Designing Sustainable Landscapes: HUC6 Aquatic Cores and Buffers

A project of the University of Massachusetts Landscape Ecology Lab

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General description

The HUC6 aquatic cores and associated buffers represent some of the principal Designing Sustainable Landscapes (DSL) landscape conservation design (LCD) products for aquatic ecosystems and species, and they are best understood in the context of the full LCD process described in detail in the technical document on landscape design (McGarigal et al 2017). These products were initially developed for the Connecticut River watershed as part of the Connect the Connecticut project (www.connecttheconnecticut.org) — a collaborative partnership under the auspices of the North Atlantic Landscape Conservation Cooperative (NALCC), and subsequently developed for the entire Northeast region as part of the Nature's Network project (www.naturesnetwork.org).

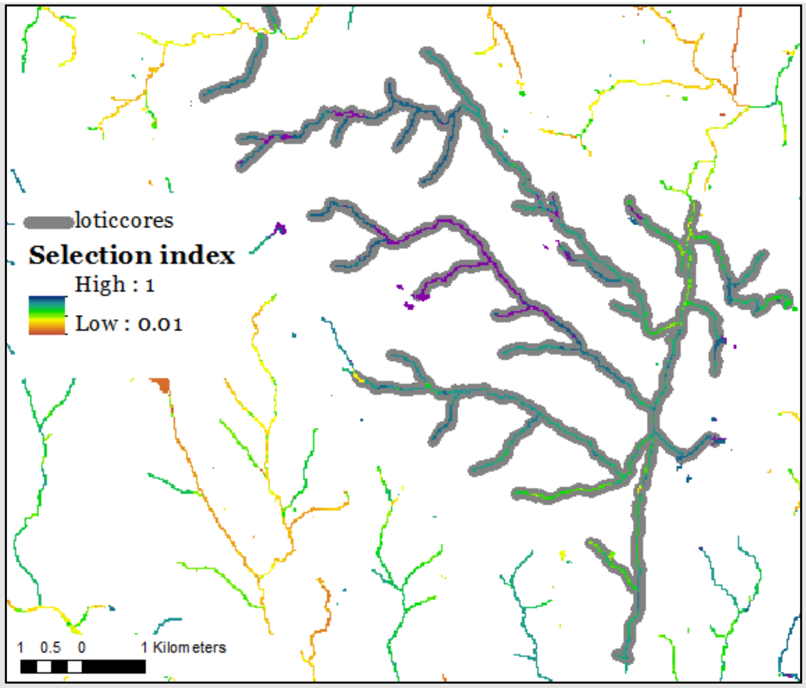

Figure 1. Lotic (riverine) core area showing the initial "seeds" (purple) and the final grown out core (gray), and the underlying aquatic ecosystem-based corea area selection index (depicted as a gradient) on the basis of which this core was derived.

HUC6 aquatic cores represent a combination of **lotic core areas** (river and stream) and **lentic core areas** (lake and pond) selected at the HUC6 scale (**Fig. 1**). In combination with the terrestrial cores, they spatially represent the ecological network designed to provide strategic guidance for conserving natural areas, and the fish, wildlife, and other components of biodiversity that they support within the Northeast.

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

1) areas of relatively high **ecological integrity** across all aquatic ecosystem types, including both lotic and lentic systems, emphasizing areas that are relatively intact (i.e., free from human modifications and disturbance within the aquatic environment as well as the surrounding area and contributing watershed) and resilient to environmental changes (e.g., climate change). Integrity has the potential to remain high in these areas, at least in the short-term due to their size and connectivity to similar natural environments; and

2) areas of relatively high current **landscape capability** for the following focal aquatic species, emphasizing areas that provide the best habitat and climate conditions today:

- Brook trout in headwater creeks, based on a model developed by B. Letcher and associates (USGS Conte Anadromous Fish Lab) that predicts the species' current probability of occurrence within headwater creeks at the catchment scale;
- Atlantic salmon rearing habitat in the rivers and streams of Maine, based on a model developed by the U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration (NOAA) that predicts rearing habitat potential throughout the range of the Gulf of Maine Distinct Population Segment (DPS) of Atlantic salmon;
- Atlantic sturgeon, short-nosed sturgeon and sea-run (salter) brook trout in the coastal rivers and streams of the Northeast, based on known occurrences compiled by D.C. Dauwalter and associates (Trout Unlimited);
- Alewife, blueback herring, and American shad (Alosids) in the major coastal rivers and streams of the Northeast, based on a prioritization developed by The Nature Conservancy; and
- Loons in lakes, based on the corresponding DSL landscape capability model.

