Designing Sustainable Landscapes: Project Executive Summary

A project of the University of Massachusetts Landscape Ecology Lab

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- North Atlantic Landscape Conservation Cooperative (US Fish and Wildlife Service, Northeast Region)
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The **Designing Sustainable Landscapes** (**DSL**) is an ongoing project of the University of Massachusetts Landscape Ecology Lab. To learn more about the DSL project please read the Project Overview document.

Our primary mission as conservationists and public stewards of fish and wildlife resources is to ensure the conservation of biological diversity; specifically, to maintain the integrity of ecosystems and well-distributed viable populations of all native species and the ecosystem processes they perform and depend on. The DSL project was established to help with this endeavor in the Northeast region of North America. To this end, we developed a modeling framework to simulate landscape change, assess the ecological impacts of those changes and design conservation strategies to combat those ecological impacts — the Landscape Change, Assessment and Design (LCAD) model (**Fig. 1**).

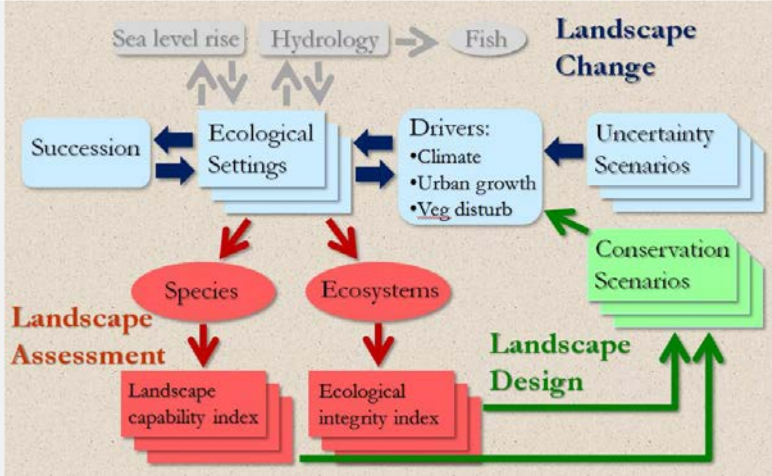

Figure 1. Outline of the Landscape Change, Assessment and Design (LCAD) model.

Landscape change — Our landscape change drivers currently include urban growth, climate change, sea level rise, and vegetation disturbance and succession. The landscape change model involves modifying a broad suite of 24 ecological settings variables (i.e., spatial data layers representing biophysical and anthropogenic attributes of the landscape such as wetness, impervious surface, and traffic) over time in response to the landscape change drivers under user-specified scenarios. A key by-product of the landscape change model is an integrated probability of development layer that serves not only to guide urban growth patterns during the simulation, but in combination with the landscape design products (below) also serves to identify high-valued places that are vulnerable to the loss of their ecological value due to projected future development (**Fig. 2**).

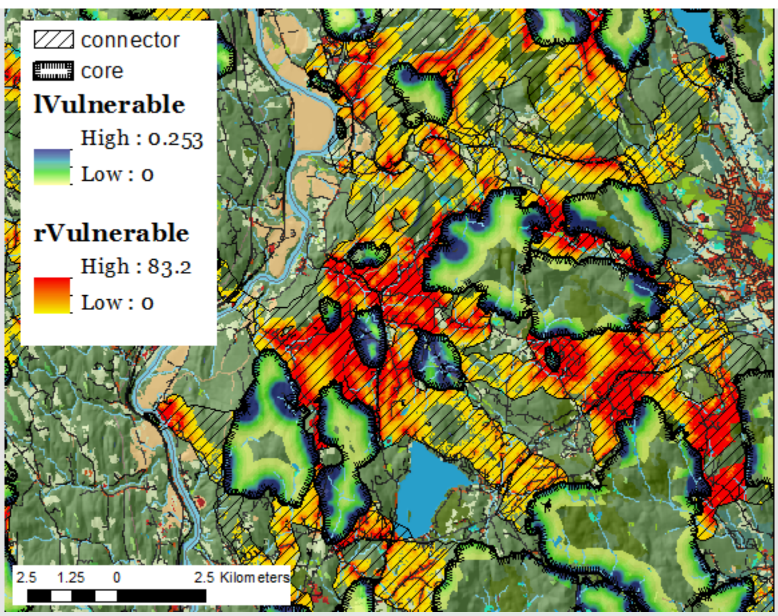

Figure 2. Vulnerability within "core areas" and important "connectors" to loss of ecological value due to potential future urban development.

