Draft March 26, 2015

Connecticut River Watershed Landscape Conservation Design
Process and Key Decisions

Background: In the Connecticut River watershed and across the nation, large connected natural areas provide habitat for fish, wildlife and plants and provide jobs, food, clean water, storm protection, recreation and many other natural benefits that support people and communities. To ensure a sustainable future for these resources in the face of climate change, urban growth and other land-use changes and pressures, scientists and conservationists must work together to strategically conserve these large landscapes. Facilitated by the U.S. Fish and Wildlife Service (FWS) and supported by the North Atlantic Landscape Conservation Cooperative (LCC), the Connecticut River Watershed Landscape Conservation Design is a collaborative effort to plan and design such a landscape. The design is led by a Core Team of conservation partners composed of federal and state agencies and private organizations working at various scales in the Connecticut River watershed, including the Friends of the Silvio O. Conte National Fish and Wildlife Refuge and other partnerships. The University of Massachusetts _Designing Sustainable Landscapes_ team is leading the technical development of the conservation design that reflects the decisions of partners during the design process.

Purpose of this document: To assist partners in their collaborative efforts and as a record of progress, this document summarizes the status of decisions that are necessary to develop the landscape conservation design, including alternatives considered but not selected.

Outline of this document

1) **Organization and Process**

   In January 2014, conservation leaders working within the Connecticut River Watershed, including leaders of the Friends of the Conte Refuge, were invited to participate in a collaborative design process by the U.S. Fish and Wildlife Service and the North Atlantic LCC. Early in the development of this "core team," participants decided to self-organize into two teams, one focused on aquatic systems and one focused on terrestrial and wetland systems. During 2014 and early 2015, monthly meetings were held with the full team. Between these meetings, and sometimes associated with a monthly meeting of the full team, subteams held additional meetings. Consensus or majority preference was used to reach decisions related to the design. Typically consensus was obtained informally, but in a few cases formal voting or structured written feedback were employed to make decisions. Presentations, meeting notes, and other materials associated with these meetings were maintained on a project webpage on the North Atlantic LCC website. Spatial products, including draft design elements, were maintained in a project group within the Conservation Planning Atlas of the North Atlantic LCC.

2) **Conservation Goals**

   Conservation Goals for the watershed (ecosystem + species) were established.
   1. The Connecticut River watershed sustains a diverse suite of intact, connected, and resilient ecosystems that provide important ecological functions and services that benefit society, such as clean water, flood protection, and lands for farming, forestry, and recreation.
   2. The Connecticut River watershed sustains healthy and diverse populations of fish, wildlife, and plant species for the continuing benefit and enjoyment of the public.

3) **Objectives of the Conservation Design**

   The following fundamental and means objectives were developed in the process of formulating the ecosystem approach for the design including core areas. Although they were not written explicitly for species populations, these general considerations can be considered to apply to species as well, and were carried forward in the final combined ecosystem-species design.

   Fundamental objectives
   - Ensure the existence of a spectrum of ecosystems and species that encompasses a full range of biodiversity (genetic, species, and natural community) and supports a multitude of ecosystem functions and services.
   - Ensure that ecosystems are of a size and condition, and situated in a landscape context, that will preserve their long-term resilience.

- Maintain ecosystems in a well-distributed, interconnected network that 1) facilitates short-term movements and long-term range shifts of a diversity of both aquatic and terrestrial species and 2) allows ecological processes such as aquatic flows to operate at large scales.

Means objectives

- The conservation design will depict areas of the highest priority ("core areas") that can be considered the most important locations for achieving the fundamental objectives (best or most urgent places to start). However, by themselves they are unlikely to be sufficient to fully achieve the objectives.
- The conservation design will also depict additional tiers of priority, including connectors or corridors between core areas, which collectively contribute to the fundamental objectives.
- The conservation design will include priorities for management and restoration that over time can enhance ecological value and improve natural processes that link ecosystems.

