Michigan Tech Research Institute

The Environmental Quality Index Approach

Concepts, Methods, and Demonstration of the EQI Approach for NRCS Conservation Program Assessment

Nancy H.F. French, Tyler Erickson, Brian Thelen, and Robert Shuchman

May 2008

USDA NRCS

The Environmental Quality Index Approach

Concepts, Methods and Demonstration of the EQI for NRCS Conservation Program Assessment

Nancy H.F. French, Tyler, Erickson, Brian Thelen, and Robert Shuchman

May 2008

Michigan Tech Research Institute (MTRI)

3600 Green Court, Suite 100 • Ann Arbor, Michigan 48105
(734) 913-6840 (p) • (734)913-6880 (f)
www.mtri.org

Table of Contents

List of Figures

List of Tables

Framework for the Assessment of NRCS Conservation Program Effectiveness

The specific programs administered by NRCS seek to "conserve, maintain, and improve" natural resources and the environment. NRCS pursues these objectives by offering financial and technical assistance to farmers to implement specific practices that are known to or thought to improve environmental quality. Therefore, the evaluation approach developed for this project seeks to associate measures of program implementation with independent measures of environmental quality. In Year 1 of the Cooperative Agreement, the project team started addressing the question of NRCS conservation effectiveness by developing an evaluation framework and conducting a case study to assess conservation practice impacts on stream water quality in the River Raisin Watershed in Southeast Michigan. Results of the River Raisin case study (see the Year 1 report: *Statistical Case Study of the River Raisin Watershed*), where we compared NRCS program implementations to water quality, showed, as suspected, that water quality alone cannot be used to assess NRCS program implementation practices.

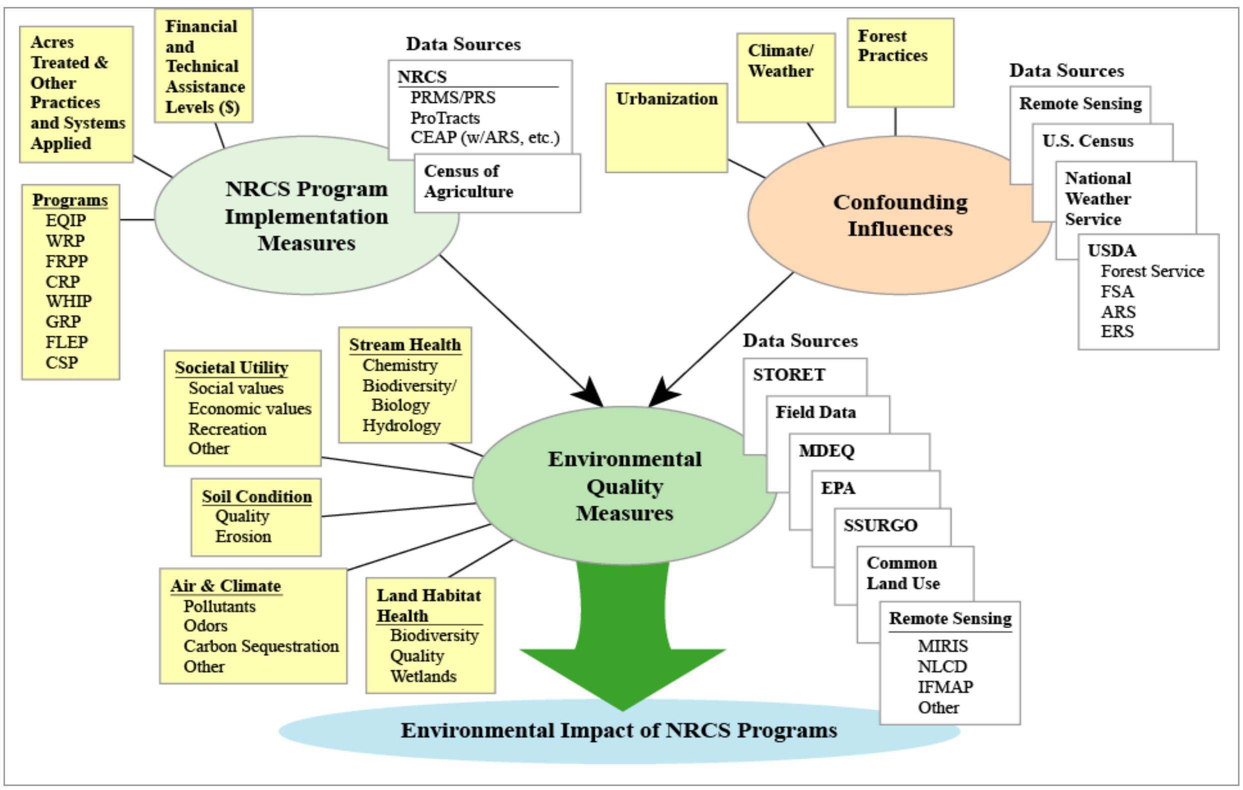


Figure 1: Conceptual model of NRCS evaluation approach. *The figure graphically represents the conceptual structure of the approach to conservation program assessment developed under the Cooperative Agreement.*

While case studies are excellent for shedding light on how and why questions and uncovering important causal variables, they are less useful for impact evaluation on a broader scale, such as determining the effects of NRCS across the State of Michigan. Thus, a conceptual model of NRCS program implementation, environmental quality, and confounding effects has been developed that can be implemented across counties and watersheds to provide statistical insight into questions of the effects of NRCS programs (Figure 1). An initial version of the conceptual model shown in Figure 1 was developed in Year 1 of the project and modified based on MI-NRCS staff feedback in Year 2 of the project. A report detailing the development of this framework was provided in Year 1 report: *Framework for Evaluating NRCS Programs and Proposed Environmental Quality Metric*, and further described in the Year 2 report: *Revised Framework for Evaluating NRCS Programs and Proposed Modifications to Environmental Quality Index*.

The conceptual model presented in Figure 1 contains three main components. The idea is to understand the influence of NRCS programs on environmental quality (light green and dark green circles). In a world perfectly designed for evaluation, NRCS programs would be the only changes that affect the environment. The real world, however, is far more complicated, and NRCS programs exist against a backdrop of other, confounding influences (the orange circle) that also affect environmental quality (for example, urbanization, land cover change, and climate). As a result, these confounding influences also must be measured and accounted for.

In this report, the approach to implementing this conceptual model is presented. First, we review the approach and method of computing the environmental quality Index (EQI), an index-based approach for quantifying change in environmental quality based on a variety of statewide data inputs. Next, we explain the approach used to quantify conservation program implementations and benefits, which should serve as a reasonable method of assessing the amount of effort made by NRCS for conservation. Finally, we review a study that demonstrates an approach to comparing EQI to conservation program implementation and allows control of confounding influences.

Development and Implementation of the EQI

In the first three years of the cooperative agreement, MTRI developed and demonstrated the mathematical feasibility of a stable and useful environmental quality index (EQI) for NRCS. Figure 2 summarizes the process used to develop the EQI and conservation program assessment approach. The approach begins by identifying resource concerns that NRCS programs address in their prescribed practices. The effects of these practices that are observable are then measured or modeled using a variety of information collection resources. These resources include remotely sensed imagery, Geographic Information System (GIS) data layers, and results from published models. A list of the inputs used in the EQI as developed by MTRI is given in Table 1. The EQI is then used to combine these inputs into a metric that can be compared to NRCS program implementations. Since program data are not available at sufficient spatial-temporal resolution to enable full potential of remotely sensed data, analysis at the county scale was decided to be the best approach for the project. A report on the initial development, structure, and planned content of the EQI was written in Year 3: *Evaluation Activities and EQI Development, Year 3*. A review of the final configuration and content of the EQI follows here.

EQI Input Selection

In the four years of the cooperative agreement, the MTRI team has pursued independent sources of environmental quality data pertinent to assessment of agricultural programs and practice effectiveness. The Year 1 report *Summary of Environmental Data Available for Michigan* describes the first attempts to identify these measures under this project. Efforts have concentrated on data that was geospatially defined based on remote sensing data and products and on products and data collected or modeled by agencies and organizations that collect environmental data, such as the U.S. Environmental Protection Agency (US-EPA) and the Conservation Technology Information Center (CTIC). These efforts build from MTRI's extensive experience with remote sensing and GIS, take advantage of existing well-documented data sources, and enable the EQI to eventually be applied for multiple time periods.

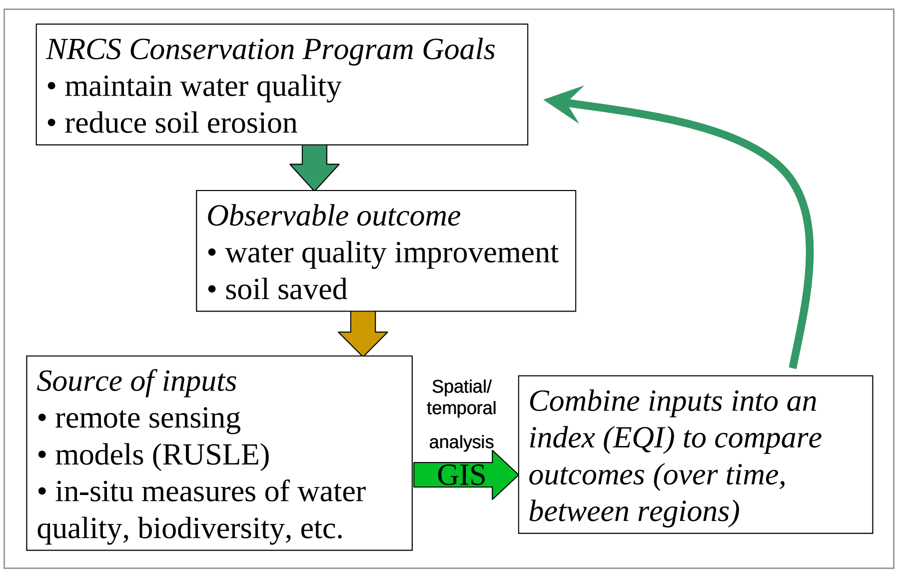


Figure 2. Overview of the process for development of the EQI. *NRCS conservation program goals drive the development of assessment measures in the form of inputs to the EQI.*

Table 1. Components and inputs used in the EQI. *EQI components were determined based on conservation program goals. Extensive searching for appropriate and available EQI input data sets resulted in these 10 initial EQI inputs.*

EQI =	Soil condition index	+	Water health index	+	Land habitat index	+	Air quality index
	Soil erosion		*Lake Clarity*		*Habitat improvement*		*Ammonia emissions*
	Residue cover/tillage practice		*Riparian buffers*		*T&E plants & wildlife*		*Particulates*
	Crop rotation				*Fragmentation*		

In Table 1, we list the measures within each of the four components of the EQI that were selected for use in the EQI with the help of the MI-NRCS staff. These were identified by considering NRCS resource concerns (the concerns that are targeted with conservation practice implementations) and discovering relevant and available information products, either measurements or model-based outputs. These ten inputs come from a variety of sources with varying level of data preparation and analysis needed before they are used in the EQI. Details on the data sets used in the EQI are given in the Year 4 report *Inputs to the Environmental Quality Index*. All of the EQI inputs used are considered to be products that are repeatable or planned to be repeated in the future so that an EQI assessment can be completed for a future timeframe and compared over time.

Table 2: EQI input sources and connection to resource concerns. *EQI inputs were found that match with NRCS-defined resource concerns. The weights used in calculation of the EQI were determined using NRCS expert opinion.*

Input	Units	Source	Resource Concern or Practice	Weight for EQI Calculation
Soil condition Index				**30**
Soil erosion	tons of sediment	EPA STEPL model (RUSLE-based)	Sheet & rill erosion	40
Tillage practice	% conservation	CTIC (Purdue)	conservation tillage practices (329, 344,345,346)	35
Crop rotation history	number of rotations	MTRI developed	Organic matter depletion	25
Surface water health Index				**30**
Lake clarity	index	USGS & MTRI developed	Turbid surface water	45
Riparian buffers	% vegetated	MTRI developed	Riparian buffer practice (391)	55
Land habitat index				**25**
Habitat improvement	acres	MTRI developed	Inadequate cove/shelter/space	10
T&E species	count	Mich. Natural Features Inventory (MNFI)	T&E species	20
Habitat fragmentation	index	MTRI developed	Habitat fragmentation	5
Air quality index				**15**
NH3 emissions	kg	EPA- National Emissions Inventory	Ammonia	25
Particulate levels	density	MTRI developed	PM 10 level	75

Table 2 includes additional information on the sources of the ten EQI inputs along with the NRCS resource concern that the measure represents. Three of the EQI inputs are taken from existing data sources, the CTIC conservation tillage product (see http://www.crmsurvey.org/), data collected by the Michigan Natural Features Inventory (MNFI) on threatened and endangered species (http://web4.msue.msu.edu/mnfi/explorer/index.cfm), and the US Environmental Protection Agency's (USEPA) National Emissions Inventory report of ammonia emissions from agricultural sources (http://www.epa.gov/ttn/chief/ap42/ch09/related/nh3inventorydraft_jan2004.pdf). The soil erosion measure is derived using the Spreadsheet Tool for Estimating Pollutant Loads (STEPL: http://it.tetratech-ffx.com/stepl/), a USEPA model that uses simple, easy to use algorithms to determine sediment loads based on the USDA Revised Universal Soil Loss Equation (RUSLE).

Six of the inputs used in the EQI are derived from remote sensing data and products through methods developed at MTRI. Three remote sensing-derived inputs, riparian buffers, habitat improvement, and habitat fragmentation, use land cover maps developed by the National Oceanographic and Atmospheric Administration (NOAA). These maps are complete for 1995 and 2000, and are planned for 2005 and continuing on a five-year basis. A review of the three inputs that use this NOAA dataset is presented in the Year 4 report: *Using C-CAP Land Cover Products for EQI Inputs*. The algorithm to determine crop rotation for the soil condition component was developed based on research conducted in Year 3 of this project using MODIS image data and field information collected at the Tiffin River test site (see Year 3 report: *Geospatial Algorithms for Agricultural Applications: A Review of New Advanced Technologies*; and the Year 4 report: *Inputs to the Environmental Quality Index*). The lake clarity product, used as one of the water health inputs, uses an algorithm developed by MTRI from Landsat images and base maps developed by the US Geological Survey (USGS; Fuller et al, 2004). Details on development of the MTRI lake clarity algorithm and products are given in the Year 4 report: *Remote Sensing of Lake Clarity*. The significance of having remote sensing-derived measures is that these products can be repeated for any time and place that appropriate remote sensing data are collected, which includes data from the past. Many data sets were considered for inclusion in the EQI that are not in the final version. These unused data sets are described in detail in the Year 4 report *Inputs to the Environmental Quality Index* and include:

- A county-level accounting of the proportion of highly erodible land (HEL) treated through conservation programs developed by Altrarum/MTRI using USDA soils data and conservation practice information. This product was dismissed for use in the EQI as it was found that the soils data did not rigorously identify HEL and HEL treated land was not always documented.
- In-situ water quality data collected by the Michigan Department of Environmental Quality (M-DEQ) was found to be too spatially and temporarily sparse to be of use at the scales required for an EQI-like statewide assessment.
- Surveys of animals and plants, including data on fish contaminants, were considered but not included because these data are rarely collected on a regular basis for all of Michigan.
- Data on odor complaints was not reliably recorded.
- Methane emissions modeled by the US-EPA is available at the state-wide scale, not by county, although there is promise that county-level modeled output could be made with some additional data and effort.
- Soil carbon sequestration information is incomplete, but ongoing research holds promise that data on soil carbon dynamics that could be of use for the EQI may be available in the next few years.

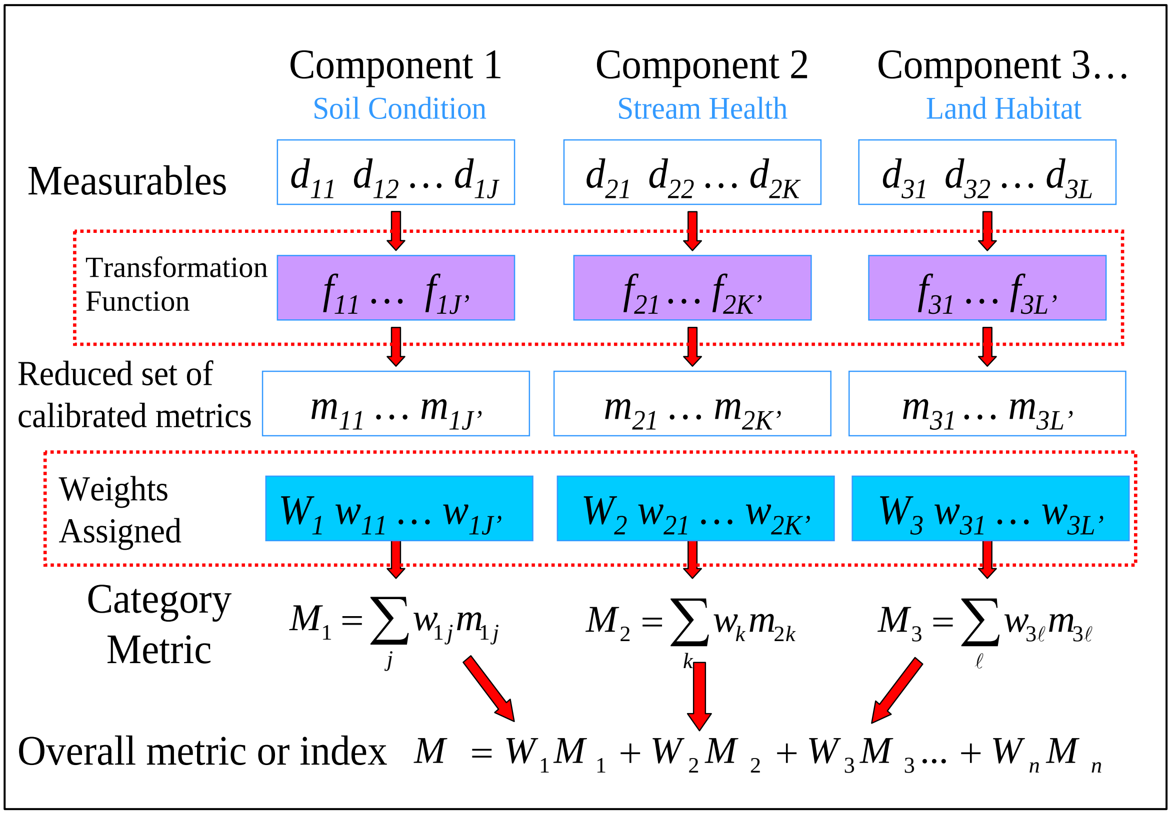


Figure 3: Approach for calculation of the EQI. *For each EQI component, the input data are collected and modified via a transformation function into quality measures that can be combined. Each input can be weighted based on its relative importance, and each component score can also be weighted to formulate the overall EQI.*

Computing the EQI

MTRI researchers have assessed a variety of methods to best calculate an EQI-like metric based on available and disparate data. A statistical approach rooted in factor analysis (e.g., principal components) is best suited for taking a set of input measures (indicators) in a variety of units and reducing these to a smaller set of calibrated metrics in a normalized unit. This method has been demonstrated in several applications in the scientific literature, including Esty, et al. 2005 and Burns, et al. 2004. As shown in Figure 3, this approach entails several steps mathematically and results in both an overall index or metric (the EQI) and component metrics that can serve to gauge outcomes within the domain of a single set of resource concerns, such as soil condition.

