Defining a Targeted Terrestrial Natural Heritage System

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Abstract

Policies that focus on protecting only the most significant habitats ultimately contribute to an overall loss of biodiversity and ecosystem function, despite good intentions. In a landscape that probably supported over 90% forest cover prior to European settlement, only about 16% of forest and wetland cover remain in the TRCA region. In response, the TRCA initiated a Terrestrial Natural Heritage Program to address terrestrial biodiversity loss. In realizing that more natural cover is required to support biodiversity in such a heavily fragmented and rapidly urbanizing landscape, a landscape-level approach to terrestrial natural heritage system planning was developed. The TRCA's landscape-level analysis has two components: 1) a vector-based evaluation of habitat patch characteristics using landscape metrics; and, 2) a raster-based analysis to aid in identifying protection and restoration opportunities. Defining the target terrestrial natural heritage system involves applying these two landscape exercises, and evaluating resulting maps against a predetermined desired minimum regional condition.

Introduction

Rapid urban expansion in the Greater Toronto Area (GTA) has led to continuous incremental loss of natural cover and sensitive species. Despite good intentions, policies that focus on protecting only the most significant habitat ultimately contribute to this overall loss of biodiversity. In a landscape that probably supported over 90% forest cover prior to European settlement, current mapping suggests that only about 16% forest and wetland cover remains.

In the late 1990s the Toronto and Region Conservation Authority (TRCA) initiated the Terrestrial Natural Heritage (TNH) Program to address terrestrial biodiversity loss in the nine watersheds that encompass the jurisdiction by applying principles of conservation biology and landscape ecology. A basic premise of the program is that in the heavily fragmented landscape of the GTA more natural cover is required to improve ecological function and integrity.

The TRCA's TNH program addresses terrestrial biodiversity at the landscape, vegetation community, and species levels. These efforts are an integral part of a *TNH Strategy* document designed to implement the targeted terrestrial natural heritage system and guide natural heritage policy. The focus here is on the landscape level of detail (for more information on the species and vegetation community levels of detail, refer to the TRCA *TNH Scoring and Ranking Methodology*, 2003). The TRCA landscape analysis has two components: 1) a vector-based evaluation of habitat patch characteristics using landscape metrics; and, 2) a raster-based analysis to aid in identifying protection and restoration opportunities. Together, these two exercises produce the maps to be evaluated against the predetermined desired (targeted) regional conditions. This document briefly reviews the steps used to achieve a targeted or expanded natural heritage system.

Methodology

Study Area Definition

The study area is defined by the exact boundaries of the Toronto and Region Conservation Authority region, although the methodology has been designed to be transferable to study areas of varying scales such as a municipality, watershed, or subwatershed. Basic statistics used in the analysis, such as the area covered by habitat types, are based on these study area limits. However, some of the landscape metrics applied also include areas adjacent to these study area boundaries, where both patches occurring entirely within the watershed and those straddling the boundary are often required for the measure and are included in the calculations (refer to TRCA, 2003a for details).

Data Preparation

In a region of rapid land-use change, landscape-level analyses must be based on the most recent information possible. The TRCA landscape analysis is based on remote mapping and digitizing of patches into discreet polygons using the most recent color, digital, orthorectified aerial photography at a scale of 1:4,000. Remote-sensing at this scale allows for accurate polygon definition based on major habitat types and land-uses. Polygons are digitized using ArcView GIS software 'on screen'. Once more recent digital aerial photography is made available, updates to polygon boundaries can be made to reflect and track changes in land-use.

Habitat and Land-use Definition

The major habitat types considered for the TRCA landscape analysis are forest, successional areas, wetland, meadow, and coastal habitats such as beach, dune, or bluff. These general categories are a variation of the Community Class Level of the *Ecological Land Classification (ELC) System for southern Ontario* (Lee *et al.*, 1998). The remaining land is classified as either agricultural or urban use. Aquatic systems such as large bodies of water and watercourses, though considered natural, are not classified for the terrestrial component of the analysis. Habitat type and land-use definitions are addressed in detail in the *TNH Program Landscape Analysis Methodology* document (TRCA, 2003a).

Patch boundaries are generally defined by obvious changes in habitat or land-use. Main roads and wide trails were considered as boundaries to habitat, and a width of 25 m was used to define breaks in habitat patches by the former. The area covered by roads is then considered as "urban" land-use. Watercourses visible at a scale of 1:4,000 were also considered to separate habitat patches into discreet polygons.

