Is *Poapratensis* An Invasive Species In Upper Midwestern Prairies?

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Kentucky bluegrass (KBG) (PoapratensisL.) was likely brought by English colonists in the 17th century as animal feed, or as a contaminant of animal feed, though it is possible native species may have existed (Huff, 2003). Descriptions of the area around Jamestown by John Smith noted few grasses, but 20 years after land clearing and grazing domestic animals as part of the settlement process, grasses were noted as plentiful (Carrier and Bort, 1916). Kentucky bluegrass could have arrived in prairies around the Midwest through overseeding for pastures, influx of propagules from nearby seeded areas or deposited through animal manure. Kentucky bluegrass is a highly variable cool season grass and an apomictic species with extensive rhizomes that allows it to spread vegetatively once established (Huff, 2003). These traits and reports of its presence in grasslands and other natural areas (Tyser and Worley, 1992; Larson, 2001; Kraszewski and Waller, 2008) have resulted in it commonly being deemed invasive by various agencies (Center for Invasive Species and Ecosystem Health and The Nature Conservancy, 2011).

Figure 1: Sampling quadrat at Avoca Prairie and Savanna, WI.

The Invasive Species Advisory Committee (ISAC) defines an invasive species as 'non-native to the ecosystem under consideration and whose introduction causes or is likely to cause economic or environmental harm or harm to human health' (ISAC, 2006). A species that has been deemed invasive often has regulations put into place that prohibit or restrict its use and transport (WIDNR).

To determine whether or not KBG was indeed an invasive species in remnant prairies in the Upper Midwest, I did a survey of ten Upper Midwestern prairies as part of my Master's research. This allowed me to determine if there were relationships between its presence, prairie size, soil type, and history of management. A total of 148 sampling points or quadrats (3x5 ft.) from the ten sites were used to determine the proportion of the quadrat was occupied by KBG, other flowering plants of various heights, woody plants, other grasses, invasive grasses and other invasive species.

Table 1. Prairie locations and descriptions used for *Poapratensis*(L.) abundance survey of Upper Midwest tallgrass prairies

Site Location	Hectares (surveyed area)†	Primary Soil Type‡	Number of Quadrats
Belmont Prairie Nature Preserve, IL	4.2 (2.4)	Silt loam/silty clay loam	5
Crossman Prairie State Preserve, IA	4	Silty clay loam/loam	7
Doolittle Prairie State Preserve, IA	10.4	Silty clay loam	12
Bluestem Prairie Scientific and Natural Area, MN	1120	Sandy loam/loamy sand/clay loam	28
Kettledrummer Prairie, MN	80	Loamy sand/silt loam	20
Malmberg Prairie Scientific and Natural Area, MN	32	Silty clay loam	15
Avoca Prairie and Savanna State Natural Area, WI	754 (156)	Loamy alluvial	24
Newark Road Prairie State Natural Area, WI	13.2 (11.4)	Silt loam/muck	11
Snapper Prairie State Natural Area, WI	12	Silty clay loam	11
Young Prairie State Natural Area, WI	322.4 (87.2)	Silt loam/Silty clay loam/sandy loam	20

† Indicates hectares used for survey if different from total.

‡Soil types determined from soil maps from Soil Survey Staff (Web Soil Survey).

Cover classes for each plant group were: 0=bare soil/thatch, 1=less than 5% cover, 2=5-25% cover, 3=25-50% cover, 4=50-75% cover, and 5=75-100% cover (Daubenmire, 1959). Other information on slope, any disturbance, distance to edge, distance to nearby golf courses, and land use around the site were recorded. Carbon and nitrogen content of a soil sample collected from each quadrat was also determined.

Data were analyzed through regression tree analysis for determining the parameters that had a relationship to KBG presence/absence and proportion of KBG. Regression tree worked by having the program sift through all 49 parameters, identifying parameters that explained experimental variability in order of descending importance. Both trees received the same input parameters.

Of the 148 quadrats surveyed, 79 (~52%) contained KBG, with each site contributing at least one quadrat containing KBG. Average cover of KBG within a quadrat was less than 5%. Only 3 quadrats contained KBG cover over 50%.

The regression tree sorted the binary data of presence or absence of KBG by sending "no KBG" to the left side of the tree and "yes KBG" to the right (Figure 1). The first split identified by this tree showed KBG tended to be present if cover of sedges and rushes was rated ≤2.5 (5-50% cover). The model continued by including soil carbon ≤1.06% and status as a State Natural Area (SNA) before1980 as indicators of KBG presence. When the year a prairie became an SNA was ≥1980 (newer), meters to edge to the west (m to edge W) from the quadrat became important and tended to not include KBG if the distance was >285 m. The model for presence or absence explained 17.7% of the variability within the data (Figure 1).

