This document is the beginning of a methodology and the synthesis of a year-long dynamic collaboration between the Northeast states and the North Atlantic LCC. Your review, input and participation is essential in helping create an appropriate and powerful approach to Regional Conservation Opportunity Areas (RCOA). Please take the time to review this document (if you do not have time to review the entire document, your review of the core document on pages 1-28 is most important). Your state's members of the RCOA workgroup are available to support your review. Any comments or question? Please do not hesitate to comment directly in this document.

- The RCOA workgroup

DOCUMENT DESCRIPTION

BACKGROUND The background section includes a brief historical context for the creation of Regional Conservation Opportunity Areas (RCOA) and describes the mission.

USER GUIDE This section explains the different components that make up this document and how to use each to best understand the methodology.

METHODS The methods section provides analysis describing the approach, analytical processes and results for all the RCOA objectives: (1) core areas, (2) regional species of greatest conservation need (RSGCN) habitats, (3) restoration and (4) connectivity.

DELIVERY OF PRODUCTS This section describes how the products of the RCOA process will be delivered and supported.

APPLICATIONS The applications section explains how RCOAs dovetail with existing initiatives and how they can be used to prioritize and plan conservation actions.

APPENDICES The appendices include flowcharts and element descriptions to provide in depth technical detail for each of the RCOA objectives' analysis. Their review is not essential, but is available for interested readers.

BACKGROUND

The conservation community in the Northeast Region has been collaborating to conserve fish, wildlife, plants and their habitats, including Species of Greatest Conservation Need identified in State Wildlife Action Plans. Regional Species of Greatest Conservation Need (RSGCN) have been recognized by the Northeast states as those species that occur within the Northeast that should be a focus of conservation because they are both of high regional responsibility and concern. Many Federal trust species are included on the list of RSGCN. To make regional land protection and habitat restoration efforts effective with limited funding, information is needed on habitat location and condition, population status, and conservation strategies for priority species and their habitats. Without such baseline information describing where, when, how much, and by what method to conserve species, there will be limited potential for coordinated action toward conservation across species' Northeastern ranges.

The Northeast states are working together with NALCC to establish Regional Conservation Opportunity Areas (RCOAs). RCOAs are spatially delineated places within the Northeast Region where actions to support or enhance populations of RSGCN and/or their habitats are likely to be most effective. RCOAs can be used by the states and conservation partners to inform and guide land protection or habitat restoration actions for the benefit of RSGCN and their habitats, especially considering broad-scale threats like climate and land use change. Certain places offer better opportunities for successful conservation because the habitat condition is relatively good, or RSGCN are particularly dependent on the habitat, or land management circumstances make conservation efforts less costly or more practical.

RCOAs will be developed using a layered landscape analysis approach employing the wealth of data that have been compiled for the Northeast region. The best available data used in this analysis include habitat classifications, species occurrences, predictions of climate, development, as well as landscape connectivity, and a host of environmental attributes that characterize the landscape. The final results will be available as composite maps and as a series of data layers that satisfy the following fundamental objectives:

Objective 1: Identify Core areas
Identify intact landscapes that, if protected or maintained in their current condition, may support the greatest diversity of RSGCN and their habitats in the Northeast.

Objective 2: Identify RSGCN habitats

Identify areas important to RSGCN, occurring outside of the core areas identified above, that if protected in their current condition would contribute significantly to the security of RSGCN and their habitats in the Northeast.

Objective 3: Guide Restoration

Identify areas of degraded habitat having high restoration potential, that if restored would contribute to the conservation opportunity areas (core and RSGCN) identified above.

Objective 4: Protect and Enhance Connectivity

Identify areas that enhance the connectivity and ecological function of landscapes that are important to RSGCN and their habitats, as identified above.

USER GUIDE

OVERVIEW

The purpose of this document is to describe the proposed RCOA methodology at a level of technical detail that allows GIS and other technical users to understand key analytical steps, data inputs and outputs, and the outstanding decisions that remain to be made. The document does not provide code or mathematical formulae to execute analyses in GIS. More extensive documentation is available for many of the data sources and analyses referenced herein, and we have provided links where possible [this will need more work]. The document begins with a narrative that describes the approach taken to meet each of four objectives, and concludes with detailed flowcharts and descriptions of the elements within the flowcharts.

METHODS

RCOA strategy is divided into its four main objectives: core areas, RSGCN habitats, restoration, and connectivity. For each objective, there is a narrative describing the major analytical phases, their placement within the larger RCOA design, as well as the key decision points, and final products. The proposed RCOA methodology has considered data availability, data applications, and analytical techniques. The final implementation will require careful consideration of technical details, such as setting threshold parameters and specifying the form of certain calculations. In some cases, resolving these questions requires trial and error by technical experts. In other cases, there are significant choices that need to made by biological experts and natural resource managers before implementation is possible. For example, expert input is required to make choices about which species to include in relevant parts of the analysis. Input is also required to identify factors that threaten habitats or enhance opportunities for conservation. Throughout the methodology, key decision points are identified for biological and technical experts to shape the final products. We will seek the help and expertise of states and other collaborators to to inform key decisions via future workshops, guided discussions, and surveys. Reading the methods section is recommended before proceeding to the corresponding appendix where the details of the methodology are expanded upon.

APPENDICES

There are four appendices that correspond to each of the fundamental objectives. Flowcharts explicitly describe every analytical step, process, decision point and dataset utilized.

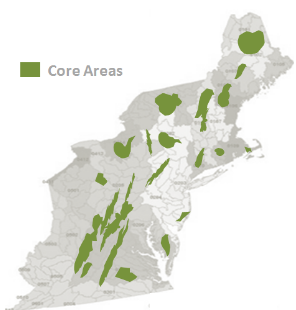
A table below each flowchart describes in greater detail each of the elements in the process, providing links to metadata and maps where available. This table can be used as a glossary in conjunction with the flowchart.

CORE AREAS ANALYSIS

CORE AREAS **OBJECTIVE + APPROACH**

The objective of the core area analysis is to identify landscapes with well-connected, intact core areas. If these cores are protected or maintained in their current condition, they may support the greatest diversity of RSGCN and their habitats in the Northeast Region under both current and projected conditions.

ILLUSTRATION



The approach to achieving this objective is to identify a network of core areas with a combination of high integrity, climate-change resiliency, and species-habitat capability based on assessments of northeast regional habitat maps, geophysical attributes, and other regionally available ecological settings data.

Addressing **ecological representation** (using the Northeast Terrestrial and Aquatic Habitat Classifications) helps ensure that the full spectrum of Northeast biodiversity is accounted for. The Northeast habitat classifications uses suites of biotic and abiotic indicators to classify similar conditions on the landscape. Because the classifications cover the entire Northeast, our full range of biodiversity is included. Within each class, consistent patterns of ecological systems, communities, and species populations occur. The Index of Ecological Integrity discussed below considers the relative condition within each class of habitat, so that the best examples of each can be identified. The result identifies the most intact examples of each class of habitat, thereby ensuring opportunity to conserve the species dependent upon each class. Describing the relative condition of each class of habitat helps satisfy the required elements of Wildlife Action Plans.

Assessing **integrity** (using the Index of Ecological Integrity) identifies the most intact and locally well-connected patches of each mapped habitat type relative to other patches of that habitat type in the region or subregion (based on regional habitat classifications and maps). These intact, well-connected areas are more likely to be resilient to short-term impacts and disturbance.

Assessing **climate-change resilience** (hereafter abbreviated as resilience) (using the Resilience index) identifies areas with highest landscape complexity (landform variety, elevation variability, wetland density) and local connectedness relative to other areas with similar geophysical settings (geology, elevation) in the region or subregion. These sites are likely to be resilient to longer-term climate changes because species and habitat can remain in the area due to the diversity of microclimates and move to new places as facilitated by local connectedness.

Assessing **species-habitat capability** for representative species (using Landscape Capability models) allows us to identify areas that meet the climate, habitat area, condition and accessibility requirements for a set of 30 species. The habitat requirements of these 30 representative species also encompass the habitat requirements of a larger set of priority species across the region. This approach ensures that the species' habitat needs not well-captured by integrity and resilience are incorporated into the analysis (link to list and status of species here).

This approach is more fully developed for terrestrial and wetland systems but can also be applied to aquatic systems by combining the aquatic index of ecological integrity with resilient stream networks and any species models that are available. Integral patches of aquatic habitats are relatively intact and well connected compared to other patches of the same habitat class in the region or subregion. Resilient stream systems are those that will support a full spectrum of biodiversity and maintain their functional integrity even as species compositions and hydrologic properties change in response to shifts in ambient conditions due to climate change. **Additional input from aquatic experts from states and partner agencies and organizations needed**.

Ecological systems (habitat types) can be weighted based on importance in the region to RSGCN or a broader set of species through associations between these species occurrences and ecological systems.

CORE AREAS **METHODS**

The overall approach as described above will develop and combine regional spatial data and assessments of integrity, resiliency, and species-habitat capability based on assessments of northeast regional habitat maps, geophysical attributes and other regionally available ecological settings data. The results can be weighted based on association of ecological systems (habitat types) with RSGCN or a broader set of species occurrences, but the optimal core landscapes will likely not include all locations necessary to conserve RSGCN.

Weighted selection index

The first step in building terrestrial core areas is to create a raster data layer representing the relative condition of each ecological system in the Northeast Terrestrial Habitat Classification, summarizing many factors relevant to each class in a numeric index. The index will be used to select sites that meet a series of criteria, and hereafter is referred to as a "selection index". The selection index can be created from any number of regionally available data layers, but for the first iteration of RCOAs, we propose combining the following spatial data products:

(Weighted) index of ecological integrity (IEI)

This data layer represents relative ecological intactness (i.e., free from human modifications and disturbance) and ecological resiliency (i.e., ability to recover from disturbance and stress) at the resolution of 30 m cells computed for both the current (2010) landscape and projected (2030 or 2080) landscape. For more detail on IEI see the technical document on integrity. This index is (quantile) scaled by ecological system within each geographic extent (e.g., region, watershed, ecoregion, state) and thus discerns cells of relatively low (0) to high (1) integrity within each ecological system and geographic area. The scaling by ecological system helps to ensure representation of all ecological systems. Scaling by watershed, ecoregion or state helps to ensure that cores are well-distributed across the landscape.

Weighting

Each ecological system can optionally be assigned a weight to increase or decrease its likelihood of inclusion in the final core areas. We propose to use a weighting based on the number of species associated with each ecological system (habitat class). The steps in weighting include selecting species groups, associating these species with ecological systems, and calculating core biodiversity weights for each ecological system based on the number of species requiring that system.

Terrestrial resiliency

This data layer is a product of The Nature Conservancy representing terrestrial ecological resiliency at the resolution of 30 m cells. To learn more about the TNC resiliency index, see Resiliency page at TNC's Conservation Gateway. This index is (quantile) scaled by geophysical settings (i.e., elevation and geological substrate) and thus discerns cells of relatively low (0) to high (1) resiliency within each geophysical setting within each geographic extent (e.g., region, watershed, ecoregion, state). Note, this index differs from *IEI* in a couple of important and complementary ways. First, *IEI* is scaled by ecological system, whereas this index is scaled by geophysical setting. Thus, when combined these two indices strive to locate areas of high integrity representing the full suite of ecological systems and geophysical settings. Second, this index addresses resiliency to climate change by highlighting places with high elevation and landform diversity, under the assumption that a locally diverse and connected geophysical template will offer the greatest opportunities for systems/species to find suitable microclimates as the climate changes (i.e., a diverse abiotic stage will allow opportunities for species to redistribute themselves over time). Consequently, this index is best viewed as addressing long-term resiliency on the scale of decades to centuries.

Additional data layers such as rare natural communities may be integrated into the index as well or can be overlain on core areas.

Grow terrestrial and wetland core areas

The next step is to build cores based on the terrestrial ecosystem-based core area selection index. The basic idea behind the core building algorithm is to select the very best places based on the selection index by "slicing" the surface above some threshold level (e.g., top 5% of each system), which should guarantee redundant representation of all terrestrial ecological systems and geophysical settings, and then "growing out" these "seed" areas through surrounding lower-valued (but still relatively high value) areas to create larger, contiguous cores in which the highest-value places (i.e., the "seeds") are now buffered by high to moderately-valued places. Growing a core area outward from the seed is constrained such that it spreads preferentially through cells with the highest value and does not cross major roads or medium-to-high density development. Note, as a result, smaller local roads and low-intensity development can and do occur within the core areas. The "growing" out process is terminated when the user-specified percentage of the landscape is included in the cores.

Representative species selection index

Representative species are taken into account during the third phase of the core areas analysis. A suite of 30 terrestrial and wetland species have been selected, following expert review workshops, to represent all of the major habitat types of the Northeast and their associated wildlife species. The intent of using them in the RCOA process is to ensure that species-habitat needs not well-captured by integrity and resilience are included.

Species' climate niche models, habitat capability models, and prevalence models are developed and combined into single landscape capability models for each representative species as part of a suite of representative species that collectively represent a larger set of priority species with similar habitat requirements across the region. Also available are projections of the degree to which current habitat may be threatened or stressed by projected future changes in development (urban growth) and climate change.

The result is a continuous 30 m raster grid map showing relative landscape capability based on a combination of climate niche, habitat capability, and prevalence models for each representative species. This map can help prioritize land protection, land use and open space planning, ecological restoration and habitat management by natural resource agencies and organizations. Thresholds (e.g., top 20%) can be applied to these relative value maps to illustrate discrete areas.

These layers provide a seamless and continuous valuation of landscape capability for each of the representative species. Importantly, these layers provide an ecological valuation of areas, both inside and outside designated core areas, and thus they can be used to identify places of high ecological value for one or more representative species outside of designated core areas that are also deserving of conservation attention. It is important to recognize that high and low values (and their relative abundance) varies dramatically among species, reflecting idiosyncrasies of each species' model. Consequently, the landscape capability index is not comparable across species. It can only be used separately for each species to evaluate the relative capability of one location against another to support that species.

It is important to note that the landscape capability index is not an estimate of occupancy. It does not give the probability that a cell will be occupied by the species. Rather, it is an index of the relative capability of a site to support reproduction and survival of the focal species in a home range centered on that cell.

A suite of wildlife species and ecosystems will benefit from incorporating representative species landscape capability models into the RCOA design using all or a subset of the 30 representative species models available across the region.

Optimized terrestrial and wetland core areas

The next step is to supplement the ecosystem-based cores (integrity and resiliency as described above) with additional core areas to partially meet the habitat needs of all representative terrestrial wildlife species. The basic idea behind this stage of the core building algorithm is to first determine how much of each species' targeted landscape capability is already included in the ecosystem-based cores, and then build additional cores to ensure that a minimum proportion of each species' landscape capability target is included in the final set of cores. The species-based cores are built sequentially, one at a time, by focusing on the species that are furthest from meeting their targets. After each new core is built, the species are re-weighted based on deviations between the species' landscape capability targets and the species' total landscape capability included in the cumulative set of cores. Thus, each new core strives to locate the best habitat for the species that are currently least well-represented in the cores. This process of building new species-based cores continues until a specified percentage of the landscape is included in the final set of cores (e.g., 25%).

Aquatic core areas

Below, we outline one option for designing aquatic core areas using existing data. More input is required from aquatic experts to refine the approach. We propose using the Freshwater Resilience data developed by TNC and the Aquatic Index of Ecological Integrity (IEI) developed by UMASS to generate aquatic core areas. These approaches complement each other because they focus on different scales; Freshwater Resilience operates on a coarser scale of interconnected stream networks, and IEI operates on a finer scale of stream segments. One approach would be to use Freshwater Resilience to focus on stream networks most likely to be resilient in the future, and then use aquatic IEI to further identify the most intact and resilient portions of those networks as candidate core areas.

Freshwater Resilience
A Freshwater Resilience Analysis evaluates characteristics of stream networks correlated with freshwater resiliency such as long linear length and high lateral (across the floodplain) connectivity, intact water quality as shaped by surrounding land use, low alterations to instream flow regime, access to groundwater, and a diversity of geophysical settings within the connected network.

Results of this analysis can help direct conservation efforts towards stream networks and segments that are likely to remain complex, adaptable, and diverse systems in the of environmental changes. By employing and encouraging a long term function-based perspective on stream networks, the results should help partners decide which conservation actions are most likely to be effective investments in current and ecological values.

Aquatic IEI
Aquatic IEI is used to identify aquatic areas of highest relative ecological integrity (includes intactness and resiliency metrics similar to those described above for terrestrial and wetland integrity) for lentic and lotic classes (using the Northeast Aquatic Classification) across the region or subregion. The result is a continuous map of the aquascape showing relative ecological integrity for each lentic and lotic class across the region or subregion in 30 m raster grid. Could show discrete areas of highest ecological integrity above a certain threshold (e.g., top 20%). Information will be useful for prioritizing watershed and riparian protection and management as well as restoration of aquatic connectivity.

Habitat classes are based on the Northeast Aquatic Habitat Classification mapped by The Nature Conservancy with a total of 23 lotic macrogroups classified by combination of lotic type, gradient, and temperature. For lentic systems, current integrity applies only to lake and pond classes, future integrity can be applied to revised lentic classification and map classified by temperature, trophic state, alkalinity, and depth. Understanding and decisions about what classes to assess is needed as part of the process.

Index of Ecological Integrity is weighted (by habitat class) linear combination of intactness and resiliency metrics. Metrics are weighted and combined in different ways depending upon the habitat class. The assessment is 30m cell-based using time-of-flow models to evaluate ecological influence from the watershed.

Relative aquatic IEI 30m grid, patches of mapped aquatic ecological systems, thresholded patches of highest integrity for individual aquatic classes and core areas of highest ecological integrity for multiple classes along with watershed buffers could all be used for prioritization for stream and riparian restoration and implementing land conservation in watersheds.

Similar to the process described for terrestrial and wetland integrity described, could utilize optimization through algorithmic approach choosing cells above a certain index value and spreading up and downstream from these "seeds" to build larger, buffered cores of relatively high ecological value that contain the best areas of each lentic or lotic class across the geographic extent to meet user defined objectives.

Stream Temperature Tolerance
Headwater stream temperature tolerance index is based on a model developed by USGS Conte Anadromous Fish Lab. It is a measure of the relative sensitivity of stream temperatures to rising air temperatures. This index identifies areas that are likely to be more tolerant under climate change, possibly because of groundwater influence or other factors. This index could be combined with IEI for headwater streams

Representative Species-Habitat
With the exception of Eastern Brook Trout, there are not currently any representative species habitat models for fully aquatic species. (However, models for some species that use streams and rivers have been developed, including wood turtle and Louisiana Waterthrush). There is also occurrence information for diadromous species for most rivers and major tributaries in the region. The brook trout and diadromous species information could be included in the selection index for aquatic core areas.

CORE AREAS **DECISION PROCESSES**

Biological Decisions
There will be several opportunities to gather essential biological input to guide the process under the core areas objective. First, we will request review of this document by state partners with technical assistance from their designated RCOA technical representative to develop recommended revisions or provide input on decisions. Next, certain technical decisions related to ecological concepts will require group discussion among biologists and technicians so that technicians can take appropriate action. In addition, the more straightforward decisions, such as selecting species, may require consensus by survey. In those cases, the LCC will develop the surveys and summarize the results, while contributing partners will provide feedback in their responses to the survey(s).

Here are anticipated biological decisions with decisions, questions and recommendations formatted as follows:

Decision
Questions

Recommendations

1. Weighting Habitat Classes: **How should species be selected and organized to weight the importance to biodiversity of each habitat class (ecological system)?** *We recommend developing a biodiversity importance weight for each habitat class drawing from all major taxonomic groups (including plants), and excluding species that fail to meet minimum data quality criteria. Do you think the rarity of habitat classes should be included in the weighting? We recommend comparing weighted vs. unweighted results.* For more information about the importance weighting process, refer to the RSGCN analysis section of this document.

2. Metrics for Assessing Integrity and Resiliency of Ecosystems: **Which metrics of current and predicted future condition and threats of ecosystems should be included to identify core areas?** *We recommend using the combination of the Index of Ecological Integrity and Resilience to identify the currently intact and well-connected patches of each habitat class (Integrity) and identify the complex and well connected areas of each geophysical setting (Resilience). We recommend a review -- and if needed and feasible -- refinement of the metrics in these indices to ensure they represent the best combination of factors. This review should be done for both terrestrial/wetland and aquatic indices.*

3. Geographic Stratification: **What geographic stratification should be used to assess and distribute core areas?** *We recommend using the Northeast Region as one stratification but also using large watersheds or ecoregions to ensure opportunity areas are distributed in each watershed or ecoregion across all parts of the Northeast region.* We can demonstrate and compare stratifications by watershed vs. ecoregion.

4. Size and Number of Core Areas: **Should there be fewer larger core areas or more smaller core areas?** *We recommend fewer larger core areas while ensuring adequate representation and distribution of each ecological system.* May also want to consider two or more tiers of core areas. May be best to compare results in a pilot area to show the differences.

5. Percentage of Landscape in Core Areas: **What percentage of the landscape (region or subregion) should be represented in core areas, recognizing that are several other types of opportunity areas, such as RSGCN habitat that will contribute to the final complete design?** *We recommend no more than 25% based on experience in the Connecticut River Landscape Conservation Design Pilot.Considering other priority areas in aggregate across the region, 25% may be too high.* Note that this percentage will include lands that are already conserved.

6. Representative Species: **How many and which representative species should be used to identify habitat-area needs to complement the ecosystem approach to core areas?** *We recommend starting with the 30 representative species associated with ecological systems across the region and adding or adjusting as needed.* These species were selected by the U.S. Fish and Wildlife Service along with state and other partners by associating federal trust and RSGCN species with habitat classes.

