Designing Sustainable Landscapes:
Northeast Terrestrial Ecosystem Cores

A project of the University of Massachusetts Landscape Ecology Lab

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McGarigal K, Compton BW, Plunkett EB, DeLuca WV, and Grand J. 2017. Designing sustainable landscapes: Northeast terrestrial ecosystem cores. Report to the North Atlantic Conservation Cooperative, US Fish and Wildlife Service, Northeast Region.

General description

Northeast terrestrial ecosystem cores is one of the principal Designing Sustainable Landscapes (DSL) landscape conservation design (LCD) products, and it is best understood in the context of the full LCD process described in detail in the technical document on landscape design (McGarigal et al 2017). This particular product was developed for the Nature's Network project (www.naturesnetwork.org) — a collaborative partnership under the auspices of the North Atlantic Landscape Conservation Cooperative (NALCC).

Northeast terrestrial ecosystem cores represents a set of terrestrial **core areas** derived using only ecosystem-based criteria (i.e., no species-specific criteria) and scaled to identify the highest valued places by ecosystem and geophysical setting within the Northeast region (**Fig. 1**). These core areas are intended to complement the HUC6-scaled terrestrial core areas and connectors (see terrestrial core area network document, McGarigal et al 2017) that were derived as the primary ecological network. These regional ecosystem-based cores help identify the best places for each unique ecosystem and geophysical setting within the entire Northeast region, whereas the HUC6-based cores help identify the best places within each HUC6 to ensure a well-distributed core area network across the region. Both of these products are designed to provide strategic guidance for conserving natural areas, and the fish, wildlife, and other components of biodiversity that they support within the Northeast.

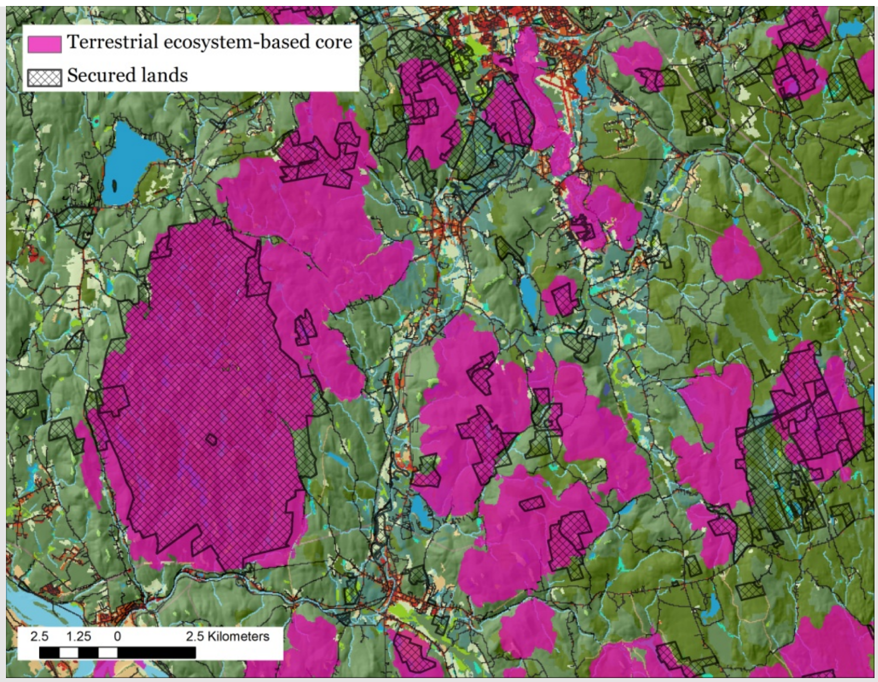

Figure 1. Northeast terrestrial ecosystem cores and secured lands on a background of the ecological systems map (without a legend).

Core areas serve as the foundation of the LCD. They reflect decisions by the LCD planning team about the highest priority areas for sustaining the long-term ecological values of the landscape, based on currently available, regional-scale information. Northeast terrestrial ecosystem core areas represent the following:

1) areas of relatively high **ecological integrity** across all terrestrial and wetland ecosystem types and geophysical settings, emphasizing areas that are relatively intact (i.e., free from human modifications and disturbance) and resilient to environmental changes (e.g., climate change). Integrity has the potential to remain high in these

areas, both in the short-term due to connectivity to similar natural environments, and in the long-term due to proximity to diverse landforms and other geophysical settings; and

2) areas of **rare terrestrial natural communities** that support unique biodiversity, regardless of their landscape context; inclusive of communities listed by state heritage programs as S1 (extremely rare), S2 (rare), and S3 (uncommon), with definitions of S1-S3 varying slightly among states.

