Development of a Natural Areas Integrity and Restorability Index and Application to Lands of the Chicago Region

Part 2 – Restorability Index

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2. Conceptual Development

Our capacity to restore the natural quality of natural communities through restoration management practices has improved dramatically over the last 30 years. As we protect and manage the remaining high quality (Illinois Natural Areas Inventory Category I) natural areas, many of which are small, the attention of conservationists naturally turns to areas that are of lesser quality, but still possess significant natural values. These lands are often larger than the remaining high quality natural areas, and still have the potential for restoration at a reasonable cost. The first part of this project focused on identifying such lands using metrics related to landscape integrity, in this part of the project we have developed a "Restorability Index" which can be used to rapidly assess the restoration potential of lands possessing landscape integrity.

Since our objective is to identify lands supporting natural communities that can be restored to high natural quality, the "Restorability Index" is not designed to be applied to existing high quality natural communities. Using the terminology of the Illinois Natural Areas Inventory (INAI) the Restorability Index is not really designed to be applied to Grade A or B natural communities, though it can be calculated for them, but rather degraded, i.e., Grade C, D, or E natural communities in the parlance of the INAI. However, since Grade E communities have essentially had the original community completely removed, Grade E communities cannot be "restored" in the same sense as grade C and D natural communities, but must be "reconstructed" from scratch, often at great cost and seldom achieving very high natural quality. Examples of Grade E communities include cleared land, cropland, improved pasture, residential/commercial development, parking lots, road or railroad embankments and rights of way. Consequently the Restorability Index was not designed to be applied to them either. If it is calculated for grade E natural communities it will yield extremely high scores, indicating the very high cost in human and financial resources and the low probability of success in achieving high quality results associated with reconstructions. Since restorability is related to community grade, we have chosen to build the Restorability Index upon the foundation of the updated INAI grading methods refined as part of the INAI Update. Much of the data collected in the grading process can be used to assess restorability. Consequently, familiarity with the revised INAI grading methods is integral to an understanding of the principles underlying the Restorability Index.

To provide a foundation for further discussion of the Restorability Index several relevant sections from the INAI Update Grading Handbook are incorporated hereafter (White, John. 2009. *Illinois Natural Areas Inventory Update: Grading Handbook*, Fourth edition. June 29

2009. Ecological Services, Urbana, Illinois, hereafter Grading Handbook, attached as Appendix I). Appendices referenced in the following excepts as numerals (1,2,3,4,10) are appendices to the Grading Handbook.

3. "Illinois Natural Areas Inventory Update – Grading Handbook"

Natural Quality and Grades
Natural Quality is defined as measure of the effects of degrading disturbance to a Natural Community. * A system of five letter grades (A, B, C, D. and E) expresses degrees of Natural Quality. The Illinois Department of Natural Resources' (IDNR) definitions and descriptions of Natural Quality Grades are in Appendix 1.

Regimes, Factors, and Indicators
Information about the attributes of a Natural Community that are useful for determining the community's Natural Quality are organized with a three-level system:

Disturbance Regime
Disturbance Factor
Quality Indicator

Disturbance Regimes
Disturbances that can have a significant effect on Natural Quality are grouped into 25 broad categories, or *Disturbance Regimes*:

Clearing
Cultivation
Deer Overabundance
Drainage
Earthmoving
Farming
Faunal Exploitation and Disturbance
Fire
Fire Suppression
Flooding
Grazing
Insects and Pathogens
Intrusions
Invasive Species
Logging
Mowing
Soil Movement, Erosion, and Deposition
Water Impoundment
Water Pollution
Weather and Climatic Extremes

Other Natural Biotic Processes
Other Natural Abiotic Processes
Other Artificial Disturbances
Artificial Disturbances in General
Natural Disturbances in General

Most Quality Indicators are found during the Final Field Survey or Initial Ground Survey, but they can also be identified during the Map & Aerial Photo Stage, Aerial Survey Stage, or Existing Information Stage.

In addition to the 25 Disturbance Regimes, two more categories are necessary to cover all of the possibilities that are encountered when evaluating Survey Sites:

Unknown disturbance
No evident disturbance

The 25 Disturbance Regimes and two additional categories are defined in Appendix 2.

Disturbance Factors
A *Disturbance Factor* is an *intrusion*, an *activity*, or a *condition* of a Natural Community that affects or may affect the Natural Quality of the community. The factor may or may not be directly observable in the field, and it can be either an *explanation for* or a *consequence of* a Quality Indicator.

Disturbance Factors are listed in Appendix 3.

Quality Indicators
A *Quality Indicator* is a feature that (a) usually can be observed in the field, * and (b) can be interpreted as an *indication* of some kind of disturbance or lack of disturbance to a Natural Community. The indicator may be (a) a kind of *intrusion* (a physical thing), (b) evidence of an *activity*, or (c) a *condition* of a Natural Community. A Quality Indicator is *evidence* of either a disturbance or the lack of disturbance in a community. In other words, a Quality Indicator is an *expression* of the Natural Quality of a community; a Disturbance Factor is a *reason* for the quality of a community. A Quality Indicator is "what you see." A Disturbance Factor is "what caused what you see." Appendix 4 consists of an ever-expanding list of Quality Indicators. When grading a Natural Community, the Surveyor identifies Quality Indicators and then documents and analyzes them in terms of Disturbance Factors on a Grading Form.

Relationship between Disturbance Regimes, Disturbance Factors, and Quality Indicators
The hierarchical relationship between a Disturbance Regime, Disturbance Factor, and Quality Indicator is roughly equivalent to the taxonomic relationship between a biological *family*, *genus*, and *species*. A Disturbance Regime is a *family* grouping of Disturbance Factors. A Disturbance Factor is stated in *generic* terms, and it may be

indicated by a number of Quality Indicators. A Quality Indicator is a *specific* expression of either a disturbance or the lack of disturbance. Each Quality Indicator is expressed individually and differently whenever it occurs in a Survey Site. The list of Quality Indicators in Appendix 4 is dynamic: it continually grows as more indicators are identified during field investigations, consultations with natural area specialists, and literature review. On the other hand, the list of Disturbance Regimes and Disturbance Factors in Appendix 3 has been designed and developed to provide a more stable, inclusive classification structure. The system for classifying Disturbance Regimes, Factors, and Indicators is ad hoc in the sense that it consists of groupings that serve the practical purposes of grading even though some elements of the classification are defined with different criteria than others ("mixing apples and oranges")."

