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Carol A. Johnston

Kayla L. Miller

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Phragmites australis in South Dakota: Historical Distribution and Environment

CAROL A. JOHNSTON¹ AND KAYLA I. MILLER

Department of Biology & Microbiology, Box 2104A, South Dakota State University,
Brookings, SD 57007, USA (CAJ, KIM)

ABSTRACT Common reed, *Phragmites australis*, has long been a component of Northern Plains wetlands, but impending invasion by the non-native *P. australis* haplotype M may displace native haplotypes in the future. To increase understanding of historical *Phragmites* occurrence, we developed a geographic information system (GIS) protocol to improve the georeferencing of specimens from South Dakota herbaria, and mapped the distribution of *Phragmites* relative to geology, physiographic regions, and water bodies. There were 91 *Phragmites* herbarium specimens from South Dakota and adjacent Wyoming. *Phragmites* collections occurred in nearly all physiographic regions of the state, with concentrations occurring in the Prairie Coteau of eastern South Dakota and the periphery of the Black Hills in western South Dakota. GIS analysis showed that the Black Hills *Phragmites* collection sites occurred in the “Red Valley” overlying the Spearfish bedrock formation. *Phragmites* usually occurred on wetlands or lakes in eastern South Dakota; *Phragmites* in unglaciated western South Dakota usually occurred on creeks and stock dams. There was no evidence of a recent increase in *Phragmites* collections. Because native *Phragmites* probably occurs throughout South Dakota, weed control practitioners should verify that *Phragmites* stands are of the non-native haplotype before implementing control measures.

KEY WORDS common reed, invasive plant, prairie pothole, stock dam, Prairie Coteau, Black Hills

Common reed, *Phragmites australis* [(Cav.) Trin. ex Steud. (syn. *Phragmites communis* Trin.)] has long been a component of wetlands and riparian zones of the U.S. Great Plains (Rudd 1951, Dixon and Johnson 1999). *Phragmites* was utilized by ranchers in North Dakota for forage and natural hay (Kirby et al. 2002) and by Native Americans for food, weapons, pharmaceuticals, and weaving material (Johnston 1970, Kiviat and Hamilton 2001). *Phragmites australis* is a facultative wetland indicator plant (Reed 1988), so its range coincides with areas of abundant wetlands. In the Dakotas, range maps depict *P. australis* as primarily occurring in glaciated terrain east of the Missouri River (Barkworth et al. 2003).

Although the species is native to the U.S., the recent spread of an aggressive Eurasian strain, *P. australis* haplotype M, has raised conservation concerns. Haplotype M was uncommon in North America prior to 1910, but began invading fresh and brackish wetlands during the late 20th century, and is quickly becoming the most widespread *Phragmites* in North America (Saltonstall 2002, Chambers et al. 2003, Tulbure and Johnston 2010). Non-native haplotypes have displaced the native subspecies to such an extent that the conservation of native *Phragmites* stands has been proposed in the eastern U.S. (Lambert and Casagrande 2006, Meyerson et al. 2009).

The spread of the non-native haplotype to the Northern Plains has been much slower, and a 2002 North American study reported only native haplotypes occurring in the Dakotas, Manitoba, and Saskatchewan (Saltonstall 2002). However, concern over possible invasion recently prompted the state of South Dakota to list the non-native *P. australis*

haplotype M as a noxious weed (South Dakota Rules §12:62:03:01.07), even though little is known about the extent of the problem. Invasive plants can cause tremendous ecological and economic harm, and their early detection can aid control measures (Pimentel et al. 2000), but control measures misdirected at non-invasive indigenous *Phragmites* stands might cause unnecessary damage to wetlands at unnecessary taxpayer expense.

Herbarium collections are valuable for determining the distribution of invading plant species (Delisle et al. 2003, Lavoie et al. 2009). Using only herbarium specimens, Delisle et al. (2003) identified 1963–84 as a period of *Phragmites* expansion in southern Quebec. Herbarium specimens can also be valuable for identifying environmental preferences of plant species, particularly if the collection location is digitally georeferenced in a geographic information system (GIS; Boylen et al. 2006, Lambert and Casagrande 2006). Environmental conditions associated with a plant species can be retroactively determined by intersecting collection point locations with suitable GIS data layers (e.g., geology, soils, and topography), provided that the point location is sufficiently precise (Johnston 1998). Georeferencing precision has improved with the advent of global positioning systems (GPS), but historical herbarium specimens often lack specific geographic coordinates. South Dakota lags behind other U.S. states in georeferencing and digitizing its herbarium data, but work is in progress (Gabel et al. 2007).

