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A natural area inventory of Ames, Iowa

William Russell Norris
Iowa State University

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A natural area inventory of Ames, Iowa

by

William Russell Norris

A Thesis Submitted to the
Graduate Faculty in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE

Department: Botany
Interdepartmental Major: Ecology and Evolutionary Biology

Signatures have been redacted for privacy

Iowa State University
Ames, Iowa
1995
DEDICATION

This master's thesis is dedicated to Dr. R.S. Furr and Dr. Bryce Smith. During my pursuit of an undergraduate biology degree at Lake Superior State University (Sault Ste. Marie, MI) more than a decade ago, these two botany professors recognized my potential and encouraged my pursuit of knowledge in all things natural.
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The Ames Natural Areas Inventory would not have been possible without the cooperation of the many landowners who allowed me to visit their land. I spent many pleasant hours in the field with some, and learned much about land use and the history of Ames in the process.

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I. INTRODUCTION

The Need for Natural Area Evaluation

Perhaps no state in the Union has suffered such widespread degradation of its natural vegetation as Iowa. Tallgrass prairie (including wet prairie communities, often considered to be wetlands) once covered at least 85% of this state's land area, but more than 99.9% of Iowa's original grasslands have fallen victim to the plow (Smith 1990). Wetlands once covered 11.1% of Iowa's landscape (Dahl 1990), but virtually all of these have been drained to make way for rowcrops (wetlands now cover only 1.2% of Iowa's landscape). Roughly 12 to 20% of the state was covered by forest at the time of settlement by Europeans, but only 6% of the state is forest today (van der Linden and Farrar 1993, Leatherberry et al. 1992, Thomson and Hertel 1981). Furthermore, the majority of the forest fragments that do remain in Iowa are isolated and significantly altered by past grazing and/or logging practices.

Farrar (1981, p. 1) vividly described this post-settlement degradation:

The vast prairies which produced rich black soil, the fine hardwood forests which provided building materials and fuelwood, and the rivers and wetlands which provided transportation and teemed with waterfowl played integral roles in [Iowa's] history, molding the character of the settlement and later development that became Iowa. Yet today, we see almost nothing of the species and ecosystems that greeted the first settlers. Not only have the prairies and most of the forests been replaced by introduced rowcrops, but the weeds that fill the fence rows and compete with the crops are also largely foreign invaders. Highway rights-of-way and lawns are carpeted with introduced grasses, and cities and farm lots are planted primarily with tree species and selected varieties not native to Iowa. Along with the introduced vegetation have come introduced birds, mammals, and fish, many of which are Iowa's most frequently seen animals and most troublesome pests. Only the forests of Iowa's bottomlands and sharply dissected uplands present a readily visible ecosystem where the dominant components are species originally native to the state. But even here, nativeness is only superficial, for all too often, most of the native understory and its associated fauna have been removed through grazing.
Early advocates of ethical land use (e.g., Henry David Thoreau, Aldo Leopold) would be appalled at the current condition of Iowa's natural areas. Nonetheless, the few remaining tracts of natural habitat in the state continue to come under pressure. In an ideal world, government officials would grant immediate protection status to all of these remnants solely on the basis of their intrinsic value. However, the concept of natural area preservation in this state has not gained universal acceptance. Frequently, undeveloped lands containing significant natural areas are eyed by developers as potential sites for prime housing developments, highway expansions, strip malls or other projects that would doom the natural resources on the site. City planners (who typically have little training in science) are then forced to weigh whatever scientific testimony is presented to them in favor of preserving these areas against the financial gains that almost always accompany a large development project.

On another note, many private property owners are unaware that they own intact natural areas. A landowner might know that a particular piece of forest in his possession has not been grazed for more than fifty years, but at the same time not realize how diverse the woodlot is in comparison with currently grazed woodlots, or know how attractive his ungrazed woodlot is to nesting songbirds. Another landowner might know that he owns a patch of prairie plants behind his house but be unaware of the proper management strategies (i.e., tree cutting, controlled burns) necessary to maintain it as a prairie. Consequently, the preservation of Iowa's privately owned natural areas is often precarious.

Iowa's existing natural areas will continue to come under pressure from competing interests. City planners are constantly called upon to approve projects proposed by developers, and realistically can not deny permission to all of them on the basis of natural area or open space preservation. In order to make informed decisions, it is
useful for these planners to have prior knowledge of all existing natural areas within their jurisdiction, and to have a clear idea of their natural quality relative to one another. Then, there can be scientific justification for withholding the highest quality of these areas from development.

Likewise, a private property owner who is considering whether or not to convert his recently ungrazed woodlot into a pasture would be able to make a more informed decision if he had access to a document (written in layman's terms) describing the natural significance of his property. Hence, the identification and (natural quality) evaluation of existing natural areas can be an important conservation tool.

**Definition of "Natural Area"**

What is meant by the term "natural area?" Although a comprehensive review of the various meanings attributed to this term will not be undertaken in this thesis, one definition will be offered (The Nature Conservancy 1975:3 cited in Duritsa 1983 p. 1):

... an area of land or water which either retains or has reestablished its natural character, although it need not be completely undisturbed, which retains unusual flora, fauna, geological or similar features of scientific or educational interest.

The qualifications in the above definition that a natural area "need not be completely undisturbed" is especially fortunate in the term's application in Iowa because most of this state's natural resources have been altered in some manner by the hand of man. One can point to any "natural area" in Iowa, be it woodland, prairie or wetland, and be certain that the vegetation community present on the site has suffered from some human perturbation. For example, in White Pine Hollow Preserve (Dubuque County), arguably Iowa's most pristine woodland, one can find old cut stumps throughout most of the tract. At Doolittle Prairie State Preserve (Story County), one of Iowa's highest quality wetland complexes, all but nine acres have been subject to past grazing by livestock (Woodley 1983). Thus, any attempt to define the
term "natural area" in terms of absolute natural integrity would preclude the term from use in discussions of Iowa natural resources.

The Study Area

Geography

Ames is located in Story County in central Iowa. The city occurs in a landscape that was covered by a glacial ice sheet 12,000 to 14,000 years ago (the Des Moines Lobe) which melted 11,000 to 12,000 years ago (Prior 1991). The soils are some of the most fertile in the world, and consequently almost all of central Iowa has been converted to cropfields.

A major river, the Skunk, flows from north to south on the east side of the city and then on across Iowa to empty into the Mississippi River. Squaw Creek is a major tributary of the Skunk, entering the project boundary from the northwest and traversing the city until its junction with the Skunk just northwest of the intersection of US-30 and I-35. In turn, a number of streams flow into Squaw Creek from the west: Onion Creek, Clear Creek, College Creek and Worrell Creek. Walnut Creek flows from west to east on the southern fringe of the project boundary and drains directly into the Skunk River southeast of the city. Most Ames woodlands occur along one of these waterways.

Climate

In central Iowa, the climate is midcontinental with hot humid summers and cold dry winters. The average temperature in winter is -6°C with an average daily minimum of -11°C. In summer (June through August) the average temperature is 22°C and the average summer daily maximum is 29°C. The frost-free growing season averages 151 days. Total annual precipitation is 848 mm, of which 73% falls as rain from April to September. The prevailing wind is from the northwest. Thunderstorms are frequent in

Vegetation of Central Iowa

Woodlands

Ames woodlands belong in the central hardwood forest region of the United States (Preston 1989). Oaks are the dominant species, with hickories, ashes, elms, maples, walnut, cottonwood, sycamore, and dogwood also important.

In an earlier analysis of Ames natural areas, Joens (1978) noted that three distinct woodland communities exist in central Iowa: xeric, mesic and floodplain. This conclusion was based on detailed examination of the literature, limited plot work, and his observations in the field.

Johnson-Groh (1983, 1985) described central Iowa woodland communities in much more quantitative terms based on analysis of permanent plot data collected at Ledges State Park (Boone County). She established 54 rectangular permanent plots (0.1 hectare, 20 m X 50 m) throughout the park at sites chosen to represent all aspects, slope levels, slope inclinations and various degrees of disturbance. Detrended correspondence analysis (DECORANA) was performed on data collected from upland (= ridgetops and slopes), bottomland, and disturbed sites. The resultant ordinations were used to search for environmental gradients within the data that were related to species distributions.

Brief descriptions of the woodland community types identified by Johnson-Groh are presented below, with several types omitted because they do not occur in Ames.

Xeric Communities  Johnson-Groh described two woodland community types that are decidedly xeric in character: the *Quercus alba* type (QA) and the *Quercus alba-Quercus rubra* type (QAR). *Quercus alba* and *Quercus rubra* are most dominant in the
canopy of these woodland communities, and *Ostrya virginiana* dominates the understory (with lesser amounts of *Fraxinus* spp. and *Amelanchier arborea*). These woodland communities are normally found on flat uplands, ridgetops and south- and west-facing slopes at Ledges State Park.

**Mesic Communities** Three woodland community types fit into the mesic category: the *Quercus rubra-Tilia americana* type (QRTA), the *Tilia americana* type (TA), and the *Tilia americana-Acer nigrum* type (TAN). These are usually found on cooler and more moist north- and east-facing slopes in the park. Canopy dominance is indicated by the title of each community type, and understory dominance is again *Ostrya virginiana* with lesser amounts of *Carpinus caroliniana*, *Tilia americana*, *Acer nigrum*, and *Fraxinus* spp.

Another woodland community type identified at the park, the *Quercus rubra* type (QR), is found in both dry and moist sites and is thus transitional between xeric and mesic communities.

**Floodplain Communities** Only three permanent plots were established by Johnson-Groh in bottomlands at Ledges State Park. On the basis of these, she identified a *Bottomland Vegetation* Type (IN) that is dominated in the canopy by *Juglans nigra* with associated *Fraxinus nigra*, *Celtis occidentalis* and *Acer nigrum*. *Celtis* is dominant in the understory of this type.

Joens (1978) was more detailed in his (anecdotal) description of central Iowa floodplain communities, recognizing two stages of development along streambottoms. An early stage, found on streambanks and subject to frequent flooding, is dominated by *Salix* spp., *Populus deltoides*, *Acer saccharinum* and *Acer negundo* in both canopy and understory. A later, more mature floodplain community usually occurs a short distance away from the river's edge on a terrace and has *Juglans nigra*, *Juglans cinerea*, *Carya*
cordifolium, Celtis occidentalis, Ulmus rubra, Fraxinus spp., Gleditsia triacanthos, Gymnocladus dioica, and Quercus macrocarpa among its canopy dominants.

Prairie

Native prairie remnants that occur in Iowa are properly referred to as tallgrass prairie communities (Risser et al. 1981). White (1983) sampled the vegetation in eleven large prairies (scattered throughout Iowa and eastern Nebraska) and analyzed these data using Two Way Indicator Species Analysis (TWINSPAN) to look for classes of prairie vegetation on a regional level. He reported that the most significant divisions in the resultant classification reflected topographic-moisture variation, and that three major prairie assemblages (or divisions) are discernable: wet prairie, mesic prairie, and dry prairie.

Wet Prairie Division  A single prairie community type (wet prairie) occurs in this major division. This prairie plant assemblage is typically found in low lying situations such as pothole edges, swales, and wet alluvial terraces. Carex spp. are dominant in this community type, with a number of grasses (Poa pratensis, Calamagrostis canadensis, Muhlenbergia racemosa, Andropogon gerardii) and forbs (Helianthus grosseseratus, Solidago canadensis, S. gigantea, Euthamia graminifolia) occasionally codominant. The wet prairie type is the least diverse of all the prairie types described by White but is the most easy to characterize by a few dominant species (i.e., those mentioned above).

Mesic Prairie Division  The six prairie types within the mesic prairie division occur on i) prairies with relatively great local topographic relief, ii) upland stands with little topographic relief or fine textured soils, and iii) the highest positions in otherwise wet local landscapes. The six mesic prairie types are compositionally diverse and somewhat difficult to characterize. Two grasses, Andropogon gerardii and Sporobolus heterolepis, reach their maximum dominance and constancy in the mesic prairie division.
**Dry Prairie Division**  Four prairie community types that fall within the dry prairie division are typically found i) on the upper slopes of prairie landscapes with great topographic relief, ii) on sites with highly permeable soils on deep, coarse substrates well above the water table, and iii) in the westernmost prairies sampled. While overall plant species composition is heterogeneous in dry prairies, one grass species (*Schizachyrium scoparius*) is consistently found in all dry prairie community types.

Freckmann (1966) found 180 native plant species during his survey of five prairie remnants near Ames. He noted that these remnants, possibly the last remaining in the area, were remarkably diverse in character with at least five indicator species for each of five prairie types (wet, wet-mesic, mesic, dry-mesic, dry) occurring in Ames at that time. This observation lends support to White's (1983) later statement that the entire spectrum of prairie community types along the topographic-moisture gradient are often contained within a local landscape, given a wide range of topographic variation within that landscape.

**Wetland**

The few wetlands that exist in Story County are properly referred to as *prairie potholes* which are subject to seasonal inundation and drought. Stewart and Kantrud (1971, 1972) presented the definitive work on description and classification of wetland vegetation in the prairie pothole region.

Vegetation is typically arranged in concentric zones in freshwater wetlands. Five zones are recognized: *low prairie, wet meadow, shallow marsh, deep marsh, and open water zones*. Wetlands are classified based on the vegetation found in the central or deepest zone (which is a measure of the permanency of water in that zone). The five wetland classes are: class I, *ephemeral ponds* with a central low-prairie zone; class II, *temporary ponds* with a central wet-meadow zone; class III, *seasonal ponds and lakes*
with a central shallow-marsh zone; class IV, semipermanent ponds and lakes with a central deep-marsh zone, and class V, permanent ponds and lakes with a central permanent open water zone.

The most pertinent floristic study wetlands specific to Story County is that of Woodley (1983), who conducted an inventory of Doolittle Prairie State Preserve (just north of the project boundary) in the early 1980's. His extensive field work resulted in a very complete list of plants for the preserve which could serve as a baseline for more detailed work in the future.

**Ames Natural Areas Inventory**

**Background**

The Ames Natural Areas Inventory was conceived in 1990, largely as a result of complications that arose on the sites of two separate development projects approved by the City of Ames (Iowa) Planning Office.

On one of these sites, a prairie remnant (the Svejde Prairie) was discovered within the boundaries of the project area subsequent to the issuance of development permits by the Ames City Planning Office. Following a large public outcry, prairie sod from Svejde Prairie was moved to a city park (Moore Park) on the outskirts of Ames.

In a separate but almost simultaneous incident, an Indian burial ground as well as three hillside prairie remnants were discovered on the site of an approved and ongoing housing development project (Northridge Subdivision) within the jurisdiction of the Ames City Planning Office. The burial ground was protected by state law and public concern was raised regarding the fate of the prairie remnants. Consequently, the Ames City Council spent many hours in public forum negotiating an easement with the Northridge Development Corporation to ensure protection of these areas.
Formation of the Ames Natural Areas Committee

In both of the above cases, knowledge of these prairie remnants prior to the issuance of development permits would have saved the Ames City Planning Office time and money, as well as embarrassing publicity. The time was ripe for the formation of a committee to explore the possibility of conducting a natural area inventory of all lands within the jurisdiction of the Ames City Planning Office.

Thus, natural history experts with a variety of backgrounds came forward in 1990 to serve on the Ames Natural Areas Committee. Chaired by Ames City Planning Office Director Brian O'Connell, other members included ISU faculty (active: Dr. Donald Farrar-Botany, Dr. James Pease-Animal Ecology; retired: Dr. Robert Dyas-Landscape Architecture, Dr. Robert Moorman-Wildlife Extension Specialist), local prairie experts (Cindy Hildebrand, George Patrick, Trish Patrick, Judy Shearer), and a county conservationist (Steve Lekwa-director, Story County Conservation Board). Two Iowa State University students joined the committee in 1991: Tangela Jones and William Norris. The details of the committee's activities in carrying out this inventory will be described in the "Methods" of this thesis.

Inventory Goals

The Ames Natural Areas Committee determined that an inventory of potential natural areas in the Ames region would have three purposes:

1) To identify, inventory and evaluate areas of natural resource significance.
2) To define the values of natural areas to residents in the Ames area.
3) To recommend methods of protecting natural areas.

This thesis deals primarily with the first of these stated goals, but brief discussion of the steps taken to achieve the other two goals appear in the "Discussion" section of this thesis.
II. LITERATURE REVIEW

Inventory, Evaluation and Assessment

The task of a natural areas inventory is to gather resource information based on a classification system (Radford et al. 1981). A natural areas inventory is a multifaceted enterprise, including i) systematic identification, ii) classification of identified areas or phenomena, iii) site location and iv) evaluation (Duritsa 1983).

This thesis is primarily concerned with the process of natural area evaluation, a subcomponent of the inventory process. Evaluation of natural areas has been characterized as the process of "making measurements from a series of criteria and deciding which areas are most significant based on these measurements" (Smith and Theberge 1987, p. 447). Indeed, evaluation is the most frequently used term employed to describe the process of priority ranking natural areas (e.g., Tubbs and Blackwood 1971, Goldsmith 1975, Gehlbach 1975, Sargent and Brande 1976, Wright 1977, van der Ploeg and Vlijm 1978, Buckley and Forbes 1979, Voogd 1981, Klopatek et al. 1981, Berry 1983, Margules 1984, Margules and Usher 1984, Roome 1984, Peat 1984 cited in Spellerberg 1992, Smith and Theberge 1986b, Wathern et al. 1986, Slater et al. 1987, O'Connor et al. 1990).

The term assessment has occasionally been used to refer to the process described in the previous paragraph, particularly among British researchers (e.g., Peterken 1974, Ward and Evans 1976, Massey et al. 1977 cited in Spellerberg 1992, Kent and Smart 1981, Goodfellow and Peterken 1981, Wittig and Schreiber 1983, Dony and Denholm 1985). The terms evaluation and assessment are clearly distinguished by Spellerberg (1992), who states that evaluations are concerned with the methods and criteria used to make selections, drawing up priority lists, and identifying species and regions which are in need of greatest protection. Spellerberg goes on to specify that assessments are
undertaken either to identify the nature and extent of impacts on wildlife or to identify species and habitats sensitive to impacts (e.g., Fuller 1980, Margules and Usher 1981, Lloyd 1984, but see Schamberger and Krohn 1982 and Fuller and Langslow 1986 for two uses of the term evaluation to describe assessment processes in the sense of Spellerberg 1992). This thesis deals primarily with the methodology of quality rating various natural resources and therefore the term evaluation will be used exclusively when referring to these methods.

Intuitive Evaluation of Natural Areas

What methods might one use to rate the quality of natural resources in Ames, Iowa? If asked, a forester might evaluate a woodland by noting the size and abundance of harvestable trees in the canopy. A botanist might put more stock in overall plant diversity if given the same task. Likewise, a hunter might evaluate a woodlot on the basis of its suitability for whitetail deer (assessment by the above definition), and almost anyone could appraise a woodland on the basis of its perceived aesthetic qualities. Thus, natural area evaluation is not necessarily a straightforward business!

In the technical report for the Illinois Natural Areas Inventory (White 1978), five grades of natural area quality are defined (p. 280). These grades reflect the degree of disturbance that has occurred in a particular community:

Grade A: Relatively stable or undisturbed communities

Grade B: Late successional or lightly disturbed communities

Grade C: Mid-successional or moderately to heavily disturbed communities

Grade D: Early successional or severely disturbed communities

Grade E: Very early successional or severely disturbed communities
In this same report, twenty-five pages are devoted to procedures for qualitatively detecting disturbance from both aerial and ground surveys of various natural communities on a case by case basis. An experienced observer, intimately familiar with the various natural resource types in Illinois, would certainly be able to employ these methods and intuitively evaluate natural areas there. However, this approach contains a certain amount of subjectivity and is susceptible to challenge by land developers, city councilman, lawyers, etc... Therefore, more quantitative approaches to natural resource evaluation were sought out as models for this inventory.

**History of Formal Natural Area Evaluation**

Early attempts (late 1960s - 1970s) to formally (i.e., based on measurement of explicitly defined criteria) evaluate the quality of natural resources were directed toward two main purposes: town and country planning and selection of nature reserves (O'Connor *et al.* 1990). In these early evaluation schemes (Tubbs and Blackwood 1971, Tans 1974, Gehlbach 1975, Goldsmith 1975, Sargent and Brande 1976, Wright 1977), more emphasis was placed on establishing evaluation criteria on a conceptual basis than on providing methodological details. In addition to ecologically-based evaluations, there were attempts to place monetary values on natural resources (Helliwell 1969, Sinden and Windsor 1981, Sorg and Loomis 1985) with the intent that these values be contrasted with anticipated financial gains from exploitive use.

Ecological Criteria for Evaluation

The Ames Natural Areas Committee decided early on that only ecological criteria would be considered for use in evaluation of natural areas in Ames. Other criteria such as aesthetic quality, potential use as an outdoor teaching laboratory, ownership (public or private), availability for acquisition and potential for future development were thus excluded from consideration.

Many ecologically based criteria have been incorporated into various schemes to evaluate natural resources. O'Connor et al. (1990) compared 53 published studies and proposals from five countries [United Kingdom (14), New Zealand (14), Netherlands (12), United States (10) and Australia (3)] and found that diversity, rarity, naturalness, representativeness, and area were cited most frequently as evaluation criteria. Each of these criteria is discussed below.

Diversity

Measures of species diversity can be obtained from at least three sources: simple species richness indices, parameters associated with species rank-abundance models, and diversity indices that attempt to combine species richness and relative abundance concepts. Each of these diversity measures is addressed below, followed by a brief discussion of structural diversity.

Species Richness  The most frequently used measure of community diversity in natural area evaluation is a direct species count, referred to as species richness. Obviously, it is not practical to measure total organism species richness in a given sample (e.g., bacteria, algae, bryophytes, fungi, mites, nematodes, etc.) so the usual
practice in evaluation has been to focus on the species richness of particular taxonomic
groups of organisms (most commonly birds, plants and mammals) as an indicator of
total community species richness (Smith and Theberge 1986a).

When comparing the species richness of two samples which contain different
numbers of total individuals, it is desirable to express species richness with an index
which takes the number of individuals into account. Two popular species richness
indices appear below:

\[
SR = \frac{S-1}{\log N} \quad \text{Margalef 1951}
\]

\[
SR = \frac{S}{N} \quad \text{Menhinick 1964}
\]

In the above expressions, SR is the index of species richness, S is the total number of
species, and N is the total number of individuals. Menhinick reports empirical evidence
(insects collected in lespedeza fields) that his species richness index is independent of
sample size.

When comparing the species richness of samples determined by geographical
area, it is highly desirable that these samples be of equal area (Smith and Theberge
1986a). Rarefaction and regression techniques have been used to remove the effect of
area in unequal samples (Dony and Denholm 1985). Unless the effect of area on
diversity is removed, the criterion is not reliable for an objective comparison between
sites (van der Ploeg and Vlijm 1978).

Species Rank-Abundance Models In a typical biological community, usually a
few species are abundant, some have medium abundance, and the rest occur rather
infrequently. A number of models have been proposed to simulate this biological
phenomenon, in particular the log normal, the geometric series, the logarithmic series,
and MacArthur's broken stick model (Magurran 1988).
Most of these models have associated diversity parameters that can be used in ecological evaluation. Typically, the parameters are calculated by iterative methods after the model which best fits a particular data set is determined. For instance, the log series distribution is completely characterized by the equation:

\[ N = a \ln (1 + N/a) \]

where \( N \) is the total number of individuals in the sample, and \( a \) is the index of diversity (Fisher et al. 1943, Poole 1974). Assuming that the log series distribution is appropriate for a particular sample of \( N \) individuals distributed among \( S \) species, the diversity index \( a \) can be determined iteratively (see Magurran 1988) and used as a measure of diversity in ecological evaluation. For example, Peat (1984 cited in Spellerberg 1992) proposed the use of this index to measure the diversity of invertebrates collected as part of an evaluation of British heathlands.

Although species rank-abundance models provide excellent descriptions of species diversity, they often require tedious calculation as well as assumptions regarding the fit of a particular model to a given data set (Magurran 1988). Therefore, when species abundance patterns are considered in diversity measures, most researchers opt for one of the popular diversity indices.

**Diversity Indices** Suppose that two samples of twenty individuals each contain the same two species (A and B). Let the first sample be AAAAAAAAAABBBBBBBBBB and the second sample be AAAAAAAAAAAAAAABAAAAAB. Both samples have the same species richness (i.e., 2), but the first sample has a more even distribution of abundance among species.

There are many diversity indices in use that account for both species richness and the abundance of species. One is Simpson's Index of Diversity:

\[ D = \sum p_i^2 \]

Simpson 1949
D is the value of the index and $p_i$ is the proportion of the $i$th species. Since diversity decreases with increasing values of $D$, Simpson's index is usually expressed as $1-D$ or $1/D$ (Magurran 1988). To illustrate using the first of these expressions, the diversity of the first sample of letters above is $1-[.5^2 + .5^2] = .5$, while the diversity of the second sample is $1 - [(.95)^2 + (.05)^2] = .095$.

The Shannon-Weiner Index is also commonly used to measure diversity in samples. This index is one of several derived from indices used in information theory which are used to measure the amount of information contained in a code or message (Magurran 1988).

$$D = -\sum p_i \ln(p_i)$$  Magurran 1988

In the above expression, $D$ is the diversity index and $p_i$ is the proportion of the $i$th species. Again referring to the two samples above, the first sample has $D = -[.5\ln(.5) + .5\ln(.5)] = .69$, while the second sample has $D = -[.95\ln(.95) + .05\ln(.05)] = .15$.

Diversity indices differ in their tendency to place more weight on the abundance of common versus rare species. Hill (1973) used this fact to develop a single equation in which the different diversity indices are obtained by varying a single parameter:

$$N_a = (p_1^a + p_2^a + p_3^a + \ldots + p_n^a)^{1/(1-a)}$$

In Hill's equation, $N$ is the total number of species in the sample, $p_i$ is the proportion of the $i$th species, and $a$ is a parameter that determines the other diversity indices when varied. When $1$ or $\infty$ are substituted for $a$ into the equation, $N_a$ is defined as the limit of the function as $a$ approaches those values.

<table>
<thead>
<tr>
<th>Value of $a$</th>
<th>Diversity Index Assumed by $N_a$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Species Richness</td>
</tr>
<tr>
<td>1</td>
<td>Exp(Shannon-Weiner Index)</td>
</tr>
</tbody>
</table>
2  Reciprocal of Simpson's Index
∞  Relative Abundance of
    Most Common Species

Obviously, the weight appropriated to the abundance of common species increases with a. Conversely, the presence of rare species receives more weight as a decreases in Hill's equation.

Although the taxonomic unit most often considered when measuring diversity is the species, recent data (Williams and Gaston 1994) suggest that diversity measures of higher taxa (i.e., family) are often adequate as estimators of species diversity. Obviously, the latter approach has the advantage of being less time consuming and less costly.

*Structural Diversity*  The number of strata into which foliage is distributed in a community strongly influences its suitability for wildlife (e.g., Ambuel and Temple 1983). In temperate forests of North America, for example, a woodland with four distinct foliage layers (canopy, subcanopy, shrub, and herbaceous) would possess more breeding bird species than a grazed woodland with shrub and herbaceous layers largely removed (Dambach 1944). In fact, Goldsmith (1975) inferred animal species richness directly from a measure of foliage stratification of vegetation in his index of ecological quality for evaluating English countryside.

*Justification*  Smith and Theberge (1986a) summarized the various justifications that have been given for the use of diversity as an evaluation criterion. One rationale is the "more for your money" argument, which states that maximum representation of ecosystems, communities and organisms is highly desirable (particularly in selection of biosphere reserves).
Another reason that might be given to support the use of diversity in evaluation procedures is that diverse communities of organisms are more stable. However, this perceived relationship has lately been challenged (May 1973, Colwell 1979, Goodman 1975, Pimm 1984), and so ecological stability may be an inappropriate argument for inclusion of diversity as a criterion in ecological evaluations.

Rarity

Conceptually, rarity is a relative term that has meaning only within defined geographic boundaries. In a widely cited paper, Rabinowitz (1981) distinguished three components of rarity: geographical range, habitat specificity and local population size, and described seven forms of rarity based on combinations of these three components.

Smith and Theberge (1986a) offered another perspective on rarity with their description of five rarity categories: widespread rare species that occur over a wide geographical area but are everywhere scarce; endemic species that occur in only one restricted locality; disjunct populations that are widely separated from the geographical center of abundance for a species; peripheral populations that occur at or near the edge of a species distribution; and declining species that were once more abundant but are now drastically reduced in numbers. Extreme cases of any of these categories are often classified as endangered or threatened species.

These descriptions are useful in discussions of rarity as a concept, but do not shed much light on the quantification of rarity. One approach to assigning numbers to different degrees of rarity is to refer to species rank-abundance models (Smith and Theberge 1986a). For instance, the distribution of individuals among species often forms a lognormal distribution (Preston 1948, 1962). In this distribution, only a few species are very abundant, while the rest are considerably less abundant. Hence, one
might define various degrees of rarity (rare, very rare, threatened, endangered) as specific intervals on the lognormal curve (Fig. 2.1).

Rarity scores have been assigned to a set of organisms in a variety of ways. Presence or absence of a plant species in the 371 2 km X 2 km tetrads that comprise Bedfordshire, England provided the basis for assigning these scores (Dony and Denholm 1985). Those "selected" species occurring in 127 or fewer of the tetrads were assigned rarity scores based on an octave scale:

<table>
<thead>
<tr>
<th>No. Tetrads</th>
<th>1</th>
<th>2-3</th>
<th>4-7</th>
<th>8-15</th>
<th>16-31</th>
<th>32-63</th>
<th>64-127</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Thus, a sum of the scores of all "selected" species occurring in a woodlot gives a plant rarity factor (PRF) for the site which can be used as a component of evaluation.

Swink and Wilhelm (1994) have informally assigned numerical scores to all vascular plants listed in their flora of the Chicago (Illinois) region based on each species' relative abundance in the region as well as its fidelity to particular habitats. Likewise, Pearson (1986) compiled a list of native prairie plants of Iowa with accompanying numerical scores that reflect each species' rarity in the state as well as other factors. The actual use of these individual species scores in the evaluation of natural areas will be discussed later in this literature review (in "Natural Area Evaluation in Iowa and the Midwest").

**Justification**  
Smith and Theberge (1986a) stated that the major justification for the use of rarity as a criterion in natural area evaluations is the preservation of genetic diversity.

**Naturalness**

Most definitions of naturalness refer to freedom from impact by humans (*e.g.*, Margules and Usher 1981, O'Connor *et al.* 1990, Spellerberg 1992). Many uses of the
Figure 2.1. Degrees of rarity defined by rank order of species abundance
(from Smith and Theberge 1986a)
term have arisen during evaluations of landscapes severely altered by the hand of man, and thus naturalness is negatively correlated with alien or introduced species (Ratcliffe 1977, Margules and Usher 1981). Consequently, the predominance of natural vegetation has often been the barometer used to measure naturalness (Margules and Usher 1981).

One would be hard pressed to point to any vegetation community in Iowa that is entirely natural. The effects of fire suppression, logging, grazing, and drainage are evident whenever one looks closely at Iowa's remaining prairies, woodlands and wetlands. Thus, the comments by O'Connor et al. (1990) that naturalness should be thought of as a continuum within which communities have recovered after human disturbance are especially appropriate in the context of the Ames Natural Areas Inventory.

A simple way to evaluate the naturalness of an area is to define a small number of categories (with associated scores) of naturalness, classify the area in question into one of these categories, and assign the appropriate score to the area. To illustrate, Wright (1977) established the following categories and scores in his evaluation scheme for potential natural areas:

- Agricultural or Artificial Landscape 1
- Seminatural Landscape with Native Flora and Fauna Present 2
- Near-Natural Landscape 3

A more formal way to define "natural" when developing methods of evaluation is to determine the condition of natural resources prior to human impacts (often "pre-European settlement") and to measure "naturalness" as the degree of departure from this standard (O'Connor et al. 1990). One might reconstruct this standard by consulting
historical accounts and early land surveys; examining pollen spectra from the bottom of lakes and ponds to determine long-range vegetation patterns; consulting soil maps; and by studying the structure and composition of existing vegetation communities as they recover from past human disturbance (Noss 1985).

Anderson (1991) presented a conceptual framework for evaluating naturalness. He proposed three indices of naturalness: 1) the degree to which a system would change if humans were removed; 2) the amount of cultural energy (e.g., energy derived from hydroelectric or nuclear sources) required to maintain the functioning of the ecosystem as it currently exists; and 3) the complement of native species currently in an area compared with the group of species in the area prior to settlement.

**Justification** The most common rationale for using naturalness in evaluation schemes, according to Smith and Theberge (1986a), is that "undisturbed natural areas provide the best source of baseline information to compare with other, considerably modified areas" (p. 722). They also acknowledge the "many spiritual, philosophical, emotional, and recreational benefits often cited in support of the preservation of wilderness" (e.g., Thoreau 1971, Leopold 1966) as a reason to use naturalness as a criterion in natural area evaluation.

**Representativeness**

Representativeness refers to the range of variation occurring on a regional scale. Smith and Theberge (1986a) recognize two interpretations of this term, referred to as typicalness and inclusiveness. Typicalness is concerned with usual species assemblages in an area, especially the commoner and more widespread species (Usher 1980). Inclusiveness refers to the entire range of variation in an area, encompassing not only typical communities (characterized by mostly common species) but also unique communities containing rare species (Margules and Usher 1981).
Although representativeness has been used as a component of natural area evaluation (e.g., classification/ordination of natural communities in a wide region for comparison with areas to be evaluated), the concept is perhaps more naturally applied in the selection of bioreserves. For example, conservation in Australia is conducted on the premise that tracts of land chosen for preservation should contain a range of species and habitats which represent the range of variation (i.e., inclusiveness) found within a defined land class or region (Spellerberg 1992). As applied in New Zealand, however, representativeness refers to a series of nature reserves which represent the main types of communities (i.e., typicalness) in the entire country (O'Connor et al. 1990).

Many of the reasons given in support of diversity and naturalness as evaluation criteria can be used to justify consideration of representativeness in evaluation of natural areas.

Area

Many schemes for natural area evaluation consider area as one criterion. However, area determinations are not always straightforward (Spellerberg 1992), particularly in fragmented landscapes (such as those found throughout Iowa) where wooded tracts are often connected by narrow corridors that follow river drainages.

The strong positive relationship between area of a natural resource and the species richness of many groups of organisms is an established tenet of ecology (e.g., Blake and Karr 1987 and many others). Therefore, it is not surprising that measures of area are so common in evaluation schemes, justified by the same argument that is often given to support diversity as an evaluation criterion (i.e., "more for your money").

Another argument given in support of large or minimum-sized tracts in evaluation schemes is that different species have different range requirements and minimum viable population sizes (Soule 1980, Franklin 1980, Shaffer 1980). Finally, Smith and
Theberge (1986a) point out that large nature preserves which are relatively unimpacted by human activity are highly desirable.

Scales of Measurement

Four scales of measurement commonly used in natural evaluation procedures have been described by Smith and Theberge (1987): nominal, ordinal, interval, and ratio.

a) Nominal Scale   This measurement scale is completely qualitative. For example, "evidence of past disturbance" versus "no evidence of past disturbance" are two mutually exclusive outcomes measured on a nominal scale.

b) Ordinal Scale   On this scale, categories can be ordered or ranked. For example:

<table>
<thead>
<tr>
<th>Ordinal Category</th>
<th>Score Class</th>
</tr>
</thead>
<tbody>
<tr>
<td>No disturbance evident</td>
<td>High</td>
</tr>
<tr>
<td>Moderate disturbance evident</td>
<td>Medium</td>
</tr>
<tr>
<td>High disturbance evident</td>
<td>Low</td>
</tr>
</tbody>
</table>

Numbers are frequently assigned to ordinal categories and are referred to as score classes (Bedward et al. 1991):

Theoreticians advise against adding or multiplying ordinal score classes in any scheme for evaluating natural areas because the categories themselves are qualitative in nature (Smith and Theberge 1987).
c) *Interval Scale*  In contrast to the ordinal scale, interval measures are clearly defined as numerical distances between categories (*i.e.*, they are countable). For example, scores for disturbance could be defined by the following interval categories:

<table>
<thead>
<tr>
<th>Interval Category</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disturbance not evident</td>
<td>2 points</td>
</tr>
<tr>
<td>One or two forms of disturbance evident</td>
<td>1 point</td>
</tr>
<tr>
<td>At least three forms of disturbance evident</td>
<td>0 points</td>
</tr>
</tbody>
</table>

d) *Ratio Scale*  Population density and species richness expressed per unit area are two straightforward examples of ratio measurements. Ratio intervals are frequently used for evaluation purposes:

<table>
<thead>
<tr>
<th>Ratio Category</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>At least 50 trees per acre</td>
<td>2 points</td>
</tr>
<tr>
<td>At least 20 but fewer than 50 trees per acre</td>
<td>1 point</td>
</tr>
<tr>
<td>Fewer than 20 trees per acre</td>
<td>0 points</td>
</tr>
</tbody>
</table>

Basic mathematical operations such as addition and multiplication can validly be performed on scores measured on either the interval or ratio scale (Smith and Theberge 1987).

