Autecology of Yellow Owlclover on the Northern Mixed Grass Prairie

Llewellyn L. Manske PhD
Research Professor of Range Science
North Dakota State University
Dickinson Research Extension Center
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The autecology of Yellow owlclover, *Orthocarpus luteus,* 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).

Yellow owlclover, *Orthocarpus luteus* Nutt., is member of the figwort family, Scrophulariaceae, and is a native, annual, dicot, herb that is hemiparasitic; it uses underground suckers (haustorium) to obtain water, minerals, and essential elements from the roots of other plants. Nuttall described this genus and species from plants first discovered in the Fort Mandan area. The first North Dakota record is Bolley 1891. Aerial growth has a single, slender, erect, stem 10-30 cm (4-12 in) tall. Leaves are spirally arranged, strangely ascending and overlapping, sessile, linear to linear-lanceolate 3-6 cm (1-2.5 in) long. The root system has a shallow taproot with fine lateral roots and several specialized root like organs (haustoria) that penetrate the roots of other plants from which nutrients are obtained. Regeneration is by sexual reproduction. Inflorescence is a narrow thick terminal spike that is progressively reduced upward. Flowers have a slender, tubular, yellow corolla 9-13 mm long appearing during early July to mid August. Fruit is an elliptic capsule with several seeds. Aerial parts are not eaten by livestock and are totally consumed by fire. This summary information on growth development and regeneration of yellow owlclover was based on works of Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, Larson and Johnson 2007.

Procedures

The 1955-1962 Study

Yellow owlclover 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 Yellow owlclover 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 1984-1985 Study

Yellow owlclover plant growth in height was determined by measuring stems from ground level to top of stem or leaf or to the tip of the inflorescence of 20 ungrazed specimens randomly selected on three replications of grazed sandy, shallow, silty, and clayey ecological sites biweekly during June, July, and August of the growing seasons of 1984 and 1985. Phenological growth stage of each specimen was recorded as vegetative, budding, anthesis, seed developing, seed shedding, or mature. Percentage of stem dryness of each specimen was recorded as 0, 0-2, 2-25, 25-50, 50-75, 75-98, or 100 percent dry. Mean stem weight was determined by clipping at ground level 7 specimens at typical phenological growth stages at biweekly sample dates on separate grazed areas of the sandy, shallow, silty, and clayey ecological sites. Clipped stems at each sample site were placed in separate labeled paper bags of known weight, oven dried at 62° C (144° F), and weighed in grams.

The 1983-2012 Study

A long-term study on change in abundance of Yellow owlclover 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 Yellow owlclover 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 forb 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

Yellow owlclover started growth from a seed primarily during the growing seasons that had greater than normal precipitation during April and/or May. A single stem with an underdeveloped root system forms. The yellow flowers develop on a narrow thick terminal spike. The mean first flowers occurred on 26 July and the five week flower period extended from early June to the first week of August (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 18.3 cm (7.2 in) with an annual variance in height from 9.0 cm (3.5 in) to 25.0 cm (9.8 in) was reached during July (table 2) (Goetz 1963). The reported normal mature stem height in

the Northern Plains ranged from 10 cm to 30 cm (3.9-11.8 in) tall. The mean stem heights from the 1955-1962 study were near the normal range in height.

Changes in phenological growth stages from the 1984-1985 study are summarized on tables 3, 4, 5, and 6. A total of 1,303 Yellow owlclover stems were sampled during this study with, 382 stems (29.3%) from the sandy sites, 132 stems (10.1%) from the shallow sites, 379 stems (29.1%) from the silty sites, and 410 stems (31.5%) from the clayey sites. Yellow owlclover can grow on sandy, shallow, silty, and clayey ecological sites, but it appears to grow poorly on the shallow sites. The mean mature stem height reached during July were not significantly different, with 16.9 cm (6.7 in) on the sandy sites, 14.4 cm (5.7 in) on the silty sites, and 12.5 cm (4.9 in) on the clayey sites. Mature stem height on the shallow sites were 10.4 cm (4.1 in) and was significantly shorter than those on the sandy and silty sites. The mean stem heights from the 1984-1985 study were all within the normal range in height for the Northern Plains. Mean stem weights of Yellow owlclover were 0.29 g on the sandy sites, 0.24 g on the silty sites, 0.21 g on the clayey sites, and 0.16 g on the shallow sites and were not significantly different.