The objectives of this paper are to document the historical occurrence and environmental conditions of *P. australis* collections in South Dakota, as baseline

¹ Corresponding author email address: carol.johnston@sdstate.edu

information for future studies of non-native *Phragmites* invasion. We summarized *Phragmites* occurrence from literature references and herbarium specimens, after first developing a GIS georeferencing protocol to use the scant information provided on most collection labels. We expected that *Phragmites* would occur primarily in wetlands, and that *Phragmites* would be more widespread in eastern than in western South Dakota due to the greater abundance of wetlands in the glaciated portion of the state. We also expected an increase in the number of *Phragmites* specimens collected during recent decades due to heightened environmental awareness, particularly if aggressive non-native *Phragmites* haplotypes had recently begun to invade the state.

STUDY AREA

The study area was the state of South Dakota, as well as portions of the Black Hills extending into Crook County, Wyoming (Fig. 1). South Dakota was glaciated east of the Missouri River during the Wisconsin ice age, which deposited thick till that interrupted drainage patterns (Gries 1996). The resulting Prairie Pothole Region contains numerous wetlands and shallow lakes (Kahara et al. 2009). Lands west of the Missouri River were not glaciated, have a drier climate, and contain fewer wetlands. Along the western edge of the state, the Black Hills is a uplift dome rising 1,200 m above the plains, consisting of an inner core of Precambrian igneous and metamorphic bedrock surrounded by Paleozoic, Triassic, and Jurassic sedimentary bedrock.

METHODS

Phragmites australis specimen data were obtained from the Black Hills State University Herbarium (2010) database, which summarizes data from 16 herbaria. In addition, specimens of *P. australis* were examined at the C.A. Taylor Herbarium of South Dakota State University (SDSU), and information transferred from specimen labels to a computer spreadsheet. The completeness of label information varied among specimens, but generally included the species and variety, collection date, collector, and location. Only three specimens, all collected since 2003, had specific latitude and longitude coordinates; most specimens used Public Land Survey coordinates (township, range, section) or place names to describe location. Specimens were classified by decade of collection and by associated water body: wetland, lake, creek, stock dam, and ditch.

Point locations of collected specimens were converted to latitude and longitude in decimal degrees, aided by a tool from Earth Point (<http://www.earthpoint.us/>) that was used to view a township, range, and section grid in Google Earth (<http://earth.google.com/>). Point locations were imported into ArcMap 9.3 (ESRI, Redlands, CA, USA), and displayed against digital databases of the geology (Martin et al. 2004) and physiographic regions in the state (Johnson et al. 1995).

Published journal articles and government reports were searched for the terms “South Dakota” and “*Phragmites*.” Publications containing both these terms were read to determine specific locations of *Phragmites* stands (e.g., county, lake name, wildlife management area name).

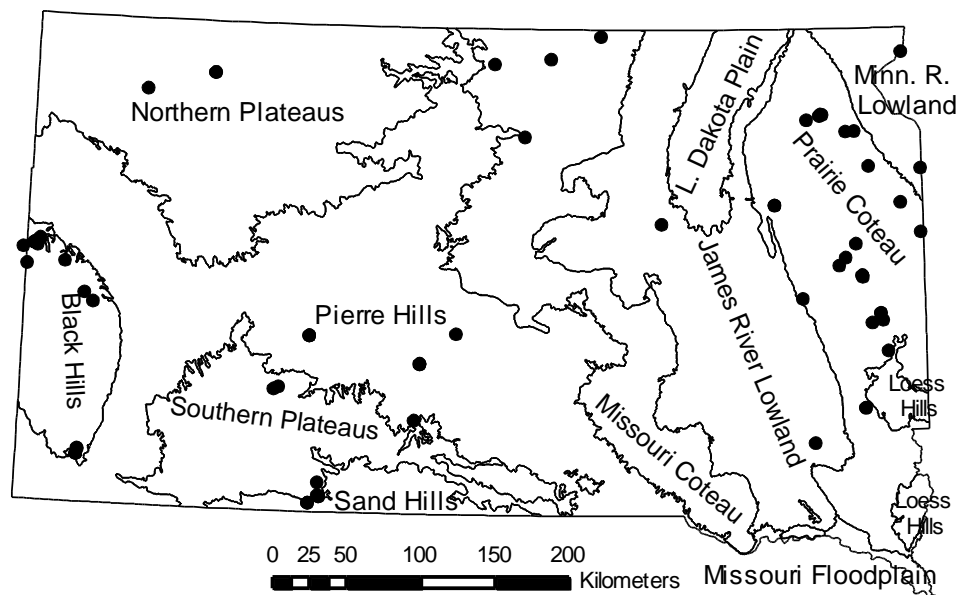


Figure 1. Specimen locations of *Phragmites* spp. relative to major physiographic regions in South Dakota (Johnson et al. 1995).

