New York Natural Heritage Program Important Area Modeling
Natural Communities

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Abstract
To maintain ecological integrity of high quality natural community occurrences, conservation efforts have to extend beyond the community's edge. In this project, we synthesize literature and expand on previous buffering efforts by utilizing a GIS to dynamically buffer communities based on local factors. Our goal is to automatically delineate areas that are important in maintaining the targeted natural community's integrity. We used EPA Multi-Resolution Landscape Characteristics to identify additional wetlands adjacent to significant palustrine communities, 30m Digital Elevation Models to determine slope and flow direction, and USDA Soil Survey data (SSURGO) for soil erodibility information. For palustrine communities, we began by adding adjacent wetlands to the natural community boundary. We then buffered this polygon by 163m, the 75% quantile for the 33 recommended buffer values found in the literature. Buffers over land sloping into the wetland were increased, with the increase contingent on slope percent and soil erodibility. Because threats vary by system, we treated estuarine and terrestrial natural communities differently. We are applying this model to all significant natural communities at the county level. This is the first effort we are aware of to dynamically vary buffer distances based on multiple factors.

Additional information

This document describes our efforts to use raw Natural Heritage element occurrence data to provide interpreted information to land use planners. Namely, we have developed a GIS-based decision matrix and a set of AML (Arc Macro Language) routines to buffer element occurrences at varying widths depending on local conditions. Here, I only discuss buffering natural community occurrences, but we have also developed similar routines for both rare plant and rare animal occurrences.

Overall, since the communities buffered in this project represent high-quality examples of each community type (e.g., these are some of the best in the state), we take a conservative approach. Thus, the goal of this project, as far as natural communities are concerned, is to describe an area surrounding the natural community in which all contributors to that target natural community are self-sustaining, thereby making the target natural community as self sustaining as possible. (A great quote: "Conservation efforts for amphibians that concentrate solely on wetlands likely will fail without consideration of the adjacent terrestrial habitat" Dodd and Cade (1998)).

Furthermore, our goals are intended to exceed the distance required for buffers to act as filters for sediment removal (note negative effects of sediment Werner and Zedler 2002) and chemicals in solution (see Woo & Zedler 2002). Indeed, buffers designed solely for water quality are much smaller than those designed with wildlife and plants in mind (e.g., Trimble & Sartz 1957, Swift 1986, Osborne & Kovacic 1993). Thus, our buffers should also mitigate for water quality in wetlands.

While there are excellent data suggesting large buffers of 1 to 2 km are required to maintain species richness in wetlands (Findlay & Houlahan 1997, Pope *et al.* 2000), we based our criteria on a series of other papers indicating an importance of buffers in the range of 100-300 m. Also, researchers have noted a directional component to amphibian movement away from wetlands (Dodd & Cade 1998). Unfortunately, no data exist that would allow us to incorporate this type of information into this buffer delineation effort.

From the perspective of the developed land, the effects of roads have been well studied (Trombulak & Frissell 2000). These effects are known to extend tens to hundreds of meters away from the road edge, depending on the effects of interest (Forman & Alexander 1998, Forman & Deblinger 2000). These types of studies emphasize the importance of maintaining natural communities at some distance from roads. (Also a review on the biological consequences of fragmentation: Saunders *et al.* 1991)

For each system described below, I outline the main threat buffering is trying to mitigate.

Estuarine:

Upland buffers will not greatly mitigate hydrologic threats to estuarine systems, as most of the hydrologic influence is from the tidal flushing of the estuary. Yet, upland buffers will help mitigate: 1. Habitat destruction, 2. Overland flow and deposition of suspended solids, and 3. Alteration of surface water levels and stream flow patterns (Shisler *et al.* 1987). The goal for estuarine communities is to minimize these impacts. We use the recommended distances in Shisler et al (1987) who vary the distance based on low intensity and high intensity land use and broad community classifications (salt marsh, freshwater tidal marsh, and hardwood swamp).

