encouraging the viewer to make the sky part of the experience of the space. By late summer the imposing foliage of Silphium laciniatum, compass plant, and Silphium terebinthinacum are added to the scene. At this time the heights of many of the plants are increasing. The linear stems of the taller grasses lead the eye upward toward the Silphium blooms and finally the sky. **Veronicastrum virginicum**, Culver's root, is also visible in a minor yet complementary role (Harrington 1986). Fall brings the full extension of the tall grass species growth and the substitution of the blooms of Aster novae-angliae for the Silphiums at the uppermost layer.

The relatively enclosed experience of this small prairie planting contrasts with the spaciousness of the prairie planting at the lake. This area has been planned such that it focuses on the horizontal plane of the body of water which reflects, symbolically, the horizontal plane of an extensive prairie.

The entire site is an experience, in microcosm, of many of the spatial and temporal relationships found in nature. The summer’s warm sunlit prairie is contrasted with the cool shade of the woodland; the cool blue green of the woodland plants is calm, in contrast to the dynamic qualities of a variety of vividly colored prairie flowers.

**LITERATURE CITED**


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**A DESIGN MODEL TO INTEGRATE PRAIRIE PLANTING WITH NON-BIOSPERIC LANDSCAPES**

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Abstract. Minnesota prairie vegetation shapes and patterns were examined at various landscape scales to generate a design model for man-made prairie landscapes. The model describes the distribution of vegetation shapes significantly concurred (p < 0.1) between different landscape scale classes. The model notes the number of protrusions, indentations and holes each shape is likely to contain. The pattern within a given area is also described. Small scale patterns are significantly different (p < 0.01) from regional patterns. A five step process is presented to visually create the essence of prairie under the most geometric and cultivated landscape conditions. Methods to manage the edges of the man-made cultivated prairies are discussed.

**INTRODUCTION**

Nature has traditionally been a major inspirational resource for the generation of urban landscape design. Over the last fifty-five years, native prairie landscapes have become a recognized and legitimate inspirational resource in the creation of urban form. Dyas (1975) documented several examples where prairie vegetation has been incorporated into urban landscape and where humans were involved in selective and controlled use of prairie planting patterns for cities. Controlled landscapes are termed "noospheric" (Vernadsky 1945). Noospheric landscapes, which are drastically controlled by man (Bakker 1979), contain few naturally occurring species and many newly introduced species (van der Maarel 1975). Naveh and Lieberman (1984) define studying noospheric vegetation patterns as part of a discipline termed "landscape ecology." Thus one could state that prairie planting design is being incorporated into noospheric landscapes and into landscape ecology.

The purpose of these plantings may not be to recreate precise pre-settlement prairies but to simulate the visual essence of prairie and to incorporate prairie plants into the urban fabric. Noospheric prairies are new prairies. They are not restored prairies nor are they preserved prairies. They are new plant associations, where the designer does not have to precisely replicate nature. The designer may decide not to faithfully follow those classical regional plant associations described by Curtis (1959) and others. However, by rejecting these naturally occurring descriptions as a model to create an urban prairie, the designer is faced with the perplexing situation of "what description (model), if any, to follow?" In urban landscapes there are few precedents to determine the appropriate prairie planting palette, appropriate planting scale, appropriate vegetation configurations or appropriate prairie interface with other urban landscapes.

Several notable landscape architects and designers have generated models for noospheric prairie. Morrison (1980) suggested two models in the creation of prairie landscapes. The first is the vista model. When viewing prairies on a large scale, prairies become a sea with weaving bands of plant materials interwoven across the landscape. When using this model the designer should attempt to create these weaving bands of plant material and create a mosaic pattern across the landscape. The second is termed the adjacent model. This model is applicable to most forb species. It states that forbs are clustered. This means that the farther one recedes from
TABLE 1. This table illustrates the relationship between the nine models described in this paper and the application to various native and cultivated landscapes.

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Human Controlled/Cultivated</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A-hemorbiotic</td>
</tr>
<tr>
<td></td>
<td>Oligo-hemorbiotic</td>
</tr>
<tr>
<td></td>
<td>Meso-hemorbiotic</td>
</tr>
<tr>
<td></td>
<td>Poly-hemorbiotic</td>
</tr>
<tr>
<td></td>
<td>Meta-hemorbiotic</td>
</tr>
<tr>
<td>Native</td>
<td></td>
</tr>
<tr>
<td>Biospheric</td>
<td></td>
</tr>
<tr>
<td>Matrix model</td>
<td></td>
</tr>
<tr>
<td>Showy garden</td>
<td></td>
</tr>
<tr>
<td>Incremental</td>
<td></td>
</tr>
<tr>
<td>Gradual transition</td>
<td></td>
</tr>
<tr>
<td>Critical area</td>
<td></td>
</tr>
<tr>
<td>Habitat model</td>
<td></td>
</tr>
<tr>
<td>Subtractive</td>
<td></td>
</tr>
</tbody>
</table>

The center of a plant cluster, the less likely one is to encounter that particular species. To execute the model, the designer should cluster each species of forbs. Both models are characteristically aesthetic, are open to interpretation and are applicable to naturalistic and cultural landscapes (Table 1).