Aquatic core areas were built separately for lotic and lentic systems from focal areas within each HUC6 watershed that have high ecological integrity. These "seeds" were expanded to encompass surrounding aquatic areas (e.g., upstream and downstream, or the entire water body) that provide additional ecological value and resilience to both short- and long-term change. These initial ecosystem-based cores were supplemented with areas of high landscape capability for one or more of the focal aquatic wildlife species. Finally, these initial cores were supplemented with additional areas to better balance the representation of aquatic ecosystems. Collectively, the final lotic cores identified in this product encompass ~30% (by stream length) of all rivers and streams in the Northeast, as decided by the LCD planning team, including a total of 6,563 core areas encompassing a total of 197,475 km in stream length and ranging in size from 5 to 1,538 km in stream length, with an average size of 30 km. Similarly, the final lentic cores identified in this product encompass ~20% (by area) of all lakes and ponds in the Northeast and ~30% excluding lakes >8,094 ha/20,000 acres), as decided by the LCD planning team, including a total of 7,777 core areas encompassing a total of 306,553 ha and ranging in size from 0.1 to 7,553 ha, with an average size of 39.

Aquatic buffers spatially represent the areas estimated to have a strong influence on the integrity of the aquatic cores based on watershed processes (**Fig. 2**). It is generally accepted that the integrity of the aquatic environment is strongly determined by the condition of the surrounding terrestrial environment, especially within the corresponding watershed. Thus, it is insufficient to identify aquatic cores without also explicitly recognizing the influential terrestrial environment. Although there are many possible ways to conceptualize and define buffers for aquatic systems, we opted to define the buffer as the area estimated to have a strong influence on the integrity of the aquatic core based on watershed processes. Specifically, from this watershed-based perspective, the buffer represents the area hydrologically connected to the aquatic core through surface runoff and instream flow