To achieve these buffers, we used the following steps:

1) Evaluate cells adjacent to the estuarine natural community. Add all wetland cells to the natural community polygon to create a base polygon of all adjacent wetlands. Attribute these cells with the natural community name of the closest natural community using spatial adjacency routines. The Hudson River is mapped as a significant natural community (tidal river), but in places mapped conservatively to low tide marks and within constraints of railroad barriers. Here, we use a more refined version of the Hudson River shoreline developed by the Hudson River Estuarine Research Reserve and DEC on their submerged aquatic vegetation beds project.
2) Create a temporary 100 m buffer around the base polygon (created in #1, above) in which to evaluate land use intensity.
3) The goal in this step is to find the high intensity land use sites. Within the 100 m buffer, select all high intensity land use cells (MRLC # 3, 4: high density residential, commercial/industrial) and buffer them 100 m.

4) All places where the buffer generated in #3 intersects the base polygon created in #1 will receive the high intensity land use buffers, all edges of the base polygon that do not intersect with the buffers generated in #3 will receive the low intensity set of buffers.
5) Apply a buffer to the base polygon using the following criteria:
For all edges identified as occurring near high intensity land use, buffer as follows:
  Woody tidal communities: 30 m
  Non-woody tidal communities: 46 m
  Salt marsh: 30 m
For all other edges:
  Woody tidal communities: 15 m
  Non-woody tidal communities: 30 m
  Salt marsh: 15 m

Riverine:

Threats to natural communities within running water mostly occcur upstream and upslope to these communities. Thus, in the buffering procedure below, we buffer only upslope and upstream of the delineated community occurrence. Goals are twofold: 1. to show the area of most influence to the aquatic natural community and, 2. to map an upland zone of habitat used by species that frequent or live in the aquatic community and to provide an interacting upland or riparian community within this zone. The main assumption for #1 is that solutes and sediment carried in water holds a strong influence on the aquatic community and the zone of influence should include all regions likely to carry solutes or sediment into the mapped natural community.

1) Depict riverine natural community types as they occur in the NY Natural Heritage Database.
2) Detemine the full watershed that feeds this natural community, from its lowest point. This should be able to be accomplished with the 10-m DEM layer. *Rationale*: Water flows downhill, everything upstream of the occurrence must be evaluated in this model. The entire catchment (all upstream lands) has been shown to be more important to water quality than simply designed buffers (Sliva & Williams 2001) and salamander populations (Willson & Dorcas 2003).
3) Create a layer containing all upstream aquatic systems connected to this natural community. This should include both riverine and lacustrine systems.
  3a. Using the 1:24,000 hydrography layer, intersect the line coverage (strmnet) with the catchment detemined in step 2, above. Buffer the resulting lines by 2.3 meters to create a polygon layer.
  3b. Using the 1:24,000 hydrography layer, intersect the polygon coverage (surfwat) with the catchment area determined in step 2.
  3c. Merge the polygon layers that resulted from steps 3a and 3b. Remove isolated (unconnected) polyons. The result should be a full depiction of upstream aquatic systems. *Rationale*: There are clear guidelines in the literature about how far upstream riverine disturbances continue to influence an aquatic community. More and more research is suggesting that activities in the entire watershed influence stream integrity. Lerberg *et al.* 2000,Sliva & Williams 2001,Wang *et al.* 2001,Yoder & Kulik 2003

4) Add a baseline buffer of 163 meters. *Rationale*: this value is the 75% quantile for the 33 values for recommended buffers in the literature (Table 1). This distance encompasses 25 of the 33 values. These 33 buffers are restricted to those posited as what would be needed to maintain animal, plant, or natural community assemblages.

5) I'm not sure what to do, if anything, about forest vs. unforested streamside. Barton et al 1985 say that trout streams need to be greater than 80% forested. Jones et al. (1999) say that you can't have a strip much longer than 1km before the fish assemblage is degraded. It seems like this might be a ranking thing, not an important areas thing. At this point, do nothing.

6) Assess cover type and slope.

