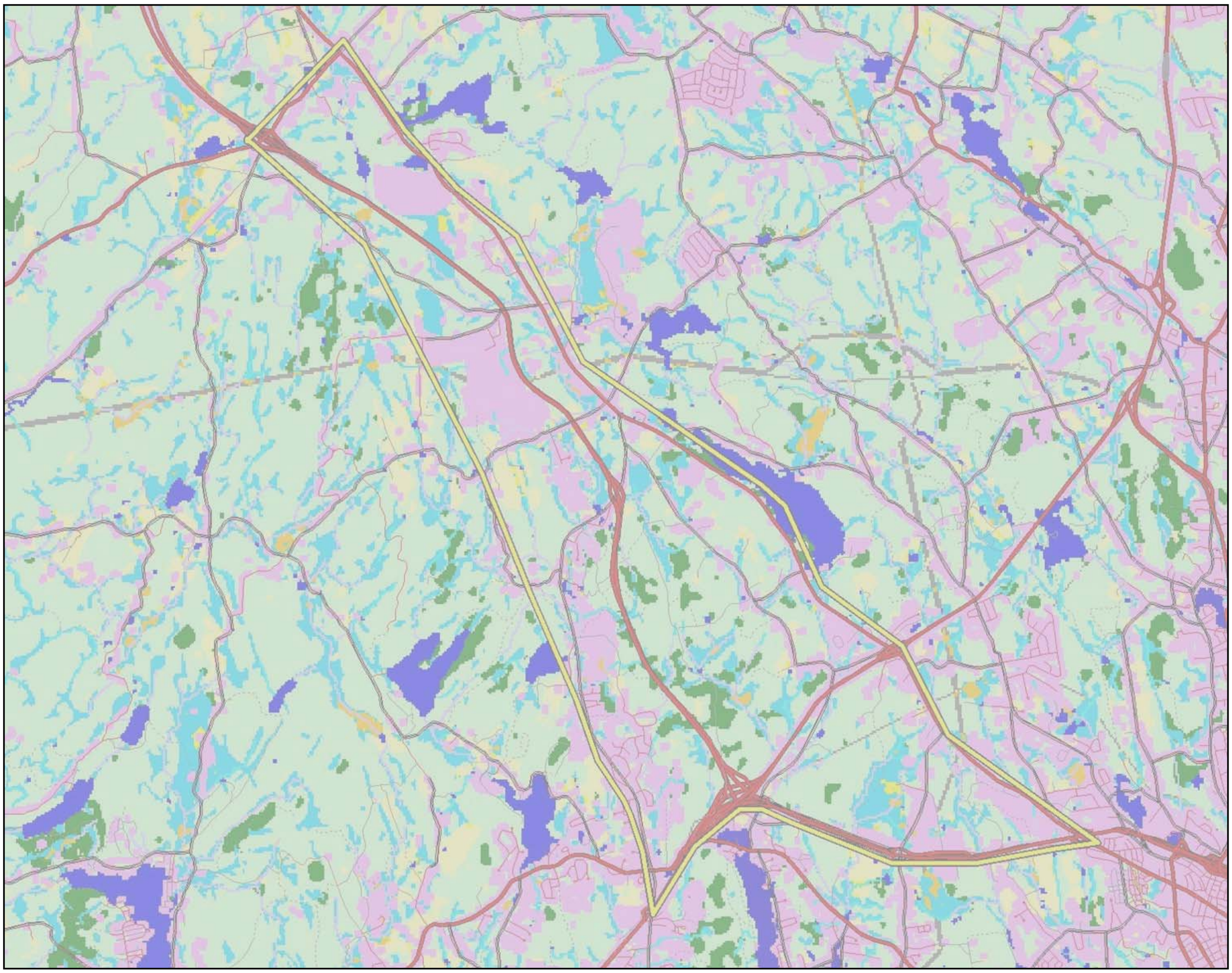
Conservation Assessment and Prioritization System (CAPS) Analysis for the Proposed Route 11 Extension

Final Report

May 7, 2004



Landscape Ecology Program
Department of Natural Resources Conservation
University of Massachusetts AmherstConservation Assessment and Prioritization System (CAPS) Analysis for the Proposed Route 11 Extension

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Introduction

The Conservation Assessment and Prioritization System (CAPS) is a computer software program and an approach to prioritizing land for conservation based on the assessment of habitat and biodiversity value for various natural communities (e.g. northern hardwood forest, grassland, shrub swamp, headwater stream) within an area. Beginning with a computer base map depicting various classes of developed and undeveloped land, we evaluated a variety of landscape-based variables ("filters") to calculate habitat and biodiversity value for every point in the landscape. We use "filters" as an analogy to camera filters—each biodiversity filter acts as a lens that allows you to see different aspects of the underlying natural community map. A filter may, for example, take into account the size of a natural community patch, its proximity to streams and rivers, the diversity of soil types in the patch, or the intensity of roads in the vicinity.

Because CAPS provides a quantitative assessment of habitat and biodiversity value it also can be used for testing various scenarios. This scenario testing capability provides opportunities to evaluate and compare the impacts of development projects and land management on habitat conditions as well as the potential benefits of environmental restoration.

Goal

The goal of this project was to use the distances and distance/impact relationships already built into CAPS as an independent and objective method to evaluate the indirect impacts of the proposed Route 11 highway project (Fig. 1) on habitat and biodiversity value for aquatic and wetland communities within the context of other development in the area, and provide a basis for evaluating alignment alternatives and decisions on appropriate compensation for impacts.