During the growing season, the percentage of Yellow owlclover stems that had passed through the anthesis phenological growth stages was 15.3% by late June, 49.7% by early July, 78.0% by late July, and 97.5% by early August. Only 0.5% of the stems did not produce flowers. The duration of the flower period was 6.5 weeks on the sandy and silty sites, 5.5 weeks on the clayey sites, and only 2 weeks on the shallow sites.

Plant species composition in rangeland ecosystems is variable during a growing season and dynamic among growing seasons. Patterns in the changes in 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 (tables 7, 8, and 9).

Yellow owlclover was present on the sandy, shallow, or silty ecological sites at low abundance during 16 growing seasons, 53.3% of the study period. The 30 year study period was separated into three 10 year groups to help evaluate changes in abundance. During the first 10 year group, Yellow owlclover was present during 1983, 1984, 1985, 1986, and 1987; during the second 10 year group, it was present during 1995, 1997, 1999, 2001, and 2002; during the third 10 year group, it was present during 2003, 2005, 2006, 2007, 2009, and 2011.

Yellow owlclover presence was highly related to early season precipitation. During 13 of the growing seasons that it was present, April and/or May had precipitation at well above average. During 2 other growing seasons, precipitation was well above average during July and August and during 1 other growing season, June, July and August had precipitation well above average. During 13 of the growing seasons that Yellow owlclover was not present, the April, May, and June precipitation was well below average during one, two, or three of these months. One growing season was an anomaly to the above precipitation conditions, this growing season had precipitation at well above average during May, however, Yellow owlclover was not present (Manske 2016). Yellow owlclover was not present during the seven year period of 1988 to 1994.

On the nongrazed treatment, Yellow owlclover was not present on the sandy and shallow ecological sites during the three 10 year groups and was not present on the silty sites during hte first and second 10 year groups. On the silty site during the third 10 year group, Yellow owlclover was present for two growing seasons (2007 and 2011) with a mean 0.60 stems/m^2 density. Yellow owlclover was present on the nongrazed treatment 2 times in 30 years.

On the ungrazed seasonlong treatment, Yellow owlclover was not present on the sandy, shallow, and silty ecological sites during the first 10 year group, and not present on the sandy and shallow sites during the second 10 year group. On the sandy site during the third year group, Yellow owlclover was present for two growing seasons (2005 and 2009) with a mean 0.90 stems/m^2 density and for one growing season (2005) with a mean 0.02% basal cover. On the shallow site during the third year group, Yellow owlclover was present for one growing season (2003) with a mean 0.10 stems/m^2 density. On the silty site during the second year group, Yellow owlclover was present for one growing season (1995) with a mean 0.33% basal cover. On the silty site during the third year group, Yellow owlclover was present for two growing seasons (2005 and 2009) with a mean 0.35 stems/m^2 density and for two growing seasons (2005 and 2006) with a mean 0.03% basal cover. Yellow owlclover was present on the ungrazed seasonlong treatment 9 times in 30 years.

On the grazed seasonlong treatment, Yellow owlclover was not present on the sandy site during the first 10 year group and not present on the shallow site during the first and second 10 year groups. On the sandy site during the second 10 year group, Yellow owlclover was present for one growing season (2001) with a mean 0.10 stems/m^2 density and for one growing season (1997) with a mean 0.03% basal cover. On the sandy site during the third 10 year group, Yellow owlclover was present for one growing seasons (2009) with a mean 0.10 stems/m^2 density. On the shallow site during the third 10 year group, Yellow owlclover was present for one growing season (2007) with a mean 0.10 stems/m^2 density and for one growing season (2005) with a mean 0.01% basal cover. On the silty site during the first 10 year group, Yellow owlclover was present for one growing season (1987) with a mean 0.70 stems/m^2 density and for one growing season (1987) with a mean 0.01% basal cover. On the silty site during the second 10 year group, Yellow owlclover was present for three growing seasons (1999, 2001, and 2002)) with a mean 0.10 stems/m^2 density and for one growing season (1995) with a mean 0.01% basal cover. On the silty site during the third 10 year group, Yellow owlclover was present for one growing seasons (2005) with a mean 0.80 stems/m^2 density. Yellow owlclover was present on the grazed seasonlong treatment 12 times in 30 years.