Core areas were built from focal areas ("seeds") that have high value within the Northeast region based on one or both of the attributes listed above. These “seeds” were expanded to encompass surrounding areas that provide additional ecological value and resilience to both short- and long-term change. The surrounding areas were typically of high to moderate ecological value. In some cases the final core areas contained low-intensity development and minor roads, but high-intensity development and major roads were excluded. Collectively, the terrestrial core areas identified in this product encompass ~22% of the Northeast, as decided by the LCD planning team, including a total of 17,444 core areas ranging in size from 1.26-155,206 ha, with an average size of 802 ha.

Use and interpretation of this layer

The Northeast terrestrial ecosystem cores are intended to complement the HUC6-based terrestrial core-connector network, or as an alternative, that can be used in combination with other sources of information to direct and prioritize conservation action within the region. The use of this product should be guided by the following considerations:

- It is important to acknowledge that the Northeast terrestrial ecosystem cores were derived from a model, and thus subject to the limitations of any model due to incomplete and imperfect data, and a limited understanding of the phenomenon being represented. In particular, the GIS data upon which this product was built are imperfect; they contain errors of both omission and commission. Consequently, there will be places where the model gets it wrong, not necessarily because the model itself is wrong, but rather because the input data are wrong. Thus, the Northeast terrestrial ecosystem cores should be used and interpreted with caution and an appreciation for the limits of the available data and models. However, getting it wrong in some places should not undermine the utility of the product as a whole. As long as the model gets it right most of the time, it still should have great utility. Moreover, the model should lead to new insights that might at first seem counter-intuitive or inconsistent with limited observations. This is so because the model is able to integrate a large amount of data over broad spatial scales in a consistent manner and thus provide a perspective not easily obtained via direct observation.

- Northeast terrestrial ecosystem cores represent a synthesis of many data products and decisions. As such, this product does not explicitly reveal why any particular area was selected as a core, and therefore it is perhaps best used in combination with the principal supporting data layers, including: 1) DSL index of ecological integrity (see IEI document, McGarigal et al 2017), and 2) The Nature Conservancy's (TNC) terrestrial resiliency index (see Resilient lands page at TNC's Conservation Gateway).

The rare natural communities are not publically available, as they contain sensitive information.

- Northeast terrestrial ecosystem cores represent ~20% of the landscape; these core areas are deemed high priority areas for conserving the best places of each unique ecosystem and geophysical setting within the Northeast region. However, it is important to recognize that the "best within the region" does not guarantee a well-distributed ecological network across the region. Consequently these regional cores are best used in combination with the HUC6-based cores (see terrestrial core area network document, McGarigal et al 2017) to ensure that both the very best places in the region are conserved and that we create a well-distributed ecological network. It is equally important to recognize that the cores alone are not believed to be sufficient for the long-term conservation of biodiversity in the landscape. Rather, the cores merely represent a possible starting point for landscape conservation; a place to get started given the need to prioritize conservation actions due to limited resources.
- Northeast terrestrial ecosystem cores were derived from regionally consistent data. As such, they may not capture all resource priorities identified at the state or local level made possible with local data. Consequently, these core areas should not be viewed as "the" conservation solution, but rather as a regional complement to the HUC6-based core-connector network and state and locally identified conservation priorities.
- After extensive consideration, we opted to define and delineate core areas as places of particularly high ecological value that met certain criteria without regard to existing protected lands (a.k.a., secured lands). In other words, we sought to identify an "ideal" core area network without bias towards existing protected lands. Existing protected lands may not represent places of particularly high ecological value based on our criteria and thus we did not want to confound the meaning of "core" with "protected.." Protected lands can serve as an overlay to the "ideal" solution to determine where additional conservation action is needed (**Fig. 1**). Indeed, much of the designated core areas are in fact already protected from development, as large areas of protected land tend to score high in models of intactness and resiliency. These areas may merely need to be managed to ensure their ecological value in the future. The unsecured portion of the core areas could represent priorities for additional land protection.
- This product can be used in combination with the probability of development layer (see probability of development document, McGarigal et al 2017) to identify places in the cores that are relatively vulnerable to future development, and thus could represent priorities for land protection (**Fig. 2**).
- Northeast terrestrial ecosystem cores, as delineated, may not always represent logical or practical conservation units, since they do not correspond to parcel boundaries or any other practical scheme such as road-bounded blocks. Core areas are places of particularly high ecological value that meet certain criteria using the highest possible resolution of the data (i.e., 30 m cells). As such, rarely will a core area boundary correspond exactly to a parcel boundary. The delineation of core areas on a map should be treated as "fuzzy" boundaries and should not prevent or deter conservation in practice based on other real-world considerations. In practice, conservation actions can (and will necessarily) be directed towards more practical geographic units, as