For the purpose of assessing restorability, Quality Indicators are important because they are what you *see* on the landscape, but once the associated Disturbance Factors are identified, they are more important in assessing restorability, because as discussed above, a Disturbance Factor is the *reason* for the quality of the site; it is the cause of what you see (the Quality Indicator). In this context restoration management is a process of altering disturbance factors, either through elimination, alteration, or substitution. How easily this is done, or how costly it is to do, is therefore a measure of restorability. However, the same disturbance factor can have degrees of effects at different locations. So we must also assess the severity of the effect on natural quality of a community. In actual application natural communities are not the unit graded, but rather grades are assigned to "grading patches." This accommodates a situation, for example, where several acres of contiguous dry-mesic prairie composed of "grading patches" of A, B, and C prairie. To help us assess the severity of the effect we can again turn to another aspect of the INAI Update Grading Methods (White, John. 2009. *Illinois Natural Areas Inventory Update: Grading Handbook*, Fourth edition. June 29, 2009. Ecological Services, Urbana, Illinois, hereafter Grading Handbook, attached as Appendix I):

"Documenting the Impact of a Disturbance Factor
The *Impact* of a Disturbance Factor is assessed by observing and documenting three attributes: the factor's *Extent*, *Level*, and *Trend*. These attributes are recorded for each Disturbance Factor on page 1 of the Grading Form.

Extent
The *Extent* of a Disturbance Factor is an estimate of the proportion of a Grading Patch that is occupied or affected by the factor. The Grading Form [*the last 3 pages of Appendix I, the Grading Handbook, which are unpaginated*] provides four choices for recording a Disturbance Factor's Extent:

Not seen: The factor or its effect is not found in the Grading Patch. *

Localized: The factor occupies or affects less than about one-tenth of the Grading Patch, often in several scattered spots.

Moderate: The factor occupies or affects roughly one-tenth to one-half of the Grading Patch.

Widespread: The factor occupies or affects more than half of the Grading Patch.

Guidelines for documenting the Extent.—The Extent of a Disturbance Factor is estimated on the basis of visual inspection during field reconnaissance. It is not ordinarily determined by any kind of measurement.

Level
The *Level* of a Disturbance Factor is the degree of development of the factor and its effects. There are four choices:

None or N/A: If a Disturbance Factor is present in a Grading Patch but it is having no apparent, active effect on the community, then the *Level* is None. Or if the *Extent* of the Disturbance Factor is recorded as Not seen, then the *Level* must be N/A (not applicable).

Low: In the parts of a Grading Patch that the Disturbance Factor occupies or affects, it is poorly developed and has a minor effect on the community.

Medium: The level of development is judged to be between Low and High.

High: In the parts of a Grading Patch that the Disturbance Factor occupies or affects, it is well developed and has a major effect on the community.

Trend
The *Trend* describes whether the *Extent* or *Level* of a Disturbance Factor appears to be increasing or decreasing. Four options:

Unknown or N/A: If a trend cannot be determined, it is Unknown. If the *Extent* of a disturbance is recorded as Not seen or if the *Level* is None or N/A, then the Trend must be N/A (not applicable).

Decreasing: The Disturbance Factor is judged to be declining, either by shrinking in area or dropping toward a lower level of development.

Stable: The factor appears to be in a steady state, neither increasing nor decreasing overall — although it may be increasing or decreasing locally within the Grading Patch.

Increasing: The factor is judged to be increasing, either in its extent or its level of development, or both.

Guidelines for documenting the Trend.—The Trend of a Disturbance Factor may be obvious, or it may be difficult or impossible to judge on the basis of the available information. Often the growth or decline of vegetation is a good indicator of a trend. Are frost-damaged plants re-sprouting? Is a patch of weeds obviously dying back?"

If the trend is stable or increasing and both the extent and level of a disturbance factor is high, it is likely to significantly lower the Condition Rating of Grading Components and Subcomponents which are at the heart of the grading methodology. The Grading Components, Subcomponents, and Condition Ratings are described by White (2009) in the Grading Handbook in this way:

> **"Grading Components and Sub-components**
> For the purposes of grading Natural Quality, a Natural Community is described and analyzed in terms of four *Grading Components*:
>
> Species composition
> Vegetation structure
> Ecological processes
> Physical environment
>
> Briefly termed:
>
> Composition
> Structure
> Processes
> Environment
>
> Each Grading Component can be broken down into a number of *Sub-components*, which are elements of a Grading Component that can be observed and evaluated, and that have a major bearing on the condition of the Grading Component.
>
> The four Grading Components and important Sub-components are defined and discussed under the next several headings.
>
> **Composition**
>
> ***Definition***
> The *composition* of a community refers to the species that are present in the community, plus three attributes of each species: its *nativity*, *abundance*, and *autecology*.
>
> A species' *nativity* may be simply denoted as either *native* or *exotic*. A detailed and comprehensive terminology for describing nativity is in Appendix 6.
>
> Terms for annotating the *abundance* of a species are in Appendix 7.
>
> *Autecology* refers to the ecology of an individual species, as opposed to the *synecology* of a community. Aspects of autecology include phenology (spring ephemeral, fallblooming, etc.), length of the reproductive cycle (annual, biennial, perennial), reproductive strategy (r/K selection), photosynthetic pathway (C3 vs. C4), tolerance to environmental extremes, tolerance to disturbances, competitive ability (allelopathy, shade tolerance), and palatability to herbivores.

Sub-components
Many aspects of the species composition of a Natural Community lend themselves to analysis when grading Natural Quality. The following Sub-components are listed on the Grading Form because they are considered to be the primary ones that indicate the condition of the Grading Component:

Richness: The number of species in a given area. This number may be derived from vegetation plot sampling, or it may be simply estimated by looking at the Grading Patch, ideally while making a plant species list.

Conservatives: Native plant species that do not tolerate most disturbances, and that usually do not occur in degraded habitats.

Decreasers: Native plant species that tend to decrease in number or vigor when their habitat is lightly to moderately disturbed. *

Increasers: Native or non-native plant species that tend to increase in number or vigor when their habitat is lightly to moderately disturbed.