On the ungrazed twice-over treatment, Yellow owlclover was not present on the sandy site during the three 10 year groups, not present on the shallow sites during the second and third 10 year groups, and nor present on the silty site during the third 10 year group. On the shallow site during the first 10 year group, Yellow owlclover was present for one growing season (1984) with a mean 0.04% basal cover. On the silty site during the first 10 year group, Yellow owlclover was present for one growing season (1986) with a mean 0.60 stems/m^2 density. On the silty site during the second 10 year group, Yellow owlclover was present for one growing season (1995) with a mean 0.16% basal cover. Yellow owlclover was present on the ungrazed twice-over treatment 3 times in 30 years.

On the grazed twice-over treatment, Yellow owlclover was not present on the sandy site during the first 10 year group and was not present on the shallow site during the first and second 10 year groups. On the sandy site during the second 10 year group, Yellow owlclover was present for two growing seasons (1999 and 2001) with a mean 0.20 stems/m^2 density and for one growing season (1999) with a mean 0.01% basal cover. On the sandy site during the third 10 year group, Yellow owlclover was present for one growing seasons (2005) with a mean 0.10 stems/m^2 density. On the shallow site during the third 10 year group, Yellow owlclover was present for one growing season (2005) with a mean 0.10 stems/m^2 density. On the silty site during the first 10 year group, Yellow owlclover was present for two growing seasons (1983 and 1984) with a mean 0.15 stems/m^2 density and for two growing seasons (1986 and 1987) with a mean 0.40% basal cover. On the silty site during the second 10 year group, Yellow owlclover was present for one growing season (1995)) with a mean 0.03% basal cover. On the silty site during the third 10 year group, Yellow owlclover was present for one growing seasons (2005) with a mean 0.01% basal cover. Yellow owlclover was present on the grazed seasonlong treatment 11 times in 30 years.

Yellow owlclover has low abundance and was present only 37 times in 16 growing seasons. Yellow owlclover was present on the shallow sites of the ungrazed (1) and grazed (2) seasonlong and ungrazed (1) and grazed (1) twice-over and grazed (3) seasonlong and grazed (4) twice-over treatments for a total of 10 times (27.0%). Yellow owlclover was present on the silty sites of the nongrazed (2), ungrazed (5) and grazed (7) seasonlong, and ungrazed (2) and grazed (6) twice-over treatments for a total of 22 times (59.5%).

Yellow owlclover was present during the first 10 year group on the sandy (0), shallow (1), silty sites for a total of 8 times (21.6%). Yellow owlclover was present during the second 10 year group on the sandy (5), shallow (0), and silty (7) sites for a total of 12 times (32.4%). Yellow owlclover was present during the third 10 year group on the sandy (5), shallow (4), and silty (8) sites for a total of 17 times (45.9%). The silty ecological sites of the grazed seasonlong and grazed twice-over treatments were the only sites that Yellow owlclover ws present during the first, second, and third year groups.

Yellow owlclover was present on the nongrazed treatment two times (5.4%). Yellow owlclover was present on the ungrazed (9) and grazed (12) seasonlong treatment for a total of 21 times (56.8%). Yellow owlclover was present on the ungrazed (3) and grazed (1) twice-over treatments for a total of 14 times (37.8%).

Discussion

Yellow owlclover has two significant attributes of interest: it is historically important to the

Northern Plains and North Dakota and it has a peculiar method of procuring water and essential nutrients.

The type specimen for which the scientific genus and species names were given to yellow owlclover was collected in North Dakota near the historic Ft. Mandan site where the Lewis and Clark expedition spent the winter of 1804-1805. Thomas Nuttal (1786-1859) was an English-American naturalist who resided in the United Stated during 1808-1841 and named many of the plant species growing in the Northern Plains. In the spring of 1811, Nuttal journeyed 1500 miles up the Missouri River with Jacob Astor party to Fort Mandan which had become a part of the Missouri Fur Company that was located near the mouth of the Knife River. Nuttal was employed to collect plants in the northwest. Among the plants collected that summer was Yellow owlclover which was previously unknown to science and Nuttal was able to name both the genus and species *Orthocarpus luteus* Nutt.