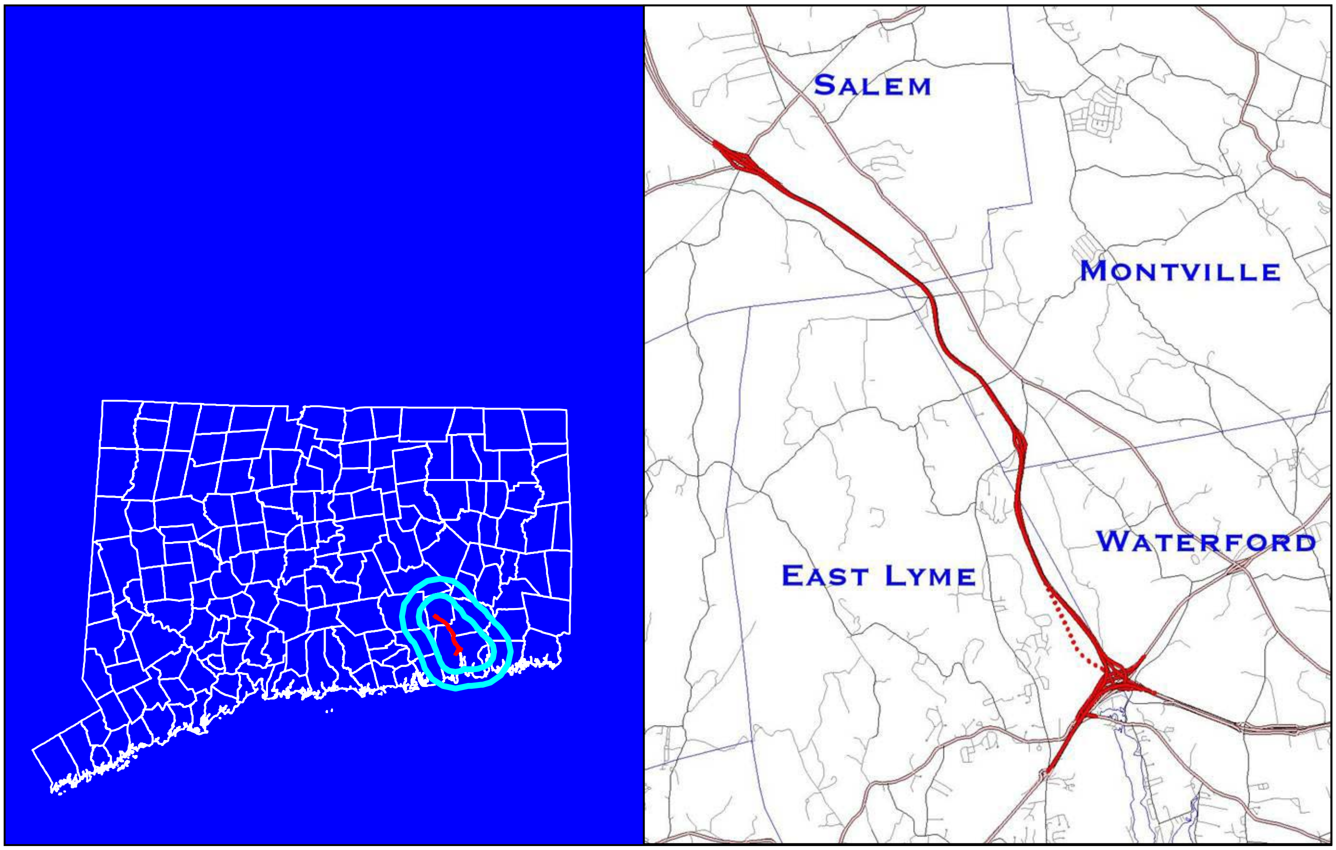

Figure 1. Location of the proposed Route 11 Extension project in southeastern Connecticut.

Methods

Data preparation and analysis consisted of the following steps:

1. Build land cover map from available GIS data. This process is described below.
2. Use the CAPS filters as they were parameterized by expert teams in the development of CAPS. This was done for southern New England during all-day meetings at UMass in November 2000 and February 2001. See Appendix C for details.
3. Run CAPS on base scenario (without highway) and alternative scenarios (with highway). Result for each scenario is a grid of final biodiversity value for each cell. Analyses were also run for the highway with and without wildlife crossing structures (Fig. 2).
4. For each community, sum the difference in biodiversity values (expressed in "biodiversity units"). See results.
5. To convert biodiversity units to compensation acres divide by mean biodiversity value in top 25% of compensation area for each community. The model output is expressed in biodiversity units. In order to convert biodiversity units to area (acres) we use the average biodiversity values for those areas predicted by our model to be the best 25% of land within the compensation area (excluding already protected land).
6. Result is 1:1 compensation for each community, assuming that compensation acres are selected from land that is among the best 25% for habitat and biodiversity value. See results.
7. Use sensitivity analyses to assess the effects of data inaccuracies. See results.

Input data sources

All data are in Connecticut State Plane, NAD 83 feet. Data were reprojected when necessary. All CAPS input layers are in 100 ft grids, with cells aligned with 2002 land cover.

- Roads:
  - 1994 roads and Railroads (Conn DEP, from MAGIC). We shifted these roads 116.5 ft east and 51.3 ft north to improve their alignment with orthophotos. Routes I95, I395 and Route 11 were delineated as expressways. Roads were reclassed (see crosswalk, below).
  - New roads (Maguire Group). These were redigitized based on orthophotos when possible to improve alignment.
  - Route 11 route alignments: E(4)m-V1 and E(4)m-V3 (Maguire Group)
  - Bridges on Route 11 E(4)m-V1 and E(4)m-V3 (Maguire Group). Bridges not spanning other roads were classified as wildlife underpasses (Fig. 2).
- Land cover: 2002 greater Connecticut land cover (Center for Land use Education And Research [CLEAR] at The University of Connecticut)
- Recent and future development (Maguire Group)
- Rt 11 study corridor area (Maguire Group)
- Hydrography (1994, Conn DEP from MAGIC). This coverage was shifted 128 ft east and 35 ft north to align with other coverages. We used the line classes WATER and INTRMT WTR to represent perennial and intermittent streams. Polygon class WATER was used to supplement land cover representation of open water. The MARSH class, which includes both forested and open wetlands, was used in conjunction with hydric soils to delineate wetlands (see below).
- Soils (1995, NRCS, from MAGIC). These data were shifted 92 ft east and 20 ft north for better alignment. We used hydric soil classes to identify wetlands missed by other sources.
- Rivermarine.shp. Marine areas and large rivers selected by hand. Marine areas were excluded from all analyses.