RESULTS

Spatial Distribution

Phragmites australis is easily recognizable in the field because of its tall stature and plumose inflorescence, and the species was frequently mentioned in articles about fish or wildlife habitat (Table 1). Half of the 21 studies cited in the literature were conducted in Brown County (Sand Lake National Wildlife Refuge) or Brookings County, home of South Dakota State University. In contrast, *Phragmites australis* is rarely mentioned in scientific literature for

western South Dakota. It occurred along Whitewood Creek in Lawrence County (Kuwabara 1992), in the Lacreek National Wildlife Refuge in Bennett County (U.S. Bureau of Reclamation 2002), and was “locally common along Cascade Creek” in Fall River County (McIntosh 1949). The only herbarium voucher specimen specifically linked to a journal article was that of McIntosh (1949), but other herbarium specimens verify the literature-mentioned presence of *Phragmites* at Lacreek National Wildlife Refuge, Oakwood Lakes, Cottonwood Lake, and Cascade Creek.

Table 1. Literature references to *Phragmites australis* or *P. communis* in South Dakota

Place of occurrence	County	Reference(s)
Lacreek NWR ^a	Bennett	U.S. Bureau of Reclamation 2002
Big Sioux River	Brookings	Lyons et al. 1997
Oakwood Lakes	Brookings	Stafford et al. 2002, Stafford and Pearse 2007, Hesler and Kieckhefer 2008
Windsor Township	Brookings	Sather-Blair and Linder 1980
Multiple locations	Brookings	Larsen et al. 1994
Sand Lake NWR ^a	Brown	Aldous 1947, DeGrazio 1964, Mott et al. 1972, Clark et al. 1991, Kernohan et al. 1994, Naugle et al. 1995
Stink Lake	Codington	Ungar 1970
Bitter Lake	Day	Ungar 1970
Cascade Creek	Fall River	McIntosh 1949
Lake Thompson	Kingsbury	Otis et al. 1986, Knittle et al. 1987
Whitewood Creek	Lawrence	Kubawara 1992
Rosholt ^b	Roberts	Kantrud 1986
Cottonwood Lake	Spink	Kruger and Repsys 2001

^a NWR = National Wildlife Refuge; ^b 9.66 km SW of Rosholt.

A total of 91 *Phragmites* herbarium specimens occurred in South Dakota and portions of the Black Hills in adjacent Wyoming, of which 86 could be georeferenced to specific point locations. In addition to specimens housed in the BHSU and SDSU herbaria, the BHSU database also included several *Phragmites* specimens from the University of South Dakota, Badlands National Park, and University of Wyoming.

Phragmites australis occurred in most of the state's

physiographic regions (Fig. 1). As expected, *Phragmites* was widespread in the Prairie Coteau physiographic region, occurring at 22 different locations. Contrary to expectations, a large number of specimens ($n = 34$) were collected in the Black Hills of South Dakota and adjacent Wyoming. Physiographic regions lacking *Phragmites* specimens were along the southern edge of the state: Sand Hills, Missouri River floodplain, and Southeastern Loess Hills (Fig. 1).

Based on the literature search and herbarium specimens,

Phragmites was documented to occur in 30 of South Dakota's 66 counties, distributed throughout the state. The county with the most specimens ($n = 27$) was Lawrence County in western South Dakota. Of these, 22 specimens were collected by 19 different collectors within the 419 ha South Dakota Game Production Area that contains the McNenny State Fish Hatchery (hereafter "McNenny GPA"). All six Bennett County specimens were collected at Lacreek National Wildlife Refuge in September 1982 and 1985 by six different collectors as part of SDSU class field trips (Gary E. Larson, SDSU Herbarium curator, personal communication). Other counties were represented by five or fewer herbarium specimens.

Phragmites frequently occurred along lakes in eastern South Dakota, but natural lakes (and therefore associated *Phragmites* stands) are rare in western South Dakota (Fig. 2A). In western South Dakota, *Phragmites* was associated with two water supply reservoirs and two natural lakes, Cox and Mud Lakes in the McNenny GPA. Three *Phragmites* collection sites were stock dams, small ponds created for the purpose of watering livestock, and four were ditches (Fig. 2A).