4) End Products of the Conservation Design

- Based on discussions among the core team at multiple meetings, the conservation design is to include both of the following:

    1) Partners' collective prioritization, based on both species and ecosystems, of high priority (core) areas, connections between them, and tiering or other methods that show entire landscape necessary to achieve goals and objectives

    2) Individual inputs to the design (e.g., ecological integrity, individual species results) that can be used independently

- The aquatic and terrestrial teams took different approaches to the design, but each agreed to derive a single, combined ecosystem and species design product with approximately 25% of the aquascape or landscape identified in core areas. The aquatic design includes buffers, referred to as zones of influence, associated with the core areas. The terrestrial design includes connectors or corridors between the cores to facilitate movement of plants and animals across the network.
- The design includes a number of additional layers developed during the design process, which are available as overlays or underlays to help prioritization and further contextualization of the overall networks.
- The final design will include information describing the relative ecological value of the entire landscape, including areas not assigned to a core or connector (i.e., no "white space" in the watershed).

5) Scope of the Conservation Design

- Land protection, restoration (e.g., for aquatic passage and terrestrial road crossing), and management (e.g., forest and shrubland management) are all to be part of the design.
- Threats addressed by the design include development pressure, barriers to terrestrial and aquatic passage, and climate change.

6) Ecosystem-based Approach: Terrestrial/Wetlands

- Inputs: To address the fundamental objectives of encompassing a full range of biodiversity and ecosystem functions with a goal of long-term resilience, the ecosystem portion of the design incorporates the following components:
  - 1) The Index of Ecological Integrity (IEI) developed by UMass, which is derived from 19 metrics addressing the intactness and resiliency of ecosystems.
    - The Northeast Terrestrial Habitat Classification System developed by TNC and the Northeast States is the base layer for identifying and prioritizing ecosystems in the conservation design.
    - The finest level of the three-level classification hierarchy, the "ecological system" level, is used for stratifying ecosystems. In other words, each example of ecological system is scaled from 0-1 across the analysis region, ensuring that the highest integrity examples of each ecological system can be incorporated into the design.
      - *Alternative not selected*: initially the intermediate level of the hierarchy, the "macrogroup," was initially selected for stratifying ecosystems. The team determined that some important ecological systems could be "lost" in the design for example when low elevation and high elevation coniferous forests are combined in a single macrogroup.
    - Weighting of specific ecological systems: A set of criteria for prioritizing ecosystems was developed and applied for several ecosystem types of concern. Criteria consisted of extent of historical loss; regional rarity and uniqueness; importance to species and ecological functions; and regional responsibility (relative importance within the watershed relative to the Northeast region). Higher weight was assigned to alpine tundra; calcareous cliffs and outcrops; coastal beaches and grasslands; boreal forest; pine barrens; and several types of wetlands. This decision was reviewed and affirmed several times over the course of the Pilot.
  - 2) The Nature Conservancy's (TNC) Terrestrial Resiliency. This dataset, which incorporates long-term resilience that may be conferred by landform complexity and geophysical diversity, is considered to complement IEI, which has strengths in short-term resiliency and current ecosystem types.
  - 3) Areas of high potential for floodplain forest restoration along major rivers, based on a product developed by TNC for the Connecticut River watershed.
  - 4) Areas of rare natural communities as mapped by the four state natural heritage programs (ranked as S1 (extremely rare), S2 (rare), or S3 (uncommon)).
- Selection Index

