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The Vegetation of the Paleozoic Plateau, Northeastern Iowa

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The present vegetation of the Paleozoic Plateau region of Iowa is a fragmented representation of the original complex of oak-hickory forest mixed with more mesophytic forest, open oak savanna and hill prairie. Because of the topographic variation and the relatively cool, moist environment of the region, the forests are the best developed of those in Iowa, and show the greatest variation, including two types of alluvial forests (*Salix* thickets and alluvial hardwood forest), and several kinds of upland forests (*Tilia, Acer, Quercus borealis, Q, alba* and *Pinus* forests). These types represent points along a more-or-less continuous topographic gradient. Many of the native oak savannas have been eliminated, but oak-juniper glades may be found on cliff faces and steep ridges. The remaining hill prairies are rich in species characteristic of the dry prairies farther to the west. Cold, north-facing slopes ("algific slopes") are the setting for a unique community containing a large number of rare and disjunct species. Outcrops of sandstones and limestone have characteristic microcommunities, often distinguished by their bryophyte or pteridophyte flora. There is a dearth of quantitative vegetation data from the region, and there are numerous research questions about the communities and their plant species that need answers. Preservation and conservation of plant communities and plant species are extremely important and should be addressed by a landscape approach to inventory and management.
INDEX DESCRIPTORS: Paleozoic Plateau, Driftless Area, vegetation of Iowa, forest vegetation, hill prairie, boreal slopes, algific slopes, preservation, natural areas, inventory.

The prevailing vegetation of the Paleozoic Plateau in northeastern Iowa is, and was, forest (Dick-Peddie 1955, Iowa State Planning Board 1935). A forest cover is intuitive from the visual aspect of the region; trees seem to "fit" naturally into the landscape, just as trees seem out of place farther west in the grassland regions. The prevalence of forest is due to climate (cooler and more moist than the rest of Iowa), and to the hilly topography, which minimizes or prevents the sweep of fire across the landscape, frequent fires being essential to the maintenance of grasslands in the Middle West.

The prevailing forest is rich and diverse, but, in addition, there is a variety of less extensive plant communities which are also interesting. These are found in unusual or extreme environments, and include hill or bluff prairies, north-facing slopes with cold air drainage ("algific slopes"), microcommunities on outcrops and cliffs of sandstone or limestone, and a community on sandy terraces.

Our purpose is to survey the natural and semi-natural plant communities of the Paleozoic Plateau of Iowa, emphasizing their structure and composition and their environmental relationships. We shall survey only terrestrial vegetation.

The task of describing the vegetation of the Paleozoic Plateau is made difficult by the outstanding lack of quantitative data. Aside from the upland forest work of Cahayla-Wynne and Glenn-Lewin (1978), and Cawley (1965), apparently all the information about the region's vegetation is subjective, a distressing situation when this is one of the most interesting parts of the state from both an ecological and phytogeographical perspective, and despite the fact that it is one of the regions most visited by botanists and ecologists. Thus, we used written descriptions, histories, species lists, notes, data from the Iowa Natural Areas Inventory Program and our own observations as the basis for what follows. We used several sources, especially for the synthesis of vegetation types. To avoid repetition, these are listed here: Shimek (1948), Conard (1952), Hartley (1966), Cahayla-Wynne and Glenn-Lewin (1978), Peck *et al.* (1980), and, for some of the special bryophyte and pteridophyte communities on sandstone and limestone, the observations of D. Farrar, Iowa State University.

