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An Ordination of Niobrara Valley Plant Communities

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ABSTRACT

The middle Niobrara River Valley of north-central Nebraska is of significant biogeographic importance due to the interaction of geologic and hydrologic features which provide habitat for species of eastern, western, and boreal affinities. Vegetation data collected from 10 herbaceous and 13 woody sites within the Niobrara Valley Preserve and adjacent areas were ordinated using BCORD. Results corroborate a previous literature review and TWINSPAN classification analysis which described seven major community types for this region: Sandhill, Mixed Prairie, Tallgrass Meadow, Upland Pine, Juniper, Hardwood, and Streambank Communities.

† † †

The Niobrara Valley of north-central Nebraska has been recognized since the 19th Century for the presence of forest plants and animals not typical of the grassland biome which characterizes this region of North America (see review in Kaul et al., 1988). Non-riparian elements of the Rocky Mountain, boreal, and eastern deciduous forests meet in this transitional zone of the Valley in close proximity to sandhill prairie and other grassland types.

Most published accounts of the vegetation in this region have been strictly qualitative or did not use the data collected to produce objectively based classifications (e.g. Bessey, 1887; Hearty, 1978; Pool, 1914; Tolstead, 1942). Kantak (1995) integrated these qualitative vegetation descriptions in the literature with quantitative field data analyzed with TWINSPAN, a divisive, hierarchical technique (Hill, 1979), in constructing an objective classification of the terrestrial plant communities of the middle Niobrara Valley. The major community types recognized include Sandhill, Mixed Prairie, Tallgrass Meadow, Upland Pine, Juniper, Hardwood, and Streambank Communities. The purpose of this paper is to strengthen this interpretation of the

vegetation pattern and community classification by presenting a corroborating alternative analysis of the field data which for brevity's sake had been omitted from the TWINSPAN analysis paper.

STUDY AREA

The study area is located along an approximately 50-km stretch of the Niobrara River in north-central Nebraska. The sample sites were located within or adjacent to the Niobrara Valley Preserve, a 219-km^2 tract owned and managed by The Nature Conservancy. A map of the study area and the sample sites is available in Kantak (1995). Descriptions of the climatic, geomorphological, hydrological and historical factors which are responsible for the origin and persistence of the unique juxtaposition of plant communities in this region are available in Churchill et al. (1988), Kantak and Churchill (1993), and Kaul et al. (1988).

METHODS

Field techniques

A more detailed description of field techniques is available in Kantak (1995). Briefly, aerial photography and input from persons familiar with the terrain were used to locate 23 sample sites representing major topographical/vegetational formations in the study area. Ten of the sites were dominated by herbaceous species and 13 by woody species. All sites were sampled between mid-June and mid-August 1983.

Areas sampled at each site ranged from 6 to 9 ha. At each herbaceous site, 20 to 30 1-m^2 circular quadrats were randomly placed along transects located through the sample site. All vascular species present were recorded in each quadrat. At woody sites, the point-centered quarter method (Cottam and Curtis, 1956; Mueller-Dombois and Ellenberg, 1974) was ap-

Table 1. Seven major community types with representative site numbers. From Kantak, 1995.

1. **Sandhill Communities**
   a. Prairie   (Site 4)
   b. Upland Thicket   (Site 21)
   c. Blowout
2. **Mixed Prairie**
   a. Upland   (Sites 8, 9)
   b. Lowland Transitional   (Sites 5, 7)
3. **Tallgrass Meadows**
   a. Transitional   (Site 3)
   b. Prairie   (Site 2)
   c. Wetlands   (Sites 22, 10)
4. **Upland Pine Communities**
   a. Forest   (Site 1)
   b. Savanna   (Site 12)
5. **Juniper Communities**
   a. Pine/Juniper   (Sites 18, 11, 16, 19)
   b. Hardwood/Juniper   (Sites 15, 17, 6, 23)
6. **Hardwood Communities**
   a. Eastern Deciduous   (Sites 20, 13)
   b. Boreal Relict
7. **Streambank Communities**

plied at 20 to 30 points along the transects. Basal area of each tree (≥10 cm dbh) was recorded. At each study site several site characteristics were visually assessed, including evidence of disturbance, slope, topographic position, soil type, and soil moisture. Aspect was determined with a compass and elevation was later determined from United States Geological Survey topographic maps.

Ordination

Species which occurred in ≤10% of the quadrats sampled at a site were deleted prior to analysis (as in Zampella et al., 1992) in order to remove the impact of rare species (Gauch, 1982). Deleted species also had relative frequencies of <6.5%. Species frequency data were relativized by samples and by species, and then ordinated using BCORD (McCune, 1991), a refined and updated version of the original Bray and Curtis (1957) ordination technique. The Sörensen distance measure and the variance-regression method of endpoint selection were applied because of their success in producing ecologically interpretable results (Beals, 1984).

