RANGE MANAGEMENT REPORT

Plants that can Poison Livestock 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.

Poisonous plants synthesize (produce) or absorb from soil toxic substances, or they contain precursor chemicals that when eaten hydrolyze (change) into toxic substances. Plants that can poison livestock has been a serious perpetual problem of animal husbandry. In recent times, the federal Agricultural Research Service (USDA-ARS) and land grant university Agricultural Experiment Stations (AES) have been the primary sources for essential information on poisonous plants. These government institutions have chemically analyzed incalculable poisonous plant parts to isolate and describe the toxic substances and have conducted controlled feeding trials and performed autopsies to compile essential pathological data on the mode of poisoning, symptoms, and effects of treatments.

All of the vascular plants that grow on the Northern Mixed Grass Prairie and are known to cause poisoning when eaten by livestock have been included in this report. Each plant has been described by its growth development and regeneration characteristics and by its poisoning characteristics that include the chemical toxin, the toxic plant parts, the poisoning process, the resulting symptoms, and a summary of treatments. A total of 43 native and 5 introduced plants were categorized into 22 different groups of poisoning syndromes (table 1). The plants usually contain more than one toxin that affect different physiological processes and body functions that also react differently to age, weight, sex, and class of livestock; horse, cattle, sheep, or goat.

The Northern Mixed Grass Prairie fortunately has few poisonous plants and relatively few livestock mortalities caused by poisonous plants. However, the few losses that do occur each year are devastating for the affected livestock producers. More commonly, the quantity of subclinically reduced animal productivity due to poisonous plants has greater widespread impact on regional animal agriculture than previously acknowledged or recorded. In an effort to increase public cognition of poisonous plant problems, Dr. W.C. Whitman presented a lecture each year on poisonous plants in his range management class at NDSU accompanied with a 2 page summary mimeographed handout (Whitman nd). That summary handout had been the main source of information about poisonous plants for innumerable livestock producers, county agents, veterinarians, and educators for decades, but it is no longer available.

Plants that can poison livestock are part of the prairie ecosystems on the Northern Mixed Grass Prairie. Proper management of these ecosystems and the livestock they support requires a working knowledge of the poisonous plants biology and poisoning characteristics. This report is a continuation and expansion of the work Dr. Whitman started to provide the needed information on plants that can poison livestock in order for managers to be able to make knowledgeable decisions.

Unfortunately, plants are not the only things that can poison livestock. Most out buildings that had previously been painted with lead base paint have been repainted, however, there are still a few that need new paint, and for some reason cattle lick on those old buildings. Also most of the old discard

batteries that had been dumped in garbage pits behind the trees, have been cleaned up. However, some seasonal equipment still have exposed batteries and if livestock have access, they will lick on those batteries. Most agricultural operations have safe storage for the herbicides and pesticides, however, if mishandled, these can harm livestock. In addition, make sure all of the treated seed are stored away from livestock access. Many years ago, Paul Nyren (NDSU retired) figured out that underground cable treated against burrowing critters can be poisonous for livestock when exposed aboveground in a pasture. When I started my job more than four decades ago, there were far more livestock poisoned by lead base paint and discard batteries than by poisonous plants, and now those problems have been cleaned up. Hopefully, the quantity of livestock harmed by poisonous plants will continue to decrease.

Acknowledgment

I am grateful to Sheri Schneider for assistance in the production of this manuscript and for development of the reports on plant poisoning syndromes and the tables.

Table 1. Plants that can poison livestock.

Pteridophyta, Sphenophyta		
Equisetaceae	(Horsetail)	
Field horsetail		Equisetum arvense
Common scouring rush		Equisetum hyemale
Smooth scouring rush		Equisetum laevigatum
Pinophyta, Gymnosperm		
Pinaceae	(Pine)	
Ponderosa pine		Pinus ponderosa
Magnoliophyta, Magnoliopsida	(Dicots)	
Ranunculaceae	(Buttercup)	
Little blue larkspur		Delphinium bicolor
White prairie larkspur		Delphinium carolinianum
Chenopodiaceae	(Goosefoot)	
Halogeton		Halogeton glomeratus
Greasewood		Sarcobatus vermiculatus
Rosaceae	(Rose)	
Juneberry		Amelanchier alnifolia
Pincherry		Prunus pensylvanica
Sandcherry		Prunus pumila
Chokecherry		Prunus virginiana
Fabaceae	(Legume)	
Two grooved milkvetch		Astragalus bisulcatus
Narrow leaved milkvetch		Astragalus pectinatus
Alkali milkvetch		Astragalus racemosus

Table 1 (cont). Plants that can poison livestock.

Purple locoweed		Oxytropis lambertii
Two grooved milkvetch		Astragalus bisulcatus
Little rattlepod		Astragalus canadensis
Groundplum		Astragalus crassicarpus
Slender prairie milkvetch		Astragalus flexuosus
Lotus milkvetch		Astragalus lotiflorus
Missouri milkvetch		Astragalus missouriensis
Silver lupine		Lupinus argenteus
Small lupine		Lupinus pusillus
False lupine, Golden pea		Thermopsis rhombifolia
White sweetclover		Melilotus alba
Yellow sweetclover		Melilotus officinalis
Apiaceae	(Parsley)	
Water hemlock		Cicuta maculata
Apocynaceae	(Dogbane)	
Spreading dogbane		Apocynum androsaemifolium
Indianhemp		Apocynum cannabinum
Asclepiadaceae	(Milkweed)	
Showy milkweed		Asclepias speciosa
Common milkweed		Asclepias syriaca
Whorled milkweed		Asclepias verticillata
Solanaceae	(Nightshade)	
Black henbane		Hyoscyamus niger
Asteraceae	(Aster)	
Broom snakeweed		Gutierrezia sarothrae

Table 1 (cont). Plants that can poison livestock.

Sneezeweed		Helenium autumnale
Colorado rubberweed		Hymenoxys richardsonii
Lambstongue ragwort		Senecio integerrimus
Prairie ragwort		Senecio plattensis
Riddell's ragwort		Senecio riddellii
Cocklebur		Xanthium strumarium
Magnoliophyta, Liliopsida	(Monocots)	
Juncaginaceae	(Arrowgrass)	
Arrowgrass		Triglochin maritima
Small arrowgrass		Triglochin palustris
Liliaceae	(Lily)	
Death camas		Zigadenus elegans
Meadow death camas		Zigadenus venenosus
Poaceae	(Grass)	
Tall mannagrass		Glyceria grandis
Fowl mannagrass		Glyceria striata
Tall fescue		Schedonorus arundinaceus

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Horsetails that can Poison Livestock on the Northern Mixed Grass Prairie

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Horsetails are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The three species of Horsetails are:

Equisetum arvense L.	Field horsetail
Equisetum hyemale L.	Common scouring rush
Equisetum laevigatum A. Braun	Smooth scouring rush

Distribution of the three horsetail species is extensive across most of the Northern Mixed Grass Prairie growing on the moist soils, ranging from damp to wet, of wet meadows but can grow on upland sites with moist subsoil that can be 6 feet or more below the surface.

Horsetails were some of the first land plants and are unchanged since the Devonian period around 400 million years ago. Horsetails have retained a complex life cycle of alternation of generation for sexual reproduction. The alternating generations are the gametophyte generation which are tiny male and female plants called prothallus which are haploid with 1n and the sporophyte generation which are diploid with 2n. Some horsetail species have one sporophyte growth form and a few others have two growth forms with a fertile form and a sterile form. The fertile form are small stems that produce spores early in the growing season and then wither away. The sterile form are the stems that are recognizable as horsetails. Fertile cones develop at the terminal end of the sporophyte stems with one growth form. Spores are released from the strobili of the fertile sporophyte stems as a powdery smoke and dispersed by wind and water. The spores are thin-walled, short-lived, and quickly germinate under moist conditions. The minute spores are equipped with elaters which are appendages that expand and contract with changes in humidity and function to dig the spores into the soil and also to tangle spores closely together to ensure fertilization. The germinated spores form male and female prothalli (gametophyte generation) that grow to 0.5-2.0 mm (0.002-0.008 inches) in height and only a few cell layers thick. The released sperm from the male prothalli must swim to a female prothalli and find the eggs. With fertilization, a new sporophytic generation can develop out of the female prothallus. The production of the gametophyte generation from spores requires exceptional conditions within a very short time period which rarely occurs, limiting sexual reproduction of horsetails.

Field horsetail, *Equisetum arvense* L., is a member of the horsetail family, Equisetaceae, and is a native, perennial, rhizomatous cryptogam (Pteridophytes). The first North Dakota record is Stevens 1961. There are two sporophyte growth forms. The fertile sporophyte generation are unbranched, browish, nonchlorophyllous, solitary stems about 10-20 cm (4-8 in) tall growing early during late April to May. Sporangia are borne on terminal strobili that produce numerous spores and then the fertile sporophyte stems soon wither. The erect sterile sporophyte generation are jointed with hollow internodes and solid nodes develop each spring, are prevalent through the growing season, and reach 5-60 cm (2 to 24 inches) tall. The epidermis has deep longitudinal ridges with regular silicified projections. Numerous thin branches develop at each node. Tiny leaves reduced to papery scales with teeth are united to form a sheath around each node. The extensive spreading and branched rhizome system is the primary perennial organ from which annual sporophyte stems are produced. Usually one stem is produced at each rhizome node, however, if the first stem is injured, a new stem branch will be produce at that node. Stem densities can range from 50 to 250 stems per square meter. The high levels of alkaloids within the horsetail plants are probably toxic to surrounding vegetation causing a reduction in the quantity of other plants. Depending on the size of each colony, the hay cut from an area with horsetails could produce highly toxic sections in the resulting hay bales. The rhizomes are like the sterile stems except solid throughout. The rhizomes develop successive horizontal layers at about 30 cm (12 inch) intervals down to 2 m (6.6 feet) or more until they reach subsoil moisture. Roots develop at the base of lateral branch buds on the rhizomes and erect shoots.

Storage tubers develop on the rhizomes. Aerial stems are top killed by fire. The rhizomes are buried deep in mineral soil and are resistant to fire.

Common scouring rush, *Equisetum hyemale* L., is a member of the horsetail family, Equisetaceae, and is a native, perennial, rhizomatous cryptogam (Pteridophytes). The sporophyte generation has one growth form. The perennial evergreen stems develop at rhizome nodes are jointed with hollow internodes and solid nodes, unbranched with deep longitudinal ridges with 2 rows of silica tubercles. Tiny leaves reduced to papery scales with teeth are united to form a sheath around each node which develops a dark brown or black ring in the middle. The cones are 0.5-2.4 cm long, sessile, and often overwinter. The extensive spreading rhizome system are solid and develop successive horizontal layers down to 2 m (6.6 feet) or more. Roots develop at the base of lateral branch buds on the rhizomes. Aerial stems are top killed by fire. The rhizomes are buried deep in mineral soil and are resistant to fire.

Smooth scouring rush, *Equisetum laevigatum* A. Braun., is a member of the horsetail family, Equisetaceae, syn.: E. kansanum Schaffner, and is a native, perennial, rhizomatous cryptogam (Pteridophytes). The first North Dakota record is Stevens 1952. The sporophyte generation has one growth form that remains green into the next year. The perennial stems develop at rhizome nodes during April, are jointed with hollow internodes and solid nodes, unbranched with shallow (smooth) longitudinal ridges. Tiny leaves reduced to papery scales with teeth are united to form a sheath around each node. The rounded cones are terminal at stem tips. The extensive spreading rhizome system are solid and develop successive horizontal layers down to 2 m (6.6 feet) or more. Roots develop at the base of lateral branch buds on the rhizome. Aerial stems are top killed by fire. The rhizomes are buried deep in mineral soil and are resistant to fire.

This summary information on growth development and regeneration of Horsetails was based on the works of Weaver and Fitzpatrick 1934, Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Great Plains Flora Association 1986, Sullivan 1993, Stubbendieck et al. 2003, Johnson and Larson 2007, and Larson and Johnson 2007.

Poisoning characteristics of three horsetail species.

Toxin: Thiaminase is a neurotoxin causing thiamine deficiency which is part of the vitamin B complex. The disease is called equisetosis. Horses are more susceptible, but affects cattle and sheep. The occurrence of the disease is considered to be unusual across both Europe and North America.

Toxic parts: All plant parts contain the toxin while some species have higher concentrations of toxins and other species have low toxin content.

Poisoning: Equisetum plants are coarse containing high concentrations of silicates and generally considered to be unpalalable. During early spring the young growth is attractive. The tops are sometimes browsed by cattle, sheep, and horses. However, rarely are plants eaten in pasture conditions in large enough quantities sufficient to cause the disease except during fall and winter the plants usually remain green. More likely large enough quantities are eaten in dried hay. Intoxication follows ingestion over 3 to 4 weeks of hay containing 20% equisetum.

Symptoms: Slowly develops over several days with poor and scurfy appearance, incoordination, muscle weakness, staggering gait, loss of equilibrium, trembling, seizures, collapse, and death caused from exhaustion.

Treatment: Intravenous of 500 mg to 1 g/day of thiamine for several days. Recovery begins in about 24 hours with full recovery within a few days.

This summary information on the poisoning characteristics of three horsetail species was based on works of Whitman n.d., Muenscher 1975, and Burrows and Tyrl 2001.

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Pine Trees that can Poison Livestock on the Northern Mixed Grass Prairie

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Pine trees is among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The pine tree species is:

Pinus ponderosa Lawson Ponderosa pine

Distribution of P. ponderosa is as fragmented large stands scattered throughout southeastern Montana, eastern Wyoming, southwestern North Dakota, western South Dakota, and western and north central Nebraska. It usually grows in poor shallow soils where competition from grasses is reduced allowing seedling establishment.

Ponderosa pine, *Pinus ponderosa* Lawson, is a member of the pine family, Pinaceae, and is a native, long lived perennial (to 300-600 years), fast growing, evergreen, conifer tree that is intolerant of shade. The first North Dakota record is Bergman 1910. Aerial growth is a single straight trunk up to 2-4 feet (0.6-1.3 m) in dbh with numerous spreading branches growing from whorls that form a pyramidal crown in young trees and a broad rounded crown in older trees that can grow over 100 feet (30-35 m) tall. Lower branches are usually self pruned. Leaves are long needles in bundles of two. The root system is deep and spreading resulting in wind firm trees. Regeneration is by sexual reproduction. The root crown does not have adventitious buds. Sexual reproduction is from male and female unisexual cones that are monoecious developing at separate locations of the same tree. Outcross pollination by wind occurs during April to June. The female cones mature during the second growing season in August to September releasing winged seeds that are mostly wind dispersed. Seedlings are relatively shade intolerant and require open areas for establishment. The typical low rainfall during late summer and early fall of the Northern Plains causes high mortality of seedlings and young trees. The thick bark of mature trees is relatively resistant to ground fires. Some seedlings can survive low intensity fires. However, high intensity ground fires and crown fires kill most of the trees. The root crown does not produce sprouts after damage to aerial stems.

This summary information on growth development and regeneration of ponderosa pine was based on the works of Stevens 1963, Great Plains Flora Association 1986, Howard 2003a, Larson and Johnson 2007, Stubbendieck et al. 2011, and Row et al. 2012a.

Poisoning characteristics of Ponderosa pine.

Toxin: Are diterpene acids, isocupressic acid and its esters, causes vascular impairment that decreases utrine blood flow resulting in development of reproductive problems at mid to late gestation pregnancy stages of cattle, bison, and sometimes sheep.

Toxic parts: Pine needles of any age, green or dry, intact or partially decomposed are toxic, and budding branch tips and bark are even more toxic than the needles.

Poisoning: Cattle eat pine needles even when other feed is available, green needles are more readily eaten than dried needles. Consuming 2.3-2.9 kg/day of fresh buds and needles caused the birth of dead calves or small weak calves which died shortly after birth. Susceptibility in female cattle increases with advancing stage of pregnancy; it begins about mid gestation and reaches a zenith during the last month. Greater quantities of pine needles are ingested when winter temperatures are low and significant snow cover prevents access to grass. Recent access to pine needles after storms may also predispose consumption. Small amounts at 0.1-0.3 kg/day are not toxic and may induce some degree of tolerance. Cattle and bison have high effects, sheep have low effects, and deer are little effected.

Symptoms: Signs of illness in the pregnant female are vague, include loss of appetite, lack of ruminal activity, depression, and weakness.

Ingestion of amounts of pine needles greater than 1 kg are required for intoxication and dosages of 1.35-1.8 kg cause high frequency of adverse effects and ingestion of more than 2 kg/day for 2 to 3 days cause premature birth in 24 hours to 3 weeks; calves are not directly affected by the toxins and survival depends on the developmental stage at birth. Dietary levels of 15-30% pine needles alter fluid dynamics in rumen and causes alterations in ruminal microflora causing reduced volatile fatty acids and nitrogen retention and reduces digestibility of forage. Ingestion of pine needles during last trimester of gestation show signs of antiestrgenic activity, serum cortisol increases, disturbances in hormonal balance and decreases in uterine blood flow resulting in premature birth of dead or weak calves usually within hours or a few days.

Treatment: The retained placenta should be removed and the cow treated for a uterine infection.

This summary information on the poisoning characteristics of Ponderosa pine was based on works of Burrows and Tyrl 2001.

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Larkspurs that can Poison Livestock on the Northern Mixed Grass Prairie

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Report DREC 18-3072

Larkspurs are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The two species of Larkspur are:

Delphinium bicolor Nutt.	Little blue larkspur
Delphinium carolinianum Walt.	White prairie larkspur

Distribution of D. bicolor extends across the southern prairie regions of Alberta and Saskatchewan into most of Montana and Wyoming and western North and South Dakota. D. carolinianum is primarily a southern plains species that extends north into most of Nebraska and South Dakota, eastern half of North Dakota and into the southern prairie region of Manitoba. Larkspurs usually grows as small, scattered communities, but can form large stands.

Little blue larkspur, *Delphinium bicolor* Nutt., is a member of the buttercup family, Ranunculaceae, and is a native, perennial, cool season, dicot, low larkspur, herb that prefers loamy type soils. The first North Dakota record is Waldron 1904. Annual aerial growth has one stout unbranched erect stem 15-40 cm (6-16 in) tall arising from a perennating thick woody caudex (crown) in early spring as soon as the snow melts. Most of the few leaves are basal with long petioles, and the fewer cauline (stem) leaves form low on stem. All leaves 2-4 cm (1-1.5 in) wide are palmately divided into linear or oblanceolate segments. Stems and leaves are mostly glabrous (smooth). The extensively branched fibrous to fleshy root system descends from the woody caudex, first as a tight bundle (fascicle) and then spreading. Regeneration may be by vegetative and is by sexual reproduction. Vegetative growth is by annual spouts from the subterranean caudex and additional sprouts may develop when first stem is damaged. Inflorescence is a spike-like loose terminal short raceme less than 15 cm (6 in) long with 3 to 15 flowers borne on long stalks. Flowers occur in late May to early June (table 1) are perfect, irregular with 5 blue sepals 15-21 mm long with a spur 13-20 mm long and lobes are wavy 15-35 mm across. Pollination is by bees. Conspicuous fruits form three follicles per flower that are 1-2 cm long, brown, contain many seeds, and dehiscent along one side. Seeds are irregularly winged 0.2 cm long. Aerial parts are top killed by fire and hot fires may kill entire plant.