modified by field-based assessments and other local considerations. Core areas are best interpreted as general places to focus attention.

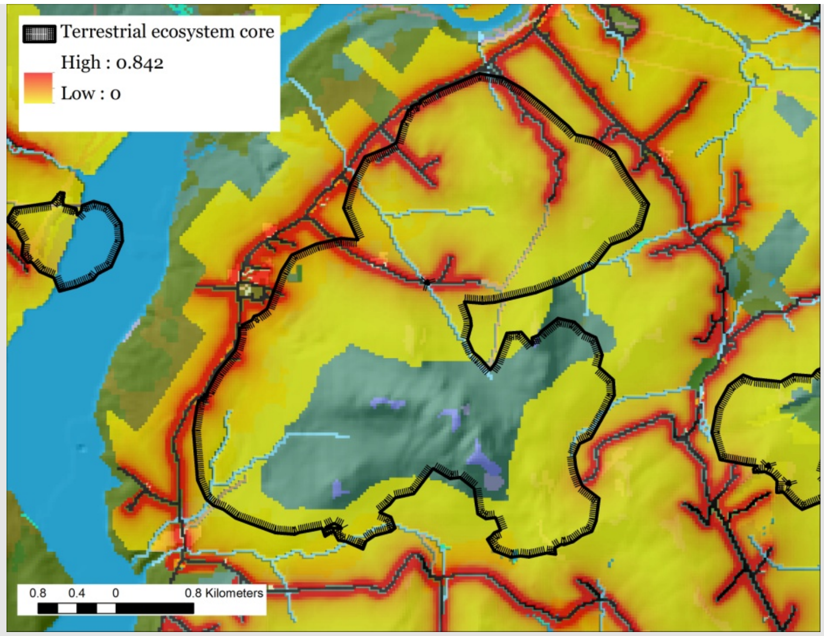

Figure 2. Northeast terrestrial ecosystem cores overlaid on the integrated probability of development surface on a background of the ecological systems map (without a legend).

- Northeast terrestrial ecosystem cores can and do include some low-intensity development, minor roads and agriculture. This is the result of growing out the cores from the highest-valued seed areas in which we elected to allow only major roads and medium-to-high intensity development to serve as barriers to spread. The inclusion of such developed areas in the cores should not be interpreted as indicating their intrinsic ecological value, but rather that they represent places with high influence on the target ecological values in the undeveloped areas of the associated cores. These developed areas could be considered high priorities for restoration or sustainable urban redevelopment.
- Lastly, while the terrestrial ecosystem core areas logically represent high priorities for land protection, they also represent opportunities for land management and restoration. In particular, some of the ecological values targeted in some cores may require active management to maintain those values. For example, some ecosystems are fire-dependent and may require the use of prescribed fire to maintain the system in its more natural state. Similarly, some species associated with those ecosystems may require grassland or shrubland habitat and thus may require active habitat management (e.g., mowing) to maintain those habitats. Of course, the management needs of each core area will vary with the composition of the cores. The GIS metadata provided with this layer (see below) include a list of the top three ecosystems and species targeted in each core area, in addition to links to detailed core area composition statistics that quantify how important each core area is for each ecosystem and species. This information can help inform the management needs for each core area.

Derivation of this layer

The derivation of the Northeast terrestrial ecosystem cores was quite complex, as described in detail in the technical document on landscape design (McGarigal et al 2017). Here, we describe a highly abbreviated version of the process that is sufficient for the use and interpretation of this product.