**Approaches to Natural Area Evaluation**

Multicriteria evaluation models are used to rank a series of alternatives on the basis of a number of criteria (Smith and Theberge 1987). Two basic types of models have been used in natural area evaluation: compensatory and noncompensatory. In compensatory models, scores for all criteria are aggregated into a single number. These should be used only when all criteria are measured on the same scale. When criteria
are measured on different scales (e.g., ordinal and interval), it is inappropriate to aggregate them into an index (Smith and Theberge 1987).

Ideally, ecological criteria aggregated into an index should be independent of one another, but this is an unreasonable assumption in most instances (van der Ploeg and Vlijm 1978, Margules and Usher 1984, Gotmark et al. 1986). For instance, diversity, area and naturalness are clearly related to one another, but they are often aggregated together in evaluation schemes.

Despite these inherent problems, compensatory models are used in most schemes for the evaluation of natural areas. However, multicriteria methods of natural area evaluation that do not require aggregation of criteria scores into an index do exist (noncompensatory models) and have occasionally been used. Examples of both compensatory and noncompensatory models are given below.

**Compensatory Evaluation Methods**

*Addition of Criteria Scores* The most common method to evaluate natural areas on the basis of multiple criteria is to sum of all criteria scores. Some of the earliest of these evaluation schemes were concerned with landscape evaluation (Tubbs and Blackwood 1971), but the first formal multi-criteria approach for evaluation of natural areas *per se* was proposed by Tans (1974) for priority ranking of natural areas in Wisconsin.

In Tans' scheme (Table 2.1), points are allocated within four main categories: biological features, physical features, degree of threat and availability. Various subcategories are delineated within some of these major categories and scored separately. Tans advises that to evaluate an area, one needs merely to sum the points allocated for quality, commonness, community diversity, size, and buffer. Then, this total and the points allocated for availability and threat can be compared for each
Table 2.1 Evaluation scheme for priority ranking of biotic natural areas in Wisconsin (condensed from Tans 1974).

CRITERIA FOR PRIORITY RANKING OF BIOTIC NATURAL AREAS

I). Biological Characteristics

A. Quality. Quality is a ranking of an area based on species richness of native plant and animal species, plant community structure and integrity, and extent of human disturbance.

<table>
<thead>
<tr>
<th>Quality Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highest Quality-area approaches the ideal community type; no disturbance or disturbance not visible</td>
<td>10</td>
</tr>
<tr>
<td>High Quality-evidence of very minor disturbance</td>
<td>8</td>
</tr>
<tr>
<td>High Quality-at least one type of more obvious disturbance</td>
<td>6</td>
</tr>
<tr>
<td>Moderate Quality-one or more types of disturbance to community is obvious and community integrity is threatened</td>
<td>4</td>
</tr>
<tr>
<td>Low Quality-disturbance with resultant loss of the biotic community structure. May still have value as species habitats</td>
<td>2</td>
</tr>
</tbody>
</table>

B. Commonness. Commonness is a measure of the importance of a natural area type derived by evaluating the acreage of the type in presettlement vegetation, historical impacts, the presence of rare or endangered species, and the amount of the type in the present landscape of the region.

<table>
<thead>
<tr>
<th>Commonness Description</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very uncommon-low acreage in presettlement vegetation and present vegetation, nearly complete conversion of type, restricted occurrence, the presence of two or more rare or endangered species, or the only known location of a nonbotanical feature.</td>
<td>6</td>
</tr>
<tr>
<td>Uncommon-moderate amount of type in presettlement vegetation and/or partial conversion of type.</td>
<td>4</td>
</tr>
<tr>
<td>Common-frequent to abundant in the present landscape, the type has increased since the advent of white settlement, or an adequate representation of the type within the scientific area system.</td>
<td>2</td>
</tr>
</tbody>
</table>
C. **Community Diversity.** The number of plant community types.

<table>
<thead>
<tr>
<th>Point Allocation</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Great Diversity-four or more community types or features</td>
<td>5</td>
</tr>
<tr>
<td>Moderate Diversity-two or three types of features</td>
<td>3</td>
</tr>
<tr>
<td>No Diversity-single community type of feature</td>
<td>1</td>
</tr>
</tbody>
</table>

II). **Physical Characteristics-Use Value**

A. **Area.** The minimum area for plant communities assumes adequate buffer zones but varies according to the community type.

B. **Buffer Zone.** A buffer zone is deemed adequate if it will afford protection to a natural area from the activities of man and the elements.

<table>
<thead>
<tr>
<th>Point Allocation</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greatly exceeds minimum size, excellent buffer, no threat of encroachment</td>
<td>8</td>
</tr>
<tr>
<td>Adequate size and buffer</td>
<td>6</td>
</tr>
<tr>
<td>Adequate size, inadequate buffer</td>
<td>4</td>
</tr>
<tr>
<td>Inadequate size, adequate buffer</td>
<td>2</td>
</tr>
<tr>
<td>Both inadequate</td>
<td>0</td>
</tr>
</tbody>
</table>

C. **Use Value.** Measured by the current and potential educational use the tract may receive. Use is intended to include formalized class and instructional activities, research, and informal nature use.

<table>
<thead>
<tr>
<th>Point Allocation</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Outstanding value, annually used by several schools or groups for both casual and structured activities; near metropolitan areas; extensive field station use or potential for extensive use.</td>
<td>4</td>
</tr>
<tr>
<td>Intermediate to high value</td>
<td>2, 3</td>
</tr>
<tr>
<td>Moderate value</td>
<td>1</td>
</tr>
</tbody>
</table>
### III). Degree of Threat

Threat is defined as a rating of an area's security with respect to the maintenance of the structure and integrity of its plant communities and other natural features.

<table>
<thead>
<tr>
<th>Point Allocation</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Threat is imminent; main features currently being developed or destroyed</td>
<td>10</td>
</tr>
<tr>
<td>Threat is imminent to portion of main features</td>
<td>8</td>
</tr>
<tr>
<td>Threat is moderate; development probable in future</td>
<td>6</td>
</tr>
<tr>
<td>Disturbance encroaching upon area</td>
<td>4</td>
</tr>
<tr>
<td>Little threat-destruction unlikely</td>
<td>2</td>
</tr>
</tbody>
</table>

### IV). Availability

Availability is an assessment of the probability that an area will come under protective ownership.

<table>
<thead>
<tr>
<th>Point Allocation</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available-offered as donation or owned by cooperating public agency</td>
<td>5</td>
</tr>
<tr>
<td>Available or near appraisal cost, within an approved land acquisition boundary, or possible candidate for donation</td>
<td>4</td>
</tr>
<tr>
<td>Probably available at high cost</td>
<td>3</td>
</tr>
<tr>
<td>Availability in doubt-perhaps in time</td>
<td>2</td>
</tr>
<tr>
<td>Not available or available by condemnation</td>
<td>1</td>
</tr>
</tbody>
</table>
of the areas evaluated to rank them comparatively.

A modification of the above scheme in which criteria are differentially weighted was proposed by Gehlbach (1974) for evaluation of Texas natural areas. In order to evaluate a given natural area, the criteria scores are multiplied by the appropriate weight, and then these weighted scores are summed for the final rating (Table 2.2).

Many later schemes for evaluation of natural areas incorporated differential weighting of criteria, but there is no general consensus regarding the relative weights of individual criteria (Margules and Usher 1984).

Recent evaluation schemes have tended to rely solely on ecological criteria. For example, Ogle's scheme for the evaluation of New Zealand forests (1981) considers habitat criteria (representativeness, habitat diversity, habitat modification), landscape features (area, degree of isolation) and species richness and rarity of animals (number of indigenous forest bird species, rarity of indigenous birds, rarity of other fauna). As in the method of Tans (1974), these eight components are scored separately and then summed to allow priority ranking of natural areas.

**Multiplication of Criteria Scores** Occasionally, component scores are multiplied together in ecological evaluation schemes. For example, Goldsmith (1975) computed an index of ecological quality (IEV) for large blocks (42 km grid squares) of English countryside by evaluating four criteria for each habitat type found inside a given block: extent of habitat (E), rarity of habitat (R = 100% - % area of the habitat type), plant species richness (S = number of plant species found in 20m square plots within the habitat type) and animal species richness (V - inferred from the stratification of the vegetation). Values for E, R, S and V were standardized and then multiplied together for each habitat type inside a block, and then these products summed to yield the IEV for that block.
Table 2.2. Evaluation scheme for evaluation of Texas natural areas (condensed from Gehlbach 1974).

<table>
<thead>
<tr>
<th>I). Heritage Value (weight = 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Point Allocation</strong></td>
</tr>
<tr>
<td>Climax condition</td>
</tr>
<tr>
<td>Late seral stage</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>II). Educational Utility (weight = 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Point Allocation</strong></td>
</tr>
<tr>
<td>Three or more special features</td>
</tr>
<tr>
<td>Two or more special features</td>
</tr>
<tr>
<td>One special feature</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>III). Species Significance (weight = 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Point Allocation</strong></td>
</tr>
<tr>
<td>Endangered species</td>
</tr>
<tr>
<td>Rare, relict, or endemic species</td>
</tr>
<tr>
<td>Peripheral species, hybrid zones</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>IV). Community Representation (weight = 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Point Allocation</strong></td>
</tr>
<tr>
<td>Localised or relict and novel types</td>
</tr>
<tr>
<td>Community or dominance-types novel to preservation system</td>
</tr>
<tr>
<td>Two or more community types</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>V). Human Impact (weight = 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Point Allocation</strong></td>
</tr>
<tr>
<td>In progress but features salvageable through succession with management</td>
</tr>
<tr>
<td>Imminent</td>
</tr>
<tr>
<td>Possible but not imminent</td>
</tr>
</tbody>
</table>
IEV = \( \sum (E_i X R_i X S_i X V_i) \)

Marsh (1978) published another method of ecological evaluation in which multiplication is used to combine components. For each habitat within a block, the values of the four components are determined: number of vegetation horizons present \((V)\), extent of habitat in hectares \((E)\), rarity \((R = 100 - C, C = \text{habitat area/total area})\) and species diversity \((S = \text{richness of both plants and animals})\). Pickering's Index of Ecological Value \((EV)\) is calculated in a fashion similar to IEV above, except that \(V\) is cubed for each habitat and the resultant sum is transformed by conversion to log form:

\[ EV = \log_{10} \sum (V_i^3 X E_i X R_i X S_i) \]

Noncompensatory Methods of Natural Area Evaluation

Theoretically, aggregation of criteria scores is warranted only when these scores are measured on the interval or ratio scales. Many of the evaluation schemes described above are in violation of this tenet.

There are potential problems with compensatory models for evaluation, even when they are used correctly. For example, a site that is average for all criteria may rank high based on aggregation of all criteria scores, while another site with an extremely high score for one criterion and low scores for other criteria may rank low in comparison (van der Ploeg and Vlijm 1978, Klopatek et al. 1981, Gotmark et al. 1986). Thus, a natural area with a very significant feature could potentially slip through the cracks when city planners are forced to make land-use decisions that rely on evaluation schemes that call for aggregation of criteria (i.e., compensatory methods).

Several attempts have been made to use noncompensatory models in natural area evaluation (several systems described by van der Ploeg and Vlijm 1978, Eagles 1980 cited in Smith and Theberge 1987a, Fuller 1980, Smith et al. 1986 cited in Smith and
Theberge 1987). In these evaluation schemes, the priority ranking of a natural area is based on the highest rank each area has for any criterion.

**Specialized Methods of Evaluation**

A very simple method for ranking woodlands in the UK that relies only on species richness of primary woodland plant species was developed by Peterken (1974). Primary woodland plant species are defined as a) species which can bear the shade of a closed woodland canopy, b) those which create the canopy, and c) others which in some way require woodland conditions, in particular woodland edge species. Typically, these species are poor colonizers of newly available habitat, and are usually found in long-established woodlands. Eliminated from consideration in Peterken's evaluation scheme are (p. 239) "grassland and ruderal species found on . . disturbed ground", as well as "secondary woodland species which rapidly become established in newly available woodlands."

Peterken's method is attractive because it is simple and quantitative, and also because the number of primary woodland species in a given site is in part a function of other components of woodland quality, such as area, soil diversity and structural diversity (Spellerberg 1992). However, a large initial investment of time in the field must be allowed for compilation of a primary woodland plant species list.

A similar method of categorizing plants was used by Ward and Evans (1976) in their procedure for evaluation of limestone pavements in Britain. Vascular plants are categorized as nationally rare (A), nationally uncommon or with a marked regional distribution (B), or nationally common (C). All plants occurring on a site are assigned an abundance rating (a = 1, 2 or 3), and then the Floral Index (FI) for the site is computed as follows:

\[
FI = 3\sum a_A + 2\sum a_B + \sum a_C
\]
Thus, the A, B and C species are weighted in the ratio 3:2:1.

Comparison of Methods for Evaluation of Natural Areas

There have been several attempts to apply different evaluation schemes to the same sites to test for differences in rank order of the sites. For example, Ogle (1981) applied his method, the method of Tans (1974) and two other methods to 25 New Zealand forests and found no statistical differences among the rankings determined by the four methods.

Gotmark et al. (1986) devised a method to evaluate bog communities and then compared the rankings resulting from his method with those achieved by a variety of diversity and rarity indices. They found little agreement in the rank order produced by their method with those produced by the various diversity indices.

Bedward et al. (1991) examined the effect of converting ratio scores to score classes on the selection of natural areas to complete a fully representative reserve network (Australian forests and wetlands). They found that changing from scores to score classes did affect the efficiency of site selection (number of sites needed to complete the network), but that the direction of the effect was not predictable from one data set to another.

Natural Area Evaluation in Iowa and the Midwest

Joens (1978) evaluated the quality of natural resources used by Iowa State University as outdoor laboratories. Most of the areas he evaluated are within the bounds of the current Ames Natural Areas Inventory. In Joens' study, he described and assigned numbers to five levels of woodland quality as follows (p. 15):

- Highest quality - several layers present, high diversity, no disturbance or disturbance not visible. 10
- High quality - several layers present, high diversity, evidence of very minor disturbance 8
High quality - several layers present, medium diversity, at least one type of more obvious disturbance

Moderate quality - one or more types of disturbance to community is obvious and community integrity threatened, one layer missing, diversity low

Low quality - disturbance with resultant loss of the biotic community structure and diversity, may still have value as a species habitat

Although Joens acknowledges the earlier work of Tans (1974) as an influence on his rating system, their methods are in fact dissimilar because Joens does not explicitly allow for the separate evaluation of different criteria (e.g., diversity, structure, disturbance). In fact, Joens' approach is reminiscent of White's (1978) intuitive procedure for natural area evaluation in Illinois.

Duritsa (1983) conducted a natural area inventory of Black Hawk County (IA) which included evaluation of all woodlands. County woodlands were evaluated on the basis of percent canopy cover and on the canopy texture as seen on aerial photographs (Fig. 2.2).

Duritsa acknowledges that precise differentiation between "A" and "B" areas was at times difficult from aerial photographs, and that ground verification was often necessary to confirm "A" quality designations. She points out that (pp. 34-35):

...even under a heavily canopied area there may be uses, primarily pasturing, which obliterate ground strata. The designation of "B" could be particularly misleading because the system represents canopy conditions which are not necessarily indicative of the quality of the woodland community. Abandoned woodland pasture may have 90 percent or greater canopy cover, but this canopy cover could be comprised of "weed" trees such as hawthorne and honey locust to the exclusion of other native species. The aerial imagery used in this study does not allow for the identification of tree species.
"A" areas (*relatively undisturbed or later successional woodland*) exhibit 90-100 percent canopy cover with a well modulated texture. The modulation indicates a variety of tree ages and therefore a fairly well stratified forest.

"B" areas (*moderately disturbed or mid-successional woodland*) are well canopied areas of 90 percent or more. They exhibit a more homogenous canopy texture than the "A" areas.

"C" areas (*moderately to heavily disturbed or early successional woodland*) are wooded lands with 50-90 percent canopy cover, or homogenous but very young canopy indicative of early successional stages. Areas with reduced canopy may have been savannas, flooded areas, logged areas, grazed areas or dry soils.

"D" areas (*severely disturbed woodland*) exhibit 10-50 percent canopy cover. They are generally considered highly disturbed woodlands (but could also represent woody growth on prairie soils).

"E" woodlands are used in a limited sense to describe cleared sites within wooded areas. An "E" area could represent a nursery, hayfield or crop field.

An "R" designation is added to some woodlands to indicate a residential area that has maintained a canopy cover.

---

Figure 2.2. Woodland quality levels used in inventory of Black Hawk County, IA (condensed from Duritsa 1983). Methodology adapted from White 1978.
Ground verification consisted of walking the entire site, recording plant species, noting any fauna and signs of fauna (e.g., nests), and making a qualitative assessment of the area based primarily on the vegetative composition.

A completely different quantitative approach for evaluating natural areas quality was described by Swink and Wilhelm (1994) in their flora of the Chicago, Illinois region. In this work, each vascular plant in the flora has been assigned a numerical "coefficient of conservation" (C value) between 0 and 10 based on several factors, such as its relative abundance in the region as well as its relative fidelity to strict synecological conditions. To rate the quality of a particular natural resource, the evaluator simply surveys the flora there, computes the average C value of all plants found, and multiplies this by the square root of N (number of species encountered).

Pearson (1986) compiled a list of native prairie plant species in Iowa and assigned to each species a value (1 to 10) to be used in a "prairie quality index" (Appendix C). These values for each species were determined by summing the scores of four components: rarity (R) reflecting statewide rarity (2, 5 or 8); disturbance (D) reflecting disturbance adaptability (-1, 0 or 1); fidelity (F) indicating fidelity to prairie communities (-1, 0 or 1); and a final bonus (B) category allowing for minor, intuitive adjustment of the overall score based on professional judgement of species value (0, 1 or 2). One could conceivably evaluate an Iowa prairie on the basis of these values using the procedure of Swink and Wilhelm (1994).

Kindscher (1992) hints at a different approach to prairie quality evaluation based on plant guild classification. Eight guilds of prairie plant species (warm-season graminoids (C4 grasses); cool-season graminoids (C3 grasses and sedges); annuals and biennials; ephemeral spring forbs; spring forbs; summer/fall forbs; legumes; and woody shrubs) were described as occurring on high quality tall grass prairies in Kansas, based
on multivariate statistical analysis of 32 ecological and morphological traits. Kindscher (pp. 132-33) suggests that the percent coverage by the guilds might aid in evaluation of prairie remnant quality. "On high quality prairies," for instance, "the coverage of the annual guild would be expected to be small and lower than on a prairie that has been degraded through over-grazing by livestock, or human disturbance."
III. METHODS

Preliminary Work of the Committee

The initial task of the Ames Natural Areas Committee was to establish boundaries for inventory work to identify natural areas. On a large map of the Ames area made available by the Ames City Planning Office, a boundary line was drawn approximately two miles outside the corporate limits of the city. Committee members then examined aerial photographs of land within the project boundary to identify known and potential natural areas. These areas were then outlined on the base map and tentatively classified as *woodland, prairie, wetland, streams* or *special resource*.

In 1991, two ISU graduate students joined the Ames Natural Areas Committee. Tangela Jones, an intern working in the Ames City Planning Office, took on the enormous task of identifying the landowners of nonpublic areas identified as potential natural areas on the project map. She obtained this information from lot maps and landowner records housed in the Ames City Planning Office and from a Story County Plat Book. Another graduate student, William Norris, joined the committee in July of 1991 with the assignment of researching natural area evaluation methods used elsewhere; developing, with the committee's assistance, evaluation methods for this study; and conducting the actual field work of the inventory. That work provided the basis for this thesis.

Definitions of Natural Area Types

Before proceeding with the various aspects of the inventory process, the committee prepared a formal set of definitions for the five natural resource types outlined on the project map: prairie, wetland, woodland, streams, and special resource. Within these definitions, specific minimum parameters were established for each
resource type. Definitions of these community types given by White (1978) were very useful models during this process.

The initial version of these definitions were presented to the Ames City Council by Ames Natural Areas Committee Chairman Brian O'Connell in early fall 1991 for approval. The council members had concerns about the wording of several definitions, and asked that the Ames Natural Areas Committee rewrite several definitions to more clearly express the minimum parameters. This was done, and the Ames City Council approved the revised definitions (Fig. 3.1) in late fall 1991.

**Quality Evaluation**

The next task facing the committee was to develop methods for evaluating the natural quality of all the natural resource types identified on the large base map. *Natural quality* refers to the condition (species diversity, structural diversity, dominance patterns) of an existing community (prairie, wetland, woodland) relative to that same community, in a mature state, at the time of settlement by Europeans in 1848 (Dinsmore 1994). Note that natural quality is not the same as naturalness (freedom from impact by humans) in the strict sense. For example, prairie communities are thought by many ecologists to be unnatural in the strict sense since they were probably maintained by fires set by native Americans prior to settlement. However, a large, diverse prairie, such as Hayden Prairie in Howard County (IA) has high natural quality because that was the vegetation type at the time of European settlement.

The Ames Natural Areas Committee decided that the methods developed to evaluate natural quality should be based on ecological criteria and that these criteria should lend themselves to quantitative measurement in the field. Furthermore, these evaluation methods would have to be repeatable in the hands of independent evaluators in order to lend credibility to the ratings arrived at during the inventory.
A final consideration was that these rating methods be simple enough that they not require the user to possess a professional level of knowledge in plant taxonomy to apply them.

The committee adopted an approach similar to that described by Tans (1974). Tans' method was quantitative and allowed for the objective scoring of multiple...
components of natural area quality. Evaluation methods for three natural area types were developed: prairie, wetland, and woodland (no attempt was made to evaluate streams per se, although adjacent bottomland forests were evaluated as woodlands). The wetland evaluation method was not tested in the field and will not be discussed here because only one sizeable wetland was encountered during the inventory (Ketelsen Marsh).

**Woodland Evaluation**

The evaluation method for evaluating Ames woodland is presented in Table 3.1. This system is designed to be carried out in 0.1 hectare (18 m radius) circular plots established within the woodland in question. Within these wooded plots, four criteria are measured for both the canopy and the understory of each woodland: diversity of expected forest species, forest structure, fidelity of dominant species to the expected forest type, and presence or absence of introduced species. For each criterion, a score of 2, 1 or 0 is assigned according to defined rules. The committee felt that the diversity criterion should receive twice the weight of the other three criteria, and hence diversity scores were doubled before all scores were totaled to yield an overall woodland quality rating (WQR). The values yielded by this evaluation method range from 0 to 20 (20 represents the highest quality rating).

When designing this woodland quality evaluation method, the existence of three major woodland community types in central Iowa was assumed: xeric, mesic and floodplain. Establishing lists of expected canopy (trees) and understory (small trees, saplings, shrubs, and vines beneath the canopy and at least 0.5 m above the ground) species for the three woodland community types was integral to this evaluation method (Table 3.2). An "expected species" is one normally encountered in recently undisturbed
Table 3.1 Method for evaluation of woodlands in Ames (Iowa).

A) Diversity

2. Possesses at least 75\% of the "diversity number" of species expected in the woodland type.

1. Possesses between 50\% and 75\% of the "diversity number" of species expected in the woodland type.

0. Possesses less than 50\% of the "diversity number" of species expected in the woodland type.

\[ DV = \text{sum of scores} \]

B) Structure

i) Canopy

2. Over 75\% total canopy cover

1. At least 50\% but less than 75\% total canopy cover

0. Less than 50\% total canopy cover

ii) Understory

2. Between 40\% and 80\% total understory cover

1. At least 20\% and less than 40\% total understory cover
   OR
   Greater than 80\% total understory cover primarily due to small trees and saplings (dbh > 5 cm).

0. Less than 20\% total understory cover
   OR
   Greater than 80\% total understory cover primarily due to shrubs and vines (dbh < 5 cm).

\[ S = \text{sum of scores} \]
Table 3.1 (continued)

C) Fidelity

2 Greater than 75% of the cover is provided by species representative of woodland types typically found in the given aspect.

1 Between 25% and 75% of the cover is provided by species representative of woodland types typically found in the given aspect.

0 Less than 25% of the cover is provided by species representative of woodland types typically found in the given aspect.

_____ canopy
_____ understory

F = _____ (sum of scores)

D) Introduced Species

2 Species not native to central Iowa woodlands are absent or not conspicuous (less than 1% cover)

1 Species not native to central Iowa woodlands are conspicuous but not dominant (between 1% and 15% cover)

0 Species not native to central Iowa woodlands are very conspicuous to dominant (greater than 15% cover)

_____ canopy
_____ understory

I = _____ (sum of scores)

WQR = 2*DV + S + F + I

The value of WQR (woodland quality rating) will range from 0 to 20, with 20 representing the highest quality.
When scoring the diversity category for woodlands found on ridgetops, assume xeric to be the proper woodland type.

When scoring the diversity category for woodlands occurring on slopes choose xeric or mesic as the woodland type by comparing the dominant canopy tree species in the plot to the lists of expected tree species for each woodland community type as a guide (Table 3.3). If the woodland appears to be intermediate between these two community types, choose the type which yields the highest canopy diversity score.

When scoring the diversity category for woodlands found on bottomlands, choose floodplain or mesic as the woodland type by comparing the dominant canopy species in the plot to the lists of expected tree species for each woodland community type as a guide (Table 3.3). If the woodland appears to be intermediate between these two community types, choose the type which yields the highest canopy diversity score.

Once the woodland community type has been determined, only species characteristic of that type shall be considered when scoring the diversity category (see Table 3.3).

The canopy of any xeric woodland that is strongly dominated (greater than 75% canopy cover) by Quercus macrocarpa or Quercus alba (as would be the case for savanna-derived woodlands) shall receive a score no lower than 1 in the diversity category.

Xeric communities are typically found on ridgetops; xeric and/or mesic communities are expected on slopes; and mesic and/or floodplain communities typically occur on bottomlands. See Table 3.3 for lists of expected species for each woodland community type.

When representative species of several woodland types occur together in a given sample, consider the total cover of species from both types when scoring the fidelity category IF both woodland types are typical of the given aspect.
Table 3.2  Expected canopy and understory species in xeric, mesic, and floodplain communities in Ames woodlands.

<p>| A) Xeric Communities (Typically encountered on ridgetops, south- and west-facing slopes) | B) Mesic Communities (Commonly encountered on north- and east-facing slopes). |</p>
<table>
<thead>
<tr>
<th>Expected Canopy Species: Canopy (Diversity Number = 5)</th>
<th>Expected Canopy Species (Diversity Number = 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Carya ovata</em> (Shagbark Hickory)</td>
<td><em>Acer nigrum</em> (Black Maple)</td>
</tr>
<tr>
<td><em>Fraxinus americana</em> (White Ash)</td>
<td><em>Carya cordiformis</em> (Yellowbud Hickory)</td>
</tr>
<tr>
<td><em>Populus grandidentata</em> (Big-Tooth Aspen)</td>
<td><em>Fraxinus nigra</em> (Black Ash)</td>
</tr>
<tr>
<td><em>Prunus serotina</em> (Black Cherry)</td>
<td><em>Juglans cinerea</em> (Butternut)</td>
</tr>
<tr>
<td><em>Quercus alba</em> (White Oak)</td>
<td><em>Quercus borealis</em> f. var. <em>maxima</em> (= <em>Q. rubra</em> - Red Oak)</td>
</tr>
<tr>
<td><em>Quercus velutina</em> (Black Oak)</td>
<td><em>Tilia americana</em> (American Basswood)</td>
</tr>
<tr>
<td><strong>Expected Understory Species: Understory (Diversity Number = 10)</strong></td>
<td><strong>Expected Understory Species: Mesic (Diversity Number = 8)</strong></td>
</tr>
<tr>
<td><em>Acer nigrum</em> (Black Maple)</td>
<td><em>Acer nigrum</em> (Black Maple)</td>
</tr>
<tr>
<td><em>Amelanchier arborea</em> (Downy Serviceberry)</td>
<td><em>Amelanchier arborea</em> (Downy Serviceberry)</td>
</tr>
<tr>
<td><em>Carya cordiformis</em> (Yellowbud Hickory)</td>
<td><em>Carya cordiformis</em> (Yellowbud Hickory)</td>
</tr>
<tr>
<td><em>Carya ovata</em> (Shagbark Hickory)</td>
<td><em>Corylus americana</em> (Hazelnut)</td>
</tr>
<tr>
<td><em>Cornus spp.</em> (Dogwood)</td>
<td><em>Cornus alternifolia</em> (Pagoda Dogwood)</td>
</tr>
<tr>
<td><em>Corylus americana</em> (Hazelnut)</td>
<td><em>Cornus spp.</em> (Dogwood)</td>
</tr>
<tr>
<td><em>Euonymous atropurpurea</em> (Wahoo)</td>
<td><em>Euonymous atropurpurea</em> (Wahoo)</td>
</tr>
<tr>
<td><em>Fraxinus spp.</em> (Ash)</td>
<td><em>Fraxinus nigra</em> (Black Ash)</td>
</tr>
<tr>
<td><em>Ostrya virginiana</em> (Ironwood)</td>
<td><em>Fraxinus spp.</em> (Ash)</td>
</tr>
<tr>
<td><em>Parthenocissus quinquefolia</em> (Virginia Creeper)</td>
<td><em>Juglans cinerea</em> (Butternut)</td>
</tr>
<tr>
<td><em>Populus grandidentata</em> (Big-Toothed Aspen)</td>
<td><em>Menispermum canadense</em> (Moonseed)</td>
</tr>
<tr>
<td><em>Prunus serotina</em> (Black Cherry)</td>
<td><em>Monus rubra</em> (Red Mulberry)</td>
</tr>
<tr>
<td><em>Prunus virginiana</em> (Choke Cherry)</td>
<td><em>Ostrya virginiana</em> (Ironwood)</td>
</tr>
<tr>
<td><em>Tilia americana</em> (American Basswood)</td>
<td><em>Parthenocissus virginiana</em> (Virginia Creeper)</td>
</tr>
<tr>
<td><em>Quercus spp.</em> (Oak)</td>
<td><em>Quercus spp.</em> (Oak)</td>
</tr>
<tr>
<td><em>Viburnum lentago</em> (Nannyberry)</td>
<td><em>Staphylea trifolia</em> (Bladdernut)</td>
</tr>
<tr>
<td><em>Viburnum rafinesquianum</em> (Downy Arrowwood)</td>
<td><em>Tilia americana</em> (American Basswood)</td>
</tr>
<tr>
<td><em>Vitis riparius</em> (River Grape)</td>
<td><em>Viburnum rafinesquianum</em> (Downy Arrowwood)</td>
</tr>
<tr>
<td></td>
<td><em>Vitis riparius</em> (River Grape)</td>
</tr>
</tbody>
</table>
Table 3.2 (continued)

<table>
<thead>
<tr>
<th>Expected Canopy Species: Floodplain (Diversity Number = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acer negundo</em> (Box Elder)</td>
</tr>
<tr>
<td><em>Acer saccharinum</em> (Silver Maple)</td>
</tr>
<tr>
<td><em>Carya cordiformis</em> (Yellowbud Hickory)</td>
</tr>
<tr>
<td><em>Celtis occidentalis</em> (Hackberry)</td>
</tr>
<tr>
<td><em>Fraxinus nigra</em> (Black Ash)</td>
</tr>
<tr>
<td><em>Fraxinus pensylvanica</em> (Green Ash)</td>
</tr>
<tr>
<td><em>Gleditsia triacanthos</em> (Honey Locust)</td>
</tr>
<tr>
<td><em>Gymnocladus dioica</em> (Kentucky Coffee Tree)</td>
</tr>
<tr>
<td><em>Juglans cinerea</em> (Butternut)</td>
</tr>
<tr>
<td><em>Juglans nigra</em> (Black Walnut)</td>
</tr>
<tr>
<td><em>Populus deltoides</em> (Cottonwood)</td>
</tr>
<tr>
<td><em>Platanus occidentalis</em> (Sycamore)</td>
</tr>
<tr>
<td><em>Quercus macrocarpa</em> (Bur Oak)</td>
</tr>
<tr>
<td><em>Salix nigra</em> (Black Willow)</td>
</tr>
<tr>
<td><em>Ulmus americana</em> (American Elm)</td>
</tr>
<tr>
<td><em>Ulmus rubra</em> (Red Elm)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Expected Understory Species: Floodplain (Diversity Number = 15)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acer nigrum</em> (Black Maple)</td>
</tr>
<tr>
<td><em>Acer negundo</em> (Boxelder)</td>
</tr>
<tr>
<td><em>Acer saccharinum</em> (Silver Maple)</td>
</tr>
<tr>
<td><em>Carya cordiformis</em> (Yellowbud Hickory)</td>
</tr>
<tr>
<td><em>Celtis occidentalis</em> (Hackberry)</td>
</tr>
<tr>
<td><em>Cornus alternifolia</em> (Pagoda Dogwood)</td>
</tr>
<tr>
<td><em>Cornus spp.</em> (Dogwood)</td>
</tr>
<tr>
<td><em>Euonymous atropurpurea</em> (Wahoo)</td>
</tr>
<tr>
<td><em>Fraxinus nigra</em> (Black Ash)</td>
</tr>
<tr>
<td><em>Fraxinus spp.</em> (Ash)</td>
</tr>
<tr>
<td><em>Gleditsia triacanthos</em> (Honey Locust)</td>
</tr>
<tr>
<td><em>Gymnocladus dioica</em> (Kentucky Coffee Tree)</td>
</tr>
<tr>
<td><em>Juglans cinerea</em> (Butternut)</td>
</tr>
<tr>
<td><em>Juglans nigra</em> (Black Walnut)</td>
</tr>
<tr>
<td><em>Menispermum canadense</em> (Moonseed)</td>
</tr>
<tr>
<td><em>Morus rubra</em> (Red Mulberry)</td>
</tr>
<tr>
<td><em>Ostrya virginiana</em> (Ironwood)</td>
</tr>
<tr>
<td><em>Parthenocissus quinquefolia</em> (Virginia Creeper)</td>
</tr>
<tr>
<td><em>Platanus occidentalis</em> (Sycamore)</td>
</tr>
<tr>
<td><em>Populus deltoides</em> (Cottonwood)</td>
</tr>
<tr>
<td><em>Quercus spp.</em> (Oak)</td>
</tr>
<tr>
<td><em>Rubus spp.</em> (Black Raspberry, Blackberry)</td>
</tr>
<tr>
<td><em>Salix spp.</em> (Willow)</td>
</tr>
<tr>
<td><em>Sambucus canadensis</em> (Elderberry)</td>
</tr>
<tr>
<td><em>Smilax hispida</em> (Greenbriar)</td>
</tr>
<tr>
<td><em>Staphylea trifolia</em> (Bladdernut)</td>
</tr>
<tr>
<td><em>Tilia americana</em> (American Basswood)</td>
</tr>
<tr>
<td><em>Toxicodendron radicans</em> (Poison Ivy)</td>
</tr>
<tr>
<td><em>Ulmus spp.</em> (Elm)</td>
</tr>
<tr>
<td><em>Viburnum rafinesquianum</em> (Downy Arrowwood)</td>
</tr>
<tr>
<td><em>Vitis riparius</em> (River Grape)</td>
</tr>
</tbody>
</table>
woodlands of the given community type in central Iowa. The species lists were based on examination of raw data from work in nearby Ledges State Park (Johnson-Groh 1983) described in the "Literature Review" of this thesis. Because subtle differences exist between woodlands in Ledges State Park and Ames, the committee members also interjected their own personal knowledge of Ames woodland species composition into the construction of these lists. For instance, *Quercus muehlenbergii* is not uncommon in Ledges State Park, but occurs nowhere in Ames. These lists were updated as necessary; for example, *Carpinus caroliniana* was deleted from all understory lists when none was encountered during field work, and *Quercus velutina* was added to the canopy list for xeric communities after its discovery in Ames.

**Diversity Component**

Species richness of expected species is used to measure the species diversity of both canopy and understory in this rating method. Prior to scoring this category, one must determine the woodland community type (xeric, mesic or floodplain) being sampled. Only species expected to occur in the community type determined for the plot may be tallied when scoring this category (e.g., the occurrence of *Quercus alba* in a xeric community plot adds to canopy species richness, whereas the presence of *Gleditsia triacanthos* does not). Thus, there is no increase in overall species richness due to invasion by shade intolerant plants following a disturbance (e.g., tree cutting) that creates a large canopy gap on an upland site.

The choice of community type for the plot is restricted by topography as follows: xeric for all ridgetops; xeric or mesic for all slopes; and mesic or floodplain for all bottomlands. With these restrictions in mind, inspection of canopy dominants within the plot and subsequent referral to the lists of expected canopy species for each woodland community type (Table 3.2) usually reveals the type. If the choice is not clear
from canopy dominance, then the community type which gives the highest score for canopy diversity (while adhering to the above topographic restrictions) is selected. 

Joens (1978) noted that the mesic community type, dominated by *Acer nigrum* and *Tilia americana*, is less diverse than either the xeric or floodplain communities. This pattern was also observed in this study. For example, in 0.1 hectare circular plots in Ames woodlands, species richness of expected canopy trees rarely exceeds 4 in the best of mesic sites. On the other hand, this canopy saturation point was found to be about 5 tree species for xeric plots and 10 tree species for floodplain plots. These saturation points (or "diversity numbers") of expected species richness in 0.1 hectare plots are given in Table 3.2 for both canopy and understory of all three woodland community types. These diversity numbers are used in the scoring of the diversity category (Table 3.1).