White prairie larkspur, *Delphinium carolinianum* Walt., is a member of the buttercup family, Ranunculaceae, syn.: D. Virescens Nutt., and is a native, perennial, cool season, dicot, low larkspur, herb. Annual aerial growth has one usually unbranched stout erect stem 40-91 cm (16-36 in) tall arising from a perennating thick woody caudex (crown) in early spring. Leaves 3-5 cm wide are alternate highly palmately segmented into narrow linear or oblanceolate lobes. Basal leaves have long petioles and cauline (stem) leaves have shorter petioles. Stems and leaves are pubescent (hairy). The branched fibrous root system descends from the woody caudex and has tuber-like divisions. Regeneration may be by vegetative and is by sexual reproduction. Vegetative growth is by annual spouts from the subterranean caudex and additional sprouts may develop when first stem is damaged. Inflorescence is a terminal raceme 10-25 cm (4-10 in) of top portion of the stem with 5 to 30 flowers borne on stalks. Flowers are perfect, irregular with 5 white with purple inside petal-like sepals that extend backwards forming a tubular spur 2-3 cm long that curves upward. Pollination is by bees. Conspicuous fruits form three follicles per flower each 2 cm long that are brown, contain many seeds, and dehiscent along one side. Seeds are scaly and brown 1.5-2 mm long. Aerial parts are top killed by fire and hot fires may kill entire plant.

This summary information on growth development and regeneration of two Larkspur species was based on works of Weaver and Fitzpatrick 1934, Weaver 1954, Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Johnson and Larson 2007, Larson and Johnson 2007, and Stubbendieck et al. 2011.

Poisoning characteristics of two species of Larkspur.

Toxins: Are diterpenoid alkaloids, methyllycaconitine, and others, causes loss of motor function of the diaphragm and esophagus.

Toxic parts: All plant parts contain toxins with toxicity quite high during early growth stages through the flower stage then decreasing gradually. Concentrations of early growth is at 3% d.w., of flower stage is at 1.6%, and of fruit stage is at 1.0% d.w. There is a marked decrease in toxicity at plant maturity.

Poisoning: Plants are readily eaten by cattle and sheep; horses tend to not eat these plants. Lethal dosage for 1000 lb cow is 20-24 lbs of leaves and lower stems. A cow must eat 20% in diet to become intoxicated (sublethal). The early growth stages have the greatest toxicity, however, the palatability at early growth seems to be low, with palatability increasing greatly during early flower stage through the fruiting stage when plants are highly toxic and palatable and readily eaten by cattle and sheep. Repetitive doses each day up to four days causes a buildup in the severity of the problems. Following cold rain showers or other stormy weather causes livestock to increase ingestion of these plants, and drought conditions causes a much reduced level of ingestion.

Symptoms: Signs may start within 3-4 hours after ingestion and fully developed in 5-8 hours with uneasiness, wide straddle legged stance, stiff and staggering gait, incoordination, respiratory difficulties. The disease progresses through 6 stages.

1. exhibits slight tremors
2. episodic falling down, struggles, rests, rises, and falls with kicking
3. can lift body but cannot stand
4. incapacitated with sternum down
5. tips lateral, lying on side, unable to rise up, bloat builds up, more severely if head faces downhill
6. death due to respiration failure

if the animal can move with head facing up hill, they have a chance of recovery.

Treatment: Tall larkspur species grow in mountain meadows and low larkspur species grow in lower foothills and the plains that are typically not cut for hay. Larkspur intoxication is primarily a disease of grazing livestock. With early onset and rapid development of the symptoms, treatment is usually not an option. Recovery may develop from an antidote of physostigmine at a dose of 0.04-0.08 mg/kg b.w. The dosage may need to be repeated in a few hours.

This summary information on the poisoning characteristics of two species of Larkspur was based on works of Whitman nd., Muenscher 1975, and Burrows and Tyrl 2001.

Table 1. Flower period of Delphinium bicolor, Little blue larkspur, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period 1969-1971		X	X			

Flower Period data from Zaczkowski 1972.

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Halogeton that can Poison Livestock on the Northern Mixed Grass Prairie

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Halogeton is among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The Halogeton species is:

Halogeton glomeratus (M. Bieb.) C. Meyer Halogeton

Distribution of H. glomeratus is an introduced noxious weed from the cold desert region of Eurasia and thrives on the acid alkaline and saline soils of the Great Basin Region, and Wyoming and southwestern North Dakota.

Halogeton, *Halogeton glomeratus* (M. Bieb.) C.A. Mey. is a member of the Goosefoot family, Chenopodiaceae, and is an introduced, warm season, summer annual, invasive, and troublesome weed. The first North Dakota record is Manske 2009. Immature plants appear similar to young Russian thistle and Kochia plants. The plant develops horizontal spreading branches that curve upward to around 2 feet in height. The taproot can grow to about 20 inches in depth. Mature plants have red stems with small, round, fleshy, bluegreen leaves about a half inch long with a single hair protruding out of the end. The leaf resembles a miniature sausage or wiener on a stick. Plants have small, inconspicuous yellow flowers during July through September and produce enormous quantities of seed, averaging around 75 seeds per inch of stem. Two types of seeds are produced each year. The black winged seeds, developed after mid August, can remain viable for about 1 year, and have a short after-ripening period that permits quick germination. The black seeds can imbibe water and germinate in less than 1 hour. The brown wingless seeds, developed before mid August, are dormant at maturity permitting the seeds to survive in soil for 10 years or more. The seeds are dispersed by wind, water, human activities, through the digestive tract of sick animals, and when dry plants break off at ground level and tumble with the wind. Germination of most seeds occurs during late fall or early spring.

Halogeton competes poorly with healthy, established perennial vegetation, however, open areas with bare saline-alkali soils facilitate its invasion and establishment. Halogeton produces enormous quantities of seed giving it the biological ability to develop into a very troublesome invasive noxious poisonous plant in our western rangelands. Control can be difficult because of the large quantity of seeds produced annually and long survival period of the brown seeds. Three herbicides have been shown to effectively manage halogeton in the Great Basin Region. Control of young plants during June, prior to the start of flowering, is possible with 2,4-D applied at 1.0 to 2.0 lbs acid equivalent (ae) (1.1 to 2.1 qt product) per acre and, when plants are mature, application of 2.0 to 6.0 lb ae (2.1 to 6.3 qt product) per acre is effective. One application of tebuthiuron (Spike 20P) at 0.5 lb active ingredient (ai) (2.5 lb product) per acre should provide control of seedlings for 3 to 5 years. Metsulfuron (Ally XP, Cimarron, Cimarron X-tra, and Cimarron Max) is effective at 0.2 oz ai (0.33 lb product) per acre. There are no currently registered biocontrol agents for halogeton, however, there are a few experimental agents ready for field testing.

This summary information on growth development and regeneration of Halogeton was based on works of Manske 2009.

Poisoning characteristics of Halogeton.

Toxin: Soluble sodium oxalates are readily absorbed into the circulatory system. The sodium ions are replaced by calcium withdrawn from blood serum. Calcium reduction and deficiency disrupt blood coagulation and nerve and muscle function resulting in staggering and muscle spasms similar to milk fever. The calcium oxalates formed in the blood are precipitated in the liver and kidneys, which then interferes with normal function of these organs.

Toxic parts: All plant parts contain toxins. Concentrations are highest in the leaves at 14 to 25%, and lower in the stems at 1 to 4%

and seeds at 2%. Most of the sodium oxalates in the stems are insoluble and thus nonpoisonous. The content of the soluble sodium oxalates tends to be relatively high during mid summer and may exceed 30% in leaf samples from late August to frost. Plants become more palatable after frost. Dead plants remain almost as poisonous as the living plants.

Poisoning: Halogeton is generally considered to not be very palatable, however, hungry animals that have recently had a good drink of water seem to like the salty taste. Cattle tend to eat halogeton when moved from a noninfested pasture into an infested pasture. Sheep are more susceptible to poisoning than cattle. Lethal dose on an empty rumen is 12 oz of plant material or 1.0 oz of soluble oxilate. With a mixture of forage plants in the rumen the lethal dose increases to 18 oz of plant material or 1.6 oz of soluble oxilate. Small amounts consumed daily cause few adverse effects and can increase tolerance.

Symptoms: Chronic form causes decreased feed intake and reduced weight gain. Subacute form causes locomotor difficulties that are unlikely to be lethal. Acute form in sheep causes dullness, loss of appetite, reluctant to follow the flock, lowering of head, coughing, drooling with white froth around mouth. Then about 5-6 hours later, weakness, stiffness, incoordination of limbs, rapid but shallow breathing, repeatedly lie down and stand up, rigid jerky motions, irregular respiration, comatose, and death in less than 24 hours. Acute form in cattle causes incoordination, apprehension, belligerence, excess salivation, laying down, bloat, skin turns blue, coma and death.

Treatment: Intravenous calcium (calcium borogluconate) will be beneficial for cattle resulting in survival, however, in sheep it may delay death but few will recover.

This summary information on the poisoning characteristics of Halogeton was based on works of Muenscher 1975, Burrows and Tyrl 2001, and Manske 2009.

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Greasewood that can Poison Livestock on the Northern Mixed Grass Prairie

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Greasewood is among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The species of Greasewood is:

Sarcobatus vermiculatus (Hook.) Torr. Greasewood

Distribution of S. vermiculatus is throughout the prairie regions of Alberta and Saskatchewan, most of Montana and Wyoming, and western North and South Dakota and panhandle of Nebraska, and prefers to grow on saline or alkali plains and dry uplands.

Greasewood, *Sarcobatus vermiculatus* (Hook.) Torr., is a member of the goosefoot family, Chenopodiaceae, and is a native, long lived perennial, rapid growing, deciduous, warm season shrub that is tolerant of drought, sodic soils, saline soils, high water table, and prolonged flooding, and is a phreatophyte. The first North Dakota record is Waldron 1904. Aerial growth has multiple rigidly stout brittle stems arising from a large root crown; the stems have many spreading branches that form a large clonal clump with an irregular to rounded crown 1-10 feet (0.3-3 m) tall; the ends of the small branches taper to sharp thorns. The root system has numerous taproots with branches that can penetrate to the edge of the ground water table down to 20-57 feet (6-17 m) below the surface, and has numerous dense shallow lateral roots that extend many yards (meters) beyond the canopy. Regeneration is by vegetative and sexual reproduction. Vegetative growth is from sprouts developing from adventitious buds on the root crown and on the shallow lateral roots. Sexual reproduction is mostly from monoecious, imperfect, unisexual, nonshowy flowers with separate male and female organs on the same plant that emerge during July-August. The flower period in western North Dakota extends from mid June to late July (table 1). These separate male and female flowers on the same plant are dichogamous and mature at different times to prevent selffertilization. Pollination is by wind. The fruit is an achene and matures during late summer. Seed production is usually low. The seeds have long wings and are disperesed by wind. Seed germination rate is usually high. Low to moderate severity fire can cause top kill and activate sprout development from buds on the root crown and on the shallow lateral roots. Severe fire on dry soil can damage or kill the root crown and some of the shallow lateral roots.

This summary information on growth development and regeneration of greasewood was based on the works of Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Great Plains Flora Association 1986, Mozingo 1987, Anderson 2004a, Benson et al. 2007, Johnson and Larson 2007, and Stubbendieck et al. 2011.

Poisoning characteristics of Greasewood.

Toxins: Are a mixture of neutral sodium and potassium oxalates. The soluble sodium oxalates are readily absorbed into the circulatory system. The sodium ions are replaced by calcium withdrawn from blood serum. The resulting calcium deficiency causes symptoms similar to milk fever. The potassium oxalates act as an anticoagulant and at high quantities can cause internal bleeding.

Toxic parts: The toxins occur in the leaves, stems, and fruits at concentrations of 10-15% d.w. with the high rates in the leaves and smaller rates in stems and fruits. Concentrations increase in early fall and may exceed 20% d.w.

Poisoning: Sheep extensively browse the foliage and cattle sometimes consume the foliage. A large singled dose of 1.5% b.w. is toxic with lethal dosage at 60 g/kg b.w.

Symptoms: Acute signs are depression, weakness, weak pulse, labored respiration, laying or falling down, coma, and death in a few hours. Subacute signs occur from low dosage over long time period causing neurologic damage and kidney failure.

Treatment: Prompt intravenous calcium solutions may result in relief of many of the symptoms and animals may become ambulatory within a few hours, however, if kidney damage is severe, recovery may be impossible.

This summary information on the poisoning characteristics of Greasewood was based on works of Whitman nd., Muenscher 1975, and Burrows and Tyrl 2001.

Table 1. Flower period of Sarcobatus vermiculatus, Greasewood, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul		Aug	Sep
Flower Period 1969-1971			XX	XX	XX		

Flower Period Data from Zaczkowski 1972.

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Cherry Trees that can Poison Livestock on the Northern Mixed Grass Prairie

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Cherry trees are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The four species of Cherry trees are:

Amelanchier alnifolia Nutt.	Juneberry, Serviceberry
Prunus pensylvanica L.	Pincherry
Prunus pumila L.	Sandcherry
Prunus virginiana L.	Chokecherry

Distribution of A. alnifolia and P. virginiana extends throughout most of the Northern Mixed Grass Prairie. P. pensylvanica and P. pumila extends across the prairie regions of Saskatchewan and Manitoba and in scattered pockets across North and South Dakota and eastern Wyoming. Cherry trees usually grow along the edge of deciduous tree groves, woody draws, and riparian woodlands. P. pumila prefers sandy and gravelly soils in grasslands.

Juneberry, Saskatoon serviceberry, *Amelanchier alnifolia* Nutt., is a member of the rose family, Rosaceae, and is a native, short lived perennial (6-20 years), deciduous, cool season shrub or small tree. The first North Dakota record is Stevens 1952. Aerial growth is single or clustered erect stems spreading to erect branches forming a rounded crown 3-26 feet (1-8 m) tall; stems arise from an aggressive network of rhizomes; increasing stem numbers develop colonies that can form into dense thickets. The root system is extensive including a mass of roots extending from the root crowns that develop below each aerial stem. An extensive rhizome network of shallow and deep vertical and horizontal rhizomes and aboveground stolons interconnect the root crowns. Regeneration is by vegetative and sexual reproduction. Vegetative growth is sprouts from buds on the root crowns, stolons, and aggressive rhizomes. Sexual reproduction is from perfect bisexual showy flowers with both male and female organs on an upright raceme that emerge during early May. The flower period in western and eastern North Dakota extends from early to late May (tables 1 and 2). The fruit is a sweet berrylike pome that matures during June. Seeds are spread by birds and mammals. However, establishment of seedlings is rare. Fire can top kill aerial stems and activate sprout growth from buds on root crowns and rhizomes. Stem cover usually increases following fire. Severe fire may kill some of the shallow rhizomes, however, the deep horizontal and vertical rhizomes usually survive.

This summary information on growth development and regeneration of juneberry was based on the works of Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Manske 1980, Great Plains Flora Association 1986, Fryer 1997, Nesom 2006b, Larson and Johnson 2007, and Stubbendieck et al. 2011.

Pin cherry, *Prunus pensylvanica* L., is a member of the rose family, Rosaceae, and is a native, short lived perennial (20-40 years), deciduous, cool season shrub to small tree that is shade intolerant. Aerial growth has a short straight stem, or trunk, arising from a stem base; widely spreading branches form a narrow round topped crown usually 5-15 feet (1.5-4.5 m) tall and spreading to 5-10 feet (1.5-3 m) wide. The root system is shallow usually less than 14-24 inches (36-61 cm) deep with many lateral branches than can grow rapidly. Regeneration is by vegetative and sexual reproduction. Vegetative growth is sprouts from the stem base and suckers from the shallow lateral roots. Aggressive root and aerial stem growth forms clonal thickets that can cover up to 153 square feet (14.3 m^2). Sexual reproduction is from perfect bisexual showy flowers with both male and female organs that emerge during mid May. Pollination is by insects. The fruit is a drupe that ripens during July-August. The seed is inside a hard woody stone. Seed distribution is by birds and small mammals. Seeds can remain viable a long time in the seed bank. Seedling survival is usually low. Fire can top kill aerial parts and activate the great potential for growth of sprouts from stem bases and suckers from lateral roots. Fire does not

kill seeds in the seed bank and stimulates rapid germination following a burn.

This summary information on growth development and regeneration of pin cherry was based on the works of Stevens 1963, Great Plains Flora Association 1986, Anderson 2004b, and Larson and Johnson 2007.

Sand cherry, *Prunus pumila* L., is a member of the rose family, Rosaceae, and is a native, perennial, deciduous, cool season shrub that is drought tolerant. The first North Dakota record is Waldron 1904. Aerial growth has several creeping stems that radiate outward from a stem base 10-15 feet (3-4.5 m) long; spreading vertical branches ascend from the horizontal stems and seldom grow to 10-15 inches (25-38 cm) tall (table 3). The root system is fibrous with extensive spreading lateral roots. Most of the root biomass remains within the top 10 inches (25 cm) of soil, with some vertical roots descending to 8-12 feet (2.4-3.7 m) deep. An abundant rhizome system exists with equal distribution at shallow and deep soil layers; the rhizome network interconnects the stem bases. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by sprouts from the root crowns and rhizomes and by suckers from the shallow lateral roots. Sexual reproduction is from perfect bisexual small showy flowers with both male and female organs that emerge during May-early June. The flower period in western and eastern North Dakota extends from early May to late June (tables 4 and 5). Self pollination is possible; cross pollination is by insects. The fruit is a drupe that ripens during late July-September. The seed is inside a hard woody stone. Seed distribution is by birds and small mammals. Low and moderate severity fire top kill aerial parts and activate shoot growth from the root crowns, rhizomes, and lateral roots. Some shallow roots and rhizomes can be killed by fire on dry soil, however, the deep roots and rhizomes are well insulated from the heat.

This summary information on growth development and regeneration of sand cherry was based on the works of Stevens 1963, Goetz 1963, Zaczkowski 1972, Manske 1980, Great Plains Flora Association 1986, NCRS Staff 2002c, Taylor 2006, and Larson and Johnson 2007.

Chokecherry, *Prunus virginiana* L., is a member of the rose family, Rosaceae, and is a native, perennial, deciduous, cool season shrub or small tree that is intolerant of shade, poor drainage, frequent flooding, and high clay soils. The first North Dakota record is Bolley 1891. Aerial growth has numerous slender stems arising from a stem base; the stem bases are interconnected by a rhizome network; stems branch near the base with the main branches upright and spreading forming a highly variable crown 3-20 feet (1-6 m) tall. The root system is extensive and deep; a complex network of rhizomes with 0.4-0.8 inch (1-2 cm) diameters have separate root systems established at intervals; the vertical roots descend to more than 6 feet (1.8 m) deep, and the lateral roots extend greater than 35 feet (10.7 m) outward from the rhizome connection. Aggressive soboliferous rhizome and aerial stem development forms extensive thickets. Regeneration is by vegetative and sexual reproduction. Vegetative growth is primarily sprouts from aggressive rhizomes. Sexual reproduction is from perfect bisexual fragrant showy flowers with both male and female organs arranged on drooping racemes that emerge during May-early June. The flower period in western and eastern North Dakota extends from mid May to mid June (tables 6 and 7). The fruit is a drupe that ripens during July-September. The seed is inside a hard woody stone. Seed distribution is by birds and small mammals. Seed germination rate improves after passing through an animals digestive tract. Fire top kills aerial stems and foliage activating rapid and prolific sprout growth from the rhizomes and shoot growth from adventitious buds on the root crowns. Seed germination rate improves with the heat treatment from a burn.