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PRESETTLEMENT VEGETATION

The presettlement (prior to ca. 1800) vegetation of the Paleozoic Plateau region of Iowa can be partially reconstructed from records of the federal land survey of the state. Dick-Peddie (1955) did this for the state in general, and the data from Allamakee County in extreme northeastern Iowa, which he analyzed in detail, can be used to illustrate the general features of the vegetation of the Paleozoic Plateau at the time of the survey (1836-1859). Species of *Quercus* were most abundant, comprising 77.1% of the survey witness trees. *Q. alba* (31.5%) and *Q. macrocarpa* (29.5%) were the main species. Some *Carya* species were also present. Thus, the presettlement forest was essentially an oak forest. Species of *Quercus* are still the most abundant kinds of trees, so the modern forests reflect their historical phytogeographical relationships, that is, they were and are a portion of the oak-hickory forest formation of the central United States. A recent compilation of surveyor's records for Dubuque County (T. Blewett, Clarke College, Dubuque, Iowa) shows that *Quercus* spp. were also the leading species there at the time of that survey (1839). Apparently, the forests in Dubuque County already were disturbed heavily to fuel the lead smelting industry. Presumably, this degree of disturbance had not occurred at the time of the survey in Allamakee County.

Dick-Peddie (1955) included Jackson and Lee Counties in his compilation. Overall, there was a basic similarity in forest composition between Allamakee County and the two counties to the south, but there were also some differences of note: *Quercus alba* was slightly less abundant in Allamakee County, while *Q. macrocarpa* was substantially more common in Allamakee County, and the southern counties had more species of *Quercus*. It is difficult to make meaningful comparisons for the less common tree species, but it appears that *Carya* was more abundant in Lee County than to the north. In the surveyors' notes, the fewest species (21) were recorded for Allamakee County. Twenty-nine species of trees were noted for Jackson County, and 34 for Lee County. Of course, in each county there are more tree species than those recorded by the surveyors.

The mean distances between the surveyors' points and the witness trees were greatest for *Quercus macrocarpa* and the other xerophytic oaks (Table 1). This means that the original dry oak woodlands had an open structure, and that many of them were more like savannas than forests. Indeed, the surveyors often noted "oak barrens" with grasses,

TABLE 1. Mean distances between surveyors' points and nearest trees recorded in the federal land survey of 1832-1859 for Allamakee County, Iowa. (Adapted from Dick-Peddie 1955)

Species	Mean point-tree distance (m)
Quercus macrocarpa	21.0
Q. alba	16.1
Q. ellipsoidalis[1]	17.7
Carya spp.	16.0
Q. borealis	7.3
Acer saccharum	5.8
Tilia americana	5.8

[1]Dick-Peddie lists this as *Q. velutina*. However, the population referred to here is probably attributable to *Q. ellipsoidalis*.

which most likely can be interpreted as oak openings or savanna. Forests of mesophytic species had a much more closed structure (Table 1).

There are several lines of evidence that indicate that forest was invading the prairie at the time of the land surveys. Forests then existed on land we know now has prairie soil (Dick-Peddie 1955, Loomis and McComb 1944). In one Clayton County township, 10% of the soils had forest profiles, while the rest were prairie or partially developed forest soils, yet 70% of the township was forest in 1849 (Loomis and McComb 1944). The surveyors' records noting "open woods" would indicate that forest invasion was occurring at that time, and was not yet complete. The partially podzolized soils of the region could be interpreted to mean that the forest advance was "relatively recent" (Loomis and McComb 1944). Dick-Peddie (1955) pointed out that *Quercus macrocarpa* was most abundant in townships with much "prairie-forest ecotone," a reflection of the fact that this species is probably an important invader of grasslands.

Since the time of settlement, the natural vegetation of the Paleozoic Plateau has been greatly modified, mainly by clearing for agriculture, selective cutting for timber, and grazing. These activities have eliminated much of the native vegetation cover, and altered that which remains, so that today the original forest exists only in small, isolated fragments. The remaining forest cover varies from moderately disturbed — a long time ago and therefore in a reasonable state of recovery — to highly modified and essentially unnatural. Savannas have been eliminated. Hill prairies have been disturbed mainly by grazing and lack of fire. This fragmentation and modification limits our understanding of the regional vegetation, and has planning implications for natural area acquisition and management.