Temporal Distribution

The earliest *Phragmites* specimens in South Dakota herbaria were collected by academicians. The oldest specimen was collected in 1892 by J. J. Thornber of the University of Arizona during a collection expedition to Sioux Falls (Nieuwland 1914). The first *Phragmites* specimen from western South Dakota was collected in 1914 by William H. Over, then a professor at the University of South Dakota (Neuhaus 2000). *Phragmites australis* specimens were collected in the 1920s and 1930s by Arthur C. McIntosh (South Dakota School of Mines) along Cascade Creek in Fall River County, where the species was reported to be "locally common" (McIntosh 1949). The current and former curators of the SDSU herbarium, Gary E. Larson and C. A. Taylor, Jr., continued the tradition of faculty collection, contributing eleven South Dakota *Phragmites* specimens.

From the 1890s to the 1970s, one to five new *Phragmites* specimens were added each decade to the collections. More specimens were collected during the 1980s ($n = 40$) and 1990s ($n = 26$), but from 2000 to 2009 only four *Phragmites* specimens were collected. A map of specimens by collection date reveals no spatial pattern that would indicate an invasion front (Fig. 2B).

DISCUSSION

These results did not support our expectation that *Phragmites* would occur primarily in eastern South Dakota. Although the number of unique *Phragmites* locations was greater in eastern South Dakota than in western South

Dakota, more specimens were collected in western South Dakota. The large number of specimens collected at the McNenny GPA was primarily due to the "botanist effect" of greater sampling intensity close to universities (Moerman and Estabrook 2006). The McNenny GPA is 17 km from Black Hills State University in Spearfish, and was a prime destination for students required to make collections for plant systematics and agrostology classes (Mark Gabel, Curator, Black Hill State University Herbarium, personal communication). Nevertheless, our work shows that *Phragmites* is more widespread in western South Dakota than is indicated by the *Flora of North America* (Barkworth et al. 2003).

The *Phragmites* sites around the periphery of the Black Hills (Fig. 1) occurred in the "Red Valley" overlying the Spearfish bedrock formation, which consists of red sandy shale, siltstone, and sandstone interbedded with abundant gypsum (Martin et al. 2004). Gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) and its anhydrous counterpart (CaSO_4) are much more soluble than carbonate rocks, and Cox and Mud Lakes at the McNenny site are natural artesian lakes formed in sinkholes within this bedrock formation (Epstein 2001). The reduction of sulfates derived from the parent bedrock to sulfides under the anaerobic conditions in wetlands could influence the vegetation present. Sulfide is toxic to many wetland plants, but *Phragmites australis* is moderately tolerant of sulfides (Chambers et al. 2003). In a study of plant zonation in sulfate-dominated soils around two saline lakes in eastern South Dakota, *Phragmites* grew in soils containing more sulfate than adjacent upland prairie soils (Ungar 1970). Thus, the association between *Phragmites* and calcium sulphate rocks in the Black Hills may be due to the species' sulfide tolerance. This association between *Phragmites* and a bedrock formation was not noted on any of the individual specimen labels, and illustrates the benefit of being able to display specimen locations relative to other environmental features in a GIS.

Contrary to expectation, we did not observe an increase in the frequency of *Phragmites* collection during the last decade. Rather, the rate of specimen collection peaked during the 1980s and 1990s, due at least in part to student collections, and was low ($n = 4$) during the 2000s. Delisle et al. (2003) noted a similar decline in collection rates in southern Quebec, which they attributed to a shift from taxonomic to ecological studies, thereby reducing the number of herbarium specimens being collected.

This research confirmed our expectation that *Phragmites* would occur primarily in wetlands. Most of the wetlands and lakes in South Dakota are hydrologically isolated in individual depressions, which would reduce opportunities for the movement of plant propagules in the landscape. The relative lack of *Phragmites* in South Dakota creeks and ditches is a positive sign, because riparian corridors and road ditches are potential avenues for the spread of invasive plants (Jodoin et al. 2008, Lavoie et al. 2009).