Additional data (reference; not used to build input for CAPS):

- Orthophotos: 1995 digital orthophotos (Conn DEP, from MAGIC). We used this layer to arbitrate misalignment and assess land cover.
- Structures (Maguire Group). Used to help assess the quality of development data.
- Towns (MAGIC)
- National Wetlands Inventory (1992, USGS from MAGIC. Incomplete: the Uncasville quad is not yet digitized). We used NWI data to help assess various sources of wetlands data.

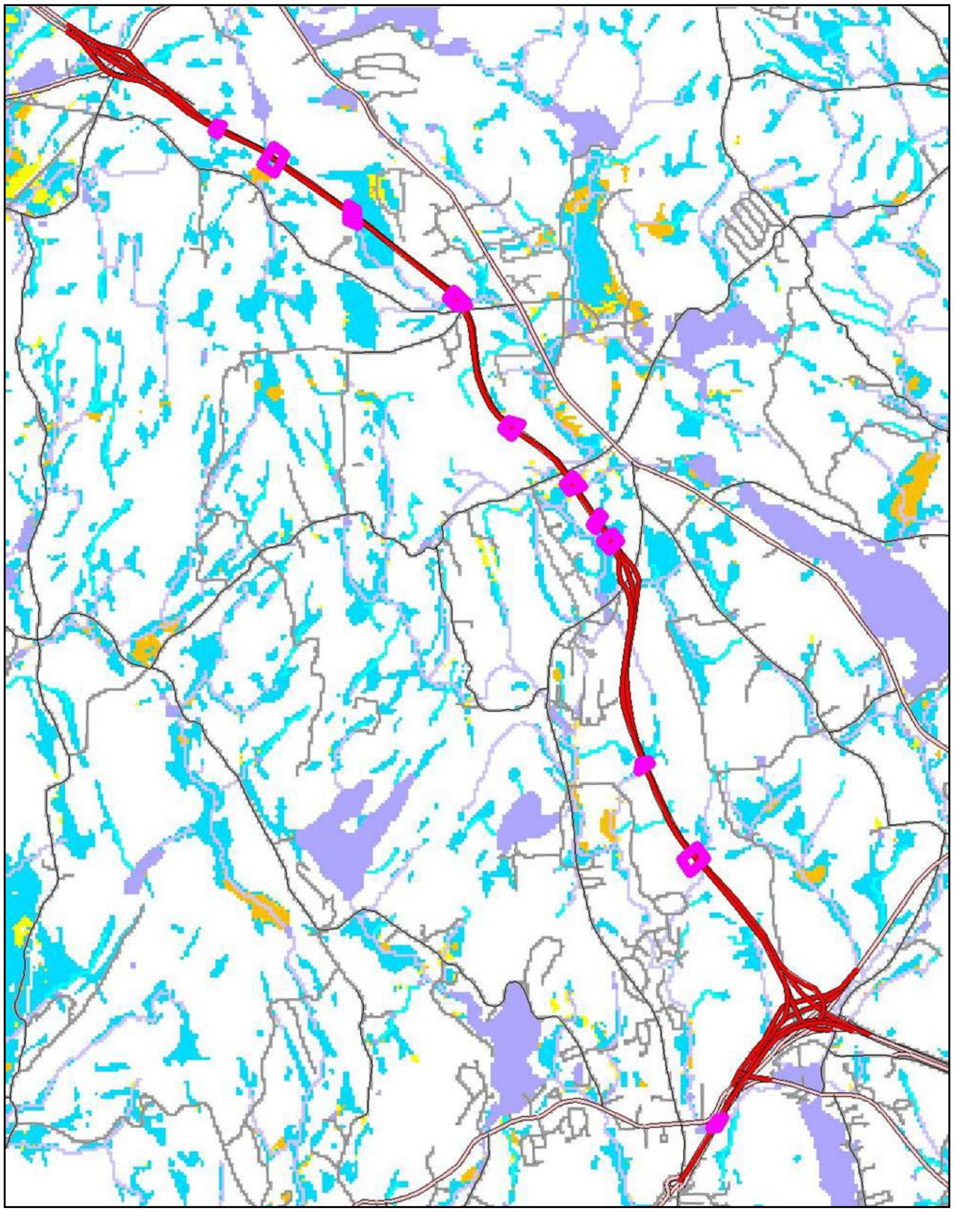

Figure 2. Location of wildlife crossing structures on the proposed Route 11 E(4)m-V3 alignment.

Data issues: Problems and solutions

- **Wetlands**

None of our representations of wetlands appear to be comprehensive. The 2002 land cover clearly under-represents wetlands. We judged the best representation to be based on a combination of areas delineated as “marsh” in the DEP wetlands data and areas with hydric soils from the NRCS soils data. Some areas of hydric soils no doubt represent wetlands that have been drained. Our combined representation of wetlands is believed to over-represent wetlands, but to be more accurate than other options, which greatly under-represent wetlands. Because soils data do not depict cover type, and the DEP “marsh” class clearly includes both forested and non-forested wetlands, we used the 2002 landcover data to separate forested from non-forested wetlands. Wetlands that fall in forested or forested wetlands in the 2002 landcover were considered forested wetlands. Wetlands that fall in barren, non-forested wetland, or powerlines in the landcover were considered non-forested wetlands. Wetlands that fall in agriculture in the landcover were classed as a new natural community, "farmed wetlands." Farmed wetlands include marshes and wet meadows in pastures and hayfields, as well as hydric soils that may have been drained for agriculture.

- **Development**

1. Our only existing representation of development (from 2002 land use) is poor (1995 Land Use is worse). Developed land in this layer is from satellite imagery. Much residential (especially rural residential) development is simply missing, and there are speckles of developed land represented in places where there clearly is no development. Roads are included as "developed" making it difficult to separate out the influences of roads from other development. There are only four classes of developed land: "developed," "barren land," "turf and grass," and "other grasses and agriculture." The 2002 land use data do not currently allow separation of developed land uses into residential, commercial, and industrial categories, nor classification as either low-intensity or high-intensity development.

   We combined "developed" + "turf & grass" into a commercial/industrial/residential developed class (parameterized as high-density residential), and combined "barren land" with "other grasses and agriculture" (which looks fairly accurate) to create an agriculture/barren land developed class. We then removed single isolated cells of developed land, and dropped roads on top, replacing most (but not all) of road cells represented as developed. An alternative (scenario "dx") is to buffer all remaining non-road developed cells to attempt to better capture developed land, although this strongly over-represents development.