The EQI went through several forms as the project progressed. As finalized, it employs four components within the overall EQI: soil condition, surface water health, land habitat health, and air quality. Each component is built from a set of input datasets for that environmental component. A list of the inputs within each of the four components is given in Table 1. A review of these EQI inputs as well as EQI inputs which were investigated but not used in the final analysis is given in the Year 4 report: *Inputs to the Environmental Quality Index.*

The approach developed allows employing different weights for each input and component grouping to form the overall EQI. Because the four components of environmental quality included in the EQI are not given equal weights in descriptions of NRCS program goals and objectives, the EQI calculation allows for different weights to be assigned to each component. For example, soil condition and habitat are given far more attention than is air quality in descriptions of program goals and objective, and these are also more likely to be affected by agricultural practices. Similarly, the relative importance of each input to the component EQI score can be weighted differently to form the component score (see blue boxes in Figure 3). NRCS maintains internal assessment of the expected environmental benefits of individual practices, and this data might be used as part of a weighting scheme. The literature (e.g., Hajkowicz 2006) demonstrates the feasibility and desirability of merging scientific and other objective environmental data with more subjective preference data in constructing environmental indices. For the EQI, input and component weights were set based on feedback obtained though a workshop run by MTRI in September of 2007 where the opinion of MI-NRCS experts was solicited. The process and results of that workshop are reported in the Year 4 report entitled: *Evaluating the Impact of NRCS Programs: New Measures and Improved Communication: Report on the EQI Experts Meeting*. Final EQI weights are listed in Table 2.

In addition to expert opinion for assigning weights of inputs and EQI components, the expert panel provided their opinion on construction of the transformation functions needed to translate the input data into a scale that allows combination with the other inputs (see lavender boxes in Figure 3). This requires that each input's units be mapped to a quality value via a transformation function. An example of a transformation function is shown in Figure 4 showing the translation of a measure of sediment load into a Q-value (quality score) that ranges from 0 to 1; more sediment transforms to a lower Q-score. The final transformation functions used for each input are given in Appendix A.

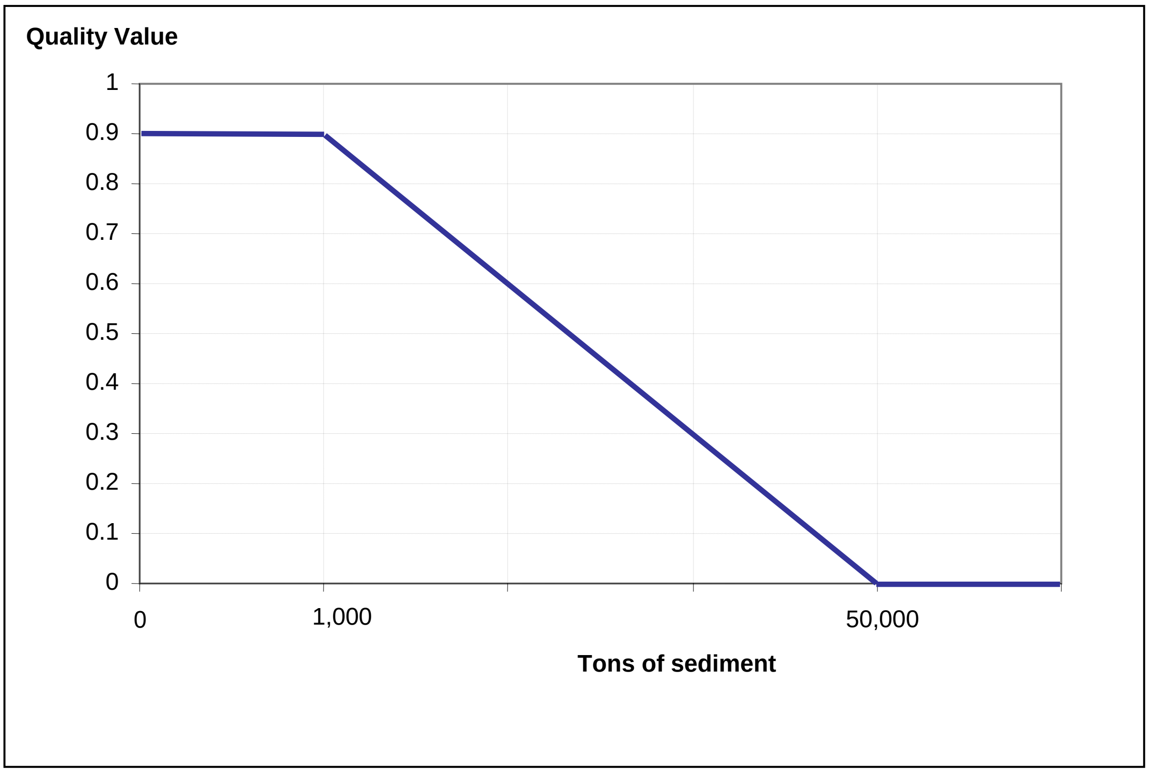


Figure 4. Example of a transformation function used to determine Q-value scores. *This function was developed for the soil erosion EQI input. Similar relationships were developed for each EQI input through a discussion with Michigan NRCS staff during the Experts meeting in February 2008.*

Visualization of EQI Results

A web-based user interface was created to allow users to visualize the EQI data in an interactive mapping application. The interface allows users to change the component and datasets weights, and to instantly see the effect they have in the overall EQI.

A screenshot of the EQI Data Viewer interface is shown in Figure 5. Key features of the interface include:

1. Map Display – an interactive ‘slippy map’ that shows EQI data
2. Pan Control – pans (moves) the map in one of the cardinal directions. The map may also be panned by clicking and dragging on the map.
3. Zoom Control – increases or decreases the map scale
4. Layer Switcher – changes the data layer that is displayed
5. Legend – displays a key that links the displayed color to the data values
6. Menu Bar – contains links to additional features
7. Scale/Coordinates – lists the scale of the map, and the coordinates of the cursor position
8. EQI Data Display – lists the EQI data values for all layers for a location after a user clicks on the map
9. EQI Editing Area – allows users to change the weights of the EQI components and EQI data inputs.

Technical details on how the EQI Data Viewer was implemented are contained in the Year 4 Report: *NRCS Data Viewers Technical Documentation*.

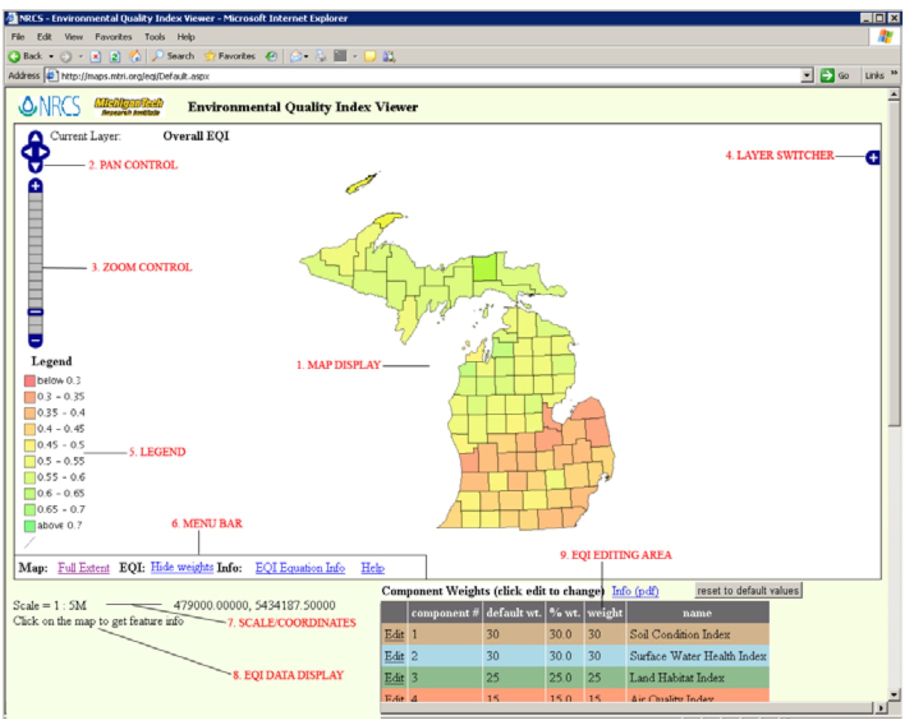


Figure 5: Screenshot of the EQI Data Viewer User Interface.

Quantifying Program Implementations and Expected Conservation Practice Benefits

To assess the change in environmental quality due to NRCS program activity, an accurate accounting of program-implemented conservation practices needs to be made. Through an initial assessment of available program implementation data during Year 1 of this project it was determined that program data are not available at sufficient spatial-temporal resolution to enable full potential of remotely sensed data; therefore, analysis at the county scale was decided to be the best approach for the project. Since 2003 the NRCS has used the Program Contracts System (ProTracts) to track contracted practices. ProTracts is a Web-enabled application that streamlines the application and contracting process for conservation programs. The system became operational nationally for the Environmental Quality Incentives Program (EQIP) and the Wildlife Habitat Incentives Program (WHIP) in October 2003. For Michigan, data from 2004 onward for these two programs is archived and available.

While the data contained in the ProTracts system provides an accurate accounting of program activity, a measure that may be of more use for comparing to environmental outcome is a measure of the resource improvements or conservation benefits derived from implementation of conservation practices. The NRCS has developed a scoring system for conservation practices in order to gauge the expected benefit that would be derived from practice implementation. The Conservation Practice Physical Effects (CPPE) scoring system was developed to help evaluate the potential effects of conservation practices on resources when developing conservation practice contracts and providing technical assistance (see http://www.nm.nrcs.usda.gov/technical/fotg/section-5/CPPE.html). For this project, the CPPE scoring system has been employed to help determine the expected benefits from the combination of the many practice implementations put in place within each county each year.

CPPE effects score expresses the major effect of a single conservation practice on a resource concern. The scores range from -5 to +5, with negative numbers indicating the practice augments the problem and positive numbers indicate the practice diminishes the problem. NRCS definitions of CPPE scores are shown in Table 3. A table showing the CPPE score given to each resource concern, as defined in the Field Office Technical Guide (eFOTG), for all Michigan NRCS practices is presented in Appendix B.

Table 3: CPPE score definitions from the NRCS Field Office Technical Guide
(http://www.nm.nrcs.usda.gov/technical/fotg/section-5/CPPE.html)

Effect	Definition	Score
Significant Increase	Augment the problem significantly	-3 to -5
Moderate Increase	Augment the problem moderately	-2
Slight Increase	Augment the problem slightly	-1
N/A	Concern does not apply to this practice	0
Slight Decrease	Diminish the problem slightly	+1
Moderate Decrease	Diminish the problem moderately	+2
Significant Decrease	Diminish the problem significantly	+3 to +5

A web-based user interface was created to allow users to visualize the ProTracts implementation record data in an interactive mapping application. The interface allows users to change specify criteria to limit the records that are summarized. The interface also allows users to visualize the expected benefits for applied or planned implementations based on CPPE scoring for each practice/benefit situation.

A screenshot of the ProTracts Data and Expected Benefit Viewer interface is shown in Figure 5. Key features of the interface include:

10. Map Display – an interactive 'slippy map' that shows EQI data
11. Pan Control – pans (moves) the map in one of the cardinal directions. The map may also be panned by clicking and dragging on the map.
12. Zoom Control – increases or decreases the map scale
13. Information Area – lists information for a location after a user clicks on the map
14. Coordinates – lists the coordinates of the cursor position
15. Selection Criteria – a series of controls that allow users to selection criteria for the data query including: NRCS Program, Item Status Group, Practice, and Year Planned
16. Map Tools – a button to refresh the map with data that match the current selection criteria and a button to return to the full zoom extent

Technical details on how the ProTracts Data and Expected Benefit Viewer was implemented are contained in the Year 4 Report: *NRCS Data Viewers Technical Documentation*.

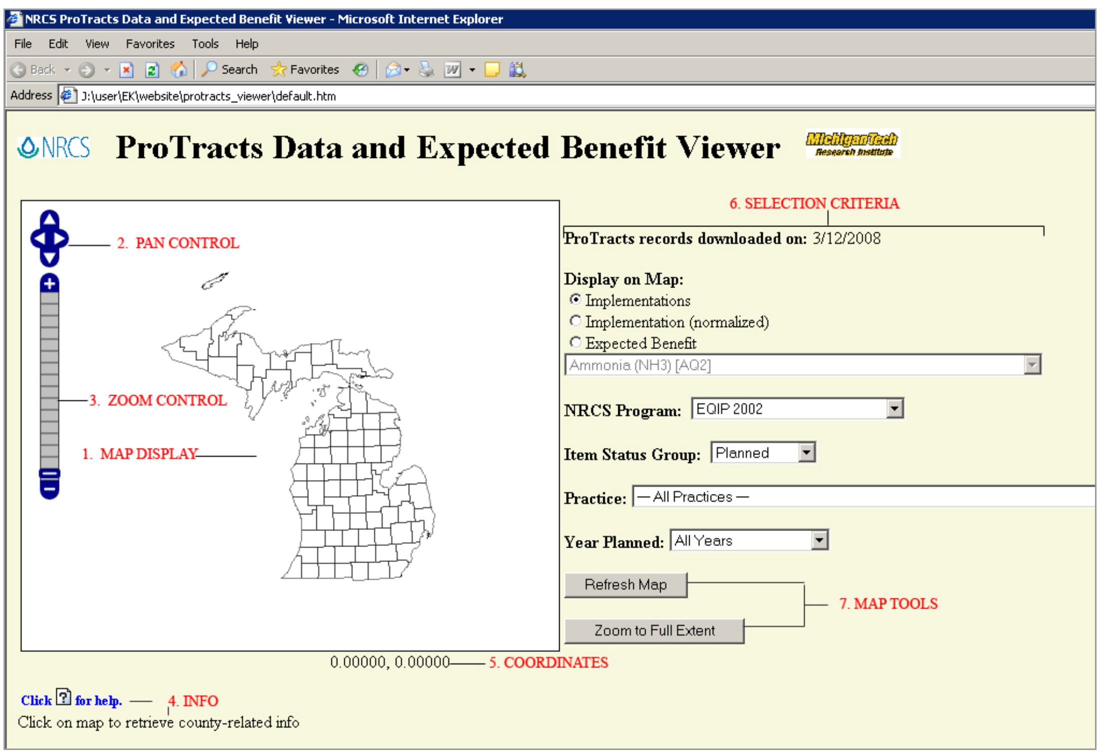


Figure 5: Screenshot of the ProTracts Data and Expected Benefit Viewer interface.

Demonstration of EQI for Retrospective Assessment

To demonstrate the application of the EQI-based conservation assessment and to address the question about program effectiveness since NRCS conservation programs were put in place, MTRI has performed an analysis using the information available. The study uses program implementation information from 1980's and 1990's and EQI data sets for water quality from pre-program (1985) and from the early 2000's. The demonstration employs a county pairing method to help control for variability in land cover type and land cover change. This section of the report provides a review of this EQI demonstration; we describe the analysis, discuss the study results, and provide a review of how this approach may be improved with more complete information on program implementation, environmental condition, and confounding influences.

Demonstration Methods

EQI input data for retrospective study

Several of the identified EQI inputs described above and in the Year 4 report: *Inputs to the Environmental Quality Index* are derived from data collected and archived since c.2000, therefore many of the inputs data sets identified for use in the EQI are not available for assessing NRCS program effectiveness before c.2000. Because of this, the retrospective assessment has been conducted for just one EQI component, Surface Water Health Index. Two inputs are used to compute this component, Lake Clarity and Riparian Buffers. The Lake Clarity product is described in the Year 4 report: *Remote Sensing of Lake Clarity*, while the Riparian Buffer product is described in the Year 4 report: *Using C-CAP Land Cover Products for EQI Inputs*. Both inputs use remote sensing to derive the information of interest. The Lake Clarity product uses Landsat satellite images from c.1985 and c.2003 that are well matched to create the pre-program and early 2000 products. The Riparian Buffer products are derived for the two time periods from two very different land cover products, the c.1978 MIRIS land cover derived from air photo interpretation of land use and the 2001 C-CAP land cover derived from Landsat satellite images.

Calculating the EQI for the retrospective analysis

The EQI is calculated by transforming the input data for each county into a Q-value based on the transformation function defined by NRCS experts. Figure 3 is an example of a transformation function. The transformation functions for Lake Clarity and Riparian Buffers are shown in Appendix A. Once the inputs are transformed into Q-values, these values are combined using a weighted sum to produce the Surface Water Quality component EQI for each county for two time periods. The change (difference) in Surface Water Quality EQI from pre-program to early 2000 is computed and compared to NRCS program implementation effort to assess the influence of NRCS program implementations on the EQI.

For implementation of the full EQI, input weights are determined based on expert opinion. In the case of this demonstration, we have set the weights to 0.95 for the Lake Clarity input and 0.05 for the Riparian Buffer input. These weights reflect both the expected influence of the input on the resource component and the general confidence that the input represents a real measure of the variable. In this case, the sources, methods, and product purpose for the c.1978 MIRIS land cover product is very different form the c.2001 C-CAP land cover product. Since the base data used to form the Riparian Buffer estimates are very different for the two time periods, our confidence in the validity of the change in Riparian Buffer Q-value is low; this input is given a low weighting so it minimally influences the EQI score. On the contrary, we have good confidence in the change in Lake Clarity between the two time periods, due to the consistency of the data used for the two products; this input is given a high weighting so that it is the main driver in the EQI scores.

Controlling for confounding variables

Identification of county pairs

In order to control for variability from county to county in this demonstration, pairs of counties were identified that were similar in land cover and hydrologic characteristics, but different in the amount of NRCS conservation program effort performed in the time between the two EQI assessments (1980's and 1990's). County pairs were identified within three major divisions of Michigan: Southern Lower Peninsula, Northern Lower Peninsula, and Upper Peninsula. The major divisions are based on NRCS district boundaries, but follow closely land cover characteristics, such as differences in soil types and farming practices.