IF cover type is forest,

-and slope is away from wetland, don't alter buffer

-and slope is towards wetland, increase buffer distance with a formula of 2.0 X (slope%) (Swift 1986, general forest management areas)

(note that the extra 50m in step #3 could easily be applied here, after polygons are attributed as greater or less than 50% cover)

IF cover type = non forested (& terrestrial)

And slope is away from wetland, don't alter buffer

And slope is towards wetland, increase the buffer based on soil erodibility, as follows (if SSURGO is not available, forego the following and increase buffer distance by: 3.86 X (slope%) (Swift 1986, moderate erosion soils)).

- Using the SSURGO layer joined to a modified table containing averaged Kfact values. These averaged values were obtained by averaging Kfact in the first two layers (LAYERNUM) for each SEQNUM and then calculating a weighted average across all SEQNUMs for each MUID. (see Appendix 1 for more detail).
- For each MUID use the following cutoffs to generate three levels of soil erosion hazard: 0-0.22 = low, 0.23-0.40 = Moderate, 0.41-0.64 = High. Create a layer that merges all polygons into these classes; for missing values, use 'low'.
- Apply the following buffer for each of these erosion hazard types (Swift 1986):
  - Low: 2.98 X (slope%)
  - Moderate: 3.86 X (slope%)
  - High: 4.78 X (slope%)

- The rationale for increasing buffer by slope, even though particulates would be caught anyway in existing buffer is: we want the existing buffer to be a fully interacting sustainable community. Thus, any sediment should be caught before entering what we consider the main portion of the buffer.

7) The resulting important area for the specified riverine natural community is the combination upstream aquatic systems and buffered terrestrial/riparian/palustrine habitats.

Palustrine:

Goal is to minimize all kinds of external disturbance to maximize community integrity and persistence of the EOs. So, the buffer should integrate land cover type, slope, and soil texture.

Note that our view of the community is the full interacting assemblage of plants and animals. For example, salamander and turtle studies ARE relevant to community buffering.

1) Evaluate cells adjacent to the palustrine natural community (adjacent on the diagonal also). Add all wetland cells to the natural community polygon to create a base polygon of all adjacent wetlands. Attribute these cells with the natural community name of the closest natural community using spatial adjacency routines. *Rationale*: because of the potential for high rates of mixing and interchange of solutes throughout wetlands, the quality of one portion of a wetland is strongly dependent on the quality of all other portions of the wetland. Thus, as a base, all abutting wetlands to a significant wetland natural community should, by default, be included in any buffering process.
2) Add a baseline buffer of 163 meters. *Rationale*: this value is the 75% quantile for the 33 values for recommended buffers in the literature (Table 1). This distance encompasses 25 of the 33 values. These 33 buffers are restricted to those posited as what would be needed to maintain animal, plant, or natural community assemblages.
3) Assess the proportion of forest cover within the buffer polygon. If forest in buffer is <50% total buffer, increase buffer length by 50m in the forested areas. *Rationale*: throughout NY, forested land is a much better wetland buffer than agricultural fields, pastureland, old fields, and most other non-forested lands. Thus, we should consider the forested portions of buffers around wetlands with a low proportion of forested buffer as more important, and use this technique to increase the amount of forested buffer. As an aside, note that trout streams need to be more than 80% forested cover to maintain trout populations (Barton *et al.* 1985).
4) Assess cover type and slope.
   IF cover type is forest,
      -and slope is away from wetland, don't alter buffer
      -and slope is towards wetland, increase buffer distance with a formula of
      2.0 X (slope%) (Swift 1986, general forest management areas)
      (note that the extra 50m in step #3 could easily be applied here, after polygons are attributed as greater or less than 50% cover)
   IF cover type = non forested (& terrestrial)
      And slope is away from wetland, don't alter buffer
      And slope is towards wetland, increase the buffer based on soil erodibility, as follows (if SSURGO is not available, forego the following and increase buffer distance by: 3.86 X (slope%) (Swift 1986, moderate erosion soils)).
      - Using the SSURGO layer joined to a modified table containing averaged Kfact values. These averaged values were obtained by averaging Kfact in the first two layers (LAYERNUM) for each SEQNUM and then calculating a weighted average across all SEQNUMs for each MUID. (see Appendix 1 for more detail).
      - For each MUID use the following cutoffs to generate three levels of soil erosion hazard: 0-0.22 = low, 0.23-0.40 = Moderate, 0.41-0.64 = High. Create a layer that merges all polygons into these classes; for missing values, use 'low'.
      - Apply the following buffer for each of these erosion hazard types (Swift 1986):
         - Low: 2.98 X (slope%)