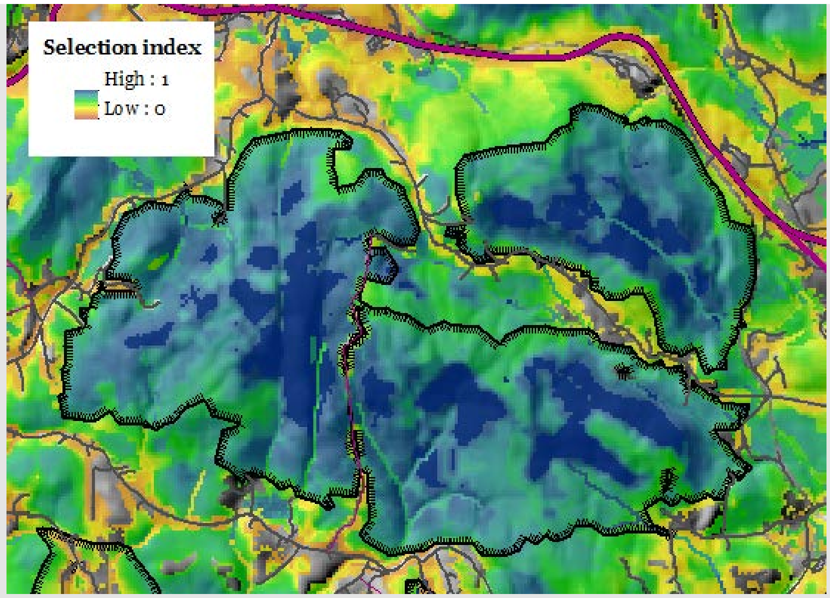

Figure 3. Northeast terrestrial ecosystem core areas (depicted by the bold polygons with feathered outlines) showing the initial “seeds” (dark blue) and the underlying terrestrial ecosystem core area selection index (depicted as a gradient).

1. Create the ecosystem-based core area selection index

The first step was to create a “selection index” that integrated the different ecosystem-based values that core areas are intended to represent within the Northeast region, which involved combining: 1) the index of ecological integrity scaled by the entire region (see IEI document, McGarigal et al 2017), 2) TNC's terrestrial resiliency scaled by the entire region (see TNC's resilient lands page at TNC's Conservation Gateway), and 3) mapped rare natural communities listed by state heritage programs as S1 (extremely rare), S2 (rare), and S3 (uncommon) (**Fig. 3**).

2. Build ecosystem-based cores

The second step was to build the cores based on the selection index, essentially by selecting the very best places by “slicing” the selection index above a threshold level and then “growing” out these “seed” areas through surrounding lower-valued areas (including undeveloped land as well as agriculture, low-intensity development and minor roads) to create larger, contiguous cores in which the highest-value places (i.e., the “seeds") are now buffered by moderately-valued places (**Fig. 3**). Note, by scaling the selection index by the entire Northeast region we ensured that the “seeds” picked up the very best places of each ecosystem and geophysical setting within the region. We grew out the “seed” areas until we captured ~20% of the landscape. **Importantly**, the 20% represents an arbitrary threshold. There is no scientific basis or scientific consensus on “how much is enough” to conserve biodiversity. Indeed, if our goal were to maintain biodiversity at its current level, then it is reasonable to conclude that there should be no loss of natural areas. However, this is not practical, nor can we affirm that even this would be sufficient to sustain biodiversity as there are other drivers of landscape change affecting biodiversity besides human development. Therefore, rather than try to construct a core area network that captures “enough” to conserve biodiversity, which is an unknown and unknowable quantity, we instead chose an arbitrary constraint on how much to include in cores that emphasizes finding the very best places or the highest priorities for conservation action.

GIS metadata

This data product is distributed in two forms that can be found at McGarigal et al (2017):

- **geoTIFF raster** (30 m cells) — cell values:

