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Assessing the utility of a novel terrestrial biodiversity quality indicator with 10 years of monitoring data

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ABSTRACT

We introduce a novel terrestrial biodiversity quality index developed to inform conservation management at a regional/local scale. Our index, the indicator species score (ISS), is derived from data for indicator birds, amphibians, mammals, plants and lichens representative of the major landscape-scale habitat types in the region and a range of sensitivities to urbanization. The ISS incorporates the conservation concern scores of the species monitored.

We assess the practical utility of the ISS using 10 years of data for 50 indicator species monitored at 54 fixed sites in the Toronto region, Ontario, Canada. We test the sensitivity of the ISS to temporal and spatial differences/trends. We assess its responsiveness to landscape-level habitat size and quality predictors including natural cover area and wetland area within 500 m, 1 km, and 2 km of the monitoring site centroid, as well as habitat patch score, and road density. We investigate the utility of the ISS in modelling landscape-level effects. We find that it responds to the habitat predictors, to road density and to urbanization impacts other than those tested.

We conclude that the ISS supports ecologically relevant interpretation and management target setting/benchmarking. It is intuitive in nature, easily communicated to a non-scientific audience and therefore useful for management reporting. ISS results following 10 years of monitoring also lead us to consider the relative importance of the many impacts that urbanization exerts on areas of natural cover that remain within an urban matrix. We recognize the need to develop metrics, where possible, in order to quantify individual impacts, monitor them, and establish priorities for the reduction or mitigation of the specific drivers of biodiversity quality decline.

1. Introduction

Cities around the world continue to expand and intensify their human populations, to the detriment of many other species and their habitats. Between 2002, when signatories to the Convention on Biological Diversity agreed to reduce the rate of decline of biodiversity, and the target year 2010, biodiversity is estimated to have continued declining, potentially at an increasing rate (Butchart et al., 2010). There is general agreement on this point despite the limited precision of current estimates (Butchart et al., 2010).

The conservation management action that is required to slow or halt biodiversity decline does not occur at a global scale, but a regional or local one. Conservation management requires local information on which to base plans and specific targets; thus there is a pressing need to effectively monitor biodiversity at multiple scales (Vackar et al., 2012).

By the late 1990's, the Toronto and Region Conservation Authority (TRCA) recognized declining terrestrial biodiversity in the Toronto region as an issue to be addressed. Biological inventories for the region indicated that a large number of formerly common and well-distributed species were now considerably reduced or entirely absent from natural lands located within the urban matrix; for the taxa inventoried, the decline in richness was more evident for vertebrate fauna than it was for vascular plants (unpublished data). With urbanization continuing, action was needed if new urban zones were not to experience a biodiversity decline as great as that evident in the established urban land-use zone.

Relevant work since that time includes:

- Geographical Information System (GIS) mapping and evaluation of landscape-scale habitat and land-use zones (TRCA, 2007)
- the designation of Species of Conservation Concern (SOCC), followed by the development and application of an objective method to score and rank conservation concern for all vascular plants and vertebrates native to the region (TRCA 2007, 2017)

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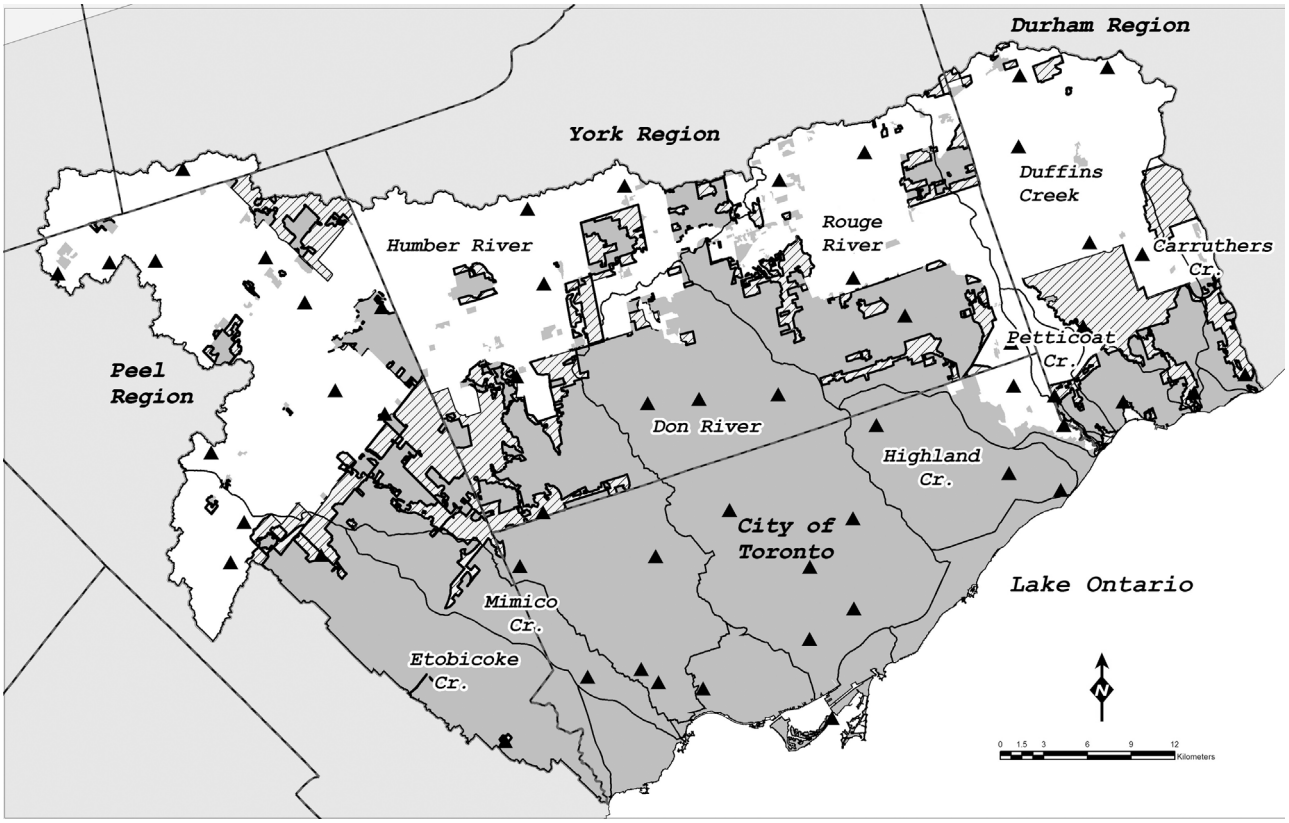

