The Loess Hills of Western Iowa: a Problem in Phytogeography

Jean M. Novacek

Iowa State University

Copyright © Copyright 1985 by the Iowa Academy of Science

Follow this and additional works at: https://scholarworks.uni.edu/pias

Recommended Citation
Available at: https://scholarworks.uni.edu/pias/vol92/iss5/13

This Research is brought to you for free and open access by the Iowa Academy of Science at UNI ScholarWorks. It has been accepted for inclusion in Proceedings of the Iowa Academy of Science by an authorized editor of UNI ScholarWorks. For more information, please contact scholarworks@uni.edu.
The Loess Hills of Western Iowa: a Problem in Phytogeography

JEAN M. NOVACEK
Botany Department, Iowa State University, Ames, Iowa 50011

Based upon personal observations over a four year period, a preliminary overview of the phytogeographical significance of the prairies of the Loess Hills of western Iowa is discussed, concentrating upon a few representative taxa. A number of Great Plains vascular plant species reach the easternmost edge of their ranges in the Loess Hills. Climatic changes during the Holocene Period, especially during the Hypothermal Interval, have had great effects upon the vegetation of the Great Plains and upon the xerophytic components of the Loess Hills. In addition, recent extended drought episodes have affected the flora. It is postulated that the Missouri River system has served, and may still serve, as a major migratory route for many of the Great Plains species found in the Loess Hills.

INDEX DESCRIPTORS: Iowa vascular flora, Iowa Loess Hills prairie, Great Plains flora, phytogeography.

Mimicking the dry conditions of the Great Plains, the Loess Hills of western Iowa (Fig. 1) support a xerophytic prairie flora including many Great Plains vascular plant species which reach the easternmost limits of their ranges on these dry bluffs. The Loess Hills support the last relatively contiguous area of mixed-grass prairie remaining in Iowa. The upland loess prairies are similar to the mixed-grass prairies of the Great Plains more than 70 miles to the west. Weaver and Bruner (1954) placed the transition of tall-grass prairie to mixed-grass prairie near 98°W longitude. The Loess Hills are located along 96°W longitude (±0.5°), and the mixed-grass prairies here represent a narrow peninsular range extension into an area which otherwise typically supports tall-grass prairie. See Novacek et al. (this issue) for further discussion of the vegetation of the Loess Hills landform.

The typical upland loess prairie is dominated by two warm-season grasses, Andropogon scoparius Michx. (little bluestem) and Bouteloua curtipendula (Michx.) Torr. (side-oats grama). The short-grass component is represented by B. hirsuta Lag. (hairy grama) most commonly and by B. gracilis (H.B.K.) Griffiths (blue grama) not so commonly, with reports of Buchloe dactyloides (Nutt.) Engelm. (buffalograss) (Pammel, 1901; Thorne, 1956; Goodnight, 1964; Iffrig, 1980). Iffrig (1980) pointed out that the loess bluffs also support the only known mixed-grass prairie community in the state of Missouri, with the dominant grasses being Bouteloua hirsuta, B. curtipendula, Buchloe dactyloides and Andropogon scoparius.

With the westerly summer winds constantly sweeping them, the southwest slopes are directly exposed to the hot mid-day sun. This, coupled with the capacity of loess soil to dry out quickly, creates a truly xerophytic environment. In general, the southwest slopes support the prairie vegetation, with the woody species growing in protected places, such as draws, lower slopes and north- and east-facing slopes.

This paper presents a preliminary overview of the phytogeographic aspects of the Loess Hills prairies, concentrating upon a few representative taxa. The ideas discussed herein result from personal observations made during a four-year floristic study of the region, which included previous thesis work (Novacek Bates, 1983). The nomenclature and distributional maps are based upon the Atlas of the Flora of the Great Plains (Barkley, 1977). The distribution maps are representations of the general area occupied by each species east of the Rocky Mountains within the Great Plains of the United States. The scale for each map is 1 inch to 240 miles (25 mm. to 386 km.).