A special exception to the usual rules for scoring canopy diversity is made in xeric communities where the canopy is a monodominant stand of either *Quercus alba* or *Quercus macrocarpa*. Complete canopy dominance by these species (to the exclusion of all other tree species) is not untypical for savanna communities and thus should not be penalized. Therefore, when this condition is encountered in xeric plots an intermediate score ("1") is rewarded by default for canopy diversity rather than the "0" called for by strict application of the rules.

Structure Component

This category is scored on the basis of estimated total percent cover by canopy and understory elements. The rules for evaluating the structure of the canopy and the understory differ somewhat (Table 3.1).

*Canopy structure* Canopy structure is evaluated in a straightforward fashion, with maximum points awarded when total canopy cover is highest (at least 75%).
Conversely, any plot falling in a woodland where total canopy cover is less than 50% receives no points for canopy structure.

**Understory structure**  
Ideal understory structure is assumed to occur when total cover by saplings, shrubs and vines form a random, mosaic pattern beneath the canopy (at least 40% but no more than 80% cover). Small canopy gaps due to intermittent natural disturbance (*e.g.*, windthrow, senescence of old trees) would conceivably produce this pattern.

When understory cover is greater than 80%, unnatural past disturbances (*e.g.*, grazing, logging) are inferred and fewer points are rewarded for understory structure. Dense understory cover hinders light penetration to the forest floor and limits the growth of woodland herbs. Dense cover primarily due to saplings and small trees (dbh at least 5 cm) is assumed to be less severe than dense cover by shrubs (dbh less than 5 cm) in a woodland. Hence, a score of "1" is awarded in the former case, while a "0" results when the understory is overgrown with shrubs.

**Fidelity Component**

Woodland community types are typified by certain characteristic dominant species. Human disturbance (*e.g.*, logging and grazing practices; introduction of exotic species) interfere with natural dominance patterns in a community in a variety of ways, and the result is often an alteration in the degree of dominance exerted by the expected species.

The fidelity component measures whether or not the observed canopy and understory dominants are those listed as expected for the topography of a sample point. For example, on a ridgetop one expects to find xeric vegetation in the canopy and understory (Table 3.2). When a majority (at least 75%) of the canopy cover on a wooded ridgetop is provided by tree species expected for xeric woodlands a maximum
score (2 pts) is awarded. On the other hand, whenever less than 25% of total canopy cover is formed by expected tree species, no points are awarded for canopy fidelity.

Both xeric and mesic woodland community types normally occur on sloping terrain. The work of Johnson-Groh (1983, 1985) suggests that these types are segregated by slope aspect (xeric communities on south- and west-slopes; mesic communities on north and east-facing slopes) in central Iowa. However, scoring of the fidelity component on sloping terrain could not be so fine-tuned for several reasons. First, there is the problem of northwest- and southeast-facing slopes: neither type clearly belongs here to the exclusion of the other. Second, plant species do not always obey the rules religiously (van der Linden and Farrar 1993); for instance, good quality mesic woodlands in Ames were often found to occur on west-facing slopes. Therefore, any combination of mesic and xeric vegetation on a slope is considered proper when scoring this category, regardless of the slope aspect. The presence of floodplain vegetation, however, is considered unnatural on a slope.

Both mesic and floodplain vegetation normally occur on a bottomland, and mixtures of these are also considered valid when scoring the fidelity component.

**Introduced Species Component**

Obviously, the conspicuous presence of plant species not native to central Iowa woodlands reduces this natural quality. Introduced species include not only exotic trees and shrubs native to Eurasia (e.g., *Ulmus pumila, Lonicera tartarica, Morus alba, Rhamnus cathartica, Rosa multiflora*) but also several tree species that occur naturally in the U.S. (e.g., *Pinus strobus, Robinia pseudoacacia*) but are not native to central Iowa woodlands. Percent cover by introduced species within the sample plot provides the basis for scoring this component, and the scoring rules are straightforward (Table 3.1).
Other Components

A fifth component, Rare Plant Species, was initially considered for inclusion in this evaluation method for Ames woodlands. For purposes of this inventory, a rare species was defined to be one that occurs on any state or federal list of uncommon (endangered, threatened or special concern) plant species. However, only two species occurring on any of these lists were encountered during field work for this inventory. Thus the criterion as defined above was not effective as an evaluation component and so was dropped from the evaluation method.

Another commonly used criterion for ecological evaluation, Area of Tract, was likewise not considered in woodland evaluation. Most Ames woodlands occur along rivers and streams and are very attenuated and hence woodland boundaries are not well defined. Therefore, the Ames Natural Areas Committee decided not to attempt measurement of tract area for evaluation of Ames natural areas.

Conspicuously absent from this evaluation method for woodlands is any consideration of the herbaceous strata (e.g., richness of woodland herbs). Reasons for this omission will be taken up in the "Discussion" section of this thesis.

Woodland Survey Protocol

Maps  Prior to field work, topographic maps of all wooded tracts were prepared from topographic maps available from the Ames City Planning Office (e.g., Fig. 3.2). The originals have a 1:12000 scale and were created in the 1950s and early 1960s. Hence, they accurately depict the topography of regions in Ames but they are often not accurate with respect to road systems and landmarks.

Some regions of the project boundary were not covered by these city planning maps, and in these instances 1:24000 USGS topographic maps were used [available from the Natural Resource Conservation Service (NRCS) office in Nevada, IA].
Figure 3.2. Sample topographic map (Pammel Woods) used in the Ames Natural Area Inventory. This map was created from 1:12000 city planning maps available in the Ames City Planning Office.
These USGS maps were also used to create the composite map which serves as the key for the individual maps in this thesis.

**Sample Points** To apply the evaluation method, sample points were marked and labeled on a topographic map of the area in question prior to actual field work such that all topographic aspects (ridge, dry south- and west-facing slopes, moist north- and east-facing slopes, bottomland) were represented (e.g., Fig. 3.3). The sample points were circular (area: 0.1 hectare; radius: 18 meters) and their number was established in rough proportion to the area of the tract. Usually, these plots were not formally marked in the field but instead paced intuitively with reference to a marked center (e.g., a distinctive tree or landmark) for increased time efficiency. This approach is not recommended for future evaluation; the center and the boundary of the plot (in each of the four cardinal directions) should be conspicuously flagged to allow for more consistent censusing.

**Data Forms** Survey data were recorded on a standard releve form (Fig. 3.4, Almendinger 1987). Total canopy (canopy trees) and understory (saplings, shrubs, twining vines) cover were estimated using standard cover classes. All woody plant species occurring in the canopy and understory inside the plot were listed in separate columns on this form along with their estimated percent cover (as cover classes) within the plot. Using all the data recorded on the form, the quality of the woodland at a particular sample point was calculated in the field immediately after the survey (example: Fig. 3.5). Total survey time per point ranged from 15 to 30 minutes, with high quality floodplain communities taking the longest time because of their high diversity.

Although not incorporated directly into the woodland rating scheme, any unusual plant or bird species encountered during the survey was recorded at the bottom of the
Figure 3.3. Topographic map (Pammel Woods) with sample points marked prior to field work.
**Figure 3.4.** Releve form used in survey of woodlands during the Ames Natural Area Inventory (Almendinger 1987).
### RELEVE CODE SHEET

**LIFE-PHORM CATEGORIES**

<table>
<thead>
<tr>
<th>Woody Plants</th>
<th>Herbaceous Plants</th>
<th>Height</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 broadleaf evergreen GR</td>
<td>3 broadleaf deciduous H</td>
<td>8.35 m</td>
<td>c &gt;75% continuous</td>
</tr>
<tr>
<td>7 needleleaf evergreen L</td>
<td>5 needleleaf deciduous</td>
<td>6.10-20 m</td>
<td>p 25-50% patchy, patchy</td>
</tr>
<tr>
<td>Special Life Forms</td>
<td>4.2-5 m</td>
<td>o 1-5% barely present</td>
<td></td>
</tr>
<tr>
<td>C climbers (lianas)</td>
<td>3.5-2 m</td>
<td>a &lt;1% almost absent</td>
<td></td>
</tr>
<tr>
<td>X succulents</td>
<td>2.1-5 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X epiphytes</td>
<td>1 &lt;%1 m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**STRUCTURAL CATEGORIES**

### BRAHMS-BLANIET'S FLORISTIC SYSTEM

<table>
<thead>
<tr>
<th>Cover/Abundance</th>
<th>Sociability</th>
</tr>
</thead>
<tbody>
<tr>
<td>r single occurrence</td>
<td>1 growing singly</td>
</tr>
<tr>
<td>* &lt;5% occasional</td>
<td>2 grouped, few plants</td>
</tr>
<tr>
<td>1 &lt;5% plentiful</td>
<td>3 large group, many plants</td>
</tr>
<tr>
<td>2 5-25% very numerous</td>
<td>4 small colonies, extensive</td>
</tr>
<tr>
<td>3 25-50% any number of plants</td>
<td>patches, broken mat</td>
</tr>
<tr>
<td>4 50-75% any number of plants</td>
<td>5 extensive mat</td>
</tr>
<tr>
<td>5 75-100% any number of plants</td>
<td></td>
</tr>
</tbody>
</table>

**CODE FOR RELIABILITY OF IDENTIFICATION**

| 0 Name assigned without qualification (variety certain or understood) |
| 1 Species identification is certain, but variety is in doubt |
| 2 Species identification is certain, but named varieties not distinguished |
| 3 Species complex or species aggregate |
| 4 Genus identification is certain, but species identification is in doubt |
| 5 Genus identification is certain, but species not distinguished |
| 6 Genus identification is uncertain |
| 7 Unknown or indeterminable, but only one species is probably included |

**CODE FOR SELECTED REMARKS**

<table>
<thead>
<tr>
<th>Vitality</th>
<th>Condition</th>
<th>Miscellaneous</th>
</tr>
</thead>
<tbody>
<tr>
<td>DY dying</td>
<td>BU budding</td>
<td>DI introduced in Minn.</td>
</tr>
<tr>
<td>JD dead</td>
<td>BR browsed</td>
<td>PA rare in Minn.</td>
</tr>
<tr>
<td>EX being driven out</td>
<td>SF defoliated</td>
<td>GP just outside plot</td>
</tr>
<tr>
<td>JO poor vitality</td>
<td>FL flowering</td>
<td>** any two-digit number</td>
</tr>
<tr>
<td>LJ luxurious growth</td>
<td>FR fruiting</td>
<td>multiple stems</td>
</tr>
<tr>
<td>FS fire scarred</td>
<td>EZ present as seed</td>
<td>was collected</td>
</tr>
<tr>
<td>CS gerrinating</td>
<td>ST sterile</td>
<td></td>
</tr>
</tbody>
</table>

The above codes and classes have been adopted as standard for releves collected by the Minnesota Natural Heritage staff. The above was largely copied from a form created by Edward J. Cushing for student use at the University of Minnesota.

Figure 3.4. Continued
**Figure 3.5. Sample releve form, completed.**

### South Slope

<table>
<thead>
<tr>
<th>Species Name or Code</th>
<th>C.S. Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Canopy - C</strong></td>
<td></td>
</tr>
<tr>
<td>Carya ovata</td>
<td>2</td>
</tr>
<tr>
<td>Quercus alba</td>
<td>2</td>
</tr>
<tr>
<td>Carya cordiformis</td>
<td>2</td>
</tr>
<tr>
<td>Ulmus americana</td>
<td>1</td>
</tr>
<tr>
<td>Juglans nigra</td>
<td>1</td>
</tr>
<tr>
<td>Quercus Macrocarpa</td>
<td>3</td>
</tr>
<tr>
<td>Fraxinus spp.</td>
<td>2</td>
</tr>
<tr>
<td>Lonicera spp.</td>
<td>1</td>
</tr>
<tr>
<td>Carya ovata</td>
<td>1</td>
</tr>
<tr>
<td>Corvus spp.</td>
<td>1</td>
</tr>
<tr>
<td>Ostrya virginiana</td>
<td>3</td>
</tr>
<tr>
<td>Zanthoxylum amer.</td>
<td>1</td>
</tr>
</tbody>
</table>

**DV:** 1 + 2

**S:** 2 + 2

**F:** 2 + 2

**I:** 2 + 1

**2(3) + 4 + 4 + 3**

---

**Note:**
- **C.S.** = cover value. sociability value
- **C.S. Remarks**
- **C.S.** = code for reliability of identification

---

**Surveyor's Releve Number:** N/A

**Surveyor's Name:** N/A

**Hi County:** N/A

**Township, Range, Section:** N/A

**Date:** 9/27/78

**Releve Size (sq. m):** N/A

**Site Name:** Panhel Woods
survey form. A list of total woodland species (woody as well as herbaceous) encountered during field work was compiled for the duration of this inventory, from which a checklist of vascular plants for Ames woodlands was prepared (Appendix B).

Quality Levels

Four levels of woodland quality were recognized by members of the Ames Natural Areas Committee after inventory work had begun: A) Highly Natural, B) Mostly Natural, C) Moderately Altered and D) Highly Altered. Written descriptions of each quality level were based on the degree of naturalness exhibited by both canopy and understory of a woodland as well as the amount of past disturbance (i.e., logging, grazing) experienced by the woodland (Fig. 3.6).

Based on examination of numerical quality ratings obtained in evaluations of woodlands falling into these four categories, the range of possible quality ratings (0-20) was subdivided into four intervals and associated with the above quality levels (Fig. 3.6).

Final Maps and Descriptions of Woodlands

The information obtained during field work (both quality ratings and dominant woody vegetation) was marked separately on topographic maps of each tract (examples: Figs. 3.7 and 3.8). The maps containing the quality ratings themselves were used to delineate different quality regions within a given woodland. Different quality regions were identified by simple inspection for aggregation of numbers in the same quality level on the map and averaging of quality values when trends were not clear. Then, these different quality regions were outlined with a black marker on a third map of each region and identified by large capital letters corresponding to each quality level (Fig. 3.9).
Written descriptions in layman's terms were prepared to accompany each map (example: Fig. 3.10). The prepared maps of dominant canopy and understory vegetation were useful aids in this process. Any unusual flora and/or fauna observed during field work in a particular woodland was included in this written description.

Reliability of Woodland Evaluation Method

An important test for any evaluation method is whether or not it is repeatable in the hands of independent evaluators. Likewise, an evaluation method must be able to differentiate

A. **Highly Natural**  Undisturbed natural communities composed of the expected diversity of native species (WQR = 18, 19 or 20).

Example: Old growth, ungrazed forest

B. **Mostly Natural**  Lightly disturbed communities in which both overstory and understory are predominately composed of species expected under natural conditions (WQR = 14, 15, 16 or 17).

Example: Forests that have been selectively logged or grazed without destroying the structure and natural diversity of the community.

C. **Moderately Altered**  Disturbed communities in which either the overstory or the understory is not predominately composed of species expected under natural conditions (WQR = 10, 11, 12 or 13).

Example: Forests in which the understory and ground cover have been altered by grazing or recreation.

D. **Highly Altered**  Heavily disturbed communities in which neither the overstory nor the understory is predominately composed of species expected under natural conditions (WQR = 0, 1, 2, ... , 9).

Example: An upland forest in which the overstory and the understory have developed following severe recent disturbance.

Figure 3.6. Descriptions of natural quality levels for woodlands in Ames, Iowa.
Figure 3.7. Topographic map (Pammel Woods) with woodland quality ratings marked at sample points.
Figure 3.8. Topographic map (Pammel Woods) with dominant woody vegetation (canopy/understory) indicated at sample points. See Appendix A for abbreviations.
Figure 3.9. Topographic map (Pammel Woods) with woodland quality regions delineated. A = Highly Natural; B = Mostly Natural; D = Highly Altered.
Pammel Woods

Pammel Woods occurs on the campus of Iowa State University, bounded by Hyland Street to the west and Pammel Drive to the south.

The majority of Pammel Woods is a rich woodland. On most slopes and a flat ridgetop located in "B" level regions, various oak species and black maple are the dominant canopy trees, while ironwood and black maple saplings are dominant in the understory. An introduced shrub (European buckthorn) is conspicuous here and there in the understory, but the majority of the vegetation is natural.

A rich bottomland forest occurs along Clear Creek as it winds its way through Pammel Woods. Both the canopy and the understory of this region ("A" quality level) contain a high diversity of species typical of bottomlands. The floodplain forest bordering the "A" quality region on either side is similar but contains less diversity of typical tree species, and introduced shrubs (i.e., white mulberry, Tartarian honeysuckle, European buckthorn) occasionally become dominant in the understory.

A small strip of unnatural vegetation ("D" quality level) occurs on the north end of Pammel Woods, bordering the railroad. An introduced tree (black locust) and shrub (European buckthorn) are dominant in the woodland here.

The majority of Pammel Woods contains a rich carpet of native wildflowers from spring through fall, and it serves as a laboratory for many botany classes at ISU. An uncommon plant, green dragon, (*Arisaema dracontium*), is among the many wildflowers found in Pammel Woods.

---

Figure 3.10. Sample written description of a woodland (Pammel Woods) surveyed during the Ames Natural Areas Inventory.
among different quality sites. In order to address these issues, five individuals with good knowledge of woody plant identification were recruited to independently test the method in the field.

Each of the five volunteers was given approximately two hours of training in the use of the method. Training was administered to each of these volunteers in the same sites and in the same sequence. Training sites were carefully chosen so that opportunities would arise for discussion of the various nuances of the method.

For the test, four different sample plots were marked by flags in different woodlands in Ames in early fall 1994. The five volunteers were given directions to the four test sites and instructed to visit these independently when evaluating them. No discussion took place among the volunteers and the administrator of this test until all evaluations had been completed and the forms submitted.

T tests (2-tailed, a = .05) were used to determine whether the mean quality rating for each test site differed significantly from the rating obtained by the surveyor during the inventory. An analysis of variance (a = .05) was performed to test for site mean differences. Finally, contrast tests (a = .05) were performed to determine which sites were distinct.

**Prairie Evaluation**

**Initial Evaluation Scheme for Prairie Remnants**

The initial method for evaluation of Ames prairie remnants took a form similar to the woodland evaluation method (Table 3.3). The method called for a number of ecological criteria to be evaluated (diversity of prairie plants, quality of vegetation, and evidence of disturbance by woody plants, non-native grasses and non-native forbs) with the ratings then aggregated into a "Prairie Quality Index" (PQR) for each site evaluated. An important resource for this method is the list of native prairie plants with their
Table 3.3. Initial method for evaluation of Ames (Iowa) prairie remnants. This method was ultimately abandoned during the Ames Natural Areas Inventory.

A) **Diversity**

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>At least 50 species present</td>
</tr>
<tr>
<td>4</td>
<td>At least 40 but fewer than 50 species present</td>
</tr>
<tr>
<td>3</td>
<td>At least 30 but fewer than 40 species present</td>
</tr>
<tr>
<td>2</td>
<td>At least 20 but fewer than 30 species present</td>
</tr>
<tr>
<td>1</td>
<td>Fewer than 10 species present</td>
</tr>
</tbody>
</table>

\[ DV = \]

B) **Quality of Vegetation**

i) Plant with the highest quality value

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Quality of top plant is 8, 9 or 10</td>
</tr>
<tr>
<td>4</td>
<td>Quality of top plant is 6 or 7</td>
</tr>
<tr>
<td>3</td>
<td>Quality of top plant is 5</td>
</tr>
<tr>
<td>2</td>
<td>Quality of top plant is 4</td>
</tr>
<tr>
<td>1</td>
<td>Quality of top plant is 3</td>
</tr>
<tr>
<td>0</td>
<td>Quality of top plant is less than 3</td>
</tr>
</tbody>
</table>

_____ plant with highest quality

ii) Plant with fifth highest quality value

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Quality of fifth highest plant is at least 6</td>
</tr>
<tr>
<td>4</td>
<td>Quality of fifth highest plant is at least 5</td>
</tr>
<tr>
<td>3</td>
<td>Quality of fifth highest plant is at least 4</td>
</tr>
<tr>
<td>2</td>
<td>Quality of fifth highest plant is at least 3</td>
</tr>
<tr>
<td>1</td>
<td>Quality of fifth highest plant is at least 2</td>
</tr>
<tr>
<td>0</td>
<td>Quality of fifth highest plant is less than 2</td>
</tr>
</tbody>
</table>

_____ plant with fifth highest quality

\[ Q = \] (sum of above two values)

B) **Disturbance**

i) Trees and shrubs

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Less than 10% cover by woody trees and shrubs</td>
</tr>
<tr>
<td>3</td>
<td>Between 10% and 25% cover by woody trees and shrubs</td>
</tr>
<tr>
<td>2</td>
<td>Between 26% and 50% cover by woody trees and shrubs</td>
</tr>
<tr>
<td>0</td>
<td>More than 25% cover by woody trees and shrubs</td>
</tr>
</tbody>
</table>

_____ score for woody disturbance
Table 3.3 (continued)

B) Disturbance (continued)

   ii) Non-native grasses

   4  Less than 10% cover by grasses not native to Iowa
   3  Between 10% and 25% cover by grasses not native to Iowa
   2  Between 26% and 50% cover by grasses not native to Iowa
   0  More than 50% cover by grasses not native to Iowa

   _____ disturbance score for non-native grasses

   iii) Non-native forbs

   2  Forbs not native to Iowa are conspicuous
   1  Forbs not native to Iowa are present but none dominant
   0  Forbs not native to Iowa are among the dominant or co-dominant species

   _____ disturbance score for non-native forbs

   DS = _____ (sum of above three scores)

E) Rare and Unusual Plants

   R = _____ One point shall be assigned for each plant species occurring on the prairie
   that is listed on the Iowa or federal list of special concern, threatened,
   or endangered plants (maximum 5 points)

   \[ PQR = (2 \times DV) + Q + DS + R \]

   The value of PQR (prairie quality rating) will range from 0 to 35, with 35 representing
   the highest quality.

   1 A plant "species" must be one included in the list of Iowa prairie plants compiled by

   2 The "quality" of each plant is a value (1-10) reported for all Iowa prairie plant on a
      list compiled by John Pearson, Iowa DNR (1987).

   3 To be evaluated on the interior half of the prairie.
associated "prairie quality indices" (Appendix C) compiled by Pearson (1986).

This evaluation scheme proved unworkable for several reasons. One, very few prairie plants encountered during surveys of Ames prairie remnants are given high ratings on the Pearson scale . . . the vast majority received only a 2 or a 3. Hence, the quality of vegetation category, which relies heavily on these values, was not useful in discriminating among prairie remnants.

Another problem with the above method is that it unduly penalizes a prairie remnant for presence of non-native or woody vegetation. Virtually all Ames prairie remnants, even those of highest quality, contain a fine, inconspicuous layer of Poa pratensis (an introduced grass commonly planted in lawns). If the evaluation scheme in Table 3.3 were adopted, then all prairies would lose 3 or 4 points for this single aberration. Also, several diverse prairies were encountered that suffered from encroachment by small trees (Juniperus virginiana). A 3 or 4 point penalty because of woody invasion seems severe when one contemplates the ease with which the offending trees can be removed.

Revised Scheme for Prairie Evaluation

For the above reasons, the initial method devised for prairie evaluation was abandoned and replaced with another, simpler method. Members of the Ames Natural Areas Committee considered it important to recognize the potential of a prairie to persist after the removal of disturbance species, and concluded that this potential is best measured simply by the species richness of prairie plants on a given remnant. A "prairie plant" is defined to be one that appears on the list of Iowa prairie plants (Appendix C) compiled by John Pearson. Thus, to evaluate a prairie, one merely compiles a species list by repeated visits to the site at different seasons. Four quality levels for prairies were defined as shown in Fig. 3.11.
The prairie quality levels in Fig. 3.11 were calibrated with respect to the species richness at Ames High School Prairie, an acknowledged high-quality prairie existing behind Ames High School within the project area.

Multiple visits (spring, summer and fall) were made to each Ames prairie remnant over several years in order to compile complete plant species lists. From these individual lists for each prairie remnant, a checklist of Ames prairie plants was prepared.

**Final Maps and Descriptions of Prairies**

Each prairie remnant received a single quality rating based on total species richness; no attempt was made to delineate subregions of quality within a given remnant. In several instances [Ames High School Prairie, Northridge (North) prairies], a network of prairie fragments embedded in a matrix of disturbed woodlands was given a single rating based on overall prairie species richness of all fragments combined.

A) **Highly Natural**

Grassland with a high diversity of native prairie species\(^1\) (at least 60 species).

B) **Mostly Natural**

Grassland with a good diversity of native prairie species (30-59 species).

C) **Moderately Altered**

Grassland with an average diversity of native prairie species (10-29 species).

D) **Highly Altered**

Grassland with a poor diversity of native prairie species (0-9 species).

\(^1\) A "prairie species" is one included in a list of native prairie plants of Iowa compiled by John Pearson, Iowa DNR.

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Figure 3.7. Descriptions of natural quality levels for prairies.
A written description in layman's terms reporting the interesting features and final quality rating of each prairie remnant was included in the final inventory report to the Ames City Planning Office, as was a cumulative list of all prairie plant species found on each remnant. Occasionally, both prairies and woodlands are identified on the same small map. Prairies that occur along old railroad grades appear only on the large final map of the different quality regions in the entire area.

Only naturally occurring prairies were evaluated by the method described above. A number of non-natural prairies (i.e., prairie reconstructions) were encountered during the inventory and these were classified as "Special Resources" in lieu of evaluation.

**Wetland Evaluation**

Only one wetland was encountered during the field work of the inventory, so an evaluation method for this natural resource type was not implemented. This wetland was classified as a "Special Resource."

**Composite Map of Ames Natural Areas.**

A composite map of the entire project area (not included in this thesis) was created to delineate the quality of all land surveyed. This map is essentially a composite of the individual maps for each individual area, except that different colors delineate the various quality levels (Highly Natural, Mostly Natural, Moderately Altered, Highly Altered, Special Resource) for Ames natural resources.

In addition to surveyed areas, unsurveyed areas known from prior knowledge of the Ames Natural Area Committee to be either Moderately or Highly Altered were identified as such on this final composite map. The last category of land identified on this composite map was "Permission Denied" (privately owned land where the landowner denied permission to survey).
The staff of the Ames City Planning Office planimetered this final composite map to determine the relative areas of all quality types within the project boundary.
IV. RESULTS

Inventory Results

Acreage of Evaluated Areas

A total of 2,294 acres was classified during the Ames Natural Areas Inventory project (Table 4.1). Of these, 1,472 acres were surveyed on foot and evaluated to be either "Highly Natural", "Mostly Natural", "Moderately Altered" or "Highly Altered". In addition, 823 acres were also classified without survey (via personal knowledge of the committee members) as either "Altered", "Special Resource" or "Permission Lacking."

Of the total 2,294 acres classified during the inventory, only 163 acres (7% of overall total) were evaluated to be "Highly Natural." On the other hand, 1,072 acres (47% of the overall total) were evaluated as "Altered", "Moderately Altered", or "Highly

Table 4.1 Total land area (acres) of all natural quality categories identified during the Ames Natural Areas Inventory (1991-1995).

<table>
<thead>
<tr>
<th>Surveyed Land (SL)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Area</td>
<td>% of Total SL</td>
<td>% of Overall Total</td>
</tr>
<tr>
<td>Highly Natural</td>
<td>163</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Mostly Natural</td>
<td>570</td>
<td>39</td>
<td>25</td>
</tr>
<tr>
<td>Moderately Altered</td>
<td>505</td>
<td>34</td>
<td>22</td>
</tr>
<tr>
<td>Highly Altered</td>
<td>233</td>
<td>16</td>
<td>10</td>
</tr>
<tr>
<td>Total Surveyed Land</td>
<td>1,472</td>
<td></td>
<td>64</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Unsurveyed Land (UL)</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Area</td>
<td>% of Total UL</td>
<td>% of Overall Total</td>
</tr>
<tr>
<td>Altered</td>
<td>333</td>
<td>41</td>
<td>15</td>
</tr>
<tr>
<td>Special Resource</td>
<td>172</td>
<td>21</td>
<td>8</td>
</tr>
<tr>
<td>Permission Lacking</td>
<td>317</td>
<td>39</td>
<td>14</td>
</tr>
<tr>
<td>Total Unsurveyed Land</td>
<td>823</td>
<td></td>
<td>36</td>
</tr>
<tr>
<td>OVERALL TOTAL</td>
<td>2,294</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Altered." If the 317 acres of land where permission to survey was denied is assumed to be pastured woods (as most of it appears to be from the highway), then 1,389 acres (61% of the overall total) would be classified as altered to some extent.

Both public and private lands were surveyed during this inventory. Of the approximately 50 private landowners contacted during the inventory, 46 (92%) consented to a survey and natural quality evaluation of their property.

Maps, Written Descriptions and Plant Species Lists

Maps and written descriptions of all surveyed sites as well as most "Special Resources" were prepared (Appendix A). Three maps have been included for all woodlands visited on foot: one delineating the different quality regions for each site; another that displays the quality ratings associated with all survey points within a site, and a third that identifies the dominant woody vegetation (canopy and understory) apparent at each survey point within a site. Although very few of the surveyed prairie remnants are mapped individually in Appendix A, lists of all prairie plant species found on each remnant during the inventory have been provided. An oversized index map covering the entire inventory region has been placed in the back of this thesis to allow easy reference to individual sites described in Appendix A.

Cumulative checklists of all native plant species found by the surveyor in Ames woodlands and Ames prairie remnants during the course of the Ames Natural Areas Inventory (1991-1995) were compiled (Appendix B). These lists do not include historic records or species reported by other individuals during this same time interval. A total of 208 native woodland plant species and 168 native prairie plant species were encountered during the inventory. One federally endangered plant, prairie bush clover (*Lespedeza leptostachya*), was documented at the Raymond Prairie, and a state
threatened plant, oval ladie's tresses (*Spiranthes ovalis*), was found in disturbed woods along Stagecoach Road [Riverside (South)].

**Repeatability Test and Contrast of Sites**

The sample statistics for the four evaluated sites are given in Table 4.2. The standard deviation for the quality at test site A (i.e., 4.64) is much larger than that calculated for the other three test sites. This disparity was caused by one volunteer's misidentification of several tree species during survey of site A which caused canopy diversity and canopy fidelity scores for the site to be artificially inflated.

Table 4.2 Sample statistics and t values ($H_0$: WQR = sample mean, two-tailed test, $DF=4$, $a=.05$) for the replicate (5) natural quality evaluation of woodland test sites in Ames, Iowa. WQR = Woodland Quality Rating (0-20) determined by the surveyor during the Ames Natural Areas Inventory.

<table>
<thead>
<tr>
<th>Site</th>
<th>WQR</th>
<th>N</th>
<th>Sample Mean</th>
<th>SD</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7</td>
<td>5</td>
<td>9.0</td>
<td>4.64</td>
<td>0.9637</td>
</tr>
<tr>
<td>B</td>
<td>10</td>
<td>5</td>
<td>13.6</td>
<td>1.52</td>
<td>5.295**</td>
</tr>
<tr>
<td>C</td>
<td>15</td>
<td>5</td>
<td>15.2</td>
<td>1.30</td>
<td>0.3421</td>
</tr>
<tr>
<td>D</td>
<td>16</td>
<td>5</td>
<td>16.0</td>
<td>0.71</td>
<td>0.000</td>
</tr>
</tbody>
</table>

** $P<.01$

As compared to the surveyors evaluation, no differences were found for the evaluation of sites A, C and D by the five volunteers (critical t value: 2.776), but a difference was found for the evaluation of site B ($P<.01$). At this site, the surveyor had estimated higher cover of introduced shrubs than was estimated by most of the independent evaluators. This disparity was responsible for low scores (as compared to that recorded by the surveyor) in two evaluation components: *fidelity* and *introduced species*.
At least one significant difference among the four test sites (as evaluated by five volunteers) was revealed (Table 4.3). The lowest quality site, site A, was found to be distinct from the other three sites in subsequent analysis (Table 4.4). Although not significant, site B is also obviously different from the remaining two sites.

These tests show that the woodland evaluation method has the potential to yield consistent results in the hands of independent evaluators. However, it is clear from Table 4.2 (i.e., standard deviation of site A) that future evaluators must have a firm grasp on woody plant identification. Also, anyone planning to use the method should receive more than the two hours training which these evaluators received. Four to five days training is recommended for anyone planning to use the woodland evaluation method.

Table 4.3 ANOVA of site differences.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F value</th>
<th>p &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>147.0</td>
<td>3</td>
<td>49.0</td>
<td>7.54</td>
<td>.002</td>
</tr>
<tr>
<td>Error</td>
<td>104.0</td>
<td>16</td>
<td>6.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>251.0</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.4 ANOVA of site comparisons.

<table>
<thead>
<tr>
<th>Contrast</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F value</th>
<th>p &gt; F</th>
</tr>
</thead>
<tbody>
<tr>
<td>A/BCD</td>
<td>132.0</td>
<td>1</td>
<td>132.0</td>
<td>20.31</td>
<td>0.0004</td>
</tr>
<tr>
<td>B/CD</td>
<td>13.3</td>
<td>1</td>
<td>13.3</td>
<td>2.05</td>
<td>0.17</td>
</tr>
<tr>
<td>C/D</td>
<td>1.6</td>
<td>1</td>
<td>1.6</td>
<td>0.25</td>
<td>0.63</td>
</tr>
</tbody>
</table>
V. DISCUSSION AND CONCLUSIONS

Quality

The Importance of High Quality Natural Areas

For all the valuable scientific information gained from the survey of natural areas, the most important goal of almost all inventories is the ultimate protection of these areas. Thus, once an inventory is actually completed, the question is invariably asked "why should this municipality preserve its highest quality natural areas?"

Science offers important evidence to support the preservation of high quality natural areas. For instance, many forms of wildlife are dependent on such areas for breeding habitat. Many songbird species fall into this category, including the cerulean warbler and loggerhead shrike encountered in "Highly Natural" areas (West Reactor Woods, R-38 Railroad Prairie) during the Ames Natural Areas Inventory. Many plant species are likewise restricted to undisturbed areas, such as the federally endangered prairie bush clover (*Lespedeza leptostachya*) which was found on a single high quality prairie (Raymond Prairie) during the inventory. Thus, high quality natural areas function as refuges that maintain overall species diversity in a region.

High quality natural areas are also important as standards of natural vegetation communities for scientists, conservationists and private landowners (Moir 1972). For instance, the "A" quality oak-hickory region in Munn Woods is one of the few examples of a mature upland forest to be found in Ames. Although the open-grown oak trees found here are a clue that livestock once wandered freely beneath the canopy, the current high diversity and large girth of expected tree species observed in Munn Woods are evidence that this woodland has recovered most of its natural character since its release from grazing pressure. Munn Woods thus offers one of the best examples of a mature, diverse woodland community to plant ecologists interested in the natural
histoire of Story County. Likewise, conservationists and private landowners in Ames can look to Munn Woods as a model of high woodland quality if they choose to manage their own woodlands for diversity. Without this model, such management would be without foundation.

Ames High School Prairie and the other prairie remnants scattered throughout Ames are among the few remaining examples of the vast grassland ecosystem that once covered most of Story County. Midwestern prairie ecologists (Curtis 1955, White 1983) routinely study such prairie remnants when describing the floristic composition and vegetation patterns of native grasslands. Local prairie enthusiasts value these prairie remnants as templates for prairie reconstruction efforts at environmental centers (McFarland Park) and on private property (Stargrass Prairie) in Story County.

Natural areas such as Ames High School Prairie, East Reactor Woods, and Brookside Park are important living laboratories that are heavily used by many educational institutions within Ames (Joens 1978). Public school teachers, university instructors, and naturalists alike can conveniently escort groups of students to most of these areas for field trips focusing on wildflowers, birds, butterflies, nature photography, etc...

There is much scientific justification for the preservation of high quality natural areas. Nonetheless, land-use managers (e.g., city officials and landowners) with limited training in the biological sciences may not be swayed by scientific reasoning (Margules and Usher 1981). What is the best rationale, then, for persuading non-biologists that high quality natural areas are valuable and worthy of preservation?

One might out point the recreational value of these areas to Ames citizens. For instance, extensive trail systems exist within River Valley Park, Brookside Park and Reactor Woods that offer opportunities for jogging, hiking and skiing to Ames citizens.
However, such a rationale is more a function of their status as parks than as natural areas.

High quality natural areas are part of a city's cultural heritage. The first European settlers in Story County encountered vast, windswept fields of prairie grasses that stretched for miles, and were faced with plowing through tough prairie sod in order to farm the land. These pioneers no doubt looked in woodlands along Squaw Creek and the Skunk River for building materials, and crouched low among the cattails and slough grass while hunting for waterfowl at Ketelsen Marsh and other area wetlands. Ames natural areas are thus like historic buildings, landmarks, and documents in that they provide connections to the past for local citizens, many of them descendants of these early settlers. Since a city's historic buildings, landmarks, and the like are routinely preserved and maintained for their heritage value, high quality natural areas deserve the same treatment for the same reason.