Counties with similar land cover and hydrologic density within each Michigan region were identified and grouped into clusters of similar counties (Figures 6). Land cover similarities were based on the proportion of forest, agriculture, wetland, and shrub/scrubland in each county using the 1995 C-CAP land cover map (for a description of the C-CAP land cover products see Year 4 report: *Using C-CAP Land Cover Products for EQI Inputs*). Hydrologic density was included in order to account for the potential impact of a county land cover and land cover use on water quality. The hydrologic density for each county was computed from the high-resolution National Hydrology Data for the Great Lakes region.

Clustering was determined using Ward's hierarchical clustering method based on an empirically derived Mahalanobis distance between land cover proportions. The Mahalanobis distance is a generalization of the standard Euclidean distance metric and takes into account the variance and covariance of the individual land cover proportions over all the counties. The Ward's hierarchical clustering method is an example of an agglomerative hierarchical method, where the trees are built from the "bottom-up" according to a specified distance metric – in this case that metric is the Mahalanobis distance. The unique feature of the Ward's method is its criteria of "minimum variance" for determining which branches to combine into a node (one branch). More details and background on the Mahalanobis distance and Ward's clustering method can be found in Gan et. al., (2007).

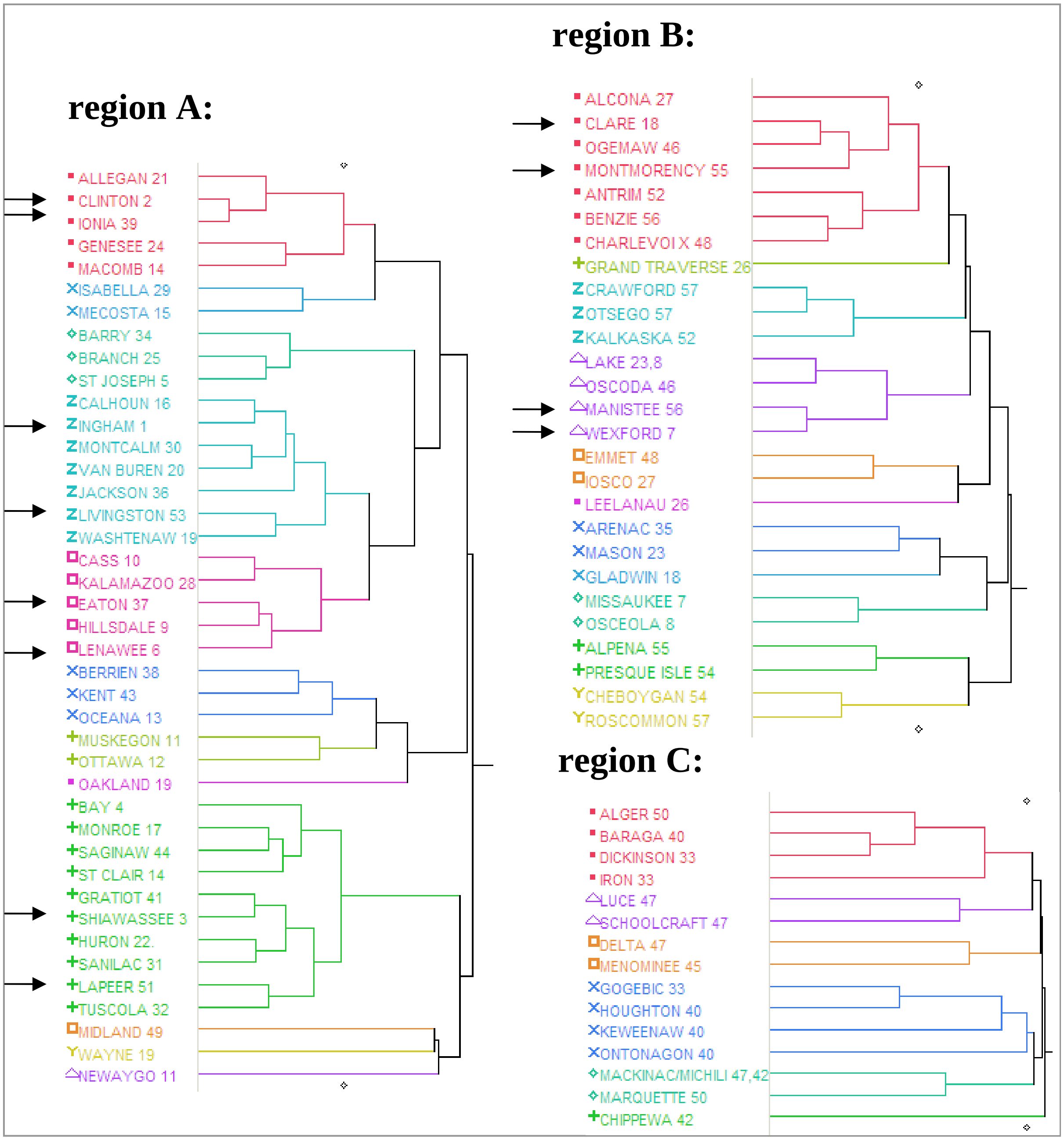


Figure 6: County clusters and pairs identified for each Michigan geographic region. *No adequate pairs were identified for region C, Michigan's Upper Peninsula. Counties were clustered based on similarity in land cover characteristics and hydrology (colors). NRCS program effort rankings determined using program data are shown as numbers next to the county name (low numbers indicate more effort in performing NRCS practices). County clusters and pairs are shown geographically in Figures 7 and 8.*

The level of NRCS program effort in an EQI assessment is based on the implementation of farming practices prescribed or performed under NRCS conservation programs. This information is collected as contracts are put in place with farmers or as NRCS implements technical assistance under a conservation program. For future assessment, the use of data archived in the ProTracts system will be helpful for this program implementation quantification (see section above related to the use of the CPPE scoring system for program implementation data). For the retrospective analysis conducted with the water quality EQI, detailed implementation information for the 1980's and 1990's is not readily available. Therefore, we have relied on practice data collected in the Field Office Computing System (FOCS), which includes data transferred from the older field office planning system (CAMPS). This archive database represents the best records of program activity for the time period, although it is not as accurate as data now provided through the ProTracts system. Despite its shortcomings, these past data records allow us to gage a "level of effort" for counties. Based on number of acres, feet, and number of practices completed by county performed under conservation program contracts, we have ranked counties with relative effort scores. From this ranking data we identified county pairs where one county had relatively low conservation practice level of effort with counties with relatively high level of effort. The resulting county clusters (Figures 6 and 7) were determined based on the "statistical" distance and can be visualized using the chart shown in Figure 6. County pairs were chosen from within one group (color set in Figure 7) and had effort ranks that are far apart (approx >30). We did not assign pairings within a cluster if there was no convincing discrepancy in effort level (approx >30). The pairs were then vetted with NRCS staff with some knowledge of activity during the 1980's and '90s to make sure they were valid pairings. They modified one pair set resulting in the pairs shown in Figures 6 and 8.

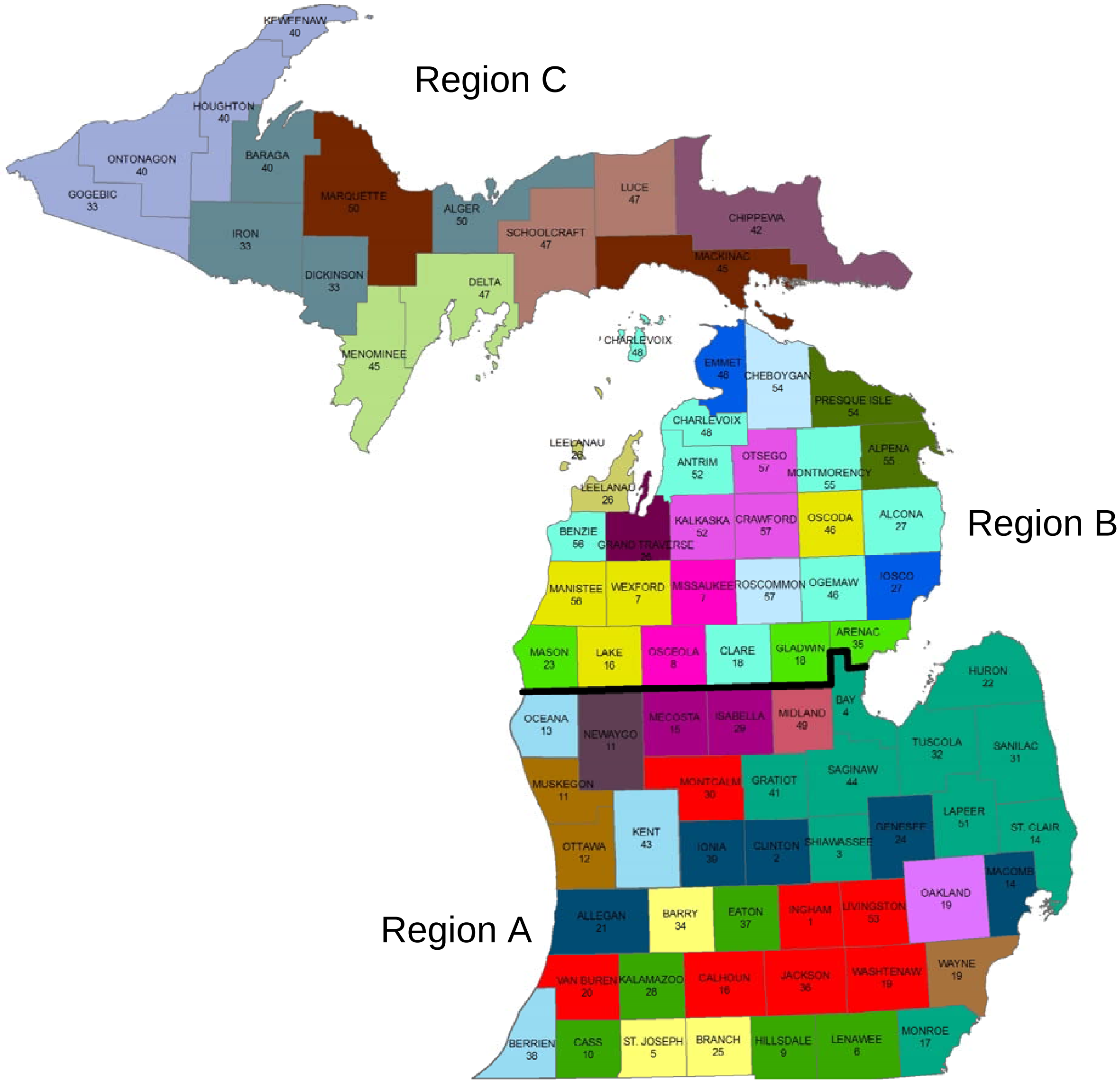


Figure 7. Map of county clusters determined for three geographic regions of Michigan using Ward's hierarchical clustering method (see text). *Clusters were developed within each region using land cover and hydrologic density information to determine counties with similar land cover characteristics. Clusters were used to identify county pairs for the pair analysis (see Figure 6).*

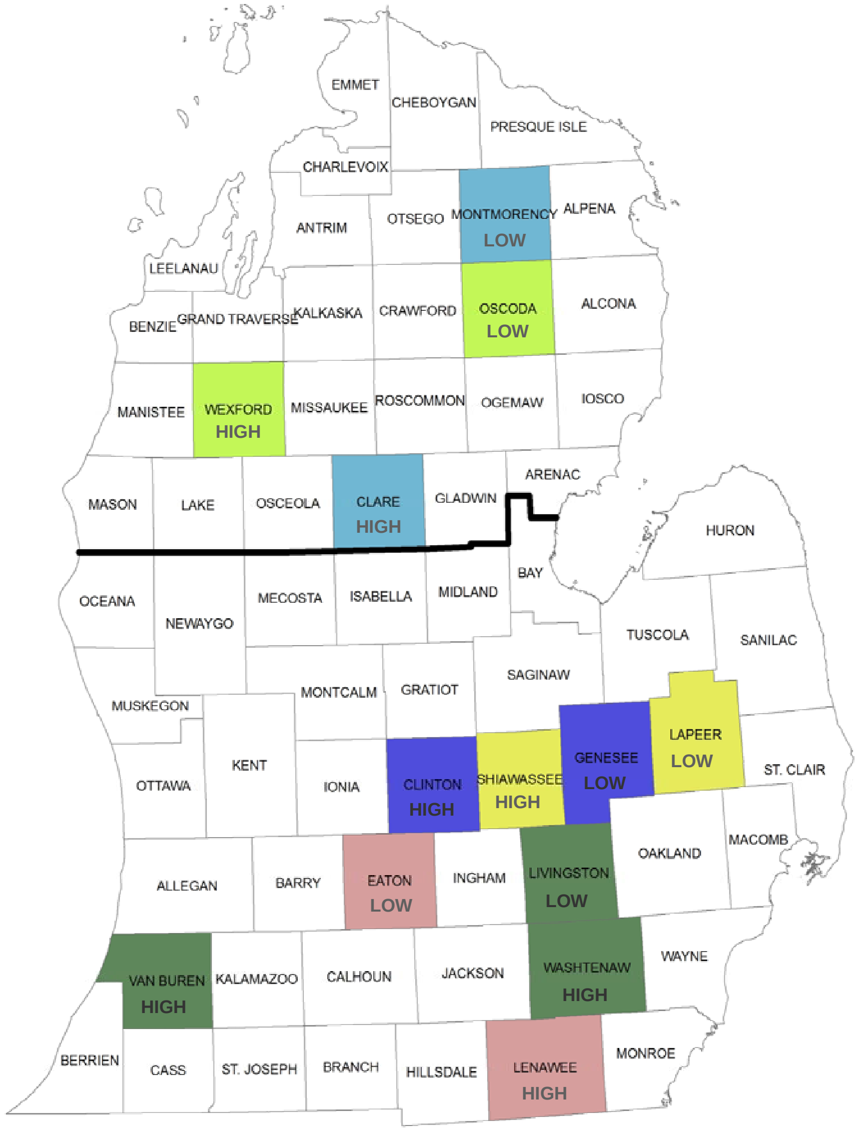


Figure 8. Final county pairs selected for analysis. *These pairs have similar land cover characteristics and different level of conservation program effort during the 1980's and 1990's indicated as "high" or "low" for each pair. Note Livingston County serves as the "low effort" county for two pairings.*

Controlling for additional variables through regression methods

As mentioned earlier, many variables can potentially affect the EQI. One particular set of variables is the proportion of land cover classes. As discussed earlier, this was the motivation for the clustering technique utilized in grouping together counties which are relatively close to each other in terms of land cover proportions. Many other variables/information besides land cover proportions are likely to influence the relationship between conservation program effort and EQI, and it is desirable to try and control for these as well. One such class of variables would be the relative changes in land cover over the time periods under consideration, since these could have a significant effect on the EQI as well. An effective quantitative framework for controlling for these additional "confuser" variables is that of univariate/multivariate regression where the independent variables are these "confuser" variables and the dependent variable is the difference in EQI between paired counties with differing levels of conservation effort. In this effort, we carried out a first-order study of the utility of regression methods for helping to provide better and clearer relationships between conservation program effort and EQI; these results are shown in the next section.

EQI Demonstration Results

Results of the retrospective analysis of NRCS conservation program effectiveness are given in Table 4 wherewe see that in 4 out of the 6 pairs, the differences in the EQI between the higher ranked county and the lower ranked county, in terms of conservation effort is negative. We do not view this as too surprising given the noisy results that result from taking a relatively small number of county pairs. However, the methodology is still valid and should provide a sound foundation for qualitatively ascertaining the relationship between various EQI metrics and measures of conservation.

To help validate this statement, we did a little more investigation of these results, trying to take into account other potentially confusing effects that could be driving these results. In particular, we looked at the relationship between the difference in EQI metrics (between high ranked and low ranked) as a function of differences in land-cover changes. To be more specific, let the change in a specific land cover for the higher ranked county be denoted by CLC_{HR} and let the analogous change in the lower ranked county be denoted by CLC_{LR}. Then the difference between these two is given by $DCLC = CLC_{HR} - CLC_{LR}$. It is this difference that we are looking at in terms influencing EQI (and its relationship to the conservation efforts). In Figure 9, we show scatter diagrams of the difference in the EQI, between the high-ranked county and the low-ranked county, as a function of the DCLC for the case of 6 different land-covers; development, cultivated, grassland, forest, scrub/shrub, and wetlands. As can be seen from the scatter diagrams, there seem to be interesting linear trends for 3 of the 6 variables: cultivated, grassland, and wetlands. Note also that there seems to be a positive trend for the cultivated and wetlands, and a negative trend for the wetlands based on this univariate analysis.

To further develop our framework, we carried out both univariate and bivariate regressions based on these 3 variables. These univariate regression results are shown in Table 5 and the bivariate regression results are shown in Table 6. The univariate regression results essentially confirm what is visually apparent from the scatter diagrams. The adjusted R^2-values are .945 for Cultivated, .868 for grassland, and 0.787 for wetlands, and the coefficients are positive for both cultivated and wetlands, and coefficient is negative for grassland. Moving on to the bivariate regression results, we see that only the bivariate regression with cultivated and wetlands as the independent variable appear to have both a high adjusted R^2-value, .975, and the pair variables both being statistically significant (as evidenced by their p-values being less than .10). One important result from this bivariate regression analysis is that the coefficient on the cultivated land-cover variable was positive and the coefficient on the wetlands was negative. Recall that the coefficients for the univariate regression results of these two variables were both positive, but on doing a further analysis we see that there is a potentially important interaction that is not revealed till carrying out the bivariate regression analysis. Based on a very preliminary review of these results, it seems more plausible that the coefficients on these two variables would be of opposite sign. Due to the preliminary nature of this study, we are not attempting to do a serious interpretation of these results in terms of relating these measured variables to EQI, but we are proposing that the techniques of clustering and regression provide powerful techniques/methods for doing such substantive analysis. These results serve as helpful examples for demonstrating how such an analysis would be carried out. We also believe that more advanced nonlinear regression and variable selection techniques will be important in carrying out more elaborate studies validating the proposed framework and enabling the framework to effectively be utilized in assessment of EQI.

Table 4: Raw EQI scores and change in EQI for county pairs.

