32.6% and 13.5% of the years with a mean 0.05 stems/m^2 density and a mean 0.01% basal cover. On the silty site, Goatsbeard was present during 46.6% and 21.7% of the years with a mean 0.16 stems/m^2 density and a mean 0.02% basal cover. The percent present for density data, stem density, and basal cover were greater on the silty site and percent present for basal cover data was greater on the sandy site.

On the sandy site of the not grazed treatments, Goatsbeard was present during 37.7% and 25.8% of the years with a mean 0.08 stems/m^2 density and a mean 0.013% basal cover. On the sandy site of the grazed treatments, Goatsbeard was present during 34.1% and 20.1% of the years with a mean 0.04 stems/m^2 density and a mean 0.006% basal cover. The percent present, stem density, and basal cover were all greater on the sandy site of the not grazed treatments.

On the shallow site of the not grazed treatments, Goatsbeard was present during 38.9% and 18.0% of the years with a mean 0.07 stems/m^2 density and a mean 0.01% basal cover. On the shallow site of the grazed treatments, Goatsbeard was present during 23.2% and 6.7% of the years with a mean 0.03 stems/m^2 density and a mean 0.001% basal cover. The percent present, stem density, and basal cover were all greater on the shallow site of the not grazed treatments.

On the silty site of the not grazed treatments, Goatsbeard was present during 52.5% and 28.2% of the years with a mean 0.21 stems/m^2 density and a mean 0.02% basal cover. On the silty site of the grazed treatments, Goatsbeard was present during 37.7% and 11.9% of the years with a mean 0.06 stems/m^2 density and a mean 0.002% basal cover. The percent present, stem density, and basal cover were all greater on the silty site of the not grazed treatments.

Goatsbeard was present on the mean of the not grazed treatments during 43.0% and 24.0% of the years with a mean 0.12 stems/m^2 density and a mean 0.02% basal cover. Goatsbeard was present on the mean of the grazed treatments during 31.7% and 12.9% of the years with a mean 0.04 stems/m^2 density and a mean 0.003% basal cover. The percent present for density data, percent present for basal cover data, stem density, and basal cover were all much greater on the mean of the not grazed treatments than those on the mean of the grazed treatments.

Goatbeard was present on the nongrazed treatment during 51.1% and 32.5% of the years with a mean 0.17 stems/m^2 density and a mean 0.03% basal cover. Goatbeard was present on the seasonlong treatment during 21.0% and 5.2% of the years with a mean 0.06 stems/m^2 density and a mean 0.001% basal cover. Goatbeard was present on the twice-over treatment during 49.3% and 26.9% of the years with a mean 0.08 stems/m^2 density and a mean 0.01% basal cover. The percent present for density data, percent present for basal cover data, stem density, and basal cover were all greater on the nongrazed treatment.

Discussion

Goatsbeard, *Tragopogon dubius*, is a naturalized nonnative introduced from Eurasia, mid succession, biennial, dicot forb of the aster family that is a voluntary intruder into healthy mixed grass prairie plant communities. Goatsbeard can grow on sandy, shallow, and silty ecological sites. It grows better on not grazed sandy, shallow, and silty sites and has slightly greater abundance on not grazed silty sites. The biennial aerial growth of Goatsbeard starts the first year with a rosette of long grass like leaves and early development of a caudex and taproot. Aerial growth the second year is a single hollow stem that can increasingly produce branches. Stems and leaves contain a bitter white milky latex. A fleshy taproot continues to descend below the caudex. Large solitary composite flowers with yellow ray florets is produced on each stem branch. The mean first flowers occurred 2 July (1955-1962 study), with a long 12 week flower period from early June to late August (1969-1971 study). The mean mature stem height of 34.4 cm (13.5 in) was reached during August (1955-1962 study). Goatsbeard also can survive by a unique type of growth that produces annual vegetative growth of leaves from the subterranian caudex for up to 10 years if flowers are not produced during a growing season for any reason called vegetative monocarpic perennial growth. When a reproductive stem produces a flower one time, the plant dies that growing season.