Ruderals: Native or non-native plant species that grow in highly disturbed areas, often becoming established on bare soil; often annuals that do not persist unless the site is repeatedly disturbed or the substrate is unnatural (*e.g.* a cindery railroad embankment).

Exotics: Species that are not native to an area.

Additional Sub-components may be added to the Grading Form on a patch-by-patch basis to characterize other relevant aspects of a Grading Patch's species composition.

Structure

Definition
Structure has three aspects:

a) the physiognomy or physical form and appearance of the vegetation as a whole,

b) the pattern of distribution of species or groups of species within a community, and

c) the growth form and morphology of individual species and even single plants in a community.

In other words, structure relates to:
a) the vertical arrangement and character of vegetation layers (including the size and density of trees),

b) the horizontal distribution of individual species or groups of species in a community (*e.g.* zones related to environmental gradients, or patches that develop in response to disturbance history and succession, or apparently random or patternless distribution), and

c) a species' growth form (graminoid, forb, shrub, tree) and the appearance of individual plants (vigor; disfigurement from herbivory, pathogens, and environmental stressors).

Sub-components

During the grading process, the Structure component is evaluated according to the Natural Community's vertical vegetation layers. A community may have as many as four possible vegetation layers:

Ground layer: Herbaceous plants and woody plants up to 1 meter tall.

Shrub layer: Shrubs, saplings, and small trees.

Subcanopy layer: Small trees that form a canopy directly beneath the overstory canopy.

Overstory layer: Trees that form the uppermost canopy in a community.

In addition, as an alternative, the shrub layer and subcanopy layer may be referred to collectively as the **understory layer** when it is efficient to do so, and when it is possible to clearly record observations or analyses about both layers at once.

Structure is also commonly evaluated in terms of another Sub-component:

Horizontal pattern: The horizontal distribution of individual species or groups of species in a community, including the size and shape of vegetation patches, the relationship between patches and environmental gradients and disturbances, and the character of boundaries between patches.

The above Sub-components are listed on the Grading Form. Other aspects of vegetation structure may be identified and added to the form as additional Sub-components if they do not fit well into any of the above Sub-components.

Processes

Definition

Ecological *processes* consist of the biological and physical actions that shape and control an ecosystem and cause it to function.

Here is a sampling of ecological processes and their effects on an ecosystem: (a) formation of soil by chemical weathering and decomposition of organic matter; (b) changes in vegetation structure, microclimate, soil, and species composition through ecological succession; (c) control of animal populations by predators, diseases, and parasites, and (d) changes in natural communities that result from disturbances such as fires and floods.

When evaluating a Survey Site, one must recognize and accept that ecological processes are significantly different now than they were two centuries ago. Farming has fundamentally transformed the hydrology of streams. Wildfires no longer sweep the plains, so a remnant prairie may no longer experience the fires that it requires for its continued existence. Large predators have been eradicated, so the population dynamics of animals as well as plants have changed dramatically. There are no free-ranging bison and no passenger pigeons. NOTE 3 The natural landscape is so fragmented that local dispersal as well as long-distance migration are severely curtailed for many species. Acid rain, atmospheric deposition of nitrogen, and global warming add new dimensions of change. Regardless of such major alterations of ecosystem processes, evaluation standards need to be applied in a manner that allows the Processes component of some Survey Sites to be rated as High.

Sub-components

Biological and physical processes are myriad and they operate at every scale, from intracellular to cosmic. An ecological process that is evidenced by a Quality Indicator may originate or extend beyond the limits of a Grading Patch and far from a Survey Site. Most processes operate well beyond the control and outside the capacity of natural area managers. The grading procedure should focus primarily on processes that function at the approximate scale of a Survey Site or a Natural Community — not at a much higher or lower level.

Two kinds of ecological processes are most important to examine when grading a community: (a) those that are most significant in determining the species composition and structure of the community, and (b) those that have been modified so much that the basic character of the local ecosystem has changed.

The Grading Form has blanks for rating the following four Sub-components of the Processes component:

> **Reproduction and Growth**: Addition of new plants (genets) through sexual reproduction, and addition of new stems (ramets) via asexual reproduction; also, increase in the size of plants.
>
> **Succession**: The process in which communities of plants and animals in a particular area are replaced over time by a series of different communities.

Fire: Actions of fire on a community, primarily by consuming organic matter and killing or injuring plants and animals.

Hydrology: Actions of running or standing water on a community: scouring soil and vegetation, inundating and drowning living things, moving nutrients, etc.

As appropriate, any number of other Sub-components may be recognized and evaluated to assess the condition of the Processes component.

Environment

Definition
The physical *environment* is the abiotic component of an ecosystem, including the substrate or medium in which plants and animals live.

Sub-components
Three main parts of the physical environment for a community are the *microclimate*, *soil*, and *water*. The microclimate (or "climate near the ground") is a basic element of the environment, but it does not usually figure into the grading equation. Even though soil and water are so full of life that it is impossible to separate the living from the nonliving environment, they are classified here as abiotic features of an ecosystem.

Three elements of the Environment component are preprinted on the Grading Form because they are most likely to come into play when evaluating an area:

Soil: The surface of the earth, extending downward to include the upper part of the parent material.

Water: Streams, diffuse surface runoff, standing surface water, soil water, and groundwater.

Intrusions: Relatively small, manmade physical features (such as a structure) or localized sites of intensive human disturbance (such as a trail).

Other environmental Sub-components may be added to the Grading Form and analyzed on an ad hoc basis (that is, to describe the unique situation of an individual Grading Patch).

Rating the Condition of Grading Components and Sub-components

When evaluating a Grading Patch, the overall condition of each of the four Grading Components and its Sub-components is estimated with a Condition Rating, which is a simple, qualitative, relative scale: Low, Medium, and High. The Medium rating has the widest latitude:

Low Lower quarter	Medium Middle half	High Upper quarter

A Grading Component or Sub-component is rated High if it is judged to have more than 75% of the characteristics that it would have if it were in a theoretical, pristine natural area (*i.e.*, without any degradation). A component or sub-component is rated Low if it is judged on the same basis to be in the bottom third. Any case in-between is Medium.
To rate the condition of a Grading Component in a Grading Patch, the Surveyor must do the following:

(1) Examine the Grading Patch to identify Quality Indicators.

(2) Document each Quality Indicator with a written description and photography.