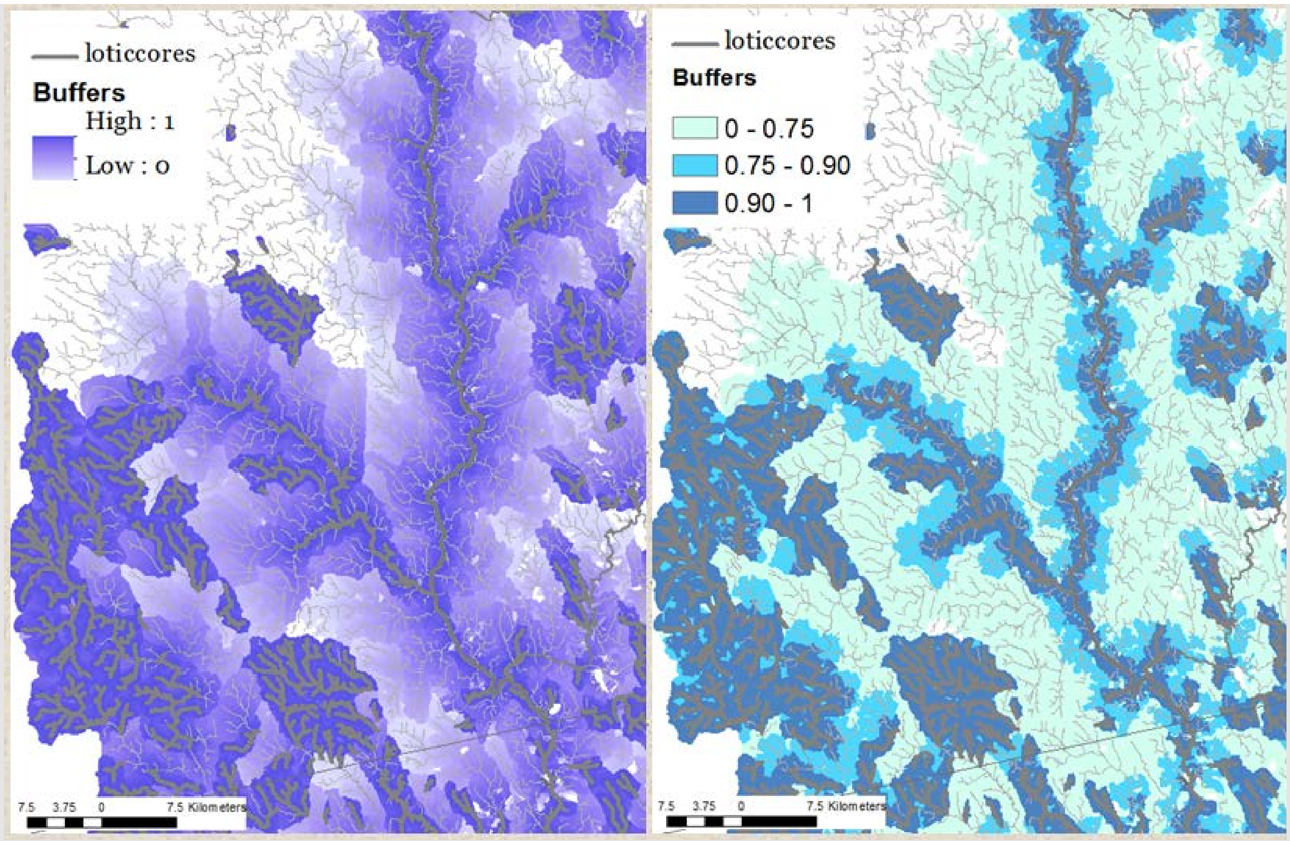

Figure 2. Watershed-based buffer zones for aquatic cores (shown here for lotic cores only), depicted as a graduated zone of influence (left figure) varying from 1 at the core to 0 at the periphery of the zone of influence and tiers of influence (right figure) in which the break-points for the tiers can be defined at any levels depending on objectives.

processes, such that anthropogenic stressors within the buffer are most likely to adversely impact the integrity of the aquatic core. Importantly, this watershed-based buffer represents places upstream and upslope of the aquatic core where human activities such as development and point and non-point pollution, etc., may have a strong impact on the ecological condition of the core. Unlike the cores themselves, the buffers do not necessarily represent areas of high ecological integrity; rather, they represent areas likely to have a strong influence on the cores through watershed-based processes.

Use and interpretation of these layers

The HUC6 aquatic cores and associated buffers are intended to serve as a starting point for a regional aquatic conservation network that can be used in combination with other sources of information to direct and prioritize conservation action. The use of these layers should be guided by the following considerations:

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

Aquatic cores:

- It must be acknowledged that lotic systems are inherently continuous networks; water and materials move from their point of entry into the riverine system continuously downstream to the ocean, and many diadromous organisms do the same (and in both directions). No one segment of a stream or river can be conceived of as an independent entity, and thus the integrity of any segment ultimately depends on the integrity of the entire riverine network. From this perspective, the entire riverine network could be considered a single aquatic core, and while this may be the ecological reality of riverine systems, it does not provide much in the way of practical guidance for conservation. Consequently, we define and delineate individual sections of rivers and streams and small to large riverine networks as aquatic core areas to focus attention on places that meet certain criteria (e.g., relatively good local conditions, high probability of supporting local brook trout populations, etc.), but acknowledge that the entire riverine system is critically important to conserve in order to maintain the integrity of any local section of the river.