- Moderate: 3.86 X (slope%)
- High: 4.78 X (slope%)

The rationale for increasing buffer by slope, even though particulates would be caught anyway in existing buffer is: we want the existing buffer to be a fully interacting sustainable community. Thus, any sediment should be caught before entering what we consider the main portion of the buffer.

Terrestrial:

Matrix forests: no buffer.

These are large enough to be self sustaining (Matlack 1994, Spellerberg 1998, Mladenoff *et al.* 1994). Here, we define matrix forests as any natural community occurrence (or cluster of adjacent occurrences) greater than or equal to 2000 acres. Natureserve EO specs define matrix communities as greater than around 5000 acres. Our frequency distribution of sizes suggests 2000 acres is a good cut-off between large patch and matrix. This is pretty arbitrary, as much smaller occurrences could be considered matrix as well.

Small and large patch:

Goals for terrestrial are mainly to deter negative direct human impacts.

1) Add a baseline buffer of 15 meters to the small patch terrestrial community. *Rationale*: This reflects the 50 foot baseline suggested in Shisler *et al.* 1987.
2) Assess cover type and slope of buffer:

IF cover type is forest,

-and slope is away from the small patch terrestrial community, don't alter buffer

-and slope is towards the small patch terrestrial community, increase buffer distance with a formula of:

2.0 X (slope%) (Swift 1986, general forest management areas)

IF cover type = non forested (& terrestrial)

And slope is away from wetland, don't alter buffer

And slope is towards wetland, increase the buffer based on soil erodibility, as follows (if SSURGO is not available, forego the following and increase buffer distance by: 3.86 X (slope%) (Swift 1986, moderate erosion soils)).

- Using the SSURGO layer joined to a modified table containing averaged Kfact values. These averaged values were obtained by averaging Kfact in the first two layers (LAYERNUM) for each SEQNUM and then calculating a weighted average across all SEQNUMs for each MUID. (see Appendix 1 for more detail).
- For each MUID use the following cutoffs to generate three levels of soil erosion hazard: 0-0.22 = low, 0.23-0.40 = Moderate, 0.41-0.64 = High. Create a layer that merges all polygons into these classes; for missing values, use 'low'.
- Apply the following buffer for each of these erosion hazard types (Swift 1986):
  - Low: 2.98 X (slope%)
  - Moderate: 3.86 X (slope%)

- High: 4.78 X (slope%)

End.

Table 1.