**DISCUSSION**

Plant Migration

In order to better understand plant geography, the nature of plant migration must be considered. McLean and Ivimey-Cook (1973) state: "The existing flora of any region may be looked upon as the survivors of an army of migrants which . . . either drifted into the region from the outside or were born in it from a migrant parentage. Their survival and distribution in the region are . . . ecologically determined."

Extensive migration of plants proceeding at fairly rapid rates occurs along routes with nearly continuous suitable habitats, for example, upland bluffs along rivers for xerophytic species (Gleason, 1922). In addition to exposure to dry westerly winds and intense solar radiation, slope and aspect are important factors influencing the vegetation of the Loess Hills. Adams (1905) pointed out that topographic conditions have significant influence upon habitats. When xerophytic elements invade an area with a greater moisture regime, he noted that they occupy the dry sites which are most similar to their original habitats, forming "islands" of xerophytes surrounded by more mesophytic plant associations.

I speculate that many of the Great Plains species found in the Loess Hills probably initially entered northwest Iowa through Plymouth County from Nebraska and the high plains of the Dakotas. It is my opinion that the Missouri River drainage system has served as a major migratory route for many of these plants. It is well known that birds are a primary disseminating factor for many plants and that the Missouri River system is a major avian flyway. The river itself may also aid in plant migration either by purely mechanical means or by offering suitable habitat on its sandbars and on the upland bluffs which line the floodplain.

As an example, I postulate that these factors may have played a role in the migration of Shepherdia argentea (Pursh) Nutt. (Elaeagnaceae), buffalo berry, a medium-sized shrub quite common in the northern Great Plains. Nearby in South Dakota, dense populations line the bluffs and sandy areas along the Missouri River. Its bright red fruit attracts birds which dine upon the berries and, in turn, disseminate the seeds. The first report of *S. argentea* in Iowa was recorded by Hitchcock (1889), who collected a specimen in 1888 from a Missouri River sandbar near Sioux City in Woodbury County. Hitchcock speculates that the plant "wandered down the river from the northwest where it abounds." Parmel (1895) also refers to it as a "waif from the northwest."

*S. argentea* is listed in Iowa as endangered (Roosa and Eilers, 1978). The largest population in Iowa is located in Plymouth County on high loess prairie. South of there in Woodbury County, there are a few individuals on upland prairie in Stone State Park, in addition to a scattered few on old dunes near an oxbow lake on the Missouri River floodplain. These are not the only sites, however, as there is a small population in Emmet County seemingly disjunct from the main population (Wolden, 1952; pers. observ.). *S. argentea* may have migrated from South Dakota through Minnesota along the appropri-
ate river bluff habitat of the West Des Moines River in order to reach Emmet County.

As mentioned previously, many Great Plains species probably initially entered Iowa through Plymouth County. Extensive field work (Novacek et al., this issue) has revealed that Plymouth County contains the greatest number of Great Plains species. Adams (1905) emphasized that "invading elements tend to enter a region not only at a definite place, but also tend to remain in definite habitat associations and conditions" after having entered. He noted that this habitat individuality causes the isolation of the invading elements and provides an "index to their direction of origin." He further contended that habitat studies reveal important insights into the geographic origin of migrating elements and the necessary conditions for their survival, which both determine the routes of dispersal.

According to Gleason (1922), when entire floras migrate together, the most rapidly advancing species arrive first and the others arrive at varying degrees behind. The present migrational status of a plant, he noted, depends upon its migration rate and the elapsed time since migration began. He also pointed out that migration is demonstrated mainly by the role the species plays in succession. When at or near the edge of its range the species participates in succession as an invader, it is advancing. However, if it is unable to withstand competition with members of a different flora or if members of its own floristic component are regularly succeeded by others of a different flora, it is retreating.