Finally, high quality natural areas should be protected for their spiritual value to the Ames community. Strolling across the rolling, wooded hills in West Reactor Woods in early spring, one can escape the frenzied pace of the city and listen to leaves crackle underfoot as well as one's own heartbeat. At the Raymond Prairie, a visitor can lie down comfortably in the grass and watch thunderous gray clouds roll overhead as Indian grass tickles his ear. Ames citizens needing relief from workplace or university pressures can venture out into one of the city's natural areas to find a calm haven.

High quality natural areas lend identity to a city, and personality. People with vastly different backgrounds are drawn together for prairie work days and nature hikes in such areas. If all of a city's natural areas are allowed to be converted or lost through neglect, something of that city's soul is lost too.
Definition of Quality

Quality concepts vary among inventories. To illustrate, one need only compare the Pammel Woods quality map produced in this inventory (Fig. 3.9) with that presented by Joens (Fig. 5.1) in his earlier study of Ames natural areas (1978). Although there is reasonable congruence between the quality determined for the upland woods among the two studies, considerable discrepancy occurs between the qualities given for the floodplain. Joens considers all of these bottomland woods to be of low quality in Pammel Woods (Fig. 5.1) because in his view any woodland community maintained by a disturbance (e.g., a floodplain community) has inherent low quality. On the other hand, floodplain woods received a higher quality evaluation within the quality concept adopted for this inventory (Fig. 3.9).

Thus, it is important that the term "quality" be carefully defined whenever it is used as the basis for natural area evaluation. As applied in this inventory (Methods), quality refers to the "mature" condition of a community "at the time of settlement." Several aspects of this definition merit further discussion.

Maturity There is considerable debate concerning the successional endpoints of a woodland occurring on dry ridgetops (and dry slopes) in central Iowa. Currently, one finds oak (*Quercus* spp.) and shagbark hickory (*Carya ovata*) trees dominant in the canopy of such woodlands, but small trees and saplings of these same species seldom occur in the understory. Some researchers believe that infrequent, devastating fires allowed intolerant oak and shagbark hickory seedlings to become established in the past by opening up the canopy. Some of these same researchers also believe that shade tolerant black maple (*Acer nigrum*) and basswood (*Tilia americana*) may become dominant in the canopy on ridgetops in the near future because current fire suppression is forestalling the regeneration of oak and shagbark hickory. Other researchers contend
Figure 5.1. Quality regions within Pammel Woods, as delineated by Joens (1978). Regions A, B, and D are high-quality; region C is low quality.
that oaks and shagbark hickory will continue to be the canopy dominants on dry ridgetops in central Iowa because they are better adapted than black maple and basswood to tolerate the occasional droughts experienced in central Iowa.

The mature condition of a forest in a central Iowa bottomland is not obvious either. Although typical floodplain species like black walnut (Juglans nigra), green ash (Fraxinus pensylvanica), and hackberry (Celtis occidentalis) are usually listed as the canopy dominants in bottomlands, black maple (Acer nigrum) and basswood (Tilia americana) are occasionally found to be canopy dominants there (e.g., West Reactor Woods). Canopy dominance is probably controlled by disturbance on bottomland terraces, with black maple becoming dominant on those sites where severe disturbance has not occurred for 100 years or more.

Obviously, disturbances such as fire, drought, flooding, disease, and windstorms affect the dominance patterns of vegetation in a woodland. Since the successional endpoint of central Iowa woodlands is unclear for ridgetops, dry slopes and bottomlands, woodland "maturity" here refers only to the presence of mature trees. Therefore, a bottomland dominated by large trees of typical floodplain species (e.g., black walnut, hackberry) is considered just as mature as a bottomland terrace dominated by large black maple trees, even though black maple may eventually succeed the typical floodplain species in the prolonged absence of disturbance.

**Conditions at the Time of Settlement: Woodlands** The definition of quality makes direct reference to the condition of a community at the time of settlement by Europeans. The current community structure and composition of Ledges State Park was used as the standard for settlement conditions for Ames woodlands. Many of the woodlands in this park are among the most mature to be found in central Iowa, but nonetheless one can not be certain that the conditions at the time of settlement are
represented here. Most of Ledges State Park has been impacted by some form of human activity (i.e. grazing, logging) in the past 100 years and thus altered to some extent since Europeans first settled in Boone County in 1846 (Dinsmore 1994). Nevertheless, the presence of many trees here over 200 years old, the high plant diversity and the occurrence of rare and disjunct plant species within the park boundaries (Johnson-Groh and Farrar 1985) suggest that some presettlement qualities are reflected by the current vegetation. Hence, the mature woodlands at Ledges State Park provide the best available surrogate for settlement conditions to be found in central Iowa.

*Conditions at the Time of Settlement: Prairies* Given the utter destruction of Iowa's prairie vegetation, one can point to only a few examples of native prairies in this state that retain any semblance of presettlement condition. Examples of these are Cayler Prairie (Dickinson County), Cedar Hills Sand Prairie (Black Hawk County), Doolittle Prairie (Story County), Hayden Prairie (Howard County), Kalsow Prairie (Pocahontas County), Sheeder Prairie (Guthrie County) and Steele Prairie (Cherokee County).

It was assumed for purposes of this inventory that prairies in 1840 contained a high diversity of prairie plant species. Hence, diversity of native prairie plants was established as the most important, highly weighted component in the evaluation of Ames prairie remnants.

The "Science" of Quality Evaluation

The quality evaluation of natural areas is without question a subjective process (Swink and Wilhelm 1994). Although the evaluation components (species diversity, structural diversity, area of tract, etc...) incorporated by a particular evaluation method may be justified ecologically (see "Literature Review" in this thesis), their very
selection from a larger pool of possible evaluation components adds a degree of arbitrariness to the method. The weighting of components, the aggregation of component scores into a quality index, and the ultimate delineation of different quality regions within an evaluated area are also somewhat arbitrary processes.

Nonetheless, quality evaluation of natural areas is reasonable provided that i) the evaluation components are justified biologically and ii) all subjective decisions that enter into evaluation are carefully thought out and explicitly stated. One can do no better than this.

Woodland Evaluation

Advantages of the Woodland Evaluation Method

A non-intuitive method was developed for the evaluation of Ames woodlands during the Ames Natural Areas Inventory. Although intuitive methods (e.g., White 1978) are useful when applied by professional biologists who are experts in the natural history of a region, the current method has the advantage of being usable by entry-level biologists. The only prerequisite is that a potential evaluator have good woody plant identification skills.

The current method was modeled after Tans' earlier (1974) scheme for natural area evaluation. Both methods call for the measurement of several ecological components whose weighted scores are then summed to yield a single quality rating for an evaluated site. In Tans' method, the rules for scoring the criteria are stated conceptually (Table 2.1), leaving an evaluator to determine in their own mind how to actually assign points for a given component. In contrast, the current method uses explicit rules for the scoring of each of four evaluation components (diversity, structure, fidelity, presence of introduced species) within a 0.10 hectare survey point (Table 3.1, Table 3.2).
The current method for evaluating woodlands can be rapidly applied in the field. A typical woodland survey point can be evaluated in less than 30 minutes. This reasonably allows for the survey of ten to fourteen survey points a day depending on the terrain and the distance between points. Since quality ratings can be calculated immediately after a survey, an evaluator has the opportunity to provide immediate feedback to a landowner regarding the quality of a woodland.

The Ames woodland evaluation method is sufficiently simple and concise that a biologist with training in woody plant identification can take it from these pages and apply it in the field. However, it is preferable that anyone unfamiliar with the method accompany an experienced evaluator in the field for 3 to 5 days in order to become familiar with the method's nuances as well as general survey procedure.

Unresolved Problems

Unanticipated problems with the use of an evaluation method are sure to arise in the field no matter how carefully one states the rules for measuring the criteria of the method on paper. The methods developed for use in this inventory were no exception. For example, adjustments were made to the diversity numbers for the three woodland community types (xeric, mesic, and floodplain) when the limits of canopy and understory species richness in 0.1 hectare survey plots were determined in the field for each community type. Most numerical adjustments of this type were made by the end of the first summer of field work (1992) for this inventory.

Several conceptual problems with the use of the woodland evaluation method were not so easily solved. These are discussed now.

a) Evaluation of woodland structure  As written, the rules for evaluating woodland structure presuppose the existence of distinct canopy and understory layers in a woodland. Although these foliage layers are easily recognized in mature woodlands
(e.g., Munn Woods), some Ames woodlands lack a well-defined canopy. For example, even-aged stands of boxelder (*Acer negundo*) and/or elm (*Ulmus* spp.) often occur in bottomlands recently converted from cropfields. Evaluating the structure of these young floodplain forests was often difficult because clear canopy and understory layers are undifferentiated in them. A possible solution to this problem for future evaluation would be to assign points for the presence of distinct canopy and understory layers.

No explicit definitions of "canopy" and "understory" were established during this inventory. The latter category was interpreted to encompass all woody vegetation at least 0.5 m tall and beneath the canopy. Thus, tall ironwoods (*Ostrya virginiana*) many meters high are lumped together with low shrubs (e.g., *Ribes* spp.) that have no potential to become trees. An alternative interpretation of this broad category would be to evaluate two woody understory strata separately: a *subcanopy* of small trees and saplings and a *shrub* layer of low woody vegetation. This is a biologically realistic subdivision since certain forms of wildlife (e.g., forest songbirds) are influenced by the presence or absence of these forest layers when selecting habitat (McArthur and McArthur 1961). However, the current method for evaluating structure may be adequate because stem diameter is taken into account when recent disturbance is indicated by dense understory cover (Table 3.1).

b) **Interdependence of evaluation criteria** The interdependence of many, if not all ecological evaluation criteria can not be denied, as mentioned in the "Literature Review" of this thesis. In the current woodland evaluation scheme, the "fidelity" and "introduced plants" components seem particularly intertwined. As a case in point, consider a recently grazed mesic woodland in which the understory is dominated by an introduced (and unexpected) shrub, Tartarian honeysuckle (*Lonicera tatarica*). Minimum scores result for both of the above categories when they are evaluated
according to the current rules (Table 3.1). Note that if the understory of this same woodland were dominated by an unexpected species such as elm (*Ulmus* spp.), a minimum score would result in the fidelity but not the introduced species category because elm is a species native to central Iowa. Thus, *woodlands dominated by unexpected, nonnative species are deemed to be lower in quality than woodlands dominated by unexpected, native species* in the woodland evaluation method. One might argue that the above scenario follows directly from the definition of quality adopted for this inventory (high quality implies species present prior to settlement).

Suppose that we drop the introduced species component from the evaluation method altogether. In this case, dominance by an unexpected, nonnative species (*e.g.*, *Lonicera tatarica*) would be weighted no worse than dominance by an unexpected, native species (*e.g.*, *Ulmus* spp.) in the understory of a mesic woodland. On the other hand, if the fidelity component were eliminated (and the introduced species component is retained), dominance by an introduced species (*e.g.*, *Lonicera tatarica*) would imply lower quality than dominance by an unexpected native species (*e.g.*, *Ulmus* spp.), but the method would be unable to discriminate between dominance by any native species (*e.g.*, unexpected *Ulmus* spp. versus expected *Acer nigrum* in a mesic woodland). Hence, the choice of evaluation components inevitably carries with it strong philosophical implications regarding one's concept of natural quality.

The reference to a woodland's "condition at the time of settlement by Europeans" in the definition of quality implies that introduced species lessen the quality of a woodland, since these species were absent from the flora then. However, the dominance of native but unexpected species in a woodland (*e.g.*, elm saplings on a slope) was certainly an infrequent reality via natural disturbance (*e.g.*, windstorm, disease, fire) at this same time of settlement. Thus, a higher penalty for unexpected,
introduced species than for unexpected, native species seems to be justified by the definition of quality.

c) Herbaceous Quality The most glaring omission among the criteria used in the adopted method for woodland evaluation is an appraisal of the herbaceous layer. A mature, recently undisturbed woodland (e.g., Munn Woods) typically contains a different herbaceous flora than a recently disturbed (i.e., grazed, logged, flooded) woodland. Disturbances such as grazing and flooding mechanically remove many perennial woodland herbs typical of mature woodlands. Furthermore, woodland wildflowers are frequently shaded out beneath the dense thickets of low shrubs that typically occur in recently grazed and/or logged woodlands. One usually encounters opportunistic weed species in the herb layer of a recently disturbed woodland as well as unnatural dominance by a few persistent herbs typical of mature woodlands (e.g., *Laportea canadensis*, *Galium aparine*). Obviously, the species composition and dominance patterns observed for the herbaceous layer in a woodland can shed much light on the past history (and hence the quality) of the woodland.

Certainly, consideration of the herbaceous layer (*diversity of expected species, herbaceous cover, fidelity, presence or absence of introduced species*) in woodland evaluation would have enhanced the ability of the method to discriminate between different quality woodlands. However, herbaceous evaluation was omitted from the adopted method because of the amount of time needed to adequately survey herbs.

Woodland wildflowers are not all evident nor easily identified at the same time of year; e.g., the Dutchman’s breeches (*Dicentra cucullata*) and spring beauties (*Claytonia virginica*) of late April and May disappear by mid-summer, most woodland sedges (*Carex* spp.) can be identified only when they produce mature fruit in June, and woodland goldenrods (*Solidago* spp.) and asters (*Aster* spp.) don’t flower until late
summer and thus are difficult to identify until that time. To determine the total species richness of the herbaceous layer in each woodland, two or three herbaceous surveys at different times of the year would be necessary. Given the hundreds of woodland acres needing to be surveyed for this inventory by one field technician over two summers, such an intense survey was not practical.

Ground cover by woodland herbs also varies seasonally. The colorful carpet of false rue anenome (*Isopyrum biternatum*) and dog-tooth violet (*Erythronium albidum*) that blankets a wooded slope in spring will have disappeared by mid-summer. This phenomenon also occurs in reverse; the forest floor of a bottomland that is naked in May may be filled with wood nettle (*Laportea canadensis*) by mid-July. If herbaceous cover were an evaluation component, one would have to survey all woodlands in the same short-time intervals to avoid these phenological differences.

Although survey of woodland herbs for evaluation purposes is highly desirable and indeed possible (Peterken 1977, Goodfellow and Peterken 1981), a significant advantage is gained by considering only woody plants in the evaluation of woodlands: the ability to carry out evaluations in winter. Some winter evaluations of woodlands did in fact occur during this inventory. The individuals who use this method in the future (city planners, county conservation agents) may need to evaluate the natural quality of a property rather quickly, without the luxury of waiting until summer to inspect the herbaceous layer. Woody plants, on the other hand, can be identified in all seasons by properly trained individuals.

Should a woodland evaluation method that is based solely on the survey of woody plants be considered valid? An inherent assumption of this approach is that overall woodland quality is positively correlated with species richness of expected woodland herbs. Intuitively, one would expect to find a diverse flora of woodland herbs in a mature, high
quality woodland. On the other hand, a low diversity of woodland herbs is anticipated for recently grazed or flooded (low quality) woodlands since disturbance tends to have specific negative effects on the herbaceous layer of a woodland (see above).

Despite the above arguments, some critics insist that evaluation of the herb layer must be included in any overall woodland evaluation method. Although the positive correlation between overall woodland quality and herbaceous quality was usually observable during the survey of Ames woodlands, uncommon woodland herbs (e.g., *Actaea rubra*, *Aralia racemosa*) were occasionally encountered in recently disturbed woodlands (e.g., the upland "C" quality woodland identified on the Squaw Valley - Hickory Hills map). Clearly, the above assumption needs to be demonstrated scientifically in order to justify the omission of herbaceous evaluation from the current woodland evaluation method.

d) Survey Intensity   Most wooded tracts outlined on the original base map of potential natural areas were surveyed very intensively. Sample points were established on almost every slope, ridge, and bottomland within a woodland, and their subsequent survey allowed easy delineation of quality regions within the tract. No one can deny the value of compiling detailed vegetation information about every woodland within the boundaries of an inventory. However, the time constraints established for most natural area inventories do not allow for such a comprehensive approach. Several possible shortcuts could reduce the time required to survey woodlands.

Consider the extensive "C" quality region delineated in the Old Bloomington Road (North) map (Appendix A). Twenty-two separate sample points were established and surveyed here, despite the fact that these woods are rather homogeneous in composition (*Quercus macrocarpa* and *Carya ovata* are canopy dominants and *Celtis occidentalis*, *Ostrya virginiana* and *Ulmus* spp. are the understory dominants) and quality
(eighteen of the twenty-two quality ratings fall within the 10-13 range). A more time efficient approach to surveying large wooded tracts would have been to take a preliminary walk through a given tract and determine on an intuitive basis whether or not quality varies significantly throughout the tract. The intensity of sample effort can then be adjusted accordingly. In the case of the "C" level Old Bloomington Road (North) woods, fewer samples would probably have been sufficient to allow for adequate determination of its overall natural quality.

Similarly, consider the "D" quality woodland identified on the Curtiss Farm map. This tract consists largely of heavily disturbed woods and active pasture. Nineteen sample points were established and surveyed within this "D" region prior to its delineation on the map. In retrospect, the poor quality of this woodland would no doubt have been obvious to the surveyor if he had strolled through it from end to end prior to its formal survey. Towards the end of this inventory, the evaluation of many low quality woodlands (e.g., South Skunk River) was shortened by this intuitive method to hasten completion of the field work.

It should be noted that the intensive survey of low quality woodlands is not without reward. A rare population of an uncommon moss, Climacium americanum, was encountered on heavily eroded slopes within the low quality "D" region of the Curtiss Farm woodland. A state threatened orchid (Spiranthes ovalis) was found for the first time in Story County within "D" quality woodlands [Riverside (South)] within the project boundary. Furthermore, an active turkey vulture (Cathartes aura) nest was found in "D" quality woodlands identified on the map of Onion Creek (West).

The rapid, intuitive evaluation of some low quality areas is probably necessary in any natural area inventory, despite the inherent problems with this approach (see previous paragraph and "Literature Review"). The usual time and budget constraints
established for most natural area inventories simply do not allow for the intensive survey of all areas. Given this reality, the above suggestions for hastening the process of woodland evaluation in the field are offered with caution. Any relaxation or suspension of formal survey should be permitted only in certain well-defined (and obvious) circumstances; e.g., automatic "highly altered" designation when both canopy and understory are dominated by unexpected species.

**Future Refinement of the Woodland Evaluation Method.**

The definition of natural quality makes reference to the "mature" condition of a community. One indicator of woodland maturity is the presence of well delimited foliage layers (canopy, subcanopy, shrub). Another obvious indicator of maturity is tree girth. For instance, in the "A" quality region of Munn Woods one is almost immediately impressed by the size of the oak trees. In retrospect, the addition of *tree size* as a fifth evaluation criterion would probably have enhanced the effectiveness of the woodland evaluation method to discriminate among different quality woodlands. The diameter at breast height (dbh) of the largest tree in each quarter of the 0.1 hectare sample plot could quickly be measured in the field and then averaged for use in evaluation as outlined in Table 5.1.

**Table 5.1. "Tree Size" as a potential criterion in future woodland evaluation.** The proposed rules for scoring "Tree Size" depend on measurement of the diameter at breast height (dbh) in centimeters of the largest tree in each of the four quadrants of the 0.1 hectare sample plot.

<table>
<thead>
<tr>
<th>Average dbh of four largest trees in sample plot</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>at least 50 cm</td>
<td>2</td>
</tr>
<tr>
<td>at least 30 cm but less than 50 cm</td>
<td>1</td>
</tr>
<tr>
<td>less than 30 cm</td>
<td>0</td>
</tr>
</tbody>
</table>
"User-Friendly" Survey Form and Evaluation Procedure

The original woodland survey form (Fig. 3.4) and evaluation procedure (Table 3.1) have been modified for future use by surveyors to make them easier to use than the original forms. The modified forms appear in Appendix D.

The new, streamlined survey form does not rely on the Braun-Blanquet code system for individually noting the cover class of every woody species encountered in a survey. Instead, the user is directed to list the woody species in one of several discrete categories that correspond to a particular cover class (e.g., "Species that cover at least 25% of the plot"). Since these are the same cover categories referred to in the evaluation form, the newcomer should feel more confident when using his survey data to evaluate a woodland under the prescribed rules.

Many of the format changes within the evaluation form were suggested by the five individuals who tested the method for repeatability. For instance, one adopted recommendation was to move the answer blanks for each category score to a more obvious position on the page (the bottom right-hand margin). Some of the terminology has been changed as well; for instance, the term "xeric" has been replaced by "ridgetop" and "dry slope" in the new evaluation form. Finally, users of this streamlined form need not refer to "diversity numbers" in order to score the diversity category. Instead, the species richness levels that determine the possible diversity scores for each community type ("ridgetop", "moist slope", "dry slope", "floodplain", "mature bottomland") have been calculated for Ames, Iowa and explicitly stated in the form.

Research Questions to be Explored

As noted earlier, the current method for woodland evaluation does not call for any consideration of the herbaceous layer in a woodland. The positive correlation between overall woodland quality and some measure of herbaceous quality needs to be
demonstrated. In order to do this, one could randomly select woodlands of "A", "B", "C", and "D" quality from Appendix A of this thesis and thoroughly sample the herbaceous strata within each one using a fixed length transect. From these data, one could then estimate the species richness of woodland herbs for each selected woodland and then determine whether any correlation occurs between this measure and the overall rating of the woodland based on woody plants alone.

A positive consequence of restricting evaluation to woody plants is that woodland evaluation can occur year round, since most trees, saplings, shrubs, and vines can be identified in the winter from bud, twig, and bark characteristics. However, most woody plants are more easily identified in the summer, and there is the potential of overlooking woody species during winter surveys. Therefore, the consistency of winter and summer evaluations needs to be demonstrated in order to validate application of the method in winter. Until this is done, winter evaluation of woodlands should be restricted to obvious low quality tracts to avoid unwarranted low evaluations of "A" and "B" quality regions.

Finally, the numerical cutoff points for each of the four woodland quality levels (Fig. 3.6) need independent verification by acknowledged woodland community experts. These experts could be sent to selected woodlands that span the range of values possible for woodland quality ratings (0-20) with written descriptions of the four woodland quality levels and asked to choose which description ("Highly Natural", "Mostly Natural", "Moderately Altered" or "Highly Altered") best applies to each woodland. A comparison of these independent evaluations with those obtained from the inventory (Appendix A) would reveal whether or not further adjustments need to be made to the numerical cutoff points for any of the four quality levels.
Potential for Future Use

Various Iowa agencies (municipal, county, state, private) will be able to consider the objective methods of woodland evaluation employed in the Ames Natural Area Inventory as an option when planning their own natural area inventories. Certainly, the current method would be appropriate for future evaluation of woodlands in Ames and perhaps all of Story County.

However, the character of central Iowa woodlands is certainly not the same as the character of woodlands elsewhere in the state. For example, the expected dominant trees on a dry ridge or slope in Ames, Iowa are white oak (*Quercus alba*), red oak (*Quercus borealis*), bur oak (*Quercus macrocarpa*), shagbark hickory (*Carya ovata*), black cherry (*Prunus serotina*), and white ash (*Fraxinus americana*). In the same habitat in northeastern Iowa, the expected tree species might also include black oak (*Quercus velutina*), Hill's oak (*Quercus ellipsoidalis*), white pine (*Pinus strobus*), sugar maple (*Acer saccharum*), and American basswood (*Tilia americana*).

In order to apply the methodology for evaluating central Iowa woodlands to woodlands elsewhere in the state, one would first need to modify the list of expected species for canopy and understory for each woodland community type (xeric, mesic, floodplain) as necessary. In the Ames Natural Area Inventory, these lists were developed after examination of raw survey data collected in quantitative surveys in high quality woodlands in Ledges State Park (Johnson-Groh 1983). If such quantitative data exist and are available from state preserves and/or parks containing high quality woodlands within the region of interest (e.g., northeast Iowa), these should be consulted to lend credibility to the lists.

One would also have to determine the appropriate diversity number for each woodland community type in the new region (Table 3.2). This could be done by
surveying high quality woodlands in the region and determining the limit of canopy and understory species richness within 0.1 hectare survey plots for each community type.

Finally, the numerical cutoff levels for each of the four woodland quality levels ("Highly Natural", "Mostly Natural", "Moderately Altered" and "Highly Altered") have to be determined for woodlands in the region of interest. One would do this by surveying and evaluating acknowledged high, good, average and low quality woodlands in the region and adjusting the current cutoff levels (Fig. 3.6) as needed.

Prairie Evaluation

The Ames Natural Areas Committee decided that a single criterion, species richness of prairie plants, is the best indicator of a prairie's potential to recover, with proper management, from a host of disturbances (e.g., invasion by woody plants, exotic grasses, and forbs). Using species richness as an evaluation criterion is certainly not novel. However, the use of this single criterion has the advantage of being simple, straightforward, and readily understood by the non-biologists (property owners, city planners) who will ultimately interpret the results of the prairie evaluation conducted during this inventory.

One might argue that the current prairie evaluation method is too simple, since it ignores the size of the prairie remnants so evaluated. Inherent in this argument is the sentiment that large prairies are usually higher in quality than small prairies. A response to this concern is that an area criterion is already embedded in the fabric of the adopted method since area and species richness are positively related in nature.

Although some of the prairie remnants evaluated during the inventory have well-defined boundaries, others are comprised of discrete subunits within a matrix of low quality woodlands (e.g., the Northridge prairies and Ames High School Prairie). The Ames Natural Areas Committee decided not to evaluate these subunits separately but
instead to treat them together as a single unit. This approach can be defended under the "potential for recovery" doctrine since with enough management (i.e., tree cutting) some of these subunits could be joined together into a single larger unit. Such agglomeration of subunits into a larger unit would presumably make the prairie more suitable for area-sensitive insects and small mammals who call the prairie home as well as facilitate gene flow within populations of the component prairie plant species.

Significance of the Ames Natural Areas Inventory

Urban Inventories in the United States

Few American municipalities have undertaken a natural areas inventory as intensive and objective as that described in this thesis. Although a methodology for natural area evaluation within a metropolitan region is briefly discussed by Swink and Wilhelm (1994) in their flora of the Chicago (IL) region, no comprehensive natural area inventory of Chicago was ever carried out there. Most of the published natural area inventories in the United States (Tans 1974, Gehlhabach 1975, Sargent and Brande 1976, White 1978) have had a statewide focus. Some of these are preliminary reports detailing evaluation methodology; often no indication is made that an inventory actually occurred.

A great many natural area inventories have been carried out by university graduate students on a small scale (e.g., county, state park/preserve level). However, the goal of many such endeavors has been the discovery of rare plant species and the generation of a cumulative plant species list for the area of interest. Although the value of such information to biologists is undisputed, one questions the usefulness of plant species lists placed in the hands of non-biologists charged with making land-use decisions. In contrast, the quality maps produced through this inventory (Appendix A) are easily understood by non-biologists (e.g., city planners). The meaning of the quality
ratings (i.e., "A", "B", "C", and "D") assigned to each delineated quality region are clear and to the point. If general information about the nature of a particular surveyed tract is required, it is available in the description (written in layman’s terms) that accompanies each map in the final report to the City of Ames. If more detailed information (actual quality ratings, plant species lists) is required, it can be found in the appendices of this thesis.

Many of the natural area inventories done as graduate projects are unpublished (e.g., Duritas 1983) and hence unavailable as a resource to citizens embarking on their own natural area inventory. When published, the details of the Ames Natural Area Inventory should be of great interest to anyone interested in urban natural area conservation. In particular, the methods developed for evaluation of natural areas in Ames will provide models that can be considered for use elsewhere in Iowa and the midwest. Hopefully, awareness of the Ames Natural Areas Inventory will spark interest in municipal inventories elsewhere.

**Cooperation and Education**

Perhaps the most remarkable aspect of this inventory is that it was initiated by a branch of local government, the Ames City Planning Office. Although conservationists and government officials are frequently portrayed as adversaries in the media, this inventory provides an example to the public that these two groups can in fact work together toward a common goal. The success of this inventory was possible because the parties involved were willing to consider alternative approaches to natural area protection (which is the ultimate goal of any natural area inventory). If the natural area advocates serving on the Ames Natural Areas Committee had insisted that this inventory be followed up by immediate regulatory legislation from the Ames City Council, meaningful discussion with city officials would have been precluded. Likewise,
it was necessary that the city planners participating in this inventory make clear their sincere intention to consider the results of this inventory when making future planning decisions.

A second remarkable finding of this study was the enthusiastic participation of nearly all private landowners (over 90% of those contacted). Initially, permission to survey private land was requested by phone, but it soon became apparent that a knock at the landowner's front door followed by a face-to-face request was a more effective method for obtaining the permission. Many landowners wished to give the surveyor a personal tour of his or her property prior to actual survey to point out property lines and talk about the inventory. This proved to be a valuable opportunity for the surveyor to share information about natural areas with the landowners as well as gain important information about the land-use history of the site.

Educating the public about natural areas was a high priority of the Ames Natural Areas Committee. An effort was made to give all property owners who consented to a survey of their land a copy of the map and written report produced after the survey. The committee felt that making landowners aware of the natural quality of their property would be the most effective means to promote natural area preservation. Hopefully, the pride instilled in these landowners upon realizing the natural quality of their land would be passed on to friends and other family members, especially those in a position to inherit the land.

Impact of the Ames Natural Areas Inventory

This inventory has already had a positive impact on Ames Natural Areas. For instance, survey of the Raymond-Rolling Prairie revealed that the prairie community was being encroached upon by red cedar trees. Soon afterwards, more than fifty local volunteers gathered to cut down and burn the invading trees during several organized
work days in 1993 and 1994. One of the landowners has since put up a sign at the edge of the site that acknowledges this effort by local citizens to restore the prairie.

The findings of this inventory have been consulted in several discussions of community issues. For instance, the high quality of the woodlands in West Reactor Woods has been cited as evidence to support a ban on mountain bikes there. In a subsequent study of potential sites for mountain bike trails in Ames (a class project for an ISU Landscape Design class) it was concluded that the low quality woodlands along Worrell Creek were suitable for mountain bike activity (see Gateway Park, Zumwalt Trail (West), Curtis Farm and Worrell Creek maps in Appendix A).

Likewise, the results of this inventory have been available to a consultant hired by the City of Ames to produce a 30-year zoning and development plan for Ames in anticipation of future growth. In this plan, growth corridors were not proposed for the northwest corner of Ames because of the high quality of the natural resources there (O'Connell pers. comm. 1995).

The findings of this inventory have been available to the general public since the Ames City Council voted to accept the final inventory report in December 1994 (Fig. 5.2). It has in fact been consulted by local Ames citizens who have studied draft versions of the long-range zoning and development plan prepared by the consultant. Spokespersons for several neighborhood and environmental watchdog groups cited portions of the inventory report while commenting on the plan during a public forum in spring 1995.

The final report of a natural area inventory must be taken off the shelf and used by the various city agencies for it to have any real impact. This point became clear in the fall of 1995 when a public works crew needed to repair a broken sewer line adjacent to Ames School Prairie. The works crew was advised by school officials to access the
City guide protects natural resources

Inventory is used to alert developers to wildlife areas

By STEPHANIE ARMOUR
Staff Writer

City planners are turning to a newly created guide on Ames' natural resources when working with builders planning new developments.

The inventory on specific resource areas is not being used to turn down building projects, said Planning and Housing Director Brian O'Connell.

But paying attention to these natural or relatively undisputed sites is a new practice that may help shape development plans, he said.

"When we meet with developers, we turn to this resource document and see if they want to build in a natural resource area," O'Connell said. "We can apprise them of that and encourage them to look at their designs."

The resource inventory may also have other implications. O'Connell said a copy of the inventory also has been forwarded to a consultant now working on a revised guide to citywide development.

The inventory will be a planning tool incorporated into the land-use policy plan, the document that helps steer development over the next 30 years.

"(The consultant) has taken it into account," he said. "The resources have been identified (as part of the development guide)."

The inventory is a non-binding guide to natural resource areas that was commissioned by the city more than two years ago. It indicates that more than 2,200 acres can be considered natural resources, both within Ames and the two-mile radius around the city.

Most of the natural wildlife areas are already protected, since they're located in city parks and recreation spots. But a few scattered at other private sites could be ripe for future development.

The inventory was drafted by Bill Norris, an Iowa State University environmental expert who conducted numerous field visits.

The cost of the study was $30,000, with the city paying about half. The National Science Foundation and ISU also shared the cost.

City Council members said they had never planned to use the guide to bar development. Instead, they saw the inventory as a tool for helping builders.

And that, said O'Connell, is exactly what it's become.

"We've been able to let developers know (where these) resource areas are," said O'Connell, adding that the inventory is referred to during preliminary discussions about possible development.

Of the 2,294 acres deemed to be a natural resource, about 64 percent — or 1,471 acres — were actually surveyed by Norris and a resource advisory committee.

The surveyed land was categorized as:

- Highly natural, which comprises 162 acres, and deemed worthy of some sort of preservation status.
- Mostly natural, which makes up about 570 acres.
- Moderately altered, of which there are 504 acres.
- Highly altered, which comprises 233 acres.

Natural resource areas include prairies, wetlands, woodlands, streams and some other special locations.

Figure 5.2. Ames Daily Tribune article (Armour 1995) describing the Ames Natural Areas Inventory.
sewer line by crossing the prairie itself to avoid damage to the adjacent woodlands. Consequently, the prairie suffered significant damage when heavy equipment was repeatedly driven across it. If either the Ames Public Works Department or the school district had consulted the inventory report, this damage might have been averted. A map of the area (Appendix A) immediately suggests the better approach to the work area through "D" quality woodlands, avoiding the "A" quality prairie.

Public awareness of the high quality natural areas in a community is no guarantee of their protection. Sometimes the needs of a municipality result in land-use decisions which are detrimental to the health of a natural area. One of the highest quality woodlands in Ames, East Reactor Woods, was bisected by a water line installed by a city public works crew in 1994. When the fundamental needs of the public conflict with the maintenance of a community's highest quality natural areas, there are no easy solutions. Nonetheless, the evaluation of natural area quality in a municipality can allow a better assessment of the true cost of alternative land use options.

Future Inventory of Ames Natural Areas

The final inventory report to the City of Ames should be viewed as a dynamic document in need of frequent updating. To illustrate, the quality of some of the medium quality prairie remnants identified in the report (Northridge prairies, Svejde prairie) could improve with proper management (i.e., tree cutting, burning). Conversely, the decline in quality of any prairie remnant should be closely monitored and documented.

Unfortunately, some of the woodlands surveyed during this inventory no longer exist. For example, the whirring of power tools could be heard as the last woodland surveys were being completed near Dayton Avenue. New houses now replace some of the "C" quality woodlands identified on the Dayton Avenue quality map in the final
inventory report. Likewise, most of the "D" quality ridgetop woods delineated on the map of Northridge (North) have recently been cleared to allow for expansion of the Northridge Housing Development. Thus, a resurvey of Ames natural areas ten or twenty years from now is warranted since the current inventory report will by that time be significantly outdated and inaccurate.

**Epilogue**

A casual inspection of the "Bibliography" section of this thesis reveals that natural area evaluation has so far received much more attention elsewhere in the world. For instance, many natural area inventories have been proposed or undertaken in England (Tubbs and Blackwood 1971, Peterken 1974, Goldsmith 1975, Goodfellow and Peterken 1981, Kent and Smart 1981, Margules and Usher 1984, Margules 1984, Dony and Denholm 1985), even though England's landscape has been almost completely altered by the hand of civilization. Numerous natural area inventories are also reported from two other countries whose natural areas have been largely devastated: the Netherlands (van der Ploeg and Vlijm 1978) and New Zealand (O'Connor 1991). Perhaps this is evidence that a society will acknowledge and deal with the natural devastation occurring within its boundaries only after it is too late to salvage more than a few crumbs of "naturalness."

Hopefully, this society will be more prompt in countering the destruction of the wild lands within its own borders.
BIBLIOGRAPHY


APPENDIX A  MAPS AND DESCRIPTIONS OF AMES NATURAL AREAS

Woodlands

Maps and written descriptions of all woodlands surveyed during the Ames Natural Areas Inventory have been placed in this appendix. Four maps were prepared for each woodland: an unmarked map for future use in the field; a map delineating the quality regions identified during the inventory; a map of the woodland quality ratings (0-20) determined for each survey point; and a map identifying the dominant woody vegetation (numerator: canopy, denominator: understory) found at each survey point.

The written descriptions are the same (with a few minor revisions) as those included in the final inventory report to the City of Ames.

Prairie

Written descriptions of all prairies (native and reconstructed) surveyed during the Ames Natural Areas Inventory are included in this appendix. Separate plant species lists were compiled for each native prairie surveyed during the inventory, and are also included in this appendix. All plants on these lists were observed by the surveyor on site except for three species (i.e. *Asclepias viridiflora*, *Baptisia bracteata* var. *glabrescens*, and *Mirabilis hirsutum*) observed by Tom Rosburg at the Raymond Prairie in the summer of 1995. Unless otherwise noted, all listed plants also occur on the list of Iowa prairie plants compiled by John Pearson (1986).

Individual maps of most Ames prairie remnants are not included in this text. However, they are all marked and identified on the large index map at the back of this thesis.