- HUC6 aquatic cores are in large part derived from the index of ecological integrity (see IEI document, McGarigal et al 2017), which is scaled from relatively low to high separately for each ecological system within each HUC6 watershed. Consequently, the best areas available for each ecological system within each HUC6 are captured by the aquatic cores. However, this does not mean that the areas selected are always unimpaired. For example, within any particular HUC6 watershed the best available area for say a cool, medium-sized river may be quite degraded since these are areas that tend to be relatively developed. Moreover, the best example of a certain ecosystem in one HUC6 (and thus selected as a core) may be in worse condition than the same ecosystem not selected as a core in another HUC6. The HUC6 scaling ensures well-distributed core areas for each aquatic ecosystem, but does not by itself guarantee that all ecosystems in all cores are in excellent absolute condition. The HUC6 scaling involves a tradeoff between capturing the highest ecological value and creating a well-distributed ecological network of core areas.

- HUC6 lotic cores can and do include sections of lower-valued rivers/streams and extend beyond road-stream crossings; however, they do not extend past dams. Similarly, HUC6 lentic cores can and do include partially-developed shorelines. For lotic cores this is the result of growing out the cores from the highest-valued seed areas, in which we elected to extend the cores through small sections of degraded river/stream in order to encompass larger, contiguous stream networks. For lentic cores this is the result of growing out the cores from the highest valued seed areas to include the entire water body, which we deemed the more logical conservation unit. The inclusion of such degraded areas in the cores should not be interpreted as indicating their intrinsic ecological value, but rather that they represent places with high influence on the target ecological values in the high-valued areas of the cores. Note, the degraded areas within cores could be considered high priorities for restoration.

- HUC6 aquatic cores were derived from regionally consistent data. As such, they may not capture all resource priorities identified at the state or local level made possible with local data. Consequently, this network of aquatic cores should not be viewed as "the" conservation network, but rather as a regional complement to state and locally identified conservation priorities.
- HUC aquatic cores can be used in combination with the dam removal impacts and culvert upgrade impacts layers (see critical linkages document, McGarigal et al 2017) to identify places where the integrity of the aquatic cores is limited by dams and/or culverts, which may represent priorities for restoration.
- For convenience, the size of each lotic core area is expressed in terms of stream length, but note that the core actually includes the entire shore-to-shore aquatic environment, and often encompasses or extends through adjacent wetlands and water bodies, as depicted in the ecological systems map (see DSLland document, McGarigal et al 2017).
- HUC6 lentic cores exclude the 14 lakes > 8,094 ha (25,000 acres), because including these largest lakes tends to skew the results. We assume that nobody will forget that Lake Champlain or Moosehead Lake are important for conservation.

<u>Aquatic buffers</u>:

- Although the aquatic buffers are presented as an absolute gradient of decreasing influence with increasing distance upstream and upslope of the cores, it is important to recognize that the gradient depicted is relative. Moreover, the gradient is implemented so as to extend progressively greater distances upslope on increasingly smaller streams. Because this graduated zone of influence can be somewhat difficult to visualize and interpret in its raw, continuous format, it may be more useful to threshold the gradient at one or more user-defined levels to depict tiered zones of influence that are more akin to conventional fixed-width buffers.
- Aquatic buffers can be used in combination with the integrated probability of development layer (see probability of development document, McGarigal et al 2017) to identify places predicted to have a strong influence on the ecological integrity of the aquatic cores (i.e., places where anthropogenic disturbances may adversely affect the aquatic cores through watershed processes such as nutrification and sedimentation) that are relatively vulnerable to future development, which could represent priorities for land protection.

Derivation of these layers

The derivation of the HUC6 aquatic cores and buffers was quite complex, as described in detail in the technical document on landscape design (McGarigal et al 2017). Here, we describe a highly abbreviated version of the process that is sufficient for the use and interpretation of these products.

1. Create the initial ecosystem-based core area selection index

The first step in building aquatic core areas was to create an initial "selection index" that integrates the different ecosystem-based values that core areas are intended to represent and reflects the landscape design criteria. The selection index can be created from any number of data layers, but for the purpose of the Northeast regional product described here, we used only the DSL index of ecological integrity (see IEI document, McGarigal et al 2017). Note, for this product IEI was quantile-scaled by ecological system within each HUC6 watershed.