   The ideal approach to development would be to digitize developed land (but not to the level of detail of the structures layer) across the study area. Note that the study area must be buffered by at least 5 km (preferably 10 km) in order to get adequate representation for CAPS. Any inconsistencies in data quality between the study area and the surrounding buffer may bias the analysis—for instance; we can't use the structures layer in the study area but not in the buffer without significant bias. This approach would be expensive and time-consuming. On the basis of our sensitivity analysis, we feel that it is unnecessary.

2. Recent and future development is incomplete and incompatible with our other representations of development (it is represented by polygons that fill entire parcels, rather than as land to actually be developed). We were concerned that this would bias results. We included alternative scenarios to test the sensitivity of results to inclusion of these data. The three polygons of new development were numbered 1 through 3, starting from the northernmost.

We performed sensitivity analysis to asses the effect of different development scenarios on the results. We expected these problems with developed land to not matter much in the final analysis, since we are looking at the relative differences between scenarios with no change in development. We also used sensitivity analysis to asses the effect of the total landscape area.

We assessed the following scenarios:

D0 – no new development
D2 – new 2 & 3 only
D3 – all new development = standard scenario
Dx – development expanded + all new development

Mapped developed areas and natural communities were combined to create land cover maps used in the CAPS Analyses (Fig. 3).

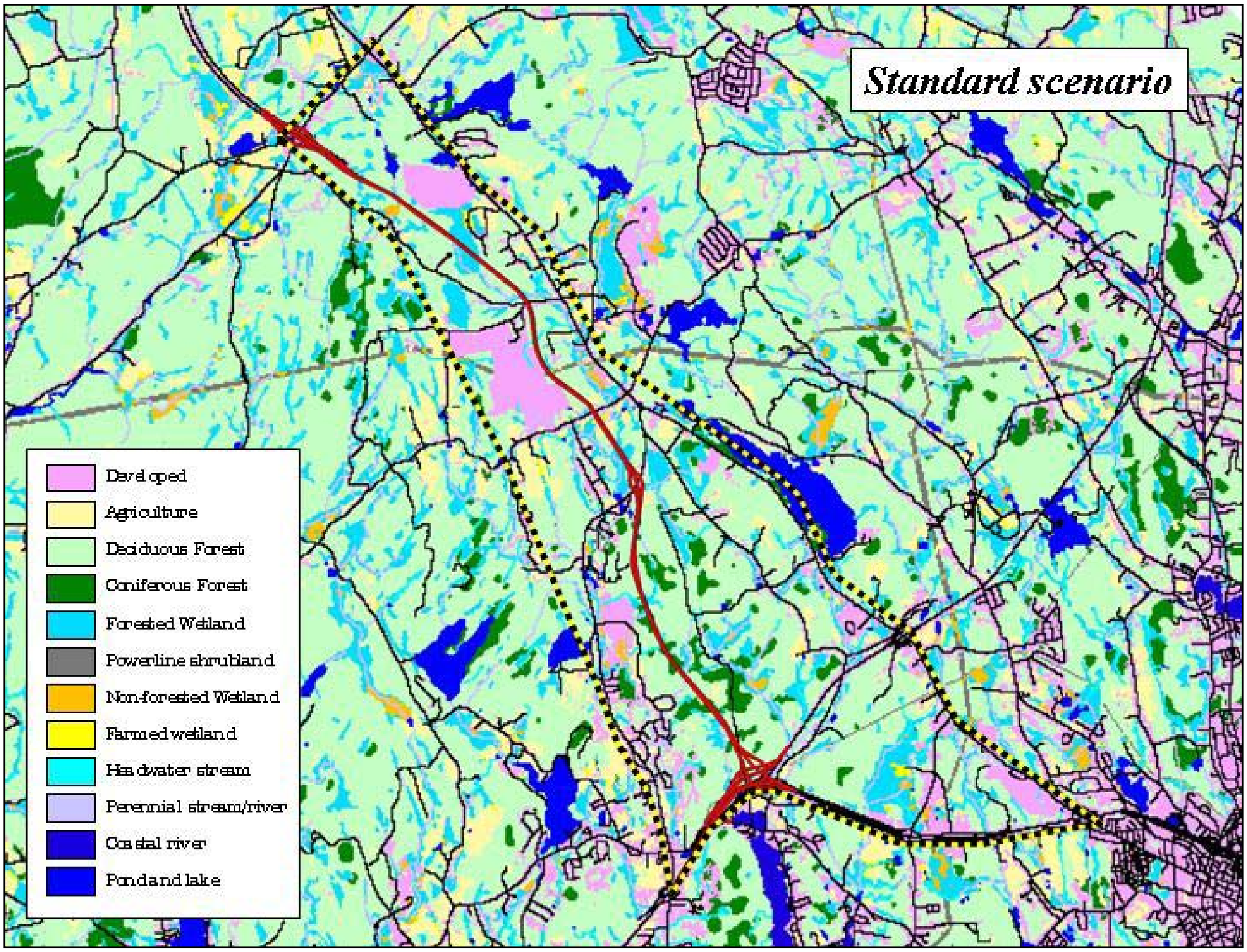

Figure 3. Land cover map including developed land and natural communities for the Route 11 assessment area using the standard scenario.

Results

Sensitivity analyses – Development

We ran CAPS for the four development scenarios, to assess sensitivity to differing representations of development (Tables 1 & 2). As expected, the expanded development scenario resulted in fewer compensation acres, while the scenarios omitting new development resulting in a slight increase in compensation acres. For most communities, these variations were fairly small in terms of percentage. Exceptions include Powerline shrubland and Lakes and ponds, which represent small areas of the compensation area.

Table 1. Sensitivity analysis, development. Total unadjusted biodiversity units by community under each scenario.