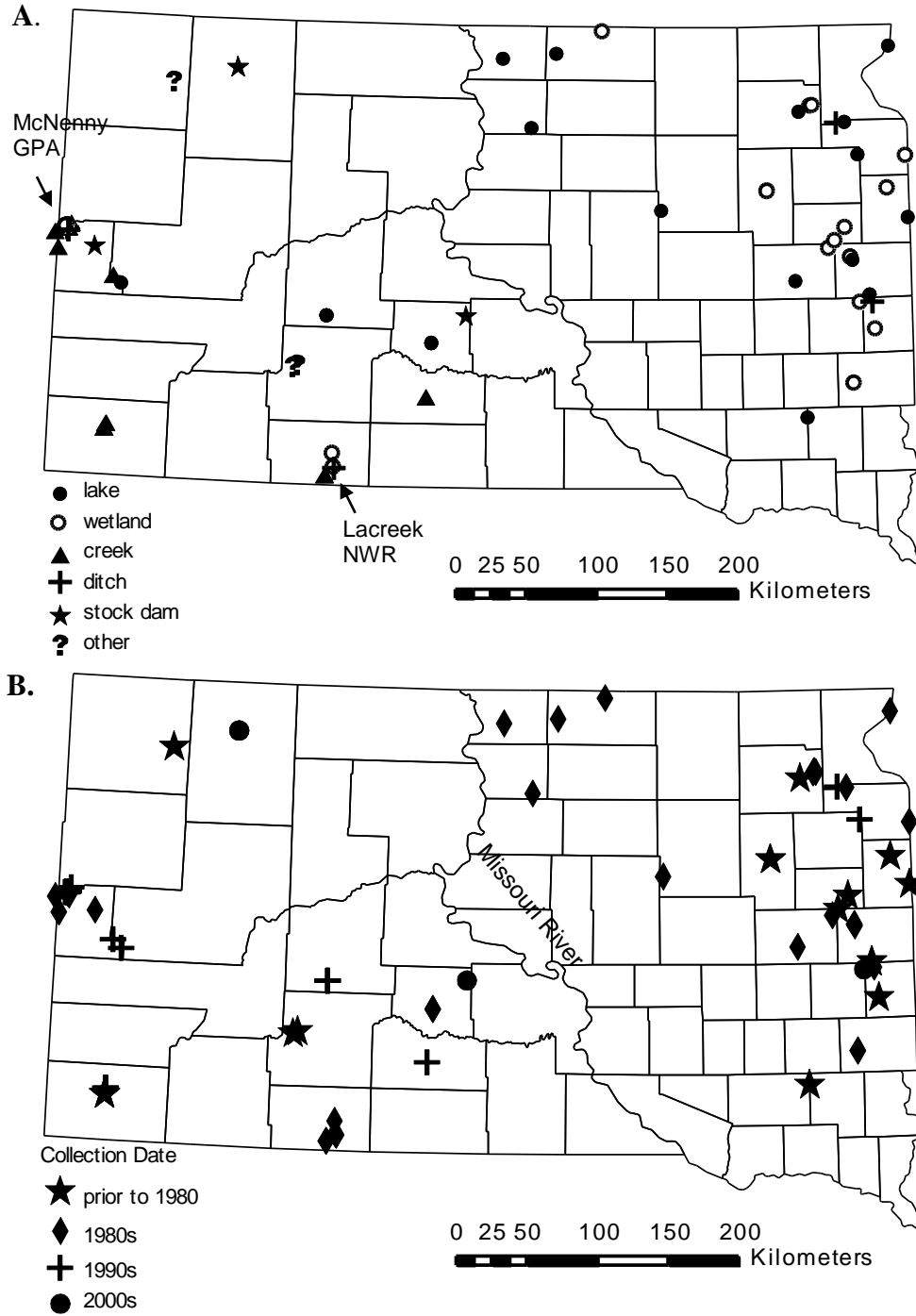


Figure 2. Specimen locations of *Phragmites* spp. across South Dakota classified by associated water body (A) and collection date (B).

MANAGEMENT IMPLICATIONS

Non-native *Phragmites* invasion has caused extensive

ecological degradation elsewhere in North America, so South Dakota is wise to be vigilant in its designation of *P. australis* haplotype M as a noxious weed. We did not attempt to distinguish the haplotypes of *Phragmites*

specimens, but several lines of evidence infer that the native subspecies is present in South Dakota. First, *P. australis* was collected in both eastern and western South Dakota by 1914, long before the widespread U.S. invasion of non-native *P. australis* began. Second, all South Dakota *P. australis* specimens analyzed by Saltonstall (2002) in her nationwide analysis were of the native haplotype. Third, there was no surge of *P. australis* collection during the 2000s that might indicate new invasion. To avoid unnecessary expense, South Dakota weed control practitioners should verify that *Phragmites* stands are of the non-native haplotype before implementing control measures.

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