THE FORESTS

The upland forests of the region have a moderate species richness (mean number of vascular plants per 0.1 ha = 39.4, Glenn-Lewin 1977; range in 35 stands from 23 to 52 spp./0.1 ha, Cahayla-Wynne 1976; these values are slightly lower than the true values, since several spring ephemerals were not included in the data). Tree stratal diversity ranges from 4 to 11 species per 0.1 ha. The greatest diversity and variation occurs in the herb layer, which is typical for temperate forests (Glenn-Lewin 1977). Normally, diversity and community height decrease toward the edges of a vegetation formation. This is generally true of the Eastern Deciduous Forest Formation, but the Paleozoic Plateau is a pocket of forest species richness due to its topography. The forests are well-structured stratal communities with a canopy, a definite understory composed of both young of the canopy species and characteristic understory trees, an incomplete or scattered shrub layer, and usually a well-developed herb layer. The canopy may be quite open, with less than 100% cover on xeric sites, and correspondingly the herb layer may be rich and dense. In contrast, the canopy is closed and multi-layered on the most mesic sites. The understory is open where the forest is mature, for example in Merritt Forest, and the herb layer may be relatively sparse.

The Forests as Plant Communities

The forest canopy structure and composition vary according to environmental setting. Open communities of xerophytic species, such as *Juniperus virginiana* and *Quercus* spp., occupy dry ridges. South-facing slopes usually have a complete forest canopy and are dominated by *Quercus alba*, while more protected slopes also have a closed canopy, but contain a variety of mesophytic species, including *Acer saccharum* and *Tilia americana*. Forests along rivers have a mixture of flood-tolerant species.

One important example of the influence of topography on forest composition is the development of *Acer saccharum* and *Tilia americana* forests on some cool, moist slopes. Nevertheless, the majority of the upland forest is an oak forest of some kind. In its preponderance of oak forest, with admixtures of maple and basswood and other kinds of forest, the Paleozoic Plateau resembles the rest of the western portion of the Eastern Deciduous Forest Formation, except that species such as *Abies balsamea* and *Betula lutea* add vegetationally interesting and phytogeographically enlightening variability.

The reach of high water along floodplains marks a discontinuity in species composition, but otherwise the compositional changes in the forest canopy are essentially continuous (Cahayla-Wynne and Glenn-Lewin 1978, cf. Curtis 1959). However, it is convenient for many purposes to classify forest types according to canopy composition. The classification presented here is based upon the numerical classification of the main upland forest types by Cahayla-Wynne and Glenn-Lewin (1978), with the addition of several subjective types based both on the work of others (cited above) and on our field experience.

We recognize two broad groups by environment, the alluvial (or floodplain) forests, and the upland forests. Within these, community types are delineated by species composition, most importantly, by their dominant species.

A. Alluvial forests

1. *Salix* thicket. Willow thickets are found along the margins of streams and rivers. *Salix amygdaloides*, *S. interior* and *S. nigra* are the common willow species, together or in monodominant stands. Numerous emergent and hydrophytic herbs occur in this community, various species of *Polygonum*, and *Leersia* spp., for example.
2. Alluvial hardwood forest. This forest vegetation is variable according to relative elevation, which governs the duration and severity of flooding and the degree of waterlogging of the soil. *Acer saccharinum*, *Populus deltoides*, *Fraxinus pennsylvanica* and *Ulmus* spp. are almost always important species. In the valley of White Pine Hollow, Pammel (1923) noted *Acer negundo* and *Celtis occidentalis* as well, which are also typical floodplain species. *Betula nigra* was recorded in the alluvial forest of the Mississippi River (Pammel 1905), but Hartley (1966) indicated that the alluvial forests of the tributary rivers are somewhat different (and certainly of lesser extent) than those of the Mississippi, and one of those differences is the absence of *B. nigra* from the alluvial woods along the tributary streams. On higher and therefore less severely flooded sites, some upland hardwood species may enter the forest, including *Tilia americana*, *Juglans nigra*, *J. cinerea* and *Quercus borealis*. A large number of mesophytic herbs grow in alluvial forests. Typical indicators include such species as *Arisaema dracontium*, *A. triphyllum*, *Helianthus grosseserratus*, *Allium tricoccum*, *Mertensia virginiana*, *Phlox divaricata*, *Hydrophyllum virginianum*, *Laportea*