RESULTS

Community classification

Seven major community types were recognized by Kantak (1995) based on TWINSPAN analyses and on other biogeographical data in the literature. This classification with representative site numbers is repeated here for cross reference with this paper's ordination results (Table 1).
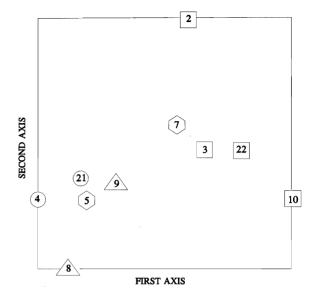

Figure 1. BCORD ordination of herbaceous communities. Community types corresponding to TWINSPAN dendrogram in Kantak (1995): squares–Tallgrass Meadows; circles–Sandhill Prairie; triangles–Mixed Prairie; hexagons–Transitional Communities.

Ordination of herbaceous communities

A total of 180 species was recorded from the ten herbaceous-community sites. Frequencies of the dominant species at each site are provided in Kantak (1995). The ordination of the herbaceous sites is depicted in Fig. 1. The first two axes extracted 28.64% and 12.11%, respectively, of the information in the data matrix. Environmental data (Kantak, 1995) show soil type and moisture correlations with the first axis. The five sites in the right half of the ordination are characterized by lower elevations (647–680 m), moist and loamy soils and flat topography. They include the Tallgrass Meadows communities clustered by the TWINSPAN analysis in Kantak (1995). The five sites in the left half of the ordination are at higher elevations (686–757 m), have drier sandy soils, and more topographical relief. They include the TWINSPAN Sandhill and Mixed Prairie sites (Kantak, 1995). The second axis in the ordination spreads the lowland sites but clumps the upland sites in the lower left corner of the ordination. The spread may be related to disturbance as there was greater variance in degree of disturbance among the lowland than the upland sites.

Ordination of woody communities

Frequencies, densities, and basal areas of the twelve species of trees present in the sample sites as well as site environmental data are available in Kantak (1995).
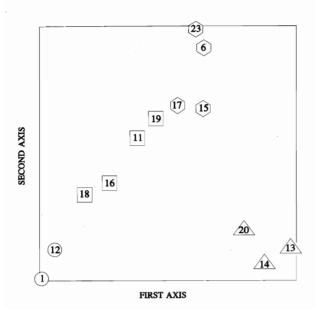
Figure 2. BCORD ordination of woody communities. Community types corresponding to TWINSPAN dendrogram in Kantak (1995): circles–Pine; squares–Pine/Juniper; hexagons–Hardwood/Juniper; triangles–Lowland Communities.

Figure 2 depicts the first and second axes of the BCORD ordination of the woody community data. These axes extracted 31.94% and 24.33% respectively of the information in the data matrix. Again, soil type and moisture correlated with the first axis. Specifically, the driest and sandiest soils were found at high elevation sites (720–759 m) in the left part of the ordination (Sites 1, 12, 16, 11) whereas the moist and loamy soils and lowest elevations (657–664 m) were at the right (Sites 20, 14, 13). Corresponding to the environmental gradient, community dominance shifts from pines on the driest sites at the left of the ordination to juniper in the middle to hardwoods at the moist sites at the right. An almost identical ordering of sites was produced by the TWINSPAN analysis in Kantak (1995). The second axis of the ordination appears to express a disturbance gradient. Sites in the upper third of the ordination showed more evidence of disturbance, both human-induced (grazing, tree cutting) and natural (wind erosion due to exposure as well as to human activities).

DISCUSSION

An in-depth discussion of the developmental history of Niobrara plant communities is available in Kaul et al. (1988). The interaction of the ultimate and proximate environmental factors leading to the development and maintenance of the Niobrara plant communities is summarized here in Fig. 3. Biotic interactions such as
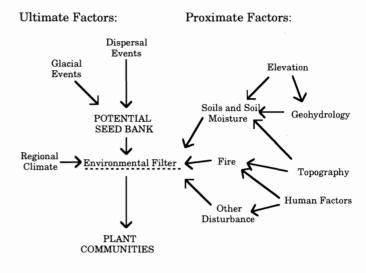

Figure 3. Historical and environmental factors impacting Niobrara plant communities.

competition also play an important role but are not treated here. The intermingling of the community types delineated by TWINSPAN as well as by BCORD analysis is the result of the availability of microhabitats for not only species of the regional grassland biome but also for Pleistocene relicts and dispersers from other biomes.

Although the BCORD ordination used frequency data and is based on a totally different algorithm than the TWINSPAN analysis which was applied to presence and absence data, the techniques clustered sites similarly. Although neither ordination nor clustering are statistical tests, their congruent results strengthen the classification of Niobrara community types presented in Kantak (1995).

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