This summary information on growth development and regeneration of chokecherry was based on the works of Stevens 1963, Zaczkowski 1972, Manske 1980, Great Plains Flora Association 1986, Johnson 2000, Stubbendieck et al. 2003, Crowder et al. 2004, Johnson and Larson 2007, and Stubbendieck et al. 2011.

Poisoning characteristics of four species of Cherry trees.

Toxins: Are cyanogenic glycosides, amygdalin and prunasin, that can be hydrolyzed into hydrocyanic acid or prussic acid (HCN) by hydrolytic enzymes. The glycoside and enzyme are usually stored in the outer layers of plant tissue with barriers separating the storage sites which are broken down by chewing resulting in production of cyanide. Concentrations of glycoside prunasin is at 6% d.w. of leaves of P. virginiana and at 8% d.w. of leaves of A. alnifolia. HCN potential of immature leaves of P. virginiana is at 2,000 + ppm.

Toxic parts: All plant parts contain toxins. The content of prunasin in the buds, flowers, and fruits are 2.6%, 2.5%, and 0.9% d.w. for A. alnifolia and 3.6%, 2.6%, and 1.2% d.w. for P. virginiana, respectively. Concentrations of toxins is reduced by fall when fruit is dark purple. Air dried leaves lose much of their toxicity in 24 to 48 hours from 2,500 ppm to 200 ppm, and then to 40 ppm. During droughts and dry periods, cyanide potentials tend to increase.

Poisoning: These four plants are generally considered to be important browse species for ruminant wildlife and livestock. However, ruminant animals are susceptible to cyanogenic glycosides because of rapid hydrolysis and absorption in rumen. Lethal dose for cattle and sheep is concentrations of 2-3% d.w. of prunasin in plants. Lethal dose for horse is 1 mg/kg b.w. of HCN which is about half the toxic dose for cattle and sheep. The lethal dose for prunasin in plant material from A. alnifolia is 5 mg HCN/kg b.w. in cattle. Lethal dose for sheep and cattle ranges between 1 and 4 g of plant material/kg b.w. depending on prunasin concentrations. Neither tolerance nor immunity develops from sublethal doses, however, the effects are not cumulative. Animals can consume one half of the lethal dose repeatedly during the course of a day for a total daily dose at 4 to 5 times the quantity of a single lethal dose because of rapid disposition of cyanide. These four plants can remain important browse species for ruminant wildlife and livestock when sublethal doses of plant material are consumed repeatedly with sufficient time intervals to dispose of the cyanide. A large amount of the cyanide remains in the digestive tract and rapidly absorbed, some HCN is in the blood, it is rapidly detoxified and eliminated in urine, exhaled into the air, and excreted from the body as thiocyanate.

Symptom: The onset of the acute form occurs quickly within 15-20 minutes after ingestion of a lethal dose. There is a rapid progression of signs with apprehension, distress, weakness, incoordination, rapid labored respiration, collapse, lying on side with kicking limbs, seizures, very slow heart rate, paddling legs, comatose, and cessation of respiration with entire set of symptoms occurring within 10-15 minutes to 45-60 minutes. If animal survives the first hour, recovery is favorable.

Treatment: The disease has rapid onset of signs and progresses quickly, and late treatment is seldom effective, however, marginally lethal dosage may respond to treatment of intravenous dose of sodium thiosulfate at 30-40% solution at a rate of 0.25-0.50 g/kg b.w. alone or with sodium nitrate at a rate of 10-20 mg/kg b.w.

This summary information on the poisoning characteristics of four species of Cherry trees was based on works of Whitman nd., Muenscher 1975, Schmutz and Hamilton 1986, and Burrows and Tyrl 2001.

Table 1. Flower period of Amelanchier alnifolia, Juneberry, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period						
1969-1971		XX				

Flower Period Data from Zaczkowski 1972.

Table 2. First flower of Amelanchier alnifolia, Juneberry, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest		1				
Latest		16				

First Flower data from Manske 1980.

Table 3. Autecology of Prunus pumila, Sandcherry, with growing season changes in mature height, on the Mixed Grass Prairie western North Dakota.

				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	7.0	14.0	10.8	78.6	81.8		100.0		

Data from Goetz 1963.

Table 4. First flower and flower period of Prunus pumila, Sandcherry, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest		7				
Mean		15				
Flower Period						
1969-1971		XX	XX XX			

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

Table 5. First flower of Prunus pumila, Sandcherry, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest		3				
Latest		18				

First flower data from Manske 1980.

Table 6. Flower period of Prunus virginiana, Chokecherry, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period						
1969-1971		X	X			

Flower Period Data from Zaczkowski 1972.

Table 7. First flower of Prunus virginiana, Chokecherry, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest		12				
Latest		23				

First flower data from Manske 1980.

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Milkvetch that can Poison Livestock on the Northern Mixed Grass Prairie

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Milkvetch are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The three species of Milkvetch that can cause Selenium Toxicosis are:

Astragalus bisulcatus (Hook.) A. Gray — Two grooved milkvetch
Astragalus pectinatus (Hook.) Douglas ex. G. Don. — Narrow leaved milkvetch
Astragalus racemosus Pursh — Alkali milkvetch

Distribution of A. bisulcatus extends across the southern prairie regions of Alberta, Saskatchewan, and Manitoba, into most of North Dakota, Montana, and Wyoming, and in southwestern South Dakota and northwestern Nebraska. Distribution of A. pectinatus extends across the southern prairie regions of Alberta and Saskatchewan, and southwestern Manitoba, into most of North Dakota, South Dakota, Montana, and Wyoming, and into southwestern Nebraska. Distribution of A. racemosus extends into the southern prairie regions of Saskatchewan, into most of North and South Dakota, into eastern Montana, eastern Wyoming, and northwestern Nebraska.

Two grooved milkvetch, *Astragalus bisulcatus* (Hook.) A. Gray, is a member of the legume (bean, pea) family, Fabaceae, syn.: A. diholcos Tidestr. and A. haydenianus A. Gray ex Brandegee, and is a native, perennial, dicot, selenium absorber, herb that prefers deep clayey soils and has an unpleasant pungent odor. The first North Dakota record is Bolley 1891. Annual aerial growth has several stout stems arising together densely tufted 20-70 cm (8-28 in) tall from a woody branching caudex (crown). Some stems are erect and others ascending or decumbent forming large clumps 60 cm (2 ft) tall and 60 cm (2 ft) across. Stem leaves are alternate, odd pinnately compound 4-12 cm (1.6-5 in) long, with 15-35 oblong to elliptic leaflets 5-35 mm long. Stems are usually reddish to purplish and finely pubescent. Leaves are smooth. The root system has prominent taproot with numerous fibrous lateral roots. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranean caudex and sprouts from the caudex branches. Inflorescence has up to 80 flowers in a dense cluster forming a raceme at top of a leafless erect axillary peduncle 10-18 cm (4-7 in) long. Flowers are perfect, irregular, typical 5 petaled legume structure 10-15 mm long, reddish purple, with calyx 4 mm long, and keel 6-13 mm long. The flower period in western North Dakota extends from late May to late June (table 1). Legume pods are linear oblong 7-20 mm long, pendulous hanging sharply downward, with 2 grooves running deeply on the upperside the full length of pod. Seeds are 3-3.5 mm long, brown, and smooth. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and caudex branches.

Narrow leaved milkvetch, *Astragalus pectinatus* (Hook.) Douglas ex G. Don, is a member of the legume (bean, pea) family, Fabaceae, and is a native, perennial, dicot, selenium absorber, herb. The first North Dakota record is Moran 1939. Annual aerial growth has many coarse stout stems arising from a subterranean branching caudex (crown). Few stems are erect, and most stems are decumbent or prostrate, branched with ascending tips 20-70 cm (8-28 in) long forming large bushy mats. Stems are covered with stiff hairs and usually have a reddish base. Caudex branches extend horizontally for 10 cm (4 in) long. Stem leaves are alternate, odd pinnately compound, sessile to stem, with 9-21 leaflets very narrowly linear 1-2 mm wide, and sparingly pubescent. The root system has a prominent, deep, woody taproot with numerous fibrous lateral roots. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranean caudex and sprouts from the caudex branches. Inflorescence has 7-30 flowers in a dense cluster forming a raceme at top of a leafless erect axillary peduncle 5-11 cm long. Flowers are perfect, irregular, typical 5 petaled legume structure 1.5-2.5 cm long, white, yellowish white, or cream, with calyx a cylindric tube 7-8 mm long and keel 14-16 mm long. The flower period in western North Dakota extends from late May to late June (table 2). Legume pods are sessile, plumply oblong ellipsoid

1.5-2.5 cm long and 5-8 mm in diameter with a short sharp point at tip. Pods are fleshy early and very woody when dry. Seeds are 3-3.8 mm long, pale brownish, smooth, and shiny. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and caudex branches.

Alkali milkvetch, *Astragalus racemosus* Pursh, is a member of the legume (bean, pea) family, Fabaceae, and is a native, perennial, dicot, selenium absorber, herb that has an unpleasant pungent odor. The first North Dakota record is Stevens 1949. Annual aerial growth has several coarse stems arising from a branching caudex with hairs. Few stems are erect, and most stems are spreading, ascending branched above 30-60 cm (12-24 in) tall forming large clumps. Stems are sparingly pubescent and usually reddish. Stem leaves are alternate, odd pinnately compound, with short petiole below and subsessile above 4-15 cm (1.5-6 in) long with 11-31 leaflets oblong, linear to narrowly elliptic 1-2 cm long and green. The root system has a prominent stout woody taproot with numerous fibrous lateral roots. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranean caudex and sprouts from the caudex branches. Inflorescence has 15-70 flowers densely nodding on a raceme at top of a leafless erect axillary peduncle 30-60 cm (1-2 ft) tall. Flowers are perfect, irregular, typical 5 petaled legume structure, white to creamy white and sometimes whitish with purple streaks, with calyx a bell shaped tube 5-9 mm long and keel 10.5-15.5 mm long with purple spots and purplish tip. The flower period in western North Dakota is late June (table 3). Legume pods are pendulous drooping from short stalks 5-7 mm long and are triangular in cross section with three faces of equal width that are flat or slightly concave 1.5-3 cm long and 3-5.7 mm in diameter. Seeds are 2.6-3.5 mm long, dark brown with purple spots and smooth. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and caudex branches.

This summary information on growth development and regeneration of three milkvetch species that can cause Selenium Toxicosis was based on the works of Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Great Plains Flora Association 1986, Johnson and Larson 2007, and Larson and Johnson 2007.

Poisoning characteristics of three species of Selenium absorbing Milkvetch.

Toxin: Accumulation of high levels of Selenium causes selenium toxicosis. Occurs in areas with high levels of Selenium in the soil and accumulates in the tissue of some plants. Selenium in the form of selenates are available for uptake by these plants. Soils with 0.5 ppm or greater selenium are hazardous. Selenium in plants and animals is incorporated into proteins as analogs of sulfur amino acids.

Toxic parts: All plant parts contain toxins. Plant tissue with 5 ppm or greater is hazardous. New growth is higher in selenium. High concentrations occur in flowers and seeds. A. racemosus has had concentrations at 15,000 ppm or 1.5% d.w.

Poisoning: Plants that have high selenium accumulation often imparts a noxious sulfurous odor to the foliage due to dimethylselenide, which grazing animals tend to avoid. When the high selenium plant parts die the selenium can be taken up by plants that animals readily eat.

Symptoms: Chronic to acute forms are a continuum of one disease with lesions shifting from mild to severe. Selenium toxicosis causes degeneration of heart, liver, and kidney tissue and also causes hoof separation and hair loss at varying degrees of severity. Sheep exhibit signs of cardiac failure, with labored respiration, exercise intolerance, and die quickly. Cattle show signs of water diarrhea, colic, bloody froth from nose, bloat, prostration, and death due to respiratory failure. Horses become stiff in movements, dull behavior, low vitality, rough hair coat, pale mucous membranes, great weight loss, loss of long hairs of mane and tail, and hooves are sore, with deformed growths, and eventually sloughing of the hooves.

Treatment: Remove animal from source of selenium and increase protein in diet. Chronic forms of selenosis can be reversed.

This summary information on the poisoning characteristics of three species of Selenium absorbing Milkvetch was based on works of Whitman nd., Schmutz and Hamilton 1986, and Burrows and Tyrl 2001.

Table 1. Flower period of Astragalus bisulcatus, Two grooved milkvetch, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period 1969-1971		X	XX XX			

Flower Period Data from Zaczkowski 1972.

Table 2. Flower period of Astragalus pectinatus, Narrow leaved milkvetch, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period 1969-1971		X	XX XX			

Flower Period Data from Zaczkowski 1972.

Table 3. Flower period of Astragalus racemosus, Alkali milkvetch, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period 1969-1971			X			

Flower Period Data from Zaczkowski 1972.

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Locoweeds that can Poison Livestock on the Northern Mixed Grass Prairie

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Locoweeds are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The seven species of Locoweeds that can cause Locoism are:

Oxytropis lambertii Pursh.	Purple locoweed
Astragalus bisulcatus (Hook.) A. Gray	Two grooved milkvetch
Astragalus canadensis L.	Little rattlepod
Astragalus crassicarpus Nutt.	Groundplum
Astragalus flexuosus (Hook.) Douglas ex. G. Don.	Slender prairie milkvetch
Astragalus lotiflorus Hook.	Lotus milkvetch
Astragalus missouriensis Nutt.	Missouri milkvetch

Distribution of O. lambertii, A. canadensis, A. crassicarpus, and A. missouriensis extend throughout most of the Northern Mixed Grass Prairie. Distribution of A. bisulcatus extends across the southern prairie regions of Alberta, Saskatchewan, and Manitoba, into most of North Dakota, Montana, and Wyoming, and in southwestern South Dakota and northwestern Nebraska. Distribution of A. flexuosus extends across the southern prairie regions of Alberta, Saskatchewan, and Manitoba, into most of North Dakota, Montana, and Wyoming, and into western and eastern South Dakota. Distribution of A. lotiflorus extends across the southern prairie regions of Alberta, Saskatchewan, and Manitoba, into most of North and South Dakota, and into western Montana.

Purple locoweed, *Oxytropis lambertii* Pursh., is member of the legume (bean, pea) family, Fabaceae, and is a native, perennial, dicot, herb. The first North Dakota record is Bolley 1891. Annual aerial growth has, no stems (acaulescent), only a stout, thick, branched or knobby crown (caudex) from which the basal leaves and leafless flower stalks arise. Basal leaves are alternate in a tufted rosette, odd pinnately compound 4-20 cm (1.6-7.9 in) long, with 7 to 19 well separated leaflets, linear to oblong, 5-40 mm long, 2-7 mm wide, with both surfaces pubescent. The root system consists of a main stout taproot and a few to several main roots that produce few to no branches and can descend 3.0 to 3.7 m (10-12 ft) in loose soil. These roots absorb water throughout the entire length. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual leaf and flower stalk shoots from the crown and crown branches. Inflorescence has 10 to 20 flowers in a cluster forming a raceme on top of a stout, erect, scape 10-31 cm (4-12 in) tall (table 1). Flowers are perfect, pea-shaped with 5 reddish purple petals, 2 cm (0.8 in) long. First flowers appear during May with flower period extending from early May to late June in western and eastern North Dakota (tables 2 and 3). Fruit is a cylindrical leathery legume pod, 3 cm (1.2 in) long with a pointed beak and numerous brown bean shaped seeds. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth shoots from the crown and the crown branches.

Two grooved milkvetch, *Astragalus bisulcatus* (Hook.) A. Gray, is a member of the legume (bean, pea) family, Fabaceae, syn.: A. diholcos Tidestr. and A. haydenianus A. Gray ex Brandegee, and is a native, perennial, dicot, selenium absorber, herb that prefers deep clayey soils and has an unpleasant pungent odor. The first North Dakota record is Bolley 1891. Annual aerial growth has several stout stems together densely tufted 20-70 cm (8-28 in) tall arising from a woody branching caudex (crown). Some stems are erect and others ascending or decumbent forming large clumps 60 cm (2 ft) tall and 60 cm (2 ft) across. Stem leaves are alternate, odd pinnately compound 4-12 cm (1.6-5 in) long, with 15-35 oblong to elliptic leaflets 5-35 mm long. Stems are usually reddish to purplish and finely pubescent. Leaves are smooth. The root system has prominent taproot with numerous fibrous lateral roots. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranean caudex and sprouts from the caudex branches. Inflorescence has up to 80 flowers in a dense cluster forming a raceme at top of a leafless erect axillary peduncle 10-18 cm (4-7 in) long. Flowers are perfect, irregular, typical 5 petaled

legume structure 10-15 mm long, reddish purple, with calyx 4 mm long, and keel 6-13 mm long. The flower period in western North Dakota extends from late May to late June (table 4). Legume pods are linear oblong 7-20 mm long, pendulous hanging sharply downward, with 2 grooves running deeply on the upperside the full length of pod. Seeds are 3-3.5 mm long, brown, and smooth. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and caudex branches.

Little rattlepod, Canada milkvetch, *Astragalus canadensis* L, is a member of the legume (bean, pea) family, Fabaceae, syn.: A. carolinianus L. and A. mortonii Nutt., and is a native, perennial, dicot, herb. The first North Dakota record is Stevens 1953. Annual aerial growth has very stout single stems or a few together arising at nodes of creeping rhizomes. Stems are 30-120 cm tall often branched forming patches. Stem leaves have short petiole or sessile are alternate, odd pinnately compound 5-35 cm (2-4 in) long, with 15-35 leaflets oblong to elliptic 2-5 cm long. The fibrous root system descends from rhizome nodes. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the rhizome nodes. Inflorescence is a dense cluster of flowers on a raceme at top of a stout leafless erect axillary peduncle 4-10 cm (1.5-4 in) tall. Flowers are perfect, irregular, typical 5 petaled legume structure greenish white, yellowish white, to cream. with calyx tube 4-7 mm long and keel 9-13 mm long. Flower period extends from mid June to mid July in western North Dakota (table 5). Legume pods are cylindrical 10-15 mm long. Pod clusters become woody when mature and remain stiffly upright all winter. The seeds in the pods rattle when shaken. Seeds are 2 mm long, brown, and smooth. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from rhizome nodes.