Dieckel and Schuster (1982) suggested a plant matrix model where the landscape is divided into plots. Forbs and grasses are planted alternately. The plant matrix model ensures coverage and plant distribution to vegetate the complete site.

Dieckel and Bruner (nd.) proposed three different models to interface prairie with traditional urban landscapes: either a “showy garden,” “incremental” or “gradual transition” treatment. These methods are intended to ease the abrupt visual qualities between a typical urban savanna (defined by Brady et al. 1979) and the prairie landscape. The showy garden model is probably one of the most cultural or near cultural models available, resulting in a landscape drastically altered (poly-hemorbiotic and meta-hemorbiotic states) from native landscapes. The incremental and gradual transition models may result in semi-natural or semi-agricultural landscapes (called meso-hemorbiotic or eu-hemorbiotic states).

Austin (1984) offered a process which identifies critical planting areas for natural landscaping. This model is resource based. Site inventory data are collected and analyzed using map overlays. Priority revegetation locations are designated by locating physically eroding and degraded sites. Plant material is then scheduled for placement at these priority locations. After the critical area plan is generated a subsequent phased planting plan is prepared which meets the specific design intent of the client. The phased planting plan should blend with the existing forms of the critical area planting plan. Austin’s approach complements the aesthetic models by being more functional. The critical area model appears to have wide landscape applicability ranging from near-natural landscapes to completely cultural landscapes.

Smyser (1982) illustrated a near-natural model where plants are located according to the site’s ecological potential. While every model may examine vegetation potential, this model is ecologically comprehensive. The program for placing vegetation is based primarily upon the land’s ability to support specific prairie vegetation. Programs from other models often incorporate a client’s needs into vegetation locations. In the model described by Smyser, the selection of vegetation is performed only after a detailed site inventory is completed and a complete ecological analysis is conducted. A plant suitability habitat map is then created which delineates the potential location of various plant associations. This model generates vegetation patterns based upon the site’s intrinsic physiography. This model is probably the most biophysiographic sympathetic. Smyser used this process to create landscapes which are in the near natural state (a-hemorbiotic or oligo-hemorbiotic states). This model is termed the “habitat model.” The habitat model is a good model to assist in the preservation and restoration of prairies. Although it can be applied to urban situations, the habitat model may overlook special needs of the urban client.

Kenfield (1966) provided a subtractive model. In the subtractive model, plants are allowed to be spontaneous. Plants are controlled by selectively removing undesired vegetation. Vegetation removal is accomplished by mechanical and chemical treatments. Kenfield defined this process a “intagio.” The subtractive model is agricultural or semi-agricultural, resulting in meso-hemorbiotic or eu-hemorbiotic landscapes.

These nine models can be utilized to visually integrate prairie and other naturalized landscapes into the urban fabric. The authors are pioneers in their efforts to delineate spatial forms derived from naturalistic landscapes for urban areas.

The nine models rely heavily upon the designer’s intuitive abilities or a cognitive mapping process to generate a prairie landscape. While these models are very useful, many of these models lack an investigatory empirical base to provide a theoretical form-giving concept in the creation of urban prairies. Therefore a new model was sought which attempted to extract the visual essence of native prairie vegetation patterns and quantitatively describe the physical configurations of prairie.

The problem statement for the new model was: “Did there exist a native Minnesota prairie planting pattern or configuration that could be mathematically identified and applied to noospheric prairies?” To examine this statement, four subproblems were identified:

1. Are there previous or potential mathematical measures to describe plant distributions and vegetation patterns? If yes, what other features might be measured? If not, what features concerning shape could be measured?
2. Are there existing historical prairie records or existing prairies that could be descriptively measured for shape and configuration?
3. Upon measuring these prairies, were there any discernible and identifiable descriptive patterns emerging from the data set?
4. Could these identifiable features be abstracted and applied to noospheric prairies?