canadensis, *Polygonum* (=*Tovara*) *virginianum*, and the liana *Parthenocissus quinquefolia*.

B. Upland Forests

The main coenocline (Whittaker 1967) of the Paleozoic Plateau upland forests was identified by Cahayla-Wynne and Glenn-Lewin (1978), using numerical classification and ordination techniques. From mesic to xeric, this coenocline contains five community types, which with their dominant species are:

1. *Acer* type. *Acer saccharum* dominates this type. Associated species include *Tilia americana*, *Quercus alba* and *Ulmus rubra*.
2. *Tilia* type. This type is dominated by *Tilia americana*, along with several associated species, including *Acer saccharum*, *Quercus borealis*, *Carya cordiformis*, *Ulmus rubra* and *Juglans nigra*.
3. *Quercus borealis* type. Covering a broad range of mid-slope positions and sites where exposure is not too great, this type is dominated by *Quercus borealis*, and has *Acer saccharum* and *Q. alba* as associated species.
4. *Quercus alba* type. Dominated by *Q. alba*, this type has *Q. borealis*, *Acer saccharum*, and *Carya ovata* as associated species, and is located on exposed or upper slopes, and on dry, flat uplands.
5. *Pinus* type. *Pinus strobus*, notable because it is near the western extent of its range, dominates certain exposed upland plateaux and exposed ridges. Associates include *Quercus alba*, *Q. borealis* and *Acer saccharum*. In the early part of the 20th Century, Pammel (1923) remarked that the pines "towered" above the hardwoods in White Pine Hollow. The pines were reproducing at that time, according to Pammel, and they are doing so today (personal observation). Most of the large pines in White Pine Hollow were cut long ago (Pammel 1923, Cawley 1965). Cawley (1965) proposed that the pine and oak vegetation of White Pine Hollow would give way to maple (*Acer saccharum*) and hophornbeam (*Ostrya virginiana*), and an initial interpretation of the ordination results in Cahayla-Wynne and Glenn-Lewin (1978) seemed to agree. However, these interpretations were based on size classes. Increment borings have shown that the pines are younger than the oaks (R.Q. Landers, personal communication), complicating our understanding of the dynamics of pine woods on the Paleozoic Plateau.

There are several tree species that rarely or never attain dominance in the region, but nevertheless are ecologically and phytogeographically interesting, and add diversity to the forest landscape. These species often occupy recently revegetated ground, or special habitats of small or local extent. These species include: *Quercus muehlenbergii*, *Betula papyrifera*, *B. lutea*, *Populus tremuloides*, *P. grandidentata*, *Fraxinus nigra*, *Ulmus thomasii*, *Acer spicatum* and *Prunus pennsylvanica*. Many of these species are discussed in the references listed in the Introduction, and in van der Linden and Farrar (1984). *Quercus macrocarpa* was an important species in the original land survey, and it is still widespread and common today. However, it is rarely a component of the mature forest; it is most often found on the forest edge or in prairies and pastures.