Groundplum, *Astragalus crassicarpus* Nutt., is a member of the legume (bean) family, Fabaceae, syn.: *Astragalus caryocarpus* Ker Gawl., and is a native, perennial, dicot, herb. The first North Dakota record is Bergman 1912. Annual aerial growth has 7 to 30 coarse, stout, fleshy, decumbent stems 10-30 cm (3.9-11.8 in) long spreading widely in a radial manner, covering a circular area 61-91 cm (2-3 ft) in diameter and 14 to 22 cm (6-9 in) tall (table 6) arising from a large crown (caudex). Stem leaves are alternate, odd pinnately compound, 4-13 cm (1.6-5.1 in) long with 13 to 27 leaflets, oblong to linear, 8-20 mm long. Leaves are pubescent below, glabrous above. The extensive root system has a stout prominent taproot descending from the woody branched caudex to 2.1 or 3.7 m (7-12 ft) deep in loose soil. Several main roots arise from the top 31 cm (12 in) of the taproot, with many branches spreading horizontally for 46 cm (1.5 ft) before turning downward and penetrating into the soil to depths of 1.8-2.4 m (6-8 ft). Numerous fibrous lateral roots develop from the main roots in the top 91 cm (3 ft) of soil with little or no absorption from the top 31 cm (12 in) of soil. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranean crown and sprouts from the crown branches. Inflorescence has 5 to 15 flowers in a dense cluster forming a raceme on top of leafless stalks arising from leaf axils. Flowers are perfect, pea shaped with 5 large purple to violet petals. First flowers appearing during mid to late May with flower period extending from mid May to early June in western and eastern North Dakota (tables 7 and 8). Pollination is by bees and butterflies. Fruit is a large, fleshy, plum like pod with two cells. The top turns red when exposed to the sun. They are eatable when young. Seeds are black 2-3 mm long. Aerial parts are sometimes eaten by wildlife and are top killed by fire. Damage to aerial parts activates regrowth shoots from the crown.

Slender prairie milkvetch, *Astragalus flexuosus* (Hook.) (Douglas) ex. G. Don, is a member of the legume (bean, pea) family, Fabaceae, and is a native, perennial, dicot, herb. The first North Dakota record is Bergman 1910. Annual aerial growth has slender solitary stems or a few together arising from a subterranean branching caudex (crown). Some stems are erect and most are decumbent trailing with ascending tips 15-60 cm (6-24 in) long, greenish to grayish covered with short hairs. Stem leaves have short petiole below and subsessile above, are alternate, odd pinnately compound 3-9 cm (1-4 in) long, with 11-25 leaflets, linear to narrowly oblong, 5-15 mm long. Stout creeping rhizomes radiate horizontally from the caudex. A taproot descends from under side of the subterranean caudex. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranean caudex and at rhizome nodes. Inflorescence is a slender loose cluster of showy flowers on a raceme at top of a leafless erect axillary peduncle 5-10 cm (2-4 in) tall. Flowers are perfect, irregular, typical 5 petaled legume structure pale purple to purplish pink, with calyx a short bell shaped tube 3-3.5 mm long and keel 5-5.5 mm long. Flower period extends from early June to early July in western North Dakota (table 9). Legume pods are subsessile with short stalk, white, ellipsoid slightly compressed with nearly rounded sides 1.5-2.5 cm (0.5-1.0 in) long. Seeds are cylindric 1.5-2.5 mm long, pale brown to brown, and smooth. Aerial parts

are top killed by fire. Damage to aerial parts activates regrowth from subterranean caudex and rhizome nodes.

Lotus milkvetch, *Astragalus lotiflorus* Hook., is a member of the legume (bean, pea) family, Fabaceae, and is a native, perennial, dicot, herb. The first North Dakota record is Bolley 1891. Annual aerial growth has tufted stems arising from a short branching subterranean caudex with hairs. Central stems are erect and outer stems are decumbent 10-15 cm (4-6 in) long, with short hairs (pubescent) forming relatively small plants. Stem leaves have short petioles and are alternate, odd pinnately compound 2-9 cm (1-4 in) long, with 7-17 leaflets oblong, elliptic, or oblanceolate 8-15 mm long, gray with short hairs. The root system has a deep taproot descending from caudex. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from caudex and caudex branches. This milkvetch has two types of inflorescence. The cross pollinated inflorescence is a congested cluster of 3-17 flowers on a raceme at top of a leafless erect axillary peduncle 3-9 cm (1-4 in) tall. Flowers are perfect, irregular, typical 5 petaled legume structure white to yellowish white tipped with purple, 8-10 mm long, with calyx a bell shaped tube 3-4.5 mm long and keel 6.5-9 mm long. The self pollinated inflorescence is a short raceme with 1-3 flowers at top of a leafless erect axillary peduncle. Flowers are perfect, irregular, typical 5 petaled legume structure white, with calyx tube 2.5-3.5 mm long and keel 4-6 mm long. Flower period extends from mid May to late June in western North Dakota (table 10). Legume pods are sessile curved ovoid 1.2-4 cm long, 5-9 mm in diameter, tappered to a long pointed beak. Entire pod is densely pubescent. Seeds are 1.5-2.5 mm long, brownish with purple spots. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from subterranean caudex and caudex branches.

Missouri milkvetch, *Astragalus missouriensis* Nutt., is a member of the legume (bean) family, Fabaceae, and is a native, perennial, dicot, herb. The first North Dakota record is Bolley 1891. Annual aerial growth has several short, loosely tufted stems, 5-13 cm (2-5 in) tall, with central stems erect, and outer radiating stems ascending to prostrate, arising from a branched compact crown (caudex). Stem leaves are alternate, odd pinnately compound 4-10 cm (1.6-3.9 in) long, with 9 to 17 elliptic to oblong leaflets, 7 to 13 mm long. Stems and leaves are covered with flattened long white hairs. The root system has a stout prominent taproot with numerous fibrous lateral roots. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranean crown and sprouts from the crown branches. Inflorescence has 3 to 9 flowers in a cluster forming a raceme on top of a leafless erect, stout stalk. Flowers are perfect, pea shaped with 5 dark bluish purple petals 1.5-2 cm (0.6-0.8 in) long. Flower period extends from mid May to late June in western North Dakota (table 11). Fruit is a fleshy, cylindrical, 2 chambered pod, 1.5-2.5 cm (0.6-1.0 in) long with a pointed beak and numerous small brown seeds. Aerial parts are occasionally eaten by wildlife and are top killed by fire. Damage to aerial parts activates regrowth shoots from the crown and the crown branches.

This summary information on growth development and regeneration of the seven Locoweed species that can cause Locoism was based on works of Weaver and Fitzpatrick 1934, Weaver 1954, 1958; Goetz 1963, Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Manske 1980, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Johnson and Larson 2007, Larson and Johnson 2007, and Stubbendieck et al. 2011.

Poisoning characteristics of seven species of Locoweeds.

Toxin: Is indolizidine alkaloids, swainsonine, cause a neurological disease, locoism, in horses, cattle, and sheep. Toxic at 0.3 mg/kg b.w. of swainsonine.

Toxic parts: All plant parts contain toxins with concentrations highest in seeds and pods, and lower in flowers and foliage. Concentrations can range from 0.007-0.1% in plant parts with concentrations at 0.001% are deemed hazardous.

Poisoning: Most animals do not eat locoweed, some grazing cattle and sheep readily eat large amounts of immature locoweeds, and a few animals acquire a taste for locoweed and seek for the plants. This last behavior is learned from watching other animals. Locoweed is more readily eaten early in the growing season. Most intoxication occurs when animals eat large amounts of plant material in a short time period. Dried stems retain enough toxins to pose a serious risk in prairie hay. The two most toxic plants in North America are Oxytropis lambertii and Astragalus mollissimus. A. mollissimus is mostly a southern plains plant that does grow in western South Dakota and Nebraska

and southeastern Wyoming. O. lambertii grows throughout the northern plains and causes intoxication when included in diet at 20% over a 3 to 4 week period.

Symptoms: Locoism is a neurologic disease that affects the nervous system, heart, and reproductive system. The neurologic problems are alteration in behavior, coordination, eating, drinking, vision, weight, body condition, and reduce the immune functions. The animals become intensely excited or frantic, with decreased productivity. At the subacute stage, the disease can be transferred from cow to calf in the milk, young animals are affected the most. The toxins are cumulative and require 180 kg or more of plant material to be eaten over a 4 to 6 week period to cause the disease in mature horses or cattle and sheep. Once locoed, the animals never fully recover. Horses are more susceptible. The subacute form causes weight loss, rough coat, incoordinated, unreliable for riding, and impaired vision. The acute form causes depression, loss of appetite, great weight loss, stiff gait, lips quiver, spastic jaw movement, head nodding, difficult to handle, becomes violent when restrained, and death occurs within 1-2 weeks. In cattle the signs include depression, weakness, dull eyes, rough hair, weight loss, stiff gait, incoordination, loss of balance, isolation, spastic jaw movement, head shaking, and sudden jumps. In sheep the signs are similar to cattle but less conspicuous. The heart problems occur in severe signs as heart failure. The reproductive problems are impaired fertility of both males and females. The males have decreased libido, spermatogenesis, and sperm viability. The females have small/weak neonates, deformed/developmentally impaired neonates or abortions after fetus dies.

Treatment: Remove intoxicated animals from areas of exposure to locoweeds and provide alternative forage. These animals seem to have a strong tendency to repeatedly become intoxicated with locoweeds.

This summary information on the poisoning characteristics of seven species of Locoweeds was based on works of Whitman nd., Muenscher 1975, Schmutz and Hamilton 1986, and Burrows and Tyrl 2001.

Table 1. Autecology of Oxytropis lambertii, purple locoweed, with growing season changes in mature height, on the Mixed Grass Prairie western North Dakota.

Data Period	Minimum Annual Mature Height cm	Maximum Annual Mature Height cm	Mean Mature Height cm	Percent of Mature Height Attained Apr %	May %	Jun %	Jul %	Aug %	Sep %
1955-1962	10.0	31.0	18.1	40.0	65.9	100.0			

Data from Goetz 1963.

Table 2. First flower and flower period of Oxytropis lambertii, purple locoweed, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest		1				
Mean		26				
Flower Period						
1969-1971		XX XX	XX XX			

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

Table 3. First flower of Oxytropis lambertii, purple locoweed, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest		13				
Latest		24				

First Flower data from Manske 1980.

Table 4. Flower period of Astragalus bisulcatus, Two grooved milkvetch, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun		Jul	Aug	Sep
Flower Period 1969-1971			X	XX XX			

Flower Period data from Zaczkowski 1972.

Table 5. Flower period of Astragalus canadensis, Little rattlepod, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period 1969-1971			XX	XX		

Flower Period data from Zaczkowski 1972.

Table 6. Autecology of Astragalus crassicarpus, Groundplum, with growing season changes in mature height on the Mixed Grass Prairie western North Dakota.

				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	22.0	17.2		97.6	100.0			

Data from Goetz 1963.

Table 7. First flower and flower period of Astragalus crassicarpus, Groundplum, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1955-1962						
Earliest		12				
Mean		16				
Flower Period						
1969-1971		X XX X				

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

Table 8. First flower of Astragalus crassicarpus, Groundplum, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest		12				
Latest			24			

First Flower data from Manske 1980.

Table 9. Flower period of Astragalus flexuosus, Slender prairie milkvetch, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun			Jul	Aug	Sep
Flower Period 1969-1971			XX	XX	X			

Flower Period Data from Zaczkowski 1972.

Table 10. Flower period of Astragalus lotiflorus, Lotus milkvetch, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun		Jul	Aug	Sep
Flower Period 1969-1971		XX	XX	XX			

Flower Period Data from Zaczkowski 1972.

Table 11. Flower period of Astragalus missouriensis, Missouri milkvetch, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun		Jul	Aug	Sep
Flower Period 1969-1971		XX	XX	XX			

Flower Period Data from Zaczkowski 1972.

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Lupines that can Poison Livestock on the Northern Mixed Grass Prairie

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Lupines are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The three species of Lupines are:

Lupinus argenteus Pursh.	Silver lupine
Lupinus pusillus Pursh.	Small lupine
Thermopsis rhombifolia (Nutt.) Richards	False lupine, Goldenpea

Distribution of the three lupine species is very similar, extending through most of Montana and Wyoming, western North and South Dakota, panhandle of Nebraska, and southern prairie region of Alberta and Saskatchewan. L. argenteus prefers low fertility and stony soils, L. pusillus prefers sandy soils of sandhills areas, and T. rhombifolia prefers dry uplands with a variety of sandy to clayey soils.

Silvery lupine, *Lupinus argenteus* Pursh., is a member of the legume (bean, pea) family, Fabaceae, and is a native, perennial, dicot, herb. The first North Dakota record is Evans 1918. Annual aerial growth has one stem in young plants and several stems in old plants 20-60 cm (8-24 in) tall erect to ascending, simple to much branched widely spreading, sometimes reddish below mid stem arising from a branching caudex (crown) that is at the surface or subterranean. Cauline (stem) leaves are alternate, palmately compound with short petiole, with 6-9 leaflets narrowly oblanceolate, 2-5 cm (1-2 in) long. Entire plant is silvery with dense hairs. The root system has a prominent woody taproot descending from the caudex with numerous fibrous lateral roots. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from caudex and caudex branches. Inflorescence is a 10-20 cm (4-8 in) long raceme at terminal end of stem or branch with flowers in dense clusters, are perfect, irregular, typical 5 petaled legume structure, 7-9 mm long, light to dark blue, violet or purple. Flower period is from early June to late July in western North Dakota (table 1). Legume pods are flattened 2-3 cm long with dense silky hairs. Seeds are 5-6, flattened oblong 3.7-4.5 mm long, gray to tan and smooth. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and caudex branches.

Small lupine, *Lupinus pusillus* Pursh., is a member of the legume (bean, pea) family, Fabaceae, and is a native, usually winter annual, sometimes a spring annual, dicot, herb, that prefers sandy soil. The first North Dakota record is Bolley 1891. A simple winter rosette forms from seed late in the first growing season. Following spring one to several stems develop from the rosette, 10-25 cm (4-10 in) tall erect with some decumbent simple to diffusely branched widely spreading. Cauline (stem) leaves are alternate, compound with 5-8 oblong to elliptic leaflets, 2-4 cm long, 3-8 mm wide. Stems and under side of leaves are very hairy with coarse stiff hairs and long soft hairs 2-4 mm long. Root system has a slender fusiform taproot that is broad in the middle and tapered at both ends with clusters of warty thickenings. Regeneration is by sexual reproduction. Inflorescence is a short dense raceme 3-7 cm long on very short stalks terminal at ends of branches. Flowers are perfect, irregular, typical 5 petaled legume structure, usually pale blue, purple, rose, or pink, but can be white, yellowish white, or cream. Flower period is about 10 weeks long from late May to early August in western North Dakota (table 2). Legume pods are 1-3 cm long and 5-7 mm wide. Seeds usually 2, can be 1-6, nearly circular and flat, 4 mm long and 1.5 mm thick, nearly white to light green. Plants are killed by fire.

False lupine, Goldenpea *Thermopsis rhombifolia* (Nutt.) Richards, is a member of the legume (bean, pea) family, Fabaceae, and is a native, perennial, dicot, herb that prefers a variety of soils from clay to sandy. The first North Dakota record is Waldron 1904. Annual aerial growth has one to several erect, ascending stems 17-31 cm (7-12 in) tall (table 3) that widely branch above, arise from a woody caudex (crown). Strong stout running

rhizomes produce stems at nodes forming large patched. Cauline (stem) leaves are alternate, palmately trifoliolate 2-4 cm long. The 3 leaflets are broadly elliptic to obovate 1.5-3 cm long and 1-2 cm wide, smooth and rather thick. The root system has long roots forming below caudex and at rhizome nodes. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts at caudex and at rhizome nodes. Inflorescence is a 3 to 10 cm (1-4 in) long dense raceme terminal at ends of branches with 10-30 showy flowers 1-2 cm long very bright golden yellow with calyx tube 4-5 mm long and keel oblong 14-16 mm long. First flowers occur between 9 and 28 May with the flower peirod from early May to early June in western North Dakota (table 4). Legume pods are leathery, flat, 5-6 cm long, curved in a semi-circle, and grayish from hairs. Seeds are 10-13, kidney shaped, 4.5-5.5 mm long, yellow to dark brown, smooth and shiny. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and rhizome nodes.

This summary information on growth development and regeneration of the three Lupine species was based on works of Stevens 1963, Goetz 1963, Zaczkowski 1972, Looman and Best 1979, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Johnson and Larson 2007, and Larson and Johnson 2007.

Poisoning characteristics of three species of Lupines.

Toxins: Are quinolizidine alkaloids, anagyrine, lupanine, and thermopsine, that cause neurological disease and severe birth deformities. L. argenteus contains lupanine at toxic levels and anagyrine at 1.44 g/kg high levels, L. pusillus contains lupanine at toxic levels, and T. rhombifolia contains anagyrine, lupanine, and thermopsine at toxic levels. A fungal infection of Diaporthe toxica produces linear hexapeptide toxins, phomopsins, that cause liver, kidney, and muscle problems.

Toxic parts: The toxic alkaloids are synthesized in the leaves and transported to other plant parts. The highest concentrations occur during early stages of growth then decline as the plant matures. Toxin concentrations in L. argenteus are at 0.5-2.5% d.w. in the vegetative parts and 1.2-9.5% d.w. in the seeds. Anagyrine concentrations are 0.0-0.6% in vegetative parts and 0.0-1.3% in seeds.

Poisoning: Lupine toxicity is a neurologic disease in sheep, cattle, and horses from grazing some lupine species. Horses and cattle readily eat lupine plants when immature but do not eat mature plants. Sheep do not eat lupines until plants are mature with legumes present during summer, and sheep graze lupines that are mature with flowers or fruit after a rain. Lupines retain some toxicity when dried and can cause problems in hay. Animals can develop a degree of tolerance with continued ingestion at low quantities of lupine plant parts.

Symptoms: The neurologic disease, lupinosis, is caused by the quinolizidine alkaloids, anagyrine, lupanine, and thermopsine, in sheep, cattle, and horses. Mild cases show signs of depression, ears drooping, incoordination, muscle twitching, nervousness, and breathing difficulty. Progression shows signs of greater depression, muscular weakness increases, and respiration labored. Sheep are excitable with little cause, exhibiting head pressing, head butting, frenzy, and seizures. Horses are colic, and walk peculiar with legs lifted very high. Acute forms show signs of great depression, incoordination, tremors, increased response to stimuli, exaggerated movements, prolonged decrease in systemic blood pressure, and death due to depression of respiration. The problems caused by phomopsins are produced by the fungal infection. The toxin interferes with cell mitosis causing a decrease in cell division and cell growth forming multinucleated cells. The chronic form shows signs of loss of appetite, progressive weakness, listlessness, reluctance to move, jaundice of skin and eyes, constipation, photosensitization, darkness of urine, head pressing, and wandering into fences. The acute form shows toxin interaction with copper, vitamin E, and selenium causing necrosis and fibrosis of the liver, degeneration of the kidneys, and degeneration of the skeletal and cardiac muscles. The teratogenic problems (deformations of the embryo) are caused by ruminal biotransformation of anagyrine. The critical time are days 40 to 100 of gestation with days 38-50 the most vulnerable. The problems are fetal skeletal deformities of the thoracic limbs, immobile elbow joints, vertebral curvatures at the neck and back,

and cleft palate. The congenital defects results in still births and abortions. Fetuses born alive usually do not live long.