Landscape Patch Analysis and Scoring Methodology

The vector component of the landscape analysis applies several criteria and measures relevant to the inherent qualities of individual patches and their position in relation to each other and to current surrounding land-uses. A wide range of measures are now used in landscape ecology (i.e., McGarigal and McComb, 1995), and a large number of these were carefully scrutinized before a choice was made on those thought to be most relevant for the TRCA's regional landscape context.

Once the major habitat and land-use types have been digitized, habitat patches can be scored and ranked according to their respective qualities. The patch analysis is undertaken using ArcView GIS software. Because this analysis can be undertaken remotely, and because representation of vegetation communities, flora, and fauna tend to be strongly correlated with the patch attributes, the landscape analysis is the most fundamental of the TNH program's conservation priority measures.

Six indicators are currently used by the TRCA to determine habitat patch quality for the landscape analysis, including quantity, distribution, matrix (surrounding land-use) influence, patch size and shape, connectivity, and biodiversity (TRCA, 2003a; Normand and Towle, 2001). Three of these indicators are scored quantitatively, the others are qualitative in nature. Individual quantitative scores for size, shape, and matrix influence can then be tallied up for a total 'quality' score. Total scores for patches are then translated into individual patch quality local ranks (L-ranks) on a scale of 1 to 5 (L1 is the highest functioning patch, L5 the lowest). Patch ranks are color-coded to help visualize the overall condition in the study region. This ranking system can be used to assess the quality of patches, as well as the quality and distribution of natural cover across the region, within a watershed, subwatershed or at a site level.

Assessing quality of future conditions

The TNH program recognizes the need to consider the quality of not only existing, but also future conditions. The landscape analysis provides an opportunity to undertake modeling exercises to look at scenarios for improving the terrestrial natural heritage system. Different land-use scenarios can be compared to determine the best possible outcome for the fate of habitat patches (i.e., modeling different size, shape, or land-use types in the matrix).

Value Surface Approach

Although the TRCA's landscape analysis is a useful tool for assessing the quality, quantity and distribution of natural cover for existing or modeled conditions, the exercise does not tell one where to increase habitat from a restoration value or improved natural heritage system standpoint. For example, areas which do not support habitat today may be valuable for their capacity to support good quality habitat and associated species in the future, yet where in the region is it most valuable to secure land for future habitat placement? A method was needed to show the restoration potential values of the surrounding landscape.

Defining an improved terrestrial natural heritage system for the study region involves not only the landscape patch analysis but also a raster-based modeling exercise that can be used to look for restoration and protection opportunities and/or priorities to achieve a desired or targeted condition. The raster exercise was chosen because it can show detailed value changes within all parts of the landscape based on any number of criteria to be measured. Raster-based GIS breaks down the landscape into cells of a specified size. In this case a grid composed of 10 m x 10 m cells was used as the raster cell size to provide a high level of detail, and to ensure that small habitat patches, particularly wetlands, would be well represented. Each cell is assigned points based on the presence or absence of a selected set of ecological and land-use (feasibility) criteria (Table 2). Refer to TRCA's Terrestrial Natural Heritage Program Landscape Analysis Methodology (2003a) for the scoring and valuation system used for each criteria layer.

Certain criteria focus solely on the protection of existing habitat patches, in particular those that are derived from the vector analysis (see Table 2), while others allow for system expansion. Because the vector analysis assigns scores for patch (polygon) size and shape, patch values can then be translated to each cell (pixel) that a patch is made up of (converting vector to raster GIS) as a means to value certain areas (pixels) over others. In this case, pixels in the landscape that are not covered by an existing habitat patch would not receive a value.

Criteria layers are 'overlaid', and the sum of the points that each cell receives for every criterion is used to determine a value gradient. The mapped total for the raster analysis provides a range of cell values across the landscape that are depicted as shades of one color that becomes darker as values for protection/restoration increase.

Where to Draw the Target System Line?