It is difficult to characterize each forest type by its understory, shrub and herb species, because the different strata have different diversities, and the species in each have different environmental amplitudes. In addition, the herb layer especially may show a great deal of patchiness. Aside from young trees of the canopy species, there are two important understory tree species: *Carpinus caroliniana* occurs on moist sites, and *Ostrya virginiana* may be abundant across a wide range of conditions, overlapping the different forest canopy types. A listing of the herbs along this coenocline would be the familiar litany of forest floor herbaceous species, such as *Hydrophyllum appendiculatum*, *Impatiens* spp., *Asarum canadense*, *Adiantum pedatum* and *Cystopteris bulbifera* in moist forests on protected slopes, and *Podophyllum peltatum*, *Amphicarpa bracteata* and *Desmodium glutinosum* in the xeric oak forests. A complete listing of forest herbs is beyond our scope; many of the primary references contain species lists of the forest herbs in the Paleozoic Plateau region.

This sequence of forest vegetation types is an abstraction, a simplification, of the pattern of vegetational variability in the forests of the Paleozoic Plateau. This variation is continuous and multidimensional, at least in the uplands, and it includes forest responses to a complex of apparent moisture, exposure, disturbance, dynamics, and perhaps other, unknown influences. In addition, individual species behave variably. Some, for instance *Acer saccharum* and *Quercus borealis*, are found in a wide range of types, although they reach their dominance at certain points along the coenocline. As another example, *Pinus strobus* may be found rooted in cracks of limestone crags, on flat, well-drained uplands, and on moist sandy slopes (Cahayla-Wynne and Glenn-Lewin 1978, Hartley 1966, Pammel 1923.)

In addition to the primary coenocline, two kinds of vegetation, oak-juniper glades and algific slopes, add significant diversity to the vegetation mosaic, and include many rare or unusual plant species for Iowa. These extremes can be thought of as extensions of the primary coenocline, although they are not simply more xeric or more mesic than the types already described. Rather, they add multidimensional variation to the vegetation pattern of the region.

C. Oak-Juniper Glades

Oak-juniper glades (*Quercus-Juniperus* glades; Hartley (1966) termed them "juniper glades") are assemblages of xerophytic species on dry, exposed, calcareous crags, cliffs and bluffs having thin or no soil. The important woody species include several species of oak, especially *Quercus muehlenbergia*, *Q. macrocarpa*, *Q. ellipsoidalis*, and *Juniperus virginiana*. The prostrate juniper, *J. communis*, grows in some locations. The herbaceous stratum comprises a large variety of species, some of which are characteristic species of prairie vegetation, such as *Commandra umbellata*, *Polygala* spp., *Gentiana* spp. and *Antennaria* spp. A typical prairie shrub, *Ceanothus americanus*, may also occur in oak-juniper glades. Other herbaceous species in the glades are more often associated with dry forest, for instance *Aquilegia canadensis* and *Amphicarpa bracteata*.

D. Algific Slopes

At the other environmental extreme are cool, moist, north-facing talus slopes, termed "boreal slopes," "boreal woods" or "algific slopes." The steep slopes have a thin, moist, humic soil that is very sensitive to physical disturbance. Geological conditions appear to be the determinant of the algific slopes; they occur at limestone or dolomite discontinuities with shale, and associated ice crevices and caves provide cold air drainage.

Algific slopes are vegetated with a combination of *Quercus* spp. (esp. *Q. borealis*), *Acer saccharum*, *Tilia americana* and *Taxus canadensis*. *Abies balsamea*, *Pinus strobus* and *Betula lutea* may also be found in this habitat. *Taxus canadensis* and *Betula lutea* are good indicator species; *Abies balsamea* and especially *Pinus strobus* are less effective for this.

Abies balsamea was "not rare" in Iowa, according to Conard (1938) who reported it in several "fine groves." *Taxus canadensis* was always associated with *Abies balsamea* on algific slopes. Pammel (1923) mentioned *Taxus* on north-facing slopes in White Pine Hollow. Apart from the well-known *Abies* stand at Bluffton, there were several stands scattered in the region, with few to many trees. One fir stand was described by MacBride (1895) and had been cut by 1936, when the trees were about 12 m tall (Conard 1938). Another stand reported by Shimek (1906) had also been cut over by 1937, leaving only a few small trees (Conard 1938).