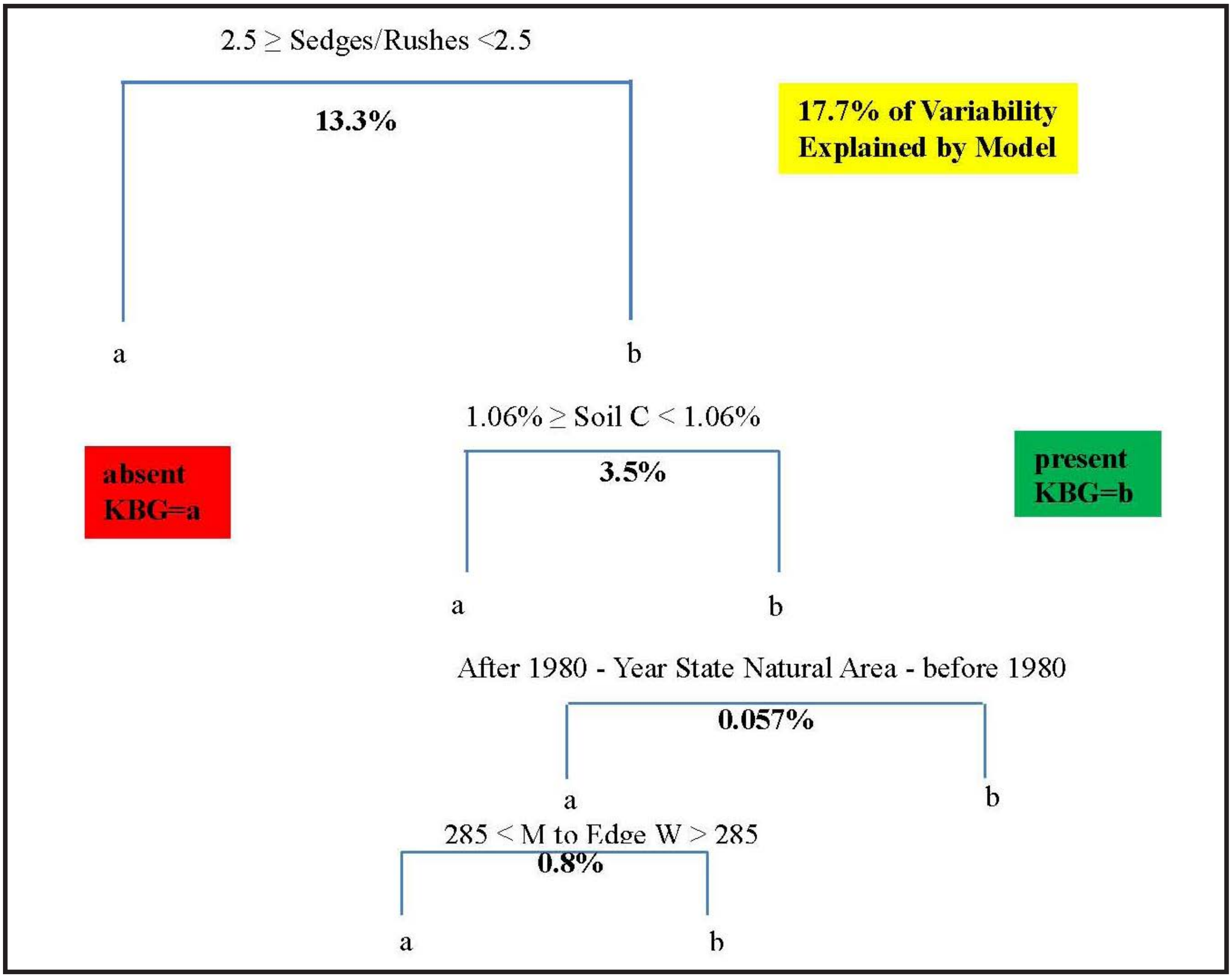

Figure 2: Regression tree model explaining presence/absence of Kentucky bluegrass (KBG) in Upper Midwest tallgrass prairies. Parameter listed sorts to left side of tree. a=KBG absent, b=KBG present, plant types/groups were evaluated based on percent cover ratings on 0-5 scale using the Daubenmire scale. C= is Soil Carbon . Year State Natural Area=Year site became a State Natural Area. Percentages below each parameter are percent of variability explained by the parameter.