7. Target Level for Each Species: **What target level should be set for each representative species?** *We recommend consulting existing national and regional plans and experts and setting simple directional targets (maintain, increase) that can be translated into "landscape capability" targets.*

8. Use of Predicted Future Climate Suitability: **Should we use current or predicted future climate suitability or combination of current and future for the representative landscape capability models?** *We recommend using current climate suitability for the core areas but using a comparison of current and future climate suitability for planning for each representative species.*

9. Stream Class Level and Stream Network Criteria: **What level of the rivers and streams classification should be used for the assessment of relative ecological integrity and what criteria should be used to select priority stream networks for aquatic resilience?** *We recommend including additional aquatic partners in the RCOA process. Initial recommendations for stream class are to use a simplified version of the lotic classification from The Nature Conservancy using size, temperature and gradient. Initial recommendation for stream networks are to use four physical properties and three condition characteristics as criteria. Help with the aquatic core delineation is very much needed!*

CORE AREAS **RESULTS**

The final resulting maps will be useful for a range of conservation agencies and organizations to plan and implement land protection, land use and open space planning at multiple scales for the short and long term. The final results will include the items listed below. For a more complete listing of data outputs, please refer to the Core areas appendix.

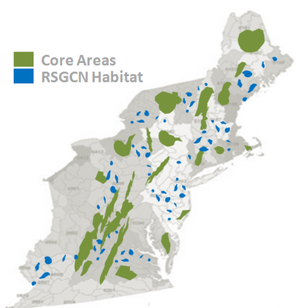
- **Optimized terrestrial and wetland core areas**
- **Aquatic core areas (and buffers) in resilient networks**

RSGCN HABITAT ANALYSIS

RSGCN HABITAT **OBJECTIVE + APPROACH**

The objective of the RSGCN habitat analysis is to identify the best opportunities to protect rare and threatened RSGCN and their habitats. The analysis will identify important locations for the most threatened species, habitats, and natural communities that may be excluded from intact core landscapes identified in the core areas portion of the analysis. If protected in their current intact condition, these locations would contribute significantly to the security of the most threatened RSGCN and their habitats in the Northeast.

ILLUSTRATION



The approach to achieving this objective is to identify a network of habitats specifically suited to RSGCN. In complement to core areas for all biodiversity, the RSGCN analysis will give special weight to streams, lakes, ponds, and terrestrial systems that are favored by RSGCN. Such habitats may not be sufficiently represented in core areas. Further, RSGCN habitats are under pressure from many threats, and may require conservation beyond core landscapes. The approach to RSGCN habitats will utilize known species occurrences to draw associations with each class of habitat, considering all species tracked by states and NatureServe in the Northeast. Further, each species will be assigned a weight for the conservation status (i.e., S-Rank) of its distribution. The combined habitat associations and status weights will identify the habitats most in need of conservation for the greatest number of RSGCN. Next, the relative condition of these habitats will be assessed to ensure high integrity and resiliency, minimal threat from measurable stresses, considering factors that limit or enhance opportunities for conservation.

Assessing **Habitat importance** (using the Northeast habitat classifications and species occurrences) for thousands of plants and animals will indicate the relative contribution of each class of habitat to biodiversity for conservation. Many species are strongly dependent on unique habitats and landscape features, and other species are less discriminating. As a result, certain habitats contribute far more to the diversity and abundance of species populations than other habitats. Considering habitat associations across thousands of species, or groups of species, will result in a mapped pattern of the relative importance of habitats for conservation. Habitat importance may also be weighted based on the conservation status (described below) of associated species. Describing the habitat importance based on the associations of many species will help satisfy the required elements of Wildlife Action Plans.

Assessing **Species status** (using NatureServe state-ranks or county ranks) will identify the species most in need of conservation in the Northeast and provide a metric to prioritize classes of habitat for conservation. The analysis will result in a ranking score for each of thousands of tracked species, considering the status of each across their North American distribution. This approach is a quantitative enhancement of the qualitative Responsibility and Concern process used to derive the RSGCN list. The value of this analysis is that it will serve as a radar screen for trends in species occurring outside the view of Northeast states. Some species reside wholly or completely within the Northeast, making them dependent on our region for conservation. Other species may appear secure in the Northeast, but are imperiled in the majority of their ranges; these species are dependent on the Northeast for conservation and represent opportunities to pre-empt the need for regulatory protection. Further, species that appear threatened in the Northeast may be secure in the majority of their range; these species may be a poor investment in conservation effort relative to other species. The species status ranks may be combined with each species habitat association, then evaluated across all species to add importance to habitats used by the greatest number of species in need of conservation in the Northeast. Ranking the status of the species of greatest conservation need helps satisfy the required elements of Wildlife Action Plans.

Assessing **Habitat condition** (using Index of Ecological Integrity, Resilience, and selected threat metrics) will indicate which locations are intact and which are degraded. Comparing across habitat classes and also within each class enables us to emphasize the habitats most in of protection and/or restoration, and then zoom in to the best or worst locations. The analysis result in an index of the intactness, connectivity and climate resilience (described above) of each location (raster cell) corresponding to ecological systems, streams, lakes and ponds. The average condition for each class of habitat will serve as a weighting metric in conjunction with habitat importance and species status, giving extra emphasis to threatened habitats. Next, specific locations will be compared within each class of habitat. This application of the habitat condition index is referred to as **Relative condition**--index values within each class of habitat are standardized, so that the best and worst examples of each class have comparable values. The locations meeting highest relative condition criteria will represent the best examples and will be evaluated as potential conservation opportunities. Describing the relative condition of each class of habitat helps satisfy the required elements of Wildlife Action Plans.

Assessing **Conservation opportunity** *(using selected threat and opportunity metrics such as energy development potential, conservation land, program priorities, regional connectivity patterns, core areas)* will help decide whether or not potential opportunities are good investments of conservation resources and effort. The analysis will result in a threat/ opportunity index for each important habitat class. Unique factors that inhibit RSGCN future security (threat metrics) and/or enhance future implementation of land protection (opportunity metrics) will be processed to create an index of opportunity. Some metrics representing threats may be included in the habitat condition assessment. The threat metrics selected to evaluate opportunities should emphasize future threats that may diminish the value of conservation investments. Including metrics to describe future threats and opportunities relevant to RSGCN will help ensure that the most pressing threats or simple conservation logistics do not preclude important opportunities to conserve high quality habitat.

RSGCN HABITAT **METHODS**

The overall approach as described above will utilize regional spatial data and assessments of integrity, resiliency, and species-habitat capability based on assessments of northeast regional habitat maps, geophysical attributes and other regionally available ecological settings data, similar to the core landscape analysis. However, the habitat needs of RSGCN will be quantitatively weighted based on each species habitat association and the status of their full North American distribution. The analysis is designed in recognition that RSGCN and and their habitats may not tolerate exclusion from core areas because of elevated risk. The result will map smaller patches of critical habitat to complement core areas..

Develop status and importance weights

Status and importance weights will provide a quantitative means to identify the most important habitats for the most at risk species. Status and importance weights will be calculated in separate applications of species occurrence point locations and state ranks (s-ranks) provided by NatureServe or state Natural Heritage programs. Occurrence data and s-ranks have known limitations. The limitations have been considered carefully. **We do not advocate using these data to make subtle comparisons among species, or suggest that habitat associations should be interpreted as stand-alone habitat models.** The recommended application of the s-ranks and species-habitat associations is to prioritize classes of habitat, considering broad patterns for hundreds or thousands of species of plants and animals.

The first step to calculate species status ranks will be summarizing each species distribution according to the proportion of the spatial extent in each category of state rank (s-rank, where SX is extinct, S1 is most imperiled, S2 is next most imperiled, etc.), currently available at the county level. Species with poor data data quality will be excluded. The entire North American distribution will be summarized for each species. The ranking formula will summarize the convergence of each distribution within the Northeast toward total imperilment and regional extirpation, where lower s-ranks (higher levels of imperilment) are assumed to indicate localities nearer to extirpation. To minimize inconsistencies in the designation and age of s-ranks across states, the ranks will be collapsed in 3 categories: extirpated, most threatened, least threatened. The Northeast pattern will be compared with the pattern of convergence toward total imperilment or extinction outside of the Northeast. In the resulting status ranking, high risk species dependent on the Northeast to avert extinction will score highest, while low risk species and species not dependent on the Northeast will score lowest.

To calculate importance weights, each point location will be assigned to a habitat class based on the underlying or co-occurring ecological system, stream, lake or pond from the relevant Northeast habitat classification. Next, the count of each habitat class will be summarized for every tracked species, resulting in a table of the frequency of each species co-occurrence with each habitat class. In this step, the data for each species could be repeatedly and randomly subsampled to control for uneven survey efforts. Next, for every class of habitat, the Northeast regional count of cells will be summarized as a constant expected frequency. The strength of species habitat associations will be measured as the deviation from the constant expected value for each class of habitat.

Habitat associations will be summarized across all species to derive the habitat importance weight for each habitat class. The species status rank may be applied as a weight to the habitat association for each species, with the result that the habitat associations for secure species contribute less to the overall importance of each habitat class, and the overall importance of habitats reflects the requirements of the most threatened species. Species with poor data quality will not be included in the weighting process. Habitat importance weights may be partitioned according to groups of species, such as taxonomic groups, status, and data quality, based on expert input.

Habitat importance (weighted by species status) will measure the relative importance of each habitat class for RSGCN, where each habitat class has a constant importance weight across all locations (raster cells). The relative condition of each location is developed in the next analytical phase.

Develop combined habitat importance and condition index

The condition index will be used to add emphasis to the most threatened and important habitats, then it will be applied identify the best and worst examples of each habitat. In this analytical step, the importance weight developed for each class of habitat (within the ecological system, stream, lake and pond classification) will first be combined with the average overall habitat condition to weight each habitat class, then the class level weight will be applied to distribute relative habitat condition at each location or raster cell. Relative habitat condition will be a weighted raster evaluating current landscape landscape features and current environmental conditions at each raster cell, stratified according to habitat classes. The combined result will also be stratified by habitat class, where 1) the highest relative condition values reflect the best examples of each class; and 2) the habitat class weight skews the values of cells so that more habitat area is represented for important habitats with increasing increments of relative habitat condition. High quality relative habitat condition data are already available, and all that is required is application of habitat importance weights for RSGCN. If the following recommendations are adopted, the combined habitat importance and condition index is analogous to the weighted selection index described above. For ecological systems, we recommend utilizing the combined Index of Ecological Integrity (IEI) and Resilience developed above in the core areas analysis. For aquatic systems, we recommend utilizing the Aquatic Index of Ecological Integrity. In both cases, the relative condition will be weighted to reflect the most important habitats for RSGN. A threshold will be applied for each habitat class to select those that are currently in the best condition. The result will be a raster map showing the best current examples of each class of important habitat. Important RSGCN habitat locations receiving mediocre scores for current condition will be exported to the Restoration analysis.

Develop threat/opportunity indices

In this analytical step, unique factors that inhibit RSGCN future security (threat metrics) and/or enhance future implementation of land protection (opportunity metrics) will be processed to create an index of opportunity. The metrics will be selected based on expert consensus. High scoring threat metrics (beyond the factors included in the current condition index above) will diminish the opportunity for land protection, and high scoring opportunity factors will increase the index. The threat and opportunity metrics may be customized (labor intensive for decision makers and technicians) for each habitat class, or generalized to reflect broad indicators of threat (such as energy development potential) and opportunity (such as current conservation status). Each metric will be weighted to screen the best opportunities, and the result of the analysis will be an index of threat and opportunity for each raster cell. Decision rules and threshold levels to select opportunities will be developed in conjunction with experts.

Screen RSGCN and habitat opportunities

The final RSGCN Habitat opportunity screening will process the best examples (highest condition) of the most important habitats for RSGCN in combination with the indices of threat and opportunity. Threshold levels and/or decision rules for threats and opportunities will be applied to the best examples of the most important habitats for RSGCN to identify the best opportunities for each class of habitat. The best tidal marsh opportunities will be exported for further analysis of marsh migration opportunities.

RSGCN HABITAT **DECISION PROCESSES**

Biological Decisions

Several modes of exchange will be employed to gather essential biological input. First, we will request review of this document by state partners with technical assistance from their designated technical representative to develop recommended revisions or provide input on decisions. Next, certain technical decisions are abstractions of ecological concepts and require group discussion between biologists and technicians and so that technicians can make relevant technical translations. In addition, straightforward choices, such as selecting species, may require consensus by survey. NALCC will develop the surveys and summarize the results, and contributing partners will provide relevant expertise to respond to the survey(s).

1. Species Status Ranks: ***How should RSGCN be prioritized?*** *Instead of using the existing RSGCN designation, we recommend using the continuous ranking developed by NALCC. This approach involves evaluating the status of the entire North American distribution of each species tracked by NatureServe. The benefit of this approach is that employs the power of data far beyond our region, for many more species than we can process ourselves. This analysis can be easily updated using the species tracking system already in place by Natural Heritage programs.*

2. Habitat importance weights: **How should species be organized to weigh the importance of each habitat class for RSGCN?** *We recommend grouping species according to major taxonomic groups (including plants), excluding species that fail to meet minimum data quality criteria, and excluding species that fail to meet RSGCN criteria. Unevenly represented taxonomic groups can then be equitably combined in one importance weight for each habitat class. We recommend including habitat rarity and overall threat as weighting factors. We recommend that exemplary natural communities be used as a check for the weighting system--if they are not well represented we can adapt the approach.*

3. Selecting metrics: **What are the key threat and opportunity metrics that will help avoid risky opportunities and enhance our ability to find good ones?** *We recommend Index of ecological integrity and resilience to evaluate the current ecological condition of RSGCN habitats--these products are currently under revision. Which of the locations that are in good condition are also good opportunities for protection? We recommend prioritizing opportunities that are near (but not in) protected lands, core areas, and connectivity zones. We also recommend seeking opportunities that co-occur with other regional conservation priorities.*

4. Setting thresholds: **How much is enough?** *Once habitat condition and opportunity metrics have been used to rank opportunities for each RSGCN habitat, we need to decide which opportunities to focus on. How good does an opportunity need to be, and how much is enough? The aggregate area of other kinds of opportunities needs to be considered, as discussed under core areas. What is an acceptable contribution of RSGCN to land protection opportunties when considered in combination with corea areas? We recommend comparing threshold levels of relative condition, such as the "90th percentile" vs. the "75th percentile" and so on. How much area is represented by these levels? Does poor overall condition of a habitat justify selecting a lower threshold level for protection? Generally, we recommend that habitats meeting a slightly lower criterion the criterion used for protection should be considered restoration opportunities.*

Technical

Develop status and importance weights
- Select importance metrics

Develop importance and condition index
- Set thresholds for high importance and high condition
- Set thresholds for high importance and moderate condition

Develop opportunity screen
- Set thresholds for threats / opportunities

Screen RSGCN and habitat opportunities
- Select final formatting for RSGCN conservation opportunities

RSGCN HABITAT **RESULTS**

The final resulting maps will be useful for a range of conservation agencies and organizations to plan and implement land protection, land use and open space planning at multiple scales for the short and long term. The final results will include the items listed below. For a more complete listing of data outputs, please refer to the RSGCN appendix.

Best RSGCN habitat opportunities
- Pond and lakes
- Streams
- Ecological systems
- Tidal marshes, as a basis for analysis for marsh migration (see Connectivity)

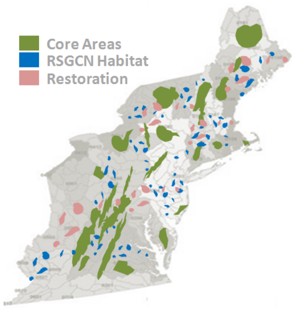
RSGCN habitat opportunities of highest importance and moderate condition
- Pond and lakes, as a basis for analysis of Restoration (see Restoration)
- Streams, as a basis for analysis of Restoration (see Restoration)
- Ecological systems, as a basis for analysis of Restoration (see Restoration)

RESTORATION ANALYSIS

RESTORATION **OBJECTIVE + APPROACH**

The objective of the restoration component of the analysis is to identify the best opportunities to restore rare and threatened RSGCN habitats. In practice, this analysis looks to identify HUC12 watersheds that have high potential, and, if restored and/or management were focused there, implemented restoration would contribute significantly to the benefit of opportunities identified in the RSGCN and core landscape analyses.

ILLUSTRATION



The approach to achieving this objective is to identify a network of **HUC 12 watersheds** specifically suited to restoring RSGCN. The analysis will incorporate outputs from the other objectives to ensure that restoration opportunities are spatially situated to enhance core areas, RSGCN habitat protection opportunities, and increase the overall connectivity of the landscape. Metrics will be summarized on HUC12 units to assess opportunities. The selected metrics will focus on restoration opportunity analysis for five **Restoration scenarios**, each representing a suite of restoration practices and/or specific kinds of habitat.

- **Early successional habitat** opportunities will identify watersheds suitable for the restoration and management of RSGCN and other species dependent on shrub, savannah, and young forest habitat structure, typically achieved through practices that reduce canopy cover.

- **Threatened ecological system (including wetlands)** restoration opportunities will identify watersheds suitable for the restoration of the most threatened and important terrestrial habitats for RSGCN, to be achieved through a variety of practices.

- **Watershed and riparian** opportunities will identify watersheds suitable for upland restoration practices enhancing stream habitat and water quality, such as cattle exclusion and buffer enhancement.

- **Agricultural land** opportunities will identify watersheds suitable for forest, wetland, or native grassland restoration and management, typically accomplished through cropland reversion, removal of drainage structures, modification of haying practices, and enhancement of pollinator habitats.

- **In-stream aquatic connectivity** opportunities will identify watersheds suitable for restoration of habitat connectivity within streams for both freshwater and diadromous species, primarily through dam removal and upgrading culverts or bridges at road crossings. The critical local linkages assessment (UMASS) measures the relative potential to improve local connectivity through restoration, including dam removals, culvert upgrades, and creating terrestrial road passage structures. The North Atlantic Aquatic Connectivity Collaborative is developing consistent approaches for assessing and prioritizing road-stream crossings for restoring connectivity.

The restoration analysis is not intended to prescribe specific actions for specific sites. It is intended to identify opportunity-rich watersheds for the named restoration scenarios. Each watershed opportunity is expected to have varying suites of practices and target habitats relevant within them. The analysis will apply consensus selection criteria for each restoration scenario to produce restoration opportunity areas. The analytical process will also refine a watershed analysis tool that will allow users to customize their own restoration opportunity analyses.

Assessing the appropriate **Unit of analysis** for restoration (using HUC12 watersheds) will provide the flexibility to adapt implementation to circumstances on the ground. The dynamics of recruiting landowners to implement restoration or land management practices are very different from recruiting landowners to protect land. Implementers need to prescribe restoration that is suitable for the habitats present on a candidate property, while satisfying the values and intended land objectives of the landowner. Success requires that implementers can present a toolbox of practices tailored to a variety of habitat objectives. Identifying generalized locations, such as HUC12 watersheds, will allow implementers to approach landowners with a toolbox suited to a general land type, and adapt to on site conditions based on landowner preferences. Further, identifying specific locations may risk the ire of targeted landowners.

Assessing **Habitat importance and Relative condition** (using data outputs from the RSGCN analysis) will ensure for the most threatened and important ecological systems, streams, lakes and ponds, that moderately stressed (moderate or better relative condition) locations are evaluated for restoration opportunities, even if the location did not meet more stringent relative condition criteria for land protection. Highly important habitats for RSGCN may be extensively stressed, and not suitable for protection without restoration. Data describing the relative condition of habitats will indicate which locations are moderately stressed, and these will be considered as candidates for restoration.

Assessing **Proximity** (using the best opportunities for RSGCN habitat and connectivity metrics) will ensure that restoration opportunities are identified near potential source populations with potential to recolonize restored sites. Conversely, restoring important habitats in proximity to the best opportunities for RSGCN may increase the the security of populations depending on the habitats identified as best opportunities for RSGCN.

Assessing **Conservation opportunities** *(for specific restoration scenarios)* will help ensure that the most pressing threats, habitat requirements, or simple conservation logistics do not preclude important opportunities to restore habitat. Unique factors that inhibit future RSGCN security, describe required habitat conditions, and/or enhance future implementation of restoration will be processed to create an index of opportunity. Not all factors can be represented in the RCOA landscape analysis, but many relevant metrics can be derived from the available data and will refine the field of possibilities and focus restoration implementation on locations with improved potential for success.

RESTORATION
METHODS

The restoration analysis will utilize a consensus process to identify key metrics and weightings for each of the five restoration scenarios listed above. The metrics will be summarized on HUC12 units, and then weighted to perform and opportunity analysis for each scenario. The HUC12 data will be available for customized analysis using an opportunity analysis tool developed by NALCC.

Develop HUC12 metrics

The output of this analytical step will be a master HUC12 attribute table containing fields summarizing opportunity metrics. Expert consensus on opportunity metrics relevant to each restoration scenario is a prerequisite. When appropriate metrics for screening restoration sites have been identified, data will be processed and metric calculations will be performed. Once calculated, each metric will be summarized on HUC12 watershed units, then standardized to make it possible to combine many weighted metrics with otherwise incompatible numeric ranges or scales.

Restoration opportunity analysis

Before analyzing HUC12 watersheds to identify restoration opportunities, the master HUC12 attribute table will be split into subsets containing only the metrics relevant to each of the five restoration scenarios, resulting in five HUC12 attribute tables. Each of the five attribute tables will be used to perform separate opportunity analyses. These will be available for customized analysis later. Next, standard metric weightings developed through expert consensus for each scenarios will be applied using the NALCC Conservation Opportunity Analyst tool, which applies weights to metrics selected from the input shapefile and attribute tables. The output will be a HUC12 shapefile containing the input metrics and with a new attribute scoring each watershed for restoration opportunity. Maps of focus areas for restoration may be produced from this dataset.

Custom restoration planning tool

We will package master HUC12 metrics, metrics for each restoration scenario, and the conservation opportunity analysis tool. This self-contained package will provide users with regional results, data, and the tool that can be used to develop customized queries and refine regional results for local relevancy. The package will be delivered to interested partners. NALCC will provide guidance on the applications of data contained in each restoration scenario package using the conservation opportunity analysis tool. Partners may add high quality local data to complement regional data and derive user-defined queries after receiving guidance.

RESTORATION
DECISION PROCESSES

Biological Decisions

Several modes of exchange will be employed to gather essential biological input. First, we will request review of this document by state partners with technical assistance from their designated technical representative to develop recommended revisions or provide input on decisions. Developing opportunities for restoration involves thorough discussion of the logistics and real experience of people implementing restoration and land management under various scenarios. These scenarios are discussed below. Can you recommend conservationists with experience implementing restoration and management on public and private land?