Treatment: Remove infected animals from areas containing lupines and provide alternative forage. Animals with subacute forms have a chance to recover. Animals with acute forms and fetuses with congenital defects have little chance to survive.

This summary information on the poisoning characteristics of three species of Lupines was based on works of Whitman nd., Muenscher 1975, Schmutz and Hamilton 1986, and Burrows and Tyrl 2001.

Table 1. Flower period of Lupinus argenteus, Silvery lupine, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun		Jul		Aug	Sep
Flower Period								
1969-1971			XX	XX	XX	XX		

Flower Period data from Zaczkowski 1972.

Table 2. Flower period of Lupinus pusillus, Small lupine, on the Mixed Grass Prairie western North Dakota.

	Apr	May		Jun		Jul		Aug	Sep
Flower Period									
1969-1971			X	XX	XX	XX	XX	X	

Flower Period data from Zaczkowski 1972.

Table 3. Autecology of Thermopsis rhombifolia, False lupine, with growing season changes in mature height on the Mixed Grass Prairie western North Dakota.

				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	17.0	31.0	20.9		82.6	85.7	100.0		

Data from Goetz 1963.

Table 4. First flower and flower period of Thermopsis rhombifolia, False lupine, on the Mixed Grass Prairie western North Dakota.

	Apr	May		Jun	Jul	Aug	Sep
First Flower							
1955-1962							
Earliest		9					
Mean			28				
Flower Period							
1969-1971		XX	XX	X			

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

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Sweetclovers that can Poison Livestock on the Northern Mixed Grass Prairie

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Sweetclovers are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The two species of Sweetclovers are:

Melilotus alba Medic.	White sweetclover
Melilotus officinalis (L.) Pall.	Yellow sweetclover

Distribution of the two Sweetclover species is synthetic from extensive use of introduced plants from the Mediterranean basin and southwest Asia as forage crops and for soil building. Both species have escaped and become naturalized growing extensively throughout the entire Northern Mixed Grass Prairie.

White sweetclover, *Melilotus alba* Medic., is a member of the legume (bean, pea) family, Fabaceae, and is an introduced from Eurasia, biennial (rarely annual), dicot, strongly scented, weedy, herb. The first North Dakota record is Stevens 1945. First year aerial growth from seed develops a rosette of leaves, with a thin, short stem of less than 30 cm (12 in) tall with a few leaves. Second year aerial growth is an erect stem highly branched 60-152 cm (24-60 in) tall. Stems are tough, fibrous, difficult to dry. Trifoliolate leaves with oblong, obovate to lanceolate leaflets 1.5-2.5 cm long, with edges of short teeth almost to base. Stems and leaves have no hairs. Root system is a semi woody taproot with extensive lateral roots that can reach 5 foot in depth that starts growth during the first year and continues growth during the second year. Regeneration is by sexual reproduction. Inflorescence is an axillary raceme 4-15 cm long. Flowers are perfect, irregular, typical 5 petaled legume structure 4-5 mm long, fragrant, white, in long slender clusters, calyx is a tapering tube 1.5-2 mm long. First flowers occur during mid June in eastern North Dakota (table 1) with the flower period from mid July to early August in western North Dakota (table 2). Flowers appear to develop a little earlier in eastern North Dakota. Pollination is by bees and other insects. Legume pod is 1-2 seeded, obovoid or ovoid, 2.5-5 mm long, network veined. Seeds are oblong, slightly flattened, yellow green when immature. An average sized white sweetclover plant produced 14,235 seeds in North Dakota. The numerous hard seeds last in the seed bank for several years. Aerial parts are killed by fire. White sweetclover is a little taller, coarser stem, smaller leaflets, smaller later flowers, and grows in a larger region but less common than Yellow sweetclover. Both sweetclovers attract grasshoppers and provide great nutritional quality for faster growth and development with lower mortality resulting in larger grasshopper populations.

Yellow sweetclover, *Melilotus officinalis* (L.) Pall., is a member of the legume (bean, pea) family, Fabaceae, and is an introduced from Eurasia, biennial (rarely annual), dicot, strongly scented, weedy, herb. The first North Dakota record is Stevens 1945. First year aerial growth from seed develops a rosette of leaves, with a thin, short stem of less than 30 cm (12 in) tall with a few leaves. Second year aerial growth is an erect stem highly branched 40-150 cm (16-59 in) tall. Stems are tough, fibrous, difficult to dry. Trifoliolate leaves with oblanceolate to obovate, or elliptic 1-2.5 cm, long and 0.5-2 cm wide, with edges of short teeth almost to base. Stems and leaves have no hairs. Root system is a semi woody taproot with extensive lateral roots that starts growth during the first year and continues growth during the second year. Regeneration is by sexual reproduction. Inflorescence is an axillary raceme 3-9 mm long. Flowers are perfect, irregular, typical 5 petaled legume structure 4-7 mm long, fragrant, yellow, calyx 1.5-2 mm long. First flowers occur during late May to mid June in eastern North Dakota (table 3) with the flower period from early June to mid July in western North Dakota (table 4). Pollination is by bees and other insects. Legume pod is 1 seeded 2.5-5 mm long, 2-2.5 mm wide, wrinkled, cross veined, brown to tan. Seeds are 2 mm long, olive green to yellow green or brown. The numerous hard seeds last in the seed bank for several years. Aerial parts are killed by fire. Yellow sweetclover is a little shorter, has larger, earlier flowers, larger leaflets, and is more common than White sweetclover. Both sweetclovers attract grasshoppers and provide great nutritional quality for faster growth

and development with lower mortality resulting in larger grasshopper populations.

This summary information on growth development and regeneration of two Sweetclover species was based on works of Stevens 1932, 1963; Zaczkowski 1972, Looman and Best 1979, Manske 1980, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Johnson and Larson 2007, Larson and Johnson 2007, and Gucker 2009.

Poisoning characteristics of two species of Sweetclover.

Toxin: Is dicoumarol that causes hemorrhagic disease in animals by preventing vitamin K regeneration by competitively inhibiting epoxidase enzyme resulting in depletion of available vitamin K preventing normal coagulation of blood resulting in severe hemorrhage in the subcutaneous tissue or body cavities of animals that have consumed improperly cured sweetclover hay. Sweetclover plants have high concentrations of coumarin which gives the freshly cut hay the pleasant vanilla-like fragrance and the slightly bitter taste. The tough succulent stems of sweetclover are difficult to properly dry even when conditioned. The wet stems in large bales permits the survival of large quantities of soil fungi (not mold) in the sweetclover stems. The fungal growth in the partially cured stems converts coumarin to hydroxycoumarin and then into dicoumarol.

Toxic parts: All plant parts that have been improperly cured and put up for hay will contain some level of dicoumarol with concentrations that range from 10 ppm to 165 ppm or more. Levels at 10 ppm are maginally toxic and levels at 20-30 ppm are toxic. Low levels of dicoumarol concentrations require a longer time of ingestion to cause problems. Grazed live sweetclover plants contain no dicoumarol, however, they can cause legume bloat.

Poisoning: Ingestion of improperly cured sweetclover hay. The tough succulent stems of sweetclover plants create an extremely difficult situation for fully drying the cut plants for hay; the valuable leaves drop off when they are well dried and the tough dried stems alone are not quality feed. Sweetclover hay with some leaves probably should be treated as containing some level of dicoumarol. Also, some weedy sweetclover plants in a grass or alfalfa hayfield would be toxic for a few animals in the herd.

Symptoms: Subacute forms of the disease show no or few signs. The animals have ingested toxic sweetclover hay for a long enough period for the quantity of dicoumarol to inhibit the epoxidase enzyme from replacing the depleted supply of vitamin K and internal hemorrhage has not started. When that animal has a wire cut, some surgery like dehorning or castration, or birth of a calf, the results are intractable bleeding due to inhibition or retardation of blood coagulation. Acute forms show signs of anemia, lameness, trouble breathing, weakness, neurologic abnormalities, stillbirths, or abortion as a result from severe hemorrhage in subcutaneous tissue or body cavities.

Treatment: Transfusion of 20 ml/kg b.w. of whole blood or 10 ml/kg b.w. of plasma to supply coagulation factors and/or red blood cells. Administer vitamin K at a dosage of 1-5 mg/kg b.w. on a daily basis for a week or more. Prevention would include not feeding sweetclover hay, do not feed sweetclover hay as the only forage source, and stop feeding sweetclover hay at least 1 month prior to calving, dehorning, and castration.

This summary information on the poisoning characteristics of two species of Sweetclover was based on works of Muenscher 1975, and Burrows and Tyrl 2001.

Table 1. First flower of Melilotus alba, White sweetclover, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest			11			
Latest			18			

First Flower data from Manske 1980.

Table 2. Flower period of Melilotus alba, White sweetclover, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period						
1969-1971				XX	X	

Flower Period from Zaczkowski 1972.

Table 3. First flower of Melilotus officinalis, Yellow sweetclover, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest		30				
Latest			9			

First Flower data from Manske 1980.

Table 4. Flower period of Melilotus officinalis, Yellow sweetclover, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period						
1969-1971			XX XX	XX		

Flower Period from Zaczkowski 1972.

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Water hemlock that can Poison Livestock on the Northern Mixed Grass Prairie

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Water hemlock is among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The species of Water hemlock is:

Cicuta maculata L. Water hemlock

Distribution of C. maculata extends throughout the entire Northern Mixed Grass Prairie on wet subirrigated habitat that is firm enough to support the weight of a cow but only during very dry growing seasons is firm enough to support the weight of a tractor or pickup.

Water hemlock, *Cicuta maculata* L., is a member of the parsley (carrot) family, Apiaceae, and is a native, perennial (sometimes biennial) dicot, herb. The first North Dakota record is Zaczkowski 1969. Annual aerial growth has a stout erect much branched stem 0.5-1.5 m (2-5 ft) tall arising from a swollen bulbous caudex (crown). Lower stem is usually mottled with purple, stout, thick 2.5 cm (1 in) in diameter, inside has several chambers containing yellow oil. Upper stem is hollow with segmented compartments with transverse partitions. Entire stem is covered with a wax that easily rubs off. Basal leaves have a long stout petiole 30-60 cm (1-2 ft) long. Cauline (stem) leaves are alternate and have shorter petiole with a swollen base sheathing the stem. Leaves are 2-5 pinnate 10-30 cm (4-12 in) long with narrowly lanceolate leaflets 2-5 cm (1-2 in) long, 5-40 mm wide, with the margin sharply toothed. The netted veins of leaflets terminate in the V-notches of each saw tooth at the margin. Part of the root system has several thick fleshy tubers 5-15 cm (2-6 in) long and 2.5 cm (1 in) in diameter clustered in a tight bundle and the nontuberous fibrous roots extend outward and downward. Each tuberous root is divided horizontally into several chambers that contain yellow oily liquid. The oil sometimes dries forming yellow crystals in the root chambers. The yellow oil is concentrated in the tuberous roots and lower stem chambers, is also present throughout the upper stems, branches, and leaves, is extremely poisonous to humans and livestock, and has the odor of parsley or carrot. Wear disposable rubber gloves if you pull up this plant, make sure to remove the tuberous root bundle that looks like a bunch of gray to light brown fat baby carrots, and do not breath the smoke if you burn this plant. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the swollen bulbous caudex (crown). Inflorescence is compound umbels 4-12 cm (1.5-5 in) wide with 14-17 rays on a peduncle 2-10 cm (1-4 in) long terminal on stems and branches. Each umbel has numerous tiny 5 petaled white flowers 1-1.5 mm long. Flower period is from mid June to early July in western North Dakota (table 1). Fruit is an oval to circular sclizocarp 2-4.5 mm long, smooth, with yellowish corky rounded ribs. The fruit splits lengthwise into two 1-seeded segments (mericarps). Seeds are oval, obovate to oblanceolate, 2-3.5 mm long, flat on one side and rounded on the other side, yellow or tan with dark blotches and dark brown lengthwise ridges. Aerial parts are top killed by fire. Damage to aerial parts above the swollen bulbous caudex activates regrowth sprouts from the caudex.

This summary information on growth development and regeneration of Water hemlock was based on works of Weaver 1954, Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Johnson and Larson 2007, and Larson and Johnson 2007.

Poisoning characteristics of Water hemlock.

Toxins: Are acetylenic alcohols, cicutoxin and cicutal, which are 17 carbon complex linear structures. The mechanisms are not completely known. The toxins inhibit electron transport of nitrogen (N) and potassium (K) in both the central nervous system and the skeletal muscles that act as a convulsant and produce cardiopulmonary effects.

Toxic parts: The toxins are present in an oily yellowish liquid concentrated in the chambers of the tuberous roots and lower stems, with lower concentrations in upper stems and leaves. Toxins are greater during early growth and decrease slightly with maturing.

Poisoning: Greatest chance of intoxication are grazing the early new growth leaves and stems in early spring, or when soil is wet enough for the entire plant to be easily pulled up, cattle will readily eat the tuberous roots when out of the ground, which are apparently not distasteful. Consumption of only a few tuberous roots by cattle quickly produce clinical signs. Lethal dosage is 0.5% b.w. or less. Dosage of 2 g/kg b.w. of tubers results in death of sheep in 1 to 2 hours. The weight of the livestock can crush the tuberous roots squeezing out the toxin liquid which may contaminate the water the animal drinks.

Symptoms: The early stages start with twitching muscles of the lips, nose, face, and ears. Intensity of seizures increase with, champing of the jaws, grinding of the teeth, and throwing the head and neck backward. Spasmodic diaphragmatic contractions occur with frenzied activity. Prolonged seizures cause the animal to fall continuing kicking and running actions, along with bellowing, frothy bloody salivation, lacerated tongue from jaw champing, and bloat. Death occurs within 1 to 8 hours due to cardiopulmonary arrest. Survival beyond 8 hours would indicate the eventual recovery after several days. Water hemlock is considered to be the most violently poisonous plant in North America.

Treatment: No specific therapy, other than sedation may reduce intensity of convulsions.

This summary information on the poisoning characteristics of Water hemlock was based on works of Whitman nd., Muenscher 1975, Schmatz and Hamilton 1986, and Burrows and Tyrl 2001.

Table 1. Flower period of Cicuta maculata, Water hemlock, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period 1969-1971			XX	X		

Flower Period data from Zaczkowski 1972.

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Dogbanes that can Poison Livestock on the Northern Mixed Grass Prairie

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Dogbanes are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The two species of Dogbanes are:

Apocynum androsaemifolium L.	Spreading dogbane
Apocynum cannabinum L.	Indianhemp

Distribution of both dogbanes extends throughout the Northern Mixed Grass Prairie, except A. androsaemifolium does not grow in southwestern Nebraska. Dogbanes prefer wet meadow habitats but can grow in drier sites.

Spreading dogbane, *Apocynum androsaemifolium* L., is a member of the dogbane family, Apocynaceae, and is a native, perennial, dicot, herb. The first North Dakota record is Zaczkowski 1969. Annual aerial growth is one to a few erect to ascending reddish smooth stems 30-60 cm (12-24 in) tall arising from a woody caudex (crown). Stems are simple (unbranched) below and widely spreading branches above. Cauline (stem) leaves are opposite have a short petiole, drooping, broadly ovate, oval to elliptic 3-8 cm (1-3 in) long, 0.5-5 cm (0.2-2 in) wide, dark green above pale beneath with entire margin and pointed tip. The extensive spreading rhizome system is about 25 cm (10 in) below the surface produces aerial stems at nodes forming large patches. The fibrous root system is deep descending from caudex and rhizome nodes. Stems, leaves, and roots contain bitter white milky latex. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from subterranean caudex and rhizome nodes. Inflorescence are cyme from leaf axils. Flowers are perfect, regular, small bell shaped, pink 6-8 mm long, and sweetly fragrant. Pollination is by insects. Flower period is from mid June to mid July in western North Dakota (table 1). Fruits are long slender pods 6-15 cm (2.5-6 in) long (pendulous) hanging in pairs called follicle. Pods split open when dry to release the numerous seeds. Seeds are white to tawny 2-3 mm long with tufts of fine bristles attached at the end for wind dispersal. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and rhizome.

Indianhemp, *Apocynum cannabinum* L., is a member of the dogbane family, Apocynaceae, syn.: A. hypericifolium Ait. and A. sibiricum Jacq., and is a native, perennial, dicot, herb. The first North Dakota record is Moran 1937. Annual aerial growth is one to a few erect to ascending fibrous reddish smooth stems 30-80 cm (12-32 in) tall arising from a woody caudex (crown). Stems are unbranched below with numerous opposite erect to spreading branches in upper half of stem. Cauline (stem) leaves are sessile, opposite, ovate to oblong 3-14 cm (1-6 in) long, 0.3-5 cm (0.1-2 in) wide, with sharply pointed tip, entire margins, and wax covered. The thick, branched, horizontal, radial spreading to 6 m (20 ft) rhizome system produces aerial stems at nodes forming large patches. The slender, fibrous, well branched, absorbing root system is deep descending to 4 m (14 ft) from caudex and rhizome nodes. Stems, leaves, and roots contain bitter, sticky, white milky latex. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from subterranean caudex and rhizome nodes. Inflorescence are dense trichasial cyme (with three branches) from leaf axils. Flowers are erect and drooping, greenish white, small, 3-5 mm long, narrowly bell shaped with 5 petals. Pollination is by insects trapped temporarily within the flower long enough to collect pollen. First flowers occur during June in eastern North Dakota (table 2) with the flower period from mid June to late July in western North Dakota (table 3). Fruits occur in pairs and are very slender long hanging pods 5-20 cm (2-8 in) long called follicle. Pods split open to release the numerous seeds, about 80 seeds per pod. Seeds are reddish brown thin, flat, narrowly spindle shaped 4-6 mm long with tufts of long soft silky hairs 1-4 cm long attach at the tip for wind dispersal. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and rhizome.

This summary information on growth development and regeneration of the two dogbane species was based on works of Weaver and Fitzpatrick 1934, Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Manske 1980, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Groen 2005, Reeves 2006, and Larson and Johnson 2007.

Poisoning characteristics of two species of Dogbane.

Toxins: Are cardiotonic glycosides, cymarin, upon hydrolysis yields cynamarigenin, which are cardiotoxins similar to digitalis glycosides.

Toxic parts: All plant parts contain toxins.

Poisoning: Greater hazard of intoxication during grazing when new shoots are tender. Dosage of 15 to 30 grams of green plant required to cause death of horse or cow. Mature plants are very fibrous and foliage becomes quite distasteful and are generally ignored by grazing livestock. Greater chance to consume died plants in hay. Ruminant animals maybe somewhat resistant due to degradation of glycosides by microorganisms. Cattle fed 1% b.w. and sheep fed 1% to 5.6% b.w. of leaves daily producing no adverse effects. Plants more hazardous for horses.

Symptoms: Subacute conditions occur when died fibrous stems and leaves cause impaction and/or constipation. Acute conditions are diarrhea, vomiting, increased urination, cardiac insufficiency with slow irregular heartbeats causing weakness and cold extremities. Late stages are expansion of the pupil of the eye, sweating in horses, and compensatory increase in heart rate.

Treatment: Oral administration of activated charcoal at 2 g/kg b.w.