Algific slope vegetation is notable because it contains a large number of species, especially herbs and cryptogams, that are unusual or rare in the state (e.g. *Aconitum novaboracense*, *Chrysosplenium iowense*). Many of these have northern phytogeographical affinities, and apparently some are boreal disjunct species. Preservation of the algific slopes of the Paleozoic Plateau will significantly assist the conservation of special species in Iowa, and in the upper Midwest in general.

Despite their extraordinary ecological and phytogeographical nature, the algific slope of the Paleozoic Plateau remain largely unstudied, except for a few floristic lists (e.g. Hartley 1966, Lammers 1981) and single species studies (e.g. Weber 1979). No quantitative data have been recorded, and little is known about ecological processes in algific slope vegetation. Because of their intrinsic interest, and because of their potential contribution to species preservation in Iowa, there are significant research problems that should be addressed in these communities.

Forest Dynamics

Very little is known about forest dynamics on the Paleozoic Plateau; certainly there are few data pertaining to the subject. The most important disturbance factors are probably fire, gap formation by wind throw, and, in the alluvial forest, floods. From the time of settlement, clearing, selective logging and grazing also have had significant impacts.

Repeated disturbance is now recognized as one of the most significant factors for explaining the dynamics of vegetation (e.g., see review by White 1979). Because of its location, the Paleozoic Plateau has experienced the ebb and flow of prairie and forest vegetation. Such a dynamic region might be especially subject to the influence of disturbance. We have already pointed out that the forest probably was encroaching upon the prairie at the time of white settlement, but on the other hand, the prairie had formerly been more extensive (Transeau 1935). Furthermore, the migration of tree species since glaciation has been from different directions and has occurred at different rates (Webb 1981, Davis 1976). The probability of fire, wind and flood in the region seems high relative to the life spans of the tree species. In short, the region was (and is) subject to disturbance, and has been both ecologically and phytogeographically dynamic. Therefore, it is unlikely that the forests of the Paleozoic Plateau (or those of the Eastern Deciduous Forest Formation in general) were in a stable state at the time of settlement, and it is equally unlikely that they ever have been, at least since the last glaciation. The vegetation has probably never been in a climax state, and it is impossible to know what such a climax might be. Thus, we shall gain an understanding of the region's vegetation best by considering it as a multiply varying community pattern, and by attempting to understand the dynamics of this multivariate pattern.

Future Research

We have repeatedly emphasized the lack of research data on the vegetation of the Paleozoic Plateau. There are innumerable research problems to attack, and, because of its vegetational variation, its phytogeographic position and its dynamic history, the region has great potential for vegetation research. We list a few problems here that would contribute greatly to our knowledge of the region. To repeat, the greatest need is for quantitative data.

1. Vegetation patterns
   a) Vegetation scientists have completely ignored the floodplain forests of the region. What are its community patterns and their environmental correlates?
   b) The upland pattern illustrated by Cahayla-Wynne and Glenn-Lewin (1978) should be extended to other sites.
2. Species biology
   a) *Acer saccharum* and *A. nigrum* (or *A. s.* var. *nigrum*) are both present in the region. Cahayla-Wynne and Glenn-Lewin (1978) reported a bimodal distribution of maple, all recorded as *Acer saccharum*. Does this bimodality represent the two varieties of *Acer*, and if so, what ecological variables explain their respective distributions?
   b) Both *Tilia americana* and *Celtis occidentalis* exhibit a topographic bimodality, growing in mesic or alluvial forests, but also on crags and rocky bluffs. Such a situation would be excellent for both genetic and population research.
3. Vegetation dynamics
   a) Patterns of forest regeneration, especially the temporal relations of *Pinus strobus* and *Quercus* spp., remain largely unexplained.
   b) What is the role of disturbance? (Good historical information would be required for this.)
   c) *Tilia americana* often sprouts from stumps. What is the effect of this on forest regeneration patterns?

