Autecology of Indian Breadroot on the Northern Mixed Grass Prairie

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Report DREC 17-1149

The autecology of Indian breadroot, *Psoralea esculenta*, 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).

Indian breadroot, *Psoralea esculenta* Pursh, is a member of the legume (bean, pea) family, Fabaceae, syn.: *Pediomelum esulentum* (Pursh) Rybd., and is a native, perennial, cool season, dicot, herb. The first North Dakota record is Bolley 1891. Annual aerial growth has one to three stout, erect stems with spreading branches above, 10-30 cm (3.9-11.8 in) tall arising from a thickened vertical crown (caudex) extending 4-10 cm (1.6-3.9 in) below the soil surface. Leaves are alternate in clusters, palmately compound of 5 foliate, with leaflets obovate to elliptic 2-6 cm (0.8-2.4 in) long, on petioles 5-10 cm (2.0-3.9 in) long. Stems and underneath of leaves densely hairy. The root system consists of a prominent taproot developing from the thick vertical crown at about 8 cm (3 in) below the soil surface, it continues downward below the enlarged portion and develops fibrous lateral roots. The taproot thickens at about 10 cm (3.9 in) below the soil surface into a tuberous egg shaped storage organ, 3-8 cm (1.2-3.1 in) in diameter, enclosed in a thick brown leathery skin. The contents of the tuber are eatable consisting mainly of 50% starch, along with 7% protein and an important amount of vitamin C. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the vertical crown. Inflorescence has a dense cluster of flowers 5-10 cm (2-4 in) long on a long stout stalk arising from leaf axil. Flowers have a blue corolla 12-15 mm long appearing during late May to early July. Fruit is a 1 seeded, egg shaped, brownish, legume pod with a beak. The aerial stems break off at ground level at an abscission layer during mid to late summer and tumble with the wind spreading seeds. Aerial parts are not eaten by livestock and are top killed by fire. Damage to aerial parts activates regrowth shoots from the vertical crown. This summary information on growth development and regeneration of Indian breadroot was based on works of Weaver and Fitzpatrick 1934, Weaver 1954, Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, and Larson and Johnson 2007.

Procedures

The 1955-1962 Study

Indian breadroot 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 Indian breadroot 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 Indian breadroot 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 Indian breadroot 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

Indian breadroot resumes annual aerial growth with a stout stem that has spreading branches above arising from a thick vertical caudex extending 4-10 cm (1.6-3.9 in) below the soil surface. A prominent taproot continues downward from caudex, thickens into a tuberous egg shaped storage organ, 3-8 cm (1.2-3.1 in) in diameter, enclosed in a thick brown leathery skin. The taproot continues downward developing fibrous lateral roots. Numerous small blue flowers develop as a dense cluster on a stout stalk. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 10 June, the mean first flowers occurred on 21 June, with a 5 week flower period from late May to the end of June (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 17.1 cm (6.7 in) with an annual variance in height from 11.0 cm (4.3 in) to 24.0 cm (9.4 in) was reached during July (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 10.0 cm (3.9 in) to 30 cm (11.8 in) tall. The mature stem height 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. 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, Indian breadroot was not present where basal cover data were collected and was present during 11.1% of the years that density data were collected with a mean 0.07 stems/m^2 density during the total 30 year period. During the early period (1983-1992), Indian breadroot was not present on the sandy site of the nongrazed treatment. During the later period (1998-2012), Indian breadroot was present during 14.3% of the years with a mean 0.09 stems/m^2 density. Indian breadroot was not present where basal cover data were collected 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 sandy site of the ungrazed seasonlong treatment, Indian breadroot was not present where density data were collected and was present during 4.0% of the years that basal cover data were collected with a mean 0.002% basal cover during the total 30 year period. During the early period (1983-1992), Indian breadroot was not present on the sandy site of the ungrazed seasonlong treatment. During the later period (1998-2012), Indian breadroot was present during 6.7% of the years with a mean 0.003% basal cover. Indian breadroot was not present where density data were collected and was not present with basal cover during the early period and all basal cover observations were made during the later period that indicated low abundance.

On the sandy site of the grazed seasonlong treatment, Indian breadroot was not present where basal cover were collected and was present during 10.5% of the years that density data were collected with a mean 0.06 stems/m^2 density during the total 30 year period. During the early period (1983-1992), Indian breadroot was not present on the sandy site of the grazed seasonlong treatment. During the later period (1998-2012), Indian breadroot was present during 13.3% of the years with a mean 0.08 stems/m^2 density. Indian breadroot was not present where basal cover data were collected 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 sandy site of the ungrazed twice-over treatment, Indian breadroot was present during 9.5% and 14.0% of the years that density and basal cover data were collected with a mean 0.06 stems/m^2 density and a mean 0.014% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Indian breadroot was present during 16.7% and 25.0% of the years with a mean 0.13 stems/m^2 density and a mean 0.029% basal cover, respectively. During the later period (1998-2012), Indian breadroot was present during 6.7% and 6.7% of the years with a mean 0.03 stems/m^2 density and a mean 0.003% basal cover, respectively. The percent present, stem density, and basal cover all decreased on the sandy site of the ungrazed twice-over treatment over time (tables 3, 4, and 5).