(3) Determine which Disturbance Factor or Factors are indicated by each Quality Indicator.

(4) Decide whether the Effect of each Disturbance Factor on the community is clearly positive, clearly negative, variable or approximately neutral, or uncertain or unknown.

(5) Determine the Impact (Extent, Level, and Trend) of each Disturbance Factor.

(6) Evaluate the Grading Component by examining relevant Sub-components and rating their condition as High, Medium, or Low. Base this rating on (a) the observed characteristics of the Sub-component and (b) the impact of Disturbance Factors on the Sub-component.

(7) Summarize the condition of the Grading Component with a rating (High, Medium, or Low) and a descriptive narrative. Base the rating on the condition of the Sub-components as well as other characteristics of the Grading Component that were not formally classified as Sub-components.

Condition Ratings for Grading Components and Sub-components are based on experienced, professional judgment and comparative knowledge of many different sites. A rating is not derived from any sort of multifactorial, numerical scoring system."

The Grading Components and Sub-components are listed on page 2 of the Grading Form (next to last page of the Grading Handbook, Appendix I). The Condition Ratings (High, Medium, or Low) are entered for each Component and Sub-component. **It is the Condition Rating for each Grading Component (Composition, Structure, Processes, Environment) that is used in the Restorability Index** (not Sub-components, they are used to arrive at the aggregate Component Rating for each Grading Component)**.** Since the number and combinations of Disturbance Factors affecting a grading patch are so potentially numerous we chose NOT to focus on

individual Disturbance Factors in calculating the Restorability Index, but rather chose to assess their cumulative impact on the Condition Ratings for Grading Components. HOWEVER, a thorough documentation of all Disturbance Factors and their impacts (trends, extent, and level) is critical in justifying the Condition Ratings of Grading Components AND in assessing their cumulative effects on Condition Ratings for each Grading Component.

The Restorability Index is, therefore, based upon the following sequence of logic: Community Grade is an inverse measure of the need for restoration; Quality Indicators are how we detect the need for restoration; Disturbance Regimes are categories of Disturbance Factors which are the reasons we need restoration and define what must be maintained, altered, eliminated, or replaced; and the degree of impacts (trend, extent, and level) associated with Disturbance Factors determine how much restoration is needed. Cost is a function of how much restoration is needed and how costly that type of restoration is. Restorability is a composite of the technical feasibility of restoration and the relative cost of restoration.

What we are missing is consideration of the technical feasibility and relative cost of restoration. Feasibility and cost are usually indirectly related (the less feasible the higher cost). The Restorability Index assumes all lands are restorable, though research may be needed to increase the efficacy of restoration (research is usually expensive). To address these considerations we have constructed a composite numerical score around several categories of restoration management that we call "Restoration Sequences." The methodology for application of these scores generally assumes an indirect relationship between feasibility and cost. The Restorability index allows the user to adjust up or down between sequences based on the category of restoration needed to address the most expensive type of restoration called for.

The four categories of restoration the Restoration Sequences are associated with are:

- Passive Restoration – restoration can be achieved by doing nothing, for example by allowing succession to continue in a forest; or by simply eliminating the disturbance factor through institutional controls, for example by limiting bicycle access to a property administratively. Small costs, such as placement of a few signs at key access points, are allowed in this category. However, if it is necessary to place a 20-ft fence around a 640-acre property to control access, this would constitute capital restoration. This demonstrates how the Restorability Index may generate different values when applied by different landowners. If it is the policy of the landowner to fence all their properties, the Restorability Index will generate higher values for that landowner.

- Manual Restoration - this type of restoration includes hand removal of exotics, herbicide application, prescribed burning, placement of boundary signs every 100 feet around a property, etc. Anything that requires one or more staff to invest multiple hours daily over one to several days. Equipment may be needed for this kind of restoration, but the kind of equipment used (e.g., a truck mounted sprayer), while it may have had a high initial cost, has a low per hour operational cost. Again, a landowner that has not made the initial investment in such equipment may need to treat the initial investment in such

equipment as capital restoration. Most currently known restoration technologies fall into this category.

- Mechanical Restoration – this type of restoration requires the employment of mechanized equipment that has a high hourly operational cost, for example brush removal equipment or earth moving equipment, but the restoration work can be achieved in one to several days using the mechanized equipment.

- Capital Restoration – this type of restoration takes its name from the capital budgeting process, because restoration in this category is so resource intensive or requires such specialized equipment it is often requires supplemental funding and is usually out-sourced. This type of restoration may also include design and engineering costs. A few resource management agencies may have in-house engineering capabilities, the heavy equipment and dedicated operators, and stores of materials available, to rank what most landowners would consider capital restoration as mechanical restoration, but this will be rare. Some Disturbance Factors, which might ordinarily be considered in another of the above categories, that are extremely pernicious and/or for which there is no know or accessible method of management, can also be placed in this category. Anything requiring research is placed in this category. There may be some exotic species removal that falls in this sequence, or if the hydrology is altered and you need access to another landowner's property and know you can't get it (i.e., restoration would actually require land acquisition) it would also employ the capital restoration sequence. Use of a high value on this scale can often simply be a means of eliminating a potential natural area from further consideration for restoration.

In general, the per acre cost associated with effecting restoration in each Restoration Sequence increases as you move from passive, to manual, to mechanical, to capital restoration. However, cost is also a function of the impact of the Disturbance Factor (larger extent and level, when the trend is negative, lowering the Condition Rating), but this is accounted for by assigning a higher number within the Restoration Sequence when the Condition Rating is lower.

The Restoration Sequences are:

Passive Restoration Sequence: 1, 2, or 3
Manual Restoration Sequence: 1, 3, or 5
Mechanical Restoration Sequence: 1, 4, 7
Capital Restoration Sequence: 1, 5, 9

With the lowest number assigned when the Condition Rating is Very High or High, use of the middle number when the Condition Rating is Medium, with the highest number reserved for Condition Ratings of Low.

By examining the Disturbance Factors affecting the Grading Components (Composition, Structure, Processes, and Environment), we can choose the appropriate Restoration Sequence to

apply to that Grading Component. The Condition Rating (High, Medium, or Low) can then be used to choose the appropriate value from the Restoration Sequence.