Fig. 1. The Toronto and region study area showing the city and regional municipal boundaries, watersheds, urbanization zones and indicator species monitoring sites.

- development and implementation of a Terrestrial Natural Heritage System Strategy (TRCA, 2007)
- terrestrial monitoring, including landscape analysis updates, indicator species presence/absence monitoring and more detailed monitoring of selected taxa and vegetation communities on forest, wetland and meadow plots (TRCA 2014a, 2015)

The focus of this paper is the indicator species monitoring. This program element was intended to provide high level indication of biodiversity trends and spatial differences in the region, by monitoring the presence over time and space of a number of historically common and well-distributed native species. Since there were no standard indices available (i.e. analogous to the fish and benthic indices of biotic integrity, or IBIs, applied to aquatic monitoring) that could be applied to meet regional needs for terrestrial monitoring and reporting, we developed a novel method.

Feest (2006) and Feest et al. (2010) discuss the practical need to track biodiversity quality. Normander et al. (2012) describe a biodiversity measurement framework for the Nordic countries that quantifies biodiversity based on available habitat, while determining biodiversity quality using indicator species. From a conservation management perspective, in the absence of a natural process that is driving a significant turnover in community composition, biodiversity quality is high if a large (or full) complement of the native species that were historically common and well-distributed in the region of interest remain so. If multiple, or many, previously common and previously well-distributed species are absent or reduced in distribution, biodiversity quality has declined. If this decline has disproportionately affected species already identified as conservation priorities, then biodiversity quality has declined more than if such is not the case. A biodiversity quality index that quantifies such differences is a strong tool for conservation management. It can also be used to assess ecological integrity. While not synonymous, biodiversity quality and ecological integrity are tightly integrated. Neither can exist without the other (De Leo and Levin 1997). The indices of biotic integrity (IBIs), widely applied to aquatic system monitoring (Hilsenhoff 1988; Minns et al., 1994; Ruaro and Gubiani 2013) could be considered biodiversity quality indices, at least for the taxa on which they are based. In terrestrial ecosystems, the floristic quality index (FQI) serves a similar role for plants (e.g. Matthews et al., 2015), but there isn't a widely applied terrestrial IBI or other index that includes flora and fauna, incorporates the level of conservation concern of component species, and includes representation across a range of terrestrial habitats. This is the purpose of our Indicator Species Score (ISS).

The ISS is a weighted score; the weighting criterion is the conservation concern score (CC score) for the species found. Because the ISS is based on indicator species and incorporates qualitative considerations, the ISS is an indicator of relative biodiversity quality rather than biodiversity *per se*.

Here we use the first 10 years of indicator species monitoring data to assess the ability of the ISS to fulfill its purpose. Specifically, we test whether the ISS:

i) is sensitive to temporal and spatial trends/differences
ii) responds to landscape-level predictor variables of ecological relevance
iii) provides information enrichment when compared to an unweighted score

We provide examples of the information obtained through analysis and interpretation of ISS monitoring results, and new questions that inform the adaptive monitoring process. We recommend the application of biodiversity quality based approaches to conservation management in urban/urbanizing regions, and highlight the utility of a simple conservation concern-weighted score as a tool for establishing priorities, measuring success, and communicating results.