County Pairs	Relative Conservation Effort	Surface Water Quality EQI Score		
		Pre-Program	Early 2000	Change
CLINTON	high	0.287	0.391	0.104
GENESEE	low	0.388	0.477	0.089
SHIAWASSEE	high	0.500	0.514	0.013
LAPEER	low	0.467	0.492	0.025
LENAWEE	high	0.463	0.435	-0.029
EATON	low	0.482	0.557	0.076
WEXFORD	high	0.482	0.517	0.035
OSCODA	low	0.520	0.557	0.037
CLARE	high	0.518	0.574	0.056
MONTMORENCY	low	0.504	0.535	0.031
WASHTENAW	high	0.449	0.493	0.044
LIVINGSTON	low	0.337	0.503	0.166

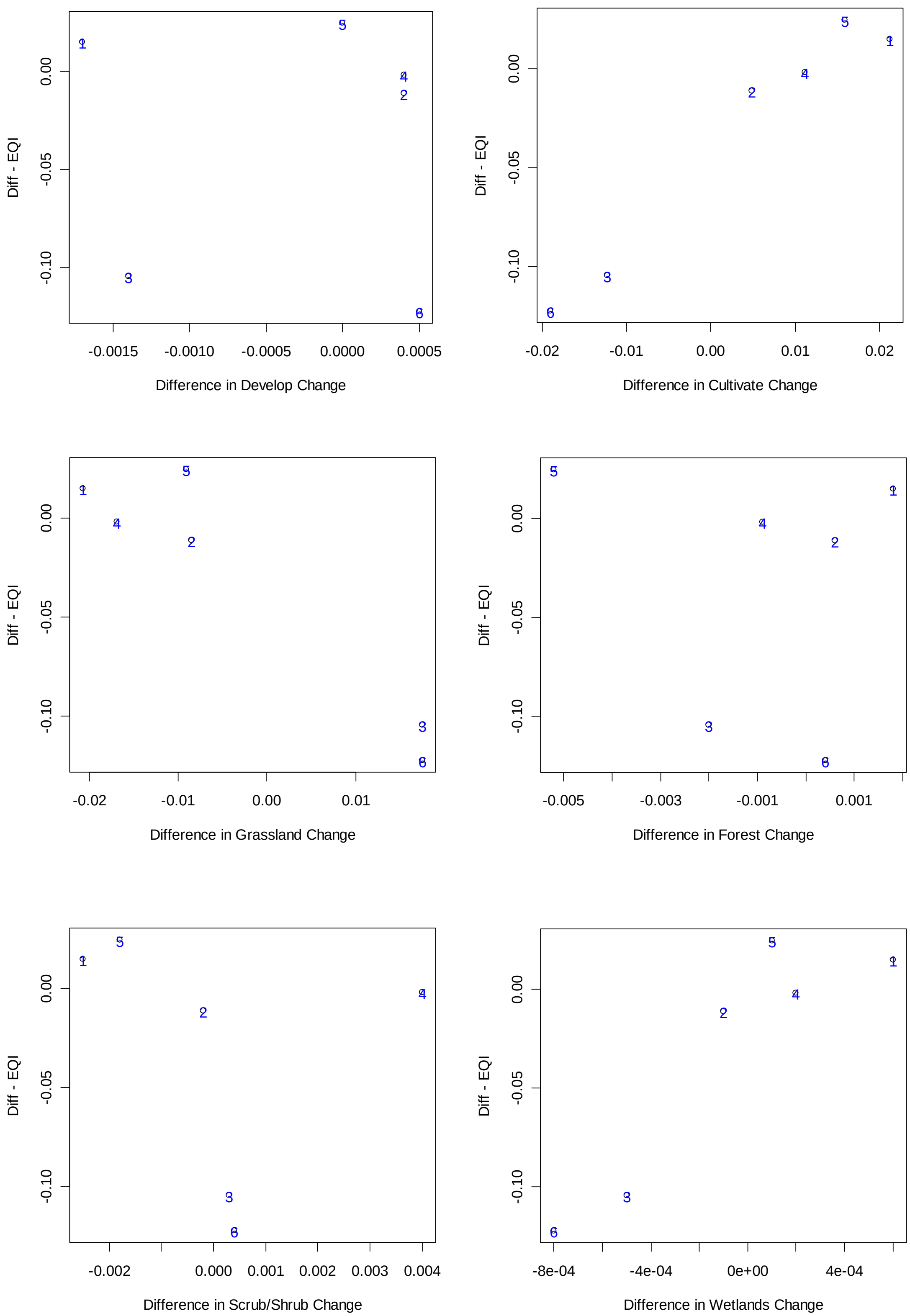


Figure 9. Scatter Diagrams of Change in EQI for county pairs vs. difference in land-cover changes: developed, cultivated, grasslands, forest, scrub/shrub, and wetlands.

Table 5. Univariate Regression Results for the change in EQI for county pairs vs. differences in land-cover change: cultivated, grassland, and wetlands.

Independent Variable	Regression Results
Change in the Cultivated Land-Cover Differences	Coefficients / Est Std. Error / t value / Pr(>|t|) (Intercept) -0.047558 0.006273 -7.582 0.001623 CultivateDiffCh 3.878845 0.416018 9.324 0.000737 Residual standard error: 0.01491 on 4 degrees of freedom Multiple R-Squared: 0.956, Adjusted R-squared: 0.945 F-statistic: 86.93 on 1 and 4 DF, p-value: 0.0007365
Change in the Grassland Land-Cover Differences	Coefficients / Est Std. Error / t value / Pr(>|t|) (Intercept) -0.045439 0.009646 -4.710 0.00924 GrasslandDiffCh -3.575983 0.613860 -5.825 0.00433 Residual standard error: 0.02308 on 4 degrees of freedom Multiple R-Squared: 0.8946, Adjusted R-squared: 0.8682 F-statistic: 33.94 on 1 and 4 DF, p-value: 0.004325
Change in the Wetlands Land-Cover Differences	Coefficients / Est Std. Error / t value / Pr(>|t|) (Intercept) -0.02382 0.01218 -1.956 0.1221 WetlandsDiffCh 114.96189 26.06033 4.411 0.0116 Residual standard error: 0.02935 on 4 degrees of freedom Multiple R-Squared: 0.8295, Adjusted R-squared: 0.7869 F-statistic: 19.46 on 1 and 4 DF, p-value: 0.01159

Table 6. Bivariate Regression Results for the change in EQI for county pairs vs. differences in land-cover change: all pairs of variables from cultivated, grassland, and wetlands.

Independent variables	Regression Results
Changes in the Cultivated Land-Cover Differences and Change in the Grassland Land-Cover Differences	Coefficients / Est Std. Error / t value / Pr(>|t|) (Intercept) -0.047417 0.007145 -6.636 0.00697 CultivateDiffCh 3.401893 1.618351 2.102 0.12632 GrasslandDiffCh -0.475314 1.542386 -0.308 0.77811 Residual standard error: 0.01695 on 3 degrees of freedom Multiple R-Squared: 0.9574, Adjusted R-squared: 0.9289 F-statistic: 33.68 on 2 and 3 DF, p-value: 0.008805
Changes in the Cultivated Land-Cover Differences and Change in the Wetlands Land-Cover Differences	Coefficients / Est Std. Error / t value / Pr(>|t|) (Intercept) -0.065439 0.008559 -7.645 0.00465 CultivateDiffCh 6.682793 1.199779 5.570 0.01142 WetlandsDiffCh -91.765604 38.174769 -2.404 0.09555 . Residual standard error: 0.01006 on 3 degrees of freedom Multiple R-Squared: 0.985, Adjusted R-squared: 0.9749 F-statistic: 98.28 on 2 and 3 DF, p-value: 0.001843
Change in the Grassland Land-Cover Differences and Change in the Wetlands Land-Cover Differences	Coefficients / Est Std. Error / t value / Pr(>|t|) (Intercept) -0.04286 0.01763 -2.431 0.0933 . GrasslandDiffCh -3.16653 2.29242 -1.381 0.2611 WetlandsDiffCh 14.36535 76.53317 0.188 0.8631 Residual standard error: 0.0265 on 3 degrees of freedom Multiple R-Squared: 0.8958, Adjusted R-squared: 0.8263 F-statistic: 12.89 on 2 and 3 DF, p-value: 0.03364

Discussion of Retrospective Assessment Results and Future Analysis Plans

The EQI-based program assessment presented here was performed to demonstrate the approach that can be taken to use the EQI to assess the effectiveness of NRCS program activity. This retrospective assessment was, by necessity, limited to analysis of surface water quality inputs due to a lack of historic data for most of the other EQI inputs developed under the cooperative agreement. The anaysis has allowed a demonstration of how the EQI scores are determined, how NRCS program implementation data could be used, and how a study might control for confounding influences. In conducting a full EQI-based assessment in the future, it is expected that more EQI input data will be available, better program implementation measures will be used, and an improved understanding and accounting of confounding influences could be made.

The clustering and regression results clearly show both the potential and the challenge of proposed framework for quantitatively and effectively relating EQI to variables of interest. In particular we see interesting trends, such as the linearity of the difference in EQI between counties with differing ranks as a function of changing land-covers. However the final results seem to show trends that still require more understanding and/or inclusion of more “confuser” variables that would provide a clearer picture of the desired relationships. In particular our examples show that it is important to control for effects of additional variables, even if they are not the primary variables of interest, since they can actually change the relationship from positive to negative or vice-versa – this was demonstrated in the bivariate regression results. We do believe that the proposed framework is a good starting point, and there are many more tools that we can invoke for continuing the development. In particular, we would propose utilizing a nonlinear multivariate regression methods based on the number of variables and the range of variables over which we would like this methodology to be applied. Fortunately, there are a number of very effective methods of developing/interpreting such nonlinear models based on empirical data. In addition to this, it will be very useful to get more complete data bases that will provide a much richer data set for estimating and validating the relationships.

Despite the fact that this “scaled down” demonstration has many differences from a fully developed EQI-based assessment, the process has allowed a review of the problems, issues, and advantages of an index-based approach to statewide assessment of NRCS program effectiveness.

Summary & Conclusions

Development of an assessment methodology for quantifying conservation program effectiveness was completed under the MI-NRCS/MTRI cooperative agreement. The framework developed (see Figure 1) requires information of three kinds: 1) Data on how much and where NRCS has provided or supported conservation practices (Program Implementation Measures); 2) data on improvements in environmental quality that is quantitative and spatial in nature and represents the concerns being addressed through NRCS conservation programs (Environmental Quality Measures); and 3) a method of controlling or accounting for changes in environmental quality that are not a result of NRCS conservation programs (Confounding Influences). The process of developing the assessment methodology has revealed many obstacles for a successful assessment of past program effectiveness, but has also provided a clear roadmap for making such an assessment in the future. It is apparent that information needed to assess program effectiveness, measures of both program implementation and environmental quality, is now available starting in the early 2000's, and will be collected and available for future assessments.

The project team has identified and compiled ten data sets that will be useful for assessing the environmental quality on a county-by-county or watershed-by-watershed basis (see Table 1). These measures, along with additional, valid data sets that will inevitably be found, can be properly used to quantify environmental quality via the EQI method developed under this project and described in this report. The project team has also developed a means to convert raw data on practice implementations into a measure of expected benefit using the CPPE scoring system, a measure more compatible with the EQI-based environmental measure. Designing a protocol for accounting for confounding influences, such as land cover, land cover change pressure, agriculture focus, and, possibly, climate changes, is demonstrated and discussed in this report via the demonstration analysis. The feasibility of a complete assessment of NRCS conservation programs from an environmentally-centric viewpoint has been demonstrated and will be possible in the future with minimal development effort.

Acronym List

C-CAP	Coastal Change Analysis Program
CPPE	Conservation Practice Physical Effects
CTIC	Conservation Technology Information Center
eFOTG	Field Office Technical Guide
EQI	Environmental Quality Index
EQIP	Environmental Quality Incentives Program
FOCS	Field Office Computing System
HEL	Highly Erodible Land
M-DEQ	Michigan Department of Environmental Quality
MI-NRCS	Michigan State Office of the Natural Resources Conservation Service
MIRIS	Michigan Resource Information System
MNFI	Michigan Natural Features Inventory
MODIS	Moderate-Resolution Imaging Spectroradiometer
MTRI	Michigan Tech Research Institute
NOAA	National Oceanographic and Atmospheric Administration
ProTracts	Program Contracts System
RUSLE	Revised Universal Soil Loss Equation
STEPL	Spreadsheet Tool for Estimating Pollutant Loads
US-EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WHIP	Wildlife Habitat Incentives Program

References

Burns, J.W., T. Cors, B. Knight, and B. Thelen. 2004. "Evaluating Advanced Automotive Energy Technologies: A Multivariate Contribution Metric." *International Journal of Energy Technology and Policy*, 2(3): 262-271.

Esty, D.C., et al. 2005. *2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship*. New Haven: Yale Center for Environmental Law & Policy.

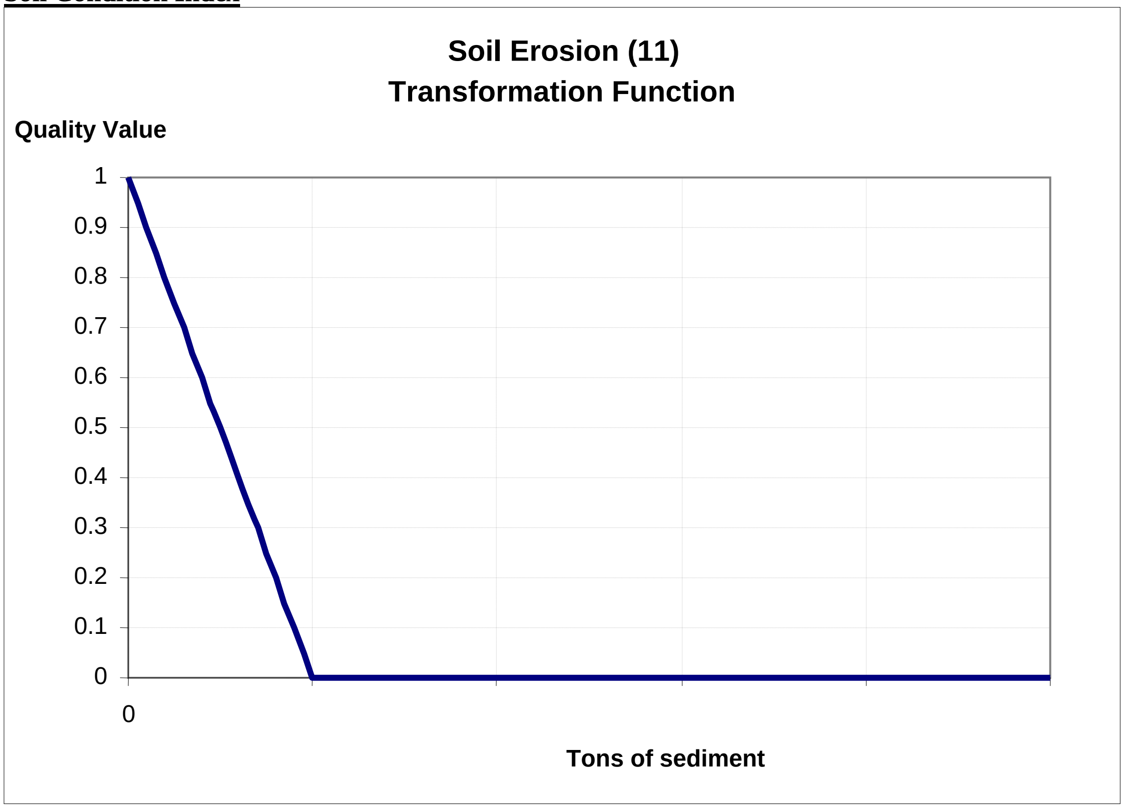
Fuller, L.M., Aichele S.S., and Minnerick R.J.. 2004. Predicting water quality by relating Secchi-disk transparency and chlorophyll a measurements to satellite imagery for Michigan Inland Lakes, August 2002: U.S. Geological Survey Scientific Investigations Report 2004-5086.

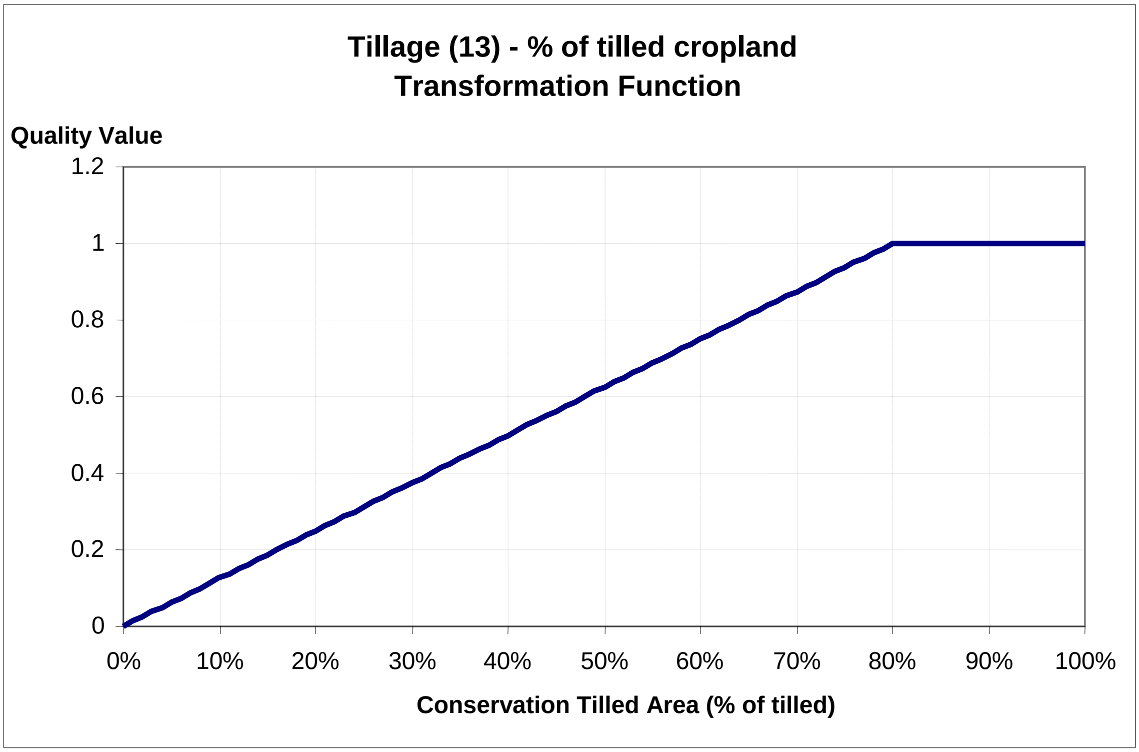
Gan, G., C. Ma, and J. Wu. 2007. *Data Clustering: Theory, Algorithms, and Applications*. New York, SIAM.