Kentucky bluegrass tended to be less likely if sedge and rush cover was ≥2.5 cover rating. Sedge cover was also important in the proportion KBG model. Sedges are grass-like plants that inhabit a variety of environments but are very typical of wet areas where they can form what are referred to as sedge meadows (Cochrane et al., 2006). The affinity of sedges for wetter areas is in contrast to KBG, which varied in its tolerance to waterlogged conditions (Wang et al., 2009).

Soil C >1.06% as an indicator of KBG absence was a surprising parameter to appear in the regression tree model due to C being associated with higher organic matter, which can be an indicator of high fertility. Anthropogenic carbon additions in the form of sawdust or sucrose to restored prairies reduced N-availability thereby decreased KBG biomass (Clark and Tilman, 2010).

Kentucky bluegrass was more common when the number of meters from a sampling quadrat to a prairie edge was >285 m. This is in contrast to many invasive species studies where invasive species were found near the edges of study sites (Tyser and Worley, 1992; Larson et al., 2001).

A regression tree was also constructed for the proportion of the quadrat occupied by KBG within each quadrat. This tree was sorted by sending "less KBG" to the left side of the tree and "more KBG" to the right (Figure 2). The first split was for slope as designated by Web Soil Survey (WSS) which explained the greatest proportion of variability. Lower slopes tended to have less KBG (0%, 0 to 3%, 0 to 4% and 4 to 6%) while steeper slopes (2 to 6%, 1 to 6%, 6 to 12%, 0 to 2%, 1 to 3%, 1 to 4%, and 3 to 5%) tended to have higher proportions of KBG (Figure 2). The next node was WSS Soil Type where more productive soil types tended to have less KBG except clay loam and pit or gravel (i.e. coarse and extremely sandy) type soil (second most variability explained). The final split of that branch consisted of sedges and rushes ≥2.5 cover rating (5-50% cover) as a factor for less KBG. A secondary branch showed that the proportion of KBG was greater if the number of years since the last burn was >4 years. This tree for the proportion of KBG explained 38.8% of the variability within the data (Figure 2). From the data we collected, it was easier to explain the proportion of KBG rather than its presence or absence meaning forces other than those we explored likely drove its presence within the site. The factors in the proportion KBG tree simply govern the amount of KBG in a given area of the site.

Steeper slopes and more productive soils tended to favor KBG. While many sites and some areas within the sites were low and relatively flat, these often were somewhat wet. Upland areas had better drainage which likely facilitated KBG presence and growth. In addition, drier upland areas with better drainage would have facilitated agricultural practices from haying to grazing to plowing.While we attempted to ensure survey sites were as remnant prairie as possible, KBG may have also been planted at our sites prior to any current knowledge. Carrier and Bort (1916) discussed KBGs spread westward without disturbance, which supported the lack of agricultural disturbance being part of our regression tree model.

Management activities may have prevented KBG from establishing at the site or management practices long term may have decreased KBG below levels detected by our survey. The proportion of KBG modeled showed that areas burned over four years ago were more likely to have higher proportions of KBG in their quadrats. Kentucky bluegrass and many other exotic species are decreased with frequent burns; however native species richness may also be decreased Smith and Knapp (1999).

Former agricultural disturbance at the site (i.e. grazing or haying or limited plowing with restoration) as well as environments around the site had no effect on KBG presence or on the proportion of KBG. Many of our sites were grazed or hayed; however, these did not factor into either model.

Surprisingly, N, size of the site, area:perimeter, and distance of the quadrat to the edge from cardinal directions other than west were not factors explaining presence or proportion of KBG at these tallgrass prairies. It was expected that large sites or those with greater interior would be less invaded compared to small sites or those with less interior as suggested by other studies (Kraszewski and Waller, 2008). Edges create areas where soil moisture, light, and resource availability is different than other areas within the site and may face an influx of propagules (Parendes and Jones, 2000). Nitrogen has been proposed as a limiting resource for many vegetation communities and increases may produce a legacy effect (Larson et al., 2001). Soil water holding capacity, drainage class, hydrological classes and depth to water table were also not factors in either model as they did not explain enough variability relative to other parameters.

Kentucky bluegrass was found across the prairie landscape in areas at moderate frequency with sparse cover and plants completing their life cycles. Sedges, soil type and slope, soil C, age of the site, and number of years since burning all contributed to explaining where KBG was found and the extent of its patches.

Kentucky bluegrass does exhibit some traits of invasive species including high seed set and vegetative reproduction (Richardson et al., 2000), but other factors appear to be keeping KBG proportions relatively low. KBG does not appear to create monocultures outside of maintained lawns or golf courses.