- The four inputs described above are integrated into a *selection index*, a spatial data layer that serves as the starting point for generating core areas. For the selection index, IEI is weighted heavier than the TNC Terrestrial Resiliency, by a factor of 3:2. Floodplains and rare natural communities are assigned the maximum index value (1 on a 0-1 scale).
  - The selection index is scaled by HUC6 in order to ensure well-distributed cores within the watershed (see more details on geographical stratification in next section).
- Core Area Decisions
  - *Core areas* are the fundamental, highest priority conservation units of the overall design. A kernel-based approach is used to "grow out" core areas from *seeds*, which are the locations of highest integrity and resilience based on the selection index.
  - In general, fewer, larger core areas (as opposed to more, smaller areas) are preferred. One method to achieve this pattern was to apply a minimum size of 3.6 ha (9 acres) before the "growth" step.
  - Geographic stratification: to address the fundamental objective of a well-distributed, interconnected network, geographic stratification was used to enhance distribution of core areas. Five alternatives were seriously considered, four of which are based on the USGS hierarchical classification of watersheds (denoted by Hydrological Unit Codes or HUCs): no stratification (i.e., the full HUC4 watershed if applied at larger scales), HUC6 (2 subwatersheds), HUC8 (14 subwatersheds), a hybrid between HUC8 and the full watershed, and TNC ecoregions. Stratification by HUC6 was chosen as the best compromise between distributing cores and focusing on areas of the highest overall integrity. It also appeared to be the best choice for extending the approach to other areas including the full Northeast. HUC8 stratification results in well-distributed cores but encompasses more areas that are relatively low in integrity and resiliency, considering the full watershed. Full watershed-based core areas were considerably less well-distributed. The hybrid approach had similar qualities to HUC6 but was more complicated and difficult to understand. For ecoregions, there was concern that if extended to other areas, they would be too large to assure adequate distribution of core areas.
  - Major development (dense urban areas, expressways, etc.) is an absolute barrier to the growth of core areas, but minor development (rural areas, lightly travelled roads) is not.
  - The group decided not to take into account existing levels of protection when creating the design (i.e., the design will not up- or down-weight existing protected lands). Rationales included that the design should identify the most important areas from an ecological standpoint and then build connections around that, and that even areas protected in name could face future threats so there is value in further confirming their importance through incorporation into the design.

7) Species-based Approach: Terrestrial/Wetlands

- Representative species

- o The primary spatial products for terrestrial and wetland species available for use at the outset of the design process were a set of 13 representative species models by developed by UMass and collaborators as part of the *Designing Sustainable Landscapes* project. These species were chosen by the North Atlantic LCC, USFWS and UMass (prior to the initiation of the collaborative process) to represent the major ecosystem (habitat) types of the watershed, and associated wildlife, that occur in the watershed. The planning team accepted use of these species in the process, plus the species model for Prairie Warbler, which became available in September 2014. The species were used in developing species-based core areas and ultimately combined ecosystem-species core areas. Several other representative species (Cerulean Warbler, Piping Plover, Saltmarsh Sparrow, Semipalmated Sandpiper) were suggested for inclusion, but habitat models are unavailable, so they were not included in the design.
    - o Population objectives were adopted for each species:
        - ▪ Increase population size of American Woodcock, Eastern Meadowlark and Wood Thrush
        - ▪ Maintain current populations of the other 11 representative species
    - o Each representative species was assessed based on threats, regional responsibility, and rarity, and weighted relative to the other representative species by the terrestrial subteam. The neutral weight was 50% and this was revised upward or downward. The percentage level is the proportion of a given species' total landscape capability values (as calculated in each representative species model developed by the UMass team) targeted by the algorithm that creates species cores.
- Rare species
    - o Certain federally threatened or endangered species (or candidates for listing) use rare habitat types not mapped in the terrestrial habitat classification system and are not likely to be well-represented by the represented species. Known habitat locations for the following species will be incorporated into the design: bats (specifically, hibernacula [caves]); cobblestone and Puritan tiger beetles (use cliff and cobblestone river shoreline); New England cottontail; and Jessup's milk-vetch.
    - o These rare species data are available to the appropriate agencies and organizations as a post-analysis overlay, but due to statutory restrictions, will not be made available to the general public. Due to concerns about revealing rare species locations, these rare species were not incorporated into the process to create species-based core areas.
    - o *Alternative not selected:* the team considered a proposal to incorporate occurrences of *all* rare species (e.g., natural heritage rankings of S1, S2; or regional high priority SGCNs) into the design. This proposal was not adopted for several reasons. Much of these data are not publicly releasable, at least with species-identifying information, and there were concerns about sharing, managing, and displaying the information in a way that did not reveal the locations of sensitive species. Additionally, there were concerns about the variability in the quality of the species data, with issues such as inconsistent or biased survey information that could compromise the design.

- Core Area Decisions
  - o The team agreed to an optimization method developed by the UMass team to efficiently identify the "best of the best locations" for multiple species in a limited land area. Through the process, high value starting points were "grown out" through a kernel-based process (similarly to the ecosystem cores). Then the habitat target (expressed in LC units) for each species was revised based on the content of the newest core, and the process repeated, until some pre-specified amount of the total watershed was occupied by core areas.
  - o Consistent with the ecosystem-based approach, the species habitat models were stratified by HUC6 and core areas were constrained to comprise 25% of the landscape.