Several notable constraints arise concerning these four subproblems. First, plant distribution has traditionally been studied in some mathematical detail; however the study of iconic landscape shapes and patterns has been limited to mathematical representations including frequency, density and dominance which may indicate uniform, clustered or regular vegetation patterns. The actual configuration of the shape and pattern has not been extensively studied. This means that there are probably limited methods to assess shape and pattern plus limited examples to follow as guidelines for generating quantitative visual images.
Second, information generated from a map also has severe
categorical and cartographic limitations (Anderson 1980).
Generalized categorical maps and generalized cartographic maps
will have a tendency to contain simple shapes and simple patterns.
Thus the map and its contents have a tendency to bias the shape
and pattern information.

Third, mapping scale is an important feature to consider.
Differing mapping scales contain different classes of information.
For this study, land units and mapping classes were established
in relationship to current anthropocentric standards in landscape
design. These categories are not absolute; instead, these categories
are based on how humans design landscapes on paper, the size of paper
humans use, the types of marking devices humans use to design
landscapes and the resolution humans are able to perceive. In
nature, these categories may be completely arbitrary and have
no empirical basis; yet for human purposes, these categories can
have meaning and may be useful. The mapping scales are divided
into the following categories:

1. Microchore (small scale distribution patterns): From a traditional
landscaping perspective, the microchore is an extremely small
landscape parcel ranging in size from 0.1 to 2 meters or about
the size of a dish garden or very small planter. The mapping
of most horticulturally grown herbaceous species
(hemicyclaxies and cryptogyne) is easily accomplished at
this scale. The representative fraction is typically 1:1. The map
scale is 1 cm = 0.01 m.

2. Mesochore (intermediate scale distribution patterns): This
landscape is about the size of a small yard, approximately
an area 10 m x 10 m. The representative fraction is typically 1:100.
The map scale is 1 cm = 1 m. This scale most woody plants
(phanerophytes and chamaephytes) are easily mapped and
located. Some hemicyclaxies and cryptogyne are too small and
detailed to map and can only be described as mass plantings.
This scale is useful for detailed site design.

3. Macrochore (large scale distribution patterns): This landscape
is about the size of a small park or 100 m x 100 m and slightly
larger. The representative fraction is approximately 1:10,000.
The scale for mapping is typically 1 cm = 100 m = 0.1 km.
Clusters and associations of phanerophytes and other plants
(termed by some authors as plant communities or landscape
units) can be easily mapped. This scale typically is useful for
large scale site planning.

4. Polychore (many patterns and distributions): This landscape
is about the size of the difficult-to-define and often ambiguous,
but important "region" and is useful for regional and state
planning. The representative fraction is approximately
1:1,000,000. The scale is 1 cm = 10,000 m = 10 km. This
mapping scale is useful to map associations of associations (called
by some biomes or land systems).

With these constraints and limitations, the study team examined
current measuring methods and developed procedures for this
study.

METHODS AND MATERIALS

While there are limited measures to describe shape and pattern,
two appeared suitable. The first is the shape diversity index “D_s”
suggested by Patton (1975):

\[
D_s = \frac{P}{2\sqrt{\pi A}}
\]

\[
D_s = \text{Shape Diversity Index} \quad A = \text{Area} \quad \pi = 3.14
\]

\[
P = \text{Perimeter}
\]

This was used to describe the shape diversity of plant distributions.
A perfect circle will result in a shape diversity score of 1. Long
snake-like shapes will have scores near 2. Highly intricate shapes
may have scores greater than 3. Intricate shapes often have physical
features such as indentations, protrusions and holes associated with
the shape.

The second measure is pattern diversity, “D_p.” An area is
examined by measuring the edges of shapes contained within the
specified area.

\[
D_p = \frac{P}{A}
\]

This measure does not consider the perimeter of the area as
part of the edge (Thomas et al. 1979). The measure is a modification
of the index suggested by Patton. A uniform landscape will result
in a pattern diversity score of 0. Highly intricate patterns with
many vegetative associations can score greater than 10.

There is limited historical information concerning prairie shapes
and patterns available for measurement. The historical data
consisted of maps (Barnard 1980) illustrating large site (macrochore)
vegetation patterns and maps (Marschner 1974) illustrating regional
(polychore) vegetation patterns and shapes. To complement the
macrochore and polychore information, the study team gathered
field observations of shape distributions for individual species. The
field observations consisted of photographs and field notes
concerning the configurations of plant species in Minnesota prairies.
The mass configurations of each plant species can be considered
the mesochore information class. No microchore information was
gathered.

Mesochore shapes (n = 56) were measured from field maps
by determining the area of the configuration in square feet and
the perimeter of the configuration in linear feet. The number of
holes, intrusions and protrusions were also noted for each
configuration. The configuration was computed using the first
equation.