"Surprisingly, N, size of the site, area:perimeter, and distance of the quadrat to the edge from cardinal directions other than west were not factors explaining presence or proportion of KBG at these tallgrass prairies.."

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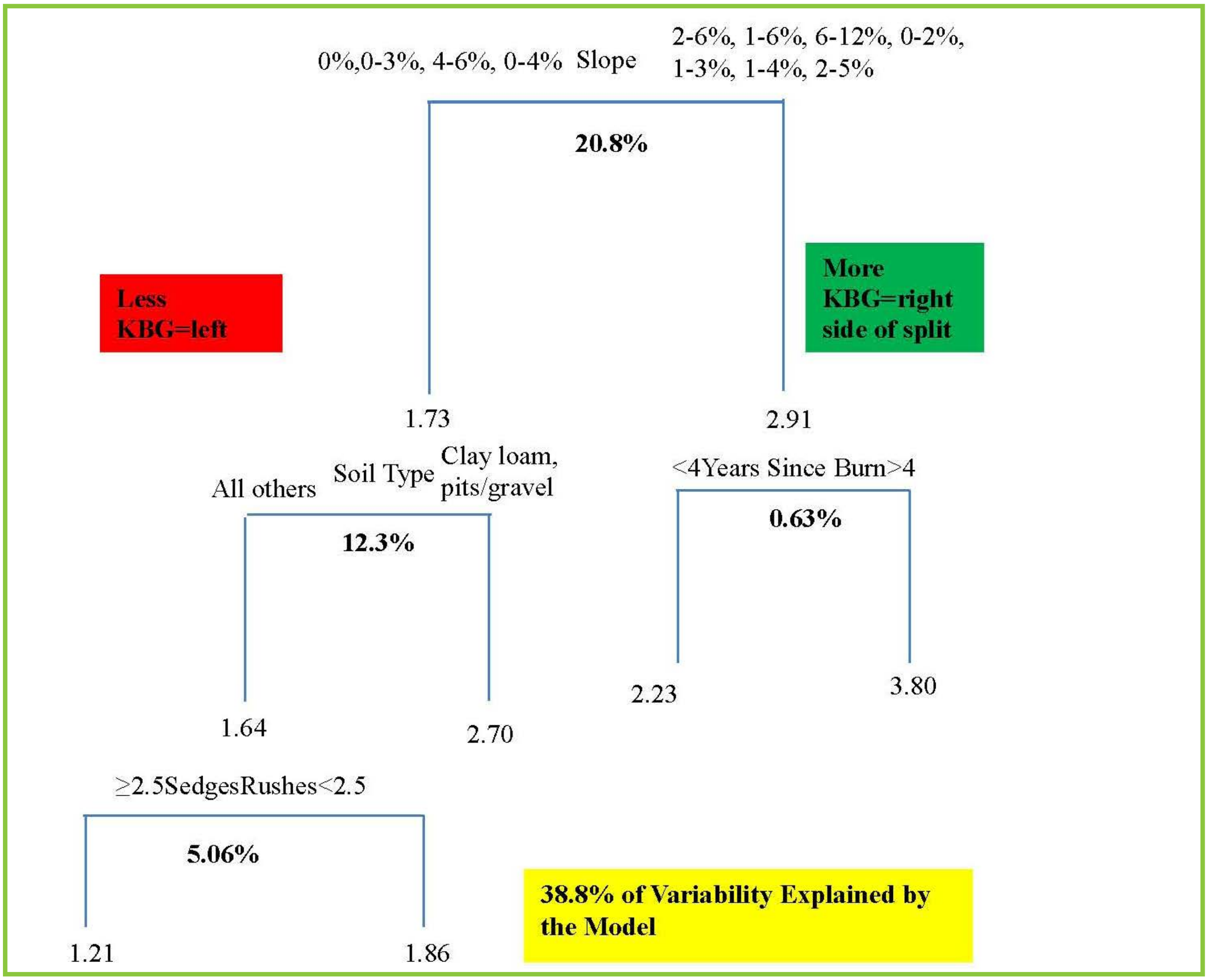

Figure 3: Regression tree model explaining the proportion of Kentucky bluegrass (KBG) in remnant tallgrass prairies of the Upper Midwest. Lower proportion of KBG is sorted to the left. Plant cover (i.e. sedges/rushes) was based on the Daubenmire cover class system. Soil types (WSS Soil Type, from Soil Survey Staff, Web Soil Survey) for "all others": silt loam, silty clay loam, sandy loam, loamy sand, muck, loamy alluvial, loam, silty clay, sand. Numbers at terminal nodes indicate proportion of KBG as determined by Daubenmire cover class