Let's look at a hypothetical example employing a new Patch Restorability Form (See Attachment I):

If species composition is largely being negatively impacted in a dry-mesic forest by invasive exotic plants that can be removed or controlled through herbicide application or prescribed fire, the Manual Restoration Sequence should be applied. If the Species Grading Component Condition Rating is rated as "high" or "very high" the first score in the Manual Restoration Sequence, or "1," should be applied for that Grading Component and entered into the example Patch Restorability Form (Attachment II). If the Structure Grading Component Condition Rating is "medium" due to lack of a mid-story as a result of past grazing, but recovery is evident, the Passive Restoration Sequence should be applied and a score of "2" used. If the Natural Processes Grading Component Condition Rating is "high" and no Disturbance Factors are indicated, the score of "1" from the Passive Restoration Sequence should be applied. Finally, if the Physical Grading Component Condition Rating is "low" because of a massive recent alteration of drainage to put in a subdivision, and this alteration is unlikely to be correctable, the Capital Restoration Sequence score of "9" should be applied, even though this Disturbance Factor hasn't manifested itself yet in the species composition and community structure. Then all 4 Restoration Scores should be summed to yield a Restorability Index Score of 13 for this grading patch. If a tract is composed of multiple grading patches, the scores of all grading patches should be multiplied by their acreages and summed, then divided by the total acreage. A "Site Restorability Form" is provided for this purpose as Attachment III. In this hypothetical case we have only a single grading patch, so the score of "13" is also the Site Restorability Rating.

4. Restorability Index Implementation

4.1. Pilot Sites and Methodology

The Restorability Index was piloted on August 25th and 26th in 2010. Dr. Brian D. Anderson, of the Illinois Natural History Survey and Dr. Wayne Schennum and Mr. Randy Vogel, of Applied Ecological Services, participated in the pilot. Several tracts of land representing Illinois Natural Areas Inventory (INAI) natural community classes and sub-classes of various INAI natural quality grades were visited in Lake and McHenry Counties including:

- Grades A, B, C, and D Mesic Upland Forest
- Grades A, B, and C Mesic Prairie
- Grades B, C, and D Mesic Savanna
- Grade D Sedge Meadow
- Grade D Freshwater Marsh

Grade A and B examples of these natural communities had already been visited, mapped, and graded using improved grading methodologies developed as part of the Illinois Natural Areas Inventory Update (Appendix I). While participating in the INAI Update, Dr. Schennum has become one of the most experienced people in applying the new INAI Update grading methodologies. Grades were assigned to the more disturbed Grade C and D natural communities employing the same protocols. The Restorability Index was then calculated for each of the graded units. The unit for which the Restorability Index is actually calculated is referred to in the INAI Update Standards and Guidelines as a "Grading Patch." One or more grading patches of different natural community grades, but the same natural community sub-class, which are physically connected to each other form a "natural community." One or more natural communities (each potentially composed of patches of different grades) which are physically connected to each other form a "Site." If the site includes a Grade A or Grade B grading patch which meets the minimum INAI acreage standards for the subject natural community sub-class, the site is considered a "Category I INAI Natural Area." Category I, therefore, refers to a high quality example of an Illinois natural community, whereas other INAI categories are assigned to other rare natural features of a property. For example a Category II natural area is a site that provides habitat for a federal or state listed endangered or threatened species. Consequently, when someone refers to a "natural area" it is important to understand whether they are simply referring to a tract of land being kept "natural" (i.e., undeveloped); whether they are referring to any of the several categories of INAI natural areas; or whether they are referring to an example of a high quality natural community, an INAI Category I natural area. Category I natural areas are therefore, in more colloquial terminology, the "gold standard" of natural areas. Category I natural areas are very rare.

The Restorability Index is designed to provide an indication of the potential for, effort associated with, and cost of, restoring a site to higher natural quality, for example in moving a grading patch from a grade of C to a grade of B. A Patch Grading Form (Attachment I) was completed for each graded patch in each site. A "Site Restorability Index" can also be calculated using the Site Restorability Form (Attachment III), if Restorability Indices have been calculated for all grading patches composing a site (Shaw Prairie discussed later is an example).

The sites visited in the pilot and the associated grading patches for which Restorability Indices were calculated were:

Daniel Wright Forest, Grade D Forest, Lake Co., IL

Kettle Moraine, Grade D Savanna and Grade D Sedge Meadow, McHenry Co., IL

McCormick Woods, Grade A Dry-Mesic Forest, Lake Co., IL

Middlefork Savanna, Grades B, C, Savanna and Grade D Savanna Reconstruction, Lake Co., IL

Pike Marsh, Grade D Freshwater Marsh, McHenry Co., IL

Ryerson Woods, Grades B and C Dry-Mesic Forest, Lake Co., IL

Shaw Prairie, Grade A, B, and C Mesic Prairie, Lake Co., IL

4.2. Results of the Pilot

Patch grading forms for the sites described above are presented in Appendix II along with one or more photographs of each area graded. Restorability indices were calculated for each grading patch based on the objective of maintaining or restoring the natural quality of each grading patch to at least grade B, the minimum quality rating for an INAI Category I designation. Generally this meant that a single restorability index was calculated for each grading patch. In other words, in most cases, an index score was calculated for restoring grade C mesic prairie to grade B mesic prairie, or grade D forest to grade B dry-mesic forest. Notice that we made no attempt to assign a natural community sub-class to Grade D natural communities. Grade D examples of natural communities are often very disturbed, and this disturbance is often related to an altered hydrologic regime, the result is these two characteristics in many cases make accurate assignment of the grading patch to a natural community sub-class problematic. For Shaw Prairie we evaluated multiple patches of prairie of different grades and filled out a "Site Restorability Form" based on the different restorability indices calculated for each grading patch (Attachment IV). Another interesting opportunity presented itself when we visited a forested tract in Kettle Moraine State Park that has been under restoration for some time. We had difficulty determining whether the grading patch should currently be considered dry-mesic upland forest or dry-mesic woodland. The site had been burned and exhibited some of the more open characteristics of woodland and other characteristics, such as a higher tree density and greater canopy cover, of a forest. After a period of consideration, all participants agreed that the site historically had been a savanna, that at some point after a long period of grazing, the cattle had been removed and due to fire suppression trees had re-established themselves on the site. Currently, so many trees are well established it might not be reasonable to restore it to its original community type, but it appears that the current management regime has resulted in an intermediate condition between woodland and forest. This situation provided an opportunity to test the usefulness of the Restorability Index in informing such decisions. To explore this possibility Restorability Indices were calculated for moving Grade D Savanna to Grade B Dry-mesic Savanna, Grade D Savanna to Grade B Dry-mesic Woodland, and Grade D Savanna to Grade B Dry-mesic Upland Forest. This situation also validates the concept of the Prairie-Forest Continuum which was eloquently articulated by Steve Apfelbaum during the Rapid Implementation Meeting on Woodlands which was convened as part of the initial implementation of the INAI Update. To capsulate those arguments: in degraded upland sites current restoration technologies allow us to "force" restoration along the prairie-savanna-woodland-forest continuum, to whatever end point we desire. Achieving that end point is limited more by effort and cost than site conditions. Since