Threatened ecological systems: **Which ecological systems should be the focus of habitat restoration for RSGCN?** *Both importance weights and relative condition help narrow the focus of restoration opportunities. We can use these data to tell us which of the most threatened systems (habitats) are most strongly associated with RSGCN. Floodplain forests, forested swamps, shrub swamps and marshes have the strongest associations with RSGCN, and are typically located in vulnerable parts of the landscape. We recommend addressing and these systems. We also recommend focusing on dunes and heaths, because these systems are strongly associated with many RSGCN, are well distributed along the coast, and tend to have similar patterns of restoration need related to management of access.* ***Which threat and opportunity metrics would you use to help screen for good opportunities for these habitats?*** *We recommend convening a small group of land managers and restoration ecologists to develop scenarios for threatened ecological systems and to evaluate potential metrics. Proximity to well-connected and high quality homologous ecological systems are examples of metrics that will be used identify opportunities.*

Early successional habitats: **Which ecological systems should be the focus of habitat restoration and management for RSGCN?** *We recommend addressing dry pine and oak forests, woodlands, and barrens because these systems are strongly associated with many RSGCN, are well distributed across the region, and tend to have similar patterns of restoration need related to fire regimes. Fire dependent systems range in structure from grassy savannah to closed canopy, and benefit common species and upland game as well as RSGCN. Other land management techniques, including forestry, may be applied to create or maintain young forests in other forest types with many benefits for RSGCN.* **Which threat and opportunity metrics would you use to help identify (or avoid) sites for early successional habitat restoration and management?** *We recommend convening a small group of land managers and restoration ecologists to develop scenarios for early successional habitats and evaluate potential metrics. Soil conditions and forest condition are examples of metrics that will be used identify opportunities.*

Watershed and riparian: **Where should restoration of upland areas be focused to benefit RSGCN?** *Preliminary tests of habitat associations suggest higher order, cool/warm, and lower gradient streams and rivers support the greatest numbers of RSGCN—typically these are found in larger valley bottoms facing many stresses. We recommend using this information in combination with assessments of water quality to focus upland buffer restoration.* **Which threat and opportunity metrics would you use to help screen for good opportunities to restore upland riparian areas?** *We recommend convening a small group of fisheries biologists, and restoration ecologists to develop scenarios for riparian restoration and evaluate potential metrics. Existence of Water*

Quality Improvement Plans, impairment designation, and occupancy by brook trout and other water quality sensitive species are examples of metrics that will be used identify opportunities.

Agricultural land: **How should agricultural landscapes be identified to restore RSGCN habitats?** *Many of the habitats RSGCN are most strongly associated with naturally co-occur with agriculture—in fertile valleys. On one hand, flooding and sedimentation create varied patterns of soil, hydrology, and landform; these patterns result in diverse habitat structure and composition. On the other hand, flooding and sedimentation constantly replenish nutrients necessary for high plant and animal productivity—great wildlife and for farming! We recommend seeking opportunities to enhance agricultural landscapes, such as reclaiming drained land and implementing sustainable farming practices in the vicinity of remnants of the most important habitats for RSGCN. Depending on the context, forests, wetlands, or native grasslands will benefit.* **Which threat and opportunity metrics would you use to help screen for good opportunities to restore agricultural lands?** *We recommend convening a small group of land managers, agricultural extension specialists, and restoration ecologists to develop sustainability scenarios for agricultural lands. Soil features, hydrological conditions, and proximity to important ecological systems are examples of metrics that will be used identify opportunities.*

In-stream aquatic connectivity: **Several efforts are already underway to identify watersheds for in-stream connectivity improvement.** T*he critical local linkages assessment (UMASS) measures the relative potential to improve local connectivity through restoration, including dam removals, culvert upgrades, and creating terrestrial road passage structures. The North Atlantic Aquatic Connectivity Collaborative is developing consistent approaches for assessing and prioritizing road-stream crossings for restoring connectivity. Downstream Strategies, the Brook Trout Joint Venture, and Fish Habitat Partnership have each developed tools for identifying important stream reaches.* **Which threat and opportunity metrics would you use to help screen for good opportunities to restore in-stream connectivity?** *We recommend coordinating a small group including the developers of each tool and key aquatic experts to develop appropriate scenarios.*

Technical

Restoration opportunities

- Select weight metrics for ecological systems, early successional restoration, watershed / riparian restoration, agricultural land restoration and in-stream connectivity

RESTORATION **RESULTS**

The final resulting maps will be useful for a range of conservation agencies and organizations to plan and implement land protection, land use and open space planning at multiple scales for the short and long term. The final results will include the items listed below. For a more complete listing of data outputs, please refer to the Restoration appendix.

Standard HUC12 restoration opportunities

- HUC12 restoration opportunities for ecological systems
- HUC12 restoration opportunities for early successional habitats
- HUC12 restoration opportunities for watershed and riparian
- HUC12 restoration opportunities for agricultural land
- HUC12 restoration opportunities for and in-stream connectivity

Customized HUC12 restoration opportunities

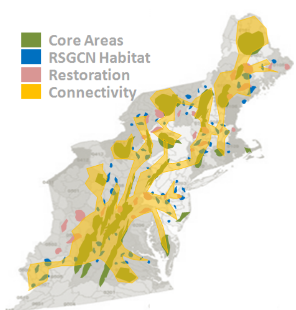
These tailored analyses created through the conservation opportunity analysis tool.

CONNECTIVITY ANALYSIS

CONNECTIVITY
OBJECTIVE + APPROACH

The objective of the connectivity analysis is to identify the best opportunities to connect and buffer RSGCN populations and habitats. In particular, this analysis endeavors to identify areas supporting the connectivity and ecological function of each landscape or location identified in the core areas and RSGCN habitat analyses as important or valuable for RSGCN and their habitats.

ILLUSTRATION



Assessing **Connectivity** (using a suite of concepts and models) will identify a suite of landscapes, habitats, and environmental features that are expected to support local movements, dispersal, and in some cases, migrations of animals in the Northeast. Three key concepts help to understand connectivity models that operate on cellular grids (rasters). First, **nodes** are beginning and end points for conceptual animal movements; nodes are sometimes called terminals and can take the form of one or more cells. Second, **resistance** or cost is the suitability of a given cell for animal passage, derived from landscape features. Third, a **path** is a series of touching cells, each selected by a model as the next most likely choice for a hypothetical animal movement. Two general approaches to connectivity modeling emphasize either nodes (node-based models) or landscape features and resistance (permeability). Neither approach is perfect; one attempts to capture efficient routes in an idealized landscape where the optimum size and location of nodes is predicted. The other seeks to represent the most likely flow of animals through the imperfectly permeable landscape, as it is now. Hopefully, employing both techniques will illuminate convergences of the ideal and the most likely opportunities.

In **node-based** models, animal movements are assumed to occur as a form of transit from one location to another, and to the extent that we can delineate the locations among which animals move, we can then make predictions about the best paths for movement based on the pattern of cell resistance. The location of a path is dependent on the locations of nodes and patterns of resistance. Model iterations may allow variation in the influence of nodes and resistance, resulting in many alternative paths--the areas of agreement between paths may be called **corridors**. In order to find a path between nodes, a path may travel through regions of high resistance because in node-based models, movements are forced through the landscape between areas of interest from node to node.

In **permeability models**, a land area is assumed to have a general capacity to allow passage of animals, more or less independently of nodes, where the landscape features defining resistance dominate the paths used by animals. The average resistance of a region could measure permeability, but would be subject to the possibility that low resistance is dispersed like islands. Therefore, a dynamic path-finding approach finding is desirable, if the directional bias of nodes is minimized. For example, starting and/or ending nodes could be randomized, selected based on rules, located far from the area of interest, or systematically repositioned for each path-finding iteration. Using an approach to minimize node bias, a region that supports many paths is predicted to be permeable, or have a high **flow** of movement. In this approach, high flow could be present in an area of interest as a diffuse or as a concentrated pattern, but might not necessarily illuminate the best path to connect two areas of interest.

Assessing **Local connectedness** (using the UMASS connectedness model) serves as a fine scale permeability approach that evaluates every cell as a starting node and grows paths that randomly seek similar habitat in every direction until resistant features are encountered. Each cell is assigned a travel cost, based on a resistance matrix, as a function of its ecological similarity to the focal cell. This application provides a buffer of connectivity around contiguous habitats, and serves as one metric used in the index ecological integrity (IEI). This result is not utilized here as a separate connectivity analysis, but we reference it as a reminder that our approach is addressing connectivity at multiple scales.

Assessing **Regional connectivity** (using results using the UMASS regional connectivity model) will identify corridors to connect core areas and RSGCN habitats. The opportunities identified in prior analyses will provide a dataset of starting and endpoints for node-based connectivity analysis. The analysis will identify the most efficient, or least costly corridors between core areas and RSGCN habitat opportunities. Least cost paths may pass through highly resistant landscapes, and are not necessarily congruent with the most likely movement corridors.

Assessing **Regional permeability** (using TNCs anthropogenic permeability analysis) will provide a perspective on animal movements through the landscape that ignores assumptions about the best opportunities to conserve core areas and RSGCN habitat, and balances efficiency with the most likely flow of animal movements across the landscape. Permeability will help delineate important supporting habitats and buffer areas to ensure the viability of the best opportunities.

Assessing **Riparian connectivity** (using TNC riparian climate corridors) will integrate regional connectivity patterns with clearly defined riparian areas that provide complexes of connected habitat for many RSGCN. Many species that utilize riparian areas are not obligate wetland species, but dependent on many other landscape features accessible only through broader patterns of connectivity.

Assessing **Flow patterns, bottlenecks, barriers, and regional pinch points** (using the results of regional connectivity and permeability analyses) will simplify complex model results for clear interpretation of connectivity patterns.

Assessing **Marsh migration** (using tidal marsh opportunities from preceding analyses the best available and sea level rise models) will allow us to identify which of the best opportunities for tidal marsh habitat have the greatest potential for upland migration with advancing sea-levels. Identification of suitable uplands adjacent to tidal wetlands will be based on topography, habitat type, land use, development and land ownership for facilitating marsh migration through land protection and/or management. Tidal marshes are among the most productive habitats on earth. The identification of existing tidal marsh of exceptional habitat value in proximity to upland zones of migration, given projected sea-level rise, will help to prioritize conservation and management actions aimed at encouraging a healthy extent of tidal marsh habitat into the future.

CONNECTIVITY **METHODS**

Our approach to connectivity is to utilize the best applications of multiple connectivity models available in the Northeast. TNC permeability products will be integrated with the UMASS Regional connectivity model by revising resistance to reflect permeability. The resulting corridors connecting core areas and RSGCN habitat are expected to balance efficient paths with larger regional patterns of probable flow. Gross patterns of constricted permeability, emphasizing climate related factors such as latitude and elevation, will be addressed by screening TNC upslope and northward permeability to identify pinch-points of flow. Riparian areas are important, well defined features providing connectivity for many RSGCN, and results from a TNC analysis screening resilient riparian areas will be incorporated in the regional connectivity results. Tidal marsh migration will be addressed by first extracting the best tidal marsh opportunities from the RSGCN habitat results, then applying SLR models and upland opportunity factors to identify zones of potential upland migration.

Regional analysis

The UMASS regional core connectivity analysis approach will be used to identify regional connectivity opportunities. In keeping with our intention to balance node-based and permeability modeling approaches, a preliminary step is to incorporate permeability in the UMASS resistance calculations, thereby reducing the influence of nodes represented by core areas and possibly RSGCN habitat opportunities (note: the desired result is that RSGCN habitat opportunities align with with key movement corridors between core areas, but it has not been determined whether to achieve that by using RSGCN habitat as nodes vs. using corridors among core areas as a criterion for selecting RSGCN opportunities). To implement the analysis, the key raster data inputs to this process are optimized terrestrial and wetland core areas (possibly including RSGCN habitat opportunities), and the revised resistance estimates. TNC Riparian climate corridors will be integrated with the regional connectivity results using an undefined calculation. The results of this process will provide a map of riparian connectivity zones and corridors between core areas, emphasizing those corridors that pass through riparian connectivity zones. The integrated output is a single raster depicting weighted regional corridors and riparian zones. Integrated regional connectivity will be more interpretable if recognizable connectivity patterns are labeled as diffuse, bottleneck, and barrier. Criteria will be developed to classify each category. The final output will be a set of raster data layers, each containing diffuse zones, bottlenecks, or barriers.

Pinch-point analysis

Pinch-point analysis will identify major constrictions in regional permeability using the suite of Northeast permeability datasets created by TNC. The result will help identify geographic regions inhibiting the flow of wide-ranging animals across the landscape. We will develop criteria to screen out localized permeability patterns and refine model results to depict coarse patterns, such as best opportunities to connect mountain ranges or major blocks of undeveloped land through developed river valleys.

Marsh migration opportunities

Developing threat and opportunity metrics is a precursory step to implementing an analysis to screen tidal marshes for opportunities to enhance upland migration opportunities in the face of sea level rise (SLR). SLR models employ factors that examine the threat of inundation or inhibit migration. We will identify factors that enhance the opportunity for tidal marshes to migrate upland or be secured from SLR, then use criteria to select zones representing the best opportunities to conserve upland areas to safeguard tidal marsh habitats from SLR.

CONNECTIVITY **DECISION PROCESSES**

Biological

Regional connectivity analysis

- Set thresholds for marsh threats and opportunities

Technical

Regional connectivity analysis

- Revise form of resistance calculation
- Select method to integrate riparian and regional connectivity

- Select criteria to classify diffuse / bottleneck / barrier

Pinch-point analysis

- Select criteria for pinch-points

Marsh migration opportunities

- Select best available sea level rise metrics

CONNECTIVITY **RESULTS**

The final resulting maps will be useful for a range of conservation agencies and organizations to plan and implement land protection, land use and open space planning at multiple scales for the short and long term. The final results will include the items listed below. For a more complete listing of data outputs, please refer to the Connectivity appendix.

- **Regional core connectivity**
- **Regional pinch-points**
- **Upland marsh migration zones (including marsh)**

DELIVERY OF PRODUCTS

Coming soon!

APPLICATIONS

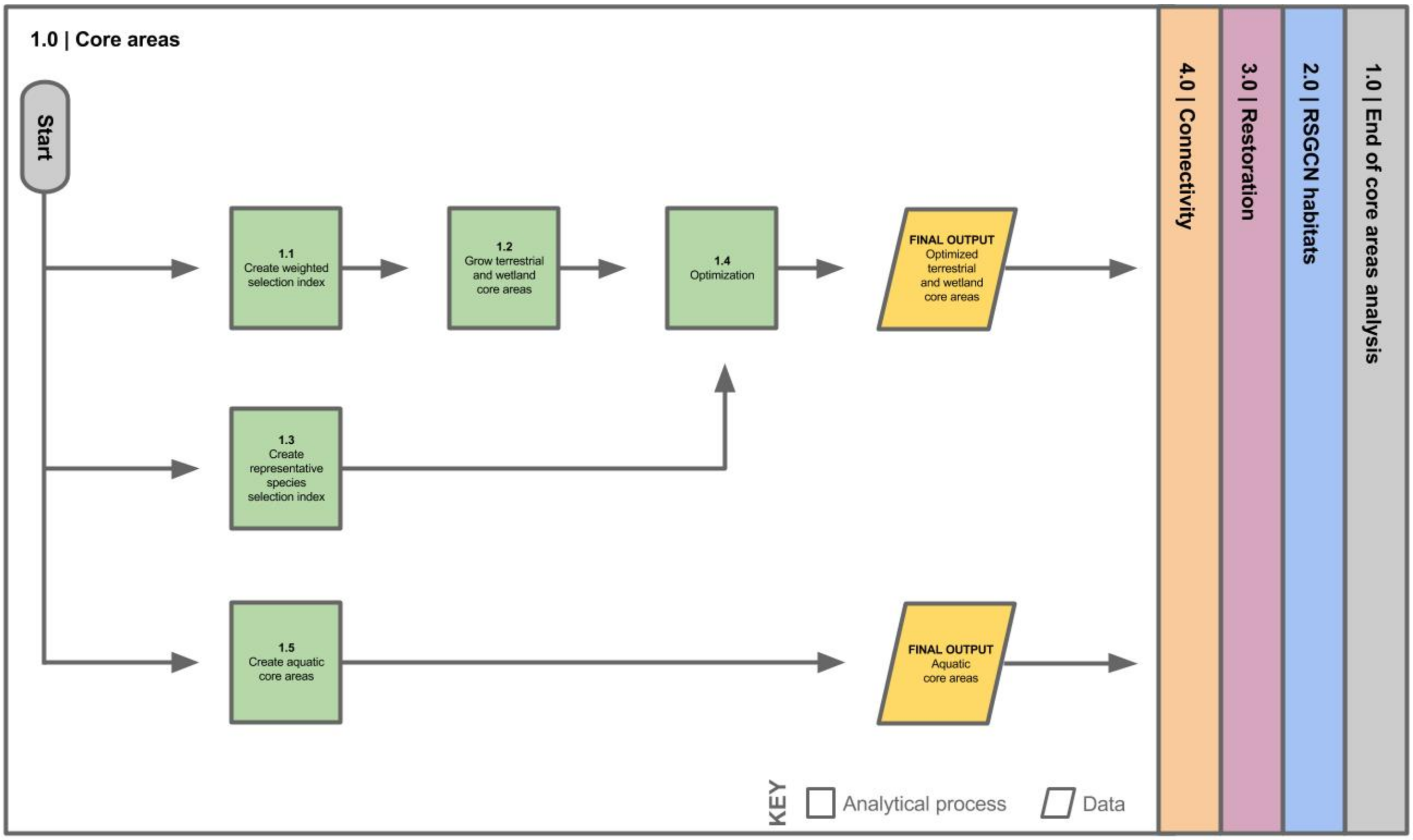
RCOAs will be used by the Northeast Fish and Wildlife Diversity Technical Committee to prioritize projects funded through the Regional Conservation Needs (RCN) grant program. State Fish and Wildlife Agencies may also use RCOAs to guide and inform conservation action priorities. In addition to these uses, state, federal, private, and non-governmental organizations and partnerships may find RCOAs and related data products helpful to prioritize and plan conservation actions. Possible uses of RCOAs include:

- Influencing funding or funders
- Increasing funding of priorities
- Technical assistance
- Draft RFPs through RCN process to implement actions within focus areas
- Prioritize acquisitions…results used as criteria in funding programs
- Prioritize projects identified in focus areas, including state effort
- Proactive targeted landowner recruitment using results
- Influence planning processes, town plans, refuge planning etc.
- Certain populations or habitat patches will be prioritized.
- Identify and prioritize opportunities for restoration actions that could benefit RSGCN or add ecological value to existing habitats.

APPENDIX A: CORE AREAS

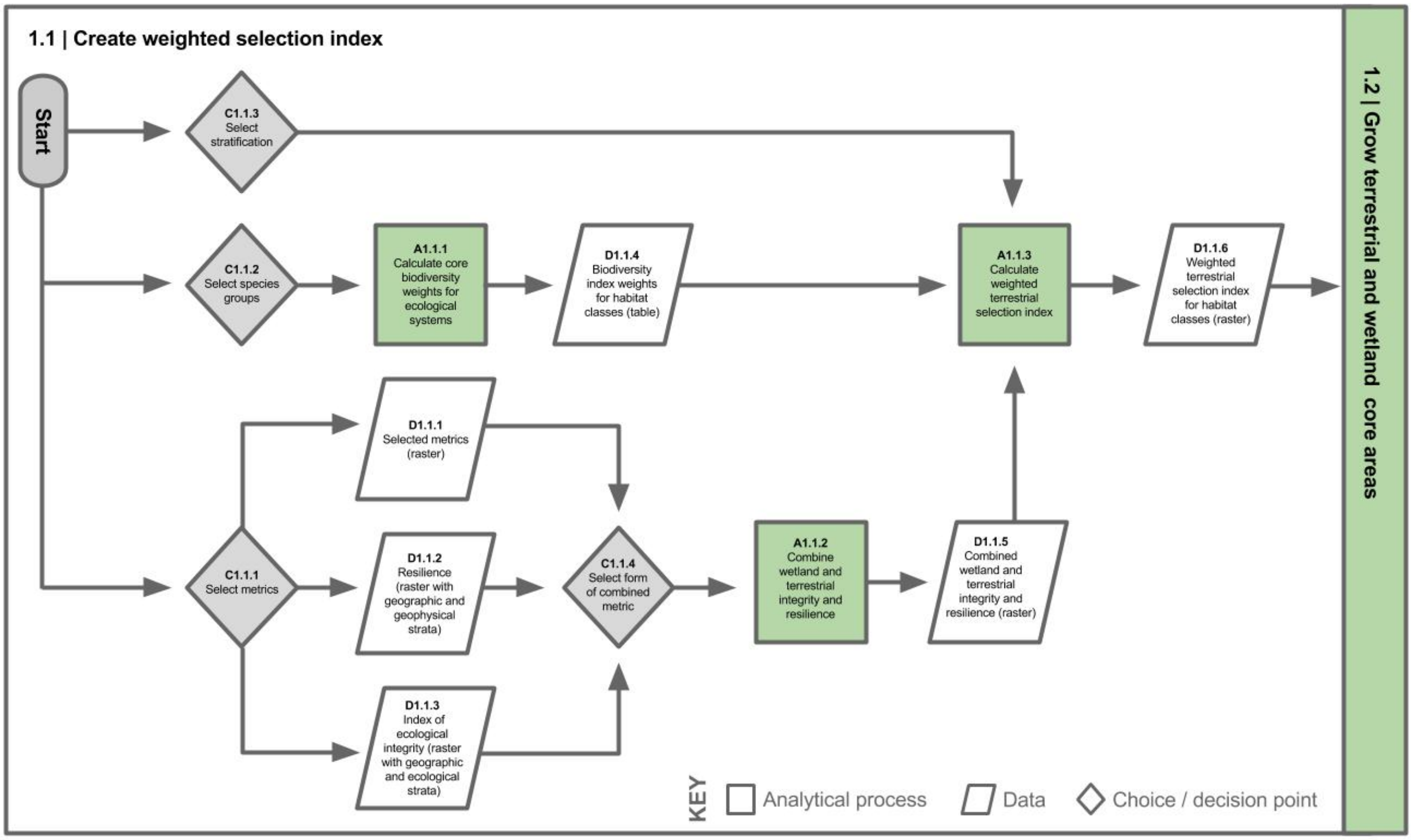
1.0 | CORE AREAS

This **Core Area Process Overview** flowchart depicts the relationships between each phase of the core areas analysis and how it connects to the other RCOA objectives. Larger version of flowchart 1.0



1.1 | CREATE WEIGHTED SELECTION INDEX

This flowchart and subsequent list of elements describes the first phase of the core areas analysis: creating a weighted selection index. [Larger version of flowchart 1.1]



ANALYTICAL PROCESSES

A1.1.1 **Calculate core biodiversity weights for ecological systems**

Each ecological system can optionally be assigned a weight to increase or decrease its likelihood of inclusion in the final core areas. We propose to use a weighting based on the diversity of all plant and animal species associated with each ecological system (habitat class), potentially including natural communities. The steps in weighting include selecting species groups, such as taxonomic groups, associating these species with ecological systems, and calculating core biodiversity weights for each ecological system.