8) Combined Ecosystem-Species Approach: Terrestrial/Wetlands

- Core Area Decisions
  - o The team considered three alternatives for generating core areas: using ecosystem information only, using species-based models only, or a combination approach using both ecosystem and species information. Based on reviewing the results, the team agreed to use the combination ecosystem-species approach to generate core areas. Furthermore, the team agreed that the final design would include a single set of terrestrial/core areas, not multiple options such as both species and ecosystem sets of cores. A noted benefit of including the species approach was that it could incorporate agricultural grassland habitat (as expressed by Eastern Meadowlark habitat) that was not assessed by IEI.
    - ▪ The ecosystem portion of the combined ecosystem-species approach incorporated all four the components described previously in section 6: 1) Index of Ecological Integrity (UMass), 2) Terrestrial Resiliency (TNC); 3) priority floodplains (TNC); and rare natural communities (state Natural Heritage). The species portion incorporated the 14 representative species models (UMass) described in the previous section. Rare and endangered species information (much of which is not publicly releasable) can be added as an overlay to identify additional priorities.
  - o Initially, the combined ecosystem-species approach was created by creating approximately half of the area in cores starting with the ecosystem models and the remaining half using species models. However, this resulted in a larger number of small cores than preferred by the team. Given that fact and the relative proficiency of the ecosystem approach in selecting high quality species habitat that met species LC targets, an alternative was selected. This involved using the ecosystem-based approach to create core areas covering 20% of the landscape and then the species models to add the remaining 5% of the landscape.
- Connector Decisions
  - o The team agreed that connectors between core areas were a critical component of the final design, second in importance only to the core areas themselves, to facilitate movement of animals and plants and as an adaptation measure for climate change.

- o After considering multiple alternatives developed by UMass, the team adopted an approach that facilitated the identification of connections between most core areas within 10 km of each other while not creating overly broad, amorphous connections among large, nearby core areas. The connectors were based on random low-cost movement paths between core areas, buffered by 250 m on each side (so the minimum connector width is 500 m).
- *Alternative not Selected: Buffers and Matrices around Core Areas*
  - o The team decided against delineating additional, fixed-width buffers around core areas. While recognizing the value of buffer areas, the team noted that the core area generation process (growing out seeds) was already a form of buffering and expressed concern about the strategic value and arbitrariness of additional buffers.
  - o The team also considered an approach to link multiple core areas in a broader region. This was referred to as the "cookie" approach, in which core areas are like chocolate chips in a matrix of cookie dough. Ultimately, the team concluded that this led to too much of the landscape in the matrix or connectors, which could make strategic prioritization more difficult and inhibit understanding of the design.

9) Ecosystem-based Approach: Aquatics

- General
  - o A variety of options were considered for the spatial extent at which aquatic systems would be prioritized, from small stream segments to a more traditional approach to prioritize by whole subwatersheds. Ultimately, the selected approach involves identifying high priority *core areas* that consist of stream segments and small stream networks at least 1 km in length.
  - o The scope of the aquatic design is on aquascapes, rather than terrestrial landscapes. Riparian areas or wetlands adjacent to water bodies are not explicitly considered when creating core areas.
  - o Unimpounded reaches of river waters in the main stem and adjacent major tributaries were mapped as priority sections of aquatic habitat for conservation. While ultimately not used as direct input in any species or habitat modeling, the mapping result is a unique product that compliments the overall conservation design. It also supports the species goals set for anadromous fishes.
- Input layers
  - o The aquatic ecosystem portion of the design incorporates two elements: Index of Ecological Integrity (UMass) and headwater stream temperature resilience (USGS).
  - o In an approach analogous to that used by the terrestrial team, the Index of Ecological Integrity is stratified by ecosystem type. For streams and rivers, this is based on the classification developed by TNC and the Northeast states, which consists of four

stream size classes, three temperature classes, and three gradient classes. All qualitative temperature categories developed by TNC (warm, cool, cold) are retained, even though some types are small or rare fragments in the project area.