Citation	Distance	Value used (m)	For what?
Findlay & Houlahan 1997	1-2km	1000	Plant richness in wetlands
Findlay & Houlahan 1997	0.5-1km	500	Bird richness in wetlands
Findlay & Houlahan 1997	>2km	2000	Herptile richness in wetlands
Findlay & Houlahan 1997	>2km	2000	Mammal richness in wetlands
Spellerberg 1998	15-50m	15	Edge effects into interior forests
Burke & Gibbons 1995	275m	275	Full protection of turtle nests
Burke & Gibbons 1995	73m	73	90% protection of turtle nests
Semlitsch 1998	164m	164	95% of salamander population
Ehrenfeld & Schneider 1991	91m	91	Protect Atlantic white cedar populations
Matlack 1994	92m	92	Piedmont forest edge effects into interior
Angold 1997	200m	200	Reduce edge effects of heathland vegetation
Spackman & Hughes 1995	28.8m	28.8	Mean minimum corridor width along stream to achieve 95% species richness, trees, shrubs, herbs
Spackman & Hughes 1995	161.7m	161.7	Mean minimum corridor width along stream to achieve 95% species richness, birds
Mladenoff *et al.* 1994	100m	100	Distance needed to make forests have interior
Following is from Fischer & Fischenich 2000			
Brosofske et al. 1997	>45m	45	Maintain microclimate gradient near streams
Burbrink et al. 1998	100-1000	100	Maintain reptile and amphibian diversity
Rudolf and dickson 1990	>30m	30	Amphibians, reptiles, other vertebrates
Bulhmann 1998	>135m	135	Turtles
Dickson 1989	>50m	50	Gray squirrel
Erman, et al. 1977	>30m	30	Benthic invertebrates adjacent logging
Moring 1982	>30m	30	Allow fish eggs to develop
Darveau et al. 1995	>60m	60	Forest dwelling birds
Hodges and krementz 1996	>100m	100	Maintain assemblages of neotropical birds
Mitchell 1996	>100m	100	Breeding habitat for birds
Tassone (1981)	>50m	50	Neotropical migrants

Triquet et al 1990	>100m	100	Neotropical migrants
Kilgo et al 1998	>500m	500	Maintain complete avifauna community
Keller et al 1993	>100	100	Nesting habitat for area-sensitive speices
Gaines 1974	>100m	100	Yellow billed cuckoo
Vander haegen and degraaf 1996	>150	150	Reduce edge related nest predation
Whitaker and montevecchi 1999	>50	50	Support low densities of interior species
Hagar 1999	>40	40	Provide benefit to forest birds
Lambert & Hannon 2000	100m	100	Conserved ovenbird numbers in riparian buffer after logging beyond buffer.

Papers addressing buffering for solutes (N, P; Osborne & Kovacic 1993), sediments (Swift 1986, Trimble & Sartz 1957), and pesticide spray release (Kleijn & Snoeijing 1997) are not included in Table 1.

Marine:

Upland buffers will attempt to mitigate stormwater pollution (nutrient enrichment), sedimentation, and physical disturbance.

Threats and needs listed by community include:

Marine eelgrass meadow

- water quality impairment from overland nutrient, pesticide, and sediment inputs (can lead to periphytic algal blooms that reduce light and oxygen available to eelgrass),
- physical disturbance from channel dredging and dredge spoil deposition,
- direct physical disturbance from boating activity (e.g., anchoring, mooring, prop scarring).
- (do not know how to address hardened shoreline except recommending that it be restored or not constructed)
- Need: adjacent suitable habitat for natural eelgrass expansion/colonization

Marine intertidal gravel/sand beach

- dredge spoil deposition (suffocates existing inhabitants?)
- water quality impairment from overland nutrient, pesticide, and sediment inputs (affects resident animals?),
- physical disturbance by beach vehicles?

Marine rocky intertidal

- water quality impairment from overland nutrient, pesticide, and sediment inputs (can smother existing inhabitants
- (how to address spread of Codium – non-native algae? Does this bloom w/ nutrient input?)
- physical disturbance by human visitation/trampling?
- Need: adjacent suitable habitat for intertidal species to colonize

1. Buffer EOs 200 meters.
2. If 200 meter buffer of EO intersects a bay (pre-selected layer of bays), grab entire bay, and select the shoreline that intersects with this buffer as well.
    - Justification: The 200 m buffer, regardless of depth, is a suggested area of caution for dredging operations and boaters to address direct impacts from prop scarring, dredging, and dredge spoil deposition. Indirect effects (plumes from dredge operations) are beyond our scope here and would require their own model. If suitable shallows exist within the 200 m buffer, it will also be an area that allows for colonization/movement within the community occurrence.