Community	**dx**	**d3**	**d2**	**d0**
Deciduous forest	295.97	349.07	357.07	373.52
Coniferous forest	52.62	54.86	54.86	55.27
Forested wetland	37.1	42.65	44.16	45.94
Powerline shrubland	1.07	1.57	1.57	3.54
Non-forested wetland	1.74	2.31	2.31	2.39
Farmed wetland	1.43	1.74	1.75	1.77
Headwater stream	6.81	7.16	7.17	7.57
Perennial stream	19.94	21.21	21.49	21.69
Coastal river	2.23	2.40	2.40	2.40
Pond or lake	1.99	2.45	3.01	3.01
Total (units)	**420.90**	**485.42**	**495.79**	**517.10**
Total compensation acres	**596**	**686**	**700**	**730**
Total deviation (acres)	**-90**	**0**	**+14**	**+44**

Table 2. Sensitivity analysis, development. Scenario d3 is the standard scenario; dx has expanded development (over-representation); d2 and d0 omit polygons of new development. Each cell shows the percent deviation from the standard scenario for each community.

	% deviation from standard			
Community	**dx**	**d3**	**d2**	**d0**
Deciduous forest	-15	0	+2	+7
Coniferous forest	-4	0	0	+1
Forested wetland	-13	0	+4	+8
Powerline shrubland	-32	0	0	+125
Non-forested wetland	-25	0	0	+3
Farmed wetland	-18	0	+1	+2
Headwater stream	-5	0	0	+6
Perennial stream	-6	0	+1	+2
Coastal river	-7	0	0	0
Pond or lake	-19	0	+23	+23

Sensitivity analyses – Landscape size

To assess the effect of landscape size on the results, we ran the standard scenario for 11 concentric landscapes, based on buffering the corridor area from 0 to 10 km. Total loss of biodiversity acres decreased as the landscape increased, because higher-valued areas were included in scaling (Fig. 4). Indirect effect zones extended beyond the 2 km buffer, so the minimum reasonable buffers size is 3 km. The difference between a buffer of 3 km and the maximum, 10 km, is about 8.5%.

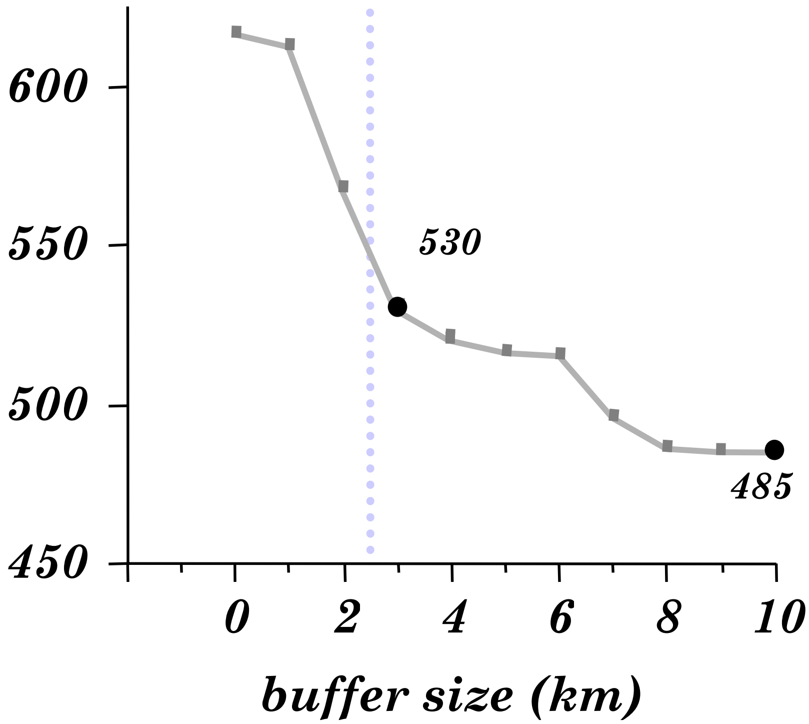

Figure 4. Sensitivity analysis, landscape size. Graph shows number of biodiversity units for the standard scenario for each buffer size. Buffer sizes less than 3 km cut off some of the indirect effect zones.

Results – Compensation area

We selected the D3 scenario with a 10 km buffered landscape *a priori*. Sensitivity analyses suggest that this was a reasonable choice. Results from the CAPS analyses of the standard scenario are presented in Tables 3-6 and Figures 5-8. Figure 5 shows output for the six filters used in the standard analysis without the Route 11 Extension. Figure 8 depicts the change for each filter when the highway is included in the analysis.

A comparison of the V1 alignment, V3 alignment, and V3 alignment without wildlife passages shows that, while the difference between the two alignments is about 7% (48 acres), the inclusion of wildlife passages reduces total compensation acres by about 22% (Table 7).

We suggest that our approach is most appropriate for assessing and determining compensation targets for the indirect impacts of the highway on habitat and biodiversity value (Tables 4 and 6). Our analyses focus on habitat and biodiversity value, but do not include other wetland values such as flood control, groundwater protection, pollution prevention, etc. Furthermore, our analyses are at a relatively coarse scale (100 ft cells) which is not as accurate as field-based engineering work. Thus, we believe it makes sense to use other assessments of direct impacts for developing wetlands mitigation, while basing compensation targets on our assessment of indirect impacts on habitat and biodiversity (the wetland function most significantly affected by indirect effects of the highway).

Note that compensation acres reported for streams are inflated by their cell-based representation. These numbers should be interpreted as acres with streams flowing through, rather than actual acres of water. Given the important relationship between streams and their surrounding riparian areas it would be valid to consider these as “stream and riparian zone” compensation acres.

Table 3. Direct and indirect impacts for standard scenario, V3 alignment.

Community	**Biodiversity units**	**Mean top 25%**	**Compensation acres**
Deciduous forest	349.07	0.74	474
Coniferous forest	54.86	0.78	70
Forested wetland	42.65	0.57	75
Powerline shrubland	1.57	0.89	2
Non-forested wetland	2.31	0.53	4
Farmed wetland	1.74	0.51	3
Headwater stream	7.16	0.53	13
Perennial stream	21.21	0.58	36
Coastal river	2.40	0.79	3
Pond or lake	2.45	0.68	4
TOTAL	**485.42**		**686**

Table 4. Indirect impacts for standard scenario, V3 alignment.