Landscape assessment — Our ecological assessment of the landscape includes a complementary two-pronged assessment of ecosystem integrity (coarse filter) and landscape capability for a suite of focal wildlife species that together allow us to evaluate the ecological condition of the current landscape and the future landscape under landscape change scenarios. While our assessment generates numerous data products, the most synoptic product from our ecosystem-based assessment is the *Index of Ecological Integrity* (*IEI*), which is a composite of several different indices representing intactness (freedom from human impairment) and resiliency (the capacity to recover from or adapt to disturbance and stress). *IEI* is scaled 0-1 by ecosystem and geographic extent so that within the extent considered the poorest cell within each ecological system gets a 0 and the best cell a 1 (**Fig. 3**). Thus, boreal forests are compared to boreal forests and emergent marshes are compared to emergent marshes, and so on, within the corresponding geographic extent. In addition, by evaluating the change in *IEI* between 2010-2080 under a landscape change scenario, we can determine where the ecological impact of development is likely to be greatest and design conservation strategies to circumvent the potential loss.

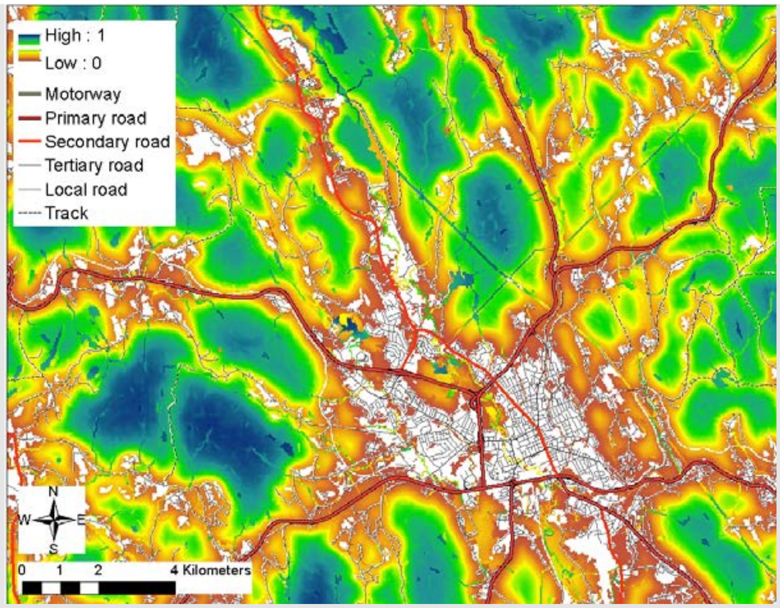

Figure 3. *Index of Ecological Integrity* (*IEI*) metric in 2010 scaled by ecosystem across the Northeast region (shown here for a random location). Developed lands are not assessed and are shown in white.

The most synoptic product from our species-based assessment is the *Landscape Capability* (*LC*) index for each focal species (currently 30 species), which is an index of the capability of each location to support the species based on climate and habitat suitability and other biographic factors represented by the species'