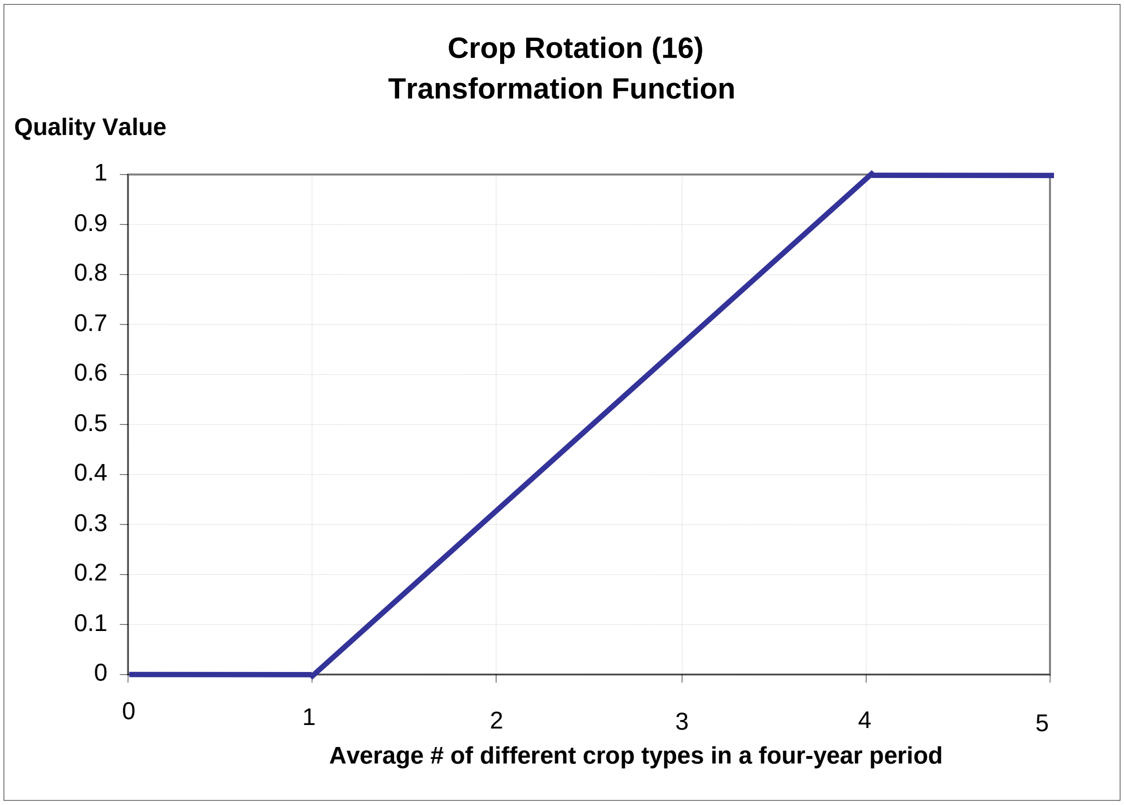
Hajkowicz, S. 2006. "Multi-attributed Environmental Index Construction." *Ecological Economics* 57: 122-139.

Appendix A: Transformation functions for inputs to the EQI

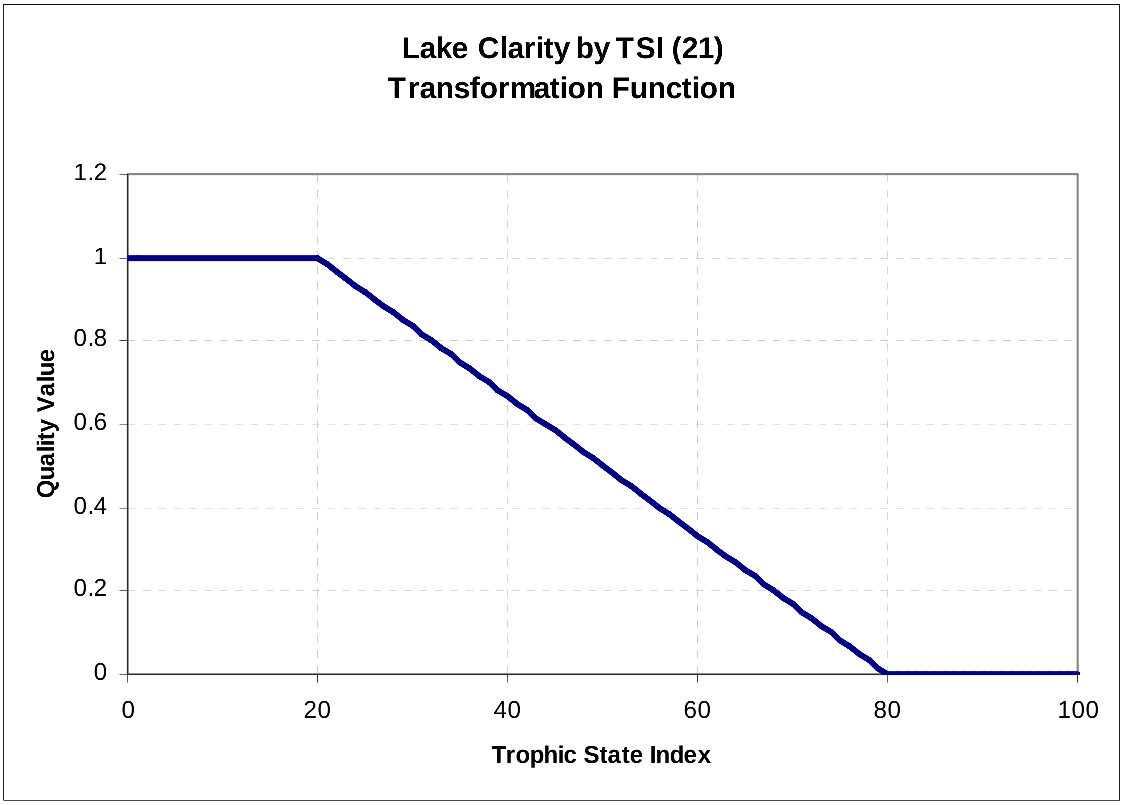
Soil Condition Index

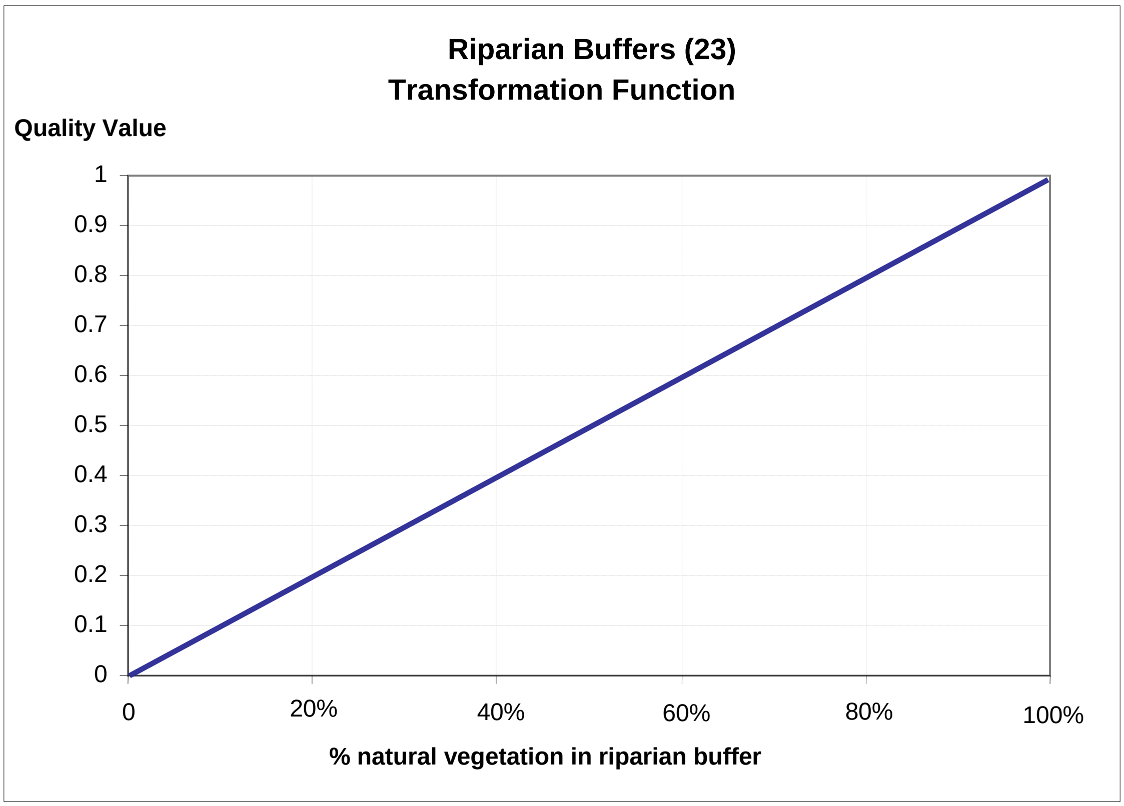




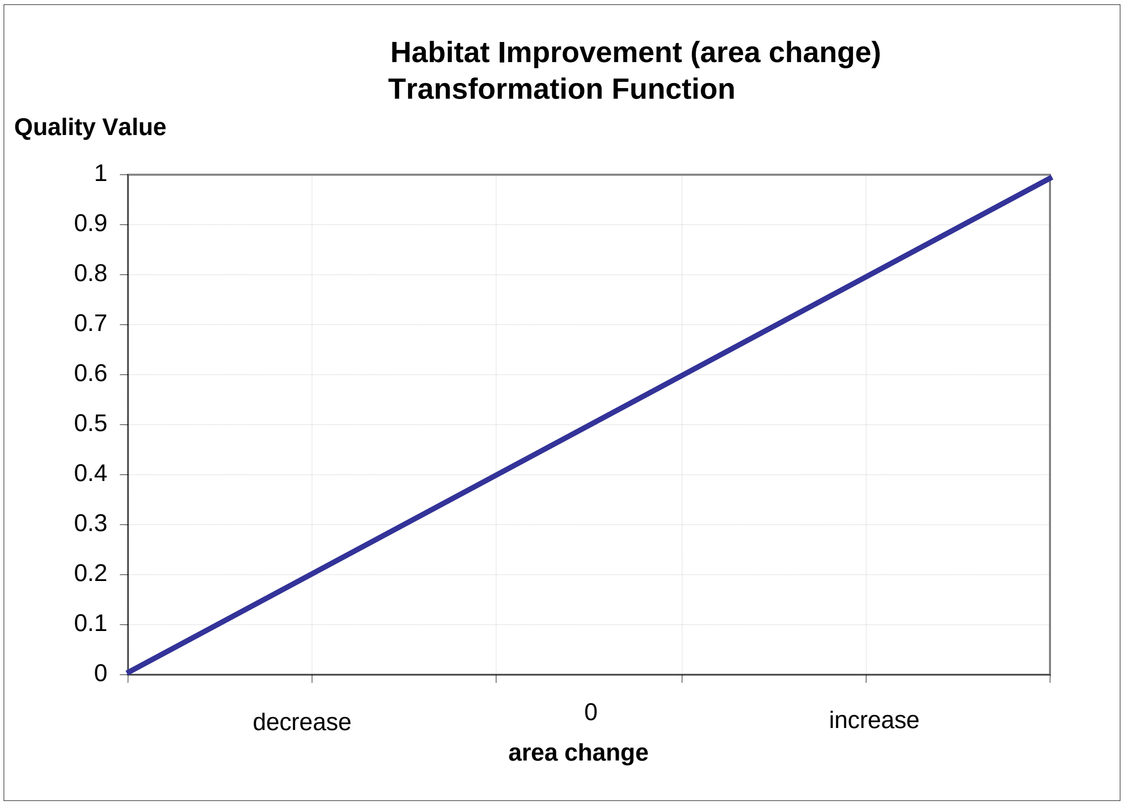

Crop Rotation (16)
Transformation Function
Quality Value
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
Average # of different crop types in a four-year period