Index Map

An oversized index map to all the Ames natural areas described in this appendix can be found in Appendix E.
List of Abbreviations Used in the Maps of "Dominant Woody Vegetation"

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Common Name</th>
<th>Common Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>AG</td>
<td><em>Acer negundo</em> (boxelder)</td>
<td><em>Quercus alba</em> (white oak)</td>
</tr>
<tr>
<td>AN</td>
<td><em>Acer nigrum</em> (black maple)</td>
<td><em>Quercus macrocarpa</em> (bur oak)</td>
</tr>
<tr>
<td>AS</td>
<td><em>Acer saccharinum</em> (silver maple)</td>
<td><em>Quercus nigra</em> (red oak)</td>
</tr>
<tr>
<td>CC</td>
<td><em>Carya cordiformis</em> (yellowbud hickory)</td>
<td><em>Ostrya virginiana</em> (ironwood)</td>
</tr>
<tr>
<td>CE</td>
<td><em>Celtis occidentalis</em> (hackberry)</td>
<td><em>Populus deltoides</em> (cottonwood)</td>
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<td>CI</td>
<td>Conifer (introduced)</td>
<td><em>Populus grandidentata</em> (big-toothed aspen)</td>
</tr>
<tr>
<td>CO</td>
<td><em>Carya ovata</em> (shagbark hickory)</td>
<td><em>Platanus occidentalis</em> (sycamore)</td>
</tr>
<tr>
<td>CR</td>
<td><em>Crataegus</em> spp. (hawthorn)</td>
<td><em>Prunus serotina</em> (black cherry)</td>
</tr>
<tr>
<td>CS</td>
<td><em>Cornus</em> spp. (dogwood)</td>
<td><em>Prunus virginiana</em> (choke cherry)</td>
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<td>FA</td>
<td><em>Fraxinus americana</em> (white ash)</td>
<td><em>Rhus glabra</em> (smooth sumac)</td>
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<td><em>Fraxinus nigra</em> (black ash)</td>
<td><em>Ribes</em> spp. (gooseberry)</td>
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<td>FP</td>
<td><em>Fraxinus pennsylvanica</em> (green ash)</td>
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</tr>
<tr>
<td>FS</td>
<td><em>Fraxinus</em> spp. (ash)</td>
<td>*(RS) <em>Rosa multiflora</em> (multiflora rose)</td>
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<td><em>Gymnocladus dioica</em> (Kentucky coffee tree)</td>
<td><em>Rubus</em> spp. (black raspberry/blackberry)</td>
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<tr>
<td>GT</td>
<td><em>Gleditsia triacanthos</em> (honey locust)</td>
<td><em>Salix</em> spp. (willow)</td>
</tr>
<tr>
<td>JC</td>
<td><em>Juglans cinerea</em> (butternut)</td>
<td>*(SS) <em>Salix nigra</em> (black willow)</td>
</tr>
<tr>
<td>JN</td>
<td><em>Juglans nigra</em> (black walnut)</td>
<td>*(SS) <em>Salix nigra</em> (black willow)</td>
</tr>
<tr>
<td>JV</td>
<td><em>Juniperus virginiana</em> (red cedar)</td>
<td>*(SS) <em>Salix nigra</em> (black willow)</td>
</tr>
<tr>
<td>LS</td>
<td><em>Lonicera tatarica</em> (Tatarian honeysuckle)</td>
<td><em>Staphylea trifolia</em> (bladdernut)</td>
</tr>
<tr>
<td>MA</td>
<td><em>Morus alba</em> (white mulberry)</td>
<td><em>Ulmus americana</em> (American elm)</td>
</tr>
<tr>
<td>ML</td>
<td><em>Malus</em> spp. (apple)</td>
<td><em>Ulmus rubra</em> (red elm)</td>
</tr>
<tr>
<td>misc</td>
<td>miscellaneous species</td>
<td><em>Ulmus</em> spp. (elm)</td>
</tr>
<tr>
<td>XA</td>
<td><em>Xanthoxylum americanum</em> (prickly ash)</td>
<td>*(SS) <em>Salix nigra</em> (black willow)</td>
</tr>
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Peterson Pits

Narrow woodland strips occur along the Skunk River in a public area known as Peterson Pits.

Most of the larger strips contain "B" quality woodlands. Almost all trees, saplings and shrubs found here are typical of floodplain forests, but diversity is not always high in these areas. Canopy trees commonly found in these areas include honey locust, cottonwood, black walnut, silver maple, hackberry, boxelder, green ash and American elm. Gooseberry is frequently dominant in the understory, as are elm and hackberry saplings.

The "C" quality regions possess the same species in the canopy and understory but they are less diverse. The "D" quality area is a very young woodland dominated by boxelder saplings.
PETEsehen PITS PARK
PETerson Pits Park
(Quality Regions)
PETERSON PITS PARK
(QUALITY RATINGS-NORTH)
PETERSON PITS PARK

(QUALITY RATINGS-NORTH)
PETERSON PITS PARK
(QUALITY RATINGS-SOUTH)
PETEASON PITS PARK
(DOMINANT WOODY VEGETATION-NORTH)
PETERSON PITS PARK
(DOMINANT WOODY VEGETATION-SOUTH)
Raymond Prairie

Woodland, pasture and a high quality prairie exist on a long east-facing slope overlooking West Peterson Pits Park.

The Raymond Prairie, with at least 65 native prairie plant species, is one of the few "A" quality prairies near Ames. Although recently in danger of being overgrown by red cedar, recent tree cutting (fall 1993-spring 1994) has opened up most of the prairie. Much of this prairie is dominated by Indian grass (*Sorghastrum nutans*). A number of plants found here were not discovered anywhere else within the project boundary during the inventory; these include Hill's thistle (*Cirsium hillii*), purple lovegrass (*Eragrostis spectabilis*), frostweed (*Helianthemem bicknellii*), hairy four-o'clock (*Mirabilis hirsuta*) and prairie bush clover (*Lespedeza leptostachya*). The last plant mentioned is on the federal list of endangered plants. Several other plants on this prairie, including prairie dandelion (*NotllOcalais cuspidata*), green milkweed (*Asclepias viridiflora*) and ebony spleenwort (*Asplenium platyneuron*), were found in only one other location within the boundaries of the inventory.

The "B" quality floodplain forest outlined on the map is similar to those described for "Peterson Pits" elsewhere in this report. The "D" region on the slope just south of the prairie (and adjacent to this floodplain) has probably been logged off in the past, because nontypical tree species (honey locust, green ash) are dominant here.

The largest parcel of "D" quality slope north of the prairie is a mixture of pasture and pastured woods with little remaining natural quality. Here and there throughout this region, however, can be found scattered prairie plants such as prairie larkspur (*Delphinium virescens*) and pale purple coneflower (*Echinacea pallida*).
Native Prairie Plant Species of the Raymond-Rolling Prairie

Species listed were observed by William R. Norris and/or Tom Rosburg at the Raymond-Rolling Prairie during the Ames Natural Areas Inventory (1991-95). A "prairie" species is one that occurs in a list of Iowa prairie plant species compiled by John Pearson of the Iowa DNR, except for species denoted with an (*). Nomenclature follows Eilers and Roosa (1994), except for Viola palmata and Viola pedatifida, which follow Gleason and Cronquist (1991).

PTERIDOPHYTES

Aspleniaceae (Spleenwort Family)
Asplenium platyneuron* (ebony spleenwort)

Equisetaceae (Horsetail family)
Equisetum laevigatum (smooth scouring rush)

ANGIOSPERMS (DICOTS)

Asclepiadaceae (Milkweed family)
Asclepias verticillata (whorled milkweed)
Asclepias viridiflora (green milkweed)

Asteraceae (Daisy Family)
Achillea millefolia* (Yarrow)
Ambrosia psilostachya (western ragweed)
Anennaria neglecta (field pussytoes)
Artemisia ludoviciana (prairie sage)
Aster azureus (azure aster)
Aster ericoides (heath aster)
Aster novae-angliae (New England aster)
Aster pilosus (hairy aster)
Brickellia eupatorium (false boneset)
Cirsium discolor (field thistle)
Cirsium hillii (Hill's thistle)
Echinacea pallida (pale purple coneflower)
Erigeron strigosus (rough fleabane)
Gnaphalium obvatum (everlasting)
Helianthus spp. (sunflower)
Liatris aspera (rough blazing star)
Nothocladis cuspidata (prairie dandelion)
Ratibida pinnata (grey-headed coneflower)
Rudbeckia hirta (black-eyed susan)
Senecio plattensis (prairie ragwort)
Solidago nemoralis (gray goldenrod)
Solidago canadensis (Canada goldenrod)
Solidago rigida (rigid goldenrod)

Boraginaceae (Borage Family)
Lithospermum canescens (hoary puccoon)
Onosmodium molle (false gromwell)

Campanulaceae (Bellflower Family)
Lobelia spicata (pale spike lobelia)

Caprifoliaceae (Honeysuckle Family)
Symphoricarpos spp.

Cistaceae (Rockrose Family)
Helianthemum bicknellii (frostweed)

Fabaceae (Bean Family)
Amorpha canescens (leadplant)
Astragalus ericoides (ground plum)
Baptisia bracteata var. glabrata (cream wild indigo)

Dalea candida (white prairie clover)
Dalea purpurea (purple prairie clover)
Desmodium illinoense (Illinois tick clover)

Lespedeza capitata (round-head bush clover)
Lespedeza lepiostachya (prairie bush clover)

Gentianaceae (Gentian Family)
Gentiana puberulenta (downy gentian)

Lamiaceae (Mint Family)
Monarda fistulosa (horsemint)
Scutellaria leonardii (small skullcap)

Linaceae (Flax Family)
Linum sucalum (grooved flax)

Nyctaginaceae (Four-O'Clock Family)
Mirabilis hirsuta (hairy four o' clock)

Onagraceae (Evening Primrose Family)
Calystegia sepium (plains yellow primrose)

Oxalidaceae (Wood Sorrel Family)
Oxalis violacea (violet wood sorrel)

Polemoniaceae (Phlox Family)
Phlox pilosa (prairie phlox)

Ranunculaceae (Buttercup Family)
Anemone cylindrica (thimbleweed)
Delphinium virescens (prairie larkspur)

Rosaceae (Rose Family)
Fragaria virginiana (wild strawberry)
Potentilla arguta (tall cinquefoil)
Rosa spp. (wild rose)
Santalaceae (Sandalwood Family)
Comandra umbellata (bastard toadflax)

Saxifragaceae (Saxifrage Family)
Heuchera richardsonii (alumroot)

Solanaceae (Nightshade Family)
Physalis heterophylla (clammy ground-cherry)
Physalis virginiana (Virginia ground-cherry)

Verbenaceae (Vervain Family)
Verbena stricta (hoary vervain)

Violaceae (Violet Family)
Viola pedatifida (prairie violet)
Viola palmata* (prairie violet)

ANGIOSPERMS (MONOCOTS)

Commelinaceae (Spiderwort Family)
Tradescantia bracteata (spiderwort)

Cyperaceae (Sedge Family)
Carex cf brevior
Carex gravis
Carex meadii

Iridaceae (Iris Family)
Sisyrinchium campestre (blue-eyed grass)

Liliaceae (Lily Family)
Hypoxis hirsuta (stargrass)

Orchidaceae (Orchid Family)
Spiranthes cf magnicamporum (great plains ladie's tresses)

Poaceae (Grass Family)
Andropogon gerardii (big bluestem)
Bouteloua curtipendula (side-oats grama)
Dicanthelium acuminatum var. implicatum
Dicanthelium oligosanthes var. scribnerianum
Eragrostis spectabilis (purple lovegrass)
Muhlenbergia cuspida (plains muhley)
Schizachyrium scoparium (little bluestem)
Sporobolus asper (tall dropseed)
Sporobolus heterolepis (prairie dropseed)
RAYMOND PRAIRIE
RAYMOND PRAIRIE

(QUALITY REGIONS)
RAYMOND PRAIRIE
(DOMINANT WOODY VEGETATION-SOUTH)
Quarries

A number of "B" and "C" quality woodlands occur in the vicinity of quarries on both sides of the Skunk River.

On the east side of the Skunk River, a large "B" quality floodplain forest occurs between the river and a series of steep slopes. The south portion of this is especially interesting, with large, dominant silver maples in the canopy. Diversity of trees, saplings and shrubs is average to good throughout the floodplain.

Most of the slopes on the east side of the Skunk River support "C" quality woodlands. These are actively pastured in a few places, but mostly the quality of these wooded tracts reflects the effects of past grazing and/or cutting. The canopy in many places contains a mixture of typical (e.g. red oak, white oak, black maple) and non-typical (e.g. black walnut, honey locust, elom) tree species. Likewise, expected ironwood saplings compete with non-naturally occurring saplings like hackberry and elm in the understory. Species diversity is only average in most places in these regions.

On the west side of the Skunk River, a steep east-facing slope supports a "B" quality woodland. Here, such expected canopy trees as red oak, white oak, black maple, basswood and shagbark hickory vie for dominance, while ironwood and bladdernut saplings are prevalent in the understory. Nonexpected saplings (e.g. hackberry) are occasionally conspicuous in the understory of this woodland, lowering it's overall quality.

The "B" quality floodplain adjacent to the slope just described (west side of the Skunk River) has almost all typical species, but tree and sapling diversity is only average in places.

The "C" and "D" quality woodlands on the west side of the Skunk have nontypical species dominant in the canopy and understory, evidence of past cutting and/or grazing.
QUARRIES
QUARRIES

(QUALITY REGIONS)
Dayton Avenue

Wooded slopes occur along a tributary of the Skunk River just west of Dayton Avenue.

The most interesting woodland on this map is the eastern "B" quality woodland. A very attractive stand of white oak, red oak, and shagbark hickory is found on the south-facing slopes and the ridge above them in this region, while ironwood is the dominant sapling throughout the understory. The only flaws in this woodland are an overgrown understory with a somewhat average diversity of saplings, shrubs and vines.

A high number of prairie plants can be found on the ridge in the above tract, including gray-headed coneflower (*Ratibida pinnata*), black-eyed Susan (*Rudbeckia hirta*), leadplant (*Amorpha canescens*), round-headed bush clover (*Lespedeza capitata*), pussy toes (*Antennaria neglecta*), Culver's root (*Veronicastrum virginicum*), big-blue stem (*Andropogon gerardii*) and New Jersey tea (*Ceanothus americanus*). Furthermore, an orchid (fall coralroot: *Corallorhiza odontorhiza*) blooms here in autumn.

The other (western) "B" quality region on the map is similar to that above, except that black maple and basswood are occasionally the dominant canopy trees on the slopes. This woodland does not possess the high diversity of prairie plants found on the former tract.

The "C" quality tracts have some natural vegetation, but in either canopy or understory of all of these can be found non-naturally occurring vegetation that indicates past cutting and/or grazing. For example, honey locust (typical in floodplain forests but not slopes and ridgetops) is codominant in the canopy of at least three of the "C" quality regions on the map, while an introduced shrub (Tartarian honeysuckle) and two non-typical saplings (hackberry and elm, expected in bottomlands but not on slopes and ridgetops) are frequently conspicuous in the understories of the "C" quality woodlands.
DAYTON AVENUE

(QUALITY REGIONS)
Riverside (North)

Wooded north and northwest-facing slopes occur just north of Riverside and west of an access road (extension of Stagecoach Road) into a quarry.

The majority of these woods are "C" quality. The canopy is intact throughout this region, with black maple dominating the north-facing slopes and shagbark hickory, red oak and basswood forming the canopy on the northwest-facing slopes here. However, the understory has been severely altered by past grazing, with non-naturally occurring vegetation (i.e. elm, hackberry, Tartarian honeysuckle) vying for dominance with more typical ironwood saplings throughout. Diversity of trees in the canopy and saplings, shrubs and vines in the understory is average to low in this woodland.

A small "A" quality woodland occurs adjacent to the quarry on this map. This tract is diverse with typical species dominating both canopy (black maple, red oak, basswood) and understory (ironwood and black maple saplings).

An uncommon wildflower for central Iowa was found only in the "C" quality woodland during this inventory: Jacob's ladder (*Polemonium reptans*).
RIVERSIDE (NORTH)
(QUALITY RATINGS)
RIVERSIDE (NORTH)
(DOMINANT WOODY VEGETATION)
Riverside (South)

A series of slopes bounded by Stagecoach Road to the east and Riverside to the north supports mature oak woodlands of varying quality.

The highest quality region on these tracts ("B" quality level) has large white oaks dominant in the canopy, with lesser amounts of bur oak and red oak present also. The understory here contains substantial amounts of naturally occurring ironwood, but mixed in with it are nontypical saplings and shrubs (i.e. hackberry, elm and prickly ash) which indicate past grazing on these slopes. The presence of these grazing indicators lowers the overall quality of this woodland.

The "C" quality tracts on the map are similar to the "B" tract (with dominant oaks in their canopies) but the understories of all three are dominated by saplings and shrubs not typical of high quality wooded slopes (hackberry, elm, prickly ash and Tartarian honeysuckle).

The "D" quality woodland have non-typical vegetation in both canopy and understory. The southern-most of the "D" regions is largely open, with grassy fields replacing the oak woodlands occurring in the "C" and "B" quality areas north of it.

Several uncommon herbs occur on these slopes. In the wooded areas, a prairie plant (Culver's root: *Veronicastrum virginicum*) is frequent underneath the oak trees. In these same areas can be found the dissected grape fern (*Botrychium dissectum* var. *obliquum*), which is one of two known sites for this species in Ames (a first county record for this fern). Finally, a state threatened plant occurs on slopes in the large "D" quality region: ladies's tresses (*Spiranthes ovalis*). The preferred habit for this orchid is disturbed woodlands, and this is precisely where it occurs here: beneath a dense thicket of shrubs.
RIVERSIDE (SOUTH)

(QUALITY REGIONS)
RIVERSIDE (SOUTH)

(QUALITY RATINGS)
RIVERSIDE (SOUTH)
(DOMINANT WOODY VEGETATION)
Old Bloomington Road (North)

A sequence of steep southwest-facing slopes occurs just west of Stagecoach Road, mostly north of Old Bloomington Road. These support a rather uniform woodland of "C" quality. The dominant trees in this woodland are expected species for such a habitat: shagbark hickory, red oak, white oak and bur oak. However, the understory contains a mixture of typical (ironwood) and nontypical (hackberry, elm) saplings throughout the tract, indicating a past disturbance (i.e. grazing).

In the "D" quality region, both the canopy and the understory contain nontypical species as dominants. For example, cottonwood and honey locust are conspicuous (but unexpected) canopy components on the northwest-facing slopes in this area, while an introduced shrub, Tartarian honeysuckle, is very evident in the understory here. This region therefore possess less natural quality than the "C" quality area on the map.

An uncommon orchid, fall coral root (*Corallorhiza odontorhiza*) was encountered on the northwest-facing slopes shown at the top of this map.
OLD BLOOMINGTON ROAD (NORTH)
OLD BLOOMINGTON ROAD (NORTH)
(QUALITY REGIONS)
OLD BLOOMINGTON ROAD (NORTH)
(QUALITY RATINGS)
OLD BLOOMINGTON ROAD (NORTH)
(DOMINANT WOODY VEGETATION)
Old Bloomington Road (South)

Bounded by Old Bloomington Road to the north and Stagecoach Road to the west, a large woodland tract occupies wide ridgetops and steep slopes. This woodland is not of uniform vegetative quality, due no doubt to past grazing and cutting of trees from existing natural forest.

The highest quality segment ("B") of this woodland tract occurs due south of Old Bloomington Road. Large white oak trees are dominant in the canopy of the flat wooded ridgetop here, while ironwood is the dominant sapling in the understory. Past grazing on this ridgetop is indicated by the conspicuous presence of such shrubs as prickly ash and gooseberry in some areas.

A variety of expected trees are the dominants on the slopes within the "B" quality region: several oak species, basswood and black maple, with ironwood again the dominant sapling in the understory. Several interesting wildflowers occur on these slopes and in the drainage area below. For example, the largest population of ginseng (*Panax quinquefolia*) encountered during this inventory occurs here, as well as several other uncommon woodland herbs: spikenard (*Aralia racemosa*) and red baneberry (*Actaea rubra*).

The "C" quality regions on this map tend also to have mature canopies of bur oak and shagbark hickory with ironwood dominant underneath, but overall diversity of trees, saplings and shrubs is lower here than in the "B" quality region. Furthermore, undesirable shrubs (*i.e.* Tartarian honeysuckle, prickly ash, gooseberry) are very conspicuous in many places throughout these regions. The presence of these shrubs indicates that extensive grazing occurred here in the past to disturb the native vegetation.
The northwestern parcel (on the map) of "C" quality woodland has numerous gaps in the canopy, especially where the slopes overlook Stagecoach Road. Several prairie plants are currently growing in these openings, including leadplant (*Amorpha canescens*) and side-oats grama (*Bouteloua curtipendula*).

In the "D" quality areas, both the canopy and the understory have dominant non-typical species in them. For example, in the "D" quality area at the south end of the map, the canopy is dominated by elm, honey locust and cottonwood. Apparently, the naturally occurring oaks, maples and basswood were cut at some time in the past here.

This entire wooded tract has a very uncommon tree (for Ames) growing in it: black oak. This tree was found only on the wooded slopes overlooking Stagecoach Road (this one and several others described elsewhere in this thesis) during this inventory.
OLD BLOOMINGTON ROAD (SOUTH)
OLD BLOOMINGTON ROAD (SOUTH)
(QUALITY REGIONS)
OLD BLOOMINGTON ROAD (SOUTH)

(QUALITY RATINGS)
OLD BLOOMINGTON ROAD (SOUTH)

(DOMINANT WOODY VEGETATION)
Izaak Walton League

A large recreational complex exists in the property owned by the Izaak Walton League. The woodlands have been altered to accommodate the many activities (archery, target shooting, boating, etc.) that occur here. Technically, most of the vegetation on Izaak Walton grounds would have to be classified as "highly altered" ("D" quality level) but this property is more appropriately designated as a special resource ("S") to recognize its importance to the Ames community.

Most of the private land to the north of the Izaak Walton League property supports "C" quality woodlands. Mature bur oaks are dominant in most places here, but the understory dominants (hackberry, elm, prickly ash, Tartarian honeysuckle) are not natural and indicate heavy past grazing in these woodlands.

A small parcel of good quality ("B") woodlands exists in this area. The north-facing slopes that occur here have dominant basswood and red oak in the canopy, while ironwood is the dominant sapling in the understory.

An ancient peat deposit, the "Ames Bog", occurs near the "B" quality woodland. It has been thoroughly studied by geologists and paleontologists who have excavated many fossils and pollen cores from the site.
South Stagecoach Road

Several wooded tracts occur just north of 13th Street at the south end of Stagecoach Road.

A "C" quality woodland occurs on slopes at the immediate junction of 13th Street and Stagecoach Road. The canopy here contains large white oak and shagbark hickory, but the understory is largely composed of nontypical saplings and shrubs (elm, black walnut, hackberry and Tartarian honeysuckle) that indicate past disturbance (e.g. logging, grazing) on this site.

Just south of the Izaak Walton League property and adjacent to Stagecoach Road is another "C" quality woodland. Bur oak is the dominant canopy tree on these slopes and is expected here, but an introduced shrub, Tartarian honeysuckle, grows abundantly in the understory. This is evidence that these slopes were grazed heavily in the past.

A small drainage area immediately east of the above woodland contains no expected vegetation, and hence is "D" quality.
SOUTH STAGECOACH ROAD

(QUALITY REGIONS)
SOUTH STAGECOACH ROAD

(QUALITY RATINGS)
SOUTH STAGECOACH ROAD

(DOMINANT WOODY VEGETATION)
Inis Grove Park-Homewood Golf Course

An attractive woodland exists on a high ridge and steep northeast-facing slopes overlooking the Skunk River in Inis Grove Park and Homewood Golf Course. A narrow floodplain separates the slopes from the river in most places.

The majority of the woodlands found on the slopes are "B" quality. The vegetation found here is quite natural for a slope habitat, except for the occasional presence of Tartarian honeysuckle (an introduced shrub) in the understory. Black maple, red oak and basswood are all found in the canopy here, while ironwood and black maple saplings are the dominant components of the understory in most places. This slope is highly eroded with no woody vegetation whatsoever in some places (particularly toward the north end of the slope on the map).

The ridgetop above the slopes, when trees are present, also supports "B" quality woods. Large, mature white oaks (and some red oak) are the dominant trees here, with ironwood being far and away the most dominant sapling in the understory.

The bottomland contains mostly typical species in the canopy (e.g. cottonwood, black willow, silver maple, etc . . . ) but the understory shows signs of disturbance with conspicuous introduced shrubs like tartarian honeysuckle and white mulberry in many places (particularly in the "C" region on the map).

A northern wildflower, wild sarsaparilla (*Aralia nudicaulis*), was encountered only underneath oak trees on the ridge adjacent to the golf course during the inventory.
INIS GROVE PARK-HOMESTEAD GOLF COURSE
Ft. TOW  

INIS GROVE PARK-HOMESTEAD GOLF COURSE  
(QUAlITY REGIONS)
INIS GROVE PARK-HOMESTEAD GOLF COURSE
(QUALITY RATINGS)
INIS GROVE PARK-HOMESTEAD GOLF COURSE
(DOMINANT WOODY VEGETATION)
River Valley Park

A large continuous floodplain forest ("B" quality level) occurs in River Valley Park on the east side of the Skunk River. Additional floodplain forest occurs north of and adjacent to the park, and is likewise "B" quality forest.

The canopy of this forest contains a good diversity of trees characteristic of bottomlands. Many large black walnuts occur in the private property north of River Valley Park. A good diversity of typical saplings and shrubs occurs in the understory, but the occasional dominance of such shrubs as Tartarian honeysuckle (nonnative) and gooseberry indicates that this forest was subject to grazing in the past. This evidence of disturbance in the understory lowers the overall quality of the woodland.

River Valley Park is one of the few sites in Ames where an uncommon herb, ginseng (*Panax quinquefolia*), was found during this inventory.
RIVER VALLEY PARK

(QUALITY REGIONS)
Ketelsen Marsh

Ketelsen Marsh is located just east of I-35 and north of 13th Street. It is a bonafide wetland complex, with several prairie potholes (true wetland vegetation) surrounded by strips of prairie vegetation.

This region shall be declared a special resource ("S") for several reasons. One, there is no other comparable wetland area in the project boundary, hence no basis for knowing what each of the four customary quality ratings (i.e. "A", "B", "C", "D") would mean if assigned to this site. Two, much of the prairie vegetation was planted here about a decade ago. Hence, while the Ketelsen prairie is a valuable natural resource, it can not rightfully be compared to the other, native prairies in Ames.
Holub Prairie

An "A" quality prairie occurs just south of the Holub Greenhouse (the greenhouse is located on 13th Street, approximately 1.5 miles east of I-35). At least 54 prairie plants occur here, many of them species characteristic of wet prairies. Included among these are two orchids (*Spiranthes cernua* and *Spiranthes magnicamporum*) and several other prairie plants found nowhere else in Ames: a sedge (*Carex frankii*), ditch stonecrop (*Penthorum sedoides*), and common agalinus (*Agalinus tenuifolia*).

Viewed from the road, the Holub prairie does not immediately impress one as being a high quality prairie because the site also supports a sizable stand of young trees. Removal of these trees would enhance the character of this prairie.
Native Prairie Plant Species of Holub's Prairie

Species listed were observed in the field by William R. Norris at Holub's Prairie during the Ames Natural Areas Inventory (1991-95). A "prairie" species is one that occurs in a list of Iowa prairie plant species compiled by John Pearson of the Iowa DNR, except for species denoted with an (*). Nomenclature follows Eilers and Roosa (1994), except for Viola palmata and Viola pedatifida which follow Gleason and Cronquist (1991).

PTERIDOPHYTES

Equisetaceae (Horsetail family)
Equisetum hyemale* (common scouring rush)

ANGIOSPERMS (DICOTS)

Apiaceae (Carrot Family)
Zizia aureus (golden alexander)

Apocynaceae (Dogbane Family)
Apocynum cannabinum var. pubescens (Indian hemp)

Asclepiadaceae (Milkweed family)
Asclepias verticillata (whorled milkweed)
Asclepias incarnata* (marsh milkweed)

Asteraceae (Daisy Family)
Aster ericoides (heath aster)
Aster pilosus (hairy aster)
Bidens comosa* (beggar's ticks)
Bidens tripartita
Cirsium altissimum (tall thistle)
Cirsium discolor (field thistle)
Erigeron strigosus (rough fleabane)
Eupatorium altissimum (tall eupatorium)
Euthamia graminifolia (common flat-topped aster)
Helianthus X laetiflorus (sunflower)
Lactuca canadensis* (wild lettuce)
Liatris pycnostachya (prairie blazing star)
Ratibida pinnata (grey-headed coneflower)
Silphium laciniatum (compass plant)
Solidago canadensis (Canada goldenrod)
Solidago gigantea* (smooth goldenrod)
Solidago rigida (rigid goldenrod)

Lamiaceae (Mint Family)
Monarda fistulosa (horsemint)
Lycopus americanus* (water horehound)
Teucrium canadense var. virginicum (American germander)

Lythraceae (Loosestrife Family)
Lythrum alatum (prairie loosestrife)

Onagraceae (Evening Primrose Family)
Epilobium coloratum (cinnamon willowherb)
Oenothera biennis (evening primrose)

Polemoniaceae (Phlox Family)
Phlox pilosa (prairie phlox)

Polygonaceae (Smartweed Family)
Polygonum smartweed* (water smartweed)
Polygonum lapathifolium*
Polygonum pensylvanicum var. laevigatum*
(Pensylvanica smartweed)

Ranunculaceae (Buttercup Family)
Anenome cylindrica (thimbleweed)
Thalictrum dasyarcmum (tall meadowrue)

Rosaceae (Rose Family)
Fragaria virginiana (wild strawberry)
Rosa spp. (prairie rose)

Santalaceae (Sandalwood Family)
Comandra umbellata (bastard toadflax)

Saxifragaceae (Saxifrage Family)
Penthorum sedoides (ditch stonecrop)

Scrophulariaceae (Figwort Family)
Agalinus tenuifolia (agalinus)
Veronicastrum virginicum (Culver’s root)

Solanaceae (Nightshade Family)
Physalis heterophylla (clammy ground-cherry)
Physalis virginiana (Virginia ground-cherry)

Verbenaceae (Vervain Family)
Verbena stricta (hoary vervain)

ANGIOSPERMS (MONOCOTS)

Cyperaceae (Sedge Family)
Carex bicknellii
Carex brevior
Carex frankii
Carex vulpinoidea
Cyperaceae (continued)
*Eleocharis* spp. (spikerush)
*Scirpus atrovirens*  
*Scirpus pendulus*

**Juncaceae (Rush Family)**
*Juncus dudleyii*  
*Juncus torreyi*

**Orchidaceae (Orchid Family)**
*Spiranthes cernua* (nodding ladies's tresses)  
*Spiranthes magnicamporum* (great plains lady's tresses)

**Poaceae (Grass Family)**
*Andropogon gerardii* (big bluestem)  
*Dicanthelium* spp.  
*Elymus canadensis* (Canada wild rye)  
*Muhlenbergia frondosa* (muhley)  
*Panicum virgatum* (switch grass)  
*Spartina pectinata* (cordgrass)  
*Sporobolus asper* (tall dropseed)

**Typhaceae (Cattail Family)**
*Typha angustifolia* (narrow-leaved cattail)
Stargrass Prairie

A 26-acre prairie occurs in the southwest corner of Section 17 in Grant Township. Over 100 prairie plants occur on this site, making Stargrass the most diverse prairie occurring within the boundaries of this inventory. Since this prairie was essentially reconstructed from seeds and rootstocks of prairie plants collected off-site, Stargrass is designated a special resource ("S").

Although some of the prairie plants found in the Stargrass Prairie occur naturally, many others were either grown from local seed (all collected within 20 miles of this site) or from soil plugs collected from local prairie remnants (none further than 35 miles from Stargrass). Many of the prairie remnants from where these prairie seeds and soil plugs were collected are now destroyed, making Stargrass an important reservoir of local prairie genotypes.
Skunk River (South of US-30)

Substantial bottomland forest occurs along the Skunk River south of US-30.

Most of this forest is "B" quality. The large parcel of "B" quality forest east of the Skunk River is unique in that it possesses an extensive stand of large bur oak trees in the canopy, best developed on the northern end of the parcel. Elm and hackberry saplings are dominant in the understory here.

The narrow strips of "B" quality forest that occur in the bends of the Skunk River (both sides) have silver maple dominant in the canopy and boxelder predominant in the understory.

The crooked tract of "B" quality forest on the west side of the river contains a good diversity of trees in the canopy, with no one species dominant throughout the tracts. However, the understory is uniformly dominated by hackberry saplings in this woodland.

The "C" quality woodland in this map is characterized by having the understory completely absent in many places, no doubt removed by the recent flooding in the area.
SKUNK RIVER (SOUTH OF US-30)

(QUALITY REGIONS)
SKUNK RIVER (SOUTH OF US-30)
(DOMINANT WOODY VEGETATION)
Ken Maril Road (North)

Extensive bottomland forests occur along the Skunk River immediately north of Ken Maril Road

The two "B" quality forests on this map have good diversity of trees in the canopy and saplings in the understory. Significantly, almost no introduced shrubs (e.g. Tartarian honeysuckle) are present to compete with native shrubs in the understory in these two regions.

The narrow, sinuous "C" quality forest on the south portion of this map is likewise free of introduced species, but diversity is average to low here. The dominant canopy trees are silver maple and cottonwood.
KEN MARIL ROAD (NORTH)

(QUALITY REGIONS)
KEN MARIL ROAD (NORTH)

(QUALITY RATINGS)
KEN MARIL ROAD (NORTH)
(DOMINANT WOODY VEGETATION)
Ken Maril Road (South)

A series of narrow strips of bottomland forest occur along the Skunk River immediately south of Ken Maril Road.

Most of the forested strips are "C" quality. Dominant canopy trees are cottonwood and silver maple while boxelder saplings are dominant in the understory. These strips of forest are only "C" quality because they are not very diverse. Nonetheless, the vegetation occurring here is more natural than that found in most other bottomland forests in Ames because introduced shrubs (e.g. Tartarian honeysuckle) are virtually absent in the understory.
KEN MARIL ROAD (SOUTH)

(QUALITY REGIONS)
KEN MARIL ROAD (SOUTH)

(QUALITY RATINGS)
KEN MARIL ROAD (SOUTH)

(DOMINANT WOODY VEGETATION)
South Skunk River

A variety of vegetation types occurs along the Skunk River at the southern extreme of the project area.

A prairie ("C" quality) occurs on a northeast-facing slope overlooking the Skunk River. This prairie contains between 20 and 30 prairie species, almost all prairie wildflowers. Curiously, almost no prairie grasses occur on this site.

A long northeast-facing slope overlooking the Skunk River supports a "D" quality woodland. This slope is densely overgrown with trees, saplings and shrubs more characteristic of floodplains, such as elm, hackberry, walnut, and boxelder. The former natural vegetation on this slope was probably logged off in the past.

The floodplain immediately adjacent to the Skunk River contains typical bottomland vegetation. Dominant trees in the canopy include cottonwood, boxelder and silver maple. These narrow woodlands are not exceedingly diverse, however, and hence are classified as "B" and "C" quality.
Native Prairie Plant Species of the South Skunk River Prairie

Species listed were observed in the field by William R. Norris at the South Skunk River Prairie during the Ames Natural Areas Inventory (1991-95). A "prairie" species is one that occurs in a list of Iowa prairie plant species compiled by John Pearson of the Iowa DNR, except for species denoted with an (*). Nomenclature follows Eilers and Roosa (1994), except for *Viola palmata* and *Viola pedatifida* which follow Gleason and Cronquist (1991).

ANGIOSPERMS (DICOTS)

Asclepiadaceae (Milkweed family)
*Asclepias verticillata* (whorled milkweed)

Asteraceae (Daisy Family)
*Ambrosia psilostachya* (western ragweed)
*Aster ericoides* (heath aster)
*Aster pilosus* (hairy aster)
*Cirsium altissimum* (tall thistle)
*Cirsium discolor* (field thistle)
*Echinacea pallida* (pale purple coneflower)
*Erigeron strigosus* (rough fleabane)
*Ratibida pinnata* (grey-headed coneflower)
*Rudbeckia hirta* (black-eyed susan)
*Solidago canadensis* (Canada goldenrod)
*Solidago rigida* (rigid goldenrod)

Fabaceae (Bean Family)
*Dalea purpurea* (purple prairie clover)
*Lespedeza capitata* (round-head bush clover)

Lamiaceae (Mint Family)
*Monarda fistulosa* (horsemint)
*Pycnanthemum virginianum* (Virginiana mountain mint)

Lythraceae (Loosestrife Family)
*Lythrum alatum* (prairie loosestrife)

Primulaceae (Primrose Family)
*Lysimachia ciliata* (fringed loosestrife)

Ranunculaceae (Buttercup Family)
*Anemone cylindrica* (thimbleweed)

Solanaceae (Nightshade Family)
*Physalis heterophylla* (clammy ground-cherry)

ANGIOSPERMS (MONOCOTS)

Cyperaceae (Sedge Family)
*Carex* spp.

Poaceae (Grass Family)
*Dicanthelium* spp.
SOUTH SKUNK RIVER
(QUALITY REGIONS)
SOUTH SKUNK RIVER

(QUALITY RATINGS)
SOUTH SKUNK RIVER

(DOMINANT WOODY VEGETATION)
Black's Prairie

Black's Prairie occurs on the east side of State Avenue about 1.5 miles north of the town of Kelly. It is a small prairie, surrounded by cropfields, that exists alongside an old railroad grade.