This summary information on the poisoning characteristics of two species of Dogbane was based on works of Whitman nd., Muenscher 1975, Schmutz and Hamilton 1986, and Burrows and Tyrl 2001.

Table 1. Flower period of Apocynum androsaemifolium, Dogbane, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period						
1969-1971			XX	XX		

Flower Period data from Zaczkowski 1972.

Table 2. First flower of Apocynum cannabinum, Indianhemp, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest			3			
Latest			20			

First Flower data from Manske 1980.

Table 3. Flower period of Apocynum cannabinum, Indianhemp, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period						
1969-1971			X	XX X		

Flower Period data from Zaczkowski 1972.

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Milkweeds that can Poison Livestock on the Northern Mixed Grass Prairie

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Milkweeds are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The three species of Milkweeds are:

Asclepias speciosa Torr.	Showy milkweed
Asclepias syriaca L.	Common milkweed
Asclepias verticillata L.	Whorled milkweed

Distribution of A. speciosa extends into eastern Wyoming, throughout most of Nebraska, South Dakota, North Dakota and Montana, and into the southern prairie region of Saskatchewan and Manitoba. Distribution of A. syriaca extends through most of Nebraska, southeastern Wyoming, eastern portions of North and South Dakota, and into southern Manitoba. Distribution of A. verticillata extends throughout most of Nebraska, South Dakota and North Dakota, into eastern Montana, southeastern Saskatchewan, and southwestern Manitoba.

Showy milkweed, *Asclepias speciosa* Torr., is a member of the milkweed family, Asclepiadaceae, and is a native, perennial, warm season, dicot, invasive, weedy, herb. The first North Dakota record is Mathson 1956. Annual aerial growth has a solitary, erect, stout, unbranched stem 50-100 cm (20-39 in) tall arising from a perennating caudex (root crown) at an enlarged aerial base. Stem is densely hairy. Cauline (stem) leaves are opposite, large broadly lanceolate to ovate 8-20 cm (3-8 in) long, 2.5-10 cm (1-4 in) wide, gray green with velvety hairs. Stems and leaves contain sticky, white milky latex sap. The rhizome system is extensive, widespread, 10-15 cm (4-6 in) deep with nodes every 5 cm (2 in) forming large colonies that are extremely invasive and difficult to control. The shallow root system has fleshy tuberous roots. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the caudex and rhizome nodes. Inflorescence are large showy umbelliform cymes 5-7 cm (2-3 in) in diameter with 10 to 40 flowers in loose clusters on peduncles 2-10 cm (1-4 in) long from top of stems and upper leaf axils. Flowers are 15-28 mm tall, rose to pinkish purple that age to yellow with flower hoods above corolla. Cross pollination is by wind and insects (butterflies and beetles). Flower period is from late June to early August in western North Dakota (table 1). Fruit is a fusiform follicle (milkweed pod) 6-10 cm (2.5-4 in) long, thicker in the middle and tappers towards both ends, that splits down one side to release the seeds. There are 630 seeds per stem in North Dakota. Seeds are flat, broadly ovate to elliptic 6-9 mm long brown with tufts of white to tan hairs 2-5 cm long (coma) for wind dispersal. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and rhizome. Showy milkweed is not as tall and has fewer but larger flowers than that of Common milkweed.

Common milkweed, *Asclepias syriaca* L., is a member of the milkweed family, Asclepiadaceae, and is a native, perennial, warm season, dicot, invasive, weedy, herb. Annual aerial growth has a solitary, erect, stout, usually not branched stem 60-200 cm (2-6 ft) tall arising from a perennating caudex (root crown) at an enlarged aerial base. Stem is covered with fine soft silky hairs. Cauline (stem) leaves are opposite, large broadly ovate to elliptic or oblong 10-19 cm (4-7.5 in) long, 5-11 cm (2-4 in) wide with entire margins, rounded tip, prominently veined, hairy above, densely hairy below. Stems and leaves contain white milky latex. The rhizome system is extensive and deep with nodes every 5 cm (2 in) forming colonies that are extremely invasive and difficult to control. The shallow root system has numerous fibrous roots. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the caudex and rhizome nodes. Inflorescence is large umbellate cyme with 20-130 small flowers from peduncle 1-14 cm (0.4-5.5 in) long at top of stems and upper leaf axils. Flowers are 11-17 mm tall, 5 petals pink or rose to purple with short blunt hood, and fragrant. First flowers appear during mid to late June in eastern North Dakota (table 2). Fruit is a fusiform follicle (milkweed pod) wide in the middle and tapered towards both ends, 7-10 cm (3-4 in) long, that splits

down one side to release the seeds. There are 200 seeds per pod. Seeds are flat, round, oval to broadly ovate 6-8 mm long brown with winged margin and tufts of white silky hairs 3-4 cm long (coma) for wind dispersal. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and rhizome. Common milkweed is taller and has more but smaller flowers than that of Showy milkweed.

Whorled milkweed, *Asclepias verticillata* L. is a member of the milkweed family, Asclepiadaceae, and is a native, long lived perennial, warm season dicot, herb. The first North Dakota record is Stevens 1955. Annual aerial growth has a single, slender, erect, unbranched stem 20-60 cm (7.9-23.6 in) tall arising from a persistent sparingly branched fibrous root crown (caudex) with other individual stems spaced a few inches apart as a result of the rhizome habit. Stem leaves are simple, linear 2-6 cm (0.8-2.4 in) long, 0.5-1.5 mm wide, sessile, with 3 to 6 verticillate (whorled) per node, crowded on the stem. Stems and leaves contain a white milky latex and also contain cardioactive glycosides and resins that can be poisonous when consumed at 2% of body weight. The root system has deep, fibrous roots that are compressed into bundles and fused together at root crown nodes (fascicled) with the rhizome nodes spaced a few inches apart. This root system has only a minor effect upon grass plants. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the root crowns and by sprouts at the nodes of the rhizomes. Inflorescence has numerous tiny flowers clustered in umbels on top of pedicels that arise from leaf axils near the top of the stem, compounded by numerous other umbels on pedicels forming a cyme. Flowers are small, 4-5 mm wide, with greenish white corolla. First flowers occur during the second week of June to early July in eastern North Dakota (table 3) with a flower period from early July to mid August in western North Dakota (table 4). Fruits are erect, narrow, spindle shaped pods with numerous seeds. Seeds are broadly ovate 5-6 mm long with tufts of white silky hairs 2.5-3.5 cm long (coma) for wind dispersal. Aerial parts are top killed by fire. Damage to aerial stems activates regrowth shoots from the crown and new sprouts develop from the rhizome nodes.

This summary information on growth development and regeneration of three milkweed species was based on works of Weaver and Fitzpatrick 1934, Weaver 1954, Stevens 1957, 1963; Zaczkowski 1972, Looman and Best 1979, Manske 1980, Great Plains Flora Association 1986, Stevens 2000a, 2000b; Stubbendieck et al. 2003, Ulev 2005, Johnson and Larson 2007, and Larson and Johnson 2007.

Poisoning characteristics of three species of Milkweeds.

Toxins: Milkweeds contain two different types of toxins. The wide leaf milkweeds, A. speciosa and A. syriaca, contain steroidal glyoside, cardenolide, at concentrations of 0.3-0.8%, that cause digestive tract/cardiac type disease problems. The narrow leaves in whorls milkweeds, A. verticillata, contain a pregnane glycoside, cynafoside, that causes neurologic disease problems.

Toxic parts: All plant parts contain toxins with fruits and seeds most toxic. The lethal quantity of plant material in % b.w. of the animal is A. speciosa 1.2% b.w., A. syriaca 1-2% b.w. and A. verticillata 0.4-1% b.w.

Poisoning: The wide leaf milkweeds are distasteful fresh and animals are reluctant to sample many bites. The toxicity is not appreciably reduced by drying with greater chance to be consumed in hay. Butterfly larvae feed on 27 species of wide leaf milkweeds containing cardenolide which is sequestered in high concentrations by active regulation as a defense against vertebrate predators that vomit shortly after eating a butterfly. The narrow leaves in whorls milkweeds that contain cynafoside seem to be eaten green without being forced and are more readily accepted when dried and mixed in hay. The hazard of intoxication of livestock is greater with the narrow leaves in whorls milkweeds than with the wide leaf milkweed because of the increased likelihood of being consumed.

Symptoms: The wide leaf milkweeds that contain cardenolide and causes digestive and cardiac problems in sheep and cattle which become very depressed often lying down and reluctant to stand, grind teeth, make distinctive groaning grunts, abdominal pain, labored respiration, and irregular heartbeats with no convulsions. The narrow leaves in whorls milkweeds that contain cynafoside and cause neurotoxic problems in horses, sheep, and cattle. Horses have toxic effect from a dosage of 1 kg of plant material and display signs of colic, marked uneasiness, periodically lie down, incoordination and

weakness of limbs, trembling, falling, dilation of the pupils, profuse sweating, increased temperature, seizures increase, inability to stand, violent paddling of legs, with death caused by apparent respiratory failure. Sheep and cattle dosage is cumulative. Sheep develop signs of weakness, incoordination of limbs, humped up with head elevated, moving with hopping motions, champing of the jaws, twitching of the eyelids, ears, and lips, headshaking, head pressing, and death within several hours. Cattle require dosage of two times that of a horse. Intoxication signs start 12 or more hours after ingestion with depression, muscle trembling, progressive weakness, incoodination, arched back, flexed limbs, excess salivation, groaning, convulsions causing collapse with death in several hours.

Treatment: For intoxication caused by cardiotoxic species is oral administration of activated charcoal at 2 g/kg b.w. There are no specific effective treatments for intoxication caused by neurotoxic species other than sedatives to reduce the convulsions.

This summary information on the poisoning characteristics of two species of three species of Milkweeds was based on works of Whitman nd., Muenscher 1975, and Burrows and Tyrl 2001.

Table 1. Flower period of Asclepias speciosa, Showy milkweed, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period						
1969-1971			X XX	XX X		

Flower Period data from Zaczkowski 1972.

Table 2. First flower of Asclepias syriaca, Common milkweed, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest			19			
Latest			24			

First Flower data from Manske 1980.

Table 3. First flower of Asclepias verticillata, Whorled milkweed, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest			9			
Latest				2		

First Flower from Manske 1980.

Table 4. Flower period of Asclepias verticillata, Whorled milkweed, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period						
1969-1971				XX XX XX		

Flower Period data from Zaczkowski 1972.

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Henbane that can Poison Livestock on the Northern Mixed Grass Prairie

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Henbane is among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The species of Henbane is:

Hyoscyamus niger L. Black henbane

Distribution of henbane extends across the southern prairie region of Manitoba and Saskatchewan into most of North Dakota and Wyoming, eastern Montana, western South Dakota and western panhandle of Nebraska. Black henbane was introduced into North America in 1670 for cultivation. Henbane is native to Europe, Asia, Mongolia, and North Africa. It escaped and became naturalized spreading extensively across the Northern Mixed Grass Prairie on highly disturbed areas.

Black henbane, *Hyoscyamus niger* L., is a member of the nightshade family, Solanaceae, and is an introduced, invasive, troublesome, biennial, dicot, weed. The first North Dakota record is Stevens 1953. The first growing season a rosette of large petioled basal leaves forms along with a large coarse whitish branched taproot. The second growing season a firm stout usually branched stem 0.3-1.0 m tall develops. Cauline (stem) leaves are large elliptic or ovate 5-20 cm long, sessile, clasping at base, apex acute, margin coarsely toothed or pinnately lobed 2-10 cm wide with a prominent white midrib. The entire plant is pubescent with sticky glandular hairs that gives an intense foul odor. Regeneration is by sexual reproduction. Flowers with calyx urn-shaped with 5 lobes 1.0-1.5 cm long and 2 cm wide, brownish yellow with purple center veins. Flowers are numerous, sessile or with short stem develop at leaf axils forming a one sided spike or raceme inflorescence. Flower period in western North Dakota extends from early to late June (table 1). Fruit is a many seeded capsule, erect, oblong 2 cm long, enclosed by calyx and opening by a lid. Numerous seeds are circular, flattened, yellowish to black, 1.0-1.5 wide, surface is rough with papillae. Aerial parts and seeds are poisonous to livestock and people. Plants are top killed by fire.

This summary information on growth development and regeneration of Henbane was based on the works of Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Great Plains Flora Association 1986, Larson and Johnson 2007, Lym and Travnicek 2012, and Sergelenkhuu and Oyuntsetseg 2014.

Poisoning characteristics of Henbane.

Toxins: Are tropane alkaloids, hyoscyamine and scopolamine, in equal proportions in the leaves at total concentrations of 0.06-0.13%.

Toxic parts: leaves and fruits.

Poisoning: The live plants are generally considered to be unpalatable to livestock. Sample bites of live plants seems to quickly diminish the animals desire to eat more. The plant is most toxic when mature and remains toxic when dry. The most likely mode for ingestion of henbane by livestock is to be inadvertently eaten in hay. Consuming 1% b.w./day of leaves or fruit is toxic after 2 days and can become lethal after being fed for several weeks. Dried plants can reduce the appetite. Honey that bees have made with henbane is toxic, and milk from cows with subacute forms is tainted with various degrees of toxin.

Symptoms: Subacute forms show signs of restlessness, pupillary dilation, increased heartrate, labored respiration, excitement, dry mouth, bloat, and rarely seizures. Seldom do animals consume lethal dosages. The plant seems to be quite distasteful.

Treatment: Generally not needed. The plant is easily identified and can be killed with most herbicides applied prior to flowering.

This summary information on the poisoning characteristics of Henbane was based on works of

Whitman nd., Muenscher 1975, and Burrows and Tyrl 2001.

Table 1. Flower period of Hyoscyamus niger, Black henbane, on the Mixed Grass Prairie, western North Dakota.

	Apr	May	Jun		Jul	Aug	Sep
Flower Period 1969-1971			XX	XX			

Flower Period Data from Zaczkowski 1972.

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Broom snakeweed that can Poison Livestock on the Northern Mixed Grass Prairie

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Broom snakeweed is among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The species of Broom snakeweed is:

Gutierrezia sarothrae (Pursh) Britt. & Rusby Broom snakeweed

Distribution of G. sarothrae is throughout the Northern Mixed Grass Prairie usually on dry upland sites and can increase greatly on heavily grazed pastures.

Broom snakeweed, *Gutierrezia sarothrae* (Pursh) Britt. & Rusby, is a member of the aster (sunflower) family, Asteraceae, and is a native, short lived perennial (20 years), deciduous with partial die back of annual aerial flower stalks, warm season shrub or subshrub that is drought tolerant and has a high water use efficiency. The first North Dakota record is Lee 1891. Aerial growth has a single to several woody decumbent spreading stems at ground level arising from a stem base; the woody stems produce numerous erect fine annual branched stalks that rebranch forming a dense crown 4-20 inches (10-50 cm) tall (table 1). The root system has a stout deep woody taproot and has numerous extensive long lateral roots. The lateral roots that grow close to the soil surface can capture moisture from light rainfall events. Regeneration is by vegetative and sexual reproduction. Vegetative growth is sprouts from adventitious buds on the root crown and from perennating buds on the woody decumbent stems. Sexual reproduction is from small flowers clustered in heads that are borne in compact terminal corymbs. The flower period in western North Dakota extends from mid July to early September (table 2). Pollination is by insects. Seed is an achene dispersed by wind. Aerial parts are highly combustible and are top killed by fire. Sprouts develop from adventitious buds on the root crown and from perennating buds on the woody decumbent stems.

This summary information on growth development and regeneration of broom snakeweed was based on the works of Stevens 1963, Goetz 1963, Zaczkowski 1972, Looman and Best 1979, Great Plains Flora Association 1986, Mozingo 1987, Tirmenstein 1999d, Stubbendieck et al. 2003, Hurteau 2006b, Johnson and Larson 2007, and Stubbendieck et al. 2011.

Poisoning characteristics of Broom snakeweed.

Toxin: The specific toxicant is not known, several possible toxins have been isolated, steroidal saponin, volatile monoterpene, and/or numerous highly oxygenated flavonals could cause the reproductive problems.

Toxic parts: All plant parts, leaves, stems, and flowers contain toxins.

Poisoning: Broom snakeweed is generally considered to be unpalatable and typically little eaten, however, sometimes it is eaten by livestock without being forced to do so. Lethal dose for cattle and sheep is 3 to 10% b.w. of green plant fed over 3 to 5 days. Risk is greatly increased with new growth which is more palatable.

Symptoms: Cattle and sheep develop weakness, listlessness, decreased appetitie, nasal discharge with crusting of nasal pad, arched back with head low, jaundice of skin and eyes, diarrhea and/or constipation. Female reproductive disease causes swelling of vulva and development of mammary tissue long before expected parturition followed by abortion, still birth, or premature birth of small weak calves or lambs that survive less than 48 hours.

Treatment: There is no specific treatment. Oral administration of activated charcoal at 1 to 1.5 g/kg b.w. may reduce some of the toxic effects.

This summary information on the poisoning characteristics of Broom snakeweed was based on works of Whitman nd., and Burrows and Tyrl 2001.

Table 1. Autecology of Gutierrezia sarothrae, Broom snakeweed, with growing season changes in mature height, on the Mixed Grass Prairie western North Dakota.

				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	21.0	14.0		35.0	67.6	90.9	100.0	

Data from Goetz 1963.

Table 2. First flower and flower period of Gutierrezia sarothrae, Broom snakeweed, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug		Sep
First Flower							
1955-1962							
Earliest				20			
Mean				30			
Flower Period							
1969-1971				X	XX	XX	X

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

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Sneezeweed and Rubberweed that can Poison Livestock on the Northern Mixed Grass Prairie

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Sneezeweed and Rubberweed are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. Two different species of Sneezeweed and Rubberweed cause the same clinical problems for livestock are:

Helenium autumnale L.	Sneezeweed
Hymenoxys richardsonii (Hook.) Cockll.	Colorado rubberweed

Distribution of H. autumnale extends into most of Nebraska, southern Wyoming, eastern North and South Dakota, northeastern Montana, and southern prairie regions of Manitoba, Saskatchewan, and Alberta and prefers moist prairie. Distribution of H. richardsonii extends into northeastern Wyoming, western North Dakota, eastern Montana, and southern prairie regions of Alberta and Saskatchewan. Both plants increase in abundance from poor grazing management.

Sneezeweed, *Helenium autumnale* L., is a member of the sunflower (aster) family, Asteraceae, syn.: H. montanum Nutt., and is a native, perennial, warm season, dicot, herb. Annual aerial growth has a single, erect, stout stem 20-70 cm (8-28 in) tall, unbranched below, narrowly branched above arising from a perennating nearly rhizomatous caudex (rootstock). Cauline (stem) leaves are alternate, lanceolate to elliptic-ovate or oblong, slightly toothed 5-10 cm (2-4 in) long, 1.3-4 cm (1-1.5 in) wide, nearly sessile to leaf base extends down along the stem, tips are pointed. Stout fibrous roots descend from caudex. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from subrhizomatous caudex and from caudex branches. Inflorescence is a flat top cluster of numerous heads, terminal at end of branches. Each head is 2-3 cm across. Center of head is a spherical cluster of yellow disk florets 8-20 mm in diameter surrounded by 10-20 yellow wedge shape ray florets to 12 mm long with three toothed or lobes at tip. First flower appear during latter July in eastern North Dakota (table 1). Fruits are 1 seeded achene with an inverse pyramidal shape attached at narrow end 1.5-2 mm long with a pappus of 5 brown lanceolate sharply pointed scales 1 mm long. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and caudex branches. Milk produced by cows that have eaten sneezeweed is tainted. The genus was named for Helen of Troy.