OTHER PLANT COMMUNITIES

Within the matrix of forest vegetation, there are several kinds of plant communities of much smaller extent, but which are nevertheless ecologically interesting. These have been described only in a qualitative way, and often in the context of their relationships to similar communities outside of the Paleozoic Plateau. Usually, key indicator species are used in such comparisons.

Hill Prairies

The Paleozoic Plateau is geographically a region of transition between the eastern deciduous forest and the prairie. Prairies were once a much more important ecological component of this region, but remain now only on predominantly south facing exposures with thin soils over bedrock. Prairies in such habitats are dry and are dominated by mid-grasses, e.g. *Andropogon scoparius* and *Bouteloua curtipendula*, and have a forb component of drought-tolerant prairie species, e.g. *Aster sericeus*, *Baptisia leucantha* and *Lithospermum canescens*. There may be variation within the prairies themselves. For instance, *Sorghastrum nutans* is often a dominant grass on the more moist, lower parts of the slope. Perhaps 40-50 hill prairies still exist in the region.

Like other plant communities, hill prairies are part of a continuum of communities. In this case, hill prairies are related to the oak-juniper glades. There is continuous variation from closed oak-juniper stands to open, savanna-like vegetation, to prairie with few or no junipers. Also, the herb layer of the oak-juniper glades contains a number of species usually thought of as prairie species.

It may be interesting to compare these prairies phytogeographically with other hill prairies, and with examples of the more typical tallgrass prairie. The soils on hill prairies are usually formed in loess, so comparisons with the deep loess hill prairies along the Missouri River are logical. In this case, characteristic plants that occur in the loess hills (e.g., *Yucca*, *Mentzelia*, *Scheddonardus*) are not found on hill prairies farther east, but otherwise, there are substantial similarities in floristic composition between these two separate regions.

It is not as easy to separate central Iowa hill prairies, e.g. those at Woodman Hollow (Niemann and Landers 1974), from Paleozoic Plateau hill prairies. Abiotic factors are similar, but no quantitative comparisons of structure and composition have been done. Because of topography, hill prairies are more common in the Paleozoic Plateau than in central Iowa, and are more variable in size (ranging from a fraction of a hectare to slopes 1.5 km in length). The types of bedrock in the two areas also are different, and they are more varied on the Paleozoic Plateau. For these reasons, genetic diversity in plant populations might be greater in the Paleozoic Plateau than in central Iowa.

The remaining hill prairies are ecologically important for another reason. Historically, the hill prairies have been restricted to their present locations by abiotic factors. They are often inaccessible to agricultural activities, even grazing and haying, and therefore may be among our best representatives of presettlement vegetation.

While fire is a prime factor in prairie dynamics, some hill prairies may have survived because substrate and aspect alone retarded woody plant invasion. Nevertheless, juniper invasion is a serious threat to the existing hill prairies; some sites have been completely overgrown. Sumac (*Rhus* spp.) is also a potential threat to the prairie vegetation. Future studies should focus on both structure and composition of the hill prairies, and on mechanisms and rates of change.

Sandstone and Limestone Microcommunities

Numerous bedrock exposures occur throughout the Paleozoic Plateau, and several characteristic plant communities are associated with cliff and ledge outcrops, such as on the St. Peter and St. Croix sandstones. Moisture is also important and interacts with bedrock type, so that there occur dry limestone and dry sandstone, as well as moist limestone and sandstone communities.

These communities are characterized by species that exhibit a preference for, and a restriction to, the localized combination of moisture and substrate. Some moist rock substrates support a complex of bryophytes and pteridophytes, some of which are rare in the state. For example, several rare (in Iowa) species of *Lycopodium*, e.g., *L. porophilum*, *L. dendroideum*, and *L. lucidulum*, are found on moist sandstone cliffs. The moist limestone sites are typified by more common species.