A1.1.2 **Combine wetland and terrestrial integrity and resilience**

The first step in building terrestrial core areas is to create an ecosystem "selection index" that integrates the different ecosystem-based values that core areas are intended to represent and reflects the design criteria described above. The selection index can be created from any number of regionally available data layers, but for the first iteration of RCOAS, we propose combining the following spatial data products: *(Weighted) index of ecological integrity (IEI)* and *Terrestrial resiliency.*

A1.1.3 **Calculate weighted terrestrial selection index**

Weighting - Each ecological system can optionally be assigned a weight to increase or decrease its likelihood of inclusion in the final core areas. We propose to use a weighting based on the diversity of species associated with each ecological system (habitat class). The steps in weighting including selecting species groups, associating these species with ecological systems and calculating core biodiversity weights for each ecological system. The resulting weight would have the end result that ecological systems associated with many species are represented more heavily in core areas.

CHOICES / DECISION POINTS

C1.1.1 **Select metrics**

Biological

Review and adjust metrics and metric weights in indices

C1.1.2 **Select species groups**

Biological

C1.1.3 **Select stratification**

Biological

C1.1.4 **Select form of combined metric**

Technical - Need decision on how to combine integrity and resilience - mean or max min.

DATA

D1.1.1 **Selected metrics** - Raster

D1.1.2 **Resilience** - Raster

Stratified by geophysical setting and ecoregion

Input

This data layer is a product of The Nature Conservancy representing terrestrial ecological resiliency at the resolution of 30 m cells. To learn more about the TNC resiliency index, see Resiliency page at TNC's Conservation Gateway. This index is (quantile) scaled by geophysical settings (i.e., elevation and geological substrate) and thus discerns cells of relatively low (0) to high (1) resiliency within each geophysical setting within each geographic extent (e.g., region, watershed, ecoregion state). Note, this index differs from *IEI* in a couple of important and complementary ways. First, *IEI* is scaled by ecological system, whereas this index is scaled by geophysical setting. Thus, when combined these two indices strive to locate areas of high integrity representing the full suite of ecological systems and geophysical settings. Second, this index addresses resiliency to climate change by highlighting places with high elevation and landform diversity, under the assumption that a locally diverse and connected geophysical template will offer the greatest opportunities for systems/species to find suitable microclimates as the climate changes (i.e., a diverse abiotic stage will allow opportunities for species to redistribute themselves over time). Consequently, this index is best viewed as addressing long-term resiliency on the scale of decades to centuries.

Metadata
https://www.sciencebase.gov/catalog/file/get/53480e40e4b06f6ce034aad0?f=__disk__77%2F51%2Fac%2F7751ac6c0caa20cd42f4d3ee9a719c12ffb7b7e1

Map
http://nalcc.databasin.org/maps/new#datasets=5f15eeaf565745a08196b117fb9f0942

D1.1.3 **Terrestrial and wetland index of ecological integrity** - Raster
Stratified by system groups (or macrogroup?) and ecoregion

Input
This data layer developed by the University of Massachusetts represents relative ecological intactness (i.e., free from human modifications and disturbance) and ecologic resiliency (i.e., ability to recover from disturbance and stress) at the resolution of 30 m cells computed for both the current (2010) landscape and projected future (2030 or 2080) landscape. For more detail on IEI see the technical document on integrity. This index is (quantile) scaled by ecological system within each the geographic extent (e.g., region, watershed, ecoregion state) and thus discerns cells of relatively low (0) to high (1) integrity within each ecological system and geographic area. The scaling by ecological system helps to ensure representativeness of all ecological systems. Scaling by watershed, ecoregion or state helps to ensure that cores are well-distributed across the landscape.

Metadata
https://www.sciencebase.gov/catalog/file/get/5432cfc7e4b0b139a5822d98?f=__disk__b8%2F82%2Fa5%2Fb882a5969edab83469472af792a01f84f4d638f4&transform=1&allowOpen=true

Map
http://nalcc.databasin.org/datasets/b4eb1d4210d04026b6798e559f6e72ca

D1.1.4 **Biodiversity index weight for habitat classes** - Table
Output
To be developed by NALCC. Each ecological system can optionally be assigned a

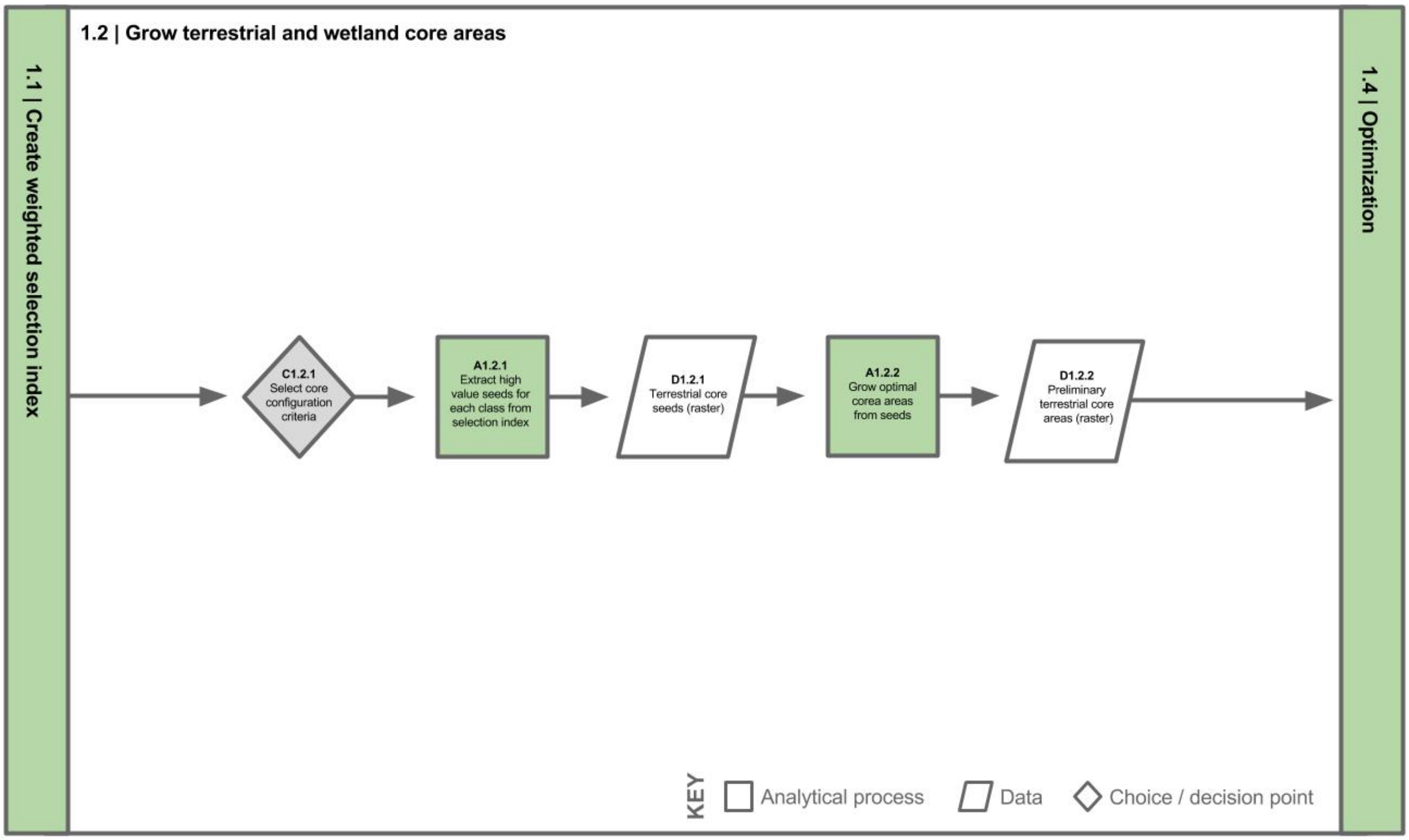
weight to increase or decrease its likelihood of inclusion in the final core areas. We propose to use a weighting based on the diversity of species associated with each ecological system (habitat class). The steps in weighting including selecting species groups, associating these species with ecological systems and calculating core biodiversity weights for each ecological system.

D1.1.5 **Combined wetland and terrestrial integrity and resilience** - Raster
Selection index combining the following spatial data products *(Weighted) index of ecological integrity (IEI)* and *Terrestrial resiliency*

D1.1.6 **Weighted terrestrial selection index for habitat classes** - Raster

1.2 | GROW TERRESTRIAL AND WETLAND CORE AREAS

The following flowchart and list of elements describe the second phase of the core areas analysis: growing terrestrial and wetland core areas. Larger version of flowchart 1.2



ANALYTICAL PROCESSES

A1.2.1 **Extract high value seeds for each class from selection index**

The next step is to build cores based on the terrestrial ecosystem-based core area selection index. The basic idea behind the core building algorithm is to select the very best places based on the selection index by "slicing" the surface above some threshold level (e.g., top 5%), which should guarantee redundant representation of all terrestrial ecological systems and geophysical settings,

A1.2.2 **Grow optimal core areas from seeds**

These "seed" areas can then be "grown out" through surrounding lower-valued (but still relatively high value) areas to create larger, contiguous cores in which the highest-value places (i.e., the "seeds") are now buffered by moderately-valued places. Growing a core area outward from the seed is constrained such that it spreads preferentially through cells with the highest value and does not cross major roads or medium-to-high density development. Note, as a result, smaller local roads and low-intensity development can and do occur within the core areas. The "growing" out process is terminated when the user-specified percentage of the landscape is included in the cores.

CHOICES / DECISION POINTS

C1.2.1 **Select core configuration criteria**

Biological consensus

Number, size and distribution

Total amount of the landscape in core areas

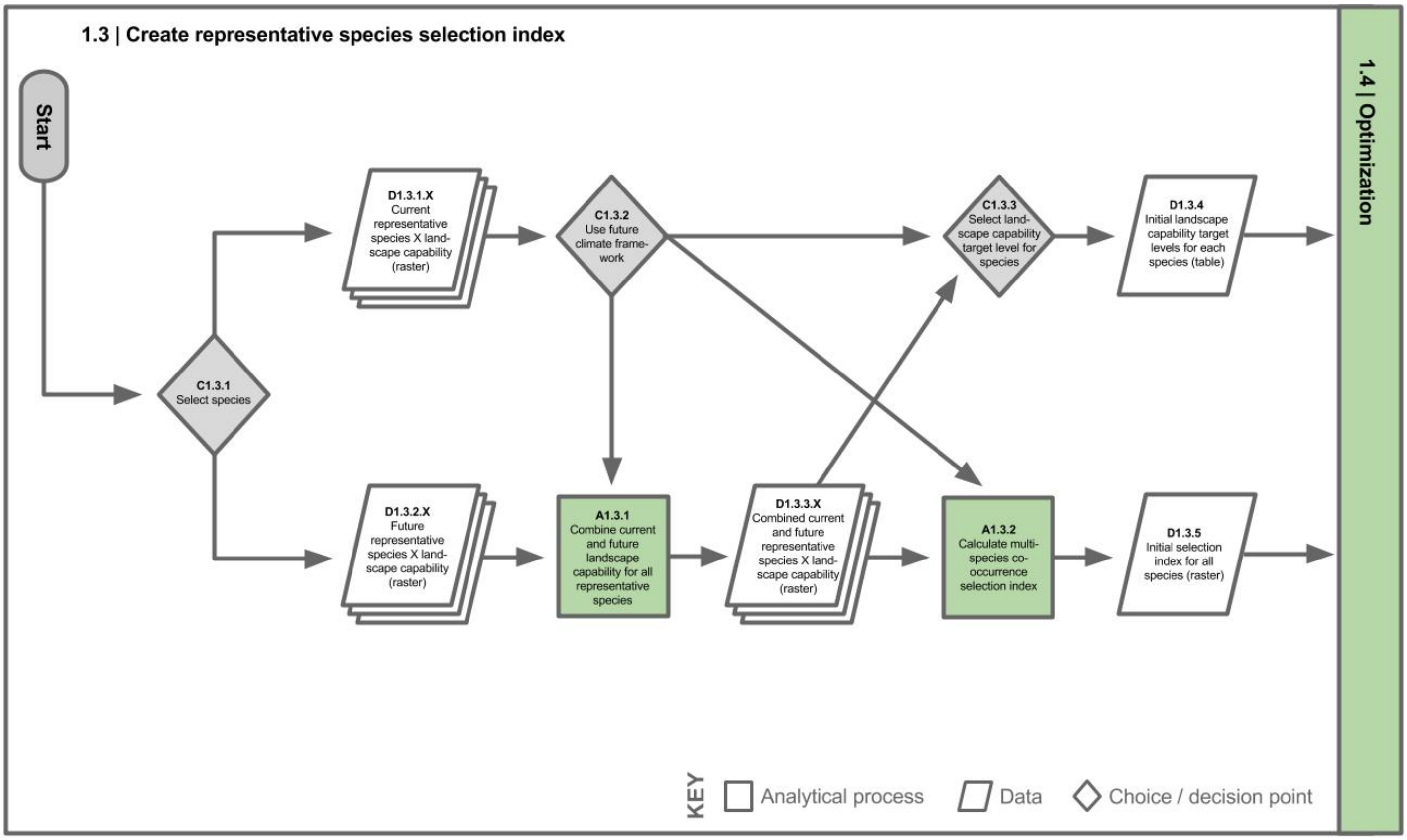
DATA

D1.2.1 **Terrestrial core seeds** - Raster

D1.2.2 **Preliminary terrestrial core areas** - Raster

1.3 | CREATING REPRESENTATIVE SPECIES SELECTION INDEX

The following flowchart and list of elements describe the third phase of the core areas analysis: creating representative species selection index. Larger version of flowchart 1.3



ANALYTICAL PROCESSES

A1.3.1 **Combine current and future landscape capability for all representative species**

The species-based approach for evaluating the Region's capability to sustain priority wildlife species under current and predicted future landscape change scenarios involves six major steps: 1) selecting a suite of representative species to represent the larger set of priority species including RSGCN species (C1.3.1) 2) developing a climate-niche model for each species, 3) developing a habitat capability model for each species, 4) developing a prevalence model for each species, and 5) combining the results of the climate, habitat, and prevalence models into a landscape capability model for each species under current conditions (D1.3.2.X) and at each time step (D1.3.3.X) under each landscape change scenario to quantify uncertainty in the predictions of species occurrence, and 6) computing the non-spatial and spatial landscape change indices for each species. Representative species table with modeling status

The result is a seamless and continuous 30 m raster grid map map showing relative landscape capability or each of the 30 representative terrestrial and wetland wildlife species across the region based on a combination of climate niche, habitat capability, and prevalence models that can help prioritize land protection, land use and open space planning, ecological restoration and habitat management by natural resource agencies and organizations.

A1.3.2 **Calculate multi-species co-occurrence selection index**
Description needed

CHOICES / DECISION POINTS

C1.3.1 **Select species**
Biological
Select a suite of representative species to represent the larger set of priority species including RSGCN species

C1.3.2 **Use future climate framework**
Biological
Users can decide whether to use the current, predicted future or combination of landscape capability

C1.3.3 **Select landscape capability target level for each species**
Biological
Users need to define a landscape capability target level for each species

DATA

D1.3.1X **Current representative species x landscape capability** - Raster
Developed by the University of Massachusetts

Map
http://nalcc.databasin.org/maps/d4da1730b27b411dbeb6260f3c1158f8/active

D1.3.2X **Future representative species x landscape capability** - Raster
Developed by the University of Massachusetts

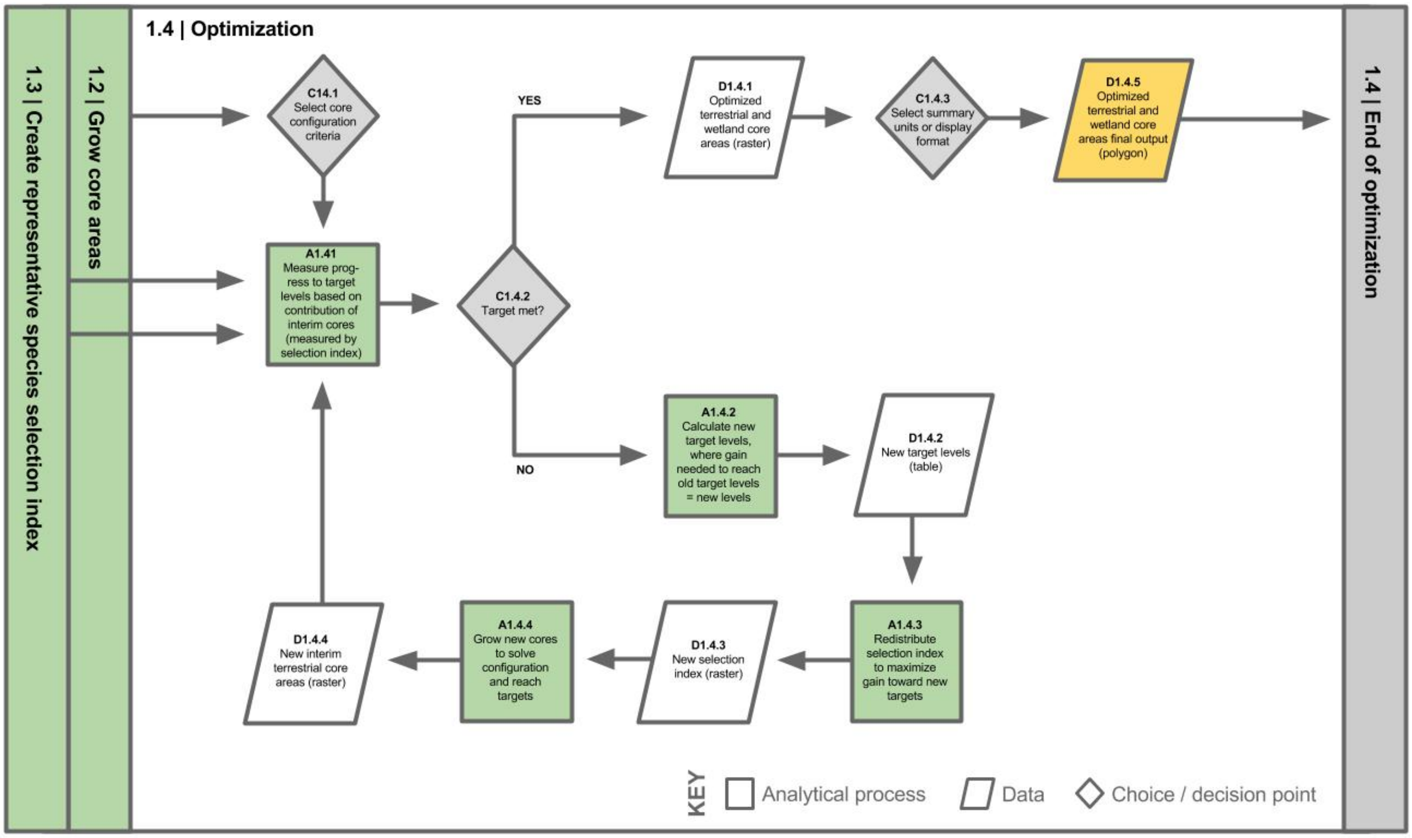
D1.3.3X **Combined current and future representative species x landscape capability** - Raster

D1.3.4 **Initial landscape capability target levels for each species** - Table

D1.3.5 **Initial selection index for all species (not a stand-alone data layer but an iterative input into optimization)** - Raster

1.4 | OPTIMIZATION

The following flowchart and list of elements describe the fourth phase of the core areas analysis: optimization. Larger version of flowchart 1.4



ANALYTICAL PROCESSES

A1.4.1 **Measure progress to target levels based on contribution of interim cores (Measured by selection index)**

The next step is to supplement the ecosystem-based cores with additional core area to partially meet the habitat needs of all representative terrestrial wildlife species. The basic idea behind this stage of the core building algorithm is to first determine how much of each species' targeted landscape capability is already included in the ecosystem-based cores, and then build additional cores to ensure that a minimum proportion of each species' landscape capability target is included in the final set of cores. The species-based cores are built sequentially, one at a time, by focusing on the species that are furthest from meeting their targets.

A1.4.2 **Calculate new target levels, where gain needed to reach old target levels = new target**

After each new core is built, the species are re-weighted based on deviations between the species' landscape capability targets and the species' total landscape capability included in the cumulative set of cores (A1.4.2, A1.4.3, A1.4.4). Thus, each new core strives to locate the best habitat for the species that are currently least well-represented in the cores. This process of building new species-based cores continues until a specified percentage of the landscape is included in the final set of cores (C1.4.2, D1.4.1).

A1.4.3 **Redistribute selection index to maximize gain toward new targets**

Thus, each new core strives to locate the best habitat for the species that are currently least well-represented in the cores. This process of building new species-based cores continues until a specified percentage of the landscape is included in the final set of cores (C1.4.2, D1.4.1).