technological capacity, effort, and cost are all components built into the Restorability Index, it may be possible to use it as a tool in assessing restoration alternatives along the continuum. In this treatment I have not addressed Grade E tracts, which are placed in the "Cultural Community Class" in the INAI community classification, and are either cleared, plowed, planted, paved, drained, or landscaped. Most natural areas professionals refer to restoration of such lands to a natural community as "reconstructions," and are by their very definition very costly and time consuming to pursue. As such, restoration of existing native natural communities should always receive priority. We did assess the potential restorability of a reconstructed Grade D savanna to Grade B dry-mesic savanna located along the entrance road to Middlefork Savanna.

4.3. Discussion and Observations

To be useful the Restorability Index should meet several criteria:

- It should correlate with natural community quality, reflecting the greater costs associated with restoring more disturbed natural communities.
- It can be calculated rapidly with a minimum of effort.
- It should reflect the efficacy of restoration of a land parcel and the potential effort and cost associated with restoration of that parcel
- It should avoid referencing dollar and cents costs, but rather reflect the demand on all needed tangible resources including expertise, technical feasibility, human resources (staff or volunteer), seed, fuel, equipment, etc. Some of which are more or less available depending on the land management entity involved, and all of which may not be calculated into a dollars and cents "restoration cost" typically presented to executive authorities.
- It must allow comparison of restorations within a community class (prairie, savanna, woodland, forest, wetland, etc.) at a minimum, and preferably across community classes.

4.3.1. Does Restorability Correlate with Natural Quality?

To assess how the Restorability Index changes in relation to Natural Quality Grade we graphed the natural quality grades of the pilot grading patches relative to their calculated Restorability Indices. Figure 1 illustrates an inverse correlation between the Natural Quality Grade (A,B,C or D) and the Restorability Index (the lower the Restorability Index the more "restorable" the grading patch) and plots the trend line that describes this relationship. Further review of Figure 1 suggests another characteristic of the Restorability Index. There is clearly much greater separation in the Restorability Indices associated with the restoration of Grade D natural communities. This higher resolution in lower grades is helpful in that most restoration efforts (and the majority of costs in human and fiscal resources) are associated with restoring grade C and D natural communities. The separation apparent in Restorability Indices for restoration of Grade D communities could be a function of the design of the grading procedures. Since there

are four “Grading Components” (Composition, Structure, Processes, and Environment) and three possible “Condition Ratings” (Low, Medium, and High), there are 81 possible combinations of “Grading Models” (Grading Handbook, Appendix 10). Of these 81 models, only 4 combinations unquestionably yield grades of A, with another 5 combinations potentially resulting in grades of A or B, 9 combinations unquestionably result in grades of B, with another 9 combinations potentially yielding grades of B or C, 27 combinations unquestionably yielding grades of C, and 27 combinations yielding grades of D. Consequently, one might hypothesize that there might be greater variability in Restorability Index scores for Grade C and D natural communities. This is exactly where we would hope to see greater separation, since this tool was developed primarily to compare the restorability of Grade C and D communities. However, it must be remembered that White (Grading Handbook, 2008) cautions that some combinations (Grading Models) may not actually occur in the landscape, and some combinations suggest a community is in transition. For example, the physical environment of a grading patch might have been altered (for example by drainage), yet the species composition, community structure, and detectable environmental processes appear to remain intact – however, as a consequence of the drainage alteration the quality of the natural community is destined with time to degrade. This is exactly the situation in the hypothetical example previously employed. Finally, while the separation for grade D community restorations in the pilot was very good, the three grade C restorability scores were closely clumped. Only additional applications of the Restorability Index will determine how broad the range of calculated Restorability Indices for Grade C restorations might be.