- *Note:* Lentic class system (lakes and ponds) used for this project is limited to a single criterion of size based on surface area. Eight hectares is the division between ponds and lakes. A more detailed classification system was developed and released late in 2014 by The Nature Conservancy with NALCC support, and may provide opportunities to improve on the lentic work done for this Connecticut River watershed project.

  o The group reviewed and modified some of the weights for the metrics that are inputs into IEI for aquatic systems.
  o Weighting of specific aquatic classes: the group weighted all aquatic system classes equally (which differed from the terrestrial team approach for ecological systems), due to a lack of clear reasons to elevate the general importance of one aquatic class in the watershed above another.

- Selection Index
  o The core selection index is comprised of an average of the Index of Ecological Integrity (UMass) and headwater stream temperature resilience (USGS). The selection index is the starting point for generating core areas. The group decided there was no reason to weight one element of the selection index over the other. The USGS product enters the selection index only for headwater streams.
  o Geographic stratification: after much discussion the team felt the use of the full watershed as the scaling area for selection of core areas would be best. However with the added interest of developing a more consistent conservation design, the choice of HUC 6 units by the terrestrial sub-team was accepted by the aquatic sub-team. Like the use of the full watershed to distribute selection of core areas, the HUC 6 unit boundaries may serve the goals of long-term stable ecological integrity and biodiversity by spreading the core areas along the long north-south axis of the CTR project area. At the same time the team felt some of the bias problems they observed using the more numerous, and occasionally urbanized HUC 8 sub-divisions are avoided.

- Core Areas
  o Approximately 25% of the aquascape (both lotic and lentic) is selected for core areas.
  o As in the terrestrial approach, a kernel-based approach is used to "grow out" core areas from *seeds*, which are the locations of highest integrity and resilience based on the selection index.
  o Seeds for core areas (i.e., before developing upstream and downstream extensions), must be at least 150 meters in length, which is at least five contiguous high scoring data pixels. Core areas, which are seeds with extensions, must be at least 1 km in length. This distance is generally measured along the river or stream center-line. This 1km limit is designed in part to provide minimum size to support a genetically viable population of brook trout, a representative species for this project and therefore a helpful measure of ecosystem core areas.

- o The team decided to enhance the linear extent of lotic aquatic core areas by extending the initially selected high score seed sites upstream and downstream as a function of the quality of data in adjacent stream cells. The goal is to create core areas that are more ecologically sound by making them longer, like natural stream/river sections.
  - o Extension of core areas does not proceed past barriers like dams.
  - o Recognizing that fish move locally between the larger and smaller rivers and streams, the group decided to remove an initial restriction on growing core area extensions downstream into different aquatic classes, e.g. from headwater streams to small rivers. The restriction preventing upstream extensions into different aquatic classes was retained because otherwise the resulting core areas became very large, losing association with the original high-scoring seed cells.
  - o Related, high scoring cells that start a core area in lentic water bodies are extended to include all the cells within that lentic body (i.e., to the extent of the pond or lake shoreline). In part this decision is necessary because physical, biological or classification data available to subdivide lakes or ponds are very limited and inconsistent throughout the project area. A new classification system from The Nature Conservancy has just been completed and may allow this decision to be changed in the future.
  - o To achieve the 25% aquascape target and to fulfill the other requirements of relatively long stream segments, cells with approximately the best 7-12% scores were used as a starting point for core areas.
  - o A special approach was used to account for the Quabbin Reservoir, a large, intact, high-ranking lentic system that alone totals about 20% of the lentic area in the watershed. The approach used was to omit the system from the initial phase of identifying lentic core area, allowing a resilient distribution of healthy lakes across the watershed to be identified. Then, the Quabbin Reservoir was added to the lentic cores.
- Buffers
  - o As part of the aquatic core area network, the team has designed *zones or areas of influence* that are similar to buffers. Specifically, they draw from the upslope watershed of the extended core area sites. Buffers are constrained so as to extend into the upland based on the size of the originating aquatic system (furthest from headwater stream core areas and least from the large river sites). Therefore, the large river system buffer areas more closely resemble riparian corridors.
    - ▪ Note: Terrestrial buffers of aquatic core areas delineate zones of influence over these areas but are not necessarily of high ecological integrity or condition. Instead, they are zones of influence adjacent and upstream of aquatic resources where conservation and management would likely have the highest impact on high value aquatic core areas. They are not designed to serve the same function as terrestrial connectors (corridors).
- Connectors: Aquatic cores do not have connectors.