On the sandy site of the grazed twice-over treatment, Indian breadroot was present during 9.5% and 6.9% of the years that density and basal cover data were collected with a mean 0.04 stems/m^2 density and a mean 0.07% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Indian breadroot was present during 16.7% and 11.1% of the years with a mean 0.07 stems/m^2 density and a mean 0.19% basal cover, respectively. During the later period (1998-2012), Indian breadroot was present during 6.7% and 6.7% of the years with a mean 0.03 stems/m^2 density and a mean 0.007% basal cover, respectively. The percent present, stem density, and basal cover all decreased on the sandy site of the grazed twice-over treatment over time (tables 3, 4, and 5). The percent present, stem density, and basal cover were fairly similar on the sandy site of the ungrazed and grazed twice-over treatments.

On the shallow site of the nongrazed treatment, Indian breadroot was not present where basal cover data were collected and was present during 15.8% of the years that density data were collected with a mean 0.08 stems/m^2 density during the total 30 year period. During the early period (1983-1992), Indian breadroot was present during 20.0% of the years with a mean 0.16 stems/m^2 density. During the later period (1998-2012), Indian breadroot was present during 14.3% of the years with a mean 0.06 stems/m^2 density. Basal cover data was not present during the total 30 year period. The percent present for density data and stem density decreased on the shallow site of the nongrazed treatment.

On the shallow site of the ungrazed seasonlong treatment, Indian breadroot was not present during the total 30 year period.

On the shallow site of the grazed seasonlong treatment, Indian breadroot was not present where basal cover data were collected and was present during 5.0% 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), Indian breadroot was not present on the shallow site of the grazed seasonlong treatment. During the later period (1998-2012), Indian breadroot was present during 6.7% of the years with a mean 0.03 stems/m^2 density. Basal cover data was not present during the total 30 year period. Indian breadroot was not present during the early period and all density observations were made during the later period indicated low abundance.

On the shallow site of the ungrazed twice-over treatment, Indian breadroot was present during 50.0% and 24.1% of the years that density and basal cover data were collected with a mean 0.32 stems/m^2 density and a mean 0.023% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Indian breadroot was present during 57.1% and 33.3% of the years with a mean 0.53 stems/m^2 density and a mean 0.05% basal cover, respectively. During the later period (1998-2012), Indian breadroot was present during 46.7% and 13.3% of the years with a mean 0.23 stems/m^2 density and a mean 0.007% basal cover, respectively. The percent present, stem density, and basal cover all decreased 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, Indian breadroot was present during 13.6% and 13.3% of the years that density and basal cover data were collected with a mean 0.10 stems/m^2 density and a mean 0.015% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Indian breadroot was present during 28.6% and 20.0% of the years with a mean 0.23 stems/m^2 density and a mean 0.02% basal cover, respectively. During the later period (1998-2012), Indian breadroot was present during 6.7% and 6.7% of the years with a mean 0.04 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, Indian breadroot was present during 5.3% and 3.9% 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), Indian breadroot was not present on the silty site of the nongrazed treatment. During the later period (1998-2012), Indian breadroot was present during 7.1% and 6.7% of the years with a mean 0.06 stems/m^2 density and a mean 0.003% basal cover, respectively. Indian breadroot was not present during the early period and all observations were made during the later period that indicated low abundance.

On the silty site of the ungrazed seasonlong treatment, Indian breadroot was not present where basal cover data were collected and was present during 15.0% of the years that density data were collected with a mean 0.08 stems/m^2 density. During the early period (1983-1992), Indian breadroot was not present on the silty site of the ungrazed seasonlong treatment. During the later period (1998-2012), Indian breadroot was present during 20.0% of the years with a mean 0.11 stems/m^2 density. Basal cover data was not present during the total 30 year period. Indian breadroot 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 silty site of the grazed seasonlong treatment, Indian breadroot 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 0.04 stems/m^2 density during the total 30 year period. During the early period (1983-1992), Indian breadroot was present during 20.0% of the years with a mean 0.08 stems/m^2 density. During the later period (1998-2012), Indian breadroot was present during 6.7% of the years, with a mean 0.03 stems/m^2 density. Basal cover data was not present during the total 30 year period. The percent present for density data and stem density decreased on the silty site of the grazed seasonlong treatment over time (tables 3 and 5). Basal cover data was not present during the total 30 year period on the silty site of the ungrazed and grazed treatment. The percent present for density data and stem density were slightly larger 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, Indian breadroot was present during 13.6% and 6.9% of the years that density and basal cover data were collected with a mean 0.06 stems/m^2 density and a mean 0.01% basal cover during the total