Colorado rubberweed, *Hymenoxys richardsonii*, (Hook.) Cookll., is a member of the sunflower (aster) family, Asteraceae, and is a native, perennial, cool season, dicot, herb. The first North Dakota record is Stevens 1914. Annual aerial growth is a bushy tuft of green resinous stems 10-20 cm (4-8 in) tall, little branched below and several branches above, arising from a clustered, divided, branched, thick, woody caudex with top surface covered with persistent old leaf bases. Leaves are mostly basal, alternate, with blade divided into several very narrow linear lobes, each 2-3 cm long and finely pitted. The root system has a coarse thick woody taproot with thick branches and smaller fibrous lateral branches. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the wide woody caudex and the caudex branches. Inflorescence is a flat topped cluster of several to many heads at the ends of branches. Each head is 1.5-2.5 cm wide, with a spherical cluster of yellow disk florets surrounded by several yellow ray florets. Flower period is from late May to late June in western North Dakota (table 2). Fruits are 1 seeded achene with pappus of several scales. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and caudex branches.

This summary information on growth development and regeneration of two different species of Sneezeweed and Rubberweed that cause the same clinical problems for livestock was based on works of Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Manske 1980, Great Plains Flora Association 1986, Stubbendieck et al. 2003, and Johnson and Larson 2007.

Poisoning characteristics of Sneezeweed and Rubberweed.

Toxins: Are pseudoguaianolide sesquiterpene lactones, with the principal toxin of H. autumnale is helenalin and the principal toxin of H. richardsonii is hymenoxon that act very similar by inhibition of essential enzymes that disrupts normal metabolism and the processes of the digestive, nervous, and cardiovascular systems. The disease has three forms. The uncommon acute form caused by high dosage resulting in severe clinical signs and death in a short time period. The most common subacute form caused by intermediate dosage resulting in less severe clinical signs and death occurs in 4 to 15 days. And the chronic form caused by ingestion of small amounts of plant material over a prolonged time resulting in few clinical signs other than weight loss and dehydration with death due to starvation and water loss.

Toxic parts: All plant parts with concentrations of 0.5-3% d.w. plant material that is highest in the flowers and is most toxic at or near flowering stage. Plant parts remain toxic as fresh or dried in hay material.

Poisoning: Both plants are generally considered to be unpalatable and thus rarely eaten, however, large losses have occurred, albeit, primarily on degraded rangeland pastures where these plants have increased in abundance. Livestock toxic dose is 9.9 mg/kg b.w. and lethal dose of H. autumnale is 100-125 mg/kg b.w. and lethal dose of H. richardsonii is 75-100 mg/kg b.w. Sheep and goats have the greatest risk and cattle and horses have a high risk.

Symptoms: For acute and subacute diseases signs are depression, decreased appetite, reduced ruminal (stomach in horses) activity, mild bloat, grinding teeth, nasal discharge, coughing, wheezing, repeated swallowing, arched back, difficult walking, muscular tremors, and regurgitation of green and foamy ruminal (stomach) contents. For chronic disease signs are weight loss and dehydration.

Treatment: There is no known specific treatment for intoxicated animals. Prevention is by sound range management practices of moderate stocking rates and pasture rotation systems to reduce abundance of these toxic plants.

This summary information on the poisoning characteristics of sneezeweed and rubberweed was based on works of Whitman nd., and Burrows and Tyrl 2001.

Table 1. First flower of Helenium autumnale, Sneezeweed, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest				26		
Latest				28		

First Flower data from Manske 1980.

Table 2. Flower period of Hymenoxys richardsonii, Colorado rubberweed, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period						
1969-1971		X	XX XX			

Flower Period data from Zaczkowski 1972.

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Ragworts that can Poison Livestock on the Northern Mixed Grass Prairie

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Ragworts are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The three species of Ragworts are:

Senecio integerrimus Nutt.	Lambstongue ragwort
Senecio plattensis Nutt.	Prairie ragwort
Senecio riddellii Torr. & A. Gray	Riddell's ragwort

Distribution of S. integerrimus extends throughout most of the Northern Mixed Grass Prairie. Distribution of S. plattensis extends through eastern Wyoming and Montana, most of Nebraska, South Dakota and North Dakota, and into the southern prairie region of Manitoba and Saskatchewan. Distribution of S. riddellii is primarily a southern plains species that does extend into western Nebraska, southeastern Wyoming, and southwestern South Dakota. Ragworts are able to grow in several ecological sites and habitat types.

Lambstongue ragwort, *Senecio integerrimus* Nutt., is a member of the sunflower (aster) family, Asteraceae, and is a native, perennial, cool season, dicot, herb. The first North Dakota record is Stevens 1963. Annual aerial growth has a single, stout stem 20-60 cm (8-24 in) tall arising from a short, button like caudex. Basal leaves are petiolate narrowly oblong to lanceolate 5-15 cm (2-6 in) long, somewhat fleshy, smooth edge to irregularly dentate, with a prominent mid rib and rolled under edges. Basal leaves are suggestive of a lamb's tongue, while calling for its lost mother. Cauline (stem) leaves are triangular with clasping base, progressively reduced, lanceolate to linear. Stem and leaves are covered with white cobwebby hairs. Root system has coarse, fleshy, fibrous roots descending from caudex. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranean caudex. Inflorescence is a corymbiform cyme with 6 to 20 heads each on short pedicel terminal from end of stem. Heads are 1.5-2 cm wide with 8-13 yellow ray florets. Flower period is from late May to early June in western North Dakota (table 1). Fruit is a smooth 1 seeded achene with pappus of soft white hairs. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex.

Prairie ragwort, *Senecio plattensis* Nutt., is a member of the sunflower (aster) family, Asteraceae, and is a native, short lived perennial or biennial, cool season, dicot, herb. The first North Dakota record is Waldron 1904. Annual aerial growth has usually a single stem, rarely with 2-3 loosely clustered stems 30-60 cm (8-20 in) tall covered with cottony hairs when young. Basal leaves are alternate, petiolate, blade elliptic-ovate to oblanceolate 2-6 cm (1-2.4 in) long, deeply pinnately cleft almost to mid rib. Basal leaves are dried up by flowering stage. Cauline (stem) leaves are progressively reduced upward. Horizontal stolons develop from caudex. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the caudex and stolons. Inflorescence is a corymbiform cyme with 6 to 20 heads. Heads are 1.5-2.5 cm wide with 8 yellow florets 10 mm long. Flower period is from late May to late June in western North Dakota (table 2). Fruit is a 1 seeded achene with pappus of soft to stiff white hairs. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and stolons.

Riddell's ragwort, *Senecio riddellii* Torr. & A. Gray, is a member of the sunflower (aster) family, Asteraceae, and is a native, perennial, warm season, dicot, herb. Annual aerial growth has multiple ascending smooth stems appearing like a small shrub 30-80 cm (12-30 in) tall with numerous branching above, arising from a woody caudex (crown). Leaves are alternate, numerous, irregularly fine pinnately divided into narrow linear leaflets 4-9 cm (1.5-3.5 in) long, 1-5 mm wide, and smooth. Root system has a stout taproot. Regeneration is by vegetative and sexual reproduction. Vegetative growth is by annual sprouts from the subterranean caudex. Inflorescence is a flat topped cluster of corymibiform cyme with 5-

20 heads on pedicels from branch ends and leaf axils. Disk florets are tubular, 5-8 mm long, yellowish orange. Eight yellow ray florets are 8-15 mm long. Fruit is a 1 seeded achene 4-5 mm long, gray by hairs, and pappus of short hairs. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the caudex and stolons.

This summary information on growth development and regeneration of three ragwort species was based on works of Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Johnson and Larson 2007, Larson and Johnson 2007, and Tilley and St. John 2012.

Poisoning characteristics of three species of Ragworts.

Toxins: Are unsaturated pyrrolizidine alkaloids, senecionine, causes liver disease in livestock.

Toxic parts: All plant parts. Toxin is synthesized in the roots and translocated to aerial parts. The highest concentrations are in young tissue with greatest amount just before flowering. After flowering, the major accumulation sites, in descending order, inflorescences, upper stems, leaves, and lower stems.

Poisoning: Plants have a period when they flourish between early spring growth and flower stage and when they are commonly eaten. After flowering, they develop lower palatability. Plants are readily eaten in hay. Toxins are cumulative. Horses and cattle are more sensitive and sheep and goats are much less sensitive. Acute liver disease develops in animals that eat 5-10% b.w. in a few days or weeks. However, most cases are more chronic type of liver disease due to ingestion of small doses or a total dosage of 25-50% of b.w. over several months. Cattle tend to eat more senecio following storms or in hay. Horses develop disease mostly from eating hay. Sheep require 10-15 times greater dosage than cattle.

Symptoms: Early signs are depression, decreased appetite, reduced milk production, marked weight loss, weakness, discoloration of blood and tissues, falling down, diarrhea or constipation, rectal straining with or without prolopse. Continued exposure to the toxicant produces increasing injury to the liver. The liver regressively fails to clear metabolic products resulting in excess ammonia circulating the blood causing nervous system disarrangement and violent abnormal behavior and then terminal liver disease.

Treatment: Includes sedation, intravenous fluids, diet of high energy and low levels of protein to reduce the ammonia load to the liver, however, protein deficiency increases toxicity. Some hepatic regeneration may occur. Generally, after liver disease is apparent, the damage is extensive and severe with little value of treatment and little or no recovery. Milk from intoxicated cows should not be consumed because the alkaloids are potentially carcinogenic.

This summary information on the poisoning characteristics of three species of Ragworts was based on works of Burrows and Tyrl 2001.

Table 1. Flower period of Senecio integerrimus, Lambstongue ragwort, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period 1969-1971		X	X			

Flower Period data from Zaczkowski 1972.

Table 2. Flower period of Senecio plattensis, Prairie ragwort, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period 1969-1971		X	XX XX			

Flower Period data from Zaczkowski 1972.

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Cocklebur that can Poison Livestock on the Northern Mixed Grass Prairie

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Cocklebur is among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The species of Cocklebur is:

Xanthium strumarium L. Cocklebur

Distribution of X. strumarium is on scattered highly disturbed areas on sandy, silty, and clayey soils throughout the entire Northern Mixed Grass Prairie.

Cocklebur, *Xanthium strumarium* L., is a member of the sunflower (aster) family, Asteraceae, syn.: X. italicum Moretti, and is a native, annual, dicot, troublesome, weedy, herb. The first North Dakota record is Lee 1891. Annual aerial growth is from seed and is a single, erect, ridged, coarse to rough textured stem, 30-150 cm (12-60 in) tall. Small purple blotches often dot stem. Leaves are alternate, with long petiole 5-15 cm (2-6 in) long, blades broadly ovate 5-13 cm (2-5 in) long, 2.5-8 cm (1-3 in) wide, wavy to slightly lobed or toothed margins, with a rough texture of coarse hairs pressed close. Root system has a taproot. Regeneration is by sexual reproduction. Inflorescence is monoecious, imperfect flowers with male and female parts on separate clusters on the same plant. Male staminate heads are green, 7-9 mm wide in very small clusters at the end of branches. Female pistillate heads are in small clusters below the male flowers, from middle and upper leaf axils. Pollination is by wind. Flower period is from mid to late July in western North Dakota (table 1). Fruit is an ellipsoid cylinder 2-3 cm long, 1.2-1.5 cm wide, covered with stiff hooked prickles and with two stout incurved beaks at one end, containing two long flat, dark brown seeds (achenes). One of the seeds is capable of germinating as soon as conditions are suitable the following growing season. The second seed has an indefinite dormancy with a long delayed germination only after the separate chamber is mechanically broken, which greatly increases the difficulty of controlling cocklebur. Aerial parts are top killed by fire. Damage at early growth stages of aerial parts activates regrowth sprouts from the root crown.

This summary information on growth development and regeneration of cocklebur was based on works of Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Johnson and Larson 2007, and Larson and Johnson 2007.

Poisoning characteristics of Cocklebur.

Toxin: Is diterpene glycoside, carboxyatractyloside (CAT), causing hypoglycemia, low blood sugar, that is almost always fatal.

Toxic parts: Toxins exist in the embryonic and cotyledonary tissue of the seeds and young seedlings up to the four leaf seedling stage when the first foliage leaf appears. Toxin concentrations are 0.46% in the seeds, 0.12% in the two leaf seedling stage, and negligible in the four leaf seedling stage.

Poisoning: This disease continues to be a significant seasonal problem mainly during the spring and early summer when abundant moisture and warm temperatures are conducive to massive sprouting of the burs. The fresh green sprouts are toxic to both pigs and calves at 1% b.w. and to sheep at 1.5 to 2% b.w. Horse, although rarely affected, are also at risk.

Symptoms: In pigs and young calves, signs appear within a few hours of consumption of sprouts. In older calves, signs are delayed for a day or more because of rumen activity. Signs are depression, weakness, loss of appetite, tucked up appearance, incoordination, spasmodic muscular activity, and in pigs vomiting but not in calves. As disease progresses, animal lie or fall down, convulsive paddling of legs, coma, and death within a few hours to several days.

Treatment: These toxicants are very potent and there is no specific treatment to counteract the affects. Oral administration of activated charcoal at 2 g/kg b.w. may be useful in decreasing rate of toxin absorption but is not curative.

This summary information on the poisoning characteristics of Cocklebur was based on works of Whitman nd., Muenscher 1975, and Burrows and Tyrl 2001.

Table 1. Flower period of Xanthium strumarium, Cocklebur, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period 1969-1971				XX		

Flower Period data from Zaczkowski 1972.

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Arrowgrass that can Poison Livestock on the Northern Mixed Grass Prairie

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Arrowgrass are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The two species of Arrowgrass are:

Triglochin maritima L.	Arrowgrass
Triglochin palustris L.	Small arrowgrass

Distribution of T. maritima is extensive throughout the entire Northern Mixed Grass Prairie. Distribution of T. palustris is less extensive and the plants are not as common and extends through most of Wyoming and North Dakota, eastern Montana, panhandle of Nebraska, southern and western South Dakota, and southern prairie region of Alberta and Saskatchewan. Both species of arrowgrass prefer wet meadow habitat that usually become dry enough to cut for hay during the summer.

Arrowgrass, *Triglochin maritima* L., is a member of the arrowgrass family, Juncaginaceae, and is a native, perennial, monocot, herb. The first North Dakota record is Stevens 1945. Arrowgrass is stemless. Annual aerial growth is grasslike tufts of basal leaves arising from a short stout rhizome. Leaves are thick somewhat fleshy, long narrow linear, 20-60 cm (8-24 in) long, 1.5-3 mm wide, somewhat half cylindric with rounded 3 angles, and pointed tip. Leaf sheath is prominent with entire or lobed ligule 1-5 mm long. Old leaf bases persist and cover above ground base. Arrowgrass leaves are difficult to differentiate from grass leaves, before flower stalk development, except arrowgrass leaves are more thick and fleshy and not as thin and flat as grass leaves. Root system has numerous fine fibrous roots that are rarely branched descending from the rhizome. Regeneration is by vegetative and rarely by sexual reproduction. Vegetative growth is by annual sprouts from stout rhizome. Inflorescence is a raceme on a scape (leafless peduncle) arising from the rhizome, 5-40 cm (2-16 in) tall. Flowers are numerous, inconspicuous, perfect, regular, purplish when in bloom, 5 mm wide, and tightly clustered. First flowers occur during early June in eastern North Dakota (table 1) with a flower period from early June to late July in western North Dakota (table 2). Fruit is 1 seeded oblong to ovoid 4-6 mm long, 2-4 mm wide with prominent longitudinal ridges, and with no endosperm (nutritive tissue). Seeds rarely produce seedlings. The inflorescence is the best structure to identify arrowgrass by sight. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the rhizome.

Small arrowgrass, *Triglochin palustris* L., is a member of the arrowgrass family, Juncaginaceae, and is a native, perennial, monocot, herb. The first North Dakota record is Stevens 1961. Small arrowgrass is stemless. Annual aerial growth is grasslike tufts of basal leaves arising from a short ascending rhizome that also produces slender stolons. Leaves are relatively thick, somewhat fleshy, long slender to needle shaped, 10-20 cm long (4-8 in) long, 1-2 mm wide. Leaf sheath is prominent with a 2 lobed cleft to base ligule, 0.5-1 mm long. Old leaf bases are persistent on rhizome base. Root system has numerous fine fibrous roots that are rarely branched descending from the rhizome. Regeneration is by vegetative and rarely by sexual reproduction. Vegetative growth is by annual sprouts from the rhizome and stolons. Inflorescence is a raceme on a scape (leafless peduncle) arising from the rhizome, that is taller than the leaves. Flowers are numerous, inconspicuous, perfect, regular, greenish, and tightly clustered. Flower period is from early to mid July in western North Dakota (table 3). Fruit is 1 seeded, linear to club shaped, 6-8 mm long, 1 mm in diameter, and with no endosperm (nutritive tissue). Seeds rarely produce seedlings. The inflorescence is the best structure to identify small arrowgrass by sight. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the rhizome and surviving stolons.

This summary information on growth development and regeneration of two arrowgrass species was based on works of Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Manske 1980, Great Plains Flora Association 1986, and Stubbendieck et al. 2003.

Poisoning characteristics of two species of Arrowgrass.

Toxin: Is a cyanogenic glucoside, triglochinin, when hydrolyzed forms hydrocyanic acid, also called prussic acid (HCN) which is a very volatile poison gas with a strong special smell. HCN potenital concentration for T. maritima is 2,640 ppm d.w. and for T. palustris is 135 ppm d.w.

Poisonous parts: All plant parts contain the toxin. Concentrations are 1.3 to 3.0% d.w. in the leaves and up to 7.0% d.w. in the flowering spikes. Both sheep and cattle readily eat fresh plants. Horses generally are reluctant to eat arrowgrass. Lethal dose for sheep is 0.5-2.0% b.w. green plant and lethal dose for cattle is 0.5-1.5% b.w. green plant. Lethal dose for both cattle and sheep is 0.25% b.w. of dried fresh hay because of the loss of some water weight. In well dried hay, the toxicity gradually decreases. However, wet meadow hay is rarely well dried when put up. With enough water content in the hay, the arrowgrass remains green and retains its toxicity levels. The greatest threat of livestock poisoning is from wet meadow hay not completely dried when put up.

Symptoms: Signs start to occur within 5 to 30 minutes following ingestion with increased respiration rate, increased anxiety, distress, weakness, incoordination, seizures, labored respiration, and collapses. If death does not occur with a few hours, the chances of recovery are high, which may take up to 24 hours.

Treatment: Intravenous of sodium thiosulfate at 30-40% solution at a rate of 0.25-0.50 g/kg b.w. alone or with sodium nitrate at a rate of 10-20 mg/kg b.w. However, this disease occurs and progresses rapidly and late treatment is usually not effective enough.