Climate
Climate is an important consideration when attempting to examine the flora of a region, especially in the Great Plains. Davis (1983) pointed out that species ranges are continually expanding and contracting in response to minor changes in overall climate. She noted that current geographic distributions have been recently attained and that they will change again as modifications in climate occur. Climatic changes during the Holocene Period have had great effects upon the vegetation of the Great Plains and, in my opinion, the Loess Hills. According to all available data (Transeau, 1935; Sears, 1942;
McComb and Loomis, 1944; Borchert, 1950; Deevey and Flint, 1957; Wright, 1976; King and Allen, 1977; Baker and Van Zant, 1980; Wendland, 1980; King, 1981; Ahlbrandt et al., 1983; Grimm, 1983), the climatic fluctuations of the Holocene were episodic in nature and, thus, have had an episodic effect upon the vegetation.

By far the most important climatic change during the Holocene was the Hypsithermal Interval, sometimes referred to as the xerothermic, which has been variously dated. Recent work in the Nebraska Sandhills (Bradbury, 1980; Ahlbrandt et al., 1983) has provided dates for climatic changes during the Hypsithermal which I believe could have directly influenced the vegetation of the Loess Hills. Ahlbrandt et al. (1983) found at least 3 periods of extremely dry conditions: 7500-4000 YBP (years before present), 3000-1500 YBP, and 600-250 YBP. The period with the most severe aridity ranges between 8500-5050 YBP (Wendland, 1980), 7300-6300 YBP (Baker and Van Zant, 1980), and 7500-4000 YBP (Ahlbrandt et al., 1983). This period was dry enough to cause dwarfing in bison, migration of human cultures, and the large scale retreat of coniferous and deciduous woodlands with the advance of the prairie flora (Ahlbrandt et al., 1983). According to Wendland (1980), the temperatures during this extremely dry interval were as much as 2 degrees Celsius higher than at present, and the precipitation amounts were about 10 percent below that of today. This has been attributed to persistent, almost year-round westerlies blowing eastward from the hot, dry continental interior (Borchert, 1950).

According to Borchert (1950), the Great Plains and the prairie peninsula region receives their greatest precipitation during the months of April through June. This results from a shift from continental airflow to tropical Atlantic airflow from the Gulf of Mexico. During summers of major drought the normal southerly winds from the Gulf fail and the majority of the airflow comes from the arid west. The stronger these westerly winds, the more extensive the drought-striken area is east of the Rocky Mountains. Borchert characterizes these drought episodes as periods of abnormally high summer temperatures accompanied by below-average cloud cover and rainfall, in addition to above-average frequency of hot continental winds. He concluded that the post-glacial eastward expansion of prairie was a result of long-term increase and dominance of mean westerly circulation and also noted that the current forest invasion of the easternmost prairies is due to a long period of decrease in westerlies to their current level.

Bernabo and Webb (1977) have suggested that the position, height and albedo of the Laurentide ice sheet created boundary conditions which directly influenced the general atmospheric circulation during the early Holocene. They stated that in summer a sharp thermal gradient would have existed near the ice margin due to differences in the albedo of the ice sheet and the land to the south. As the ice sheet receded to the north, this thermal gradient also shifted, thus affecting the location of storm tracks during summer months. The period of progressively drier climate due to these boundary effects according to their data was from 10,000 to 7000 YBP. They also stated that the changes in atmospheric circulation were less dramatic once the ice sheet retreated north of Hudson Bay approximately 7000 YBP. Cooler and wetter conditions followed causing the retreat of the prairies and allowing the advancement of mesic forests.

Borchert (1950) noted that vegetational gradients coincide with climatic gradients. If the pattern of climatic changes changes, so also does the vegetational pattern. This idea has been more recently emphasized by Davis (1983). The Hypsithermal Interval was a period of long-term changes which exerted extensive effects upon the vegetation of the Great Plains. However, comparatively short-term droughts have also been important events influencing the vegetation (Tomanek and Hulett, 1970). Coupland (1958) observed that during the decade of drought in the 1930's the mid-grass prairies were replaced by mixed-grass prairies, which became dominated by short-grasses, and the species composition of the short-grass prairies was modified. He noted that these changes were so extensive that they resulted in the migration of mixed-grass prairie about 100 to 150 miles (161-242 km.) eastward in the central Great Plains. Weaver (1943) indicated that mixed-grass prairie replaced tall-grass prairie along a front more than 1000 miles in length. This is quite significant when considering that such a massive movement of floras occurred during such a short period of time. In 1954 Weaver and Bruner observed that the recovery of tall-grass prairie after this drought was quite slow, noting that even after 12 years mixed-grass prairie still dominated over two-thirds of the land it had invaded during the 7 years of drought.