30 year period, respectively. During the early period (1983-1992), Indian breadroot was present 28.6% and 22.2% of the years with a mean 0.11 stems/m^2 density and a mean 0.03% basal cover, respectively. During the later period (1998-2012), Indian breadroot was present during 6.7% and 0.0% of the years with a mean 0.03 stems/m^2 density and a mean 0.0% basal cover, respectively. The percent present, stem density, and basal cover all decreased greatly 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, Indian breadroot was present during 22.7% and 10.0% of the years that density and basal cover data were collected with a mean 0.11 stems/m^2 density and a mean 0.007% basal cover during the total 30 year period, respectively. During the early period (1983-1992), Indian breadroot was present during 28.6% and 10.0% of the years with a mean 0.17 stems/m^2 density and a mean 0.01% basal cover, respectively. During the later period (1998-2012), Indian breadroot was present during 20.0% and 6.7% of the years with a mean 0.08 stems/m^2 density and a mean 0.003% basal cover, respectively. The percent present, stem density, and basal cover all decreased 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 fairly similar on the silty site of the ungrazed and grazed twice-over treatment.

On the sandy site, Indian breadroot was present during 8.1% and 4.9% of the years with a mean 0.05 stems/m^2 density and a mean 0.02% basal cover. On the shallow site, Indian breadroot was present during 16.9% and 7.5% of the years with a mean 0.11 stems/m^2 density and a mean 0.01% basal cover. On the silty site, Indian breadroot was present during 13.3% and 4.2% of the years with a mean 0.07 stems/m^2 density and a mean 0.004% basal cover. The percent present and stem density were greater on the shallow site and basal cover was greater on the sandy site.

On the sandy site of the nongrazed treatment, Indian breadroot was present during 11.1% and 0.0% of the years with a mean 0.07 stems/m^2 density and a mean 0.0% basal cover. On the sandy site of the seasonlong treatment, Indian breadroot was present during 5.3% and 2.0% of the years with a mean 0.03 stems/m^2 density and a mean 0.001% basal cover. On the sandy site of the twice-over treatment, Indian breadroot was present during 9.5% and 10.4% of the years with a mean 0.05 stems/m^2 density and a mean 0.04% basal cover. The percent present for density data and stem density were greater on the sandy site of the nongrazed treatment. The percent present for basal cover data and basal cover were greater on the sandy site of the twice-over treatment.

On the shallow site of the nongrazed treatment, Indian breadroot was present during 15.8% and 0.0% of the years with a mean 0.08 stems/m^2 density and a mean 0.0% basal cover. On the shallow site of the seasonlong treatment, Indian breadroot was present during 2.5% and 0.0% of the years with a mean 0.01 stems/m^2 density and a mean 0.0% basal cover. On the shallow site of the twice-over treatment, Indian breadroot was present during 31.8% and 18.7% of the years with a mean 0.21 stems/m^2 density and a mean 0.02% basal cover. The percent present, stem density, and basal cover were all greater on the shallow site of the twice-over treatment.

On the silty site of the nongrazed treatment, Indian breadroot was present during 5.3% and 3.9% of the years with a mean 0.04 stems/m^2 density and a mean 0.002% basal cover. On the silty site of the seasonlong treatment, Indian breadroot was present during 12.5% and 0.0% of the years with a mean 0.06 stems/m^2 density and a mean 0.0% basal cover. On the silty site of the twice-over treatment, Indian breadroot was present during 18.2% and 8.5% of the years with a mean 0.08 stems/m^2 density and a mean 0.01% basal cover. The percent present, stem density, and basal cover were all greater on the silty site of the twice-over treatment.