This summary information on the poisoning characteristics of two species of Arrowgrass was based on works of Whitman n.d., Muenscher 1975, and Burrows and Tyrl 2001.

Table 1. First flower of Triglochin maritima, Arrowgrass, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest			1			
Latest			4			

First Flower data from Manske 1980.

Table 2. Flower period of Triglochin maritima, Arrowgrass, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun		Jul		Aug	Sep
Flower Period								
1969-1971			XX	XX	XX	XX		

Flower Period data from Zaczkowski 1972.

Table 3. Flower period of Triglochin palustris, Small arrowgrass, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period						
1969-1971				XX		

Flower Period data from Zaczkowski 1972.

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Death camas that can Poison Livestock on the Northern Mixed Grass Prairie

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Death camas are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The two species of Death camas are:

Zigadenus elegans Pursh.	Death camas
Zigadenus venenosus S. Wats.	Meadow death camas

Distribution of Z. elegans extend throughout the prairie regions of Alberta, Saskatchewan, and Manitoba, into North Dakota, South Dakota, eastern Montana, eastern Wyoming, and western Nebraska. Distribution of Z. venenosus extends from southeastern Saskatchewan into eastern Montana and most of Wyoming, western North and South Dakota, and panhandle of Nebraska. Both species prefer wet meadow and moist prairie habitat.

Death camas, *Zigadenus elegans* Pursh., is a member of the lily family, Liliaceae, and is a native, perennial, monocot, herb. Annual aerial growth are a tuft of basal leaves arising from a deeply buried membranous coated, onion like with thickened fleshy scales, bulb. Basal leaves are long, linear, grass like 20-40 cm (8-16 in) long, 1-2 cm wide, waxy, flat above, folded into a V below, pale green, with sheath at base. Root system has numerous fibrous roots rarely branched descending from base of bulb. Regeneration is by sexual reproduction and rarely by vegetative. Usually one new bulb is produced each year from which the next years aerial parts arise. Sometimes two new bulbs are produced during one growing season, with each producing aerial parts the next year. Inflorescence is an open sometimes branched terminal raceme on a scape (leafless peduncle) 30-60 cm (12-24 in) tall arising from the bulb. Flowers are perfect, regular, greenish white to nearly white with a yellow spot at base, 10 mm wide. First flowers occur from early to mid June in eastern North Dakota (table 1). Fruit is a 3 lobed ovoid capsule 15-20 mm long containing many seeds. Seeds are 4-5 mm long. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the bulb.

Meadow death camas, *Zigadenus venenosus* S. Wats., is a member of the lily family, Liliaceae, syn.: Z. gramineus Rydb., and is a native, perennial, monocot, herb. The first North Dakota record is Zaczkowski 1969. Annual aerial growth are a tuft of basal leaves arising from a deeply buried, 6-15 cm (2.5-6 in) deep, membranous coated, onion like with thickened fleshy scales, bulb. Basal leaves are linear, grass like 10-20 cm (4-8 in) long, 2-6 mm wide, not waxy, strongly folded, green, minutely roughened, margin smooth, entire, with no hairs. Root system has numerous fibrous roots rarely branched descending from base of bulb. Regeneration is by sexual reproduction and rarely by vegetative. Usually one new bulb is produced each year from which the next years aerial parts arise. Sometimes two new bulbs are produced during one growing season, with each producing aerial parts the next year. Inflorescence is a dense simple raceme with pedicels ranging from 5-20 mm long forming a pyramidal shape on a slender to moderately stout scape (leafless peduncle) 10-35 cm (4-14 in) tall, arising from the bulb. Flowers are perfect, regular, pale yellow, yellowish white, cream, to white, bell shaped, 8 mm wide. Flower period occurs from late May to late June in western North Dakota (table 2). Fruit is a 3 lobed ovoid capsule 7-15 mm long containing several seeds. Seeds are 3-6 mm long, light to dark brown, with rough texture. Aerial parts are top killed by fire. Damage to aerial parts activates regrowth sprouts from the bulb.

This summary information on growth development and regeneration of two death camas species was based on works of Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Manske 1980, Great Plains Flora Association 1986, Stubbendieck et al. 2003, Johnson and Larson 2007, and Larson and Johnson 2007.

Poisoning characteristics of Death camas.

Toxins: Are cevanine-type alkaloids, zygadenine.

Toxic parts: The leaves and flowering stalks contain toxins along with the bulb. The leaves have a high concentration of alkaloids with the fruits and seeds the most toxic. Z. venenosus is much more toxic than Z. elegans.

Poisoning: Sheep are more susceptible because of greater forb content in diet, with cattle and horses at risk. Early spring growth has the most serious hazard of being eaten. Mature plants have apparently quite a bitter taste and are generally avoided by grazing animals. The plant is top killed by fire, and the regrowth leaves have increased levels of alkaloids and have increased nitrogen (crude protein) levels that may be readily eaten. Minimal lethal dose of Z. venenosus would be 1% b.w. of green plant in sheep. Dosage producing serious illness may be as low as 0.2-0.5% b.w.

Symptoms: Subacute form signs beginning within several hours or as long as 24 hours after ingestion and show profuse frothy salivation with ropy strings hanging from mouth, depression, nausea, vomiting, colic, and grinding of the teeth. Cattle and horses may recover in one or two days. Acute forms show loss of appetite, trembling, incoordination, sever depression, weakness, head held low, ears dropping, back arched, wave like contractions of digestive tract propelling its contents, increased respiration with spasmodic struggling to breath, coma. At this stage fatality rate is high for sheep, low for cattle, and negligible for horses.

Treatment: A combination of 2 mg atropine to provide relief of the cardiovascular effects and 8 mg of picrotoxin to counteract the severe depression. Oral administration of activated charcoal at 2 g/kg b.w. may help.

This summary information on the poisoning characteristics of Death camas was based on works of Whitman n.d., Muenscher 1975, Schmultz and Hamilton 1986, and Burrows and Tyrl 2001.

Table 1. First flower of Zigadenus elegans, Death camas, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest			2			
Latest			17			

First Flower data from Manske 1980.

Table 2. Flower period of Zigadenus venenosus, Meadow death camas, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period						
1969-1971		X	XX XX			

Flower Period data from Zaczkowski 1972.

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Mannagrass that can Poison Livestock on the Northern Mixed Grass Prairie

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Mannagrass are among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The two species of Mannagrass are:

Glyceria grandis S. Watson	Tall mannagrass
Glyceria striata (Lam.) Hitchc.	Fowl mannagrass

Distribution of two mannagrass species are similar and extend throughout the entire Northern Mixed Grass Prairie on wet meadow habitat that can be hayed during the summer, with some plants growing next to or in shallow open water that has a firm bottom.

Tall mannagrass, *Glyceria grandis* S. Watson, is a member of the grass family, Poaceae, tribe Meliceae, and is a native, perennial, monocot, cool season, tall grass, that prefers damp to wet firm ground. The first North Dakota record is Zaczkowski 1969. Early aerial growth consists of basal leaves arising from creeping rhizome tiller buds. Basal leaf blades are 20-60 cm (8-24 in) long, 6-12 mm wide, pale green, flat, smooth to rough surface with rough margins. The sheath is smooth, relatively loose, and tubular with united margins. The ligule is 2-5 mm long, squared or rounded, and stiff or flexible. The creeping rhizome system is extensive. Single aerial stems are produced per node at progressive intervals. The root system has fibrous main roots arising from rhizomes nodes with several lateral roots arise from main roots. Regeneration is by vegetative and sexual reproduction. Vegetative growth is annual sprouts from rhizome tiller buds. Flower stalks are stout, erect, 100-150 cm (39-59 in) tall with numerous cauline (stem) leaves. Inflorescence is an open pyramidal panicle, 20-35 cm (8-14 in) long, 12-20 cm (5-8 in) wide, with branches widely spreading and drooping with 35 to 80 spikelets. Spikelets with 3-7 florets, oblong 4-7 mm long. First flowers occur during mid June in eastern North Dakota (table 1) with the flower period from early July to early August in western North Dakota (table 2). Spikelets fall apart easily at maturity releasing plump ovoid to oblong, hard, caryopses 1-1.5 mm long, and dark brown. Observations of the released grains floating on water inspired the name mannagrass.

Fowl mannagrass, *Glyceria striata* (Lam.) Hitchc., is a member of the grass family, Poaceae, tribe Meliceae, syn.: G. nervata Trin., and is a native, perennial, monocot, cool season, mid grass, that prefers damp to wet habitats. The first North Dakota record is Zaczkowski 1969. Early aerial growth consists of basal leaves arising from tiller buds on long creeping rhizomes. Basal leaves are 10-30 cm (4-12 in) long, 2-6 mm wide, light green, flat to folded, with smooth to rough surface. The sheath is smooth to rough, compressed, closed, and tubular. The ligule is 1-4.5 mm long, and rounded. The creeping rhizome system is long. Several aerial stems are produced at rhizome nodes forming loose tufts. The root system has fibrous lateral roots arising from rhizomes nodes. Regeneration is by vegetative and sexual reproduction. Vegetative growth is annual sprouts from rhizome tiller buds. Flower stalks are stout to slender, erect, 20-60 cm (8-24 in) tall, smooth, growing in large clumps. Inflorescence is an open pyramidal panicle 6-15 cm (2.4-6 in) long, with straight or lax branches 5-13 cm (2-5 in) long, spreading and drooping, with 15 to 50 spikelets. Tiny spikelets with 3-6 florets, oval, 3-4 mm long, 1.3-2.4 mm wide, purplish. Flower period is from late June to mid July in western North Dakota (table 3). Caryopses are obovoid, 0.5-2 mm long, and nearly black.

This summary information on growth development and regeneration of two mannagrass species was based on works of Stevens 1963, Zaczkowski 1972, Looman and Best 1979, Manske 1980, Great Plains Flora Association 1986, Barkworth et al. 2007, Johnson and Larson 2007, and Larson and Johnson 2007.

Poisoning characteristics of two species of Mannagrass.

Toxin: Is cyanogenic glucoside, dhurrin, that hydrolyze into hydrocyanic acid or prussic acid (HCN) causes abrupt death in cattle when ingested rapidly in large amounts.

Toxic parts: All plant parts contain toxins with the highest concentrations during rapid plant growth in spring and regrowth in fall when concentrations can reach 4,000-10,000 ppm. Seeds have low concentrations.

Poisoning: Lethal dosage is not known but less when plants are rapidly growing with increased risk when livestock are moved from a pasture without to a pasture with Glyceria. In well dried hay, the toxicity gradually decreases. However, wet meadow hay is rarely well dried when put up. With enough water content in the hay, the plant tissue may remain green and retain its toxicity levels.

Symptoms: Signs start to occur within minutes following grazing and ingestion with apprehension, distress, and increased respiration rate followed by weakness, incoordination, and labored respiration. Acute forms, the animal cannot stand, with periodic paddling of limbs, and seizures. Death can occur in 5-15 minutes. If death does not occur early, the chances of recovery are high, which may take up to 24 hours.

Treatment: The primary antidote for ruminants is intravenous sodium thiosulfate at a dose of 0.25-0.50 g/kg b.w. with or without sodium nitrate at 10-20 mg/kg b.w. However, this disease occurs and progresses rapidly and late treatment is usually not effective enough.

This summary information on the poisoning characteristics of two species of Mannagrass was based on works of Burrows and Tyrl 2001.

Table 1. First flower of Glyceria grandis, Tall mannagrass, on the Sand Hills Prairie southeastern North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
First Flower						
1976-1978						
Earliest			16			
Latest			16			

First Flower data from Manske 1980.

Table 2. Flower period of Glyceria grandis, Tall mannagrass, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period						
1969-1971				XX XX X		

Flower Period data from Zaczkowski 1972.

Table 3. Flower period of Glyceria striata, Fowl mannagrass, on the Mixed Grass Prairie western North Dakota.

	Apr	May	Jun	Jul	Aug	Sep
Flower Period						
1969-1971			X	XX		

Flower Period data from Zaczkowski 1972.

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Tall Fescue that can Poison Livestock on the Northern Mixed Grass Prairie

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Tall Fescue is among the relatively small list of plants that can poison livestock on the Northern Mixed Grass Prairie. The species of Tall fescue is:

Schedonorus arundinaceus (Schreb.) Dumort. Tall fescue

Tall fescue is native to central Europe. It was introduced into North and South America during the late 1800's for use as pasture and haylands. In the United States, improved cultivars were seeded into 12-14 million ha (30-35 million acres) in the southeastern states and on irrigated land in the Pacific northwest between 1942 and 1979, with addition selected land areas seeded in eastern Canada. This plant is aggressive and invasive and has become naturalized spreading on disturbed areas and into established grasslands. Tall fescue is being promoted and seed is available in the Northern Mixed Grass Prairie.

Tall fescue, *Schedonorus arundinaceus* (Schreb.) Dumort., is a member of the grass family, Poaceae, tribe Poeae, syn.: Festuca arundinacea Schreb., Festuca elatior var. arundinacea (Schreb.) Wimm., and Lolium arundinaceum (Schreb.) S.J. Darbyshire, and is an introduced, naturalized, perennial, cool season grass. Annual aerial growth starts very early in the spring forming a tuft of basal leaves from numerous tillers growing in a bunch. Leaves are broad, flat, stiff, 5-45 cm (2-18 in) long, 3-10 mm wide, with prominent midrib, upper surface and margins rough, edges rolled under, shiny with waxy appearance, and dark green. Sheath is round, smooth to slightly rough, split with overlapping translucent margins, and reddish at base. Ligule is membranous, 0.2-0.8 mm wide, with a square, jagged or toothed apex. Collar is conspicuous, broad, yellow green, with ciliated (hairy) margins. Auricles are prominent, small, narrow, 0.5 mm long, and ciliated (hairy). Basal leaf weight produced very early in spring, prior to when the flower stalks elongate during May, composes 67% of the total annual growth. Each tiller retains very low quantities of photosynthetically active leaf material. Vegetation growth ceases during mid summer and resumes again in fall with some fall tillers remaining green after frost. Most bunches have several short rhizomes that assist the plants to spread, some bunches have long rhizomes that assist the plants to be more persistent under heat and drought stress and much more aggressive and invasive. Root system is coarse, extensive, and descends much deeper than most introduced cool season grasses. Regeneration is by vegetative and sexual reproduction. Vegetative growth is mostly by crown tillers with a few rhizome tillers, except the bunches with long rhizomes produce more rhizome tillers than the bunches with short rhizomes. Flower stalks (culms) are erect, stout, smooth, 90-120 cm (3-4 ft) tall with numerous cauline leaves. Inflorescence is an erect, relatively narrow, contracted panicle 10-25 cm (4-10 in) long, with short, nodding branches bearing several spikelets. Spikelets with 4-5 florets, 7-15 mm long , 2.5-3.5 mm wide. Flower period is during May to early June in the southeastern states, which is earlier than smooth bromegrass. Flower stalk density is usually very low compared to other introduced cool season grasses.

The life cycle of the endophytic fungus, Neothyphodium coenophialum, follows the life cycle of Tall fescue. The endophyte is transmitted in the Tall fescue seeds. With seed germination, the fungal mycelia grow within the intercellular spaces of the developing grass shoot. During vegetative growth stages, the fungi remains in the leaf sheath only. The toxins produced in the sheath are translocated to the entire blade, with the toxins transferred to the grazing animal when the leaf blade is consumed. During the reproductive growth stage, the fungi rises up the culm with the developing inflorescence. As the seeds develop, the fungi colonizes in the aleurone layer, which is the outer layer of the endosperm in the grass grain. This outer layer of endosperm synthesizes the enzyme alpha-amylase. When the grass seed germinates, alpha-amylase is secreted into the starch filled endosperm, breaking down the starch into maltose and glucose and signalling the fungi into active growth. The fungus provides an advantage to the tall fescue plant by drought resistance, enhanced

nitrogen uptake, and increased insect resistance. The fungus gains access to nutrients and a favorable environment for growth. More than 90% of all tall fescue stands are highly infected with the endophyte.

This summary information on growth development and regeneration of Tall fescue was based on works of Beard 1973, Smith 1978, Great Plains Flora Association 1986, Barnes et al. 1995, Stubbendieck et al. 2003, and Barkworth et al. 2007.

Poisoning characteristics of Tall fescue.

Toxin: Ergot-type alkaloids produced by the endophytic fungus, Neotyphodium coenophialum. The fungus grows entirely within the grass plant and does not alter the appearance of the plant. The life cycle of the fungus is completed entirely within the plant's tissues. There are no spore formation for external dissemination. Transmission of the fungus is strictly in the grass seeds.

Toxic parts: All plant parts contain toxins with concentrations of the alkaloid at 14 ppm which about half are ergopeptides. The highest concentrations are in the seeds, leaf sheaths, and lower leaf blades. Concentrations peak in late June and then gradually decline. Alkaloid concentrations increase with nitrogen fertilization and decrease with heavy grazing pressure. Toxins are stable in fresh forage and in dried hay.

Poisoning: Occurs anytime livestock graze tall fescue pastures or eat tall fescue hay.

Symptoms: The festuca diseases associated with tall fescue are probably the most economically important toxicologic problems of livestock in North America causing an unusual group of four syndromes: Summer slump, Fat necrosis, Fescue foot, and Reproductive problems. Summer slump signs include increased body temperature and respiration rate and decreased food intake, growth, milk production, and reproductive performance. Animals have a poor appearance caused by weight loss and rough hair coat that does not shed. Animals stand in shade or in water. The greater the heat above 90° F and the higher the humidity, the more severe the syndrome. Problems are mainly caused by decreased blood flow to skin reducing the ability for body heat dissipation. Fat necrosis signs include the appearance of numerous hard fat masses of the abdominal cavity associated with a decrease in serum cholesterol and total lipids resulting in signs of vascular obstruction in the intestinal, urinary, and genital systems. Fescue foot signs include weight loss, rough hair coat, slight diarrhea, body temperature increase, arched back, reluctant to move because of soreness of limbs, during winter and early spring swelling and reddening of the coronary bands between the hoof and dewclaws, swelling progresses to dry gangrene and eventual loss of the foot due to vasoconstriction effects associated with cold temperatures. Also similar lesions occur in the tail with loss of the switch. Reproductive problems in cattle signs are a decrease in prolactin secretion with subsequent decreases in milk production. Acute forms have degeneration of the corpus luteum caused by vasoconstrictions and reduced blood flow leading to inability to maintain pregnancy. Reproductive problems are severe in horses, signs include incoordination, decreased conception rate, prolonged gestation, weak foals, still births, abortion, and firm thickened placentas. Foals have overgrown hooves, irregular incisor eruption, long hair coats, and poor muscling. Prolonged gestation results in a large fetus, difficult delivery with increased risks to both fetus and dam. Reproductive problems in sheep signs are decreased reproductive efficiency, conception delay, if pregnancy goes to term the birth weights are decreased.

Treatment: Prevention is the best action. Do not be swayed by promotional extravagant claims about tall fescue as pasture and hayland. Do not purchase and plant tall fescue seeds for forage on your land. Do not purchase tall fescue hay that may contain seeds during low hay production periods, such as drought conditions.

This summary information on the poisoning characteristics of Tall fescue was based on works of Burrows and Tyrl 2001.

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