2. Build initial ecosystem-based cores

The next step was to build cores based on the selection index. Here, we built lotic cores separately from lentic cores owing to some fundamental differences between the treatment of contiguous stream networks and discrete ponds and lakes. However, the basic idea behind the core building algorithm in both cases was to select the very best places based on the selection index by "slicing" the surface above some threshold level, which essentially guaranteed 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) were now buffered (**Fig. 1**).

Growing a core area outward from the seed was relatively straightforward for <u>lentic</u> cores (ponds and lakes). If the seed met a minimum size threshold (0.9 ha), then the seed was grown out to include the entire water body regardless of the selection index value for these cells. Thus, the entire water body (pond or lake) was treated as the logical unit for lentic cores. However, we excluded large lakes (>8,094 ha/20,000 acres) from consideration.

Creating a <u>lotic</u> core was somewhat more complicated. Briefly, if the seed met a minimum size threshold (0.9 ha), then the seed was grown out by spreading upstream and downstream (including back upstream on the downstream tributaries) along the stream centerline such that it spread further through cells with higher value (based on the selection index) and did not spread through lakes or past a dam (of any size). Moreover, it spread further with increasing stream size, so that all other things being equal it would spread further on larger rivers. The final expanded seed had to exceed a minimum total stream length threshold of 5 km to become a lotic core. The actual process of building the lotic cores was of course considerably more complex.

It is important to recognize that through this process of spreading outward from the high-value seeds, the final lotic cores may include sections of lower-valued streams and extend beyond road-stream crossings; however, they do not extend past dams. Similarly, the lentic cores may include partially-developed shorelines. The expanded seed areas, however, typically include areas with high to moderate ecological value and often include a variety of aquatic ecosystem types that differ from those in the initial seed areas.

3. Build species-complemented cores

The next step was to supplement the ecosystem-based (stage 1) cores with additional core area to meet the habitat needs of all focal aquatic species. The basic idea behind this stage of the core-building algorithm was to complement what was already captured in the stage 1 cores by expanding them or creating new cores to ensure that a specified target for each focal species was included in the final cores. Here, we expanded the stage 1 cores for the focal species as follows:

- *Brook trout in headwater creeks* — based on a model developed by B. Letcher and associates, USGS Conte Anadromous Fish Lab, that gives the species' current probability of occurrence within headwater creeks at the catchment scale. Specifically, we added headwater creeks to lotic cores sequentially starting with the highest probability of brook trout occurrence and continuing until we captured 25% (by stream length) of headwater creeks in the Northeast region within lotic cores. In this manner, we ensured that the best headwater creeks within the region for brook trout were included as lotic cores;

- *Atlantic salmon rearing habitat in the rivers and streams of Maine* — based on a model developed by the U.S. Fish and Wildlife Service and the National Oceanic and Atmospheric Administration (NOAA). The model assesses salmon rearing habitat throughout the range of the Gulf of Maine Distinct Population Segment (DPS) of Atlantic salmon, which is federally listed as an endangered species. The model was developed using data from habitat surveys conducted in the Machias, Sheepscot, Dennys, Sandy, Piscataquis, Mattawmkeag, and Soudabscook Rivers. The model uses reach slope derived from contour and digital elevation model (DEM) datasets, cumulative drainage area, and physiographic province to predict the total amount of rearing habitat within a stream reach. The variables included in the model explain 73% of the variation in rearing habitat. More details about the model are available at: https://www.greateratlantic.fisheries.noaa.gov/prot_res/altsalmon/Appendix%20C%20-%20GIS%20Salmon%20Habitat%20Model.pdf. We transferred the line-work to our high-resolution (1:24k) NHD stream line work and added stream reaches to lotic cores as needed to capture the top 10% (by stream length) of the salmon rearing habitat in Maine;