Discussion

Indian breadroot, *Psoralea esculenta*, is a native, late succession, perennial, cool season, dicot, forb of the legume family that is commonly present on healthy mixed grass prairie plant communities. Indian breadroot can grow on sandy, shallow, and silty ecological sites. It grows better on the shallow site and best on the shallow sites managed with the twice-over treatment. Annual aerial growth produces a single widely branched stem arising from a perennating caudex that extends 4-10 cm (1.6-3.9 in) into the soil. A prominent taproot continues downward from the caudex, thickens into a large storage organ, then continues to descend deeper. The lower portion has numerous lateral roots. Numerous small blue flowers form in a dense cluster on a stout stalk. The mean first flowers appeared 21 June (1955-1962 study), with a 5 week flower period from late May to the end of June (1969-1971 study). The mean mature stem height of 17.1 cm (6.7 in) was reached during July (1955-1962 study). The stem breaks off at an abscission joint in late summer and

spreads seeds as a tumbleweed. The abundance of Indian breadroot was affected by management treatment. The abundance was considerably lower on the seasonlong and nongrazed treatments than that on the twice-over treatment.

The perennating deep caudex, the deep taproot, the large storage organ, and the tumbleweed method to spread seeds help Indian breadroot to persist through the harsh conditions of the Northern Mixed Grass Prairie.

Acknowledgment

I am grateful to Sheri Schneider for assistance in the production of this manuscript and for development of the tables.

Table 1. First flower and flower period of Psoralea esculenta, Indian breadroot.

	Apr	May	Jun		Jul	Aug	Sep
First Flower							
1955-1962							
Earliest			10				
Mean				21			
Flower Period							
1969-1971		X	XX	XX			

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

Table 2. Autecology of Psoralea esculenta, Indian breadroot, 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	11.0	24.0	17.1		29.6	96.4	100.0		

Data from Goetz 1963.

Table 3. Autecology of Psoralea esculenta, Indian breadroot, 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	0.00	0.00	0.00	2.62	0.85
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	0.56	0.57	0.00
2004-2009	1.22	0.00	0.35	0.00	0.45
2010-2012	0.00	0.00	0.00	0.00	0.00
Shallow					
1983-1987	0.00	0.00	0.00	3.50	0.96
1988-1992	3.45	0.00	0.00	7.02	3.65
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	0.67	1.13	0.00
2004-2009	0.54	0.00	0.00	2.36	0.35
2010-2012	0.64	0.00	0.00	0.99	0.00
Silty					
1983-1987	0.00	0.00	1.65	1.17	1.07
1988-1992	0.00	0.00	0.00	0.00	1.83
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	0.00	0.74	1.31
2004-2009	0.62	1.23	0.32	0.00	0.31
2010-2012	0.00	0.00	0.00	0.00	0.00

Table 4. Autecology of Psoralea esculenta, Indian breadroot, 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	0.00	0.00	0.00	0.00	0.00
1988-1992	0.00	0.00	0.00	0.62	4.45
1993-1998	0.00	0.00	0.00	0.16	0.00
1999-2003	0.00	0.00	0.00	0.10	0.15
2004-2009	0.00	0.06	0.00	0.00	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00
Shallow					
1983-1987	0.00	0.00	0.00	0.19	0.13
1988-1992	0.00	0.00	0.00	0.56	0.21
1993-1998	0.00	0.00	0.00	0.22	0.36
1999-2003	0.00	0.00	0.00	0.09	0.09
2004-2009	0.00	0.00	0.00	0.06	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00
Silty					
1983-1987	0.00	0.00	0.00	0.16	0.16
1988-1992	0.00	0.00	0.00	0.38	0.00
1993-1998	0.00	0.00	0.00	0.00	0.07
1999-2003	0.00	0.00	0.00	0.00	0.08
2004-2009	0.11	0.00	0.00	0.00	0.00
2010-2012	0.00	0.00	0.00	0.00	0.00

Table 5. Autecology of Psoralea esculenta, Indian breadroot, with growing season changes in density, 1983-					
Ecological Site Year Period	Nongrazed	Seasonlong		Twice-over	
		Ungrazed	Grazed	Ungrazed	Grazed
Sandy					
1983-1987	0.00	0.00	0.00	0.03	0.01
1988-1992	0.00	0.00	0.00	0.00	0.00
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	0.02	0.01	0.00
2004-2009	0.02	0.00	0.01	0.00	0.01
2010-2012	0.00	0.00	0.00	0.00	0.00
Shallow					
1983-1987	0.00	0.00	0.00	0.07	0.03
1988-1992	0.02	0.00	0.00	0.04	0.02
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	0.01	0.02	0.00
2004-2009	0.01	0.00	0.00	0.03	0.01
2010-2012	0.01	0.00	0.00	0.01	0.00
Silty					
1983-1987	0.00	0.00	0.04	0.03	0.01
1988-1992	0.00	0.00	0.00	0.00	0.02
1993-1998	0.00	0.00	0.00	0.00	0.00
1999-2003	0.00	0.00	0.00	0.01	0.02
2004-2009	0.01	0.03	0.01	0.00	0.01
2010-2012	0.00	0.00	0.00	0.00	0.00

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