Community	**Biodiversity units**	**Mean top 25%**	**Compensation acres**
Deciduous forest	271.39	0.74	369
Coniferous forest	44.36	0.78	57
Forested wetland	33.54	0.57	59
Powerline shrubland	1.17	0.89	1
Non-forested wetland	2.26	0.53	4
Farmed wetland	1.31	0.51	3
Headwater stream	5.32	0.53	10
Perennial stream	17.27	0.58	30
Coastal river	2.40	0.79	3
Pond or lake	2.25	0.68	3
TOTAL	**381.27**		**539**

Table 5. Direct and indirect impacts for standard scenario, V3 alignment, wetland and aquatic communities only.

Community	**Biodiversity units**	**Mean top 25%**	**Compensation acres**
Forested wetland	42.65	0.57	75
Non-forested wetland	2.31	0.53	4
Farmed wetland	1.74	0.51	3
Headwater stream	7.16	0.53	13
Perennial stream	21.21	0.58	36
Coastal river	2.40	0.79	3
Pond or lake	2.45	0.68	4
TOTAL	**79.92**		**139**

Table 6. Indirect impacts for standard scenario, V3 alignment, wetland and aquatic communities only.

Community	**Biodiversity units**	**Mean top 25%**	**Compensation acres**
Forested wetland	33.54	0.57	59
Non-forested wetland	2.26	0.53	4
Farmed wetland	1.31	0.51	3
Headwater stream	5.32	0.53	10
Perennial stream	17.27	0.58	30
Coastal river	2.40	0.79	3
Pond or lake	2.25	0.68	3
TOTAL	**64.35**		**112**

Table 7. Comparison of direct plus indirect compensation acres between alignments E(4)m-V1, E(4)m-V3, and E(4)m-V3 without wildlife passages.

	Compensation acres		
Community	**V1**	**V3**	**V3 (np)**
Deciduous forest	442	474	621
Coniferous forest	59	70	86
Forested wetland	73	75	98
Powerline shrubland	2	2	2
Non-forested wetland	4	4	5
Farmed wetland	3	3	4
Headwater stream	13	13	14
Perennial stream	36	36	39
Coastal river	3	3	3
Pond or lake	4	4	4
TOTAL	**638**	**686**	**876**

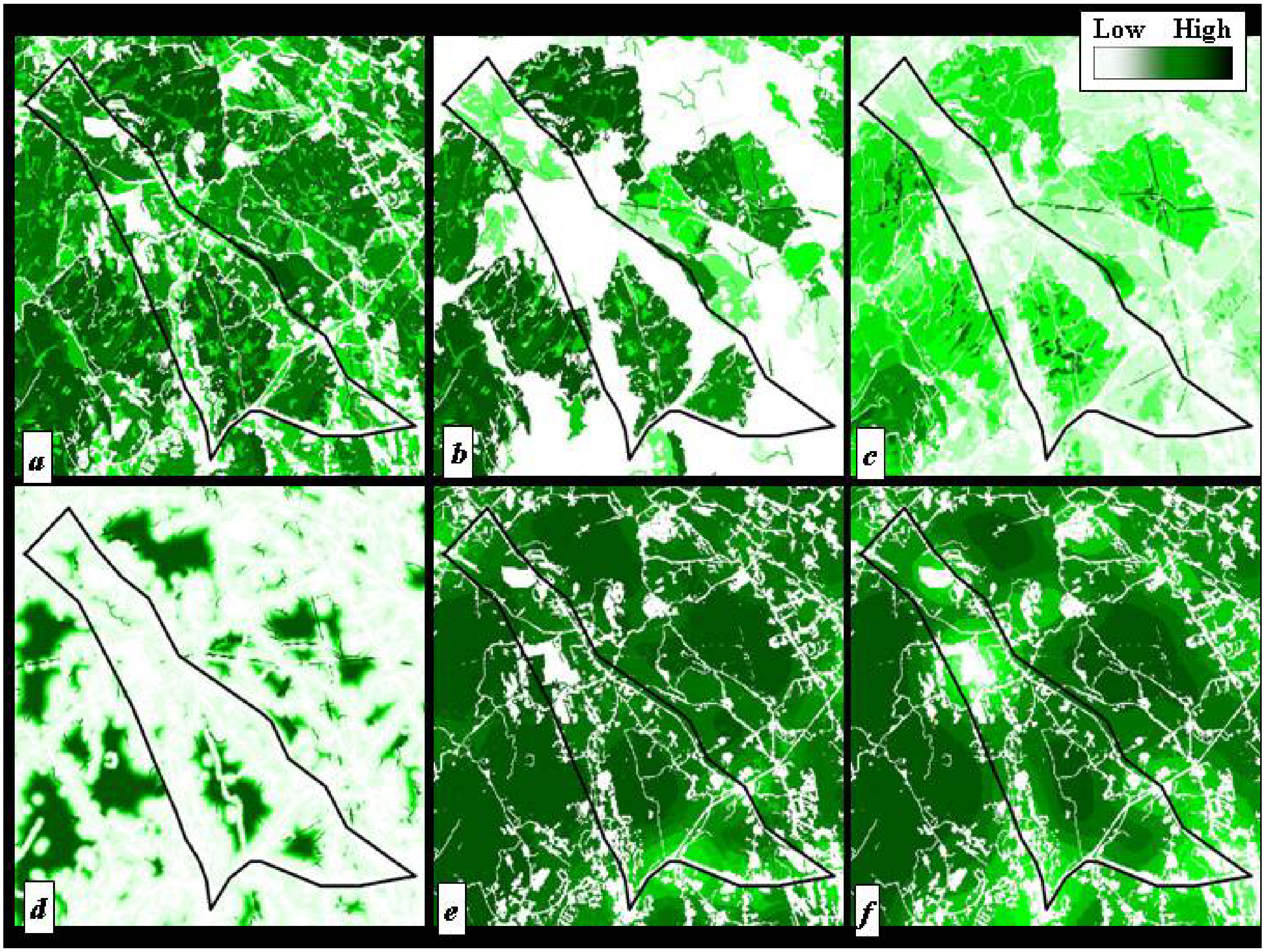

Figure 5. Output for the six filters used in the standard analysis without the Route 11 Extension: a) patch area, b) core area, c) connectedness, d) edge effects, e) road intensity, and f) development intensity. Darker colors represent higher contributions to habitat and biodiversity value.