- *Atlantic sturgeon, short-nosed sturgeon and sea-run (salter) brook trout in the coastal rivers and streams of the Northeast* — based on known occurrences compiled by D.C. Dauwalter and associates, Trout Unlimited, mapped to 1:100K NHDplus stream line work. We transferred the line work to our high-resolution (1:24K) NHD stream lines and added all identified rivers and streams to lotic cores;

- *Alewife, blueback herring, and American shad (Alosids) in the major coastal rivers and streams of the Northeast* — based on a prioritization of HUC12 watersheds using four metrics: (1) population or run size, 2) habitat quantity based on unrestricted access to the ocean, 3) water quality based on extent of impervious surface, and 4) water quantity based on upstream dam storage potential, developed by The Nature

Conservancy and mapped to 1:100K NHDplus stream line-work. These metrics were weighted by importance for each species based on expert knowledge. The results of the simple weighted ranking prioritization algorithm were then binned into 5% tiers for each species; the top tier was considered to have the greatest restoration potential. The top tiers for each of the three species were combined to result in a combined Top 5% representing the highest tier for one or more of the three species. We transferred the line work for the combined Top 5% to our high-resolution (1:24K) NHD stream lines added these to lotic cores; and

- *Loons in lakes* — based on the corresponding DSL landscape capability model (see common loon document, McGarigal et al 2017). Considering only lakes <8,094 ha (20,000 acres), we rank ordered lakes based on the maximum Landscape Capability value in each lake and then added lakes to lentic cores as needed to capture the top 25% (by area) of lakes within the loon's range.

4. Build additional ecosystem-based cores to balance out ecosystem representation

The result of building the initial ecosystem-based cores (step 2 above) and then supplementing them to meet the focal species targets (step 3 above) resulted in a set of lotic and lentic cores that included representative and well-distributed areas of relatively high ecological integrity across all aquatic ecosystem types, plus additional areas representing the best habitat for several focal aquatic species. Not surprisingly, given the selection of focal species and the varying targets set for each species, the representation of each aquatic ecosystem in the aquatic cores was highly uneven (**Table 1**). For the purpose of the Northeast regional product described here, the LCD planning team decided that the representation of lentic ecosystems was adequate. For the lotic ecosystems, we created a new aquatic core area selection index that upweighted lotic ecosystems by the degree of their underrepresentation (up to 20%). For example, the most underrepresented stream class (Stream (headwater/creek) cool low), at 16.3%, got upweighted by 20%. Based on this weighted selection index, we built additional lotic cores as before (step 2 above) but using a slightly higher "slice" of the selection index to define the "seeds". Our goals was to end up with a minimum of roughly the top 25% (by stream length) of each lotic ecosystem. In general, the underrepresented ecosystems gained enough and the overrepresented ones didn't gain much (**Table 1**).

5. Build terrestrial buffers for the aquatic cores

The last step was to build terrestrial buffers for the aquatic cores. Briefly, for each lotic and lentic core, we created a watershed buffer based on a time-of-flow model that extends as a gradient upstream and upslope from the core varying distance depending on slope and land cover. Areas immediately upstream and upslope of the core have the greatest influence (i.e., shortest time-of-flow). The influence decreases much faster across land than water so that the buffer typically extends much farther upstream than upslope from the core. Thus, the buffer does not represent a discrete zone distinguishing "inside" from "outside" of the buffer. Rather, it represents a graduated zone of influence in which cells upstream and closer to the core have greater influence. Cells in the upland and farther from the stream, especially on flat slopes with forest cover, have less influence. In addition, the graduated

Table 1. Representation of lotic ecosystems in the HUC6 lotic cores (i.e., % of each ecosystem in the Northeast by stream length captured in lotic cores) after the initial ecosystem and species cores (steps 2-3) and in the final cores (step 4), and the percent gain.