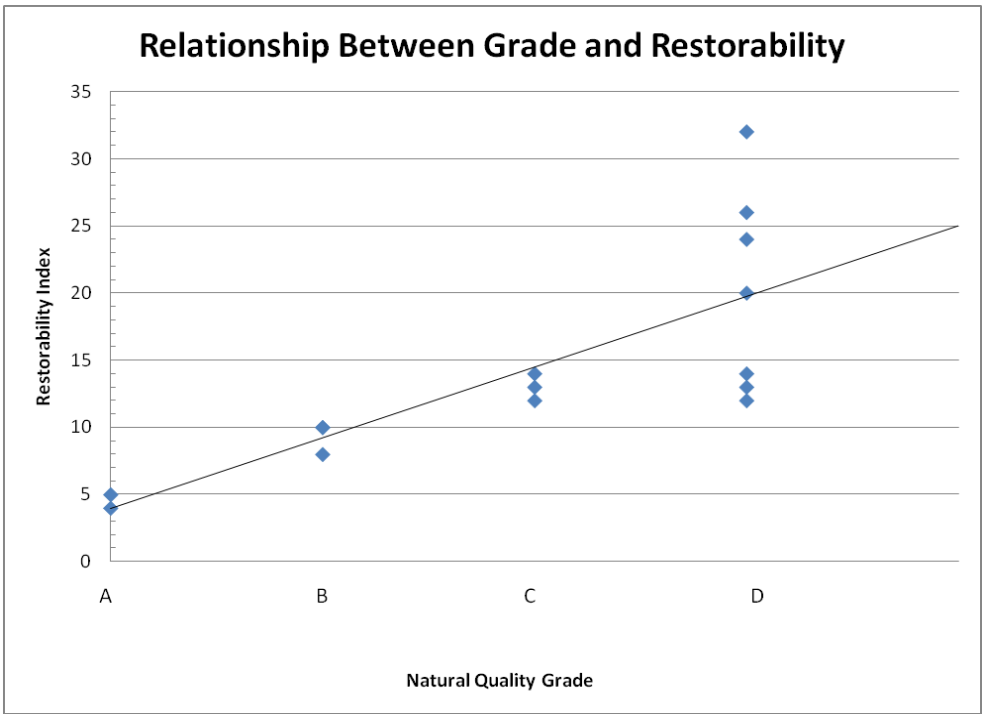
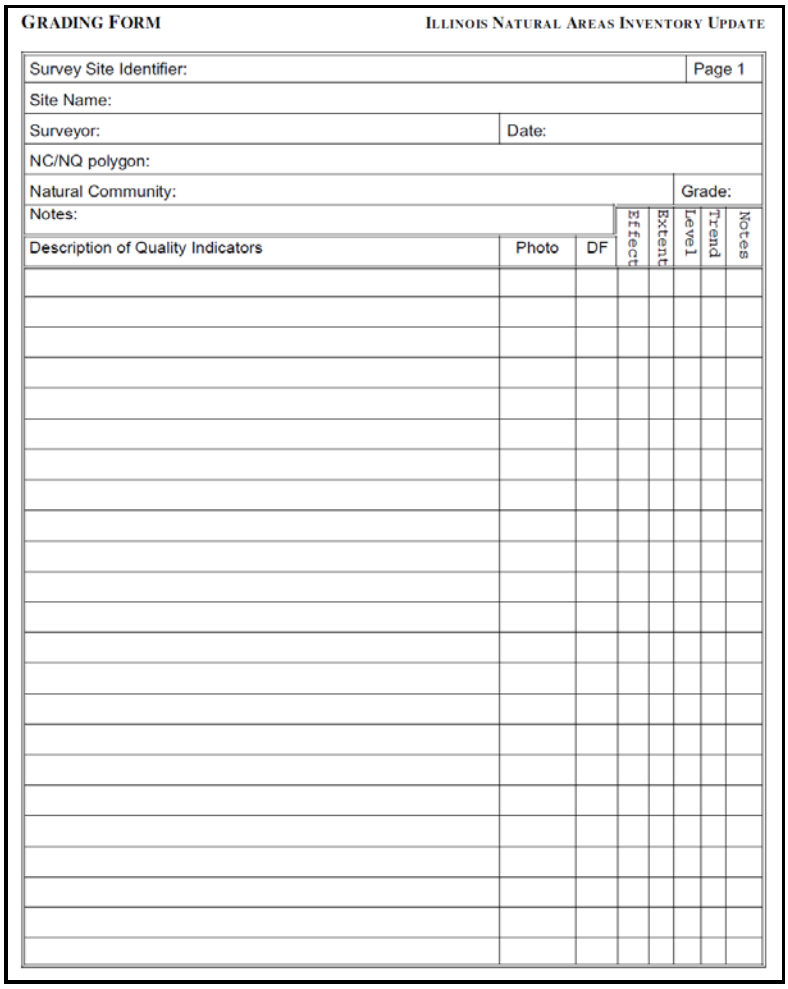


Figure 1.

4.3.2. Can the Restorability Index be Calculated with a Minimum of Effort?

Experience in the pilot project demonstrated that calculation of the Restorability Index can be done very rapidly if INAI Update grading forms for grading patches have already been filled out. In fact, if the person calculating the Restorability Index is a natural resource manager familiar with the site, and they are familiar with the restoration methods available to respond to natural community Disturbance Factors described in the Grading Handbook, the Restorability Index could be calculated in the office directly from the INAI Update grading form. There was one problem encountered with using the INAI Update grading form to calculate the Restorability Index. On page 1 of the INAI Update grading form (Figure 2) "Quality Indicators" are listed and described. Quality Indicators are things that you see, e.g., a browse line, that are indicators of a Disturbance Factor, in this case grazing by an overabundance of deer. The Disturbance Factor is only coded on the INAI Update grading form, using codes from Tables 7.1-Table 7.14 of the Grading Handbook. It is tedious to look up the codes to identify the Disturbance Factor that must be addressed through restoration. However, in actual practice the Disturbance Factor indicated by the Quality Indicator was often referenced in the "Description of Quality Indicators," or it is self-evident. Botanists who have been working on the INAI Update also found use of Appendix 3, Table 5 of the Grading Handbook tedious and developed a "Cheat Sheet" for use in the field which is attached as Attachment V (Items highlighted in yellow were added as part of this exercise). It may eventually be necessary to modify the grading form to require graders to input both "Descriptions of Quality Indicators and Disturbance Factors" as text (refer to Figure 2).

With practice, an experienced natural resource manager can calculate the Restorability Index on site in less than 15 minutes for each grading patch. If the grading form has not already been completed, doing both can be achieved by an experienced natural resource manager/restoration specialist in 45 minutes. The majority of the time consumed in calculating the Restorability Index during the pilot was in traveling between grading patches at a site and travel between sites.



GRADING FORM — ILLINOIS NATURAL AREAS INVENTORY UPDATE

Survey Site Identifier:							Page 1
Site Name:							
Surveyor:	Date:						
NC/NQ polygon:							
Natural Community:							Grade:
Notes:			Effect	Extent	Level	Trend	Notes
Description of Quality Indicators	Photo	DF					

Figure 2.

4.3.3. Does the Restorability Index Assess the Efficacy and Relative Cost of Restoration?

Some Disturbance Factors may preclude the possibility of restoration of a site under prevailing circumstances. However, a Restorability rating can still be calculated for such properties. For example, there may be no known practical method for elimination of a newly-introduced, very aggressive invasive plant. But there is always the possibility that research could result in a practical method of control. However, if research is required to address any Disturbance Factor our methodology requires that the Capital Restoration Sequence be applied (since research must be contracted), so if the Condition Rating is medium or low for the Composition Grading Component, the Restorability Index rating is likely to be very high. Likewise, if a Disturbance Factor originates offsite, for example alteration of the hydrology of a site, and is therefore out of the control of the landowner of the subject property, the Capital Restoration Sequence automatically applies (since other land would have to be bought to address the change in

hydrology), again quickly driving up the Restorability Index for the site. The Restorability Index is in a way intrinsically "optimistic" in assuming any property is potentially restorable.