A Sand Community

A plant community known from only one place on the Paleozoic Plateau of Iowa is a sand prairie and dune complex. This is located at Sandy Cove, in an old channel of the Upper Iowa River, on an ancient terrace of a rock-cored meander. Open sand is still subject to wind movement, and many psammophilic species are found in this place, among them *Commelina erecta*, *Aristida oligantha*, *A. purpurescens*, *Petalostemum villosum*, *Talinum rugospermum*, *Polygala polygama* and *P. incarnata*.

THE FORESTS AND LANDSCAPE CONSERVATION

The Paleozoic Plateau is one of two regions of Iowa with a large number of rare plants (the other is the Loess Hills region of western Iowa). Equally, it is a region with a large number of rare or unusual, and reasonably undisturbed, plant communities. Because of its uniqueness and its diversity, and because there are still natural communities, the Paleozoic Plateau is perhaps the most important region of the state for the preservation of natural areas.

In its most straightforward form, preservation in the region means state or private acquisition of more preserves, and of a wider variety of preserves. Beyond this, however, we must look at the nature of existing natural vegetation, and at its environmental setting, to understand how to preserve the valuable sites. In Iowa in general, and in the Paleozoic Plateau specifically, patches of natural vegetation exist surrounded by disturbed or managed land. These natural patches usually are small enough that activities and disturbances on adjacent land may affect the natural patch. This means that a natural area cannot be preserved easily in and of itself, but must be preserved in its natural setting. Put another way, a natural area must be preserved as part of an integrated landscape, because that is the way that each community existed during its phytogeographic history.

This is the landscape approach to inventory and preservation. Such a landscape view recognizes community continuity, which, for the present discussion, has several important corollaries:

1. Borders between communities are not clearly definable, either in a classification nor sometimes in the field.
2. Communities grade into one another.
3. Communities are related closely to their substrate, meaning geology and physiography are important in the Paleozoic Plateau.
4. When communities are related physiographically or topographically, they are related biologically.

This interfacing of communities generates biological diversity. The entire complex of communities may be unique or significant, even if its constituent parts are less so.

Vegetation is but one attribute of the land. Others include (geo)morphology, soil, water, land use and humans. Integration of these land attributes means that an integrated survey and mapping system is required. This integration should show three things: a) spatial relationships between these attributes, b) chorological aspects (i.e., changes in relationships across geographic space), and c) contents of the attributes.

Simply stated, in order to preserve small, isolated natural communities, we need to preserve the natural landscape settings in which they exist. There are some implications of this. First, when we acquire a nature preserve, we well may need to acquire also land around it, even if that land is itself not natural. As an example, algific slope communities are extremely fragile, and are especially sensitive to activities on the land above them. To preserve adequately an algific slope, we must acquire a good deal of the surrounding forest, especially that on the slopes and uplands above the algific slope. This not only provides a buffer zone for the algific slope, it also provides some land that could be managed for trails or access so that the algific slope may be seen without the observer being directly on it. Second, the extent of several of our existing preserves should be increased. Third, when inventorying and mapping the region for its natural vegetation, the integration of communities must be addressed, which means that landscape units must be identified and mapped. Finally, a natural area within a mosaic of disturbed or managed land may not remain in the form in which it was preserved unless management steps are taken to maintain its desired condition. This means that active human intervention will be required. We should manage to maintain and restore natural abiotic processes and landscapes, and species of special interest will normally respond. In this way, management of species or communities does not become an *ad hoc* activity.

In order to be certain that intervention in natural areas has the needed and desired effects, a program of management research must be undertaken. A thorough understanding of natural area management can only be predicated upon a thorough program of modelling and testing of management activities in different communities. We in Iowa, and elsewhere in the United States, have generally ignored this aspect of natural area preservation, but we ignore this at the peril of the long-term life of these areas, and therefore we endanger long-term appreciation and understanding of natural vegetation and its role in human affairs.

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