	Percent of Ecosystem within the Northeast		
Lotic ecosystem	**Initial**	**Final**	**Gain (%)**
Freshwater Tidal Riverine	55.48	55.71	0.23
Stream (headwater/creek) cold low	26.93	28.47	1.54
Stream (headwater/creek) cold moderate	26.68	28.45	1.77
Stream (headwater/creek) cold high	30.48	31.64	1.16
Stream (headwater/creek) cool low	16.31	24.18	7.87
Stream (headwater/creek) cool moderate	19.19	27.29	8.10
Stream (headwater/creek) cool high	27.04	32.54	5.50
Stream (headwater/creek) warm low	18.82	25.02	6.20
Stream (headwater/creek) warm moderate	21.80	27.19	5.39
Stream (headwater/creek) warm high	25.33	29.16	3.83
Stream (small) cold low	30.84	32.03	1.19
Stream (small) cold moderate	42.23	42.97	0.74
Stream (small) cool low	21.05	27.08	6.03
Stream (small) cool moderate	30.36	34.41	4.05
Stream (small) warm low	29.43	32.90	3.47
Stream (small) warm moderate	33.20	36.21	3.01
Stream (medium) cold	46.32	46.32	0.00
Stream (medium) cool	30.25	32.35	2.10
Stream (medium) warm	33.33	35.47	2.14
Stream (large) cool	59.94	60.12	0.18
Stream (large) warm	30.83	31.83	1.00

zone of influence increases in size with decreasing stream size. As such, the zone of influence on larger rivers tends to be relatively narrow, whereas the zone of influence on headwater creeks tends to be wider and typically encompasses the entire upstream catchment. The actual process of building the watershed buffers was considerably more complex.

GIS metadata

There are four different GIS data products associated with HUC6 aquatic cores and buffers, and they can be obtained at McGarigal et al (2017):

1. **HUC6 lotic cores shapefile —** ESRI ArcGIS shapefile (polylines) including the attributes listed below for each polygon.
   - FID = ESRI assigned unique number (which we do not use) for each polyline.
   - Shape = ESRI assigned feature type = "polyline".
   - coreID = unique number (ID) assigned to the core.
   - lengthKm = stream length (km) of the core. The length of the lotic core is approximated by the number of 30 m centerline cells. In addition, lotic cores can include centerlines through contiguous wetlands as well as contiguous lentic cores; thus, length of the lotic core represents the approximate length of contiguous lotic (including through wetlands) and lentic cores.
   - system1, system2, system3 = list of the top three lotic ecological systems for which the core is particularly important; specifically, systems for which the cumulative ecological integrity of the system within the core is greater than expected (from a statistical perspective) given its distribution across the entire core area network. Note, the lotic systems listed here are not necessarily the most abundant systems in the core, but rather reflect the systems for which the core is especially important. A complete listing of all aquatic systems present in the core (including wetland and lentic systems), along with their relative abundance, is available separately in the Ecosystem table described below.
   - troutSum = sum of the brook trout probability of occurrence index in the core.
   - troutMean = mean of the brook trout probability of occurrence index in the core.
   - salmonSum = total number of cells in the core comprised of the top 10% of Atlantic salmon rearing habitat.
   - salmonMean = percentage of the core comprised of the top 10% of Atlantic salmon rearing habitat.
   - anadSum = total number of cells in the core comprised of the designated anadromous fish habitat, including all sturgeon and salter brook trout rivers and streams, and the top 5% HUC12 watersheds for the three Alosid species.
   - anadMean = percentage of the core comprised of the designated anadromous fish habitat.

<u>Detailed core area composition statistics</u>

Detailed aquatic ecosystem composition statistics are available for each lotic core and are provided as a separate table for each core (see files in the loticCoreHUC6Stats folder). In these tables, there are four different indices computed (and their corresponding ranks) that represent different ways of understanding the relative importance of the cores to specific ecosystems. In all cases, larger values indicate greater importance.

Ecosystem table:

- coreID = unique number assigned to each core.