A1.4.4 **Grow new cores to solve configuration and reach targets**

This process of building new species-based cores continues until a specified percentage of the landscape is included in the final set of cores (C1.4.2, D1.4.1).

CHOICES / DECISION POINTS

C1.4.1 **Select core configuration criteria**

Biological

C1.4.2 **Target met?**

Biological

Select targets for each species

C1.4.3 **Select summary units or display format**

Biological

DATA

D1.4.1 **Optimized terrestrial and wetland core areas** - Raster

D1.4.2 **New target levels** - Table

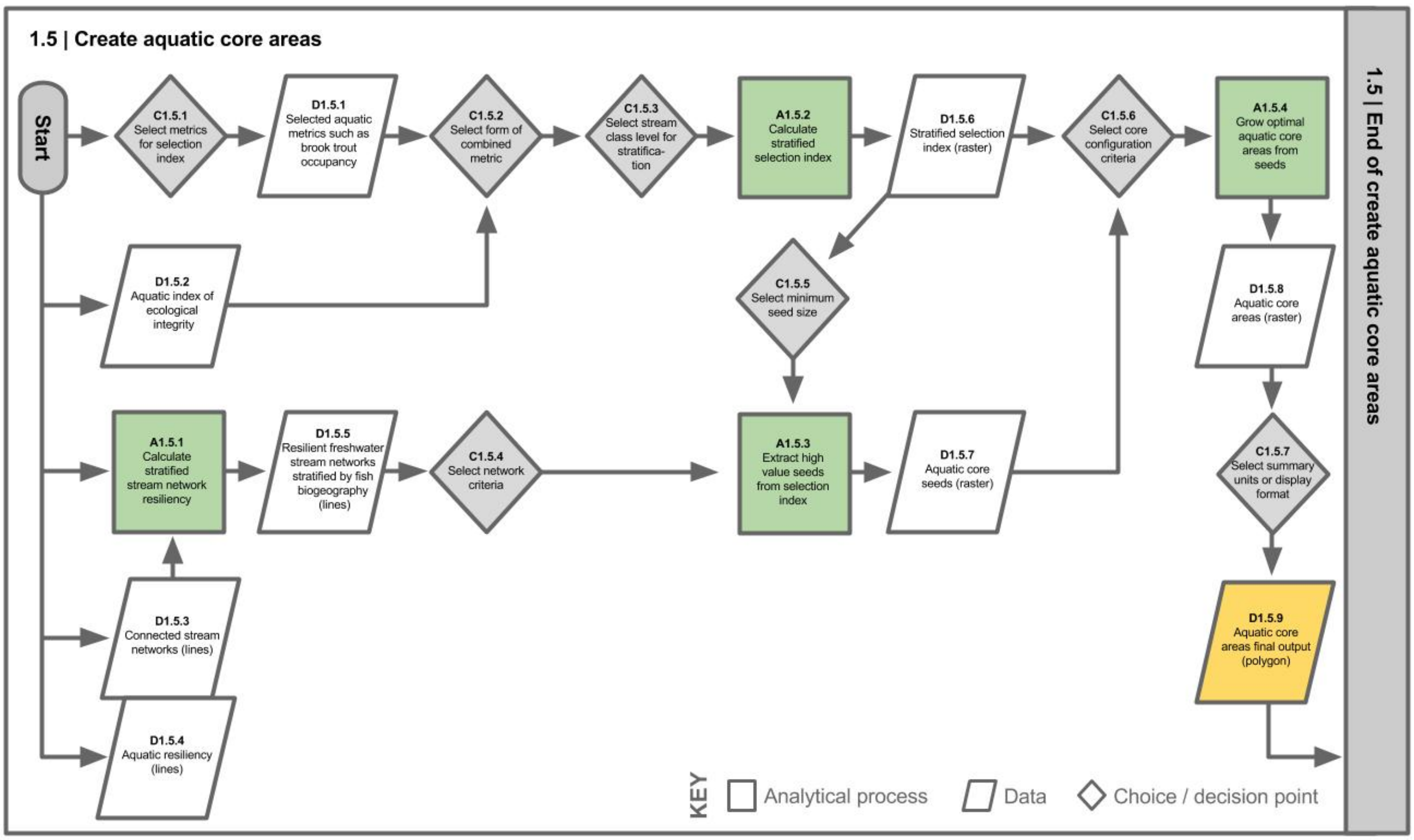
D1.4.3 **New selection index** - Raster

D1.4.4 **New interim terrestrial core areas** - Raster

D1.4.5	**Optimized terrestrial and wetland core areas final output** - Polygons Final output

1.5 | CREATE AQUATIC CORE AREAS

The following flowchart and list of elements describe the fifth phase of the core areas analysis: creating aquatic core areas. Larger version of flowchart 1.5



ANALYTICAL PROCESSES

A1.5.1 **Calculate stratified stream network resiliency**
A Freshwater Resilience Analysis evaluates characteristics of stream networks correlated with freshwater resiliency such as long linear length and high lateral (across the floodplain) connectivity, intact water quality as shaped by surrounding land use, low alterations to instream flow regime, access to groundwater, and a diversity of geophysical settings within the connected networks

A1.5.2 **Calculate stratified selection index**

Index of Ecological Integrity is weighted (by habitat class) linear combination of intactness & resiliency metrics. Metrics are weighted and combined in different ways depending upon the habitat class. Quantile-scaled (0-1) by class & extent (benchmarked to 2010). High value = high integrity. Assessment is 30m cell-based using time-of-flow kernel model to evaluate ecological influence from the watershed. A set of >10 beneficial and stressor metrics are evaluated, combined and rescaled resulting in an Index of Ecological Integrity by habitat classes.

A1.5.3 **Extract high value seeds from selection index**

The next step is to build cores based on the aquatic ecosystem-based core area selection index. Here, we build lotic cores separately from lentic cores owing to some fundamental differences between the treatment of contiguous stream networks and isolated ponds and lakes. However, the basic idea behind the core building algorithm in both cases is to select the very best places based on the selection index by "slicing" the surface above some threshold level, which should guarantee redundant representation of all aquatic ecological systems, and then "growing" out these "seed" areas through surrounding areas of lower-value areas to create larger, contiguous cores in which the highest-value places (i.e., the seeds) are now buffered.

A1.5.4 **Grow optimal aquatic core areas from seeds**

Growing a core area outward from the seed is relatively straightforward for lentic cores (ponds and lakes). If the seed meets a minimum size threshold (e.g., 0.45 ha), then the seed is grown out to include the entire water body regardless of the selection index value for these cells. Thus, the water body (pond or lake) is treated as the logical unit for lentic cores.

Creating a lotic core is somewhat more complicated. Briefly, if the seed meets a minimum size threshold (e.g., 0.45 ha), then the seed is grown out by spreading upstream and downstream (including back upstream on tributaries) along the stream centerline such that it spreads further through cells with higher value (based on the selection index) and does not spread through lakes or past a dam (of any size). The final expanded seed must exceed a minimum total stream length threshold (e.g., 1 km) to become a lotic core.

CHOICES / DECISION POINTS

C1.5.1 **Select metrics for selection index**

Biological

C1.5.2 **Select form of combined metric**

Technical

C1.5.3 **Select stream class level for stratification**
Biological

C1.5.4 **Select network criteria**
Technical

C1.5.5 **Select minimum seed size**
Technical

C1.5.6 **Select core configuration criteria**
Biological

C1.5.7 **Select summary units or display format**
Biological

DATA

D1.5.1 **Selected aquatic metrics such as brook trout occupancy**

D1.5.2 **Aquatic index of ecological integrity** - Raster
Aquatic IEI is part of the Index of Ecological Integrity but has been pulled out for demonstration purposes.

Input
Developed by the University of Massachusetts

Metadata
https://www.sciencebase.gov/catalog/file/get/5432cfc7e4b0b139a5822d98?f=__disk__b8%2F82%2Fa5%2Fb882a5969edab83469472af792a01f84f4d638f4&transform=1&allowOpen=true

Map
http://nalcc.databasin.org/datasets/0d6f673031a94d93a8a6842a17d78ab8

D1.5.3 **Connected stream networks -** Lines

D1.5.4 **Aquatic resiliency** - Lines

Input

developed by The Nature Conservancy

Metadata

https://www.sciencebase.gov/catalog/file/get/54526474e4b0d48d9fb0292d?f=__disk__0e%2F48%2F25%2F0e48251bdfd807a6b5fb733d2bfe952656d41fe2

Map

http://nalcc.databasin.org/datasets/666a31750bce4d268734bf5402f24efc

D1.5.5 **Resilient freshwater stream networks stratified by fish biogeography** - Lines

Input

developed by The Nature Conservancy

Metadata

https://www.sciencebase.gov/catalog/file/get/559b08c5e4b0b94a6401701f?f=__disk__a7%2Fbe%2F2e%2Fa7be2e3c566aeb6ff8ab92ef7503716079d7122a

Map

http://nalcc.databasin.org/maps/new#datasets=02afd711077948aebd41c3429de4d408

D1.5.6 **Stratified selection index** - Raster

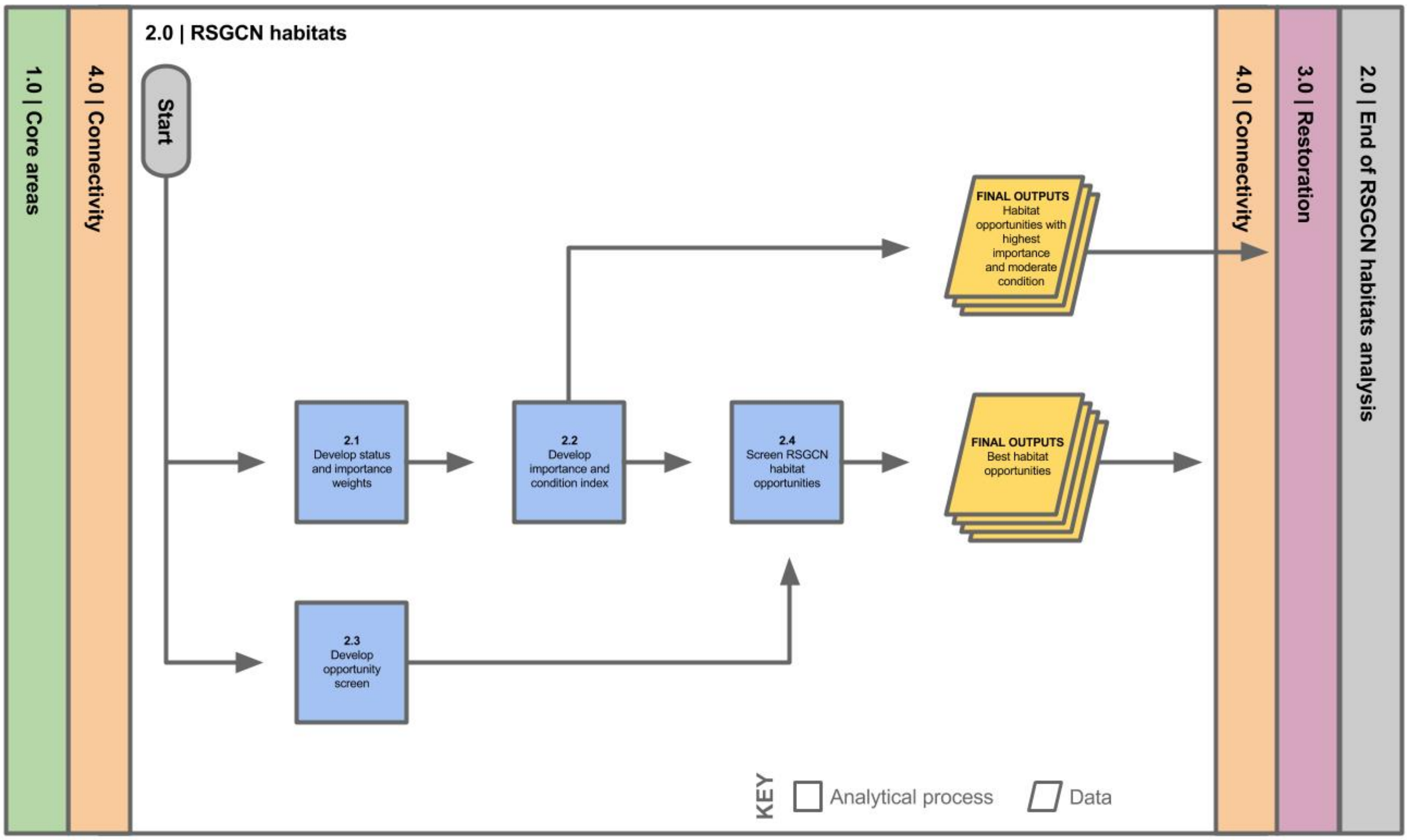
D1.5.7 **Aquatic core seeds -** Raster

D1.5.8 **Aquatic core areas** - Raster

D1.5.9 **Aquatic core areas final output** - Lines and polygons

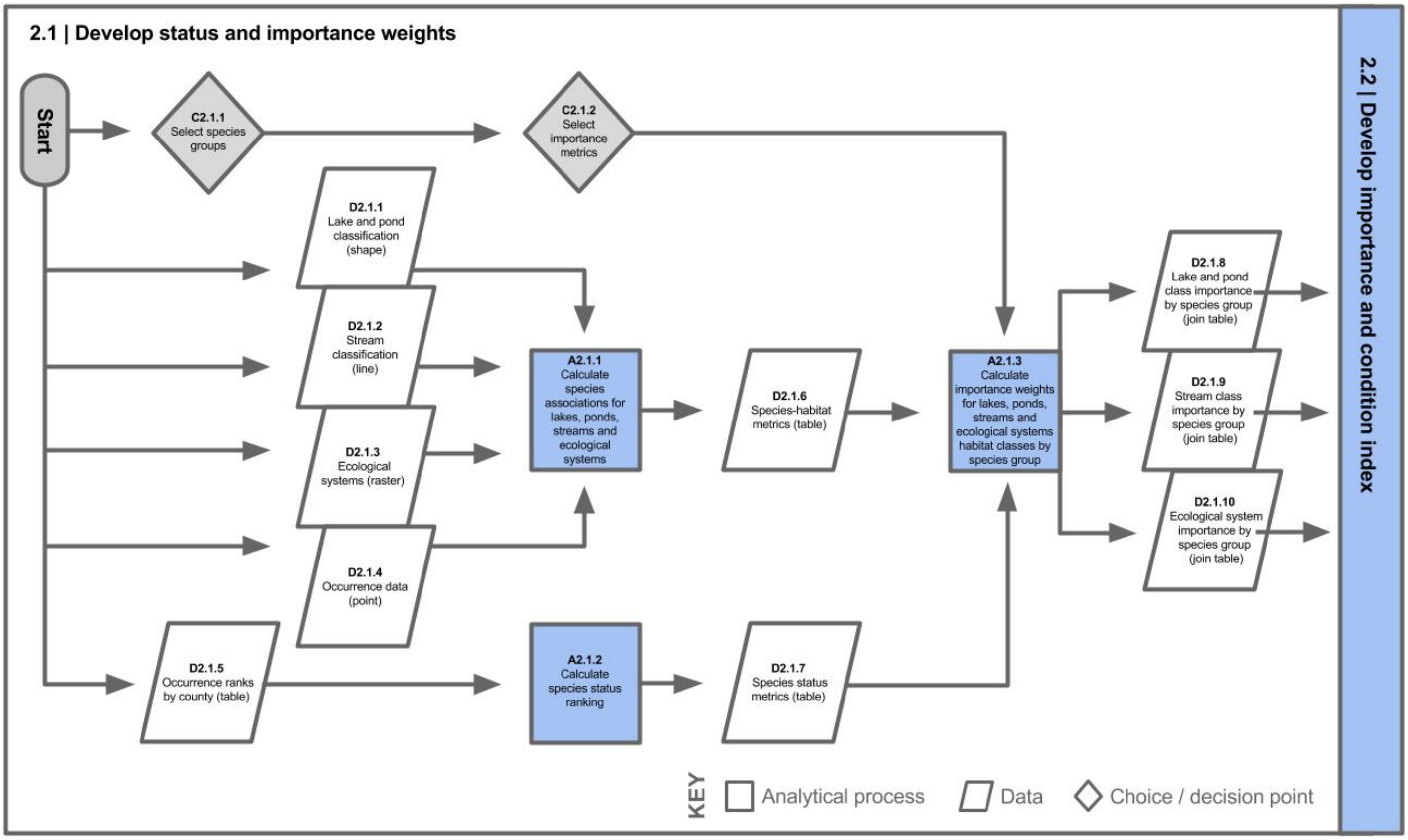
APPENDIX B: RSGCN HABITAT

2.0 | RSGCN HABITAT This overview flowchart depicts the relationships between each phase of the RSGCN and habitats analysis and how it connects to the other ROCA objectives. Larger version of flowchart 2.0



2.1 | DEVELOP STATUS AND IMPORTANCE WEIGHTS

The following flowchart and list of elements describe the first phase of the RSGCN and habitats analysis: developing status and importance weights. Larger version of flowchart 2.1



ANALYTICAL PROCESSES

A2.1.1 **Calculate species associations for lakes, ponds, streams and ecological systems**

Each point location will be assigned to a habitat class based on the underlying or co-occurring ecological system, stream, lake or pond from the relevant Northeast habitat classification (D2.1.1, D2.1.2, D2.1.3, D2.1.4) . Next, the count of each habitat class will be summarized for every tracked species, resulting in a table of the frequency of each species co-occurrence with each habitat class (D2.1.6). In this step, the data for each species could be repeatedly and randomly subsampled to control for uneven survey efforts. Next, for every class of habitat, the Northeast regional count of cells will be summarized as a constant expected frequency. The strength of species habitat associations will be measured as the deviation from the constant expected value for each class of habitat.

Habitat associations will be summarized across all species to derive the habitat importance weight for each habitat class. The species status rank (D2.1.7) may be applied as a weight to the habitat association for each species, with the result that the habitat associations for secure species contribute less to the overall importance of each habitat class, and the overall importance of habitats reflects the requirements of the most threatened species. Species with poor data quality will not be included in the weighting process (C2.1.1). The output of calculating the species associations will be a species-habitat metrics table (D2.1.6).

A2.1.2 **Calculate species status ranking**

Calculating the species status ranking will begin with summarizing each species distribution according to the proportion of the spatial extent in each category of state rank (s-rank, where SX is extinct, S1 is most imperiled, S2 is next most imperiled, etc.), currently available at the county level (D2.1.5). The entire North American distribution will be summarized for each species. The ranking formula will summarize the convergence of each distribution within the Northeast toward total imperilment or regional extirpation, where s-ranks higher levels of imperilment are assumed to indicate localities nearer to extirpation. The Northeast pattern will be compared with the pattern of convergence toward total imperilment or extinction outside of the Northeast. In the resulting status ranking, high risk species dependent on the Northeast to avert extinction will score highest, while low risk species and species not dependent on the Northeast will score lowest. The output of this process is a table of species status metrics (D2.1.7).

A2.1.3 **Calculate importance weights for lakes, ponds, streams and ecological systems habitat classes by species group**

Calculating the importance weight begins with the species-habitat metrics table (D2.1.6). The habitat importance weights may be partitioned according to groups of species, such as taxonomic groups, status, and data quality, based on expert input (C2.1.2). Habitat importance (weighted by species status) will measure the relative importance of each habitat class for RSGCN, where each habitat class has a constant importance weight across all locations (raster cells). The relative condition of each location is developed in the next analytical phase (2.2).