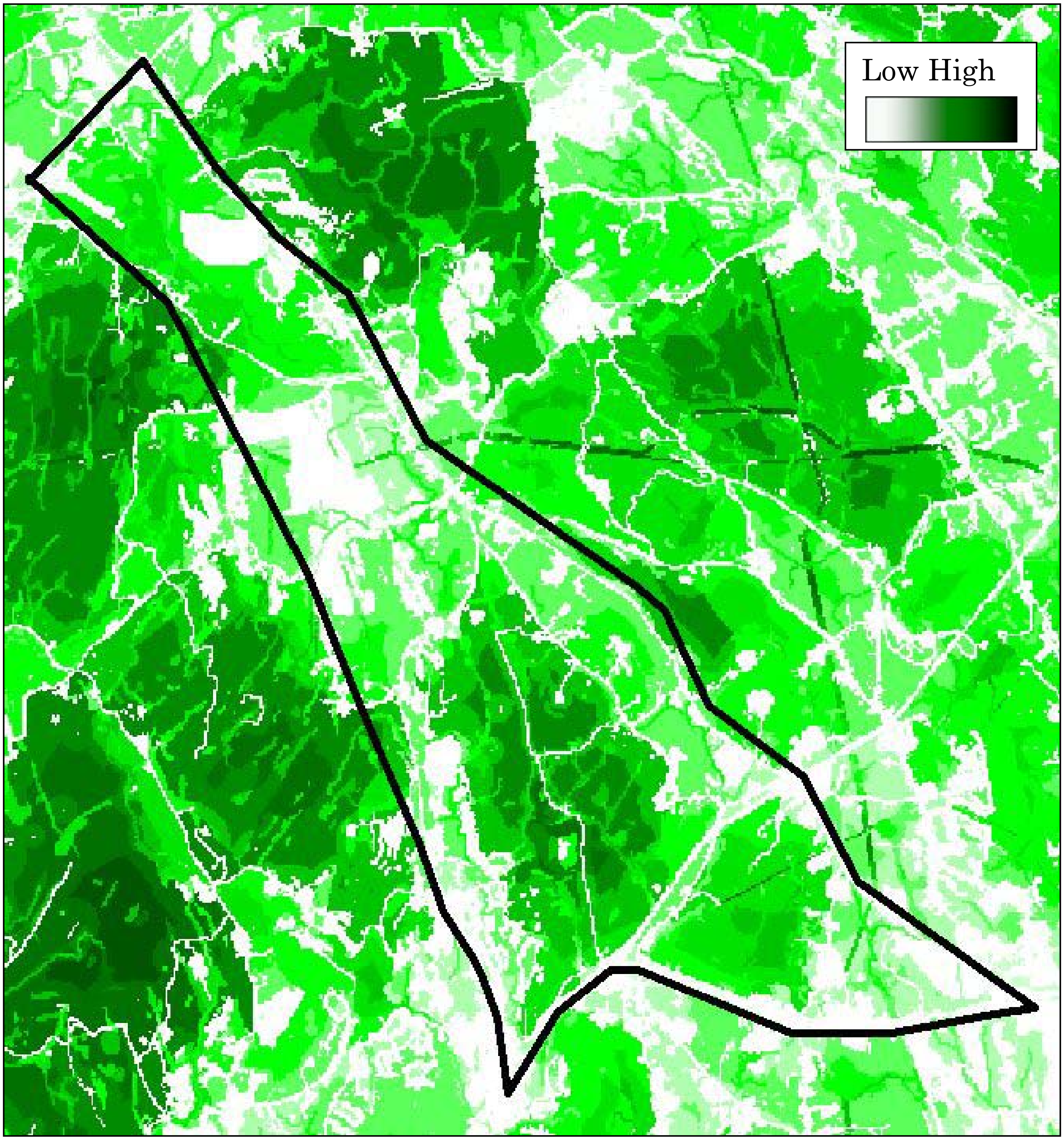

Figure 6. Total habitat and biodiversity value: base scenario without Route 11 E(4)m-V3. Darker colors represent higher habitat and biodiversity value.