Ahlbrandt et al. (1983) stated that during the last 800 to 500 years drought conditions persisted long enough in parts of the Nebraska Sandhills that the vegetative cover was effectively reduced such that aeolian movement of sand occurred a number of times. Dendrochronological data (Weakly, 1943) indicate that at least 13 droughts lasting 5 or more years have occurred in western Nebraska during the past 400 years. Six of these lasted more than 10 years and 2 continued for over 20 years. The average period between major drought episodes was 20-38 years. The most extensive drought according to Weakly's data lasted for 26 years and occurred between 1539 and 1564 A.D. The data from Weakly's study correlate well with the data of Ahlbrandt et al.

More recently, there have been dry decades occurring in 1927-1936, 1933-1942, 1947-1956 and 1953-1962 according to Barry (1983). In addition, Tomanek and Hulett (1970) pointed out the occurrence of droughts of more than three years duration in 1868-1873, 1879-1884, 1910-1914, 1933-1939 and 1952-1956. Certainly during these times there must have been shifting of floristic elements in the Great Plains region.

Great Plains Species in the Loess Hills

The state of a flora is a dynamic; there are continual adjustments, migrations in and out by various species, possible species extinctions and species differentiation, and relicts left behind by a previous flora. According to Gleason (1922), relicts are individual species or vegetation types which are surrounded by an advancing flora and left isolated from the main body, and relicts are common wherever migrations are relatively recent. An example of a relic in the Loess Hills, in my opinion, is Sphaeralcea coccinea (Pursh) Rydb. (Malvaceae), cowboy's delight (Fig. 2). There are two populations, one located in Plymouth County and the other in Harrison County, separated by a distance of approximately 80 miles (129 km.). The Plymouth County population is disjunct from the main body of S. coccinea in South Dakota and Nebraska by about 100 miles (161 km.) to the east. Kearney (1935) noted that this extremely xerophytic species is widely distributed, extending farther eastward than any other North American Sphaeralceae, but is more common west of the 98th meridian. Coupland (1958) pointed out that during the 1930's drought, this plant was the only generally distributed forb besides cactus (Opuntia spp.) to increase in mixed-grass prairie, presumably due to vegetative reproduction, early spring growth and the habit of semi-dormancy during drought. After this drought it decreased in numbers nearly to its pre-drought abundance. It is unknown whether S. coccinea in the Loess Hills is a relic from the Hypsithermal or from a more recent extended drought.

As Gleason (1922) pointed out, some rapidly migrating species may currently be at their maximum potential range, awaiting some environmental change to initiate movement once again. One such species in the Loess Hills might be Dalysia emandrus Nutt. (Fabaceae), a time-another date. Its distribution pattern at the eastern edge of its range is classic (Fig. 3). This species occupies a narrow zone in all Loess Hills counties right up to the terminus of the loess landform in Missouri (Bush, 1895; Goodnight, 1964; Iffrig, 1980). These plants
Loess Hills outliers indicated by asterisks.

are connected to the main population farther west via the appropriate river bluff habitat along the Missouri River. This constricted peninsular distribution in the Loess Hills is completely surrounded by more mesic tall-grass prairies and woodlands, environments inhospitable to this xerophytic species.