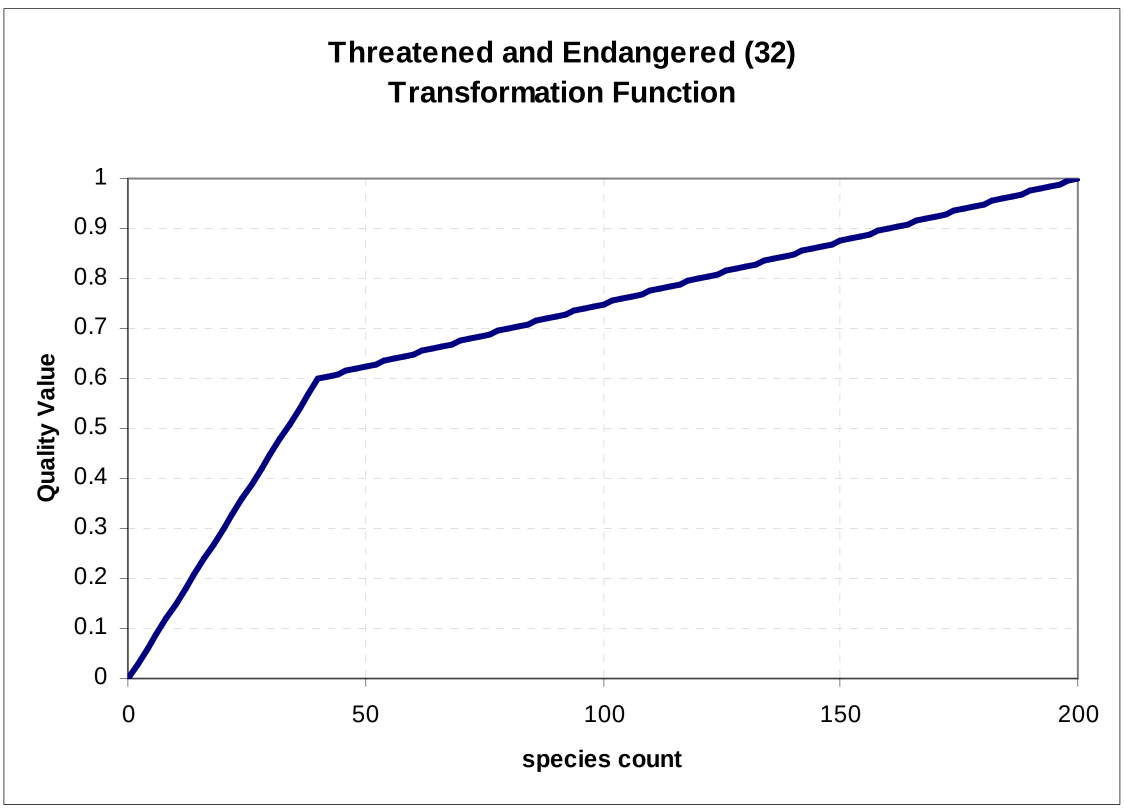
Surface Water Health Index

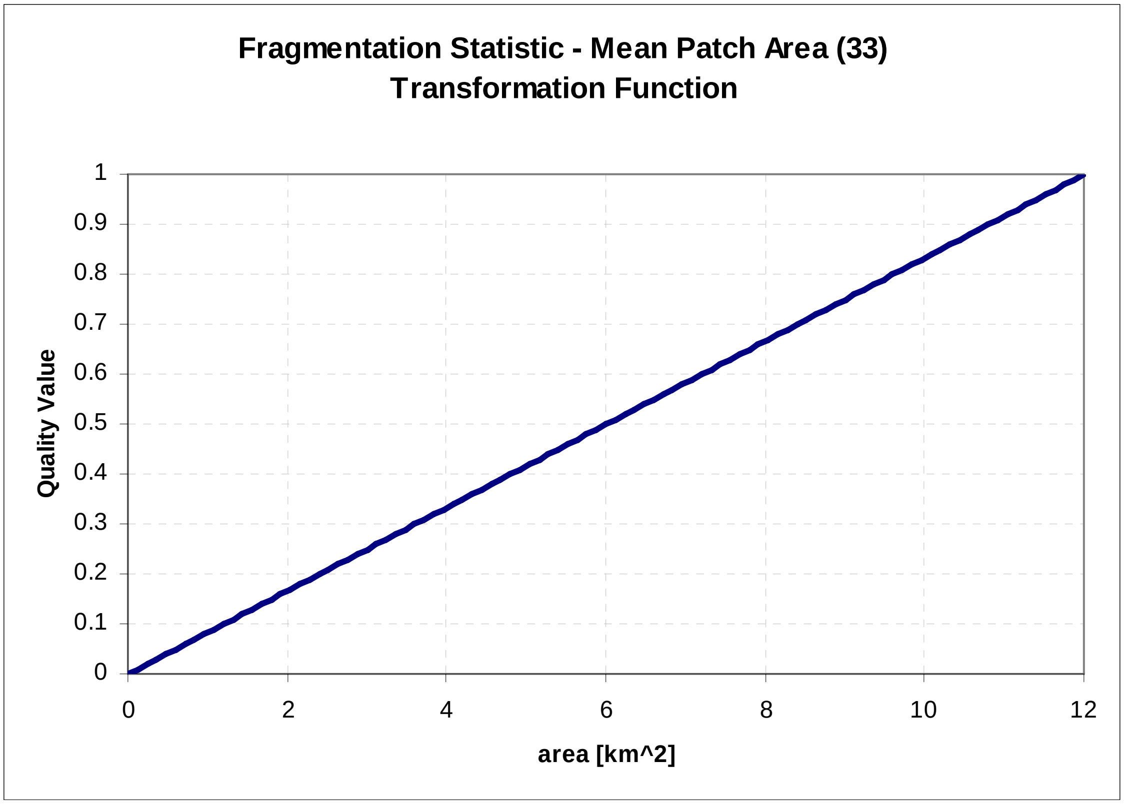


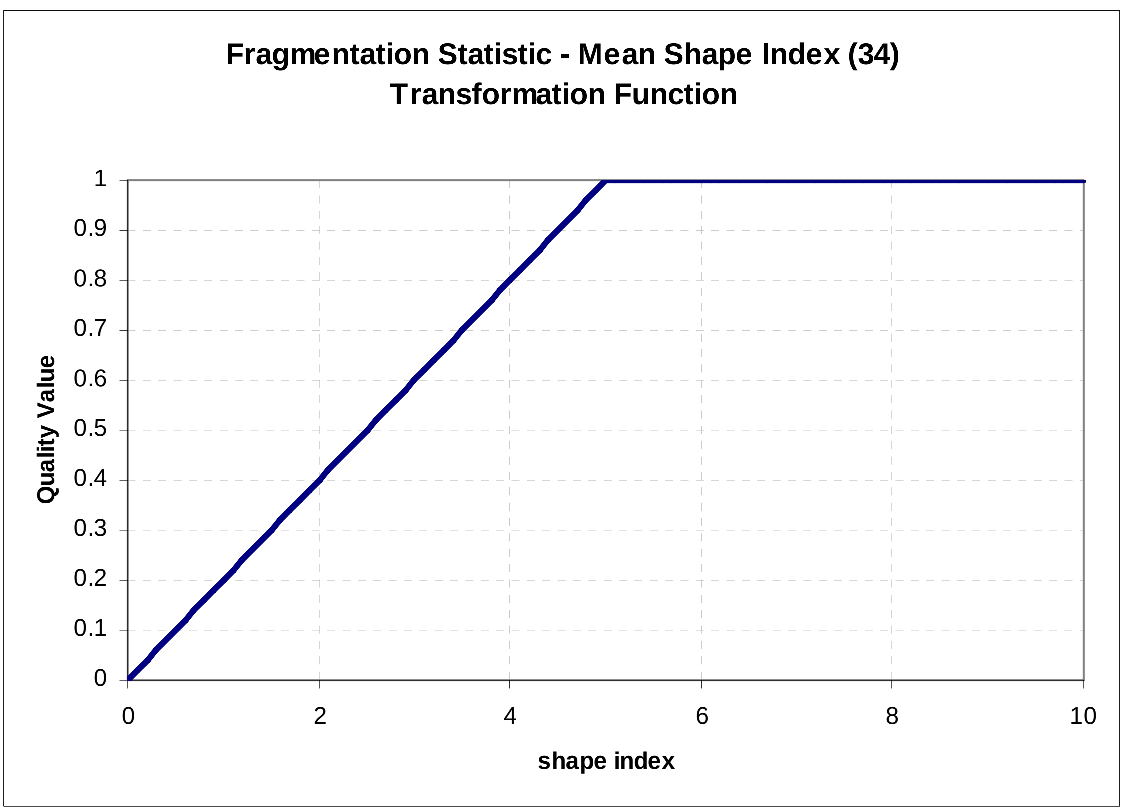


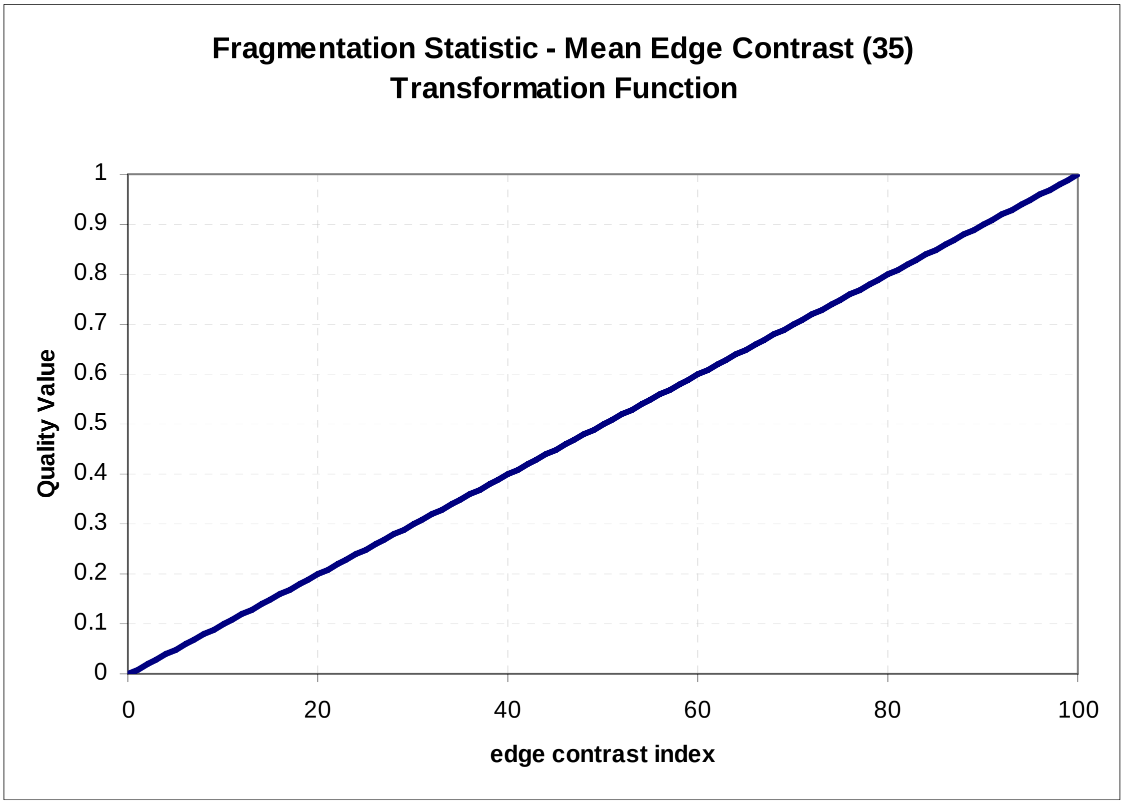
Land Habitat Index



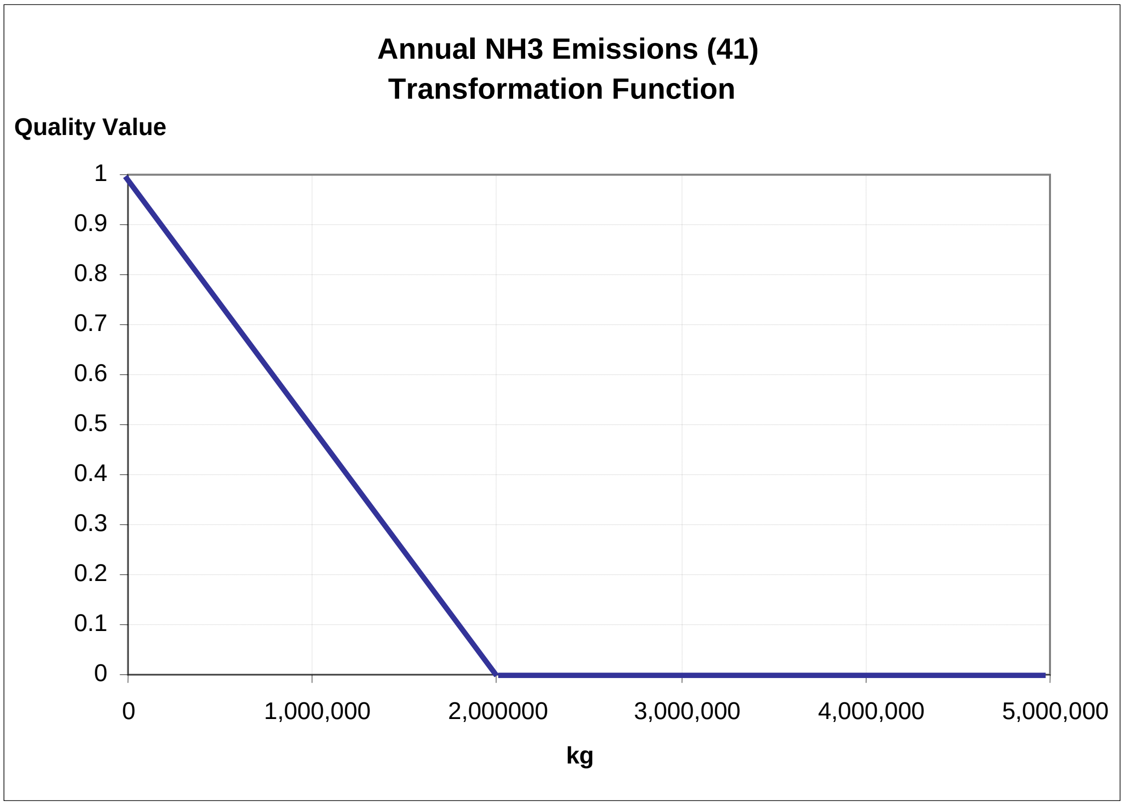


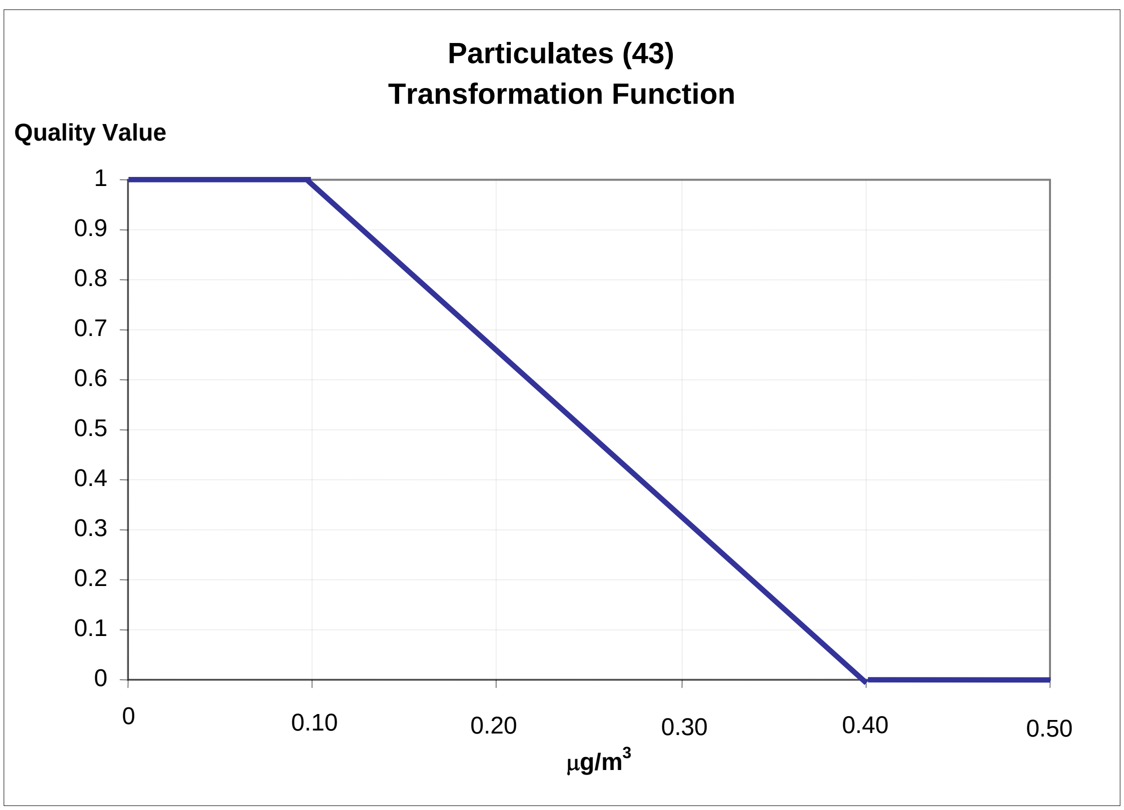

Fragmentation Statistic - Mean Patch Area (33)
Transformation Function
Quality Value
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
area [km^2]


Fragmentation Statistic - Mean Shape Index (34)
Transformation Function
Quality Value
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
shape index


Fragmentation Statistic - Mean Edge Contrast (35)
Transformation Function
Quality Value
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
20
40
60
80
100
edge contrast index

Air Quality Index





Appendix B: CPPE Scores for NRCS Resource Concerns

CPPE scores from the Field Office Technical Guide (eFOTG) given to each resource concern for all Michigan NRCS practices.

Appendix B

-5	5
-4	4
-3	3
-2	2
-1	1
0	

Resource Concern	Access Road (560)	Agrichemical Containment Facility (702)	Alley Cropping (311)	Anaerobic Digestor, Controlled Temperature (366)	Animal Trails and Walkways (575)	Aquaculture Ponds (397)	Brush Management (314)	Channel Stabilization (584)	Clearing and Snagging (326)	Closure of Waste Impoundment (360)	Composting Facility (317)	Conservation Cover (327)	Conservation Crop Rotation (328)	Constructed Wetland (656)	Contour Buffer Strips (332)	Contour Farming (330)	Contour Orchard and Other Fruit Area (331)	Cover Crop (340)	Critical Area Planting (342)	Cross Wind Trap Strips (589C)	Deep Tillage (324)	Dike (356)	Diversion (362)	Drainage Water Management (554)	Dry Hydrant (432)	Early Successional Habitat Development/Management (647)
Air Quality																										
Adverse Air Temperature	0	0	4	0	0	0	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ammonia (NH3)	0	0	0	3	0	0	0	0	0	1	0	0	1	0	0	1	0	2	0	0	1	0	0	1	0	0
Chemical Drift	0	0	5	0	0	0	-2	0	0	0	0	0	2	0	0	0	0	0	0	0	1	0	0	0	0	0
Excessive Greenhouse Gas - CH4 (methane)	0	0	0	4	0	0	0	0	0	1	-1	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0
Excessive Greenhouse Gas - CO2 (carbon dioxide)	0	0	2	3	0	0	0	0	0	0	0	1	1	2	1	1	1	2	1	0	0	0	0	1	0	0
Excessive Greenhouse Gas - N2O (nitrous oxide)	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Excessive Ozone	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Objectionable Odors	0	0	0	3	0	0	0	0	0	1	3	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0
Particulate matter less than 10 micrometers in diameter (PM 10)	1	0	2	0	0	0	0	0	0	0	0	2	2	0	1	0	0	3	2	2	2	0	0	2	0	0
Particulate matter less than 2.5 micrometers in diameter (PM 2.5)	1	0	2	0	0	0	0	0	0	0	0	2	2	0	1	0	0	2	2	2	2	0	0	2	0	0
Reduced Visibility	2	0	4	0	0	0	0	0	0	0	0	1	1	0	1	1	1	3	2	2	2	0	0	1	1	0
Undesirable Air Movement	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0
Domestic Animals																										
Inadequate Stock Water	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Inadequate Quantities and Quality of Feed and Forage	0	0	3	0	1	0	4	0	0	0	0	0	3	0	1	0	0	3	1	1	2	0	0	4	0	1
Inadequate Shelter	0	0	0	0	1	0	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stress and Mortality	0	0	0	0	1	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fish and Wildlife																										
Imbalance Among and Within Populations	0	0	2	0	0	3	3	0	0	0	0	3	2	2	1	0	0	2	2	0	0	0	0	0	0	4
Inadequate Cover/Shelter	1	0	3	0	0	3	3	1	-2	0	0	3	2	2	2	0	0	2	2	2	0	1	1	0	0	4
Inadequate Food	1	0	3	0	0	4	3	1	-2	0	0	3	2	2	2	0	0	2	2	2	0	1	1	0	0	4
Inadequate Space	-1	0	3	0	-1	4	3	2	-2	0	0	2	2	3	2	0	0	2	2	2	0	1	1	1	0	4
Inadequate Water	0	0	0	0	0	3	0	1	-1	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	0	0
Threatened and Endangered Fish and Wildlife Species	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Habitat Fragmentation	-1	0	3	0	-1	0	3	2	-2	0	0	2	2	2	2	0	0	2	2	2	0	1	1	0	0	4
T&E Species: Declining Species, Species of Concern	0	0	0	0	0	1	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Plant Conditions																										
Forage Quality and Palatability	0	0	4	0	0	0	4	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	0	0
Noxious and Invasive Plants	0	0	4	0	-1	4	4	4	0	0	1	4	3	2	4	0	4	4	4	4	-1	0	3	0	0	4
Plants not adapted or suited	0	0	5	0	0	0	4	4	0	0	0	4	4	2	5	0	0	5	5	5	0	0	3	0	0	4
Productivity, Health and Vigor	0	0	5	0	0	0	3	3	0	0	0	4	4	3	3	1	1	2	5	3	3	0	4	2	0	4
Threatened and Endangered Plant Species	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wildfire Hazard	4	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T&E Plant Species: Declining Species, Species of Concern	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Soil Condition																										
Compaction	0	0	2	0	3	-1	-1	0	0	0	0	3	2	0	0	0	0	2	3	0	5	0	0	-1	0	0
Contaminants - Residual Pesticides	0	4	3	0	0	0	-1	0	0	0	0	3	3	0	-1	-1	-1	2	1	0	2	0	-1	0	0	0
Contaminants - Salts and Other Chemicals	0	0	2	0	0	0	2	0	0	0	0	2	2	0	0	0	0	1	1	0	2	0	-1	0	0	0
Damage from Sediment Deposition	0	0	3	0	0	0	2	2	0	0	0	3	3	0	4	4	4	2	3	2	2	0	2	0	0	0
Organic Matter Depletion	0	0	3	0	0	0	2	0	0	0	0	5	4	0	1	2	2	2	1	2	0	0	1	2	0	0
Subsidence	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Contaminants-Animal Waste and Other Organics - N	0	0	4	1	0	0	0	0	0	0	2	2	4	0	0	0	0	2	0	0	2	0	0	4	0	0
Contaminants-Animal Waste and Other Organics - P	0	0	4	0	0	0	0	0	0	0	2	2	4	0	0	0	0	2	0	0	2	0	0	0	0	0
Contaminants-Animal Waste and Other Organics - K	0	0	4	0	0	0	0	0	0	0	2	2	4	0	0	0	0	2	0	0	2	0	0	0	0	0
Contaminants-Commercial Fertilizer - N	0	4	4	0	0	0	0	0	0	0	2	2	4	0	0	0	0	2	0	0	2	0	0	4	0	0
Contaminants-Commercial Fertilizer - P	0	4	4	0	0	0	0	0	0	0	2	2	4	0	0	0	0	2	0	0	2	0	0	3	0	0
Contaminants-Commercial Fertilizer - K	0	4	4	0	0	0	0	0	0	0	2	2	4	0	0	0	0	2	0	0	2	0	0	0	0	0
Rangeland Site Stability	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
Soil Erosion																										
Classic Gully	1	0	0	0	0	0	3	3	0	0	0	1	1	0	1	1	1	1	4	0	1	1	3	0	0	0
Ephemeral Gully	1	0	2	0	0	0	3	0	0	0	0	2	2	0	2	2	2	4	5	0	1	0	3	0	0	0
Irrigation-induced	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	2	0	0	0	1	0	0	0	0	0
Mass Movement	0	0	0	0	0	0	-2	0	0	0	0	1	0	0	0	0	0	-1	0	0	-1	0	2	0	0	0
Road, Road Sides and Construction Sites	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	3	2	0	0	0
Sheet and Rill	0	0	2	0	0	0	3	0	0	0	0	3	4	0	4	3	4	4	5	0	2	0	1	0	0	-1
Shoreline	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
Streambank	0	0	0	0	0	0	1	4	3	0	0	1	0	0	1	1	1	0	4	0	1	-2	1	0	0	0
Wind	0	0	5	0	0	0	3	0	0	0	0	3	4	0	0	0	0	4	5	4	0	0	0	2	0	0
Water Quality																										
Excessive Nutrients and Organics in Groundwater	0	4	1	0	0	-2	0	0	0	2	2	2	2	1	-1	-1	-1	2	1	0	-2	0	-1	0	0	0
Excessive Nutrients and Organics in Surface Water	0	4	2	0	0	-2	0	0	0	2	2	2	2	3	3	3	3	2	2	2	3	0	2	1	0	0
Excessive Salinity in Groundwater	0	0	1	0	0	0	-1	0	0	1	0	1	2	1	-1	-1	-1	1	0	0	-2	0	0	0	0	0
Excessive Salinity in Surface Water	0	0	1	0	0	0	1	0	0	0	0	1	1	1	1	1	1	0	0	1	2	0	0	0	0	0
Excessive Suspended Sediment and Turbidity in Surface Water	1	0	2	0	0	0	3	1	-2	0	0	3	2	4	3	3	3	2	4	1	2	0	2	0	0	0
Harmful Levels of Heavy Metals in Groundwater	0	0	1	0	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	0	-1	0	0	0	0	0
Harmful Levels of Heavy Metals in Surface Water	0	0	1	0	0	0	1	0	0	0	0	2	1	2	3	2	2	2	2	0	3	0	1	2	0	0
Harmful Levels of Pathogens in Groundwater	0	0	0	0	0	0	0	0	0	2	2	2	2	3	-1	0	0	2	1	0	-1	0	0	1	0	0
Harmful Levels of Pathogens in Surface Water	0	0	2	0	0	-2	0	0	0	0	2	1	1	2	1	1	1	1	1	0	3	0	1	1	0	0
Harmful Levels of Pesticides in Groundwater	0	4	2	0	0	0	-1	0	0	0	0	3	2	1	0	-1	-1	2	0	0	-2	0	1	2	0	0
Harmful Levels of Pesticides in Surface Water	0	4	3	0	0	0	-1	0	0	0	0	3	2	2	2	1	1	2	0	2	3	0	1	2	0	0
Harmful Levels of Petroleum in Groundwater	-1	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Harmful Levels of Petroleum in Surface Water	-1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	1	1	0	0
Harmful Temperatures of Surface Water	0	0	0	0	0	-2	0	1	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	-2
Water Quantity																										
Aquifer Overdraft	0	0	-2	0	0	-1	1	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	0	1	0	0
Drifted Snow	-2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Excessive Runoff, Flooding, or Ponding	-1	0	-1	0	0	0	2	0	2	0	0	2	2	3	1	1	1	2	0	0	2	3	3	-2	0	0
Excessive Seepage	0	0	2	0	0	0	-2	2	0	0	0	2	1	0	-2	-2	-2	1	0	0	-2	-1	-1	1	0	0
Excessive Subsurface Water	0	0	2	0	0	0	-2	0	0	0	0	2	1	0	-1	-1	-1	1	0	0	-2	-1	2	2	0	0
Inadequate Outlets	2	0	2	0	0	0	1	0	2	0	0	0	0	1	0	0	0	1	0	0	1	-2	-2	1	0	0
Inefficient Water Use on Irrigated Land	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	0	0	0	2	0	2	0	-1	0
Inefficient Water Use on Non-irrigated Land	0	0	1	0	0	0	2	0	0	0	0	2	2	0	1	1	2	3	0	0	2	0	2	0	-1	0
Insufficient Flows in Water Courses	-1	0	-2	0	0	-2	3	2	0	1	0	0	0	0	0	0	0	0	0	0	-1	0	1	1	0	0
Reduced Capacity of Conveyances by Sediment Deposition	0	0	1	0	0	0	3	1	2	0	0	3	3	4	4	4	4	3	5	4	2	1	2	0	0	0
Reduced Storage of Water Bodies by Sediment Accumulation	0	0	4	0	0	0	3	1	2	0	0	3	3	3	2	2	2	3	4	4	2	-1	2	0	0	0
Rangeland Hydrologic Cycle	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Average	**0.127**	**0.456**	**1.62**	**0.215**	**0.051**	**0.127**	**0.937**	**0.443**	**-0.013**	**0.139**	**0.291**	**1.392**	**1.494**	**0.633**	**0.671**	**0.367**	**0.494**	**1.329**	**1.291**	**0.62**	**0.747**	**0.076**	**0.595**	**0.57**	**-0.013**	**0.481**