The subterranian caudex, the fleshy taproot, the unique vegetative monocarpic perennial growth, and the large fleshy umbrella like pappus that permits seeds to travel long distance by wind help Goatsbeard to persist through the harsh conditions of the Northern Mixed Grass Prairie.

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Table 1. First flower and flower period of Tragopogon dubius, Goatsbeard.

	Apr	May	Jun		Jul		Aug		Sep
First Flower									
1955-1962									
Earliest				18					
Mean					2				
Flower Period									
1969-1971			XX	XX	XX	XX	XX	XX	

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

Table 2. Autecology of Tragopogon dubius, Goatsbeard, 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	27.0	45.0	34.4		65.6	81.3	98.6	100.0	

Data from Goetz 1963.

Table 3. Autecology of Tragopogon dubius, Goat's beard, 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	7.32	0.00	2.97	0.54	0.12
1988-1992	6.73	0.00	0.00	0.59	0.00
1993-1998	0.00	0.00	0.00	0.84	0.50
1999-2003	0.48	0.00	0.38	0.21	0.51
2004-2009	1.94	0.18	0.00	0.63	0.25
2010-2012	1.78	0.00	0.00	0.93	0.67
Shallow					
1983-1987	1.52	0.00	0.00	0.00	0.16
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.58	0.00
1999-2003	0.20	0.00	0.22	1.04	0.07
2004-2009	1.33	0.18	0.18	0.70	0.42
2010-2012	0.99	0.93	0.00	0.48	0.28
Silty					
1983-1987	2.75	0.00	0.69	0.53	0.42
1988-1992	0.00	0.00	0.00	2.36	0.00
1993-1998	1.06	0.55	0.00	5.36	3.48
1999-2003	1.52	0.22	0.49	1.64	1.70
2004-2009	1.16	2.52	0.09	0.36	0.55
2010-2012	2.38	2.60	0.18	0.28	0.35

Table 4. Autecology of Tragopogon dubius, Goat's beard, 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	0.00	0.00	0.00	0.00	0.03
1988-1992	0.08	0.00	0.00	0.00	0.00
1993-1998	0.91	0.00	0.03	0.27	0.24
1999-2003	0.04	0.00	0.09	0.15	0.03
2004-2009	0.14	0.00	0.07	0.04	0.10
2010-2012	0.14	0.00	0.00	0.08	0.05
Shallow					
1983-1987	0.00	0.00	0.00	0.00	0.02
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.36	0.00	0.00	0.09	0.00
1999-2003	0.17	0.00	0.00	0.21	0.01
2004-2009	0.19	0.00	0.00	0.08	0.02
2010-2012	0.00	0.00	0.00	0.10	0.02
Silty					
1983-1987	2.84	0.00	0.00	0.00	0.00
1988-1992	0.00	0.00	0.00	0.30	0.04
1993-1998	1.53	0.00	0.00	0.27	0.00
1999-2003	0.44	0.07	0.03	0.19	0.03
2004-2009	0.30	0.02	0.00	0.09	0.06
2010-2012	0.09	0.00	0.00	0.03	0.02

Table 5. Autecology of Tragopogon dubius, Goat's beard, with growing season changes in density, 1983-2012.					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.12	0.00	0.03	0.01	0.00
1988-1992	0.03	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.01	0.01
1999-2003	0.01	0.00	0.01	0.00	0.01
2004-2009	0.07	0.00	0.00	0.01	0.00
2010-2012	0.03	0.00	0.00	0.01	0.01
Shallow					
1983-1987	0.02	0.00	0.00	0.00	0.00
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.01	0.00
1999-2003	0.01	0.00	0.00	0.02	0.00
2004-2009	0.02	0.00	0.00	0.01	0.01
2010-2012	0.02	0.01	0.00	0.01	0.00
Silty					
1983-1987	0.04	0.00	0.03	0.01	0.01
1988-1992	0.00	0.00	0.00	0.02	0.00
1993-1998	0.02	0.01	0.00	0.04	0.03
1999-2003	0.06	0.01	0.01	0.02	0.02
2004-2009	0.03	0.07	0.00	0.01	0.01
2010-2012	0.02	0.02	0.00	0.00	0.01

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