A similar pattern exists for Yucca glauca Nutt. (Liliaceae), yucca, albeit not as dramatic as that of Dalea enneandra. In the Loess Hills, yucca is confined mainly to west-facing slopes on upland prairies (Fig. 4). It is quite common in western Kansas and Nebraska and the Dakotas, but it constricts its range in northeastern Nebraska and southeastern South Dakota, confined to the upland prairies along the Missouri River bluffs; from there it is found only on the loess bluff prairies of western Iowa and northwestern Missouri. Pammel (1901) mentioned that yucca was a rare plant in the Loess Hills, but more common northward near Sioux City. This statement infers that, at that time, yucca was uncommon in the southern Loess Hills. Personal observations indicate that yucca does decrease in frequency in the southern part. It is further interesting to note that yucca is currently listed on Missouri's rare and endangered species list (Nordstrom et al., 1977). This distributional pattern throws some credibility upon the idea of a northwest entry for migrating Great Plains taxa.

The most valuable evidence for migration in progress is the successional behavior of a species at the edge of its range. According to Gleason (1922), if the species acts as an invader, it is advancing. In my opinion, Petalesistemum occidentale (Gray) Fern. (Fabaceae), western prairie clover, is expanding its range within the Loess Hills. This species is the xerophytic counterpart to P. candidum Michx., white prairie clover, and is ubiquitous throughout its range in the Great Plains. (See Isely and Welsh, 1960.) According to Wemple (1970), P. occidentale is "adventive to the east in particularly xeric environments, e.g. the Loess Hills of western Iowa." It is an aggressive plant which demonstrates its invasional capacity by its ability to colonize roadcuts and eroded areas (Wemple, 1970; pers. observ.).

The migrational status of some Great Plains species in the Loess Hills is questionable as to whether they are retreating or advancing. An example is Mentzelia decapetala (Pursh) Urban & Gilg. (Loasaceae), sand lily. In Iowa its distribution is limited to till or shale outcrops or to steep, near-vertical faces of loess on the extreme western bluffs in Plymouth, Woodbury, Harrison and Pottawattamie counties (Fig. 5). Its occurrence is not continuous, the distances between stands being variable; the greatest separation is between the Woodbury and Harrison county sites, approximately 70 miles (113 km.). This species is weakly perennial and typically occupies disturbed sites or barren ground (Darlington, 1934; Hill, 1975); as a result, if the appropriate habitat is available, M. decapetala may yet advance in the Loess Hills.

Two westerly, morphologically similar, but taxonomically distinct, species of Astragalus are present on upland loess prairies: A. missourien­sis Nutt., Missouri milkvetch, and A. lotiflorus Hook., lotus-flowered milkvetch (Fabaceae). A. missouriensis, a threatened species in Iowa (Roosa and Eilers, 1978), is locally abundant in western Plymouth County, but becomes less common southward, with its southern terminus just north of Holly Springs in Woodbury County (Fig. 6). Thus, it barely occupies a narrow area in Iowa approximately 50 miles (81 km.) in length. Apparently, this distribution has not changed greatly since the first documented collections were made (Fox, 1945; Grant, 1953; Thorne, 1956; Carter, 1960; Novacek Bates, 1983). One possible reason it has not advanced might be because the distance between its preferred habitat is perhaps too great for effective dissemination. In this species, the seeds are shed quite close to the parent plant (Barney, 1964); in addition, the areas between likely habitats

Fig. 2. Distribution of Sphaeralcea coccinea; Loess Hills outliers indicated by asterisks.

Fig. 3. Distribution of Dalea enneandra, exhibiting an extremely narrow distribution toward the eastern part of its range.

https://scholarworks.uniu.edu/pias/vol92/iss5/13
have been greatly modified by human activities, possibly preventing its further migration.

On the other hand, *A. lotiflorus* is found the entire length of the Loess Hills (Fig. 7). This plant is similar to *A. missouriensis* in its preference for a fairly open microhabitat (Barneby, 1964), but it is unknown why it has migrated farther than *A. missouriensis*. *A. lotiflorus* may have migrated prior to disruption of its required habitat and possibly long before *A. missouriensis*, which may represent a relatively "recent" entry into Iowa. Current research (Novacek, unpublished data) has revealed, however, the presence of *A. lotiflorus* on sand dune areas along the Missouri River. Perhaps this is an answer to this distributional problem.