  1 = terrestrial ecosystem core

- **ESRI ArcGIS shapefile** (polygons) – including the attributes listed below for each polygon:
  - FID = ESRI assigned unique number (which we do not use) for each polygon.
  - Shape = ESRI assigned feature type = "polygon."
  - type = indicator designating the polygon as: "core."
  - coreID = each core has a unique ID > 1.
  - areaCount = size of the core area in number of cells (30 × 30 m); this includes any developed cells.
  - areaHa = size of the core area in hectares; this includes any developed area.
  - rareCom = percentage of the core comprised of S1-S3 rare communities as defined and mapped by the state Heritage Programs.
  - system1, system2, system3 = The top one to three terrestrial or wetland ecological systems for which the core is particularly important based on index1 described below. For these systems the cumulative ecological integrity of the system within the core is greater than expected (from a statistical perspective) given its distribution across the entire core area network (i.e., index1>1). A blank indicates that no additional ecosystem had an index1>1. Note, the systems listed here reflect the systems for which the core is especially important, but are not necessarily the most abundant systems in the core. A complete listing of the relative importance of the core for all ecological systems, including the relative abundance of systems within the core, is available separately in the Ecosystem table described below.
  - species1, species2, species3 = The top one to three representative species for which the core is particularly important based on index1 described below. For these species the cumulative landscape capability index within the core is greater than expected (from a statistical perspective) given its distribution across the entire core area network (i.e., index1>1). A blank indicates that no additional species had an index1>1. Note, the species listed here reflect the species for which the core is especially important, but are not necessarily the species with the highest total landscape capability in the core. A complete listing of the relative importance of the core for all species, including the total landscape capability in the core attributed to each species (index2, see below), is available in the Species table described below.

Detailed core area composition statistics

Detailed composition statistics are available for each individual core (see files in the tEcoCoreStats folder corresponding to the coreID field in the shapefile). In these tables, there are four different indices computed (and their corresponding ranks) that represent different ways of understanding the relative importance of the individual cores to specific ecosystems. NOTE, we included tables for the species indices even though the these cores were not built based on any species-specific criteria. In all cases, larger values indicate greater importance.

Ecosystem table:

- coreID = unique number assigned to each core.
- systemName = name of the ecosystem as given in the DSLLand map (developed classes are not included).
- areaCount = number of cells of the corresponding system in the core. Note, because developed classes were excluded, the sum of areaCount across systems in the core as listed in this table may be less than the core area size as given in the layer attributes.
- areaHa = hectares of the corresponding system in the core.
- index1 = index of importance of the core for the corresponding system, based on deviation of the observed sum of the selection index for the system from its expected value, which is based on the size of the core and the system's average selection index and proportional representation across all cores. The index ranges from 0 to unbounded on the upper end; <1 indicates observed value less than expected, whereas >1 indicates the opposite.
- index1Rank = rank of index1 (1 = max index1).
- index2 = index of importance of the core for the corresponding system, defined as the percentage of the core's total selection index comprised of the corresponding system. The index ranges from 0-100.
- index2Rank = rank of index2 (1 = max index2).
- index3 = index of importance of the core for the corresponding system, defined as the percentage of the system's total selection index across all cores found in the focal core. The index ranges from 0-100.
- index3Rank = rank of index3 (1 = max index3).
- index4 = index of importance of the core for the corresponding system, defined as the difference between the system's average selection index in the focal core and its average selection index across all cores. The index ranges from -1 to 1; negative values indicate an average selection index in the focal core less than its average across all cores, whereas positive values indicate the opposite.
- index4Rank = rank of index4 (1 = max index4).

Species table:

- coreID = unique number assigned to each core.

- speciesName = name of the representative species.
- sumLC = sum of the current landscape capability (LC) index for corresponding species.
- index1 = index of importance of the core for the corresponding species, based on deviation of the observed sum of the LC index for the species from its expected value, which is based on the size of the core and the species' average LC index across all cores. The index ranges from 0 to unbounded on the upper end; <1 indicates observed value less than expected, whereas >1 indicates the opposite.
- index1Rank = rank of index1 (1 = max index1).
- index2 = index of importance of the core for the corresponding species, defined as the percentage of the core's total LC index comprised of the corresponding species. The index ranges from 0-100.
- index2Rank = rank of index2 (1 = max index2).
- index3 = index of importance of the core for the corresponding species, defined as the percentage of the species' total LC index across all cores found in the focal core. The index ranges from 0-100.
- index3Rank = rank of index3 (1 = max index3).
- index4 = index of importance of the core for the corresponding species, defined as the difference between the species' average LC index in the focal core and its average LC index across all cores. The index ranges from -1 to 1; negative values indicate an average LC index in the focal core less than its average across all cores, whereas positive values indicate the opposite.
- index4Rank = rank of index4 (1 = max index4).

Literature Cited

McGarigal K, Compton BW, Plunkett EB, DeLuca WV, and Grand J. 2017. Designing sustainable landscapes products, including technical documentation and data products. https://scholarworks.umass.edu/designing_sustainable_landscapes/