Polychore shapes (n = 68) were measured by randomly selecting
vegetation configurations on the Marschner (1974) map,
determining the area of the configuration in square miles and
determining the perimeter of the configuration in linear miles.
The diversity index was computed using equation one. The number of
indentations, protrusions, and holes were also recorded for each
configuration.
Macrochore patterns \((n = 27)\) were measured on the Barnard (1980) map by determining the area of the map in square miles and determining lineal miles of interior edges. The pattern of the area was computed using the second equation.

Polychore patterns \((n = 30)\) were measured by randomly selecting plots three-hundred forty-two square miles in area and measuring the lineal miles of interior edges. The pattern of the area was computed using equation two.

Mesochore and polychore shape diversity index \((D_s - \text{derived from the first equation})\), plus indentation means, protrusion means and hole means were compared in “Epistat” (Gustafson nd.). Macrochore and polychore pattern diversity index \((Dp - \text{derived from the second equation})\) were compared using non-parametric statistical methods.

RESULTS

The distribution of the pattern diversity index scores, “\(D_p\),” approximated a normal distribution, allowing parametric statistical procedures. There was a significant difference \((p < 0.01)\) between the macrochore pattern diversity index mean and the polychore pattern diversity index mean. The estimate of the mean polychore pattern was 0.46. A score of 0.46 indicates a relatively uniform pattern with occasional disruptions in uniformity. The distribution of the polychore pattern is illustrated in Fig. 1. The estimate of the macrochore pattern diversity was 15.4. A score of 15.4 indicates a complex pattern with no indication of uniformity. The distribution of the macrochore pattern is illustrated in Fig. 2. A regression line was constructed for the pattern diversity:

\[
D_p = 15.3 - 4.6 (A)
\]

\[
D_p = \text{Pattern Diversity Index}
\]

\[
A = \text{Area}
\]

The distribution of the shape diversity index scores, “\(D_s\),” did not approximate a normal distribution. Non-parametric statistical procedures were used to analyze the shape diversity index scores. In a comparison of mesochore and polychore shape diversity index means, there was a significant consensus of association \((p < 0.01)\) between the means. The microchore and polychore indentation, protrusion and hole means are listed in Fig. 2. The mode for the shapes approximated a circle. However the median shape was more complex with two protrusions, one indentation and zero holes. Shapes with a diversity index of greater than four, tended to contain holes.

DISCUSSION

From the results, a generalized model can be constructed to guide noospheric prairie form generation within the urban fabric. The model can guide general shape determination of vegetation massings and to guide the orchestration of these shapes into patterns.

Essentially, the shape of vegetation configurations measured in this study appear to indicate that there is a tendency for both species massing shapes and plant community shapes for Minnesota prairies to be similar, regardless of chor classification. The distribution of shapes in a design project could resemble the relative frequency histogram in Fig. 3. Forty-nine percent of the shapes should approximate short fat “C” shapes. Twelve percent of the shapes should approximate long skinny “S” shapes. The remaining percentage should be comprised of complex ameboid shapes. This distribution of shapes is approximately representative of Minnesota prairies. Thus, there are prairie shapes which approximate a circle and shapes which are more complex than a circle. Complex shapes often contain holes and often have nearby circular shapes outside of the main body. The holes are usually simple, with no indentations and no protrusions, meaning the shape of the hole approaches a circle. However, complex shapes are only occasional and not the rule.

The area patterns of vegetation measured in this study appear to indicate that there is a tendency for spatial patterns to decrease in spatial complexity with an increase in chor classification size. The median macrochore pattern edge to area ratio is approximately ten to one. The polychore pattern edge to area ratio is approximately one to one. The macrochore pattern is moderately busy; while the polychore pattern is relatively simple and uniform.

FIG. 2. Notice the relatively large variance in macrochore patterns.

FIG. 3. This figure illustrates the complex distribution and configurations of prairie shapes.
TABLE 2. This table describes the shape guidelines for various size classes of landscapes.