- systemName = name of the ecological system group as given in the ecological systems map. Note, although wetland and lentic systems are included in the composition of the core (lengthKm), the four importance indices described below apply only to the riverine systems for which the lotic cores have been developed.
- lengthKm = stream length (km) of the corresponding system in the core. Note, the length of the system in the core is approximated by the number of 30 m centerline cells of the system.
- index1 = index of importance of the core for the corresponding lotic system, based on deviation of the observed sum of the selection index for the system from its expected value, which is based on the size of the core and the system's average selection index and proportional representation across all cores. The index ranges from 0 to unbounded on the upper end; <1 indicates observed value less than expected, whereas >1 indicates the opposite.
- index1Rank = rank of index1 (1 = max index1).
- index2 = index of importance of the core for the corresponding lotic system, defined as the percentage of the core's total selection index comprised of the corresponding system. The index ranges from 0-100.
- index2Rank = rank of index2 (1 = max index2).
- index3 = index of importance of the core for the corresponding lotic system, defined as the percentage of the system's total selection index across all cores found in the focal core. The index ranges from 0-100.
- index3Rank = rank of index3 (1 = max index3).
- index4 = index of importance of the core for the corresponding lotic system, defined as the difference between the system's average selection index in the focal core and its average selection index across all cores. The index ranges from -1 to 1; negative values indicate an average selection index in the focal core less than its average across all cores, whereas positive values indicate the opposite.
- index4Rank = rank of index4 (1 = max index4).

2. **HUC6 lentic cores shapefile —** ESRI ArcGIS shapefile (polygons) including the attributes listed below for each polygon.
   - FID = ESRI assigned unique number (which we do not use) for each polygon.
   - Shape = ESRI assigned feature type = "polygon".
   - coreID = unique number (ID) assigned to the core. Note, each lentic core is assigned a unique coreID regardless of whether it is contiguous with a lotic core.
   - areaHa = area (ha) of the core.
   - system = the ecosystem type of the core.
   - loonSum = sum of the loon landscape capability (LC) index in the core.
   - loonMean = mean of the loon LC index in the core.

Detailed core area composition statistics

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Ecosystem table:

- coreID = unique number assigned to each core.
- systemName = name of the ecological system group as given in the ecological systems map.
- areaCount = number of 30 m cells in the core.
- areaHa = area (ha) of the corresponding system in the core.
- index1 = index of importance of the core for the corresponding lentic system, based on deviation of the observed sum of the selection index for the system from its expected value, which is based on the size of the core and the system's average selection index and proportional representation across all cores. The index ranges from 0 to unbounded on the upper end; <1 indicates observed value less than expected, whereas >1 indicates the opposite.
- index1Rank = rank of index1 (1 = max index1).
- index2 = index of importance of the core for the corresponding lentic system, defined as the percentage of the core's total selection index comprised of the corresponding system. The index ranges from 0-100.
- index2Rank = rank of index2 (1 = max index2).
- index3 = index of importance of the core for the corresponding lentic system, defined as the percentage of the system's total selection index across all cores found in the focal core. The index ranges from 0-100.
- index3Rank = rank of index3 (1 = max index3).
- index4 = index of importance of the core for the corresponding lentic system, defined as the difference between the system's average selection index in the focal core and its average selection index across all cores. The index ranges from -1 to 1; negative values indicate an average selection index in the focal core less than its average across all cores, whereas positive values indicate the opposite.
- index4Rank = rank of index4 (1 = max index4).

3. **HUC6 aquatic cores raster —** geoTIFF raster (30 m cells) with the following cell values:

   10 = lotic seeds

   11 = lotic expansion

   12 = brook trout

13 = Atlantic salmon

14 = anadromous fish (any of the six focal species)

20 = lentic seeds

21 = loon

This raster version is provided for those who wish to use these results for overlays or other further modeling; the shapefile versions are generally preferable for viewing. Note that sometimes lotic cores run through lakes that are also lentic cores; in those cases, we've coded them as lotic.

4. **HUC6 aquatic buffers raster —** geoTIFFf raster (30 m cells); cell values = the magnitude of influence based on the time-of-flow model; values range from 1 (maximum influence) at the core to zero 0 (no influence) at the cell with the least influence (i.e., furthest upstream and upslope of the core).

Literature Cited

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