At least 64 species of native prairie species can be found at Black's Prairie, justifying its rating as an "A" quality site. Many of the plants found here are typical of wet prairie sites, including a number of wetland grass and sedge species. One plant, Sullivant's milkweed (*Asclepias sullivantii*), was found only at Black's Prairie during the inventory.

Aside from a small patch of shrubs in the middle of the prairie, Black's Prairie is an attractive native grassland. Its accessible location makes it a valuable outdoor lab for area schools.
Native Prairie Plant Species of Black's Prairie

Species listed were observed by William R. Norris at Black's Prairie during the Ames Natural Areas Inventory (1991-95). A "prairie" species is one that occurs in a list of Iowa prairie plant species compiled by John Pearson of the Iowa DNR, except for species denoted with an (*). Nomenclature follows Eilers and Roosa (1994), except for Viola palmata and Viola pedatifida which follow Gleason and Cronquist (1991).

PTERIDOPHYTES

Equisetaceae (Horsetail family)
Equisetum X femssU* (hybrid scouring rush)
Equisetum laevigatum (smooth scouring rush)

ANGIOSPERMS (DICOTS)

Apiaceae (Carrot Family)
Eryngium yuccifolium (rattlesnake master)
Zizia aureus (golden alexander)

Apocynaceae (Dogbane Family)
Apocynum cannabinum var. pubescens (Indian hemp)

Asclepiadaceae (Milkweed family)
Asclepias sullivantii (Sullivant's milkweed)

Asteraceae (Daisy Family)
Aster ericoides (heath aster)
Aster laevis (smooth blue aster)
Aster pilosus (hairy aster)
Cacalia plantaginea (Indian plantain)
Cirsium altissimum (tall thistle)
Cirsium discolor (field thistle)
Eupatorium altissimum (tall eupatorium)
Helianthus grosseserratus (saw-toothed sunflower)
Helianthus X laetiflorus (sunflower)
Heliotropis helianthoides (ox-eye)
Lactuca canadensis* (wild lettuce)
Liatris pycnostachya (prairie blazing star)
Ratibida pinnata (grey-headed coneflower)
Rudbeckia hirta (black-eyed Susan)
Silphium lacinatum (compass plant)
Solidago canadensis (Canada goldenrod)
Solidago rigida (rigid goldenrod)

Boraginaceae (Borage Family)
Lithospermum canescens (hoary puccoon)

Campanulaceae (Bellflower Family)
Lobelia spicata (pale-spire lobelia)

Fabaceae (Bean Family)
Dalea purpurea (purple prairie clover)
Desmodium canadense (hoary tick clover)
Lespedeza capitata (round-head bush clover)

Lamiaceae (Mint Family)
Monarda fistulosa (horsemint)
Pytenanthemum virginianum (Virginiana mountain mint)
Scutellaria leonardii (small skullcap)

Onagraceae (Evening Primrose Family)
Oenothera biennis (evening primrose)

Oxalidaceae (Wood Sorrel Family)
Oxalis violacea (violet wood sorrel)

Polemoniaceae (Phlox Family)
Phlox pilosa (prairie phlox)

Ranunculaceae (Buttercup Family)
Anenome cylindrica (thimbleweed)
Thalictrum dasycarpum (tall meadowrue)

Rosaceae (Rose Family)
Fragaria virginiana (wild strawberry)
Rosa spp. (wild rose)

Rubieae (Madder Family)
Galium obtusum (wild madder)

Santalaceae (Sandalwood Family)
Comandra umbellata (bastard toadflax)

Scrophulariaceae (Figwort Family)
Veronicastrum virginicum (Culver's root)

Solanaceae (Nightshade Family)
Physalis spp. (ground cherry)

Verbenaceae (Vervain Family)
Verbena stricta (hoary vervain)

Violaceae (Violet Family)
Viola pedatifida (prairie violet)
ANGIOSPERMS (MONOCOTS)

Commelinaceae (Spiderwort Family)
*Tradescantia bracteata* (spiderwort)

Cyperaceae (Sedge Family)
*Carex bicknelli*
*Carex buxbaumii*
*Carex grvida*
*Carex haydenii*
*Carex meadii*
*Carex molesta*
*Carex vulpinoidea* *
*Eleocharis* spp. (spikerush)

Juncaceae (Rush Family)
*Juncus dudleyii*

Iridaceae (Iris Family)
*Sisyrinchium campestre* (blue-eyed grass)

Liliaceae (Lily Family)
*Hypoxis hirsuta* (stargrass)

Poaceae (Grass Family)
*Andropogon gerardii* (big bluestem)
*Calamagrostis canadensis* (bluejoint)
*Dicanthemium* spp.
*Dicanthemium oligosanthes* var. *scribnerianum*
*Elymus canadensis* (Canada wild rye)
*Panicum virgatum* (switch grass)
*Schizachyrium scoparium* (little bluestem)
*Sorghastrum nutans* (Indian grass)
*Spartina pectinata* (cordgrass)
*Sporobolus heterolepis* (prairie dropseed)
*Stipa spartea* (needlegrass)
Adams Prairie

A high ("A") quality prairie exists along an abandoned railroad grade that intersects Elwood Drive just after it becomes a dirt road when one travels south on it.

The Adams Prairie is a moist prairie, very similar to the R-38 railroad prairie described elsewhere in this report. At least 68 native prairie plants occur here, including many sedges, bulrushes, and other semi-aquatic plants. While most of the prairie plants found on the Adams Prairie can be found somewhere else on a prairie in Ames, there are very few other local prairies that have so many altogether on one site like this one. Particularly striking in the fall are the blooming bottle and downy gentians that occur here.
Native Prairie Plant Species of the Adams Prairie

Species listed were observed at the Adams Prairie by William R. Norris during the Ames Natural Areas Inventory (1991-95). A "prairie" species is one that occurs in a list of Iowa prairie plant species compiled by John Pearson of the Iowa DNR, except for species denoted with an (*). Nomenclature follows Eilers and Roosa (1994), except for Viola palmata and Viola pedatifida which follow Gleason and Cronquist (1991).

PTERIDOPHYTES

Equisetaceae (Horsetail family)
*Equisetum X ferrissii (hybrid scouring rush)*

ANGIOSPERMS (DICOTS)

Apiaceae (Carrot Family)
*Eryngium yuccifolium (rattlesnake master)
*Cicuta maculata (Water Hemlock)
*Zizia aureus (golden alexander)

Apocynaceae (Dogbane Family)
*Apocynum cannabinum var. pubescens (Indian hemp)

Asteraceae (Daisy Family)
*Aster azureus (azure aster)
*Aster ericoides (heath aster)
*Aster laevis (smooth blue aster)
*Aster lanceolatus ssp. simplex (panicled aster)
*Aster novae-angliae (New England aster)
*Aster pilosus (hairy aster)
*Cirsium altissimum (tall thistle)
*Cirsium discolor (field thistle)
*Coreopsis palmata (finger coreopsis)
*Helianthus grosseserratus (saw-toothed sunflower)
*Helianthus X laetiflorus (sunflower)
*Helianthus helianthoides (ox-eye)
*Lactuca canadensis (wild lettuce)
*Liatris pycnostachya (prairie blazing star)
*Ratibida pinnata (grey-headed coneflower)
*Senecio plattensis (prairie ragwort)
*Silphium laciniatum (compass plant)
*Solidago canadensis (Canada goldenrod)
*Solidago gigantea (smooth goldenrod)

Asteraceae (continued)
*Solidago rigida (rigid goldenrod)

Boraginaceae (Borage Family)
*Lithospermum canescens (hoary puccoon)

Cornaceae (Dogwood Family)
*Coronaria americana (Virginia dogwood)

Euphorbeaceae (Spurge Family)
*Euphorbia corollata (flowering spurge)

Fabaceae (Bean Family)
*Lathyris palustris (marsh vetchling)

Gentianaceae (Gentian Family)
*Gentiana andrewsii (bottle gentian)
*Gentiana puberulenta (downy gentian)

Lamiaceae (Mint Family)
*Monarda fistulosa (horsemint)
*Pycnanthemum virginianum (Virginia mountain mint)
*Teucrium canadense (wild germander)

Onagraceae (Evening Primrose Family)
*Oenothera biennis (evening primrose)

Polemoniaceae (Phlox Family)
*Phlox pilosa (prairie phlox)

Polygonaceae (Smartweed Family)
*Polygonum amphibium (water smartweed)
*Polygonum lapathifolium (dock-leaved smartweed)
*Polygonum pensylvanicum (Pennsylvania smartweed)

Primulaceae (Primrose Family)
*Lysimachia quadriflora (loosestrife)

Ranunculaceae (Buttercup Family)
*Anemone canadensis (Canada anenome)
*Anemone cylindrica (Thimbleweed)
*Anemone virginiana (tall anenome)
*Ranunculus spp. (prairie buttercup)
*Thalictrum dasycarpum (tall meadowrue)
Rosaceae (Rose Family)
  *Fragaria virginiana* (wild strawberry)
  *Rosa* spp. (wild rose)

Rubiaceae (Madder Family)
  *Galium obtusum* (wild madder)

Santalaceae (Sandalwood Family)
  *Comandra umbellata* (bastard toadflax)

Scrophulariaceae (Figwort Family)
  *Pedicularis canadensis* (Prairie lousewort)
  *Veronicastrum virginicum* (Culver’s root)

Violaceae (Violet Family)
  *Viola pedatifida* (prairie violet)
  *Viola palmata* (prairie violet)

ANGIOSPERMS (MONOCOTS)

Commelinaceae (Spiderwort Family)
  *Tradescantia bracteata* (spiderwort)

Cyperaceae (Sedge Family)
  *Carex bicknellii*
  *Carex brevior*
  *Carex buxbaumii*
  *Carex haydenii*
  *Carex lanuginosa*
  *Carex sartwellii*
  *Carex vulpinoidea*
  *Eleocharis* spp. (spikerush)
  *Scirpus atrovirens*

Juncaceae (Rush Family)
  *Juncus dudleyii*

Iridaceae (Iris Family)
  *Iris shrevei* (blue flag)
  *Sisyrinchium campestre* (blue-eyed grass)

Liliaceae (Lily Family)
  *Hypoxis hirsuta* (stargrass)

Poaceae (Grass Family)
  *Andropogon gerardii* (big bluestem)
  *Calamagrostis canadensis* (bluejoint)
  *Dianthelium oligosanthes* var. *scribnerianum*
  *Elymus canadensis* (Canada wild rye)
  *Panicum virgatum* (switch grass)
  *Phalaris arundinacea* (reed canary grass)
  *Poaceae (continued)*
  *Sorghastrum nutans* (Indian grass)
  *Spartina pectinata* (cordgrass)
  *Sporobolus heterolepis* (prairie dropseed)
Svejde Prairie

A "B" quality prairie exists just south of the US-30 overpass near the end of a bicycle trail. At least 32 prairie species were found here during the inventory, none of them unique to this prairie. These plants are scattered on the east side of the bicycle trail among many small, weedy trees.

The casual observer might not recognize the Svejde Prairie as a "prairie" because there is no field of tall, waving grasses to catch the eye. Indeed, one has to get off of the bicycle trail and tramp alongside it to discover the prairie plants among the weeds. Nonetheless, this site has a good diversity of prairie species and thus the potential to be managed into a much more eye-catching prairie than exists now.
Native Prairie Plant Species of Svejde Prairie

Species listed were observed in the field by William R. Norris at Svejde Prairie during the Ames Natural Areas Inventory (1991-95). A "prairie" species is one that occurs in a list of Iowa prairie plant species compiled by John Pearson of the Iowa DNR, except for species denoted with an (*). Nomenclature follows Eilers and Roosa (1994), except for *Viola palmata* and *Viola pedatifida* which follow Gleason and Cronquist (1991).

PTERIDOPHYTES

Equisetaceae (Horsetail family)
*Equisetum laevigatum* (smooth scouring rush)

ANGIOSPERMS (DICOTS)

Apocynaceae (Dogbane Family)
*Apocynum cannabinum* var. *pubescens* (Indian hemp)

Asteraceae (Daisy Family)
*Aster ericoides* (heath aster)
*Aster lanceolatus* ssp. *simplex* (paniced aster)
*Aster pilosus* (hairy aster)
*Cirsium altissimum* (tall thistle)
*Cirsium discolor* (field thistle)
*Coreopsis palmata* (finger coreopsis)
*Erigeron strigosus* (rough fleabane)
*Helianthus grosseserratus* (saw-toothed sunflower)
*Helianthus X laetiflorus* (sunflower)
*Heliopsis helianthoides* (ox-eye)
*Ratibida pinnata* (grey-headed coneflower)
*Silphium laciniatum* (compass plant)
*Silphium perfoliatum* (cupplant)
*Solidago canadensis* (Canada goldenrod)
*Solidago gigantea* * (smooth goldenrod)
*Solidago rigida* (rigid goldenrod)

Boraginaceae (Borage Family)
*Lithospermum canescens* (hoary pucoon)

Euphorbeaceae (Spurge Family)
*Euphorbia corollata* (flowering spurge)

Fabaceae (Bean Family)
*Lathyrus palustris* (marsh vetchling)

Gentianaceae (Gentian Family)
*Gentiana puberulenta* (downy gentian)

Lamiaceae (Mint Family)
*Monarda fistulosa* (horsemint)

Lythraceae (Loosestrife Family)
*Lythrum alatum* (prairie loosestrife)

Polemoniaceae (Phlox Family)
*Phlox pilosa* (prairie phlox)

Rosaceae (Rose Family)
*Rosa* spp. (wild rose)

Santalaceae (Sandalwood Family)
*Comandra umbellata* (bastard toadflax)

Scrophulariaceae (Figwort Family)
*Veronicastrum virginicum* (Culver's root)

Solanaceae (Nightshade Family)
*Physalis* spp. (ground cherry)

Violaceae (Violet Family)
*Viola palmata* * (prairie violet)

ANGIOSPERMS (MONOCOTS)

Cyperaceae (Sedge Family)
*Carex gravisita* 
*Carex lanuginosa* 
*Carex molesta* 

Juncaceae (Rush Family)
*Juncus dudleyii* 

Iridaceae (Iris Family)
*Sisyrinchium campestre* (blue-eyed grass)

Liliaceae (Lily Family)
*Hypoxis hirsuta* (stargrass)

Poaceae (Grass Family)
*Andropogon gerardii* (big bluestem)
*Panicum virgatum* (switch grass)
*Sorghastrum nutans* (Indian grass)
*Spartina pectinata* (cordgrass)
*Sporobolus heterolepis* (prairie dropseed)
Worrell Creek

Wooded slopes and pasture occur on either side of Worrell Creek between South Dakota Avenue and that property described as the "Curtiss Farm" in this thesis.

All of the woodlands on these slopes have been altered in the past. The canopies of the better quality woodlands (indicated as "C" quality on this map) are dominated by naturally occurring bur oak, but the understory contains many nontypical shrubs such as gooseberry, elm and introduced honeysuckle. Heavy past grazing is indicated by the dominance of these shrubs.

The "D" quality woodlands in the Worrell Creek map are similar to those just described but have even less natural quality. Here, the canopies contain many nontypical trees in addition to bur oak, such as green ash, black locust and American elm. Again, heavy past grazing is indicated.

Two reconstructed prairies occur just north of Worrell Creek. These contain many native prairie species which were planted here, hence the designation of these prairies as special resources ("S").
WORRELL CREEK
WORRELL CREEK

(QUALITY REGIONS)
WORRELL CREEK
(QUALITY RATINGS)
WORRELL CREEK

(DOMINANT WOODY VEGETATION)
Curtiss Farm

Wooded slopes and some floodplain occur on both sides of Worrell Creek immediately west of State Avenue and north of Dartmoor Road.

The "D" quality woodlands in this property have obviously undergone significant tree cutting and grazing in the past. The slopes support woodlands dominated by non-typical trees such as elm, hackberry and black walnut; or else widely spaced open-grown white oaks. In either case, a shrubby understory of gooseberry and Tartarian honeysuckle occurs underneath the trees as evidence of past grazing. Occasionally, these slopes are exposed and highly eroded.

Along the river in this "D" quality region, a weedy field occurs near the east end of this property (adjacent to State Avenue). Moving westward along Worrell Creek from here, the canopy is open and the understory is almost entirely composed of grazing indicators (gooseberry, Tartarian honeysuckle and multiflora rose).

The large "C" quality woodlands in this property also show signs of past grazing (disturbed understory), but the tree canopy is dominated by typical species such as bur oak, white oak and shagbark hickory.

Several small "B" quality woodlands occur along slopes on the south side of Worrell Creek in this property. Here, the canopies contain expected trees such as oak and maple species, while naturally occurring ironwood is a conspicuous component of the understory.
CURTISS FARM

(QUALITY REGIONS)
CURTISS FARM

(QUALITY RATINGS)
CURTISS FARM

(DOMINANT WOODY VEGETATION)
Zumwalt Trail (West)

Much of the property bounded by State Avenue to the east and Dartmoor Road to the north ("D" quality woodlands) contains actively pastured woods, with scattered bur oaks and honey locust in the canopy and multiflora rose in the understory.

A small portion of higher quality woodlands occurs at the south end of the Zumwalt Trail (quality level "B"). Various oak species and basswood occur here in the canopy, while the understory contains a mixture of typical saplings (i.e. ironwood and black cherry) and introduced shrubs (Tartarian honeysuckle).
ZUMWALT TRAIL (WEST)
(DOMINANT WOODY VEGETATION)
Zumwalt Trail (East)

Wooded slopes and floodplains occur just south of the Zumwalt Trail between State Avenue and US-30. Worrell Creek meanders through this property, and when the vegetation was surveyed in 1993 the bridge crossing the creek (part of the Zumwalt Trail) had collapsed.

A small portion of the slopes in this property contain "B" quality woodlands. At least four prairie plants occur underneath the trees here: golden alexander (*Zizia aurea*), pussytoes (*Antennaria neglecta*), Culver's root (*Veronicastrum virginicum*), and a panic grass (*Dicanthusium spp.*) Additionally, a woodland grass very uncommon to Ames is found on this slope: *Brachycletrnum erectum*.

The majority of the woodlands in this property are "C" quality. While the tree canopy on the slopes contains mostly typical species (*e.g.* black maple, basswood, various oaks), the understory is dominated in many places by introduced shrubs such as Tartarian honeysuckle and European buckthorn.

In the "C" quality floodplain forest on either side of Worrell Creek, expected tree species occur in the canopy (cottonwood, black willow, elm, hackberry, green ash, black walnut) but the understory likewise possesses a preponderance of Tartarian honeysuckle. A very uncommon woodland herb occurs in this floodplain: green dragon (*Arisaema dracontium*).

In summary, while some of the slopes contain some natural character (particularly those just south and east of the collapsed bridge), the majority of the woodlands along the Zumwalt Trail show signs of past disturbance (such as grazing).
ZUMWALT TRAIL (EAST)

(QUALITY REGIONS)
ZUMWALT TRAIL (EAST)

(QUALITY RATINGS)
ZUMWALT TRAIL (EAST)

(DOMINANT WOODY VEGETATION)
Gateway Park

Gateway Park is an area of fields and disturbed woodlands bounded by US-30 to the south and Elwood Drive to the east.

The woodlands in the "C" regions occur mostly on slopes. These contain a mixture of typical (i.e. black maple, basswood, red oak) and nontypical (e.g. black walnut, hackberry, green ash, red elm) trees in their canopies.

The canopy of the "D" quality woodland on the slopes at the north end of Gateway Park is dominated by nontypical tree species (black walnut, elm, hackberry). An introduced shrub (Tartarian honeysuckle) is dominant in the understory of this "D" woodland.

The slopes in Gateway Park were probably subjected to heavy grazing and tree cutting in the past, as indicated by the lack of dominant natural vegetation. No significant natural areas occur here.
GATEWAY PARK

(QUALITY REGIONS)
GATEWAY PARK

(QUALITY RATINGS)
GATEWAY PARK

(DOMINANT WOODY VEGETATION)
R-38 Railroad Prairie

A very rich and unique prairie occurs on both sides of a railroad track west of its intersection with R-38 and extending for about a mile.

This prairie is the second most diverse in Ames, with at least 83 native prairie species occurring in it, and hence is "A" quality. This is a wet prairie, in contrast to such local hillside (dry) prairies as the Northridge prairies and the Raymond Prairie. Furthermore, many of the 83 prairie species found here are unique to this prairie in the Ames region. These include rosinweed (*Silphium integrifolium*), glaucous white lettuce (*Prenanthes racemosa*) and stiff gentian (*Gentianella quinquefolia*). Another native prairie plant found here, silvery scurf-pea (*Pediomelum argophyllum*), is found in only one other site in Ames. Additionally, a pair of loggerhead shrikes (a very uncommon grassland songbird species) was found nesting in this prairie during the summer of 1993.

This prairie occurs in a relatively obscure location and is not as well known as most of the others cited in this thesis. Nonetheless, it is as unique as any prairie in Ames. The only potential danger to the vegetation here is if heavy spraying is conducted by the railroad company to remove encroaching brush.
Native Prairie Plant Species of the
R-38 Railroad Prairie

Species listed were observed at the R-38 Railroad Prairie by William R. Norris during the Ames Natural Areas Inventory (1991-95). A "prairie" species is one that occurs in a list of Iowa prairie plant species compiled by John Pearson of the Iowa DNR, except for species denoted with an (*). Nomenclature follows Eilers and Roosa (1994), except for *Viola palmata* and *Viola pedatifida* which follow Gleason and Cronquist (1991).

**PTERIDOPHYTES**

Equisetaceae (Horsetail family)
*Equisetum X ferrissii* (hybrid scouring rush)
*Equisetum hyemale* (common scouring rush)
*Equisetum laevigatum* (smooth scouring rush)

**ANGIOSPERMS (DICOTS)**

Apiaceae (Carrot Family)
*Cicuta maculata* (water hemlock)
*Eryngium yuccifolium* (rattlesnake master)
*Zizia aureus* (golden alexander)

Apocynaceae (Dogbane Family)
*Apocynum cannabinum* var. *pubescens* (Indian hemp)

Asclepiadaceae (Milkweed family)
*Asclepias verticillata* (whorled milkweed)

Asteraceae (Daisy Family)
*Artemisia ludoviciana* (prairie sage)
*Aster ericoides* (heath aster)
*Aster laevis* (smooth blue aster)
*Aster lanceolatus* ssp. *simplex* (panicled aster)
*Aster novae-angliae* (New England aster)
*Aster pilosus* (hairy aster)
*Cacalia plantaginea* (Indian plantain)
*Cirsium altissimum* (tall thistle)
*Cirsium discolor* (field thistle)
*Coreopsis palmata* (finger coreopsis)
*Echinacea pallida* (pale purple coneflower)
*Erigeron strigosus* (rough fleabane)
*Euthamia graminifolia* (common flat-topped aster)
*Heleneum autumnale* (sneezeweed)

Asteraceae (continued)
*Helianthus grosseserratus* (saw-toothed sunflower)
*Helianthus X laetiflorus* (sunflower)
*Heliosis helianthoides* (ox-eye)
*Lactuca canadensis* (wild lettuce)
*Liatis aspera* (rough blazing star)
*Liatis pycnostachya* (prairie blazing star)
*Prenanthes racemosa* (glaucous white lettuce)
*Ratibida pinnata* (grey-headed coneflower)
*Rudbeckia hirta* (black-eyed susan)
*Senecio plattensis* (prairie ragwort)
*Silphium integrifolium* (rosinweed)
*Silphium laciniatum* (compass plant)
*Solidago canadensis* (Canada goldenrod)
*Solidago rigida* (rigid goldenrod)
*Vernonia fasciculata* (ironweed)

Boraginaceae (Borage Family)
*Lithospermum canescens* (hoary puccoon)

Campanulaceae (Bellflower Family)
*Lobelia siphilitica* (great lobelia)

Caprifoliaceae (Honeysuckle Family)
*Symphoricarpos* spp.

Cornaceae (Dogwood Family)
*Cornus* amomum ssp. *obliqua* (silky dogwood)

Euphorbeaceae (Spurge Family)
*Euphorbia corollata* (flowering spurge)

Fabaceae (Bean Family)
*Amorpha canescens* (leadplant)
*Dalea purpurea* (purple prairie clover)
*Desmodium canadense* (hoary tick clover)
*Lathyrus palustris* (marsh vetchling)
*Lespedeza capitata* (round-head bush clover)
*Pediomelum argophyl/um* (silvery scurf pea)

Gentianaceae (Gentian Family)
*Gentiana andrewsii* (bottle gentian)
*Gentianella quinquefolia* ssp. *occidentalis* (stiff gentian)
Lamiaceae (Mint Family)
Lycopus americanus* (water horehound)
Monarda fistulosa (horsemint)
Pycnanthemum virginianum (Virginiana mountain mint)
Scutellaria leonardii (small skullcap)

Lythraceae (Loosestrife Family)
Lythrum alatum (prairie loosestrife)

Onagraceae (Evening Primrose Family)
Oenathera biennis (evening primrose)

Oxalidaceae (Wood Sorrel Family)
Oxalis violacea (violet wood sorrel)

Polemoniaceae (Phlox Family)
Phlox pilosa (prairie phlox)

Polygonaceae (Smartweed Family)
Polygonum amphibium* (water smartweed)
Polygonum pensylvanicum* (Pensylvania smartweed)

Ranunculaceae (Buttercup Family)
Anenome canadensis (Canada anenome)
Ranunculus spp. (prairie buttercup)
Thalictrum dasycarpum (tall meadowrue)

Rosaceae (Rose Family)
Fragaria virginiana (wild strawberry)
Rosa spp. (wild rose)

Rubiaceae (Madder Family)
Galium obtusum (wilder madder)

Santalaceae (Sandalwood Family)
Comandra umbellata (bastard toadflax)

Scrophulariaceae (Figwort Family)
Veronicastrum virginicum (Culver's root)

Solanaceae (Nightshade Family)
Physalis virginiana (Virginia ground-cherry)

Violaceae (Violet Family)
Viola pedatifida (prairie violet)
Viola palmata* (prairie violet)

ANGIOSPERMS (MONOCOTS)

Commelinaceae (Spiderwort Family)
Tradescantia bracteata (spiderwort)

Cyperaceae (Sedge Family)
Carex atherodes*
Carex brevior
Carex buxbaumii
Carex haydenii
Carex lacustris*
Carex laeviconica
Carex lanuginosa
Carex meadii
Carex molesta
Carex sartwellii
Carex vulpinoidea* (spike rush)

Juncaceae (Rush Family)
Juncus dudleyii
Juncus torreyi

Iridaceae (Iris Family)
Iris shrevei (blue flag)
Sisyrinchium campestre (blue-eyed grass)

Liliaceae (Lily Family)
Allium canadense (wild onion)
Hypoxis hirsuta (stargrass)

Orchidaceae (Orchid Family)
Spiranthes magnicamporum (great plains ladie's tresses)

Poaceae (Grass Family)
Andropogon gerardii (big bluestem)
Calamagrostis canadensis (bluejoint)
Dicanthelium oligosanthes var. scribnerianum
Elymus canadensis (Canada wild rye)
Muhlenbergia frondosa* (muhly)
Muhlenbergia racemosa (marsh muhly)
Panicum virgatum (switch grass)
Schizachyrium scoparium (little bluestem)
Sorghastrum nutans (Indian grass)
Spartina pectinata (cordgrass)
Sporobolus heterolepis (prairie dropseed)
Stipa spartea (needlegrass)
Clear Creek (West)

Wooded slopes overlook Clear Creek on both sides as it flows toward North Dakota Avenue from the west.

The vast majority of the wooded slopes south of Clear Creek are "C" quality. The canopy of these woodlands is made up of mostly typical trees such as red oak, bur oak and black maple, but the understory is completely dominated by non-typical species (*i.e.* Tartarian honeysuckle, elm, hackberry).

The floodplain in the largest "C" quality region possesses all typical trees (e.g. American elm, black willow, black walnut, cottonwood, hackberry, honey locust) in the canopy, but the understory is almost completely overgrown with an introduced shrub (*i.e.* Tartarian honeysuckle). Species diversity in both canopy and understory is average to low in this floodplain.

The "D" woodland on the slopes north of the creek possesses almost no trees, saplings and shrubs typical of wooded slopes. Apparently, the native trees were all removed in the past thus allowing the floodplain vegetation to creep up the slopes in its place.

A small "B" quality woodland exists on the south side of the river. Basswood, red oak and bur oak are the dominant trees in the canopy here, while ironwood and basswood are the most common saplings in the understory. The understory is overgrown in most places, lowering the overall quality of the woodland.

A large population of an attractive wildflower, blue cohosh (*Caulophyllum thalictroides*) is found in the "B" region of this map, the only place in Ames where it was discovered. Growing with it is a very uncommon woodland grass, *Brachyletrum erectum* (one of only two populations encountered during this inventory).
CLEAR CREEK (WEST)
CLEAR CREEK (WEST)
(QUALITY REGIONS)
Cemetery Prairie (North Dakota Avenue)

A small native prairie exists on a steep embankment between a cemetery and a sidewalk along North Dakota Avenue. This prairie has about 16 native prairie species, and hence is "C" quality. None of the 16 prairie species found here are uncommon in Ames.

Currently, this prairie is being invaded by an alien plant commonly used to reseed roadsides (crown vetch), which is particularly conspicuous on the north end.
Native Prairie Plant Species of the North Dakota Cemetery Prairie

Species listed were observed in the field by William R. Norris at the North Dakota Cemetery Prairie during the Ames Natural Areas Inventory (1991-95). A "prairie" species is one that occurs in a list of Iowa prairie plant species compiled by John Pearson of the Iowa DNR, except for species denoted with an (*). Nomenclature follows Eilers and Roosa (1994), except for Viola palmata and Viola pedatifida which follow Gleason and Cronquist (1991).

PTERIDOPHYTES

Equisetaceae (Horsetail family)
Equisetum laevigatum (smooth scouring rush)

ANGIOSPERMS (DICOTS)

Asteraceae (Daisy Family)
Aster ericoides (heath aster)
Aster pilosus (hairy aster)
Echinacea pallida (pale purple coneflower)
Erigeron strigosus (rough fleabane)
Ratibida pinnata (grey-headed coneflower)
Solidago canadensis (Canada goldenrod)
Solidago rigida (rigid goldenrod)

Ranunculaceae (Buttercup Family)
Anenome cylindrica (thimbleweed)
Delphinium virescens (prairie larkspur)

Rosaceae (Rose Family)
Rosa spp. (prairie rose)

Poaceae (Grass Family)
Andropogon gerardii (big bluestem)
Bouteloua curtipendula (side-oats grama)
Dicanthelium spp.
Elymus canadensis (Canada wild rye)
Stipa spartea (needlegrass)
Munn Woods

One of the highest quality woodlands in Ames, Munn Woods, occurs along Clear Creek on the west side of town. However, the adjacent wooded tracts vary widely in quality.

The bulk of Munn Woods is in the "A" quality region shown on the map. The ridgetop supports a very mature canopy of dominant white and red oak, while ironwood, ash and basswood saplings are the conspicuous components of the understory here. The slopes within this "A" quality region have dominant black maple, red oak, and basswood in the canopy, while ironwood and basswood saplings are conspicuous in the understory. At the junction of ridgetop and slope are found large, handsome trunks of downy serviceberry (*Amelanchier arborea*). This tract has an overall high diversity of expected trees, saplings and shrubs throughout, hence its high rating.

The large bottomland in the "B" quality region immediately north of that just described has a very mature floodplain forest, with vegetation resembling that much more commonly found on slopes. Trees such as red oak, black, maple and basswood are just as frequent here as more conventional bottomland tree species (*e.g.* hackberry, elm and black walnut). The presence of oak, black maple and basswood in the canopy of this floodplain forest probably represents natural succession and hence does not lower the overall quality of the forest. However, Tartarian honeysuckle (an introduced shrub) is very conspicuous in the understory here, which does lower the rating given to it.

The dry, south-facing slopes in this same large "B" quality region have many white and red oaks in the canopy, as expected, and typical saplings such as black maple, ironwood and basswood are found in the understory. However, the understory is
overgrown in many places, and overall species diversity is not as high as that found in the "A" quality woodland described above.

The large "C" quality region shown on the map is an area that has obviously been disturbed in the past. The slopes possess non-typical species in both canopy (e.g. cottonwood, honey locust, black walnut) and understory (Tartarian honeysuckle). The floodplain within this tract has low species diversity and an abundance of Tartarian honeysuckle. The "D" quality regions have almost no naturally occurring vegetation in them.

Several uncommon woodland wildflowers can be found in Munn Woods in the late summer and fall. These are an orchid (fall coralroot: *Corallorhiza odontorhiza*) and Indian pipe (*Monotropa uniflora*). Furthermore, green dragon (*Arisaema dracontium*) occurs in the "C" quality floodplain in large numbers.
MUNN WOODS
(QUALITY REGIONS)
MUNN WOODS

QUALITY RATINGS
MUNN WOODS

(DOMINANT WOODY VEGETATION)
Emma Mc'Carthv Lee Park

Wooded slopes occur along Clear Creek in Emma Mc'Carthv Lee Park and adjoining properties. This property is bounded by Hyland Street to the east and Ross Road to the north.

The highest quality woodland along this section of Clear Creek occurs on the north-facing slopes south of the creek ("B" quality woodland). Red oak and black maple are the dominant trees in the canopy here, and ironwood, black maple and basswood saplings are dominant in the understory. The understory on these slopes is overgrown in most places.

The "C" quality woodlands on the south-facing slopes north of the creek contain dominant white oak and black maple in the canopy. An introduced shrub, Tartarian honeysuckle, is conspicuous in the understory here, lowering the overall quality of the woodland.

The south-facing slopes ("D" quality woodland) overlooking the park itself are covered with scrubby vegetation having little natural character.

An uncommon wildflower, green dragon (Arisaema dracontium), occurs in the floodplain contained within the "B" quality region on the map.
EMMA MC'CARthy LEE PARK
(QUALITY REGIONS)
EMMA MC'CARthy LEE PARK

(QUALITY RATINGS)
EMMA MC'CARthy LEE PARK
(DOMINANT WOODY VEGETATION)
Pammel Woods

Pammel Woods occurs on the campus of Iowa State University, bounded by Hyland Street to the west and Pammel Drive to the south.

The majority of Pammel Woods is a rich woodland. On most slopes and a flat ridgetop located in "B" level regions, various oak species and black maple are the dominant canopy trees, while ironwood and black maple saplings are dominant in the understory. An introduced shrub (European buckthorn) is conspicuous here and there in the understory, but the majority of the vegetation is natural.

A rich bottomland forest occurs along Clear Creek as it winds its way through Pammel Woods. Both the canopy and the understory of this region ("A" quality level) contain a high diversity of species typical of bottomlands. The floodplain forest bordering the "A" quality region on either side is similar but contains less diversity of typical tree species, and introduced shrubs (i.e. white mulberry, Tartarian honeysuckle, European buckthorn) occasionally become dominant in the understory.

A small strip of unnatural vegetation ("D" quality level) occurs on the north end of Pammel Woods, bordering the railroad. An introduced tree (black locust) and shrub (European buckthorn) are dominant in the woodland here.

The majority of Pammel Woods contains a rich carpet of native wildflowers from spring through fall, and it serves as a laboratory for many botany classes at ISU. An uncommon plant, green dragon (*Arisaema dracontium*), is among the many wildflowers found in Pammel Woods.
PAMMEL WOODS

(QUALITY REGIONS)
PAMMEL WOODS
(QUALITY RATINGS)
PAMMEL WOODS
(DOMINANT WOODY VEGETATION)
Onion Creek (West)

Woodlands of varying quality abut Onion Creek as it meanders toward North Dakota Avenue from the west.

A large, high quality ("B") floodplain forest is situated between two poor quality ("D") woodlands on the map. This woodland has average to good diversity of typical floodplain tree species in the canopy (e.g. bur oak, American elm, black walnut, hackberry, honey locust) and saplings in the understory (e.g. elm hackberry, boxelder). Significantly, introduced shrubs such as Tartarian honeysuckle and white mulberry are virtually absent in this forest tract. A large population of an attractive wildflower, yellow giant hyssop (*Agastache nepetoides*), grows in the bottoms here.

The poor quality ("D") woodland northwest of the one just described has obviously experienced past grazing, with a mixture of typical (*i.e.* bur oak) and nontypical (hackberry, black walnut) trees in the canopy and lots of prickly shrubs (e.g. prickly ash, multiflora rose, gooseberry) in the understory.

The poor quality ("D") woodland adjacent to North Dakota Avenue has almost all nontypical species in both canopy and understory, evidence that the former canopy trees have been cut.

The "B" quality region adjacent to North Dakota Avenue has average to good diversity of mostly typical species in both canopy and understory. Some of the largest black walnuts in Ames occur here in the floodplain. The knoll adjacent to the floodplain within this tract has a small but nice stand of white oak, red oak and basswood with dominant ironwood in the understory.
ONION CREEK (WEST)
ONION CREEK (WEST)
(QUALITY REGIONS)
ONION CREEK (WEST)
(DOMINANT WOODY VEGETATION)
Onion Creek (East)

Woodlands representing all four quality levels (A, B, C and D) occur between North Dakota Avenue and West Reactor Woods along Onion Creek.