CHOICES / DECISION POINTS

C2.1.1 **Select species groups**

Biological

C2.1.2 **Select importance metrics**

Biological

DATA

D2.1.1 **Lake and pond classification** - Polygons
Input
Map
http://nalcc.databasin.org/maps/a6d420a916994e8088bc2895f1aa7d7

D2.1.2 **Stream classification** - Lines
Input
Map
http://nalcc.databasin.org/maps/e8ee8364ee0a4dea911a30e906f7ae15/active

D2.1.3 **Ecological systems** - Raster
Input
Metadata
https://www.sciencebase.gov/catalog/file/get/5407831ae4b09f802c9ee4da?f=__disk__38%2Fde%2F8c%2F38de8ca5bc2a4436d2e0ad5ebfd6747bf4fb4665
Map
http://nalcc.databasin.org/maps/ca5dec110aef46d1901d2ee7219d0146/active

D2.1.4 **Occurrence data** - Points
Input

D2.1.5 **Occurrence ranks by county** - Table
Input

D2.1.6 **Species-habitat metrics** - Table
Output
From calculated species associations analytical process (A2.1.1)

D2.1.7 **Species status metrics** - Table
Output
From calculated species status analytical process (A2.1.2)

D2.1.8 **Lake and pond class importance by species group** - Join table
Output
From importance weights for habitat classes by species group analytical process (A2.1.3)

D2.1.9 **Stream class importance by species group** - Join table
Output
From importance weights for habitat classes by species group analytical process (A2.1.3)

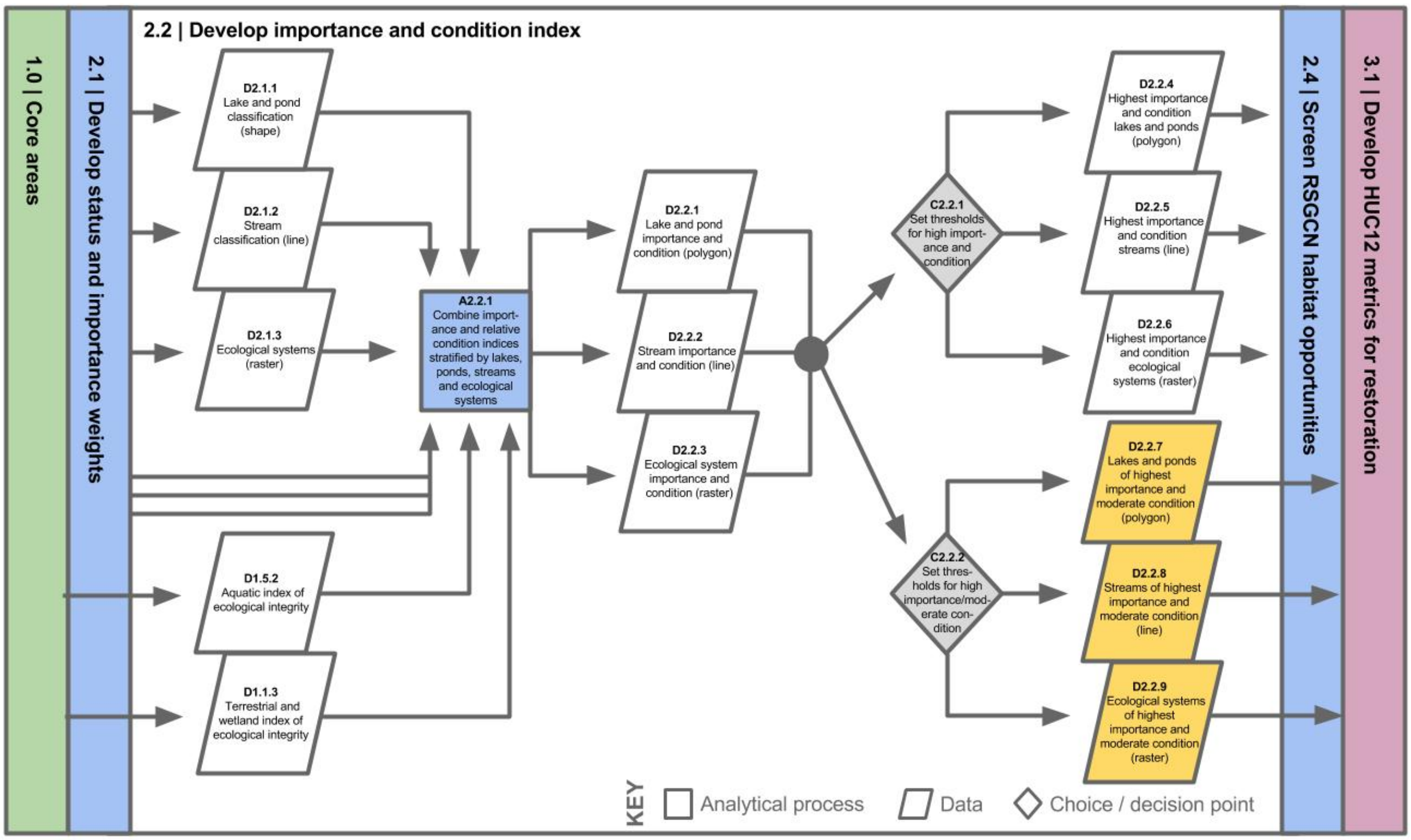
D2.1.10 **Ecological system importance by species group** - Join_table

Output

From importance weights for habitat classes by species group analytical process (A2.1.3)

2.2 | DEVELOP IMPORTANCE AND CONDITION INDEX

The following flowchart and list of elements describe the second phase of the RSGCN and habitats analysis: developing importance and condition index. [Larger version of flowchart 2.2]



ANALYTICAL PROCESSES

A2.2.1 **Combine importance and relative habitat condition indices stratified by lakes, ponds, streams and ecological systems**

In this analytical step, the importance weight developed for each class of habitat (within the ecological system (D2.1.3), stream (D2.1.2) , lake and pond (D2.1.1) classification) will first be combined with the average overall habitat condition to weight each habitat class, then the class level weight will be applied to distribute relative habitat condition at each location or raster cell. Relative habitat condition will be a weighted raster evaluating current landscape landscape features and current environmental conditions at each raster cell, stratified according to habitat classes. The combined result will also be stratified by habitat class, where 1) the highest relative condition values reflect the best examples of each class; and 2) the habitat class weight skews the values of cells so that more habitat area is represented for important habitats with increasing increments of relative habitat condition. High quality relative habitat condition data are already available, and all that is required is application of habitat importance weights for RSGCN. If the following recommendations are adopted, the combined habitat importance and condition index is analogous to the weighted selection index described above. For ecological systems, we recommend utilizing the Index of Ecological Integrity (IEI) or the combined IEI and Resilience developed above in the core areas analysis. For aquatic systems, we recommend utilizing the Aquatic Index of Ecological Integrity (D1.5.2). In both cases, the relative condition will be weighted to reflect the most important habitats for RSGN (D2.2.1, D2.2.2, D2.2.3). A threshold will be applied for each habitat class to select those that are currently in the best condition (C2.2.1). The result will be a raster map showing the best current examples of each class of important habitat (D2.2.4, D2.2.5, D2.2.6). Important RSGCN habitat locations receiving mediocre scores for current condition will be exported to the Restoration analysis (D2.2.7, D2.2.8, D2.2.9).

CHOICES / DECISION POINTS

C2.2.1 **Set thresholds for high importance and condition**
Technical

C2.2.2 **Set thresholds for high importance and moderate condition**
Technical

DATA

D2.1.1 **Lake and pond classification** - Polygons
Input

D2.1.2 **Stream classification** - Lines
Input

D2.1.3 **Ecological systems** - Raster
Input

D1.5.2 **Aquatic index of ecological integrity** - Raster

Input
Developed by The University of Massachusetts

Metadata
https://www.sciencebase.gov/catalog/file/get/5432cfc7e4b0b139a5822d98?f=__disk__b8%2F82%2Fa5%2Fb882a5969edab83469472af792a01f84f4d638f4&transform=1&allowOpen=true

Map

http://nalcc.databasin.org/datasets/0d6f673031a94d93a8a6842a17d78ab8

D1.1.3 **Terrestrial and wetland index of ecological integrity -** Raster
Stratified by system groups and ecoregion

Input
Developed by The University of Massachusetts

Metadata
https://www.sciencebase.gov/catalog/file/get/5432cfc7e4b0b139a5822d98?f=__disk__b8%2F82%2Fa5%2Fb882a5969edab83469472af792a01f84f4d638f4&transform=1&allowOpen=true

Map
http://nalcc.databasin.org/datasets/b4eb1d4210d04026b6798e559f6e72ca

D2.1.8 **Lake and pond class importance by species group** - Join table
Input
From developing status and importance weights (2.1)

D2.1.9 **Stream class importance by species group** - Join table
Input
From developing status and importance weights (2.1)

D2.1.10 **Ecological system importance by species group** - Join table
Input
From developing status and importance weights (2.1)

D2.2.1 **Lake and pond importance and condition** - Polygons
Output
From combining importance and relative condition indices analytical process (A2.2.1)

D2.2.2 **Stream importance and condition** - Lines
Output
From combining importance and relative condition indices analytical process (A2.2.1)

D2.2.3 **Ecological system importance and condition** - Raster
Output
From combining importance and relative condition indices analytical process (A2.2.1)

D2.2.4 **Highest importance and condition lakes and ponds** - Polygons
Output
From the thresholds for high importance and condition decision (C2.2.1)

D2.2.5 **Highest importance and condition streams** - Lines
Output
From the thresholds for high importance and condition decision (C2.2.1)

D2.2.6 **Highest importance and condition ecological systems** - Raster
Output
From the thresholds for high importance / condition decision (C2.2.1)

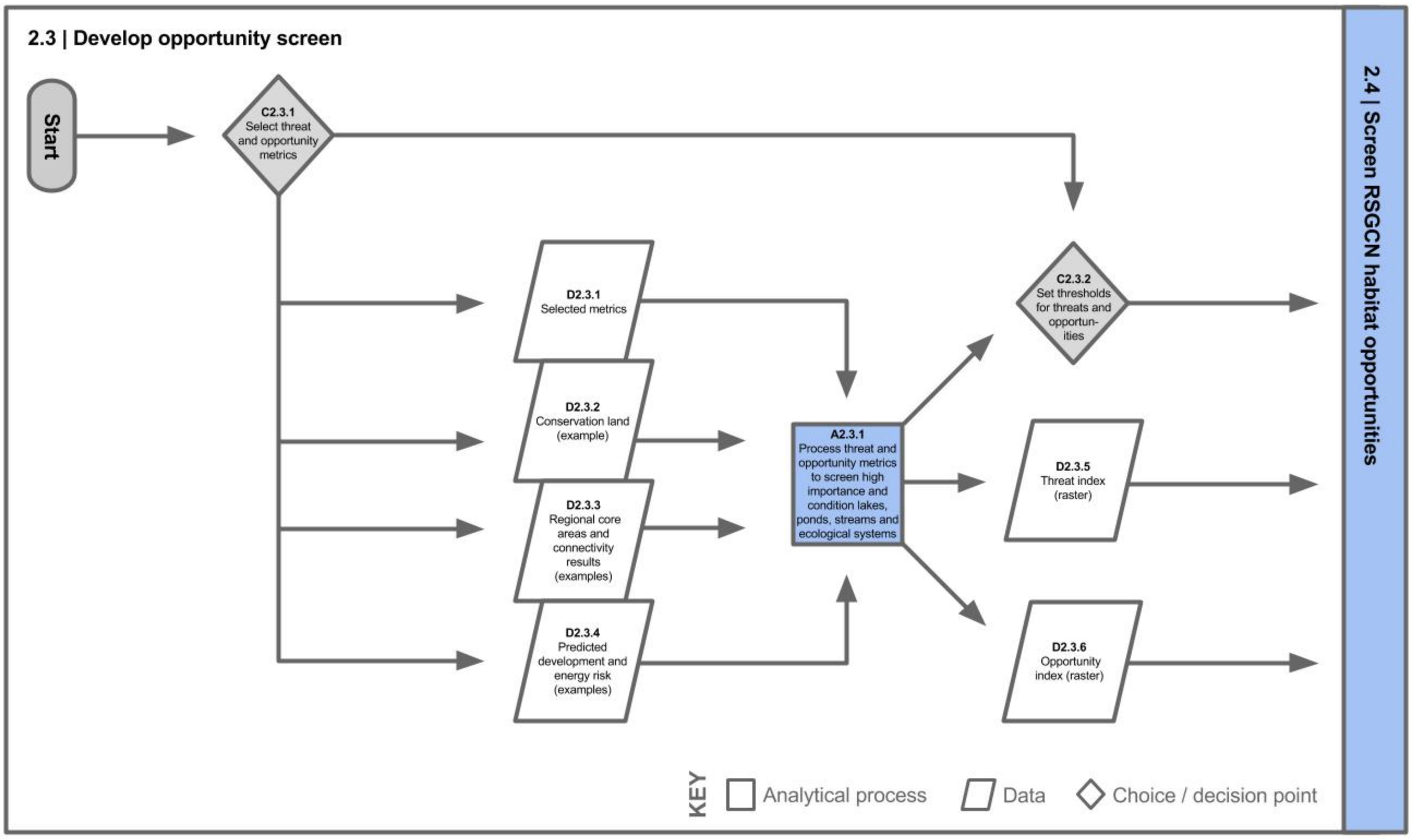
D2.2.7 **Lakes and ponds of highest importance and moderate condition** - Polygons
Final output
From the thresholds for high importance and moderate condition decision (C2.2.2)

D2.2.8 **Streams of highest importance and moderate condition** - Line
Final output
From the thresholds for high importance and moderate condition decision (C2.2.2)

D2.2.9 **Ecological systems of highest importance and moderate condition** - Raster
Final output
From the thresholds for high importance and moderate condition decision (C2.2.2)

2.3 | DEVELOP OPPORTUNITY SCREEN

The following flowchart and list of elements describe the third phase of the RSGCN and habitats analysis: developing opportunity screen. Larger version of flowchart 2.3



ANALYTICAL PROCESSES

A2.3.1 **Process threat and opportunity metrics to screen high importance and condition lakes, ponds, streams and ecological systems**

In this analytical step, unique factors that inhibit RSGCN future security (threat metrics) and/or enhance future implementation of land protection (opportunity metrics) will be processed to create an index of opportunity. The metrics will be selected based on expert consensus (C2.3.1). High scoring threat metrics (beyond the factors included in the current condition index above) will diminish the opportunity for land protection, and high scoring opportunity factors will increase the index. The threat and opportunity metrics may be customized (labor intensive for decision makers and technicians) for each habitat class, or generalized to reflect broad indicators of threat (such as energy development potential) and opportunity (such as current conservation status). Each metric will be weighted to screen the best opportunities, and the result of the analysis will be an index of threat (D2.3.5) and opportunity (D2.3.6) for each raster cell. Decision rules and threshold levels to select opportunities will be developed in conjunction with experts (C2.3.2).

CHOICES / DECISION POINTS

C2.3.1 **Select threat and opportunity metrics**
Biological

C2.3.2 **Set thresholds for threats and opportunities**
Technical

DATA

D2.3.1 **Selected metrics**
Output
From selected threat and opportunity metrics decision (C2.3.1)

D2.3.2 **Conservation land** - Polygons
Input
Developed by The Nature Conservancy

Metadata
https://www.sciencebase.gov/catalog/file/get/555ca345e4b0a92fa7eb6a99?f=__disk__0c%2F9e%2Fc5%2F0c9ec5b90a1bcb31d7791a0502a63a37abe77199

Map
http://nalcc.databasin.org/maps/new#datasets=4906816f489244638b93e0de3e93fbbb

D2.3.3 **Regional core and connectivity results**
Input
From core areas and connectivity analyses

D2.3.4 **Predicted development and energy risk**
Input

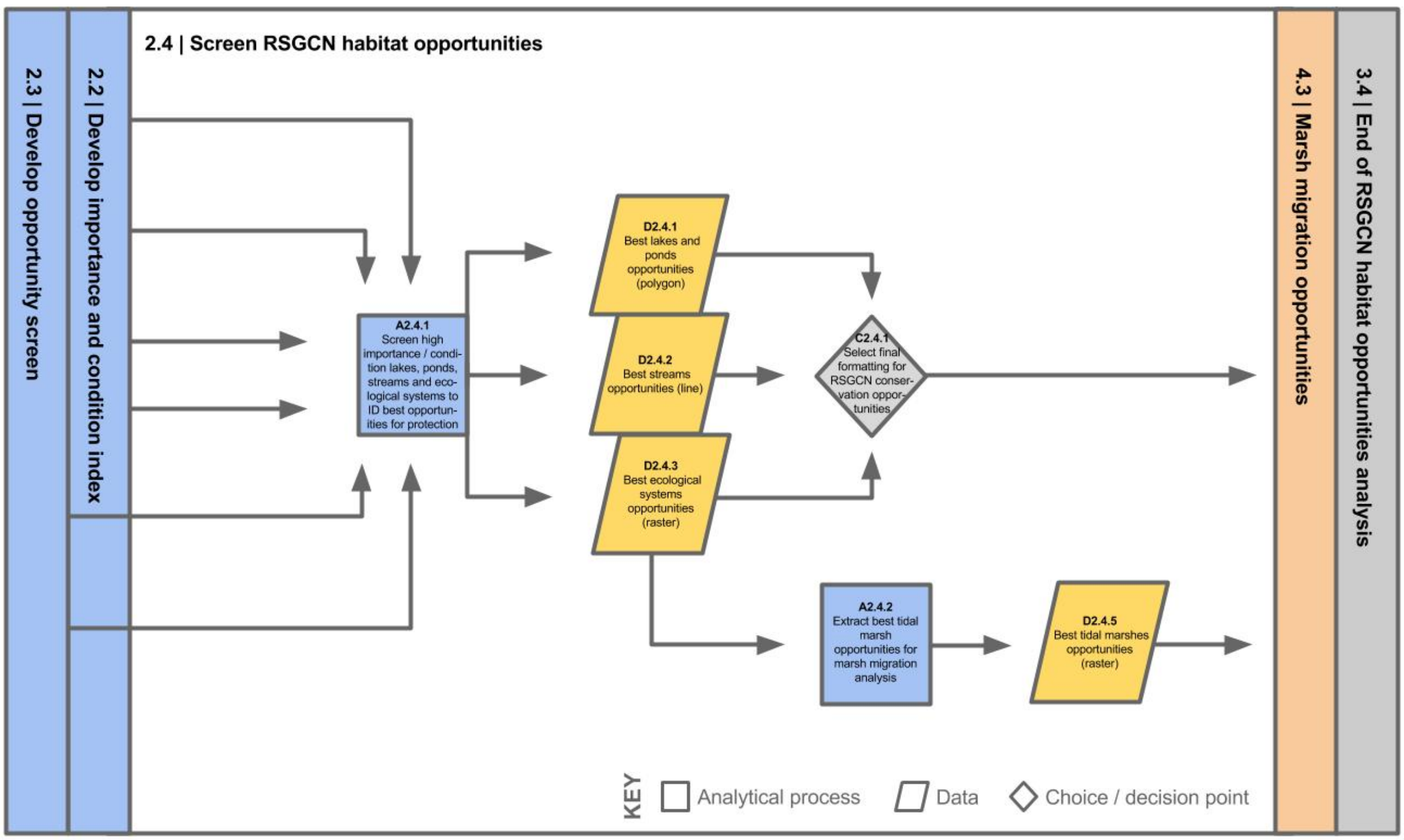
D2.3.5 **Threat screens** - Raster
Output
From threat and opportunity metrics screen for high importance and condition analytical process (A2.3.1)

D2.3.6 **Opportunity screens** - Raster
Output

From threat and opportunity metrics screen for high importance and condition analytical process (A2.3.1)

2.4 | RSGCN HABITAT OPPORTUNITIES

The following flowchart and list of elements describe the fourth phase of the RSGCN and habitats analysis: screening RSGCN habitat opportunities. Larger version of flowchart 2.4



ANALYTICAL PROCESSES

A2.4.1 **Screen high importance and condition lakes, ponds, streams and ecological systems to identify best opportunities for protection**

The final RSGCN Habitat opportunity screening will process the best examples (highest condition) of the most important habitats for RSGCN in combination with the indices of threat and opportunity (2.3). Threshold levels and/or decision rules for threats and opportunities will be applied to the best examples of the most important habitats for RSGCN to identify the best opportunities for each class of habitat (D2.4.1, D2.4.2, D2.4.3).

A2.4.2 **Extract best tidal marsh opportunities for marsh migration analysis**
The best tidal marsh opportunities will be exported for further analysis of marsh migration opportunities (D2.4.5).

CHOICES / DECISION POINTS

C2.4.1 **Select final formatting for RSGCN conservation opportunities**
Technical

DATA

D2.4.1 **Best lakes and ponds opportunities** - Polygons
Final output
From screen for high importance and condition to identify the best opportunities for protection analytical process (A2.4.1)

D2.4.2 **Best streams opportunities** - Lines
Final output
From screen for high importance and condition to identify the best opportunities for protection analytical process (A2.4.1)

D2.4.3 **Best ecological systems opportunities** - Raster
Final output
From screen for high importance and condition to identify the best opportunities for protection analytical process (A2.4.1)

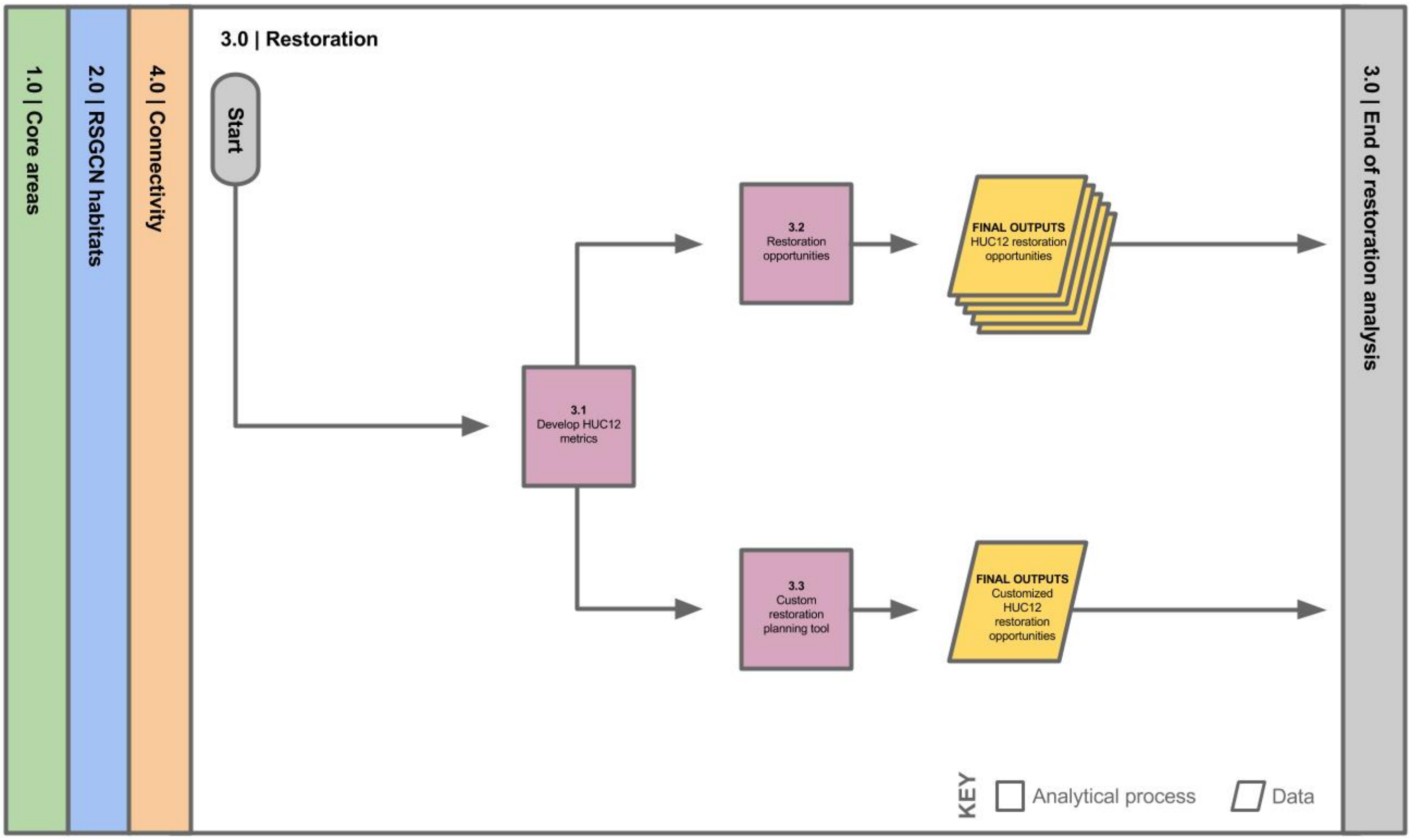
D2.4.4 **Best tidal marshes opportunities** - Raster
Final output
From extraction of tidal marsh opportunities analytical process (A2.6.1)