Yellow owlclover is a hemiparasite which is technically a partial or facultative parasite. The plant can perform photosynthesis, however, because it has developed root systems, it cannot supply all of the nutrient requirements sufficiently. As a result, it has developed specialized root-like structures, haustoria, that can penetrate the roots of nearby host plants to absorb nutrients and water.

Yellow owlclover, *Orthocarpus luteus* Nutt., is a late succession annual hemiparasitic forb of the figwort family that is present on healthy mixed grass prairie communities when early spring precipitation is well above average. Yellow owlclover was present on the sandy sites 6 times with a mean 0.40 stems/m^2 density and 4 times with a mean 0.02% basal cover. Yellow owlclover was present on the shallow sites 3 times with a mean 0.10 stems/m^2 density and 2 times with a mean 0.03% basal cover. Yellow owlclover was present on the silty sites 12 times with a mean 0.38 stems/m^2 density and 10 times with a mean 0.17% basal cover. Yellow owlclover can grow on sandy, shallow, silty and clayey ecological sites, however, it grows poorly on shallow sites. Early spring aerial growth is from a seed during years with greater than average precipitation during April and/or May. A single stalk develops. The mean first flower date was 26 July (1955-1962 study) with a five week flower period from early July to first week of August (1969-1971 study) and within a 6.5 week flower period on the sandy and silty sites from late June to early August, a 5.5 week flower period on the clayey sites from late June to late July, and a 2 week flower period on the shallow sites during late July (1984-1985 study). Mean mature stem height reached during July was 18.3 cm (7.2 in) (1955-1962 study) and was 16.9 cm (6.7 in) on the sandy sites, 14.4 cm (5.7 in) on the silty sites, 12.5 cm (4.9 in) on the clayey sites, and 10.4 cm (4.1 in) on the shallow sites (1984-1985 study). Mean ste weight ranges from 0.29 g to 0.16 g (1984-1985 study). Yellow owlclover grows from seed in the spring and is dependent on early season above average precipitation for germination and relies on root-like haustoria to procure water and essential nutrients from nearby host plants.

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Table 1. First flower and flower period of Orthocarpus luteus, yellow owlclover.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest				20		
Mean				26		
Flower Period						
1969-1971			XX	XX	X	

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

Table 2. Autecology of Orthocarpus luteus, yellow owlclover, 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	9.0	25.0	18.3				100.0		

Data from Goetz 1963.

Table 3. Phenological growth stage changes during the growing season for Orthocarpus luteus, yellow owlclover, 1984-1985.

Site Sandy	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	100.0	68.4	39.3	18.9	2.8	
Bud		21.1	15.5	5.6		
Anth		10.5	35.7	38.9	7.0	
Seed Dev			8.3	20.0	40.8	11.5
Seed Shed				4.4	31.0	15.4
Mat			1.2	12.2	18.3	73.1
Mean Height (cm)						
Veg	10.2	13.3	9.7	9.6	3.9	
Bud		19.3	13.4	15.4		
Anth		18.6	18.9	16.8	13.3	
Seed Dev			19.2	11.2	11.9	13.8
Seed Shed				18.3	17.9	17.1
Mat			20.1	19.5	18.3	17.9
% Dryness						
Veg	0.0	0.4	3.4	31.8	2.0	
Bud		0.5	0.7	13.0		
Anth		1.0	9.6	7.3	11.2	
Seed Dev			32.2	45.8	30.5	41.7
Seed Shed				93.8	52.4	62.0
Mat			75.0	95.2	96.0	82.8
Mean Weight (g)	0.15	0.23	0.31	0.40	0.19	0.46

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 4. Phenological growth stage changes during the growing season for Orthocarpus luteus, yellow owlclover, 1984-1985.

Site Shallow	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	100.0	100.0		22.2		
Bud						
Anth				50.0		
Seed Dev				27.8	58.3	10.0
Seed Shed					41.7	60.0
Mat						30.0
Mean Height (cm)						
Veg	6.2	1.5		6.2		
Bud						
Anth				8.7		
Seed Dev				11.0	11.6	17.2
Seed Shed					17.4	18.0
Mat						13.1
% Dryness						
Veg	0.0	0.0		31.2		
Bud						
Anth				4.3		
Seed Dev				35.4	22.3	25.0
Seed Shed					25.0	45.8
Mat						100.00
Mean Weight (g)	-	0.08	0.21	0.21	0.20	0.10

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 5. Phenological growth stage changes during the growing season for Orthocarpus luteus, yellow owlclover, 1984-1985.