The largest tract of woodland delineated on the map is "B" quality. The long, northeast-facing slope here contains dominant black maple and red oak in the canopy, with ironwood and black maple saplings predominant in the understory. White oak is dominant in the canopy on the ridgetop immediately above this slope, while ironwood is the most common sapling in the understory. The floodplain separating this slope from Onion Creek (also "B" quality) contains good diversity of trees, saplings and shrubs typical of bottomland forests.

The "C" and "D" quality woodlands identified in this map contain less diversity of expected species in both canopy and understory. In particular, the three "D" regions appear to have undergone cutting of naturally occurring trees in the past because the trees and saplings that occur here now (elm, hackboery, walnut, honey locust) are not typical of undisturbed woodlands on slopes.

For a description of the "A" quality woodland identified on the map, see the report on West Reactor Woods in this report.

Several large populations of uncommon wildflowers occur in these woodlands. For example, cream gentian (*Gentiana alba*) occurs in the central L-shaped ("C" quality) tract on the map. Both fall coralroot (*Corallorhiza odontorhiza*) and Indian pipe (*Monotropa uniflora*) are frequent on the white oak-dominated ridgetop in the "B" quality tract.
ONION CREEK (EAST)

(QUALITY REGIONS)
ONION CREEK (EAST)

(QUALITY RATINGS)
ONION CREEK (EAST)

(DOMINANT WOODY VEGETATION)
West Reactor Woods

Along with East Reactor Woods, West Reactor Woods contains the largest amount of high quality woodland in Ames.

The canopy of wooded ridgetops and slopes contains dominant white oak, red oak and black maple in "A" and "B" quality regions, while ironwood is the dominant sapling in the understory here. A small stand of big-toothed aspen occurs on top of a knoll in the largest "A" quality region in West Reactor Woods, one of the few such stands in Ames.

The floodplain forest in the "A" and "B" quality areas is some of the richest in Ames. Both the canopy and understory here are very diverse in species typical of floodplains. Several large sycamores (uncommon in central Iowa) occur in the bottomland forest of the largest "B" quality region (north end of West Reactor Woods).

More uncommon wildflowers occur in West and East Reactor Woods than in any other woodland in Ames. For example, yellow pimpernel (Taenidia integerrima) is found only on high dry slopes in the largest "A" quality woodland in West Reactor Woods. Showy orchis (Galearis spectabilis), a colorful orchid, was found only in West Reactor Woods during this inventory. Likewise, the spinulose wood fern (Dryopteris carthusiana) was only encountered in these woods. Other uncommon woodland herbs found in West Reactor Woods include green dragon (Arisaema dracontium), cream gentian (Gentiana alba), ginseng (Panax quinquefolia), red baneberry (Actaea rubra), spikenard (Aralia racemosa), lady fern (Athyrium felix-femina) and a number of sedge species (Carex hirtifolia, Carex hitchcockiana, Carex Jamesii, Carex oligosperma and Carex sparganioides).

The slopes in the western "tail" of West Reactor Woods contain a number of prairie species in woodland openings, including prairie lousewort (Pedicularis
canadensis), alumroot *(Heuchera richardsonii)* and Culver's root *(Veronicastrum virginicum)*.

During the first full season of field work for this inventory (1992), a pair of cerulean warblers (rare for central Iowa) was found (June) in the floodplain of the largest "A" quality regions.
WEST REACTOR WOODS
WEST REACTOR WOODS
(QUALITY REGIONS)
WEST REACTOR WOODS
(QUALITY RATINGS)
WEST REACTOR WOODS

(DOMINANT WOODY VEGETATION)
East Reactor Woods

East Reactor Woods (often referred to as "YMCA Woods) contains some of the highest quality woodlands in Ames. The area is characterized by highly dissected topography, with a floodplain on the northeast border of the park.

Natural vegetation is found in all "A" and "B" quality regions. White oak, red oak and shagbark hickory are the dominant canopy trees on ridgetops and dry south-facing slopes, while black maple, red oak and basswood are the dominant trees on moist north and east-facing slopes. Ironwood is the dominant sapling in the understory of almost all the woodlands found on ridgetops and slopes. In many places (particularly the "B" quality regions) the ironwood provides almost 100% cover of the forest floor, preventing sunlight from effectively reaching the herbs underneath. In the "A" quality woodlands on slopes, however, this ironwood subcanopy is broken here and there by gaps that allow sunlight to penetrate to the wildflowers on the forest floor. This last characteristic is typical of high quality woodlands.

A small but rich floodplain forest occurs on the south end of the large "A" quality region. At least a dozen tree species contribute to the canopy here, and the understory likewise contains a high diversity of saplings, shrubs and vines. Significantly, almost no introduced shrubs (e.g. European honeysuckle, white mulberry, Tartarian honeysuckle) occur in the understory here, an unusual and desirable condition in an urban environment.

The "C" quality region in East Reactor Woods contains a young woodland with an overgrown understory.

East Reactor Woods, along with West Reactor Woods, contains the highest diversity of woodland wildflowers in Ames. Among these are uncommon species such as spikenard (*Aralia racemosa*), red baneberry (*Actaea rubra*), lady fern (*Athyrium felix-femina*) and a sedge (*Carex albursina*). East Reactor Woods is
frequently used by Iowa State University botany classes as a laboratory in the spring and fall.
EAST REACTOR WOODS
EAST REACTOR WOODS

(QUALITY REGIONS)
EAST REACTOR WOODS

(QUALITY RATINGS)
EAST REACTOR WOODS
(DOMINANT WOODY VEGETATION)
Squaw Valley-Hickory Hills

Small woodland tracts exist between two housing subdivisions (Squaw Valley and Hickory Hills) north of Ames along Squaw Creek.

The southwest-facing slope adjacent to Squaw Valley Subdivision supports a "C" quality woodland (delineated as a triangle on the map). Expected tree species such as basswood, yellowbud hickory and red oak are found in the canopy here along with other, nonexpected species like honey locust and green ash. The understory is dominated by nontypical elm and hackberry saplings, and gooseberry is prevalent here as well. Most likely, this slope has had some of its native canopy trees logged off, and the disturbed understory probably reflects past grazing activity.

The other two "C" quality strips are bottomland along Squaw Creek. All the vegetation here is typical for floodplain forests, dominant silver maple in the canopy, but overall diversity of trees, saplings and shrubs is average to low, while the understory is almost non-existent in places.

The other bottomland strip indicated on the map is "A" quality. It possesses a high diversity of typical species in both canopy and understory, and the understory is well developed.

The sloping terrain that occurs adjacent to the Hickory Hills subdivision supports a "B" quality woodland. Bur oak and red oak are the canopy dominants, while black cherry and choke cherry are common components of the understory. An uncommon wildflower, green dragon (*Arisaema dracontium*), was found here during the inventory.
SQUAW VALLEY - HICKORY HILLS
SQUAW VALLEY - HICKORY HILLS
(QUALITY RATINGS-EAST)
SQUAW VALLEY - HICKORY HILLS
(QUALITY RATINGS-WEST)
SQUAW VALLEY - HICKORY HILLS
(DOMINANT WOODY VEGETATION-EAST)
SQUAW VALLEY - HICKORY HILLS
(DOMINANT WOODY VEGETATION-WEST)
Northwood Heights Subdivision

A large floodplain forest occurs near the Northwood Heights Subdivision on the east side of Squaw Creek. The quality of this forest varies from "B" to "A", with high diversity in both canopy and understory. The canopy contains some of the largest, most majestic silver maples to be found in the Ames area. Elm and hackberry saplings are the usual dominants in the understory throughout. Significantly, introduced shrubs such as Tartarian honeysuckle and white mulberry are virtually absent in this woodland.

The southwest-facing slope bordering the floodplain supports "D" quality woodland. This region has probably been logged in the past, since none of the canopy trees present (elm, honey locust, black walnut, green ash) occur naturally on sloping terrain.

A large, attractive sedge (*Carex grayii*) is fairly common in the floodplain.
NORTHWOOD HEIGHTS SUBDIVISION

(QUALITY RATINGS)
NORTHWOOD HEIGHTS SUBDIVISION

(DOMINANT WOODY VEGETATION)
Northridge (North)

Wooded west-facing slopes overlook Squaw Creek adjacent to the Northridge Housing Development. Several prairie remnants occur on these slopes at the north end of the property, while an extensive floodplain forest separates the slopes from the creek.

Most of the wooded slopes are "D" quality. Where one would expect oaks and maples in the canopy, American elm, red elm, green ash and hackberry are found instead. The understory here is choked with non-typical shrubs such as prickly ash, European buckthorn and Tartarian honeysuckle. The predominance of this non-natural vegetation suggests that this slope has been logged off and heavily grazed in the past. A description of the "B" quality woods on this slope can be found in "Northridge (South)" in this report.

The prairies located on this same slope are themselves "B" quality. At least 31 native prairie species occur here, including the pale four o'clock (*Mirabilis albidum*), encountered nowhere else during this inventory. The slopes in these prairies are covered by a grass typical of dry prairies: side-oats grama (*Bouteloua curtipendula*). The largest population of toothed evening primrose (*Calylophus serrulatus*) in Ames occurs on the northern most of these prairies. The first county records of two ferns, the ebony spleenwort (*Asplenium platyneuron*) and the dissected grape fern (*Botrychium dissectum var. obliquum*) came during this inventory from the woods peripheral to these prairies.

The floodplain regions on both sides of Squaw Creek on this map are uniformly "C" quality. Diversity of the canopy and understory ranges from average to good, but is dominated in places by dense groves of hawthorn that may have been planted.
Native Prairie Plant Species of the Northridge Prairies

Species listed were observed in the field by William R. Norris at the Northridge Prairies during the Ames Natural Areas Inventory (1991-95). A "prairie" species is one that occurs in a list of Iowa prairie plant species compiled by John Pearson of the Iowa DNR, except for species denoted with an (*). Nomenclature follows Eilers and Roosa (1994), except for Viola palmata and Viola pedatifida which follow Gleason and Cronquist (1991).

PTERIDOPHYES

Aspleniaceae (Spleenwort Family)
Asplenium platyneuron (ebony spleenwort)*

Equisetaceae (Horsetail Family)
Equisetum X ferrissii* (hybrid scouring rush)

ANGIOSPERMS (DICOTS)

Asteraceae (Daisy Family)
Antennaria neglecta (field pussytoes)
Aster azureus (azure aster)
Aster ericoides (heath aster)
Aster pilosus (hairy aster)
Brickellia eupatorioidea (false boneset)
Cirsium discolor (field thistle)
Erigeron strigosus (rough fleabane)
Gnaphalium obtusum (everlasting)
Lactuca canadensis* (wild lettuce)
Solidago canadensis (Canada goldenrod)

Boraginaceae (Borage Family)
Lithospermum incisum (yellow puccoon)
Onosmodium molle (false gromwell)

Campanulaceae (Bellflower Family)
Lobelia spicata (pale-spike lobelia)

Fabaceae (Bean Family)
Amorpha canescens (leapland)
Astragalus crassicarpus (ground plum)

Lamiaceae (Mint Family)
Monarda fistulosa (horsemint)
Scutellaria leonardii (small skullcap)

Linaceae (Flax Family)
Linum sulcatum (grooved flax)

Nyctaginaceae (Four-O’Clock Family)
Mirabilis albidum (pale four o’clock)

Onagraceae (Evening Primrose Family)
Calycanthus floridus (yellow primrose)

Ranunculaceae (Buttercup Family)
Anemone cylindrica (thimbleweed)
Delphinium virens (prairie larkspur)

Rosaceae (Rose Family)
Malus ioensis (wild crab)
Potentilla arguta (tall cinquefoil)
Rosa spp. (prairie rose)

Solanaceae (Nightshade Family)
Physalis virginiana (ground-cherry)

Verbenaceae (Vervain Family)
Verbena stricta (hoary vervain)

Violaceae (Violet Family)
Viola pedatifida (prairie violet)

ANGIOSPERMS (MONOCOTS)

Cyperaceae (Sedge Family)
Carex meadii

Iridaceae (Iris Family)
Sisyrinchium campestre (blue-eyed grass)

Poaceae (Grass Family)
Andropogon gerardii (big bluestem)
Bouteloua curtipendula (side-oats grama)
Dianthus oligosanthes var. scriberianum
Muhlenbergia mexicana (muhley)
Schizachyrium scoparium (little bluestem)
Sporobolus heterolepis (prairie dropseed)
NORTH RIDGE (NORTH)
(QUALITY REGIONS)
NORTH RIDGE (NORTH)

(QUALITY RATINGS)
NORTH RIDGE (NORTH)

(DOMINANT WOODY VEGETATION)
Northridge (South)

At the south end of the Northridge Housing Development, wooded west-facing slopes overlook Squaw Creek, while an extensive floodplain occurs at the confluence of Squaw Creek and Onion Creek.

The woodland occurring on the slopes is "B" quality. South of the confluence, dominant canopy trees are black maple and red oak, while bur oak is dominant at top of the high knoll at the north end of this region. Ironwood is dominant in the understory throughout the woodland on these slopes.

The floodplain forest at the confluence of the two creeks is "C" quality. Diversity is average to good in the canopy and understory, but introduced European buckthorn is dominant in many places in the understory. A virtual monoculture of hawthorn in the canopy suggests that it has been introduced as well. The forest is quite young, and the canopy and understory are not well differentiated in some locations.

An ancient Indian burial ground occurs on top of the high knoll within the "B" quality woodland. It is indicated on the map with an "X". On the steep slopes just south of the burial ground occur scattered prairie remnants. Among the prairie plants found here is the largest population of incised puccoon (*Lithospermum incisum*) encountered during the inventory.
NORTHRIDGE (SOUTH)
(QUALITY REGIONS)
NORTHRIDGE (SOUTH)
(QUALITY RATINGS)
NORTH RIDGE (SOUTH)

(DOMINANT WOODY VEGETATION)
Thirteenth Street Prairie

A prairie occurs on a gentle slope overlooking Squaw Creek on the north side of Thirteenth Street, just west of its intersection with Stange Avenue. The Thirteenth Street Prairie was planted in the early 1980's and hence cannot be considered a natural prairie. For this reason, it is considered a special resource ("S").

About ten prairie species occur on the Thirteenth Street Prairie. A dense growth of prairie grasses such as Indian grass (Sorghastrum nutans) and little blue stem (Schizachyrium scoparium) occurs in many places, along with lesser amounts of big blue stem (Andropogon gerardii) and switch grass (Panicum virgatum). However, very few forbs (prairie wildflowers) occur on the prairie.

Lately, a dense carpet of two introduced plants commonly used to reseed roadsides (bird's foot trefoil and crown vetch) has taken over large areas inside the prairie. These will have to be controlled if the Thirteenth Street Prairie is to be maintained.
Brookside Park

Brookside Park is a much used public area in the center of Ames.

A large alluvial woodland occurs on the north end of Brookside Park ("B" quality woodland) adjacent to Squaw Creek. At least 12 species of canopy trees typical of floodplain forests (some of the largest in Ames) occur here. The understory contains a high diversity of native saplings and shrubs, but some introduced shrubs (e.g. Tartarian honeysuckle and white mulberry) are conspicuous here and detract from the overall natural quality of this woodland. A rich diversity of woodland wildflowers occurs in this part of Brookside Park and the entire woodland swarms with migratory songbirds during the spring months. These woods are heavily utilized as an outdoor teaching lab by various biology classes taught at Iowa State University.

The portion of Brookside Park designated as a special resource ("S" quality level) is an area with very large shade trees where the understory (saplings and shrubs) has been almost completely removed to accommodate recreational activities in the park.
BROOKSIDE PARK
BROOKSIDE PARK
(QUALITY REGIONS)
BROOKSIDE PARK

(QUALITY RATINGS)
BROOKSIDE PARK

(DOMINANT WOODY VEGETATION)
Ames High School Prairie

A large prairie complex, consisting of four separate subunits, exists adjacent to Ames High School.

A wide variety of habitats are available to plants in the four subunits of this prairie, from flat dry hilltop to steep moist slope. This no doubt explains why more native prairie plants (at least 93) were encountered at Ames High School Prairie than in any other local prairie during the inventory, earning it an "A" quality rating. A number of prairie species occur locally only here, including hairy grama (*Bouteloua hirsuta*), junegrass (*Koeleria pyrimidata*), silky aster (*Aster sericeus*), butterfly weed (*Asclepias tuberosus*), showy partridge pea (*Chaemaecrista fasciculata*), great St. John's wort (*Hypericum pyrimidatum*), and Baldwin's ironweed (*Vernonia baldwinii*). Ames High School Prairie boasts the only sizable population of prairie dandelion (*Nothocalais cuspidata*) in the Ames region, and is only one of two local prairies where the green milkweed (*Asclepias viridiflora*) was found during the inventory.

The large, flat plateau in the largest subunit of the prairie (adjacent to the road behind the high school) has substantial amounts of weedy species such as sweet clover and smooth brome grass growing on it. No doubt this is due to some of the past uses of this area, as a hog pen decades ago and as a storage area for heavy equipment in the early 1970's. Nonetheless, the vast majority of this prairie is dominated by native prairie species, and nowhere else in the boundary of this inventory (except perhaps the Raymond Prairie) can one see vast fields of prairie grasses waving in the wind as they once did across the state prior to settlement.

The woods surrounding the subunits of the prairie are all severely disturbed, with virtually no natural vegetation occurring in them. Elm, hackberry, honey locust, and black walnut are the dominant trees in the canopy, while Tartarian honeysuckle is
extremely lush in the understory of the woodland. Obviously, these slopes were cleared of timber years ago. Therefore, this woodland receives a "D" quality rating.
Native Prairie Plant Species of
Ames High School Prairie

Species listed were observed by William
R. Norris and/or Dave Brenner at Ames High
School Prairie during the Ames Natural Areas
Inventory (1991-95). A "prairie" species is one
that occurs in a list of Iowa prairie plant species
compiled by John Pearson of the Iowa DNR,
except for species denoted with an (*).
Nomenclature follows Eilers and Roosa (1994),
except for Viola palmata and Viola pedatifida

PTERIDOPHYTES

Equisetaceae (Horsetail family)
Equisetum laevigatum (smooth scouring rush)

ANGIOSPERMS (DICOTS)

Apiaceae (Carrot Family)
Zizia aureus (golden alexander)

Asclepiadaceae (Milkweed family)
Asclepias tuberosa (butterfly weed)
Asclepias verticillata (whorled milkweed)
Asclepias viridiflora (green milkweed)

Asteraceae (Daisy Family)
Ambrosia psilostachya (western ragweed)
Artemisia ludoviciana (prairie sage)
Aster azureus (azure aster)
Aster ericoides (heath aster)
Aster laevis (smooth blue aster)
Aster lanceolatus ssp. simplex (panicled aster)
Aster novae-angliae (New England aster)
Aster pilosus (hairy aster)
Aster sericeus (silky aster)
Brickellia eupatorioides (false boneset)
Calalpa plantaginea (Indian plantain)
Cirsium altissimum (tall thistle)
Cirsium discolor (field thistle)
Coreopsis palmata (finger coreopsis)
Echinacea pallida (pale purple coneflower)
Erigeron strigosus (rough fleabane)
Helianthus grosseserratus (saw-toothed
sunflower)
Heliopsis helianthoides (ox-eye)
Lactuca canadensis* (wild lettuce)
Liatris aspera (rough blazing star)

Asteraceae (continued)
Liatris pycnostachya (prairie blazing star)
Nothocalais cuspidata (prairie dandelion)
Ratibida pinnata (grey-headed coneflower)
Rudbeckia hirta (black-eyed susan)
Solidago canadensis (Canada goldenrod)
Solidago rigida (rigid goldenrod)
Vernonia baldwinii (Baldwin's ironweed)

Boraginaceae (Borage Family)
Lithospermum canescens (hoary puccoon)
Lithospermum incisum (yellow puccoon)
Onosmodium molle (false gromwell)

Campanulaceae (Bellflower Family)
Lobelia spicata (pale-spike lobelia)

Fabaceae (Bean Family)
Amorpha canescens (leadplant)
Astragalus crassicarpus (ground plum)
Baptisia bracteata var. glabrescens (cream wild
indigo)
Baptisia lactea (white wild indigo)
Chamaecrista fasciculata (showy partridge pea)
Dalea candida (white prairie clover)
Dalea purpurea (purple prairie clover)
Desmodium canadense (hoary tick clover)
Desmodium illinoense (Illinois tick clover)
Lespedeza capitata (round-head bush clover)
Pediomelum argophyllum (silvery scurf pea)

Gentianaceae (Gentian Family)
Gentiana puberulenta (downy gentian)

Hypericaceae (St. John's wort Family)
Hypericum pyramidalum (Giant St. John's wort)

Lamiaceae (Mint Family)
Monarda fistulosa (horsemint)
Pyrenanthemum virginianum (Virginia
mountain mint)
Scutellaria leonardii (small skullcap)

Linaceae (Flax Family)
Linum sulcatum (grooved flax)

Onagraceae (Evening Primrose Family)
Calylophus serrulatus (plains yellow primrose)
Oenothera biennis (evening primrose)
Oxalidaceae (Wood Sorrel Family)
*Oxalis violacea* (violet wood sorrel)

Polemoniaceae (Phlox Family)
*Phlox pilosa* (prairie phlox)

Primulaceae (Primrose Family)
*Lysimachia ciliata* (fringed loosestrife)

Ranunculaceae (Buttercup Family)
*Anenome cylindrica* (thimbleweed)
*Delphinium virensens* (prairie larkspur)

Rhamnaceae (Buckthorn Family)
*Ceanothus americanus* (New Jersey tea)

Rosaceae (Rose Family)
*Fragaria virginiana* (wild strawberry)
*Malus ioensis* (wild crab)
*Potentilla arguta* (tall cinquefoil)
*Rosa spp.* (wild rose)

Santalaceae (Sandalwood Family)
*Comandra umbellata* (bastard toadflax)

Saxifragaceae (Saxifrage Family)
*Heuchera richardsonii* (alumroot)

Scrophulariaceae (Figwort Family)
*Veronicastrum virginicum* (Culver’s root)

Solanaceae (Nightshade Family)

*Physalis heterophylla* (clammy ground-cherry)
*Physalis virginiana* (Virginia ground-cherry)

Verbenaceae (Vervain Family)
*Verbena stricta* (hoary vervain)

Violaceae (Violet Family)
*Viola pedatifida* (prairie violet)

**ANGIOSPERMS (MONOCOTS)**

Commelinaceae (Spiderwort Family)
*Tradescantia bracteata* (spiderwort)

Cyperaceae (Sedge Family)
*Carex bicknellii*
*Carex brevior*
*Carex davisii*

Iridaceae (Iris Family)
*Sisyrinchium campestre* (blue-eyed grass)

Liliaceae (Lily Family)
*Hypoxis hirsuta* (stargrass)

Poaceae (Grass Family)
*Andropogon gerardii* (big bluestem)
*Bouteloua curtipendula* (side-oats grama)
*Bouteloua hirsuta* (hairy grama)
*Dicanthelium acuminatum var. implicatum*
*Dicanthelium oligosanthes var. scribnerianum*
*Elymus canadensis* (Canada wild rye)
*Koeleria macrantha* (June grass)
*Muhlenbergia cuspidata* (plains muhley)
*Panicum virgatum* (switch grass)
*Schizachyrium scoparium* (little bluestem)
*Sorghastrum nutans* (Indian grass)
*Sporobolus asper* (tall dropseed)
*Sporobolus heterolepis* (prairie dropseed)
*Stipa spartea* (needlegrass)
AMES HIGH SCHOOL PRAIRIE

(QUALITY REGIONS)
Railroad Prairie (South of Gilbert)

Prairie vegetation is found along a railroad for more than a mile just south and west of Gilbert. This area was surveyed once, in mid-summer, and 15 native prairie species were found. Thus, this prairie receives a "C" quality rating.

While this area is not diverse, one can find some showy prairie wildflowers without difficulty. These include pale purple coneflower (*Echinacea pallida*), grey-headed coneflower (*Ratibida pinnata*), prairie phlox (*Phlox pilosa*) and compass plant (*Silphium laciniatum*).
Native Prairie Plant Species of the Gilbert Railroad Prairie

Species listed were observed in the field by William R. Norris at the Gilbert Railroad Prairie during the Ames Natural Areas Inventory (1991-95). A "prairie" species is one that occurs in a list of Iowa prairie plant species compiled by John Pearson of the Iowa DNR, except for species denoted with an (*). Nomenclature follows Eilers and Roosa (1994), except for Viola palmata and Viola pedatifida which follow Gleason and Cronquist 1991).

ANGIOSPERMS (DICOTS)

Apiaceae (Carrot Family)
*Zizia aureus* (golden alexander)

Apocynaceae (Dogbane Family)
*Apocynum cannabinum* var. *pubescens* (Indian hemp)

Asteraceae (Daisy Family)
*Echinacea pallida* (pale purple coneflower)
*Erigeron strigosus* (rough fleabane)
*Helianthus grosseserratus* (saw-toothed sunflower)
*Helianthus laetiflorus* (sunflower)
*Heliospis helianthoides* (ox-eye)
*Ratibida pinnata* (grey-headed coneflower)
*Rudbeckia hirta* (black-eyed susan)

Fabaceae (Bean Family)
*Lespedeza capitata* (round-head bush clover)

Polemoniaceae (Phlox Family)
*Phlox pilosa* (prairie phlox)

Ranunculaceae (Buttercup Family)
*Anenome canadensis* (Canada anemone)
*Anenome cylindrica* (thimbleweed)
*Thalictrum dasycarpum* (tall meadow rue)

Rosaceae (Rose Family)
*Rosa* spp. (prairie rose)

ANGIOSPERMS (MONOCOTS)

Commelinaceae (Spiderwort Family)
*Tradescantia bracteata* (spiderwort)

Iridaceae (Iris Family)
*Iris shrevei* (wild iris)

Poaceae (Grass Family)
*Dicanthelium oligosanthes* var. *scribnerianum*
APPENDIX B  PLANT SPECIES CHECKLISTS FOR AMES WOODLANDS AND PRAIRIES
Native Woodland Plant Species of Ames, Iowa

The 208 species listed were observed in the field by William R. Norris during the Ames Natural Areas Inventory (1991-95), except for Polypodium verticillata (reported by Mark Widnall) and Dasistoma macrophylla (reported by Deb Lewis). Nomenclature follows Eilers and Roosa (1994).

PTERIDOPHYTES

Adiantaceae (Maidenhair Fern Family)

_____ Adiantum pedatum (maidenhair fern)

Aspleniaceae (Spleenwort Family)

_____ Asplenium platyneuron (ebony spleenwort)
_____ Athyrium filix-femina (northern lady fern)
_____ Cystopteris prostrata (creeping fragile fern)
_____ Dryopteris carthusiana (spinulose wood fern)

Equisetaceae (Horsetail Family)

_____ Equisetum arvense (common horsetail)

Ophioglossaceae (Adder's Tongue Family)

_____ Botrychium dissectum f. obliquum (oblique grape fern)
_____ Botrychium virginianum (rattlesnake fern)

GYMNOSPERMS

Cupressaceae (Juniper Family)

_____ Juniperus virginiana (red cedar)

ANGIOSPERMS (DICOTS)

Aceraceae (Maple Family)

_____ Acer negundo (box elder)
_____ Acer nigrum (black maple)
_____ Acer saccharinum (silver maple)

Anacardiaceae (Cashew Family)

_____ Rhus glabra (smooth sumac)
_____ Toxicodendron radicans (poison ivy)

Apiaceae (Carrot Family)

_____ Chaerophyllum procumbens (chervil)
_____ Cryptotaenia canadensis (honewort)
_____ Heracleum lanatum (cow parsnip)
_____ Osmorhiza claytonii (sweet cicely)
_____ Osmorhiza longistylis (anise root)
_____ Sanicula canadensis (black snakeweed)
_____ Sanicula gregaria (common snakeweed)
_____ Taenidia integerrima (yellow pimpernel)
_____ Zizia aurea (golden alexander)

Araliaceae (Ginseng Family)

_____ Aralia nudicaulis (wild sarsaparilla)
_____ Aralia racemosa (spikenard)
_____ Panax quinquefolius (ginseng)

Aristolochiaceae (Birthwort Family)

_____ Asarum canadense (wild ginger)

Asteraceae (Daisy Family)

_____ Antennaria neglecta (pussytoes)
_____ Aster cordifolius (blue wood aster)
_____ Aster cordifolius X drummondii (hybrid aster)
_____ Aster lateriflorus (side-flowered aster)
_____ Aster ontarioensis (Ontario aster)
_____ Aster sagittifolius (arrow-leaved aster)
_____ Erigeron annuus (daisy fleabane)
Asteraceae (continued)

- Erigeron philadelphicus (fleabane)
- Erigeron strigosus (rough fleabane)
- Eupatorium purpureum (purple joe-pye-weed)
- Eupatorium rugosum (white snakeroot)
- Lactuca floridana (blue lettuce)
- Prenanthes alba (rattlesnake root)
- Rudbeckia hirta (black-eyed susan)
- Rudbeckia laciniata (tall coneflower)
- Rudbeckia triloba (brown-eyed susan)
- Silphium perfoliatum (cupplant)
- Solidago flexicaulis (zig-zag goldenrod)
- Solidago nemoralis (field goldenrod)
- Solidago ulmifolia (elm-leaved goldenrod)
- Verbesina alternifolia (wingstem)

Balsaminaceae (Jewelweed Family)

- Impatiens capensis (spotted touch-me-not)
- Impatiens pallida (pale touch-me-not)

Berberidaceae (Barberry Family)

- Caulophyllum thalictroides (blue cohosh)
- Podophyllum peltatum (may apple)

Betulaceae (Birch Family)

- Corylus americana (hazelnut)
- Ostrya virginiana (ironweed)

Boraginaceae (Borage Family)

- Hackelia virginiana (stickseed)
- Mertensia virginica (bluebell)

Brassicaceae (Mustard Family)

- Arabis canadensis (sicklepod)
- Dentaria laciniata (toothwort)

Campanulaceae (Bellwort Family)

- Campanula americana (tall bellflower)
- Lobelia inflata (Indian tobacco)
- Lobelia siphilitica (great lobelia)

Caprifoliaceae (Honeysuckle Family)

- Sambucus canadensis (elderberry)
- Lonicera spp. (wild honeysuckle)
- Triosteum perfoliatum (feverwort)
- Viburnum lentago (nannyberry)
- Viburnum rafinesquianum (downy arrowwood)

Caryophyllaceae (Carnation Family)

- Silene stellata (starry campion)

Celastraceae (Bittersweet Family)

- Celastrus scandens (bittersweet)
- Euonymous atropurpurea (wahoo)

Cornaceae (Dogwood Family)

- Cornus alternifolia (pagoda tree)
- Cornus foemina ssp. racemosa (grey dogwood)

Ericaceae (Heath Family)

- Monotropa uniflora (Indian pipe)

Fabaceae (Bean Family)

- Amphicarpaea bracteata (hog peanut)
- Amorpha canescens (leadplant)
- Apios americana (ground nut)
- Astragalus canadensis (milk vetch)
- Desmodium glutinosum (sticky tick-trefoil)
- Gleditsia triacanthos (honey locust)
- Gymnocladus dioica (Kentucky coffee tree)
- Lespedeza capitata (round-headed bush clover)
Fagaceae (Beech Family)
   ______ Quercus alba (white oak)
   ______ Quercus borealis f. var. maxima (red oak)
   ______ Quercus macrocarpa (bur oak)
   ______ Quercus velutina (black oak)

Gentianaceae (Gentian Family)
   ______ Gentiana alba (pale gentian)

Geraniaceae (Geranium Family)
   ______ Geranium maculatum (wild geranium)

Hydrophyllaceae (Waterleaf Family)
   ______ Ellisia nyctalea (wild tomato)
   ______ Hydrophyllum virginianum (Virginiana waterleaf)

Hypericaceae (St. John's Wort Family)
   ______ Hypericum punctatum (spotted St. John's wort)

Juglandaceae (Walnut Family)
   ______ Carya cinerea (yellowbud hickory)
   ______ Carya ovata (shagbark hickory)
   ______ Juglans cinerea (butternut)
   ______ Juglans nigra (black walnut)

Lamiaceae (Mint Family)
   ______ Agastache nepetoides (yellow giant-hyssop)
   ______ Stachys tenuifolia (hedge nettle)
   ______ Teucrium canadense (germander)

Menispermaceae (Moonseed Family)
   ______ Menispermum canadense (moonseed)

Moraceae (Mulberry Family)
   ______ Morus rubra (red mulberry)

Oleaceae (Olive Family)
   ______ Fraxinus americana (white ash)
   ______ Fraxinus nigra (black ash)
   ______ Fraxinus pensylvanica (green ash)

Onagraceae (Evening Primrose Family)
   ______ Circaea lutetiana (enchanter's nightshade)
   ______ Epilobium coloratum (cinnamon willowherb)

Papaveraceae (Poppy Family)
   ______ Dicentra cucullata (Dutchman's breeches)
   ______ Sanguinaria canadensis (bloodroot)

Phrymaceae (Lopseed Family)
   ______ Phryma leptostachya (lopseed)

Platanaceae (Sycamore Family)
   ______ Platanus occidentalis (sycamore)

Polemoniaceae (Phlox Family)
   ______ Phlox divaricata (woodland phlox)
   ______ Polemonium reptans (Jacob's ladder)

Polygonaceae (Milkwort Family)
   ______ Polygala verticillata (whorled milkwort)

Polygonaceae (Smartweed Family)
   ______ Polygonum punctatum (dotted smartweed)
   ______ Polygonum scandens (climbing false buckwheat)
   ______ Polygonum virginiana (jumpseed)

Portulacaceae (Purslane Family)
   ______ Claytonia virginica (spring beauty)

Primulaceae (Primrose Family)
   ______ Lysimachia spp. (yellow loosestrife)
Ranunculaceae (Buttercup Family)

___ Actaea spp. (baneberry)
___ Anenome quinquefolia (wood anemone)
___ Anenome virginiana (tall anemone)
___ Aquilegia canadensis (columbine)
___ Hepatica nobilis var. acuta (liverleaf)
___ Isopyrum bitematum (false rue anemone)
___ Ranunculus abortivus (kidney-leaf buttercup)
___ Ranunculus septentrionalis (swamp buttercup)
___ Thalictrum dasycarpum (tall meadow-rue)
___ Thalictrum dioicum (early meadow-rue)
___ Thalictrum thalictroides (rue-anemone)

Rhamnaceae (Buckthorn Family)

___ Ceanothus americanus (New Jersey Tea)

Rosaceae (Rose Family)

___ Agrimonia pubescens (soft agrimony)
___ Amelanchier arborea (downy serviceberry)
___ Craetaegus spp. (hawthorne)
___ Geum canadense (white avens)
___ Prunus serotina (black cherry)
___ Prunus virginiana (choke cherry)
___ Rubus allegheniensis (blackberry)
___ Rubus occidentalis (black raspberry)

Rubiaceae (Madder Family)

___ Galium aparine (cleavers)
___ Galium circaeazzans (bedstraw)
___ Galium concinnum (shining bedstraw)
___ Galium triflorum (sweet-scented bedstraw)

Rutaceae (Citrus Family)

___ Zanthoxylum americanum (prickly ash)

Salicaceae (Willow Family)

___ Populus deltoides (cottonwood)
___ Populus grandidentata (big-toothed aspen)
___ Salix exigua (sandbar willow)
___ Salix nigra (black willow)

Saxifragaceae (Saxifrage Family)

___ Heuchera richardsonii (alumroot)
___ Ribes missouriense (wild gooseberry)
___ Dasistoma macrophylla

Scrophulariaceae (Figwort Family)

___ Mimulus ringens (monkeyflower)
___ Pedicularis canadensis (lousewort)
___ Scrophularia marilandica (figwort)
___ Veronicastrum virginicum (Culver's root)

Staphyleaceae (Bladdernut Family)

___ Staphylea trifolia (bladdernut)

Tiliaceae (Basswood Family)

___ Tilia americana (American basswood)

Ulmaceae (Elm Family)

___ Celtis occidentalis (hackberry)
___ Ulmus americana (American elm)
___ Ulmus rubra (red elm)

Urticaceae (Nettle Family)

___ Laportea canadensis (wood nettle)
___ Parietaria pensylvanica (pellitory)
___ Pilea pumila (clearweed)
___ Urtica dioica (stinging nettle)

Verbinaceae (Vervain Family)

___ Phyla lanceolata (fogfruit)

Violaceae (Violet Family)

___ Viola pubescens (downy yellow violet)
___ Viola soraria (hairy blue violet)
- Vitaceae (Grape Family)
  ___ Parthenocissus quinquefolia (Virginia Creeper)
  ___ Parthenocissus vitacea (woodbine)
  ___ Vitis riparius (river grape)

ANGIOSPERMS (MONOCOTS)

Araceae (Arum Family)
  ___ Arisaema dracontium (green dragon)
  ___ Arisaema triphyllum (jack-in-the-pulpit)

Cyperaceae (Sedge Family)
  ___ Carex albursina
  ___ Carex amphibola var. turgida
  ___ Carex blanda
  ___ Carex cephalophora
  ___ Carex davisi
  ___ Carex grvida
  ___ Carex gravi
  ___ Carex hirtifolia
  ___ Carex hitchcockiana
  ___ Carex jamesii
  ___ Carex molesta
  ___ Carex oligocarpa
  ___ Carex pensylvanica
  ___ Carex rosea
  ___ Carex sparganioides
  ___ Carex sprengelii

Dioscoreaceae (Yam Family)
  ___ Dioscorea villosa (wild yam)

Juncaceae (Rush Family)
  ___ Juncus tenuis (path rush)

Liliaceae (Lily Family)
  ___ Allium canadense (wild onion)
  ___ Allium tricoccum (wild leek)
  ___ Erythronium albidum (dog-tooth violet)
  ___ Polygonatum pubescens (solomon's seal)
  ___ Smilacina racemosa (false solomon's seal)

Liliaceae (continued)
  ___ Smilacina stellata (starry solomon's seal)
  ___ Smilax echirata (carrion flower)
  ___ Smilax herbacea (carrion flower)
  ___ Smilax hispida (greenbriar)
  ___ Uvularia grandiflora (bellwort)

Orchidaceae (Orchid Family)
  ___ Corallorhiza odontorhiza (fall coral-root)
  ___ Galearis spectabilis (showy orchis)
  ___ Spiranthes ovalis (lady's tresses)

Poaceae (Grass Family)
  ___ Andropogon gerardii (big bluestem)
  ___ Agrostis perennans (upland bent)
  ___ Brachelytrum erectum
  ___ Bromus pubescens (Canada brome)
  ___ Cinna arundinacea (woodreed)
  ___ Diarrhena americana
  ___ Dicentherium latifolium
  ___ Dicentherium oligosanthus var. scribnerianum
  ___ Elymus villosus (slender wild rye)
  ___ Elymus virginicus (Virginia wild rye)
  ___ Festuca obtusa (nodding fescue)
  ___ Glyceria striata (fowl manna grass)
  ___ Hystrix patula (bottlebrush grass)
  ___ Leersia virginica (whitegrass)
  ___ Muhlenbergia bushii (muhley)
  ___ Muhlenbergia mexicana (muhley)
  ___ Muhlenbergia schreberi (nimblewill)
  ___ Sphenopholis obtusata (wedgegrass)
Native Prairie Plant Species of Ames, Iowa

The 168 species listed were observed in the field by William R. Norris during the Ames Natural Areas Inventory (1991-95), except for *Mirabilis hirsutum* reported by Tom Rosburg. A "prairie" species is one that occurs in a list of Iowa prairie species compiled by John Pearson of the Iowa DNR, except for species denoted with an (*). Nomenclature follows Eilers and Roosa (1994), except for *Viola palmata* and *Viola pedatifida* which follows Gleason and Cronquist (1991).