Map
http://nalcc.databasin.org/datasets/2010e21c6b7842d29cb11e3ecfeb9086

APPENDIX C: RESTORATION

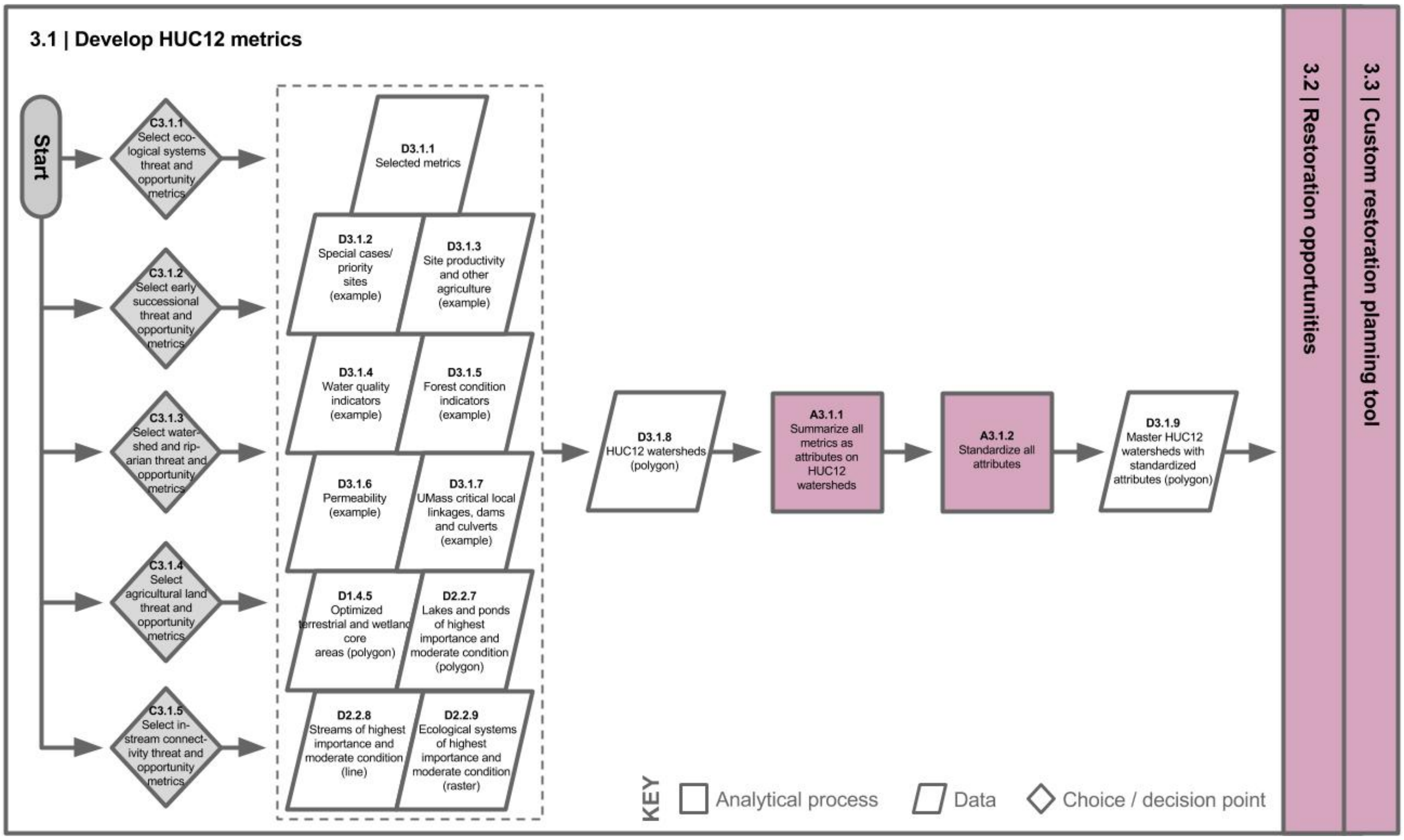
3.0 | RESTORATION

This overview flowchart depicts the relationships between each phase of the restoration analysis and how it connects to the other RCOA objectives. Larger version of flowchart 3.0



3.1 | DEVELOP HUC12 METRICS

The following flowchart and list of elements describe the first phase of the restoration analysis: developing HUC12 metrics. [Larger version of flowchart 3.1]



ANALYTICAL PROCESSES

A3.1.1 **Summarize all metrics as attributes on HUC12 watersheds**

The result of this analysis will serve as the basis for queries and customizable weighting exercises to identify a wide range of restoration opportunities. A significant precursory decision step is refining specific priority habitat requirements for restoration and associated opportunity metrics; key categories of restoration that could benefit from this approach have been identified from a data availability perspective (C3.1.1 through C3.1.5). When appropriate metrics for screening restoration sites have been identified, each metric (D3.1.2 through D3.1.6, see also examples) will be summarized on HUC12 watershed units (D3.1.1). HUC12 units were selected because they obscure potential target properties, yet provide enough location precision to guide implementation efforts.The interim output will be a HUC12 attribute table containing fields summarizing opportunity metrics relevant to each category of restoration; this output will serve only as an input to the following step (A3.1.2).

A3.1.2 **Standardize all attributes**

The result of this analysis makes it possible to weigh many different metrics with otherwise incompatible numeric ranges or scales. each metric will be converted to a quantile scaling, where the highest and lowest values of each metric have equitable scores. Quantile scores are robust to differences in the shape of distributions. The output from this analysis will be a master HUC12 attribute table containing standardized scores for each metric.

CHOICES / DECISION POINTS

C3.1.1 **Select threat and opportunity metrics for ecological system restoration**

Biological consensus

A survey will be provided to implementers and biological experts to ascertain priority habitat attributes and relevant metrics. Based on survey results, metrics will be developed contingent on data availability.

C3.1.2 **Select threat and opportunity metrics for early successional restoration**

Biological consensus

A survey will be provided to implementers and biological experts to ascertain priority habitat attributes and relevant metrics. Based on survey results, metrics will be developed contingent on data availability.

C3.1.3 **Select threat and opportunity metrics for watershed and riparian restoration**

Biological consensus

A survey will be provided to implementers and biological experts to ascertain priority habitat attributes and relevant metrics. Based on survey results, metrics will be developed contingent on data availability.

C3.1.4 **Select threat and opportunity metrics for agricultural land restoration**

Biological consensus

A survey will be provided to implementers and biological experts to ascertain priority habitat attributes and relevant metrics. Based on survey results, metrics will be developed contingent on data availability.

C3.1.5 **Select threat and opportunity metrics for in-stream connectivity restoration**

Biological consensus

A survey will be provided to implementers and biological experts to ascertain priority habitat attributes and relevant metrics. Based on survey results, metrics will be developed contingent on data availability.

DATA

D3.1.1 **Selected metrics**

D3.1.2 **Special cases/priority sites** (example metric)

D3.1.3 **Site productivity and other agricultural factors** (example metric)

D3.1.4 **Water quality indicators** (example metric)

D3.1.5 **Forest condition indicators** (example metric)

D3.1.6 **Permeability** (example metric)
Raster data Input
From The Nature Conservancy

D3.1.7 **UMass critical local linkages, dams and culverts** (example metric)
Point data Input
From The University of Massachustts

Maps
Culverts
http://nalcc.databasin.org/datasets/8baacdc6f9444fa98ad70c743d9cc4b3

Dams
http://nalcc.databasin.org/datasets/a683001e809e4cc597abe706ca2e7f23

D1.4.5 **Optimized terrestrial and wetland core areas final output** - Polygon data input
From core areas optimization (1.4)

D2.2.7 **Lakes and ponds of highest importance and moderate condition** - Polygons
Input
From RSGCN and habitats development of importance and condition index (2.2)

D2.2.8 **Streams of highest importance and moderate condition** - Lines
Input
From RSGCN and habitats development of importance and condition index (2.2)

D2.2.9 **Ecological systems of highest importance and moderate condition** - Raster
Input
From RSGCN and habitats development of importance and condition index (2.2)

D3.1.8 **HUC12 watersheds** - Polygons
Summarization unit

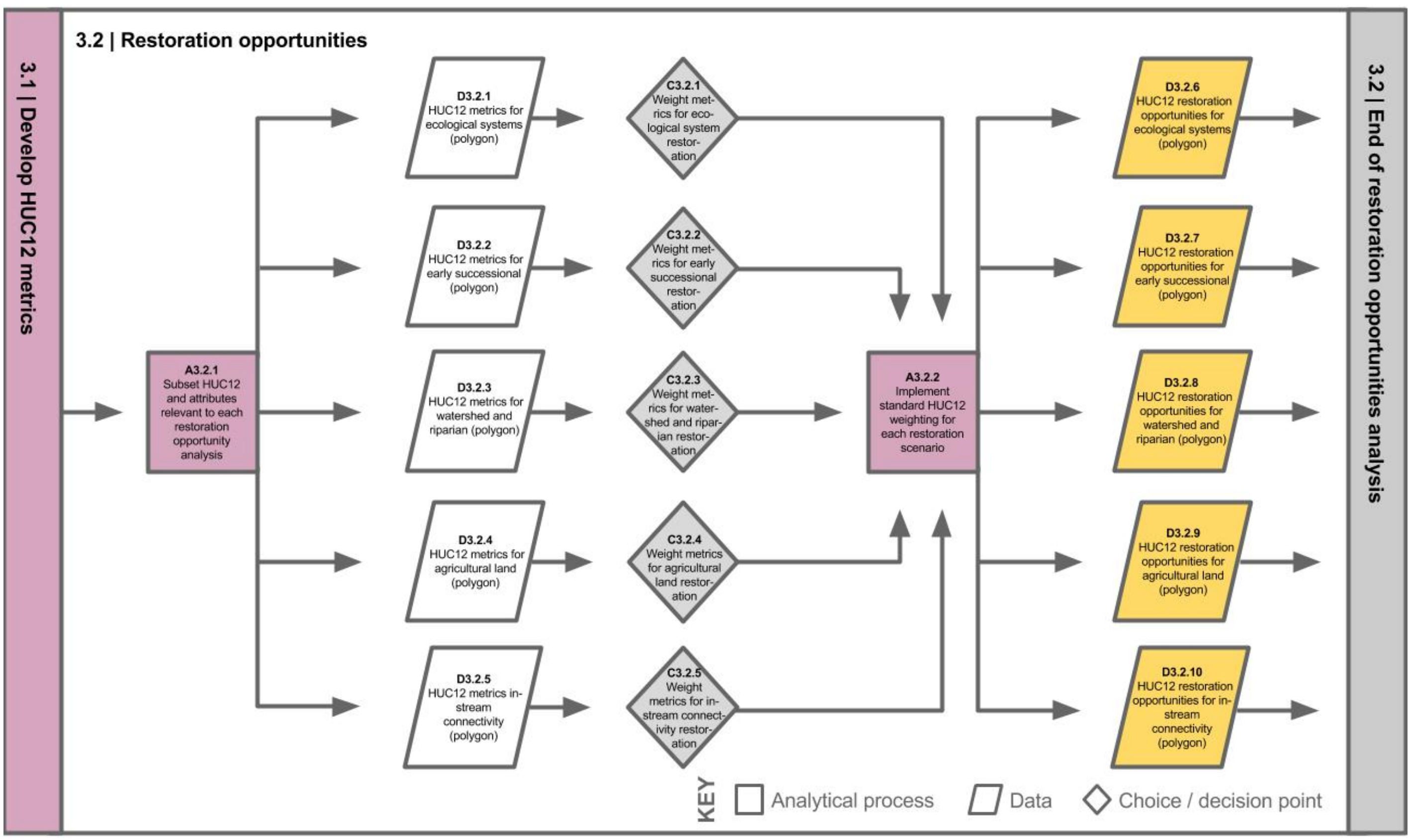
D3.1.9 **Master HUC12 watersheds with standardized metric attributes** - Polygons

Output

From standardizing all attributes analytical process (A3.1.2)

3.2 | RESTORATION OPPORTUNITIES

The following flowchart and list of elements describe the second phase of the restoration analysis: restoration opportunities. Larger version of flowchart 3.2



ANALYTICAL PROCESSES

A3.2.1 **Subset HUC12 and attributes relevant to each restoration opportunity analysis**

The result of this process is a simple reduction of the fields in the master HUC12 metric attribute table to only those relevant to each category of restoration. The output will be five HUC12 attribute tables containing only the relevant metrics (D3.2.1 through D3.2.5)

A3.2.2 **Implement standard HUC12 weighting for each restoration scenario**

The result of this process will provide a summary index scoring each HUC12 watershed on the strength of opportunities to implement each category of restoration. The scores could be used to prioritize locations for on the ground assessment of implementation feasibility. A precursory step is consensus development of weights for opportunity factors relevant to each category; once weights are developed (C3.2.1 through C3.2.5), they will be applied using the NALCC Conservation Opportunity Analyst tool, which applies weights to metrics selected from the input shapefile and attribute tables (D3.2.1 through D3.2.5). The output will be a HUC12 shapefile containing the input metrics and with a new attribute scoring each watershed for restoration opportunity. Maps of focus areas for restoration may be produced from this dataset.

CHOICES / DECISION POINTS

C3.2.1 **Weight metrics for ecological system restoration**

Biological

C3.2.2 **Weight metrics for early successional restoration**

Biological

C3.2.3 **Weight metrics for watershed and riparian restoration**

Biological

C3.2.4 **Weight metrics for agricultural land restoration**

Biological

C3.2.5 **Weight metrics for in-stream connectivity restoration**

Biological

DATA

D3.2.1 **HUC12 metrics for ecological systems** - Polygons

Output

From subset HUC12 and attributes relevant to ecological systems analytical process (A3.2.1)

D3.2.2 **HUC12 metrics for early successional** - Polygons

Output

From subset HUC12 and attributes relevant to early successional analytical process (A3.2.1)

D3.2.3 **HUC12 metrics for watershed and riparian** - Polygons
Output
From subset HUC12 and attributes relevant to watershed and riparian analytical process (A3.2.1)

D3.2.4 **HUC12 metrics for agricultural land** - Polygons
Output
From subset HUC12 and attributes relevant to agricultural land analytical process (A3.2.1)

D3.2.5 **HUC12 metrics for in-stream connectivity** - Polygons
Output
From subset HUC12 and attributes relevant to in-stream connectivity analytical process (A3.2.1).

D3.2.6 **HUC12 restoration opportunities for ecological systems** - Polygons
Final output
From implementation of regional standard HUC12 weighting for ecological systems analytical process (A3.2.2). Contains ranked polygons that can be mapped as focus areas for restoration.

D3.2.7 **HUC12 restoration opportunities for early successional** - Polygons
Final output
From implementation of regional standard HUC12 weighting for early successional analytical process (A3.2.2). Contains ranked polygons that can be mapped as focus areas for restoration.

D3.2.8 **HUC12 restoration opportunities for watershed and riparian** - Polygons
Final output
From implementation of regional standard HUC12 weighting for watershed and riparian analytical process (A3.2.2). Contains ranked polygons that can be mapped as focus areas for restoration.

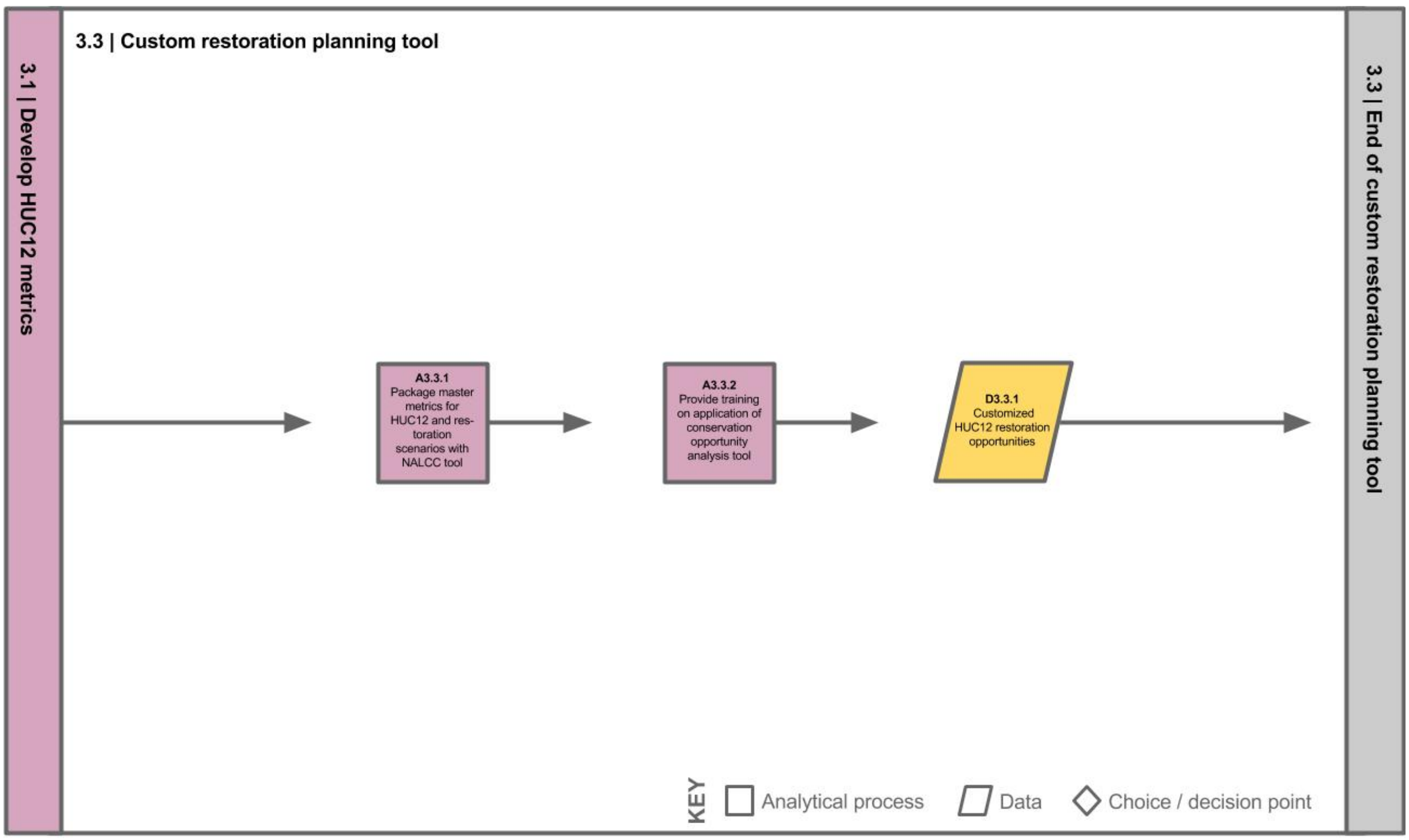
D3.2.9 **HUC12 restoration opportunities for agricultural land** - Polygons
Final output
From implementation of regional standard HUC12 weighting for agricultural land analytical process (A3.2.2). Contains ranked polygons that can be mapped as focus areas for restoration.

D3.2.10 **HUC12 restoration opportunities for in-stream connectivity** - Polygons
Final output

From implementation of regional standard HUC12 weighting for in-stream connectivity analytical process (A3.2.2). Contains ranked polygons that can be mapped as focus areas for restoration.

3.3 | CUSTOM RESTORATION PLANNING TOOL

The following flowchart and list of elements describe the third phase of the restoration analysis: custom restoration planning tool. [Larger version of flowchart 3.3]



ANALYTICAL PROCESSES

A3.3.1 **Package master HUC12 metrics and metrics for each restoration scenario with NALCC conservation opportunity analysis tool**

The result of this process will be a self-contained package of regional results, data, and a tool that can be used to develop customized prioritization queries for each category of restoration. The package will be delivered to interested partners. Using the data and tools in the package, users will be able to refine regional results for local relevancy. The output provided by NALCC will be the package of restoration conservation opportunity analysis products.

A3.3.2 **Provide training on application of conservation opportunity analysis tool**
NALCC will provide guidance on the applications of data contained in each restoration scenario package using the conservation opportunity analysis tool. Partners may add high quality local data to complement regional data and derive user-defined outputs (D3.3.1) after receiving guidance.