Resource Concern	Fence (382)	Field Border (386)	Filter Strip (393)	Firebreak (394)	Fish Passage (396)	Fish Raceway or Tank (398)	Fishpond Management (399)	Forage Harvest Management (511)	Forest Harvest Trails and Landings (655)	Forest Stand Improvement (666)	Grade Stabilization Structure (410)	Grassed Waterway (412)	Grazing Land Mechanical Treatment (548)	Heavy Use Area Protection (561)	Hedgerow Planting (422)	Herbaceous Wind Barriers (603)	Invasive Plant Species Control In Natural Habitats (797)	Irrigation or Regulating Reservoir (552)	Irrigation Storage Reservoir (436)	Irrigation System, Microirrigation (441)	Irrigation System, Sprinkler (442)	Irrigation System, Surface and Subsurface (443)	Irrigation Water Conveyance, Pipeline, High-Pressure, Underground, Plastic (430DD)	Irrigation Water Conveyance, Pipeline, Low-Pressure, Underground, Plastic (430EE)	Irrigation Water Management (449)	Land Reconstruction, Abandoned Mined Land (543)	Land Reconstruction, Currently Mined Land (544)
Air Quality																											
Adverse Air Temperature	0	2	0	0	0	0	0	0	0	-2	0	0	0	0	4	0	0	0	0	0	2	0	0	0	2	0	0
Ammonia (NH3)	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Chemical Drift	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0
Excessive Greenhouse Gas - CH4 (methane)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Excessive Greenhouse Gas - CO2 (carbon dioxide)	0	1	1	4	0	0	0	1	0	4	0	1	1	0	1	1	0	0	0	0	0	0	0	0	0	2	2
Excessive Greenhouse Gas - N2O (nitrous oxide)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Excessive Ozone	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Objectionable Odors	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	-1	0	0	0	0	0
Particulate matter less than 10 micrometers in diameter (PM 10)	0	1	1	0	0	0	0	0	0	0	0	0	-2	2	2	3	0	0	0	2	2	2	0	0	3	2	2
Particulate matter less than 2.5 micrometers in diameter (PM 2.5)	0	1	1	0	0	0	0	0	0	0	0	0	-1	2	2	2	0	0	0	2	2	2	0	0	3	-2	-2
Reduced Visibility	0	2	0	2	0	0	0	0	0	-1	0	0	0	1	2	2	0	0	0	0	0	-1	0	0	0	-1	-1
Undesirable Air Movement	0	1	0	0	0	0	0	0	0	-1	0	0	0	0	5	5	0	0	0	0	0	0	0	0	0	0	0
Domestic Animals																											
Inadequate Stock Water	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	0	0	0	0	0	0	0	0
Inadequate Quantities and Quality of Feed and Forage	0	0	1	0	0	0	0	4	2	4	0	1	4	0	0	1	3	0	0	4	4	4	0	0	4	4	4
Inadequate Shelter	4	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Stress and Mortality	4	0	0	0	0	0	0	3	0	3	0	0	1	3	0	0	0	4	4	0	0	0	0	0	0	0	0
Fish and Wildlife																											
Imbalance Among and Within Populations	0	1	1	0	2	3	3	1	0	3	0	0	0	0	1	0	3	1	1	0	0	0	0	0	0	1	0
Inadequate Cover/Shelter	0	3	3	0	3	2	4	2	2	3	0	1	2	0	4	2	3	0	-1	0	0	0	0	0	0	2	2
Inadequate Food	0	3	3	1	3	2	4	2	1	3	0	1	2	0	4	2	3	0	2	0	0	0	0	0	0	2	2
Inadequate Space	-2	3	3	-1	3	3	4	2	-1	2	0	1	0	0	2	2	1	-1	-1	0	0	0	0	0	0	1	1
Inadequate Water	0	0	0	0	0	2	2	0	0	0	1	1	1	0	0	0	0	1	2	1	1	1	0	0	0	0	0
Threatened and Endangered Fish and Wildlife Species	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Habitat Fragmentation	-2	2	1	0	3	2	0	3	-1	2	0	1	0	0	2	2	1	0	0	0	0	0	0	0	0	2	2
T&E Species: Declining Species, Species of Concern	0	0	2	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Plant Conditions																											
Forage Quality and Palatability	0	0	0	0	0	0	0	4	0	4	0	0	4	0	0	2	3	0	0	0	0	0	0	0	3	5	5
Noxious and Invasive Plants	0	4	4	-2	0	0	4	4	4	4	0	4	-1	4	4	4	5	0	0	1	1	1	0	0	1	4	4
Plants not adapted or suited	0	5	5	5	0	0	4	3	4	4	0	4	3	0	5	5	5	0	0	0	0	0	0	0	0	5	5
Productivity, Health and Vigor	0	5	5	3	0	0	4	4	2	5	0	5	4	3	3	3	5	3	3	3	3	3	3	3	3	4	4
Threatened and Endangered Plant Species	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Wildfire Hazard	0	0	0	5	0	0	0	4	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
T&E Plant Species: Declining Species, Species of Concern	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
Soil Condition																											
Compaction	0	3	5	-2	0	0	0	4	-4	-2	0	0	4	-1	1	0	0	0	0	0	-1	-1	0	0	0	1	1
Contaminants - Residual Pesticides	0	2	2	-1	0	0	0	3	0	0	0	-1	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0
Contaminants - Salts and Other Chemicals	0	1	1	0	0	0	0	1	0	0	0	-1	1	0	0	0	0	0	0	1	3	0	0	0	3	4	4
Damage from Sediment Deposition	0	2	-2	0	0	0	0	1	1	0	0	2	2	2	-1	2	0	2	0	0	0	-1	0	0	0	0	0
Organic Matter Depletion	0	2	1	-4	0	0	0	1	0	-2	0	1	1	0	1	2	0	0	0	0	0	0	0	0	1	3	3
Subsidence	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contaminants-Animal Waste and Other Organics - N	0	2	2	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contaminants-Animal Waste and Other Organics - P	0	2	2	0	0	0	0	2	0	2	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contaminants-Animal Waste and Other Organics - K	0	2	2	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contaminants-Commercial Fertilizer - N	0	2	2	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contaminants-Commercial Fertilizer - P	0	2	2	0	0	0	0	2	0	2	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Contaminants-Commercial Fertilizer - K	0	2	2	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rangeland Site Stability	0	0	0	0	0	0	0	0	0	0	0	0	4	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Erosion																											
Classic Gully	0	2	0	-1	0	0	0	0	1	0	3	4	1	0	0	0	0	3	3	0	0	-1	2	2	0	1	1
Ephemeral Gully	0	3	0	-1	0	0	0	2	-1	2	0	5	3	3	0	-1	0	0	0	0	0	0	0	0	0	4	4
Irrigation-induced	0	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	3	3	-1	0	0	3	0	0
Mass Movement	0	-1	0	0	0	0	0	0	0	-2	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	5	5
Road, Road Sides and Construction Sites	0	0	0	0	1	0	0	0	0	0	0	2	0	3	0	0	0	0	0	0	0	0	0	0	0	5	5
Sheet and Rill	0	4	0	-1	0	0	0	3	-1	2	0	0	3	3	0	-1	1	0	0	0	0	0	0	0	0	4	4
Shoreline	0	1	0	0	1	0	0	0	0	0	0	1	1	3	0	0	0	-2	-2	0	0	0	0	0	0	0	0
Streambank	0	1	0	0	0	0	0	0	0	0	3	1	1	3	0	0	0	1	1	0	0	-1	0	0	0	0	0
Wind	0	4	0	-1	0	0	0	3	0	0	0	0	2	3	1	4	0	0	0	0	3	1	0	0	3	4	4
Water Quality																											
Excessive Nutrients and Organics in Groundwater	0	2	3	0	0	-2	-2	2	0	3	0	0	-1	0	0	0	0	-1	-1	3	1	1	0	0	3	0	0
Excessive Nutrients and Organics in Surface Water	0	2	5	0	0	-2	0	2	1	3	0	2	2	1	2	1	0	2	0	3	2	1	1	1	3	0	0
Excessive Salinity in Groundwater	0	1	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	3	2	1	2	2	3	1	1
Excessive Salinity in Surface Water	0	0	1	0	0	-1	0	1	0	1	0	0	2	0	0	1	0	0	0	0	2	1	1	1	2	1	1
Excessive Suspended Sediment and Turbidity in Surface Water	0	2	5	-1	0	0	0	2	0	0	2	2	2	2	0	1	0	0	2	0	0	0	1	1	3	4	4
Harmful Levels of Heavy Metals in Groundwater	0	1	1	0	0	0	0	1	0	1	0	0	-1	0	0	0	0	0	0	1	1	1	1	1	2	1	1
Harmful Levels of Heavy Metals in Surface Water	0	1	4	0	0	0	0	1	0	1	0	1	1	0	0	1	0	0	0	1	1	1	-1	-1	3	0	0
Harmful Levels of Pathogens in Groundwater	0	0	1	0	0	-1	0	1	0	1	0	0	-1	1	0	0	0	0	0	1	1	1	1	1	2	0	0
Harmful Levels of Pathogens in Surface Water	0	1	1	0	0	-1	-1	1	0	3	0	1	2	2	0	0	0	0	0	3	2	1	-1	-1	3	3	3
Harmful Levels of Pesticides in Groundwater	0	2	1	0	0	0	0	2	0	2	0	0	-2	0	0	0	0	2	0	3	2	1	0	0	3	0	0
Harmful Levels of Pesticides in Surface Water	0	2	3	0	0	0	0	2	0	2	0	2	2	0	1	1	0	2	0	3	2	1	0	0	3	0	0
Harmful Levels of Petroleum in Groundwater	0	0	0	0	0	0	0	0	-1	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	1	0	0
Harmful Levels of Petroleum in Surface Water	0	1	1	0	0	0	0	0	0	1	0	1	0	2	0	0	0	0	0	3	2	1	0	0	3	3	3
Harmful Temperatures of Surface Water	0	0	0	0	0	-1	0	0	0	-1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Water Quantity																											
Aquifer Overdraft	0	0	0	0	0	-2	0	1	0	1	0	0	0	0	0	0	0	1	1	3	3	1	0	0	2	0	0
Drifted Snow	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0
Excessive Runoff, Flooding, or Ponding	0	2	0	0	0	0	0	2	0	3	0	3	2	0	0	0	0	2	2	3	2	1	0	0	0	3	3
Excessive Seepage	0	-2	0	0	0	0	0	0	0	-2	0	0	-1	0	0	0	0	-1	-1	3	0	1	1	1	0	0	0
Excessive Subsurface Water	0	-1	0	0	0	0	0	0	0	-2	0	2	-1	0	0	0	0	-1	-1	3	1	1	1	1	1	0	0
Inadequate Outlets	0	0	0	0	0	0	0	0	0	-1	0	4	2	0	0	0	0	1	1	5	3	-1	2	2	0	3	3
Inefficient Water Use on Irrigated Land	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	3	3	3	5	3	3	3	3	0	0
Inefficient Water Use on Non-irrigated Land	0	0	0	0	0	0	0	1	0	3	0	0	2	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Insufficient Flows in Water Courses	0	-1	-1	0	1	-2	2	1	0	3	0	0	0	0	0	0	0	-1	-1	3	1	1	1	1	2	0	0
Reduced Capacity of Conveyances by Sediment Deposition	0	2	5	-1	1	0	0	0	0	1	1	2	1	2	0	2	0	3	3	3	3	1	0	0	3	5	5
Reduced Storage of Water Bodies by Sediment Accumulation	0	2	5	-1	0	0	0	1	0	1	1	2	1	2	0	1	0	0	0	3	3	1	0	0	3	5	5
Rangeland Hydrologic Cycle	0	0	0	0	0	0	0	1	0	0	0	0	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Average	**0.051**	**1.127**	**1.089**	**0.051**	**0.228**	**0.025**	**0.354**	**1.165**	**0.139**	**1.025**	**0.139**	**0.709**	**0.734**	**0.671**	**0.709**	**0.722**	**0.494**	**0.354**	**0.304**	**0.924**	**0.797**	**0.38**	**0.228**	**0.228**	**0.975**	**1.152**	**1.139**

Appendix Cont.