**PTERIDOPHYTES**

Aspleniaceae (Spleenwort Family)

____ *Asplenium platyneuron* (ebony spleenwort)*

Equisetaceae (Horsetail Family)

____ *Equisetum X ferrissii* (hybrid scouring rush)*
____ *Equisetum hyemale* (common scouring rush)*
____ *Equisetum laevigatum* (smooth scouring rush)

**GYMNOSPERMS**

Cupressaceae (Juniper Family)

____ *Juniperus virginiana* (red cedar)*

**ANGIOSPERMS (DICOTS)**

Apiaceae (Carrot Family)

____ *Eryngium yuccifolium* (rattlesnake master)
____ *Zizia aureus* (golden alexander)

Apocynaceae (Dogbane Family)

____ *Apocynum cannabinum var. pubescens* (Indian hemp)

Asclepiadaceae (Milkweed Family)

____ *Asclepias sullivantii* (Sullivant's milkweed)
____ *Asclepias tuberosa* (butterfly weed)
____ *Asclepias verticillata* (whorled milkweed)
____ *Asclepias viridiflora* (green milkweed)

Asteraceae (Daisy Family)

____ *Ambrosia psilostachya* (western ragweed)
____ *Antennaria neglecta* (field pussytoes)
____ *Artemesia ludoviciana* (prairie sage)
____ *Aster azureus* (azure aster)
____ *Aster ericoides* (heath aster)
____ *Aster laevis* (smooth blue aster)
____ *Aster lanceolatus* ssp. *simplex* (panicled aster)
____ *Aster novae-angliae* (New England aster)
____ *Aster pilosus* (hairy aster)
____ *Aster sericeus* (silky aster)
____ *Brickellia eupatorioides* (false boneset)
____ *Cacalia plantaginea* (Indian plantain)
____ *Cirsium altissimum* (tall thistle)
____ *Cirsium discolor* (field thistle)
____ *Cirsium hillii* (Hill's thistle)
____ *Coreopsis palmata* (finger coreopsis)
____ *Echinacea pallida* (pale purple coneflower)
____ *Erigeron strigosus* (rough fleabane)
____ *Eupatorium altissimum* (tall eupatorium)
____ *Euthamia graminifolia* (common flat-topped aster)
____ *Gnaphalium obtusum* (everlasting)
____ *Helianium autumnale* (sneezeweed)
____ *Helianthus grosseserratus* (saw-toothed sunflower)
____ *Helianthus X laetiflorus* (sunflower)
____ *Heliopsis helianthoides* (ox-eye)
Asteraceae (continued)

- Lactuca canadensis (wild lettuce)
- Liatris aspera (rough blazing star)
- Liatris pycnostachya (prairie blazing star)
- Nothocalais cuspidata (prairie dandelion)
- Prenanthes racemosa (glaucous white lettuce)
- Ratibida pinnata (grey-headed coneflower)
- Rudbeckia hirta (black-eyed susan)
- Senecio plattensis (prairie ragwort)
- Silphium integrifolium (rosinweed)
- Silphium laciniatum (compass plant)
- Silphium perfoliatum (cupplant)
- Solidago nemoralis (gray goldenrod)
- Solidago canadensis (Canada goldenrod)
- Solidago gigantea (smooth goldenrod)
- Solidago rigida (rigid goldenrod)
- Vernonia baldwinii (Baldwin's ironweed)
- Vernonia fasciculata (ironweed)

Boraginaceae (Borage Family)

- Lithospermum canescens (hoary puccoon)
- Lithospermum incisum (yellow puccoon)
- Onosmodium molle (false gromwell)

Campanulaceae (Bellflower Family)

- Lobelia spicata (pale-spike lobelia)

Caprifoliaceae (Honeysuckle Family)

- Symphoricarpos spp.

Cistaceae (Rockrose Family)

- Helianthemum bicknellii (frostweed)

Cornaceae (Dogwood Family)

- Cornus amomum ssp. obliqua (silky dogwood)

Euphorbeaceae (Sporge Family)

- Euphorbia corollata (flowering spurge)

Fabaceae (Bean Family)

- Amorpha canescens (leadplant)
- Astragalus canadensis (Canada milk vetch)
- Astragalus crassicarpus (ground plum)
- Baptisia bracteata var. glabrescens (cream wild indigo)
- Baptisia lactea (white wild indigo)
- Chamaecrista fasciculata (showy partridge pea)
- Dalea candida (white prairie clover)
- Dalea purpurea (purple prairie clover)
- Desmodium canadense (hoary tick clover)
- Desmodium illinoense (Illinois tick clover)
- Lathyrus palustris (marsh vetchling)
- Lespedeza capitata (round-head bush clover)
- Lespedeza leptostachya (prairie bush clover)
- Pediomelum argophyllum (silvery scurf pea)

Gentianaceae (Gentian Family)

- Gentiana andrewsii (bottle gentian)
- Gentiana alba (pale gentian)
- Gentiana puberulenta (downy gentian)
- Gentianella quinquefolia ssp. occidentalis (stiff gentian)
Lamiaceae (Mint Family)
    ____ *Mentha arvensis* (wild mint)
    ____ *Monarda fistulosa* (horsemint)
    ____ *Pycnanthemum virginianum* (Virginiana mountain mint)
    ____ *Scutellaria leonardii* (small skullcap)

Linaceae (Flax Family)
    ____ *Linum sulcatum* (grooved flax)

Lythraceae (Loosestrife Family)
    ____ *Lythrum alatum* (prairie loosestrife)

Nyctaginaceae (Four-O’Clock Family)
    ____ *Mirabilis albidum* (pale four o’clock)
    ____ *Mirabilis hirsutum* (hairy four o’clock)

Onagraceae (Evening Primrose Family)
    ____ *Calylophus serrulatus* (plains yellow primrose)
    ____ *Epilobium coloratum* (cinnamon willowerb)
    ____ *Oenothera biennis* (evening primrose)

Oxidaceae (Wood Sorrel Family)
    ____ *Oxalis violacea* (violet wood sorrel)

Polemoniaceae (Phlox Family)
    ____ *Phlox pilosa* (prairie phlox)

Primulaceae (Primrose Family)
    ____ *Lysimachia ciliata* (fringed loosestrife)
    ____ *Lysimachia quadriflora* (loosestrife)

Ranunculaceae (Buttercup Family)
    ____ *Anenome canadensis* (Canada anenome)
    ____ *Anenome virginiana* (tall anenome)
    ____ *Delphinium virescens* (prairie larkspur)
    ____ *Ranunculus* spp. (prairie buttercup)
    ____ *Thalictrum dasycarpum* (tall meadowrue)

Rhamnaceae (Buckthorn Family)
    ____ *Ceanothus americanus* (New Jersey tea)

Rosaceae (Rose Family)
    ____ *Fragaria virginiana* (wild strawberry)
    ____ *Malus ioensis* (wild crab)
    ____ *Potentilla arguta* (tall cinquefoil)
    ____ *Rosa arkansana* (dwarf prairie rose)
    ____ *Rosa blanda* (smooth rose)

Rubiaceae (Madder Family)
    ____ *Galium obtusum* (wild madder)

Santalaceae (Sandalwood Family)
    ____ *Comandra umbellata* (bastard toadflax)

Saxifragaceae (Saxifrage Family)
    ____ *Heuchera richardsonii* (alumroot)
    ____ *Penthorum sedoides* (ditch stonecrop)

Scrophulariaceae (Figwort Family)
    ____ *Agalinus tenuifolia* (agalinus)
    ____ *Pedicularis canadensis* (prairie lousewort)
    ____ *Veronicastrum virginicum* (Culver’s root)
Solanaceae (Nightshade Family)

___ Physalis heterophylla (clammy ground-cherry)
___ Physalis virginiana (Virginia ground-cherry)

Verbenaceae (Vervain Family)

___ Verbena stricta (hoary vervain)

Violaceae (Violet Family)

___ Viola palmata*
___ Viola pedatifida (prairie violet)

ANGIOSPERMS (MONOCOTS)

Commelinaceae (Spiderwort Family)

___ Tradescantia bracteata (spiderwort)

Cyperaceae (Sedge Family)

___ Carex annectens var. xanthocarpa
___ Carex atherodes
___ Carex bicknellii
___ Carex brevior
___ Carex buxbaumii
___ Carex davisi
___ Carex frankii
___ Carex gravida
___ Carex haydenii
___ Carex lacustris*
___ Carex lanuginosa
___ Carex meadii
___ Carex molesta
___ Carex sartwellii
___ Carex tribuloides
___ Carex vulpinoidea
___ Eleocharis erythropoda (spikerush)
___ Scirpus atrovirens
___ Scirpus pendulus

Juncaceae (Rush Family)

___ Juncus canadensis
___ Juncus dudleyii
___ Juncus torreyi
___ Juncus spp.

Iridaceae (Iris Family)

___ Iris shrevei (blue flag)
___ Sisyrinchium campestre (blue-eyed grass)

Liliaceae (Lily Family)

___ Allium canadense (wild onion)
___ Hypoxis hirsuta (stargrass)

Orchidaceae (Orchid Family)

___ Spiranthus cernua (nodding lady's tresses)
___ Spiranthus magnicamporum (great plains lady's tresses)

Poaceae (Grass Family)

___ Andropogon gerardii (big bluestem)
___ Bouteloua curtipendula (side-oats grama)
___ Bouteloua hirsuta (hairy grama)
___ Calamagrostis canadensis (bluejoint)
___ Dicanthelium acuminatum var. implicatum
___ Dicanthelium oligosanthes var. scribnerianum
___ Eragrostis spectabilis (purple lovegrass)
___ Elymus canadensis (Canada wild rye)
___ Koeleria macrantha (June grass)
___ Muhlenbergia cespitata (plains muhley)
___ Muhlenbergia frondosa* (muhley)
___ Muhlenbergia mexicana (muhley)
___ Muhlenbergia racemosa (marsh muhley)
___ Panicum virgatum (switch grass)
___ Schizachyrium scoparium (little bluestem)
___ Sorghastrum nutans (Indian grass)
___ Spartina pectinata (cordgrass)
___ Sporobolus asper (tall dropseed)
___ Sporobolus heterolepis (prairie dropseed)
___ Stipa spartea (needlegrass)
APPENDIX C  IOWA PRAIRIE PLANT LIST (IOWA DNR)
October 3, 1991

Bill Norris  
Botany Department  
Iowa State University  
Ames, IA 50011

Dear Bill:

Here are current lists of Iowa prairie species with their numeric values for the "prairie quality index". One list is arranged alphabetically by scientific name, the other grouped by index value. The legend for the column headings is:

<table>
<thead>
<tr>
<th>R</th>
<th>Rarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Common species, widely and abundantly distributed in Iowa,</td>
</tr>
<tr>
<td>5</td>
<td>Uncommon species, restricted to only portion of Iowa or occurs in low numbers across state,</td>
</tr>
<tr>
<td>8</td>
<td>Rare species, severely restricted in range and abundance, officially listed as Threatened or Endangered under state law.</td>
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</table>

<table>
<thead>
<tr>
<th>D</th>
<th>Disturbance Adaptability</th>
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<tbody>
<tr>
<td>+1</td>
<td>Species usually occurs in undisturbed habitats (i.e., generally not in roadsides and pastures),</td>
</tr>
<tr>
<td>0</td>
<td>Species occurs both in undisturbed and disturbed habitats (i.e., facultative in prairies, pastures, and roadsides),</td>
</tr>
<tr>
<td>-1</td>
<td>Species usually occurs in disturbed habitat (i.e., &quot;weedy&quot; plants specializing in disturbed sites such as pastures and roadsides).</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>F</th>
<th>Fidelity to Prairie Communities</th>
</tr>
</thead>
<tbody>
<tr>
<td>+1</td>
<td>Species highly restricted to prairie communities,</td>
</tr>
<tr>
<td>0</td>
<td>Species facultative across narrow range of prairies and open prairie-like communities (savanna, non-forested wetlands),</td>
</tr>
<tr>
<td>-1</td>
<td>Species facultative across wide range of prairies and non-prairie communities (forests).</td>
</tr>
</tbody>
</table>
B, "bonus", [used only sparingly] a subjective, intuitive adjustment of the overall score based on professional judgment of species value; intended to compensate for omissions and biases in previous factors:

+1, species more desirable than indicated by previous data,

0, species value accepted without adjustment,

-1, species less desirable than indicated by previous data.

The summed scores were constrained to be between 1 and 10. All exotic and non-prairie species were categorically defined to have no value in prairie communities. This, of course, limits application of this index to the evaluation of prairie communities; evaluation of other communities must use another set of species values. I am developing such lists for Forest, Savanna, Saturated Wetlands (fens, sedge meadows), and Inundated Wetlands (marshes).

I first became interested in this evaluation approach in 1986 after being exposed to the "Wilhelm Index" of Gerould Wilhelm of the Morton Arboretum. My first concern was to reduce the subjectivity of species evaluation and to lessen reliance on "expert opinion" (although I discovered that complete objectivity is elusive due to lack of basic ecological information). My first proffered list of March 1987 attracted no reviewers, so I have sporadically developed the list since then more or less alone with some input from Mark Leoschke; it therefore suffers from lack of general peer review. Several additional modifications were adopted, the main one being specification of community-specific lists instead of a general whole-flora list. Sources consulted to determine rarity, disturbance adaptability, and fidelity included the draft annotated checklist of Iowa vascular plants by Larry Eilers and Dean Roosa as well as floras from surrounding states and regions (Steyermark, Van Bruggen, Mohlenbrock, Flora of the Great Plains, etc.).

I am pleased to learn of your interest in this product and look forward to working with you to further develop and apply it.

Sincerely,

John Pearson, Plant Ecologist
Preserves & Ecological Services
### PRELIMINARY PRAIRIE SPECIES INDEX VALUES FOR RARITY (R), DISTURBANCE (D), FIDELITY (F), BONUS (B), AND TOTAL (TOT) COMPONENTS

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<th>B</th>
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<td>Vicia americana</td>
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<td>1</td>
<td>-1</td>
<td>3</td>
<td>Viola pedatifida</td>
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<td>0</td>
<td>1</td>
<td>0</td>
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<td>Viola sagittata</td>
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<td>Zigadenus elegans</td>
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<td>-1</td>
<td>0</td>
<td>1</td>
<td>Zizia aurea</td>
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APPENDIX D  "USER-FRIENDLY" WOODLAND SURVEY AND EVALUATION FORMS
WOODLAND SURVEY FORM

Date: _______ Observer(s): ____________________

I) Tract Information

Tract: _______ Plot # (18m radius circle): ______
County: _______ USGS Quadrangle: ____________
Township: ______ Range: ______ Section(s): ______

Topography (Check one):
  i) Ridge
  ii) Slope
  iii) Bottomland

Slope Aspect (Check one, if applicable)
  i) North
  ii) Northeast
  iii) East
  iv) Southeast
  v) South
  vi) Southwest
  vii) West
  viii) Northwest

II) Canopy Trees

A) Total Canopy Cover

Check the total percent of the plot that is shaded by canopy trees:
  i) at least 75%;
  ii) between 50% and 75%;
  iii) less than 50%.

B) Canopy Species Composition and Dominance

Species that cover at least 25% of the plot

Species that cover less that 25% of the plot

C) Introduced Canopy Species

Check the total percent of the plot that is shaded by canopy trees not native to central Iowa (e.g. Siberian elm, white poplar, white pine, black locust):
  i) at least 15%;
  ii) between 1% and 15%;
  iii) less than 1%
III) Understory Saplings, Shrubs and Vines

A) Total Understory Cover

Check the total percent of the plot that is shaded by understory saplings, shrubs and vines:
- i) at least 80% due primarily to small trees and saplings (dbh > 5 cm)
- ii) at least 80% due primarily to shrubs and vines (dbh < 5 cm)
- iii) between 40% and 80%
- iv) between 20% and 40%
- v) less than 20%

B) Understory Species Composition and Dominance

Species that cover at least 25% of the plot

Species that cover between 1% and 25% of the plot

Species that cover less than 1% of the plot

C) Introduced Understory Species

Check the total percent of the plot that is shaded by saplings, shrubs and vines not native to central Iowa (e.g. Tartarian honeysuckle, European buckthorn, white mulberry, multiflora rose, European barberry, Guelder rose)
- i) at least 15%;
- ii) between 1% and 15;
- iii) less than 1%
Method for Evaluation of Woodlands in Ames (Iowa)

I) DIVERSITY

If woodland occurs on a . . .

Ridgetop or flat upland
Slope
Creek bottom or bottomland

GOTO A) RIDGETOP DIVERSITY
GOTO B) SLOPE DIVERSITY
GOTO C) BOTTOMLAND DIVERSITY

A) RIDGETOP DIVERSITY

Canopy

2 Canopy contains at least 4 of the tree species expected to occur on a ridgetop.¹
1 Canopy contains 3 of the tree species expected to occur on a ridgetop.
0 Canopy contains 2 or fewer of the tree species expected to occur on a ridgetop.

Understory

2 Understory contains 8 or more of the sapling, shrub and vine species expected to occur on a ridgetop.²
1 Understory contains 5, 6 or 7 of the sapling, shrub and vine species expected to occur on a ridgetop.
0 Understory contains 4 or fewer of the sapling, shrub and vine species expected to occur on a ridgetop.

(If on a ridgetop the canopy is dominated by a pure stand of white oak or bur oak, score "1" for canopy diversity)

RIDGETOP DIVERSITY SCORE (CANOPY): _____
RIDGETOP DIVERSITY SCORE (UNDERSTORY): _____

¹ See list of expected canopy tree species for ridgetops.
² See list of expected understory species for ridgetops.
B) SLOPE DIVERSITY

If woodland canopy is dominated primarily by...

- Black maple, basswood and red oak
- Oaks (white, red or bur) and/or shagbark hickory

GOTO i) Moist Slopes

GOTO ii) Dry Slopes

(If you are not sure, score canopy diversity as both a moist slope and a dry slope and choose the category that gives the higher score).

**i) Moist Slopes**

<table>
<thead>
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<th>Canopy</th>
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<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Canopy contains 3 or more of the tree species expected to occur on a moist slope.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Canopy contains 2 of the tree species expected to occur on a moist slope.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Canopy contains 1 or fewer of the tree species expected to occur on a moist slope.</td>
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<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Understory</th>
<th>2</th>
<th>1</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Understory contains 6 or more of the sapling, shrub and vine species expected to occur on a moist slope.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Understory contains 4 or 5 of the sapling, shrub and vine species expected to occur on a moist slope.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Understory contains 3 or fewer of the sapling, shrub and vine species expected to occur on a moist slope.</td>
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**ii) Dry Slopes**

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<tbody>
<tr>
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<td>Canopy contains 4 or more of the tree species expected to occur on a dry slope.</td>
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<td></td>
</tr>
<tr>
<td>1</td>
<td>Canopy contains 3 of the tree species expected to occur on a dry slope.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>Canopy contains 2 or fewer of the tree species expected to occur on a dry slope.</td>
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<table>
<thead>
<tr>
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<tbody>
<tr>
<td>2</td>
<td>Understory contains 8 or more of the sapling, shrub and vine species expected to occur on a dry slope.</td>
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</tr>
<tr>
<td>1</td>
<td>Understory contains 5, 6 or 7 of the sapling, shrub and vine species expected to occur on a dry slope.</td>
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<tr>
<td>0</td>
<td>Understory contains 4 or fewer of the sapling, shrub and vine species expected to occur on a dry slope.</td>
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(If on a dry slope the canopy is dominated by a pure stand of white oak or bur oak, score "1" for canopy diversity)

**SLOPE DIVERSITY SCORE (CANOPY):** __________

**SLOPE DIVERSITY SCORE (UNDERSTORY):** __________

---

3 See list of expected canopy tree species for moist slopes.
4 See list of expected understory species for moist slopes.
5 See list of expected canopy tree species for dry slopes.
6 See list of expected understory species for dry slopes.


**C) BOTTOMLAND DIVERSITY**

If woodland canopy is dominated primarily by . . .

- Cottonwood, black willow, boxelder, silver maple, elm, hackberry, walnut, green ash and/or honey locust
- Sugar maple, basswood and red oak

GOTO i) Floodplain Forest

GOTO ii) Mature Bottomland

If you are not sure, score canopy diversity as both floodplain forest and mature bottomland and choose the category that gives the higher score.

i) Floodplain Forests

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<table>
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<td>2</td>
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ii) Mature Bottomlands

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<table>
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<tr>
<td>1</td>
</tr>
<tr>
<td>0</td>
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**BOTTOMLAND DIVERSITY SCORE (CANOPY):**

**BOTTOMLAND DIVERSITY SCORE (UNDERSTORY):**

---

7 See list of expected canopy tree species for floodplain forests.
8 See list of expected understory species for floodplain forests.
9 See list of expected canopy tree species for mature bottomlands.
10 See list of expected understory species for mature bottomlands.
## II) STRUCTURE

### Canopy

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<th>Description</th>
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<td>Between 50% and 75% canopy cover</td>
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<tr>
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<td>Less than 50% canopy cover</td>
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### Understory

<table>
<thead>
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<th>Score</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>2</td>
<td>Between 40% and 80% understory cover</td>
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<tr>
<td>1</td>
<td>Between 20% and 40% understory cover OR Greater than 80% understory cover due primarily to small trees and saplings (dbh &gt; 5 cm)</td>
</tr>
<tr>
<td>0</td>
<td>Less than 20% understory cover OR Greater than 80% understory cover due primarily to shrubs and vines (dbh = &lt; 5 cm)</td>
</tr>
</tbody>
</table>

**STRUCTURE SCORE (CANOPY): _____**
**STRUCTURE SCORE (UNDERSTORY): _____**
III) FIDELITY

If woodland occurs on a . . .

Ridgetop or flat upland  GOTO A) RIDGETOP FIDELITY  
Slope  GOTO B) SLOPE FIDELITY  
Creek bottom or bottomland  GOTO C) BOTTOMLAND FIDELITY  

A) RIDGETOP FIDELITY

Canopy

2  At least 75% of the canopy cover is provided by species expected for ridgetops (e.g. oak (bur, white, red) and shagbark hickory).  
1  Between 25% and 75% of the canopy cover is provided by species expected for ridgetops.  
0  Less than 25% of the canopy cover is provided by species expected for ridgetops (often replaced by unexpected species such as honey locust and elm).  

Understory

2  At least 75% of the understory cover is provided by species expected for ridgetops (e.g. ironwood).  
1  Between 25% and 75% of the understory cover is provided by species expected for ridgetops.  
0  Less than 25% of the canopy cover is provided by species expected for ridgetops (often replaced by unexpected species such as elm, hackberry, Tartarian honeysuckle, European buckthorn and multiflora rose).  

RIDGETOP FIDELITY SCORE (CANOPY):  
RIDGETOP FIDELITY SCORE (UNDERSTORY):  

11 See list of expected canopy tree species for ridgetops.  
12 See list of expected understory species for ridgetops.
B) SLOPE FIDELITY

**Canopy**

2  At least 75% of the canopy cover is provided by species expected for *slopes* (e.g. black maple, basswood, all oak and hickory species).\(^{13}\)

1  Between 25% and 75% of the canopy cover is provided by species expected for *slopes*.

0  Less than 25% of the canopy cover is provided by species expected for *slopes* (often replaced by unexpected species such as honey locust, hackberry, elm, green ash and black walnut).

**Understory**

2  At least 75% of the understory cover is provided by species expected for *slopes* (e.g. ironwood, black maple and basswood).\(^{14}\)

1  Between 25% and 75% of the understory cover is provided by species expected for *slopes*.

0  Less than 25% of the canopy cover is provided by species expected for *slopes* (often replaced by unexpected species such as elm, hackberry, Tartarian honeysuckle and European buckthorn).

\(^{13}\) See lists of expected canopy tree species for *moist slopes* and *dry slopes*.

\(^{14}\) See lists of expected understory species for *moist slopes* and *dry slopes*.
C) BOTTOMLAND FIDELITY

Canopy

2 At least 75% of the canopy cover is provided by species expected for bottomlands (almost all tree species native to Iowa, except white oak, shagbark hickory, white ash, black cherry and black locust (non-native), are expected).  

1 Between 25% and 75% of the canopy cover is provided by species expected for bottomlands.

0 Less than 25% of the canopy cover is provided by species expected for bottomlands.

Understory

2 At least 75% of the understory cover is provided by species expected for bottomlands (e.g. almost all saplings, shrubs and vines native to central Iowa are expected).

1 Between 25% and 75% of the understory cover is provided by species expected for bottomlands.

0 Less than 25% of the canopy cover is provided by species expected for bottomlands (often replaced by introduced shrubs like Tartarian honeysuckle, European buckthorn and white mulberry).

BOTTOMLAND FIDELITY SCORE (CANOPY): 
BOTTOMLAND FIDELITY SCORE (UNDERSTORY): 

15 See lists of expected canopy tree species for floodplain forests and mature bottomlands.
16 See lists of expected understory species for floodplain forests and mature bottomlands.
IV) INTRODUCED SPECIES

Canopy

2 Species not native to central Iowa woodlands (e.g. Siberian elm, white pine, black locust, white poplar) are absent or not conspicuous in the canopy (less than 1% total cover).

1 Species not native to central Iowa woodlands are conspicuous but not dominant in the canopy (between 1% and 15% total cover).

0 Species not native to central Iowa woodlands are very conspicuous to dominant in the canopy (greater than 15% total cover).

Understory

2 Species not native to central Iowa woodlands (e.g. Tartarian honeysuckle, European buckthorn, white mulberry, multiflora rose) are absent or inconspicuous in the understory (less than 1% total cover).

1 Species not native to central Iowa woodlands are conspicuous but not dominant in the understory (between 1% and 15% total cover).

0 Species not native to central Iowa woodlands are very conspicuous to dominant in the understory (greater than 15% total cover).

INTRODUCED SPECIES SCORE (CANOPY): 
INTRODUCED SPECIES SCORE (UNDERSTORY): ___
### Calculating the Ames Woodland Quality Rating (WQR)

<table>
<thead>
<tr>
<th>Category</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diversity (Canopy)</td>
<td>x 2</td>
</tr>
<tr>
<td>Diversity (Understory)</td>
<td>x 2</td>
</tr>
<tr>
<td>Structure (Canopy)</td>
<td></td>
</tr>
<tr>
<td>Structure (Understory)</td>
<td></td>
</tr>
<tr>
<td>Fidelity (Canopy)</td>
<td></td>
</tr>
<tr>
<td>Fidelity (Understory)</td>
<td></td>
</tr>
<tr>
<td>Introduced Species (Canopy)</td>
<td></td>
</tr>
<tr>
<td>Introduced Species (Understory)</td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL (Range: 0-20) = ______ = WQR**

**What do these numbers mean?**

A. (WQR = 18, 19 or 20): Highly Natural Woodland. Undisturbed natural communities composed of the expected diversity of native species.

Example: Old growth, ungrazed forest

B. (WQR = 14, 15, 16 or 17): Mostly Natural Woodland. Lightly disturbed communities in which both overstory and understory are predominately composed of species expected under natural conditions.

Example: Forests that have been selectively logged or grazed without destroying the structure and natural diversity of the community.

C. (WQR = 10, 11, 12 or 13): Moderately Altered Woodland. Disturbed communities in which either the overstory or the understory is not predominately composed of species expected under natural conditions.

Example: Forests in which the understory and ground cover have been altered by grazing or recreation.

D. (WQR = 0, 1, 2, ..., 9): Highly Altered Woodland. Heavily disturbed communities in which neither the overstory nor the understory is predominately composed of species expected under natural conditions.

Example: An upland forest in which the overstory and the understory have developed following severe recent disturbance.
<table>
<thead>
<tr>
<th>RIDGETOPS AND DRY SLOPES</th>
<th>MOIST SLOPES AND MATURE BOTTOMLANDS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Expected Canopy Tree Species</strong></td>
<td><strong>Expected Canopy Tree Species:</strong></td>
</tr>
<tr>
<td><em>Carya ovata</em> (Shagbark Hickory)</td>
<td><em>Acer nigrum</em> (Black Maple)</td>
</tr>
<tr>
<td><em>Fraxinus americana</em> (White Ash)</td>
<td><em>Carya cordiformis</em> (Yellowbud Hickory)</td>
</tr>
<tr>
<td><em>Populus grandidentata</em> (Big-Tooth Aspen)</td>
<td><em>Fraxinus nigra</em> (Black Ash)</td>
</tr>
<tr>
<td><em>Prunus serotina</em> (Black Cherry)</td>
<td><em>Juglans cinerea</em> (Butternut)</td>
</tr>
<tr>
<td><em>Quercus alba</em> (White Oak)</td>
<td><em>Quercus borealis</em> f. var. <em>maxima</em> (<em>=Q. rubra</em> - Red Oak)</td>
</tr>
<tr>
<td><em>Quercus borealis</em> f. var. <em>maxima</em> (<em>=Q. rubra</em> - Red Oak)</td>
<td><em>Tilia americana</em> (American Basswood)</td>
</tr>
<tr>
<td><em>Quercus macrocarpa</em> (Bur Oak)</td>
<td></td>
</tr>
<tr>
<td><em>Quercus velutina</em> (Black Oak)</td>
<td></td>
</tr>
<tr>
<td><strong>Expected Understory (Sapling, Shrub and Vine) Species:</strong></td>
<td><strong>Expected Understory (Sapling, Shrub and Vine) Species:</strong></td>
</tr>
<tr>
<td><em>Acer nigrum</em> (Black Maple)</td>
<td><em>Acer nigrum</em> (Black Maple)</td>
</tr>
<tr>
<td><em>Amelanchier arborea</em> (Downy Serviceberry)</td>
<td><em>Amelanchier arborea</em> (Downy Serviceberry)</td>
</tr>
<tr>
<td><em>Carya cordiformis</em> (Yellowbud Hickory)</td>
<td><em>Carya cordiformis</em> (Yellowbud Hickory)</td>
</tr>
<tr>
<td><em>Carya ovata</em> (Shagbark Hickory)</td>
<td><em>Corylus americana</em> (Hazelnut)</td>
</tr>
<tr>
<td><em>Cornus</em> spp. (Dogwood)</td>
<td><em>Cornus</em> spp. (Dogwood)</td>
</tr>
<tr>
<td><em>Corylus americana</em> (Hazelnut)</td>
<td><em>Euonymous atropurpurea</em> (Wahoo)</td>
</tr>
<tr>
<td><em>Euonymous atropurpurea</em> (Wahoo)</td>
<td><em>Fraxinus</em> spp. (Ash)</td>
</tr>
<tr>
<td><em>Fraxinus</em> spp. (Ash)</td>
<td><em>Juglans cinerea</em> (Butternut)</td>
</tr>
<tr>
<td><em>Ostrya virginiana</em> (Ironwood)</td>
<td><em>Menispermum canadense</em> (Moonseed)</td>
</tr>
<tr>
<td><em>Parthenocissus quinquefolia</em> (Virginia Creeper)</td>
<td><em>Morus rubra</em> (Red Mulberry)</td>
</tr>
<tr>
<td><em>Populus grandidentata</em> (Big-Toothed Aspen)</td>
<td><em>Ostrya virginiana</em> (Ironwood)</td>
</tr>
<tr>
<td><em>Prunus serotina</em> (Black Cherry)</td>
<td><em>Parthenocissus virginiana</em> (Virginia Creeper)</td>
</tr>
<tr>
<td><em>Prunus virginiana</em> (Choke Cherry)</td>
<td><em>Quercus</em> spp. (Oak)</td>
</tr>
<tr>
<td><em>Tilia americana</em> (American Basswood)</td>
<td><em>Staphylea trifolia</em> (Bladdernut)</td>
</tr>
<tr>
<td><em>Quercus</em> spp. (Oak)</td>
<td><em>Tilia americana</em> (American Basswood)</td>
</tr>
<tr>
<td><em>Viburnum lentago</em> (Nannyberry)</td>
<td><em>Viburnum rafinesquianum</em> (Downy Arrowwood)</td>
</tr>
<tr>
<td><em>Viburnum rafinesquianum</em> (Downy Arrowwood)</td>
<td><em>Vitis riparius</em> (River Grape)</td>
</tr>
<tr>
<td><em>Vitis riparius</em> (River Grape)</td>
<td></td>
</tr>
</tbody>
</table>
### Floodplain Forests

**Expected Canopy Tree Species:**

- *Acer negundo* (Box Elder)
- *Acer saccharinum* (Silver Maple)
- *Carya cordiformis* (Yellowbud Hickory)
- *Celtis occidentalis* (Hackberry)
- *Fraxinus pennsylvanica* (Green Ash)
- *Gleditsia triacanthos* (Honey Locust)
- *Gymnocladus dioica* (Kentucky Coffee Tree)
- *Juglans cinerea* (Butternut)
- *Juglans nigra* (Black Walnut)
- *Populus deltoides* (Cottonwood)
- *Platanus occidentalis* (Sycamore)
- *Quercus macrocarpa* (Bur Oak)
- *Salix nigra* (Black Willow)
- *Ulmus americana* (American Elm)
- *Ulmus rubra* (Red Elm)

**Expected Understory (Sapling, Shrub, and Vine) Species:**

- *Acer nigrum* (Black Maple)
- *Acer negundo* (Boxelder)
- *Acer saccharinum* (Silver Maple)
- *Carya cordiformis* (Yellowbud Hickory)
- *Celtis occidentalis* (Hackberry)
- *Cornus* spp. (Dogwood)
- *Euonymus atropurpurea* (Wahoo)
- *Fraxinus* spp. (Ash)
- *Gleditsia triacanthos* (Honey Locust)
- *Gymnocladus dioica* (Kentucky Coffee Tree)
- *Juglans cinerea* (Butternut)
- *Juglans nigra* (Black Walnut)
- *Menispermum canadense* (Moonseed)
- *Morus rubra* (Red Mulberry)
- *Ostrya virginiana* (Ironwood)
- *Parthenocissus quinquefolia* (Virginia Creeper)
- *Platanus occidentalis* (Sycamore)
- *Populus deltoides* (Cottonwood)
- *Quercus* spp. (Oak)
- *Rubus* spp. (Black Raspberry, Blackberry)
- *Salix* spp. (Willow)
- *Sambucus canadensis* (Elderberry)
- *Smilax hispida* (Greenbriar)
- *Staphylea trifolia* (Bladdernut)
- *Tilia americana* (American Basswood)
- *Toxicodendron radicans* (Poison Ivy)
- *Ulmus* spp. (Elm)
- *Viburnum rafinesquianum* (Downy Arrowwood)
- *Vitis riparius* (River Grape)
APPENDIX E INDEX MAP