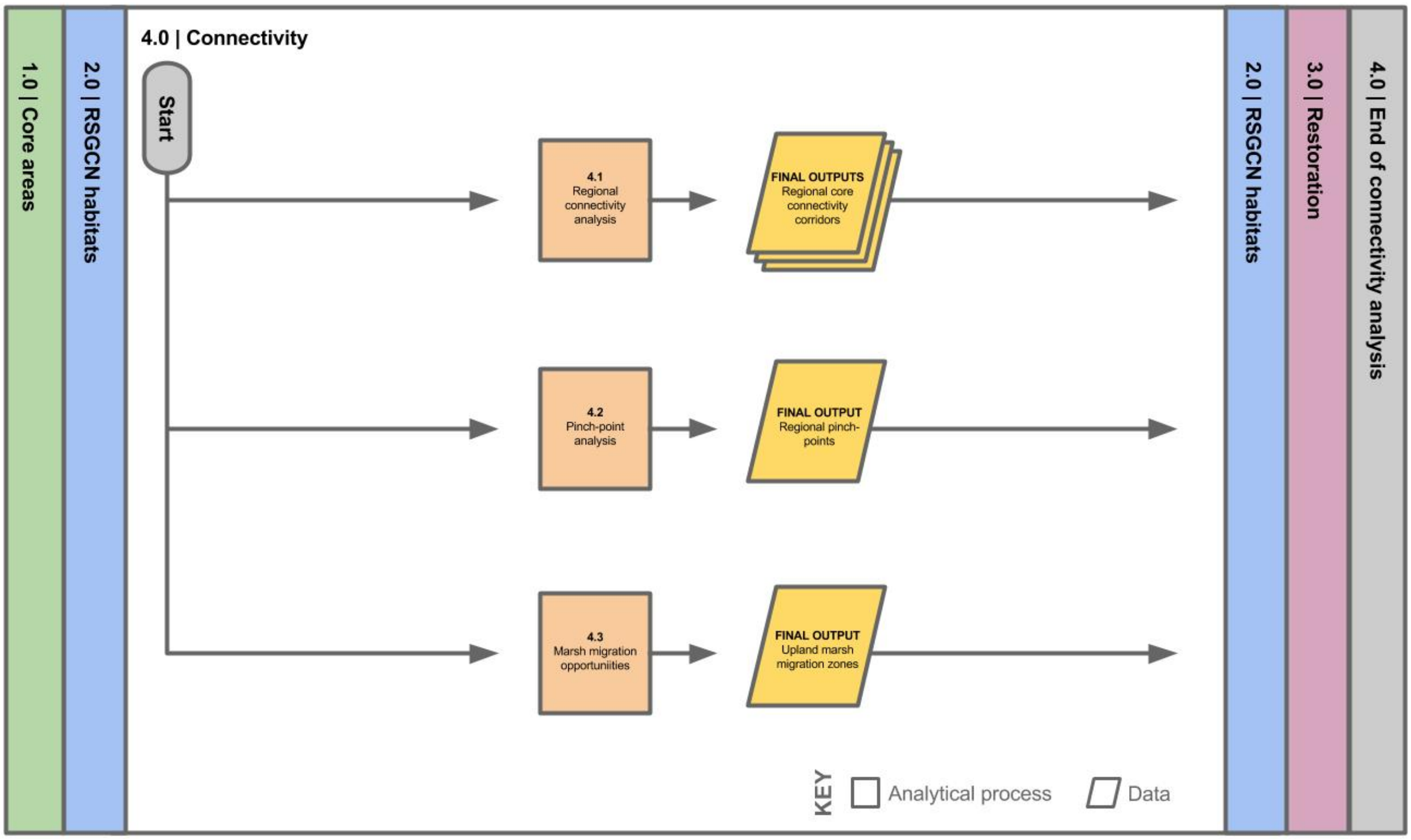
DATA

D3.3.1 **Customized HUC12 restoration opportunities**
Final customized outputs from conservation opportunity analysis tool. The final customized outputs will be user-defined and may be used in conjunction with regional outputs.

APPENDIX D: CONNECTIVITY

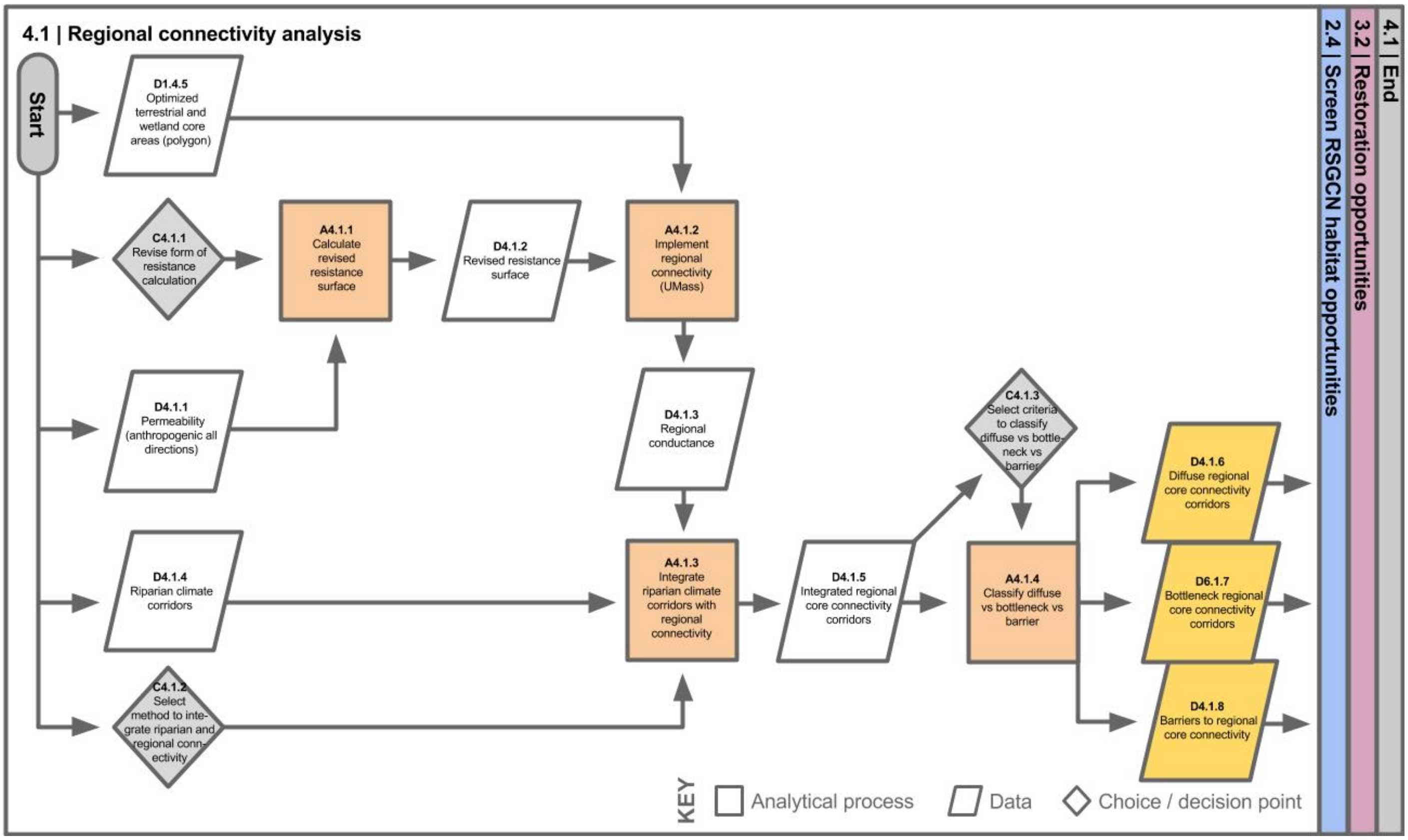
4.0 | CONNECTIVITY

This overview flowchart depicts the relationships between each phase of the connectivity analysis and how it connects to the other RCOA objectives. Larger version of flowchart 4.0



4.1 | REGIONAL CONNECTIVITY ANALYSIS

The following flowchart and list of elements describe the first phase of the connectivity analysis: regional connectivity analysis. Larger version of flowchart 4.1



ANALYTICAL PROCESSES

A4.1.1 **Calculate revised resistance surface**

Calculating a resistance surface is a precursory step to implementation of A4.1.2. Regional core connectivity analysis (Umass), utilizes a least cost path analysis to map corridors between specified nodes (D1.4.5, optimized terrestrial and wetland core areas). A required raster data input is a surface containing cellular estimates of the resistance or "cost" of animal movement through a cell, based on local environmental settings. The resistance (or cost) surface will be calculated to integrate the UMass resistance estimates with large-scale estimates of anthropogenically influenced permeability (D4.1.1, TNC) In the TNC model, the least costly paths of movement (flows) are calculated iteratively for every direction in the Circuitscapes software package, where for each iteration the model is run across the Northeast region between a pair of linear terminals positioned at opposite sides of the region. The position of the terminals is rotated through 360 degrees and the effect of every direction is averaged, eliminating directional bias inherent to a node-based approach. Integrating the two approaches is expected to increase the co-occurrence of node-based least-cost corridors with larger and less biased patterns of regional connectivity. The output of this step is revised resistance (D4.1.2).

A4.1.2 **Implement regional core connectivity (UMass)**

The results of this analysis will provide a map of corridors connecting core areas. The key raster data inputs to this process are D1.4.5 (optimized terrestrial and wetland core areas) and D4.1.2 (revised resistance). In the first step a least-cost path algorithm is applied to the resistance surface, generating many randomized low cost pathways between each pair of core areas within a specified cost distance. In the second step the number of low cost pathways that traverse each cell are summed; the result (D4.1.3) is termed conductance by UMass. In the final step, all cells with conductance less than a specified value are to zero; all cells with conductance above the threshold will therefore be identified in the regional connectivity result (D4.1.4) as a corridor.

A4.1.3 **Integrate riparian climate corridors with regional core connectivity**

The results of this process will provide a map of riparian connectivity zones and corridors between core areas, emphasizing those corridors that pass through riparian connectivity zones. The key raster data inputs to this process are D4.1.3 (regional connectivity) and D4.1.4 (riparian climate corridors). The form of the combining calculations has not been determined. Many simple alternatives are available, such as calculating a riparian proximity surface, applying proximity to weight corridors, then combining the input data. The desired output is a single raster depicting weighted regional corridors and riparian zones (D4.1.5).

A4.1.4 **Classify diffuse vs bottleneck vs barrier**

In general, the physical landscape structure filtered through various connectivity analyses creates areas of high and low concentrations (flows) of expected animal movement, similar to the diffuse flow, braided channels, and concentrated channels one associates with a river system. The integrated regional core connectivity corridor results (D4.1.5) are expected to have similar variations in predicted concentration. The integrated regional core connectivity will be more interpretable if recognizable connectivity patterns are labeled as diffuse, bottleneck, and barrier. Criteria will be developed to classify each category. Cells satisfying the criteria will be assigned a value and all other cells will be set to zero. The desired output is a set of raster data layers, each containing diffuse zones (D4.1.6), bottlenecks (D4.1.7), or barriers (D4.1.8).

CHOICES / DECISION POINTS

C4.1.1 **Revise form of resistance calculation**
Technical

C4.1.2 **Select method to integrate riparian and regional connectivity**
Technical

C4.1.3 **Select criteria to classify diffuse vs bottleneck vs barrier**
Technical

DATA

D4.1.1 **Permeability (anthropogenic all directions)** - Raster
Input
From The Nature Conservancy

D4.1.2 **Revised resistance surface**
Output
From revised resistance surface analytical process (A4.1.1)

D1.4.5 **Optimized terrestrial and wetland core areas final output** - Polygons
Input
From core areas optimization analysis (1.4)

D4.1.3 **Regional conductance** - Raster
Output
From UMass regional connectivity analytical process (A4.1.2)

D4.1.4 **Riparian climate corridors** - Raster
Input

D4.1.5 **Integrated regional core connectivity corridors**
Output
From integration of riparian climate corridors with regional connectivity analytical process (A4.1.3)

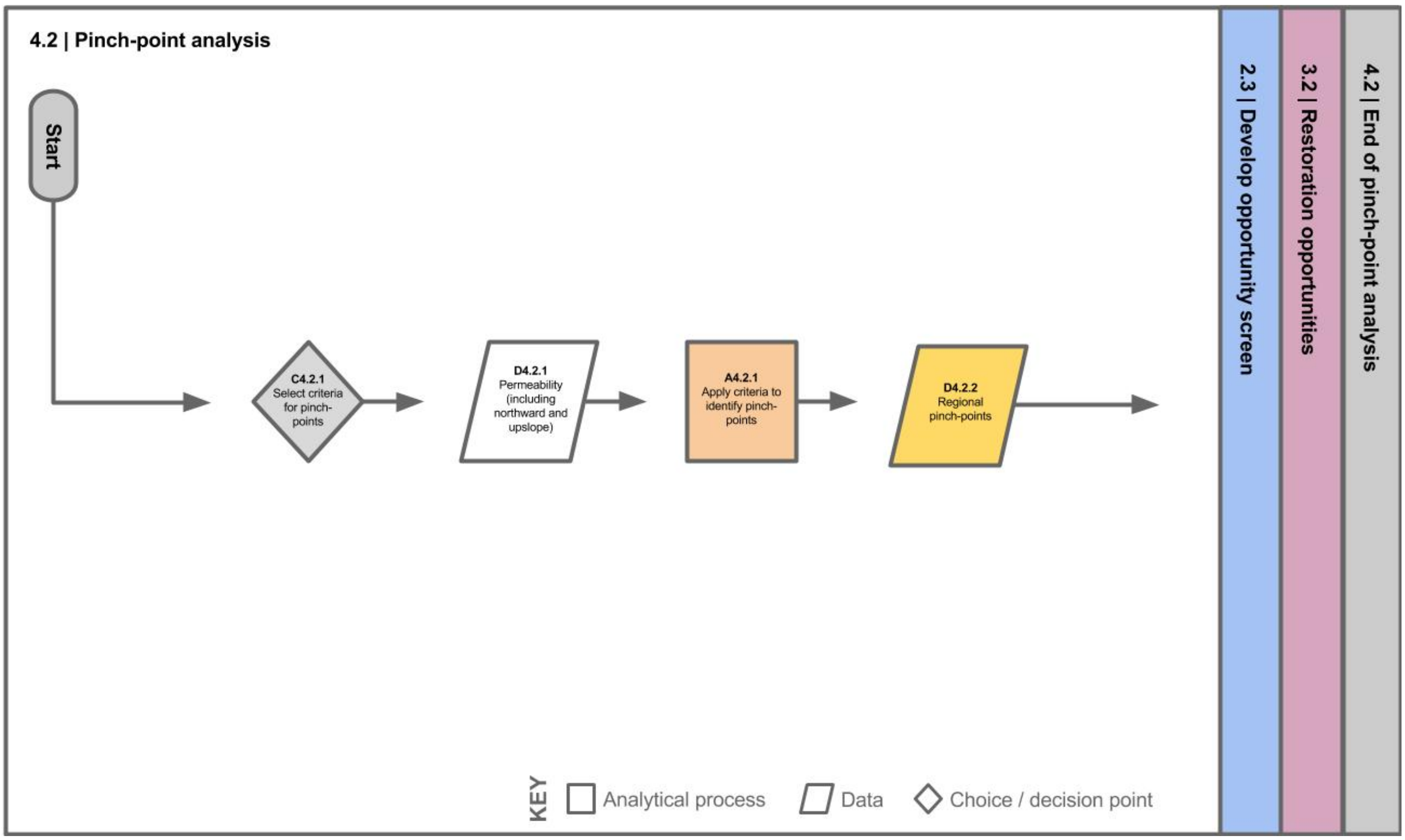
D4.1.6 **Diffuse regional core connectivity corridors**
Final output
From classification of diffuse vs bottleneck vs barrier analytical process (A4.1.4)

D4.1.7 **Bottleneck regional core connectivity corridors**
Final output
From classification of diffuse vs bottleneck vs barrier analytical process (A4.1.4)

D4.1.8	**Barriers to regional core connectivity** Final output From classification of diffuse vs bottleneck vs barrier analytical process (A4.1.4)

4.2 | PINCH-POINT ANALYSIS

The following flowchart and list of elements describe the second phase of the connectivity analysis: pinch-point analysis. Larger version of flowchart 4.2



ANALYTICAL PROCESSES

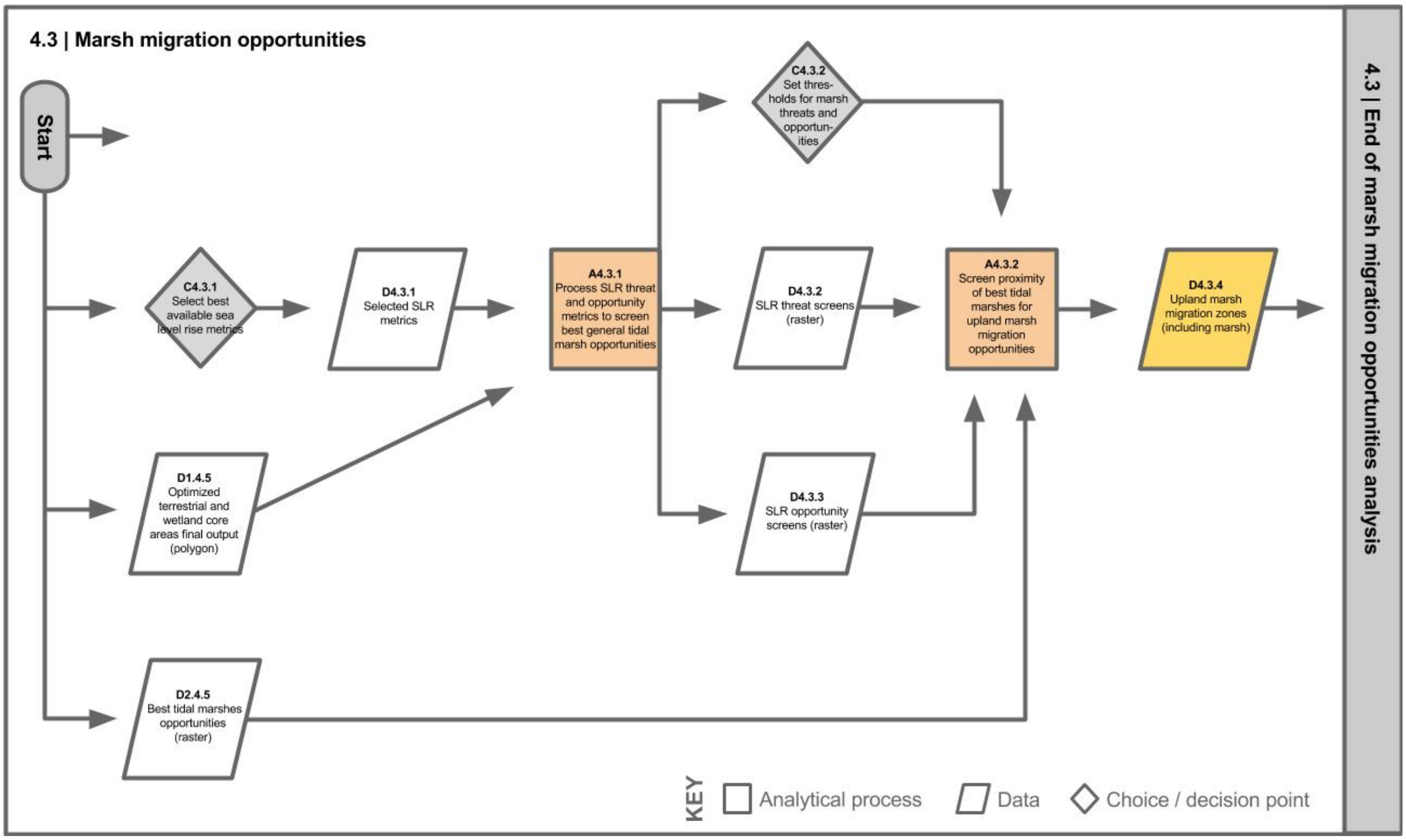
A4.2.1 **Apply criteria to identify pinch-points**

In order to simplify landscape permeability predictions for application to the conservation of large landscapes in the context of shifting climate, habitat, and species distributions, we will screen key landscape patterns from the TNC permeability analysis allowing northward and upslope flow bias (D4.2.1). Other permeability grids will be evaluated to assess gross regional patterns. Recognizing high uncertainty in fine-scale shifts in habitats and species, large-scale patterns of highly restricted flow may be more confidently predicted from s large-scale drivers such as major topographic features, geography, and human infrastructure. In this analytical step, criteria (C4.2.1) will be applied to classify each category. Cells satisfying the criteria will be assigned a value and all other cells will be set to zero. The desired output is a raster data layer containing regional pinch points (D4.2.2).

CHOICES / DECISION POINTS	C4.2.1	**Select criteria for pinch-points** Technical
DATA	D4.2.1	**Permeability (including northward and upslope)** - Raster Input From The Nature Conservancy
	D4.2.2	**Regional pinch-points** Final output From identification of pinch-points analytical process (A4.2.1)

4.3 | MARSH MIGRATION OPPORTUNITIES ANALYSIS

The following flowchart and list of elements describe the third phase of the connectivity analysis: marsh migration opportunities analysis. Larger version of flowchart 4.3



ANALYTICAL PROCESSES

A4.3.1 **Process SLR threat and opportunity metrics to screen tidal marshes**

Developing threat and opportunity metrics is a precursory step to implementing an analysis to screen tidal marshes for opportunities to enhance upland migration opportunities in the face of sea level rise (SLR). Metric data inputs are undefined, but will include SLR data (D4.3.1) and core areas (D1.5.9). Metrics will be calculated to measure landscape attributes that increase the threat of inundation or inhibit migration. Metrics will also be calculated to measure attributes that enhance the opportunity for tidal marshes to migrate upland or be secured from SLR. The output of this step will be an SLR threat index (D4.3.2) and an SLR opportunity index (D4.3.3) in raster format, specifically designed to select the best opportunities to safeguard tidal marsh habitats from SLR. The outputs may be used independently or combined in a single opportunity index, analogous to the core landscape selection index developed by UMass.

A4.3.2 **Screen proximity of best salt marshes for upland marsh migration opportunities**

The result of this analysis will identify opportunities to enhance upland migration opportunities for tidal marshes threatened by sea level rise. The opportunity index developed in A4.3.1 will be applied to the best tidal marsh opportunities identified as part of the RSGCN importance/condition analysis (D2.4.5), and adjacent upland areas. The desired output is raster data layer showing upland marsh migration zones (D4.3.4); the zones will include a subset of tidal marsh locations with adjacent upland cells ranked according to the opportunity index.

CHOICES / DECISION POINTS

C4.3.1 **Select best available sea level rise metrics**

Biological

C4.3.2 **Set thresholds for marsh threats and opportunities**

Technical

DATA

D4.3.1 **Selected SLR metrics**

Output

From best available sea level rise metrics decision (C4.3.1)

D1.4.5 **Optimized terrestrial and wetland core areas final output -** Polygons

Input

From core areas optimization analysis (D1.4.5)

D4.3.2 **SLR threats index** - Raster

Cells contain index values representing weighted sum of threat metrics for tidal marshes.

Output

From processing SLR threat and opportunity metrics (A4.3.1)

D4.3.3 **SLR opportunity index** - Raster

Cells contain index values representing weighted sum of threat metrics for tidal marshes.

Output

From processing SLR threat and opportunity metrics (A4.3.1)

D2.4.4 **Best tidal marshes opportunities** - Raster

Input

	From RSGCN and habitats opportunities analysis (2.4) Map http://nalcc.databasin.org/datasets/2010e21c6b7842d29cb11e3ecfeb9086
D4.3.4	**Upland marsh migration zones (including marsh)** - Raster Final output From screening proximity of best tidal marshes for upland marsh migration opportunities (A4.3.2).