CONTENTS
VOLUME 3

Autecology of Forbs on the Northern Mixed Grass Prairie

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Prairie ecosystems are complex; exceedingly more complex than the most complicated machines ever built by humans. The long-standing standard process to understand complex systems is to initially investigate the separate component parts. The gained knowledge of each part combined with the synergistic effects resulting when the parts work together provide the information needed to develop an understanding of the whole ecosystem. This classical concept of biological systems was developed by the Greek philosopher/scientist Aristotle (384-322 BC) who taught that "the whole is greater than the sum of its parts".

The goals of this study were developed by Dr. Warren C. Whitman (c. 1950) and Dr. Harold Goetz (1963) which were to gain quantitative knowledge of each component species and to provide a pathway essential for the understanding of the whole prairie ecosystem that would result in the development and establishment of scientific standards for proper management of native rangelands of the Northern Plains.

This report contains descriptions of the changes in growth and development during the annual growing season life history of 47 forbs, 17 cool season perennials, 19 warm season perennials, 6 biennials, 2 winter annuals, and 3 annuals, species living on Northern Mixed Grass Prairie ecosystems. These data were collected during 67 growing seasons of ecological studies at the NDSU Dickinson Research Extension Center over a time period from 1946 to 2012.

Forbs are broad-leaved, flowering herbaceous plants that do not develop permanent woody stems and the aerial parts die at the end of each growing season. During unfavorable conditions, biennial and perennial forbs persist by specialized subterranean caudexes that have vegetative buds from which the next growing season's aerial parts develop.

Companion reports of autecological studies provide quantitative descriptions of the growing season life history of grass and upland sedge species and of shrubs and subshrubs species living on the Northern Mixed Grass Prairie.

Autecology of Toothleaved evening primrose on the Northern Mixed Grass Prairie

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The autecology of Toothleaved evening primrose (Plains yellow primrose), *Calylophus serrulatus*, 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).

Toothleaved evening primrose (Plains yellow primrose), *Calylophus serrulatus* (Nutt.) Raven, is a member of the evening primrose family, Onagraceae, syn.: *Oenothera serrulata* Nutt., and is a native, perennial, dicot, herb that is extremely drought and heat tolerant. The first North Dakota record is Moran 1937. Annual aerial growth has a single to several slender erect to decumbent stems 15-50 cm (5.9-19.7 in) tall arising from a persistent stout, highly branched woody crown (caudex) that may rise above the soil surface. Stem leaves are alternate linear, lanceolate, or oblanceolate to oblong, 2-5 cm (0.8-2.0 in) long with fine shallow teeth. Stems and leaves are covered with dense hairs. The root system has a long, tough taproot arising from the woody crown that can descend 1.2-1.5 m (4-5 ft) deep. Numerous main roots arise from near the crown, spread horizontally, then descend vertically to the depth of the taproot. Numerous, mostly unbranched fibrous lateral roots about 1 mm in diameter fill the area from immediately below the soil surface to a depth of about 61 cm (2 ft). This root system has the capacity for vigorous absorption of water and nutrients. A system of horizontal rhizomes develop from the crown. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the woody crown and by sprouts from the rhizome system. Inflorescence are numerous solitary flowers arising from leaf axils of the upper stems. Flowers have 4 yellow petals, 2-3 cm (0.8-1.2 in) wide, that open in the morning and close in the afternoon that appear during early June to early August. Fruit is a cylindrical capsule. Aerial parts are sometimes eaten by livestock and are top killed by fire. Damage to aerial stems activates sprouts from the rhizomes. This summary information on growth development and regeneration of Toothleaved evening primrose was based on works of Weaver 1958, Stevens 1963, Zaczkowski 1972, Great Plains Flora Association 1986, Esquivel 2006, and Larson and Johnson 2007.

Procedures

The 1955-1962 Study

Toothleaved evening primrose 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 Toothleaved evening primrose 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.

Results

Toothleaved evening primrose (Plains yellow primrose) resumes annual aerial growth usually as multiple ascending woody stems arising from a stout woody branched caudex with a deep tough taproot that can descend 1.2 to 1.5 m (4-5 ft) deep. Numerous main roots arise from the taproot near the crown, spread horizontally, turn downward and descend to the level of the taproot. Numerous fibrous lateral roots arise from the main roots in the

top 61 cm (2 ft) of soil. This extensive root system vigorously absorbs water and nutrients. A creeping horizontal rhizome system develops just below the soil surface from the woody branched caudex. Numerous solitary flowers with yellow petals arise from leaf axils of the upper portion of the stem. Flowers open in the evening or early morning and close by noon. On the fall grazed pastures of the 1955-1962 study, the earliest first flowers appeared 9 June, the mean first flowers occurred on 25 June, and the long nine week flower period extends from early June through the first week of August (table 1) (Goetz 1963, Zaczkowski 1972). A mean mature stem height of 16.6 cm (6.5 in) with an annual variance in height from 14.0 cm to 19.0 cm (5.5-7.5 in) was reached during August (table 2) (Goetz 1963). The reported normal mature stem height in the Northern Plains ranged from 15 cm to 50 cm (5.9-19.7 in) tall. The mean stem heights measured during the 1955-1962 study were within or slightly shorter than the low end of the normal range in height for the Northern Plains. The stems become quite woody and on some occasions the branched woody caudex may rise above the soil surface and persist at that condition. As a result of the woody stems and elevated woody caudex, some plant taxonomists have classified this growth behavior as a halfshrub or subshrub. Goetz (1963) found Toothleaved evening primrose to grow best on shallow ecological sites on the upper slopes of hills. Zaczkowski (1972) found Toothleaved evening primrose to grow best on shallow ecological sites on hill slopes and on sandy ecological sites.

Discussion

Toothleaved evening primrose (Plains yellow primrose), *Calylophus serrulatus*, is a native, late succession, perennial, dicot, forb of the evening primrose family that is sometimes present on healthy mixed grass prairie plant communities. Toothleaved evening primrose can grow on sandy and shallow ecological sites. Annual aerial growth consists of a few to several ascending to decumbent stems that become woody arise from a stout perennating highly branched woody caudex with spreading horizontal rhizomes. The long tough woody taproot can descend to 1.2-1.5 m (4-5 ft) deep. Numerous main roots densely covered with 1 mm diameter fibrous lateral roots radiate horizontally from the taproot before descending to the depth of the taproot are effective at absorption of water and nutrients. The flowers have four large yellow petals develop singly from leaf axils at the upper stem. The mean first flower date is 25 June (1955-1962 study), with a long nine week flower period from early June through the first week of August (1969-1971 study). The mean mature stem height of 16.6 cm (6.5 in) was reached during August (1955-1962 study). Toothleaved evening primrose has low abundance on the sandy and shallow ecological sites. The stout persistent branching woody caudex, the deep woody taproot, and the extensive, highly absorbent root system help Toothleaved evening primrose to persist through the harsh conditions of the Northern Mixed Grass Prairie.

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Table 1. First flower and flower period of Calylophus serrulatus, Pains yellow primrose.

	Apr	May	Jun		Jul		Aug	Sep
First Flower								
1955-1962								
Earliest			9					
Mean				25				
Flower Period								
1969-1971			XX	XX	XX	XX	X	

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

Table 2. Autecology of Calylophus serrulatus, Pains yellow primrose, 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	14.0	19.0	16.6		46.0	80.9	98.9	100.0	

Data from Goetz 1963.

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