According to Barneby (1964), the majority of *Astragalus* species exist in fine-tuned balance with the environment, their distributional patterns dependent upon complex ecological and genetic factors. He has indicated that the largest number of species thrive only in harsh situations without a continuous groundcover, or they are confined to soils literally hostile to other plant life. From turn-of-the-century records and accounts, the prairies of the Loess Hills at that time had a greater amount of bare interstitial soil, and there were far fewer trees and shrubs than at the present time (Hitchcock, 1889; Bush, 1895; Pammel, 1895; Shimek, 1909, 1915). Since that time, fires have been suppressed, allowing a greater litter accumulation on the prairies and the advancement of woody species. It remains to be seen whether either species of *Astragalus* will maintain their numbers or decline in the Loess Hills.

If conditions are favorable to migration along the Missouri River bluffs, then are there any plants which "should" be in the Loess Hills or are on their way? One possibility is *Astragalus racemosus* Pursh, creamy poisonvetch. According to Barneby (1964), *A. racemosus* is quite common on dry, rugged and eroded terrain along rivers, and its primary natural habitat is on open prairie, particularly around calcareous or shaley outcrops. The nearest population to western Iowa is just 70 miles (113 km.) west along the Missouri River in Nebraska and South Dakota, where it is quite common (Van Bruggen, 1976) (Fig. 8). Possibly with the correct environmental impetus, this species will eventually reach the Loess Hills.

**CONCLUSIONS**

While circumstantial evidence may seem to indicate that, since the Hypsithermal Interval, the Great Plains floral component in the Loess Hills of western Iowa is retreating, I believe that there may be a few exceptions to the case: plants which are either currently advancing, such as *Petalostemon occidentale* and possibly *Mentzelia decapetala*, or at least appear to be at their maximum potential range, such as *Dalea cymandra* and *Yucca glauca*. There may be a number of relict species from the Hypsithermal Interval, but certainly a good candidate, in my opinion, is *Sphaeralcea coccinea*. I do not feel, however, that all of the Great Plains components in the Loess Hills are retreating Hypsithermal relics. If the xerophytic Great Plains species expanded eastward beyond the Loess Hills and northwest Iowa and are now retrograding, why is there no evidence of these plants remaining eastward in Iowa or westward in eastern Nebraska? Surely there are spots of suitable habitat scattered here and there in both of these areas; in which case, there should be a few relict colonies hanging on in favorable sites. Since there appear not to be, however, I am led to the conclusion that the migratory route for many of the Great Plains taxa present in the Loess Hills today has been the Missouri River system, either the bluffs

---

**Fig. 5.** Distribution of *Mentzelia decapetala*; it must be noted that its range is not nearly as continuous as the map indicates.

**Fig. 4.** Distribution of *Yucca glauca*, which may be currently at its maximum range potential.
ACKNOWLEDGEMENTS

I would like to thank Dr. Theodore Van Bruggen, University of South Dakota, for his guidance and encouragement throughout my undergraduate years; by his boundless enthusiasm for floristics and the Great Plains, he set an example to which I can only hope to aspire. I also thank Dr. Dean M. Roosa, Iowa Preserves Board, who has provided many valuable suggestions and insights for my work in the Loess Hills. Thanks also goes to Bill Pusateri, Donald Farrar, Jack White, and my parents, Donald and Beverly, for their support. Part of the research for this project was supported by contract work undertaken for the Iowa Natural Areas Inventory, and by funds provided by the University of South Dakota Honors Program.

REFERENCES


Fig. 6. Distribution of Astragalus missouriensis, found growing in only two Iowa counties, Plymouth and Woodbury.
lining river or the dry sandy habitats on the floodplain. I also speculate that there is a good possibility that some of the actual migration occurred relatively recently, that is, at least within the last 3000 years. Work is currently underway more thoroughly investigating the Missouri River as a migratory pathway for species of the northern Great Plains and the Nebraska Sandhills.

Fig. 7. Distribution of Astragalus lotiflorus, found on most loess prairies, but not abundantly.
Fig. 8. Distribution of *Astragalus racemosus*, which may eventually reach the Loess Hills given the correct environmental impetus.

University of Missouri, Kansas City.