Land Smoothing (466)	Lined Waterway or Outlet (468)	Manure Transfer (634)	Mine Shaft and Adit Closing (457)	Mulching (484)	Nutrient Management (590)	Obstruction Removal (500)	Open Channel (582)	Pasture and Hay Planting (512)	Pest Management (595)	Pipeline (516)	Pond (378)	Pond Sealing or Lining, Bentonite Sealant (521C)	Pond Sealing or Lining, Flexible Membrane (521A)	Pond Sealing or Lining, Soil Dispersant (521B)	Prescribed Burning (338)	Prescribed Grazing (528)	Pumping Plant (533)	Recreation Area Improvement (562)	Recreation Land Grading and Shaping (566)	Recreation Trail and Walkway (568)	Residue and Tillage Management, Mulch Till (345)	Residue and Tillage Management, No-Till/Strip Till/Direct Seed (329)	Residue and Tillage Management, Ridge Till (346)	Residue Management, Seasonal (344)	Restoration and Management of Rare or Declining Habitats (643)	Riparian Forest Buffer (391)	Riparian Herbaceous Cover (390)	Roof Runoff Management (558)	Sediment Basin (350)	Shallow Water Management for Wildlife (646)	Spring Development (574)	Stream Crossing (578)	Stream Habitat Improvement and Management (395)	Streambank and Shoreline Protection (580)	Stripcropping (585)	Structure for Water Control (587)	Subsurface Drain (606)	Surface Drainage, Field Ditch (607)	Surface Drainage, Main or Lateral (608)	Terrace (600)	Tree/Shrub Establishment (612)	Tree/Shrub Pruning (660)	Tree/Shrub Site Preparation (490)	Underground Outlet (620)	Upland Wildlife Habitat Management (645)	Use Exclusion (472)	Vegetative Barrier (601)	Waste Facility Cover (367)	Waste Storage Facility (313)	Waste Utilization (633)	Wastewater Treatment Strip (635)	Water and Sediment Control Basin (638)	Water Well (642)	Watering Facility (614)	Well Decommissioning (351)	Wetland Creation (658)	Wetland Enhancement (659)	Wetland Restoration (657)	Wetland Wildlife Habitat Management (644)	Windbreak/ Shelterbelt Establishment (380)	Windbreak/ Shelterbelt Renovation (650)
0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	-2	0	0	4	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4	4	0	0	0	0	0	0	5	0	0	0	3	0	0	0	0	0	0	0	0	0	0	3	3	3	3	4	4
0	0	-2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	2	0	0	0	0	0	0	0	0	0	2	2
0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	-1	-1	-1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
0	0	-2	0	-1	2	0	0	0	0	0	0	0	0	0	-3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	-2	0	0	0	0	0	0	-1	-1	-1	-1	0	0
-1	0	0	0	1	1	0	0	2	2	0	0	0	0	0	4	2	3	2	0	0	2	2	2	2	1	4	2	0	0	0	0	0	1	1	0	0	0	0	0	0	5	0	1	0	1	1	1	0	0	2	1	0	0	0	0	2	2	2	2	2	1
0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	1	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
0	0	1	0	0	4	0	0	0	4	0	0	0	0	0	-1	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2	-2	4	0	0	0	0	0	-1	-1	-1	-1	2	2
0	0	1	0	2	2	0	0	2	2	0	0	0	0	0	2	2	0	1	0	0	3	3	3	2	0	1	1	0	0	0	0	0	0	0	3	0	0	0	0	0	2	0	-2	0	2	2	0	0	0	-1	0	0	0	0	0	0	0	0	0	2	2
-2	0	1	0	2	3	0	0	2	2	0	0	0	0	0	2	2	0	1	0	0	0	0	0	2	0	1	1	0	0	0	0	0	0	0	3	0	0	0	0	0	2	0	-1	0	2	2	0	0	0	-1	0	0	0	0	0	0	0	0	0	2	2
-2	0	1	0	2	2	-1	0	0	0	0	0	0	0	0	2	2	0	1	1	1	0	0	0	2	0	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0	3	0	1	0	1	1	1	0	0	1	0	0	0	0	0	1	0	1	0	2	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	2	5	5
0	0	0	0	0	2	0	0	0	0	5	5	4	4	4	0	0	5	0	0	0	0	0	0	0	0	0	0	3	1	0	5	3	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5	5	0	0	0	0	0	0	0
0	0	0	0	2	4	0	0	5	4	0	0	0	0	0	5	5	0	0	0	0	1	1	1	1	2	4	4	0	0	1	3	3	2	1	0	0	4	4	4	0	2	2	0	0	2	4	1	0	0	4	1	0	2	3	0	2	2	2	2	3	3
0	0	0	0	0	0	-1	0	0	0	0	0	0	0	0	-1	3	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	4	0	0	0	0	0	0	0	4	-3	-1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	5	5
0	0	0	2	0	3	0	0	3	4	4	4	3	3	3	2	4	4	0	0	0	0	0	0	0	0	4	4	0	0	0	4	4	4	0	0	0	0	0	0	0	4	0	0	0	0	4	0	0	0	3	0	0	4	4	0	0	0	0	0	5	5
-1	0	0	2	0	0	0	0	1	0	0	2	0	0	0	2	3	0	0	0	-1	2	2	2	2	4	4	4	0	1	5	1	0	4	1	0	0	0	0	-1	0	4	0	0	0	5	3	1	0	0	0	0	0	4	4	0	4	4	4	5	3	3
0	-2	0	2	1	1	-2	0	3	2	0	3	0	0	0	3	3	0	2	-2	-1	2	2	2	2	4	4	4	0	-1	3	0	0	4	2	2	0	0	0	0	1	4	1	0	0	5	3	1	0	0	0	0	0	0	0	0	5	5	5	5	4	4
0	-2	0	0	1	1	-1	0	3	2	0	3	0	0	0	3	3	0	2	-2	-1	2	2	2	2	4	4	4	0	-1	4	0	0	4	2	2	0	0	0	0	0	3	1	0	0	5	3	1	0	0	0	0	0	0	0	0	5	5	5	5	4	4
-1	0	0	2	0	0	0	0	1	0	0	2	0	0	0	4	2	0	0	-2	-2	1	1	1	1	4	4	4	0	0	4	2	0	4	2	1	0	0	0	0	0	5	0	0	0	5	3	1	0	0	0	0	0	0	2	0	4	4	4	4	4	4
0	0	0	0	0	0	0	-2	0	0	0	4	1	1	1	0	0	0	2	0	0	0	0	0	0	4	2	2	0	1	4	4	0	3	0	0	2	0	0	0	0	0	0	0	0	0	2	1	0	0	0	0	2	2	2	0	3	3	3	3	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4	4	4	4	0	0
-1	0	0	0	0	0	0	-2	0	0	0	2	0	0	0	1	4	0	0	-1	-1	0	0	0	0	4	4	4	0	0	2	2	0	4	2	1	0	0	0	0	0	4	0	0	0	4	3	1	0	0	0	0	0	0	2	0	4	4	4	4	4	4
0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	4	4	4	4	0	0
0	0	0	0	0	4	0	0	5	4	0	0	0	0	0	5	4	0	0	0	0	0	0	0	0	4	4	4	0	0	0	0	0	0	0	0	0	4	3	3	0	5	0	0	0	4	4	0	0	0	4	0	0	0	0	0	0	0	0	0	4	4
3	0	-1	0	3	0	0	0	4	5	0	0	0	0	0	4	4	0	4	4	0	0	0	0	0	4	4	4	0	0	1	0	0	4	4	0	0	0	0	0	0	4	0	4	0	4	4	4	0	0	0	4	0	0	0	0	4	4	4	4	4	4
0	0	0	0	0	3	0	0	5	5	0	0	0	0	0	4	4	0	5	3	5	0	0	0	0	4	4	4	0	0	4	0	0	4	4	0	0	0	0	0	0	5	0	4	0	4	3	5	0	0	3	5	0	0	0	0	4	4	4	4	5	5
3	0	0	0	3	3	0	0	5	5	2	2	1	1	1	5	5	3	5	3	4	2	2	2	2	4	5	5	0	0	3	2	0	4	4	3	0	2	2	2	2	5	5	5	0	4	4	3	0	2	3	2	0	1	2	0	4	4	4	4	5	5
0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	5	3	0	3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	0
-2	0	0	0	2	-2	-1	0	4	2	0	0	0	0	0	0	3	0	2	0	2	1	2	3	0	0	4	4	0	0	0	-1	0	0	0	0	0	2	1	0	-1	2	0	-1	0	0	4	-2	0	1	0	0	0	0	0	0	0	0	0	0	2	2
0	0	0	0	1	0	0	0	2	3	0	0	0	0	0	1	2	0	0	0	0	0	0	1	0	0	2	2	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0	-2	0	0	1	0	0	0	0	0	0	0	0	0	1	1
-1	0	0	0	2	2	0	0	3	0	0	0	1	1	0	-1	2	0	2	0	0	1	1	1	1	-1	1	2	0	0	0	0	0	0	0	0	0	3	2	0	0	2	0	0	0	0	2	-2	0	0	0	-2	0	1	0	0	0	0	0	0	1	1
3	1	0	0	1	1	0	1	2	2	0	2	0	0	0	1	3	0	3	2	0	2	3	2	2	0	2	2	1	3	-1	0	1	0	2	4	2	0	0	0	2	0	0	0	2	0	2	-2	0	0	1	0	3	2	0	0	0	0	0	0	-2	-2
-2	0	0	0	3	2	0	0	3	2	0	0	0	0	0	1	5	0	3	1	0	3	5	3	2	0	1	1	0	0	1	0	0	0	0	2	0	-2	-2	0	1	4	-1	-2	0	0	2	0	0	0	3	1	0	0	0	0	2	1	1	0	4	4
0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-2	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	2	0	0	4	0	0	0	1	1	1	1	2	0	0	0	0	0	0	0	0	0	3	3	0	0	0	2	0	0	0	0	0	2	1	0	0	2	1	0	0	0	2	-2	0	2	0	-2	0	1	0	0	1	1	1	0	2	2
0	0	0	0	0	2	0	0	4	0	0	0	1	1	1	1	2	0	0	0	0	0	0	0	0	0	3	3	0	0	0	2	0	0	0	0	0	2	1	0	0	2	1	0	0	0	2	-2	0	2	0	-2	0	1	0	0	1	1	1	0	2	2
0	0	0	0	1	2	0	0	4	0	0	0	1	1	1	1	2	0	0	0	0	0	0	0	0	0	3	3	0	0	0	2	0	0	0	0	0	1	1	0	0	2	1	0	0	0	2	-2	0	2	0	-2	0	1	0	0	1	1	1	0	2	2
0	0	0	0	1	2	0	0	4	0	0	0	1	1	1	1	2	0	0	0	0	0	0	0	0	0	3	3	0	0	0	2	0	0	0	0	0	2	1	0	0	2	1	0	0	0	2	-2	0	2	0	-2	0	1	0	0	1	1	1	0	2	2
0	0	0	0	0	2	0	0	4	0	0	0	1	1	1	1	2	0	0	0	0	0	0	0	0	0	3	3	0	0	0	2	0	0	0	0	0	2	1	0	0	2	1	0	0	0	2	-2	0	2	0	-2	0	1	0	0	1	1	1	0	2	2
0	0	0	0	1	2	0	0	4	0	0	0	1	1	1	1	2	0	0	0	0	0	0	0	0	0	3	3	0	0	0	2	0	0	0	0	0	1	1	0	0	2	1	0	0	0	2	-2	0	2	0	-2	0	1	0	0	1	1	1	0	2	2
0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	2	4	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	0	0	1	0	0	0	1	3	0	3	0	0	0	1	2	0	1	4	4	0	0	0	0	0	0	0	1	2	0	1	0	0	0	1	0	1	-1	-1	2	0	0	-2	4	2	2	2	0	0	0	0	3	0	1	0	0	0	0	0	0	0
1	5	0	0	4	0	0	0	4	3	0	0	0	0	0	3	4	0	4	1	0	4	4	4	1	2	2	1	3	2	0	0	0	0	0	4	0	4	2	2	4	2	0	-2	5	3	2	5	0	0	1	0	2	2	2	0	0	0	0	0	2	2
1	0	0	0	3	-1	0	0	3	3	0	0	0	0	0	0	2	0	0	0	0	2	3	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	-1	-1	-1	0	0	3	1	0	-1	0	1	0	0	4	0	0	2	0	0	-1	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
0	2	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	2	0	2	2	0	0	3	0	3	0	0	0	0	0	0	0	0	0
0	0	0	0	4	0	0	0	4	3	0	0	0	0	0	3	4	0	4	0	0	4	4	4	2	2	2	2	1	0	0	0	0	0	0	4	0	4	0	0	5	2	1	-1	0	3	2	4	0	0	2	0	0	2	2	0	0	0	0	0	2	2
0	1	0	0	1	0	0	0	0	0	0	-2	1	1	1	1	3	0	1	3	3	0	0	0	0	0	3	4	0	0	3	0	1	0	4	0	0	0	0	0	0	0	0	0	0	1	2	1	0	0	0	0	0	0	4	0	3	3	3	3	0	0
0	1	0	0	2	0	0	3	0	0	0	1	0	0	0	1	3	0	1	2	3	0	0	0	0	0	3	4	0	0	0	1	3	5	4	0	0	1	0	0	1	0	0	0	0	1	2	1	0	0	0	0	1	0	4	0	0	0	0	0	0	0
0	0	0	0	4	0	0	0	4	3	0	0	0	0	0	2	4	0	4	0	0	4	4	4	3	2	2	2	0	0	0	0	0	0	0	4	0	-1	-1	-1	1	5	0	-1	0	3	2	1	0	0	1	0	0	2	2	0	0	0	0	0	5	5
2	0	2	0	-1	5	0	0	2	0	0	-1	2	3	3	1	1	0	0	0	0	-1	-1	-1	-1	0	5	5	2	-1	1	0	0	0	0	-1	0	1	1	1	-2	2	1	0	0	0	1	-1	0	4	2	-2	-1	0	0	3	1	1	1	0	5	5
1	2	3	0	2	5	0	-1	2	0	0	2	2	2	2	2	1	0	0	0	0	2	2	1	1	0	5	5	2	5	1	0	-1	0	1	3	0	-2	-2	-2	2	2	1	0	0	0	2	2	0	4	2	4	2	0	0	0	3	3	3	0	1	5
0	0	2	2	-1	1	0	0	1	0	0	0	3	3	3	0	1	0	0	0	0	-1	-1	-1	-1	0	1	1	0	-1	-1	0	0	0	0	-1	0	2	1	2	-2	1	0	0	0	0	0	-1	0	1	2	-1	-1	0	0	3	0	0	0	0	0	0
0	0	2	0	1	1	0	0	1	0	0	0	0	0	0	0	2	0	0	0	0	1	1	1	1	0	1	1	2	2	0	1	0	0	0	1	0	-2	-2	-2	2	1	0	0	0	0	0	1	0	2	2	1	1	0	1	0	1	1	1	0	0	0
1	2	0	0	2	0	0	0	2	2	0	3	0	0	0	1	3	0	4	2	2	1	3	2	1	2	4	4	1	4	2	1	2	3	3	3	1	2	-2	-2	3	4	0	-1	1	2	0	2	0	0	0	2	4	0	2	0	2	2	2	3	2	1
0	0	0	1	0	2	0	0	1	0	0	0	1	1	1	0	1	0	0	0	0	1	1	1	1	0	1	1	0	-1	1	0	0	0	0	-1	0	1	1	2	-1	1	0	0	0	0	1	-1	1	1	0	0	-1	0	0	3	0	0	0	0	0	0
1	0	0	2	1	3	0	-1	2	0	0	0	0	0	0	1	1	0	0	0	0	1	1	1	1	0	2	2	0	2	2	2	0	0	0	3	0	0	-2	-2	2	1	0	0	1	0	1	2	1	0	0	0	2	0	1	0	2	2	2	0	1	1
0	0	2	0	0	1	0	0	1	0	0	0	3	3	3	0	1	0	0	0	0	0	0	0	0	0	2	2	0	-1	-1	0	0	0	0	-1	0	1	1	2	-1	4	0	0	0	0	1	0	1	2	2	-1	-1	0	-1	3	0	0	0	0	0	0
0	0	3	0	1	1	0	0	1	0	0	-2	0	0	0	0	3	0	0	0	-2	1	1	1	1	0	3	3	3	2	2	1	-1	0	1	1	0	0	-2	-2	2	3	0	0	1	0	2	2	0	2	0	4	2	-1	1	0	1	1	1	1	0	0
1	0	0	0	1	0	0	0	2	5	0	0	0	0	0	0	1	0	2	0	0	1	1	1	-1	0	2	2	0	-1	0	0	0	0	0	0	0	2	1	0	-2	4	1	0	0	0	0	-1	0	0	2	0	-1	0	0	3	1	1	1	0	0	0
1	0	0	0	2	0	0	0	2	5	0	0	0	0	0	0	1	0	2	0	0	4	4	4	1	0	4	2	0	2	0	0	0	0	0	2	0	2	0	0	3	4	1	0	0	0	0	2	0	0	0	0	2	0	0	0	1	1	1	0	2	2
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	-1	1	0	0	0	0	2	0	0	0	0	0	0	0	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	2	0	0	0	0	0	3	1	0	1	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	-2	0	1	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0	0	1	-1	-1	-1	0	0	1	0	0	0	1	1	1	1	0	0	0	1	1	0	0	0	0	0	0	0	-1	-1	-1	1	-2	0	0	0	0	0	1	0	0	0	0	0	-2	0	2	1	0	0	0	-2	-2
0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5
3	2	0	0	2	0	0	5	2	0	0	2	0	0	0	1	2	2	2	2	2	1	2	2	1	0	-3	-3	-1	2	3	1	0	0	0	1	2	4	3	3	4	-1	0	0	4	-3	-2	-2	-1	0	0	0	2	0	0	0	3	3	3	3	-1	-1
3	2	0	0	-1	0	0	1	0	0	0	-2	1	1	1	0	0	2	0	0	0	-1	-1	-1	-1	0	2	2	1	-2	0	2	0	0	0	-2	0	4	0	0	-2	2	0	0	0	0	1	0	0	0	0	-2	-2	0	0	0	0	0	0	0	2	2
3	2	0	3	-1	0	0	3	0	0	0	-1	2	2	2	0	0	2	0	0	0	0	0	0	0	0	2	2	1	-2	0	2	0	0	0	-1	0	4	3	3	-2	2	0	0	0	2	2	2	0	0	0	-2	-2	2	0	0	-1	0	0	0	2	2
0	3	0	0	1	0	2	5	0	0	0	0	0	0	0	1	0	2	0	2	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	-2	-3	-3	2	2	0	0	3	0	1	2	0	0	0	0	1	0	0	0	3	3	3	0	0	0
3	0	0	0	3	0	0	0	1	1	0	3	3	3	3	0	0	3	0	0	0	1	2	2	1	0	0	0	0	0	0	2	0	0	0	0	2	2	3	3	0	0	0	0	0	0	0	3	0	1	2	0	0	2	0	0	0	0	0	0	5	5
3	0	1	0	3	0	0	0	2	1	0	3	3	3	3	0	2	3	0	0	1	2	3	3	1	0	0	0	3	0	0	2	0	0	0	1	2	1	3	3	3	2	0	4	0	0	3	3	0	0	2	1	0	0	1	0	0	0	0	0	2	2
0	1	0	0	0	0	1	3	1	0	0	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	4	2	-1	0	-1	0	0	0	0	2	2	2	2	-1	2	0	0	0	1	2	2	0	-1	0	-1	1	0	0	0	-1	0	0	0	-2	-2
0	2	0	0	3	0	3	2	1	1	0	3	0	0	0	1	2	0	5	0	2	2	3	2	1	0	5	4	1	4	0	0	0	0	3	4	2	1	-2	-2	2	4	0	0	2	1	2	5	0	0	0	0	4	0	1	0	0	0	0	0	1	1
0	2	0	0	3	0	3	-2	2	1	0	0	0	0	0	1	1	0	2	0	2	2	3	2	2	0	5	5	1	4	3	0	1	0	3	2	2	1	-2	-2	2	4	0	0	2	1	2	5	0	0	0	0	4	0	1	0	3	3	3	0	1	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	-1	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.253	0.342	0.177	0.228	0.949	0.937	0.063	0.19	1.582	1.228	0.139	0.519	0.456	0.468	0.456	1.152	1.646	0.405	0.937	0.291	0.367	0.684	0.848	0.772	0.519	0.911	2.051	1.835	0.38	0.38	0.582	0.646	0.203	0.797	0.671	0.62	0.253	0.709	0.19	0.114	0.443	1.987	0.228	0.114	0.367	1.101	1.392	0.633	0.101	0.367	0.722	0.038	0.392	0.43	0.595	0.215	1.038	1.051	1.063	0.823	1.608	1.633