3. Buffer the captured shoreline (including the bay shoreline) 200 meters, including inland.
4. Capture the 1:24K scale hydrography polygons within the 200 meter shoreline buffer.
5. Union the hydrography polygons, the shoreline buffer, and the EO buffer
6. Select the palustrine and estuarine cells from the CCAP 2006 land use/land cover with the unioned features from the previous step.
7. Union and dissolve the features resulting from steps 5 and 6
8. Eliminate 'donut' holes in features resulting from step 7

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Appendix 1. Averaging Kfact values for each soil polygon

Using the SSURGO II databases, do the following steps. (SQL queries will be pasted below the completed steps). In general: Find the average kwfact value across all components in each soil type. The source for SSURGO data is: http://soildatamart.nrcs.usda.gov/

1. For each *areasymbol* and *areaname* in the legend table, *mukey* in the mapunit table, and *cokey* and *comppct_r* in the component table, average the values for *kwfact* in the chorizon table. Count the number of *kwfact* values used in each average.

2. For each *mukey* in the component table, sum the values for *comppct_r*.

3. Calculate the proportion of total *comppct_r* for each mukey from #1, using the sum from #2.

4. Sum the product of *comppct_r* proportion times *kwfact* average for each mukey. This is the final kfact value for each mukey.

SQL queries:

Step #1. (query named: _tgh_qryAvKfactByMukey)

```
SELECT legend.areasymbol, legend.areaname, mapunit.mukey, component.cokey,
component.comppct_r, Avg(chorizon.kwfact) AS AvgOfkwfact, Count(chorizon.kwfact) AS
CountOfkwfact
FROM (legend INNER JOIN mapunit ON legend.lkey = mapunit.lkey) INNER JOIN (component
INNER JOIN chorizon ON component.cokey = chorizon.cokey) ON mapunit.mukey =
component.mukey
GROUP BY legend.areasymbol, legend.areaname, mapunit.mukey, component.cokey,
component.comppct_r
ORDER BY component.cokey;
```

Step #2. (query named: _tgh_qrySumCompPct)

```
SELECT component.mukey, Sum(component.comppct_r) AS SumCompPct
FROM component
GROUP BY component.mukey;
```

Step #3. (query named: _tgh_qryCalcPropCompPct)

```
SELECT [_tgh_qrySumCompPct].mukey, [_tgh_qrySumCompPct].SumCompPct,
[comppct_r]/[SumCompPct] AS PropCompPct, [_tgh_qryAvKfactByMukey].AvgOfkwfact
FROM _tgh_qrySumCompPct INNER JOIN _tgh_qryAvKfactByMukey ON
[_tgh_qrySumCompPct].mukey = [_tgh_qryAvKfactByMukey].mukey;
```

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Step #4. (query named: _tgh_qryFinalCalculation)

```
SELECT [_tgh_qryCalcPropCompPct].mukey, Format(Sum([PropCompPct]*[avgofkwfact]),"0.000")
AS FinalKfact
FROM _tgh_qryCalcPropCompPct
GROUP BY [_tgh_qryCalcPropCompPct].mukey;
```

The SSURGO 1 notes below are now outdated as a result of our conversion over to SSURGO 2

I imported the layer and comp tables into MS Access and did the following to the data (filename = SoilData.mdb.)

1. From the SSURGO "layer.dat" table (U.S. Department of Agriculture, Natural Resources Conservation Service 1995), average kfact values by MUID, by SEQNUM. Use only the layers 1&2, as the only kfact values for layer 3 were 0 and, in most cases indicated bedrock (some values for 2 also equaled 0 and at this time are still averaged in).
2. Sum COMPPCT in the comp.dat table by MUID. These values do not sum to 100 and thus this intermediary step is needed to get true proportions for the reported values.
3. Calculate the proportion of each soil component (SEQNUM) by dividing COMPPCT by SumCOMPPCT (=PropCOMPPCT).
4. For each SEQNUM within each MUID, multiply PropCOMPPCT by AverageKfact and sum these values across SEQNUM within each MUID. This is the final, single Kfact value for each MUID.