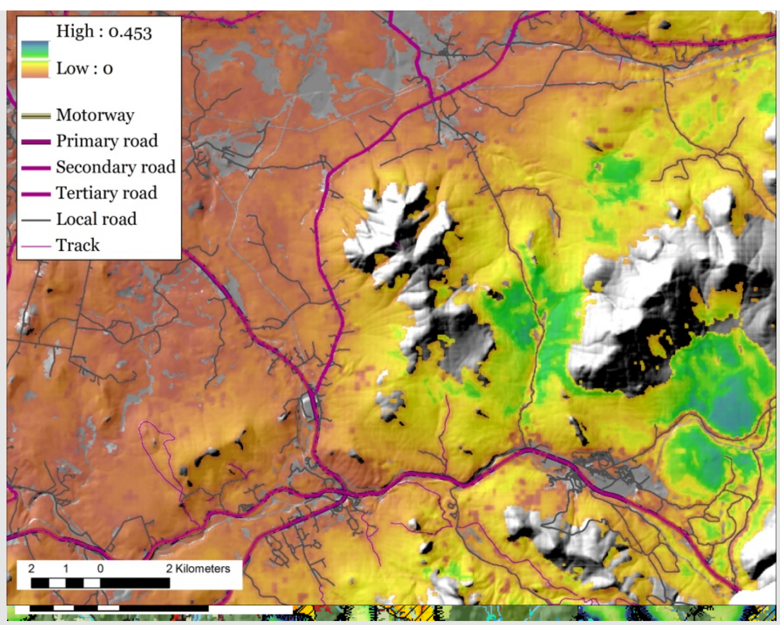

Figure 4. Blackburnian warbler landscape capability under climate conditions in 2080 (*Climate Response Index*) for a random location; on a hillshade map.

prevalence in the area. We use *LC* to evaluate the current condition of the landscape for each species, and we use the change in *LC* between 2010-2080 to evaluate potential impacts of habitat and climate changes on a species (e.g. **Fig. 4**), and all of this information can be used to inform conservation design.

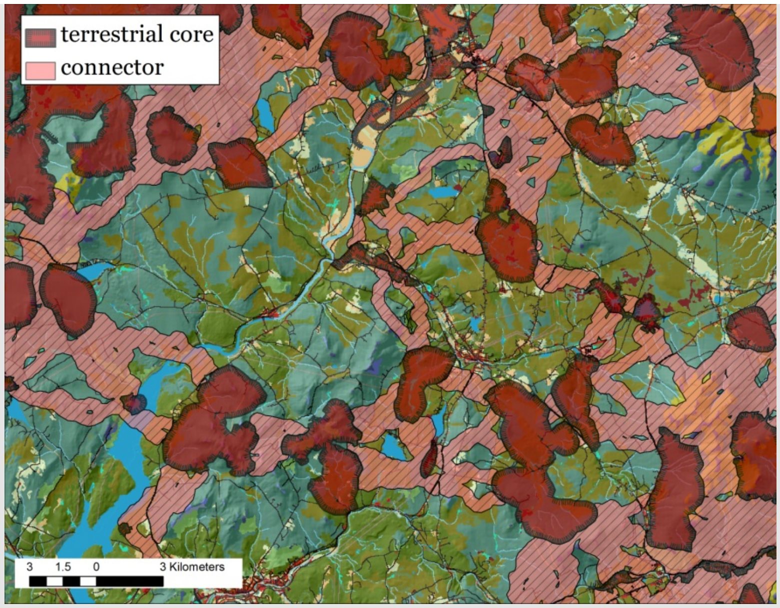

Figure 5. Terrestrial cores and connectors, shown here for a small portion of the Connecticut River watershed on a background of the ecological systems map (without a legend).

Landscape design — Our landscape conservation design (LCD) approach includes a suite of tertiary products derived from the ecological assessment and aimed at identifying priorities for conservation action within an adaptive conservation design framework. Our LCD has four major components: 1) establishing a set of conservation "core areas" to spatially represent the ecological network designed to provide strategic guidance for conserving natural areas, and the fish, wildlife, and other components of biodiversity that they support within the landscape; 2) identifying places critical to promoting ecological connectivity independent of and between the core areas to ensure adaptive capacity of ecosystems and species in the face of climate and land use change; 3) determining conservation priorities and active management needs of individual core areas, supporting landscapes and/or connectors; and 4) prioritizing opportunities for restoring ecological patterns and processes, with an emphasis on restoring connectivity.