10) Species-based Approach: Aquatics

- General
  - o The aquatic design incorporated only species that live in or use aquatic environment for the majority of their life cycle. Semi-aquatic/wetland species, such as odonates, birds and turtles, were considered to be the realm of the terrestrial portion of the process. After reviewing of the lists of species common in each aquatic class (TNC summary data – mostly fin fish), the aquatic team felt there were geographically consistent and adequate data available only for anadromous fish and brook trout. Therefore, species-based core areas were developed for those species.
  - o Because brook trout was the only species with detailed modeling data, the aquatic group did not need to consider multi-species prioritization like the terrestrial sub-team.
  - o The only aquatic rare species of importance identified with available data is the dwarf wedge mussel. Rare species will be a post-hoc overlay.
- Representative species
  - o Brook trout (represents cold water streams) and American shad (represents anadromous fish) were used for the species-based approach.
  - o All areas used by the five diadromous species (based on prior TNC compilations) are denoted as core areas.
  - o Goals for anadromous fish: maintain current access to the extent of mainstem and adjacent major tributaries for the suite of anadromous fish represented by alewife, blueback herring, shad, shortnose sturgeon, and sea lamprey; retain and enhance the amount of unimpounded stretches of riverine habitat.
    - ▪ *Alternative not selected.* Proposed fish passage goals were considered but not selected. Ideally these would be developed for American shad, river herring, and brook trout. Ultimately the sub-team chose not to use as a goal the number of anadromous fish passed out of the Connecticut River. Those data were determined to be not reliably available for all the anadromous fish species being considered and weakly associated with site based conservation actions such as identification of priority core areas.
  - o Objectives for brook trout consider the goals set by the Eastern Brook Trout Joint Venture, summarized as: maintain the presence of native (?eastern?) brook trout in the current number and distribution of stream reaches throughout the watershed.

11) Combined Ecosystem-Species Approach: Aquatics
- Core Areas
  - o Final design will have a set of combined ecosystem + species cores
  - o Brook trout and ecosystem cores are combined by taking the top 20% eco-based lotic plus, for headwaters we add an additional 5% headwater lotic to capture the best remaining brook trout, and then we add on top of this the anadromous. So, we end up

with 25% of headwaters and a slightly higher percent of the full loticscape. So, the final design includes a bit more than 25% of the aquascape in core areas.

12) Considering Future Scenarios of Climate and Development

- Terrestrial/Wetlands
  - o Development
    - ▪ Development risk (probability) will be used (as an "overlay") to help target high integrity areas and habitats that are vulnerable. This approach replaced the initial thinking of placing a higher weight on ecosystem locations and species habitats that were at a greater risk of development.
  - o Climate (*final approach still under discussion*)
    - ▪ Want to include areas with climate resilience: index of projected change in climate niche that places higher weight on areas with high climate resilience be incorporated into the species habitat models, but these should be reviewed on a species-by-species basis as to whether using this index of change in climate suitability is something that makes sense and what the weight should be (should not be uniformly applied across all species without assessment).
    - ▪ Additionally, species with projected greater vulnerability to climate change will receive increased weight when species results are combined.
    - ▪ Use the climate persistence metric developed by the UMass DSL team – the average of current LC and future LC with climate (for species).
    - ▪ UMass team will produce a future IEI
    - ▪ UMass will use the (weighted?) average of current IEI and future IEI as inputs to the ecosystem-based selection index.
    - ▪ UMass will use the (weighted?) average of current LC and climate persistence (future LC, essentially) as inputs to the species-based selection index
- Aquatics
  - o Development: Although degradation to aquatic systems from adjacent terrestrial human development is not clearly quantified for our purposes, of greater direct impact to the aquatic environment is the presence of dams and culverts, and human induced reductions and variations of water flow. Dams, culverts, and bridges are explicitly incorporated into the connectivity portion of the aquatic IEI. The source database for these barriers is ????.
  - o Climate change: stream resiliency (essentially, insensitivity to changes in air temperature) as mapped by USGS is incorporated into the ecosystem portion of the lotic design.

13) Reviewing the Design

14) Communicating Results

15) Delivering and Implementing the Design (Long-term)