Botanical Description of Lesser Spikemoss (Clubmoss) on the Prairie of the Northern Great Plains

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Reclassification

Lesser spikemoss, *Selaginella densa*, has a designated common name different from the familiar standard name of clubmoss. The Pteridophytes (vascular cryptogams) were recently reclassified by the Pteridophyte Phylogeny Group 1 (PPG1) (2016). The Lycopodiophyta (clubmoss) were separated into three orders of Lycopodiales (clubmoss), Isoetales (quillworts), and Selaginellales (spikemoss) (table 1) and these were divided from the divisions of Sphenophyta (horsetails), and the Pterophyta (ferns).

The plants that have had the common name of clubmoss for a long time are the Lycopods; in Greek, Lyco means wolf, and pod means foot, thus the name wolf foot, but they were called clubmoss, as were all the other plants that had been lumped under the old category of Lycophytes. The plants that were called clubmoss but currently have the designated common name of lesser spikemoss is Selaginella densa. In Latin, densa means thick, ella means diminutive or small, and selagin actually does mean clubmoss, thus this name means thick, small, clubmoss. Stevens (1963) called Selaginella densa, small clubmoss. O.A. Stevens knew the classical languages that pertained to plant names. Unfortunately, to the replacement botanists, plant common names do not follow their classical meanings.

Origin

Selaginella are an ancient primitive diminutive evergreen, appearing delicate but tough, perennial herbaceous nonflowering plant. These were among the first land plants to successfully develop basic vascular tissue and absorbing true roots. This group of plants originated more than 350 million years ago that dominated the earth during the Carboniferous period and helped form the worlds hard coal (anthracite) deposits (Burns 1974). Most of the plants from this group are extinct. All of the surviving extant members are rather small and often go unnoticed. Living in North America for over 350 million years is quite a remarkable accomplishment. Not many organisms have done that and survived three major mass extinction events.

Morphology

Selaginella densa Rydb. has several prostrate creeping stems that are 2 to 6 in (5 to 15 cm) long, with numerous erect branches, densely packed, that are seldom more than 1 in (2.5 cm) in height, forming thick cushionlike mats. The branches are completely covered with tiny lanceshaped leaves (microphylls) 1.7-2.5 mm long, 0.2-0.3 mm wide in ranks of four pressed close to the branch. The lower leaves are a little longer than the upper leaves, which have minute whitish setae (bristles) that change color with age and form conspicuous tufts at the branch tips. Roots are very fine about 0.008 in (0.2 mm) in diameter, are minutely branched and have small root hairs and a root cap. They do not extend deeper than 0.78 to 2.0 in (2-5 cm) below the soil surface. All of the roots are adventitious arising at intervals along the horizontal stems and from special short stem branches called rhizophores. The extensive tangle of roots may comprise a high percentage of the plants total dry matter (Stevens 1963, Looman and Best 1979, GPFA 1986, Crane 1990, Anonymous 2021).

As a result of the extremely shallow root system, growth is limited to periods of the year when moisture is available at shallow depths. Vegetative growth and rate of spreading is slow. Under normal conditions, measured growth was about 0.4 in (1 cm) per year. Under dry conditions, growth was less than 0.2 in (5 mm) in 5 years (Crane 1990). If growth occurs radially at equal rates, it would require 15 years to grow 6 inches, with normal rainfall.

The stems contain no pith. The very simple primary vascular tissue of xylem and phloem collectively are called the stele that is separated from the cortex in a cylindrical cavity arranged in many platelike zones that are suspended by trabeculae (modified elongate endodermal cells) that have Casparian strips on their lateral wall. The Casparian strips secrete salts into the vascular tissue that helps develop a lower hydrostatic pressure in the plant. The stele structure, in cross section, forms a plectostele type vascular system that is continuous with the roots. A single unbranched vein develops from the central stele for each microleaf and has no leaf gap (Burns 1974).

Selaginella dry weight is comprised of 16.5% silica, which is very high (Crane 1990). Silica has no nutritional qualities for the plant and would be a great deterrent for any animals to eat it. Livestock do not eat it and there is no documented evidence that any wildlife eat it. Silica is used by plants to increase the rigidity of stems and branches (Shakoor et al. 2015). Selaginella has a very primitive vascular system that most likely provides poor turgor. Turgor is the hydrostatic pressure on cell walls that result from transpiration of soil water through the leaves causing more advanced plants to be rigid. Selaginella must have to use high quantities of silica to compensate for the low turgor produced by its vascular tissue. Using lignin or structural carbohydrates to produce rigidity has a much greater biological cost to plants than using silica (Shakoor et al. 2015).