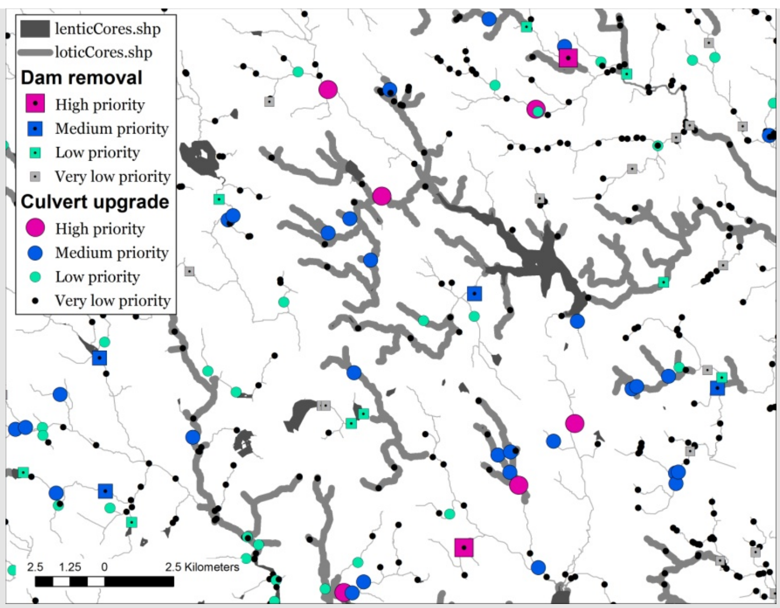

Figure 6. Aquatic cores and priorities for dam removals and culvert upgrades to improve aquatic connectivity for a random location.

While our LCD includes several tertiary products, the centerpiece of our design is a network of connected (potentially tiered) conservation *core areas* designed separately for terrestrial and aquatic ecosystems and species within sub-units of the landscape (**Figs. 5-6**), with the aim of protecting the lands and waters with the greatest ecological value — based primarily on ecological integrity across all ecosystems and landscape capability for a suite of focal wildlife species, but allowing the consideration of any number of other factors such as rare natural communities that support unique biodiversity, and floodplains and riparian areas that perform critical functions in the interface between terrestrial and aquatic ecosystems. Indeed, the criteria for selecting core areas is flexible and can include anything so long as the data are consistent over the extent of the landscape. In addition, the exact composition and extent of the core area network depends on user-specified conservation targets dictated by goals and objectives (e.g., how to weight ecosystems and focal species, how much of the landscape to include in core areas, minimum size of core areas, etc.) establish by a LCD planning team.

Model application — Our LCAD model can be applied to any reasonably large extent (say, State or HUC6 watershed or larger) within the Northeast region for which we have developed the required input data. To date, we have applied to the LCAD model to develop products for the Connect the Connecticut LCD (www.connecttheconnecticut.org), which represents a 2.9 million hectare (7.2 million acre) HUC4 watershed (comprised of two HUC6 watersheds), and for the Nature's Network LCD (www.naturesnetwork.org) that encompasses the entire Northeast region (64.5 million ha/159 million acres). However, our LCAD modeling approach is generalizable to any geography so long as the required input data are developed.

Scope and limitations — While the current suite of DSL products provide tremendous decision support for biodiversity conservation, there is much more to be done to improve the quality of the products (e.g., by improving the quality of the input data) and to expand the scope of the products: 1) our approach was developed for application in northeastern North America, but with appropriate modifications and/or extensions (e.g., including adding specific natural and anthropogenic vegetation disturbance drivers to the landscape change model) our approach could be extended to have broader geographic application; 2) our approach emphasizes landscape change, assessment and design at regional to sub-regional spatial scales and relies on spatial data that is consistent at the regional scale, but this comes at the cost of not always making use of the best available information that exists locally, and as such our products are intended to complement and supplement local conservation planning efforts that incorporate detailed and specific local information; 3) our approach is currently limited to the ecological dimension of landscape conservation, although we recognize the importance of socio-cultural and economic factors in real-world landscape conservation; 4) our approach emphasizes conservation actions directed at land protection and ecological restoration, with only minor attention to land management, and emphasizes short- to moderate-range planning on the order of one to several decades (currently considering out to 2080; 5) our approach relies entirely on models to assess ecological values, and one thing that is true of all models is that they are only as good as the input data, which are fraught with errors, thus our products should not be scrutinized for accuracy too carefully at the finest resolution of the data (30 m) and any depicted boundaries (e.g., core area and connector boundaries) should be viewed as "fuzzy" (i.e., merely general places to focus attention). Indeed, we recognize that "essentially, all models are wrong, but some are useful" (Box 1976) — we believe that our LCAD model is in fact useful in its current state, but that it can be improved substantially with continued support.