The four categories of restoration built into the Restorability Index (Passive, Manual, Mechanical, and Capital) suggest increasing investments of human, material, and financial resources, but this perceived progression of investment may not hold up in all cases. For example, there may be cases where it is cheaper to outsource mechanical restoration that might otherwise be done in-house by staff. However, when you consider the effort involved in development of scopes-of-work, performance standards, and executing procurement through bids as is often required in contracted projects, the times when the Capital project route actually represents less investment are rare. The numerical progression in the restoration sequences, for example from 1 to 3 to 5 in the Mechanical Restoration category, respective to High, Medium, and Low condition ratings, reflects the increase in resources necessary to address a Disturbance Factor along the gradient of increasing extent of disturbance, increasing level of disturbance, and upward trend in the disturbance. As impacts associated with a disturbance increase in extent, level, and as they trend upward, it almost always requires more resources to address them. However, while those relationships are always positively correlated, they may not be directly correlated because of economies of scale. Having the expertise of AES staff participate in the pilot was very helpful since they often are asked to bid on restoration work. Not only is the Restorability Index constructed to positively correlate with all the costs of restoration, even hidden costs, it was also our impression that restoration of the sites with higher Restorability Index Ratings would be more costly to restore through contracting as well.

4.3.4. Does the Restorability Index Avoid Dollars and Cents Comparisons?

Yes. And it is, in a way, a more comprehensive assessment of actual costs in human, material, and financial resources than many dollars and cents comparisons of restoration costs. The example given above demonstrates that there are many hidden costs to a sponsoring agency or organization in outsourcing projects that are not reflected in the final project "bid" from a contractor. Yet, it is not unusual to see restoration costs cited that never consider the in-house burdens associated with executing them.

4.3.5. Does the Restorability Index allow Comparisons across Natural Community Classes?

Based on the results of the pilot it appears the index can be used to make comparisons between forest, prairie, savanna, and sedge meadow restorations. Another way to approach this question is to consider whether within each restoration category (Passive, Manual, Mechanical, and Capital) there are restoration techniques specific to a community class that are significantly more expensive than those commonly employed in other community classes. The actual range of

restoration techniques available to land managers is really quite limited. You can remove vegetation manually (weeding), mechanically (plowing, chain sawing, chipping), or chemically (herbicide); plant vegetation manually (broadcasting seed or hand planting) or mechanically (planters, seed drills, tree spade); or you can simulate natural processes (prescribed burning, flooding, watering, fertilizing). The only situation encountered in the pilot that raised this concern was associated with tree removal. Tree removal to reduce canopy cover in restoring a savanna or woodland can be very expensive and no corollary exists in prairies and wetlands, except perhaps cattail removal in marshes. However, in this case, the trees removed can have value as lumber or fuel, which might be used to offset the removal costs. Further, it may soon be possible to employ processes like shrub removal to generate biostock for biofuel production. Broader application of the Restorability Index and comparisons between Restorability Ratings and the actual costs of restorations will be needed to unequivocally answer this question.

5. Summary

The results of the pilot implementation project suggest the Restorability Index holds promise as a tool for rapid assessment of the relative restorability of natural communities across natural community classes. The next logical step is to place this tool in the hands of the management agencies who originally requested such a tool, primarily Illinois' Forest Preserve and Conservation Districts. Broader application of the Restorability Index will, however, require that agencies and organizations have access to and become familiar with the new INAI Update grading protocols which at this point have not been formally adopted by the Natural Areas Evaluation Committee of the IDNR and integrated into their "Standards and Guidelines for Illinois Natural Areas." It is preferable that IDNR codify the grading methods articulated in the Grading Handbook, but if they do not, they will still become available as a matter of public policy.

6. Frequently Asked Questions

6.1. What if more than one Disturbance Factor is affecting a Grading Component? For example if several invasive species are affecting Plant Community Composition as is deer grazing by overabundant deer?

You should identify which disturbance requires the more resource- intensive response, and choose the restoration category that response falls into (Passive, Manual, Mechanical, or Capital). If all the invasive species problems can be addressed using manual restoration (pulling and herbicide application), but the overabundance of deer can be addressed passively by allowing deer hunting, then the restoration sequence for the Mechanical category should be used. However, if the property lies in a county where deer hunting is not allowed, and you would have to contractually hire sharpshooters, you would choose the restoration sequence for the Capital restoration category.

6.2. Do you "double count" the Disturbance Factors that affect more than one Grading Component? For example, if deer grazing due to deer overabundance is affecting both Composition and Structure grading components do you record a number for both components or just put in a zero for one.

During the pilot it became clear that you should enter a value under both components. Doing so clearly generated greater separation among Restorability Ratings, and it appeared that if a disturbance factor like cattail invasion or deer browse affect composition and structure, for example it was a reflection of either a greater extent or level of disturbance, and therefore required more resources than one affecting just one or the other.

6.3. Do you ever enter a 0?

No. Even if the Composition, Structure, Physical Processes, and Physical Environment grading components all have condition ratings of "High" and no disturbances were obvious for any of the grading components, you should always enter a "1" from the "Passive Management" sequence for each of the four grading components. Consequently, the lowest Restorability Rating possible is 4. This acknowledges the fact that even grade A communities require some passive management if nothing more than periodic observation. Where this practice appeared to have the greatest impact was in assessing grade C and D communities where disturbance of Ecological Processes and to the Physical Environment were often not observed. If 0 were entered in such cases some of the separation between restorability ratings appeared to be reduced. This also compensates for disturbances that are just missed or less observable in these two grading components.

6.4. Can the Restorability Index Ratings be compared across landowners?

Probably not. The management and restoration capacities of owners and managers of natural communities vary dramatically. A small land trust may not possess any management capacity beyond Passive Management. This can result in them having to develop a capital campaign to accomplish even minor restoration work, resulting in use of the Capital restoration sequence, and thereby resulting in high restorability indices. A landowner like a Forest Preserve District may have heavy equipment in their possession that may make it unnecessary to contract all but the most ambitious restorations in-house. In a previously cited example, deer control can be addressed passively by allowing public hunting in most counties, but in a few counties deer control would require the use of an expensive contractor, since public hunting is not allowed. It is possible, however, that land management entities with comparable restoration capacities, like two adjoining Forest Preserve Districts, could make such comparisons.