Reproduction

Selaginella produces neither flowers nor seeds during its reproductive processes. Reproduction is sporiferous from the production of spores. Selaginella plants are heterosporous and produce two different sizes of spores, the megaspores are the female gametes and the microspores are the male gametes. A four-angled strobili that is 1 to 2 cm or up to 3.5 cm long, is a conelike cluster of sporophylls (leaflike structures of the strobili) that form at the tip of a branch. The megasporangia are the structures that produce the female megaspores and are attached to the axis of the branch towards the lower portions of the strobili. A megasporophyll is a leaflike structure to protect the megasporangia from the outside. A ligule, that is a small flap of tissue, is located between the base of the sporangium and the base of the sporophyll. The microsporangia are the structures that produce the male microspores and are attached to the axis of the branch towards the upper portions of the strobili. A microsporophyll is a leaflike structure to protect the microsporangia from the outside. A ligule, that is a small flap of tissue is located between the base of the sporangium and the base of the sporophyll (Burns 1974, GPFA 1986, Crane 1990).

At maturity, the microspores produce microscopic flagellated male sperm cells that are released when there is available water to swim to the female egg cells. Tissue surrounding the fertilized egg can photosynthesize carbohydrates for the developing embryo. A young sporeling consists of a root, a stem, and two young leaves or cotyledons. When there is available water, the developed sporelings are released to fall to the ground. If conditions are perfect, the sporelings are successful (Burns 1974, Crane 1990).

Management of the Problem

In the northern Great Plains, Selaginella densa var. densa primarily grows on shallow grassland sites and usually increase on grasslands managed by traditional seasonlong grazing. Selaginella has no identifiable advantageous characteristics, it provides no forage for livestock or wildlife, it provides no protective cover for ground nesting prairie birds, and it occupies space that forage plants could grow. Clubmoss is generally considered to be a problem plant. After decades of research, there are no direct control treatments from mechanical, chemical, fertilizer, or fire practices that have demonstrated repeatable successful results at reducing clubmoss (Crane 1990).

Management of clubmoss needs a different approach. What if Selaginella were not a problem plant but a symptom of a poor soil functionality problem. Typically, shallow grassland soils managed by traditional practices have low microbial activity, low available mineral nitrogen, and extremely low water holding capacity. Selaginella has lower water and nutrient requirements than grasses and it has greater capabilities for complete or nearly complete summer dormancy and can regulate its recovery rate from partial to full depending on amounts of precipitation received.

Grass plants have not developed drought mechanisms. Grasses have developed mechanisms to live in dry open habitats, grazing defense mechanisms, and cold tolerance mechanisms (Manske 2022). When grasses transform into summer dormancy because of the lack of soil water, it is not complete dormancy, they appear to maintain the same quantity of active tissue as during winter dormancy. On shallow sites, when the small amount of soil water is used up and the interval between rain events is long, a greater percent of the grass biomass dies compared to the percent of biomass of Selaginella. The growth rate of Selaginella is very slow. The open spaces left by the dead grass plants are not back filled by Selaginella in one or two years. It takes decades for clubmoss to become a problem.

The old traditional style management should be changed to biologically effective management that was designed to increase soil microbial activity by transferring the surplus carbohydrates produced by vegetative lead tillers through the roots to the soil microbes, the resulting increase in microbial activity would increase the quantity of available mineral nitrogen that would activate the internal grass growth mechanisms that would replace the lost grass stems and leaves. Also the increased microbial activity would improve soil aggregation that would increase the water holding capacity of shallow soils. These improved changes in soil functionality would give grass plants a competitive advantage over the clubmoss and gradually decrease the land area occupied by Selaginella, producing greater quantities of forage and better cover for ground nesting prairie birds (Manske 2018).

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Table 1. Pteridophyte Phylogeny Group 1 Classification, 2016.

Kingdom:	Plaintae	Multicellular, photosynthetic	
Phylum:	Tracheophyta	Vascular plants	
Division:	Lycopodiophyta/Lycophytes	Seedless, spore bearing	
Class:	Lycopodiopsida	Bartl. PPG1 2016 modern classification	
	Order: Lycopodiales	DC	1 family, 16 genera
	Family: Lycopodiaceae	P. Beauv.	Clubmoss
	Order: Isoetales	Prantl.	1 family, 1 genera
	Family: Isoetaceae	Dumort.	Quillwort
	Order: Selaginellales	Prantl.	1 family, 1 genera
	Family: Selaginellaceae	Willk.	Spikemoss
	Genus: Selaginella	P. Beauv.	small clubmoss
	Species: S. densa	Rydb.	dense spikemoss
	Variety 1: S. densa var. densa	lesser spikemoss	
		prairies of northern Great Plains	
	Variety 2: S. densa var. scopulorum	Rocky Mountain spikemoss	
		northern Rocky Mountains	
	Variety 3: S densa var. standleyi	Standley's spikemoss	
		only above timberline	

Data from PPG1 (2016), Crane 1990.

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