Site Silty	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	100.0	73.8	39.2			
Bud		18.0	11.4	3.8	4.3	
Anth		8.2	29.1	67.3	4.3	
Seed Dev			17.7	28.8	34.8	
Seed Shed			2.5		37.0	32.0
Mat					19.6	68.0
Mean Height (cm)						
Veg	8.1	5.1	9.4			
Bud		17.7	11.2	10.7	14.1	
Anth		13.6	16.2	13.4	17.6	
Seed Dev			13.1	16.0	15.4	
Seed Shed			13.5		18.9	17.2
Mat					15.8	17.3
% Dryness						
Veg	1.0	4.5	3.4			
Bud		2.8	1.1	0.0	26.0	
Anth		1.2	6.2	7.8	13.5	
Seed Dev			33.9	14.1	45.3	
Seed Shed			50.0		55.7	99.3
Mat					88.0	86.6
Mean Weight (g)	0.17	0.06	0.25	0.45	0.31	0.22

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 6. Phenological growth stage changes during the growing season for Orthocarpus luteus, yellow owlclover, 1984-1985.

Site Clayey	8 Jun	23 Jun	8 Jul	23 Jul	8 Aug	23 Aug
% Population						
Veg	100.0	66.7	33.3	14.9	1.5	2.0
Bud		6.1	12.1	3.0	1.5	
Anth		27.3	45.5	50.7		
Seed Dev			9.1	10.4	46.3	13.7
Seed Shed				1.5	34.3	29.4
Mat				19.4	16.4	54.9
Mean Height (cm)						
Veg	9.5	7.8	9.9	11.7	4.6	6.5
Bud		9.6	12.3	11.0	6.8	
Anth		12.4	14.0	13.2		
Seed Dev			11.4	13.7	12.1	11.4
Seed Shed				10.1	12.3	12.7
Mat				11.4	12.8	14.1
% Dryness						
Veg	10.4	0.6	2.8	48.3	50.0	75.0
Bud		0.0	4.8	2.0	2.0	
Anth		0.5	4.2	5.8		
Seed Dev			12.0	64.3	37.4	46.1
Seed Shed				100.0	72.8	89.7
Mat				86.4	83.9	91.9
Mean Weight (g)	-	0.08	0.16	0.24	0.25	0.33

Phenological Growth Stages: Vegetative (Veg), Budding (Bud), Anthesis (Anth), Seed Developing (Seed Dev), Seed Shedding (Seed Shed), Mature (Mat).

Table 7. Autecology of Orthocarpus luteus, Owl clover, 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					
1988-1992					
1993-1998					
1999-2003			0.09		0.18
2004-2009		1.23	0.08		
2010-2012					
Shallow					
1983-1987					
1988-1992					
1993-1998					
1999-2003		0.09			
2004-2009			0.07		0.11
2010-2012					
Silty					
1983-1987			2.40	0.73	0.51
1988-1992					
1993-1998					
1999-2003			0.31		
2004-2009	0.19	0.39	0.34		
2010-2012	1.46				

Table 8. Autecology of Orthocarpus luteus, Owl clover, with growing season changes in basal cover importance value, 1983-2012.					
Ecological Site Ten Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987					
1988-1992					
1993-1998					
1999-2003					0.01
2004-2009		0.02	0.05		0.01
2010-2012					
Shallow					
1983-1987				0.05	
1988-1992					
1993-1998					
1999-2003					
2004-2009			0.01		
2010-2012					
Silty					
1983-1987			0.30		0.57
1988-1992					
1993-1998		0.55	0.25	0.24	0.04
1999-2003					
2004-2009		0.07			0.01
2010-2012					

Table 9. Autecology of Orthocarpus luteus, Owl clover, with growing season changes in density, 1983-2012.					
Ecological Site Ten Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987					
010988-1992					
1993-1998					
1999-2003			0.01		0.01
2004-2009		0.03	0.01		
2010-2012					
Shallow					
1983-1987					
1988-1992					
1993-1998					
1999-2003		0.01			
2004-2009			0.01		0.01
2010-2012					
Silty					
1983-1987			0.07	0.02	0.01
1988-1992					
1993-1998					
1999-2003			0.01		
2004-2009	0.01	0.01	0.01		
2010-2012	0.03				

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