The next challenge is to decide where to draw the line around the 'targeted' terrestrial natural heritage system, i.e., where should protection for existing and potential cover occur across the gradient of values? This could be simply based on defining a range of cell values (or shades) at which they would either be in or outside of the targeted system. However, because the ultimate goal is to improve the quality and expand the size of the system rather than only to protect existing conditions, it was decided that the boundary would not only be set by percent cover targets, but would be driven by a desired quality (size, shape, matrix influence) and distribution of natural cover. The model does need a percent cover to start with and the TRCA chose to apply the *Great Lakes Remedial Action Plan* target of 30% forest cover (Environment Canada, Ontario Ministry of Natural Resources, and Ontario Ministry of Environment, 1998), to the TRCA jurisdiction, providing adequate quality and distribution goals are met. Therefore the system line is initially drawn around the value gradient until 30% of the most valuable land is captured.

Table 2. *Ecological and feasibility layers employed in the value surface analysis.*

ECOLOGICAL LAYERS	FEASIBILITY LAYERS
Habitat Patch Size*	Provincially Significant Wetlands (PSW)
Habitat Patch Shape*	Areas of Natural and Scientific Interest (ANSI)
Distance from Urban Areas	Environmentally Significant Areas (ESA)
Distance from Natu ral Areas	Fill/Fill Extension Line
Distance from Roads	TRCA Property
Interior Forest	Oak Ridges Moraine
Distance of a Forest to a Wetland	Niagara Escarpment
Distance of a Wetland to a Forest	
Distance to a Watercourse	
Distance to a Water body	
Distribution**	
Shape Modification**	

*Note: i) Natural cover included in the analysis includes forest and wetland cover only; ii) Refer to TRCA Terrestrial Natural Heritage Program Landscape Analysis Methodology, 2003a for the scoring system for each criteria layer; iii) A description of each layer and why it was selected is available; * Vector landscape analysis polygons converted to raster, thus giving a score to pixels falling within existing habitat boundaries only; ** Criteria applied only after a 'total' value surface has been achieved.*

Once the target line has been selected a shape modification/buffering exercise is performed using ArcView to smooth out patch shapes and fill in holes within patches. This exercise results in a slightly greater, though not significant, percent natural cover included in the target system.

Evaluating the Quality of the Target System

Once the desired quantity (30% forest and wetland cover) is achieved, the resulting terrestrial natural heritage system is evaluated for quality (size, shape, and matrix influence, as described in section 2.3 *Landscape Analysis and Scoring Methodology*), and a new total score is provided. At this time the remaining agricultural landscape can be modeled as "urban" cover to ensure that the matrix influence values of the system are robust enough to increasing urban pressures. The resulting scores can then be compared with existing conditions to demonstrate improvements in the system. Improved values in size, shape, and matrix influence, as well as total cover and distribution then serve as a draft target. If improvements in quality are not detected at 30% cover, the quantity (% natural cover) and distribution of habitat must be changed until reasonable quality targets are met. It is this iterative process, along with a predetermined desired 'minimum' regional condition that defines the target terrestrial natural heritage system.

Target System Scenarios

Scenarios can be produced based on a range of habitat cover targets (quantity), different qualities of habitat patches, different natural cover distributions in the landscape, and a variety of land-use planning scenarios. To determine the ideal target system for the region, the TRCA's municipal partners, other stakeholders and peers can review the various scenarios and the methodology behind them, in a review process similar to that used for other aspects of the TRCA TNH Program.

Next Steps

Implementation of the target system

The ultimate goal is to have landscape targets and the mapped system interpreted in TRCA policies and municipal official plans, delivered by the TNH Strategy. The targets will be included within TRCA watershed plans and will help to guide acquisition programs and public restoration efforts to where they can be most effective. Rather than becoming a fixed boundary on a map, it is expected that some of the revised terrestrial natural heritage system will be flexible enough to allow for regional targets to be met through site level planning as development or land-use change proposals are introduced.

Integration with other ecological, political and social criteria

As data becomes available the value surface approach for the terrestrial system will be integrated with hydrological and aquatic habitat criteria to define a more complete natural heritage system. The new generation of integrated watershed plans will benefit from this multi-disciplined effort. An effort is also being made to ensure a degree of compatibility between the TRCA defined system with those being defined by neighboring Conservation Authorities, non-profit organizations, and the Province. Finally, a statistical analysis is currently underway to identify correlations between the presence or absence of avian species and the size, shape, and matrix values received by patches in the landscape analysis. This is an important step towards the defensibility of the targeted terrestrial natural heritage system.

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