<table>
<thead>
<tr>
<th>Area</th>
<th>Class</th>
<th>Wavelength</th>
<th>Indentations</th>
<th>Protrusions</th>
<th>Holes</th>
<th>Texture</th>
<th>Ds</th>
<th>DP</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;10m² PLANTER</td>
<td>Microchore</td>
<td>~1-2m</td>
<td>.5m</td>
<td>1m</td>
<td>0</td>
<td>ultra-fine</td>
<td>simple</td>
<td></td>
</tr>
<tr>
<td>50-1000m² YARD</td>
<td>Mesocore</td>
<td>~10-1000m</td>
<td>5-50m</td>
<td>10-100m</td>
<td>1</td>
<td>fine</td>
<td>simple</td>
<td>~1.25(2.5)</td>
</tr>
<tr>
<td>5000 to 10000m²</td>
<td>Macrochore</td>
<td>1000m</td>
<td>500m</td>
<td>1000m</td>
<td>10</td>
<td>medium</td>
<td>complex</td>
<td>~1.25(2.5)</td>
</tr>
<tr>
<td>PARK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;100000m²</td>
<td>Polychore</td>
<td>&gt;1000m</td>
<td>&gt;500m</td>
<td>&gt;1000m</td>
<td>100</td>
<td>coarse</td>
<td>simple</td>
<td>~1.25(2.5)</td>
</tr>
<tr>
<td>REGION</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

List of Equations:
Equation 1. \[ Ds = \frac{P}{2 \sqrt{\pi A}} \]
Equation 2. \[ Dp = \frac{P}{A} \]
Equation 3. \[ Dp = 15.3 - 4.6 (A) \]

Ds = Shape Diversity Index; Dp = Pattern Diversity Index; P = Perimeter; A = Area; \( \pi = 3.14 \).

These shape and pattern descriptive measures have applications in landscape design. Providing that one desires to create an urban landscape which visually captures the patterns and shapes of the prairie, one might desire to utilize these descriptive measures. To utilize the model one should utilize the following steps.

Step One: Area Determination

Determine the area destined to become prairie. Examine Table 2 and decide what landscape size class the area best fits. The first class is small planter and dish garden. The second class is the small front or back yard. The third class is about the size of a quarter-section of land or the size of a small park. The fourth class is a region. Determining the class of the landscape is important because it will guide the choice of shapes and patterns.

Step Two: Spatial Guidelines

Utilize the spatial guidelines in Table 2. The guidelines suggest the size of four spatial features to be included in the landscape.

1. The table indicates the wavelength of the curves to be incorporated into the landscape.
2. The table indicates the approximate size of indentations to be used.
3. The table indicates the approximate size of protrusions to use.
4. The table indicates the approximate size of holes to be incorporated into the design.

These guidelines should assist in the creation of circular and simple irregular ameboïd shapes. Variations and deviations from the guidelines are allowed. However the mean of the four spatial features should be closely approximated.

Step Three: Draw Prairie Shapes

In step number three the object is to draw shapes on a site plan which incorporate the shape guidelines from step number two. The shapes should be distributed similarly to figure three. Include numerous simple shapes on the plan to approximate a relatively busy pattern.

The shapes should be applicable to a wide variety of settings and circumstances. Even in urban geometric plazas the basic idea can be applied to fit rectangular forms (Fig. 4). The essence of prairie shapes and patterns will then be intrinsically present.

Step Four: Plant Material Selection

Plant material should match the scale requirements of the site. In planters and some small yards, mesic prairie plants may not be appropriate. These mesic prairie plants may be too tall for a small space and can destroy the prairie-like ambience. Instead select the xeric prairie plants and plants with a fine delicate texture; otherwise the prairie landscape design will begin to take on the spatial qualities of a shrubland or young forest stand. If xeric plant material is inappropriate for the site conditions, it may be difficult to capture the visual essence of prairie. Small shrubs may be present at the edges of the meso-landscape. The placement of these shrubs should be similar to the incremental or transitional models described by Dieckmann and Bruner (nd.). Trees may be added to the park and regional landscapes.

FIG. 4. Notice how the general prairie shapes and patterns can be applied to even strict geometrical layouts.
The model generated in this study is essentially a beginning in understanding the shapes and patterns of prairie landscapes. To generate this model, there were some generalizations and statements one may wish to explore further. More samples from the microchore would assist in refining the model. Mesochore information would be helpful in establishing a more accurate regression line to describe pattern diversity from one landscape class to another landscape class. Measurements taken outside Minnesota would be helpful in applying this model to other prairie regions. It would be interesting to apply these measures in the study of woodlands, tundra and tropical vegetation.

There are existing measures to describe shapes and patterns. However, basic research to find more descriptive methods to measure shape and patterns may lead to new insights into prairie form generation. The further development of applied research models could lead to a greater understanding of prairie and incorporation of prairie landscaping into the urban fabric.

**LITERATURE CITED**


Gustafson, T.L. nd. Episett Round Rock, Texas.


Marschner, F.J. 1974. The original vegetation of Minnesota. North Central Experiment Station, USDA, St. Paul, MN.