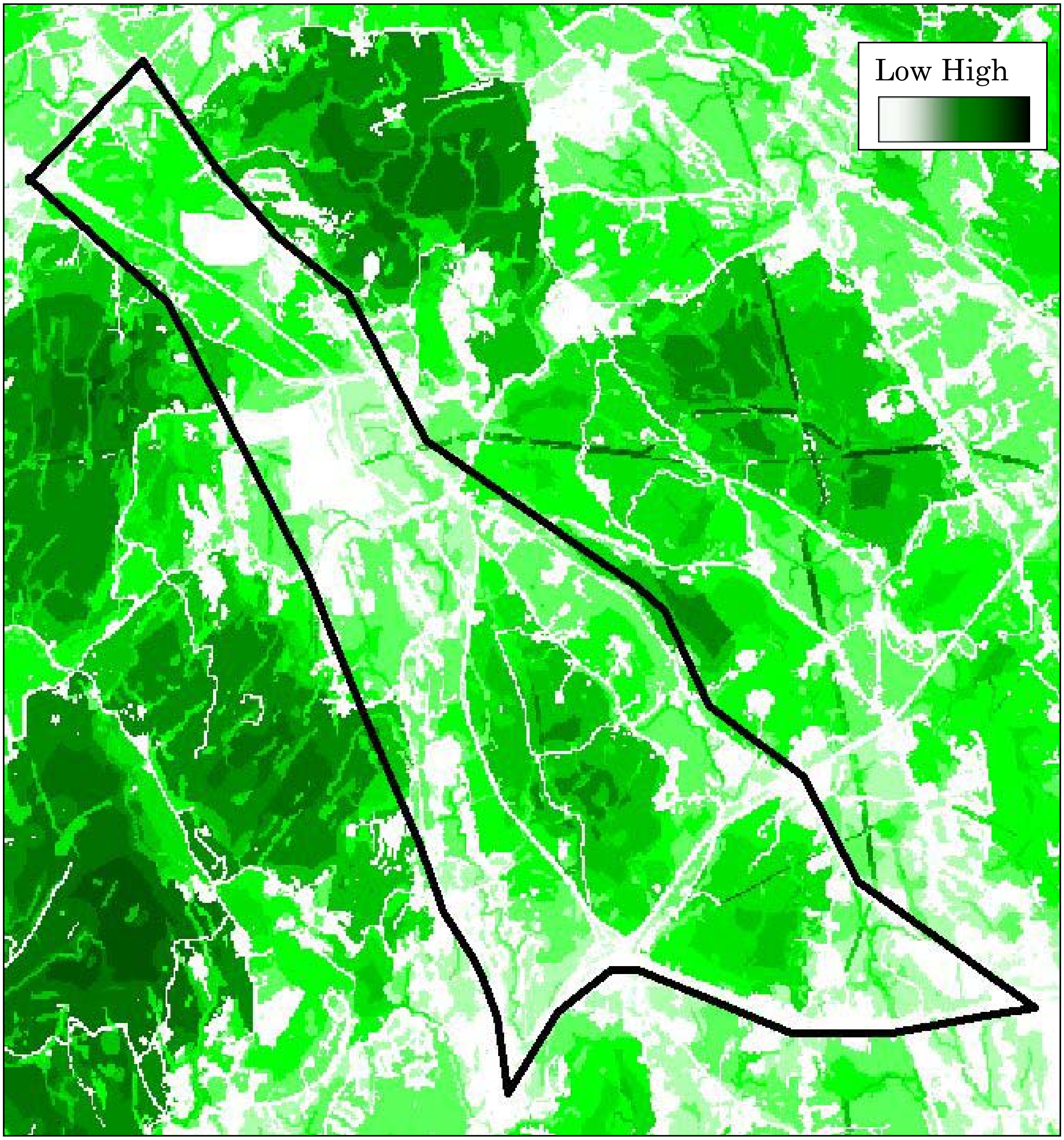

Figure 7. Total habitat and biodiversity value: with Route 11 E(4)m-V3. Darker colors represent higher habitat and biodiversity value.

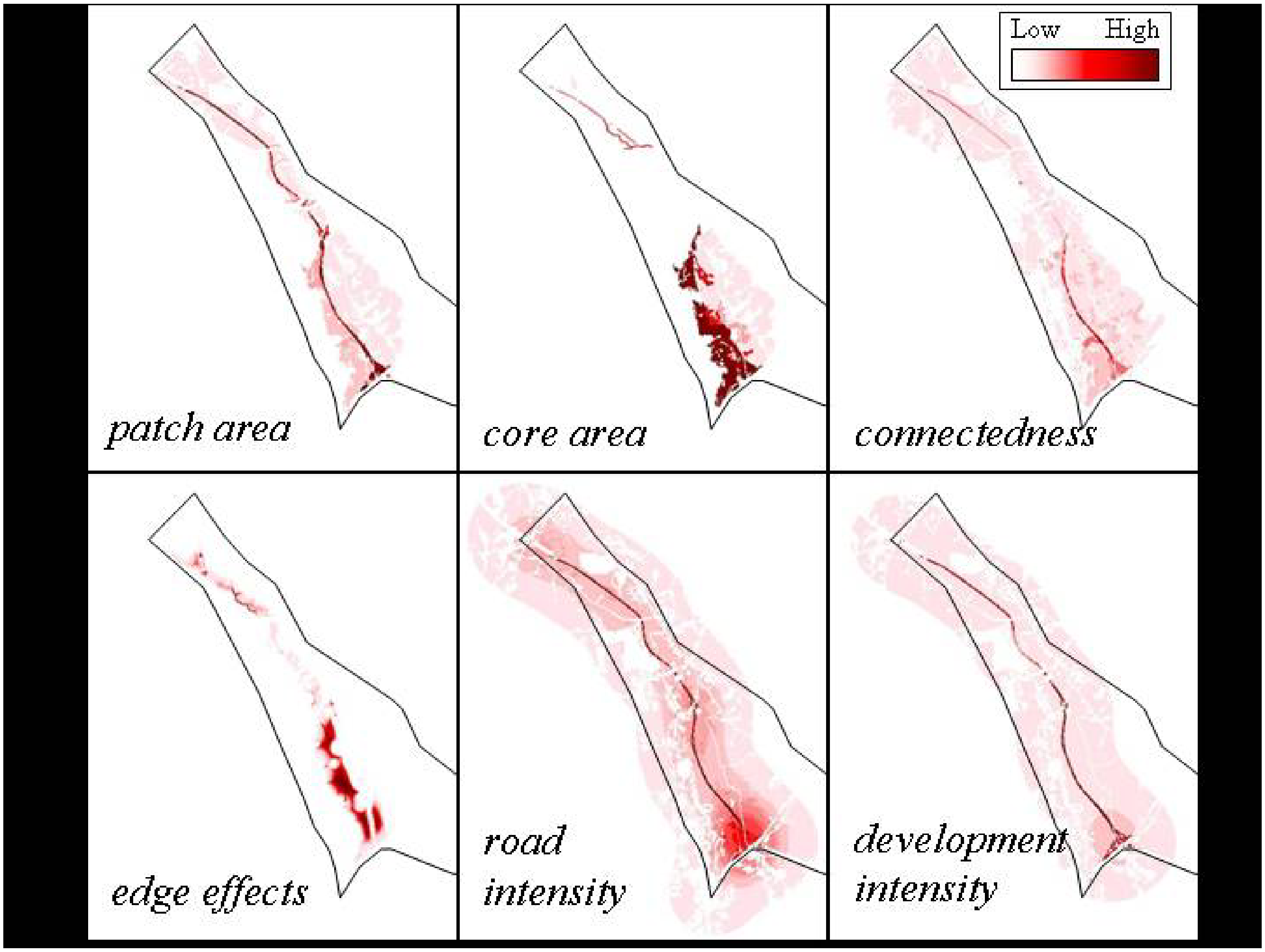

Figure 8. Change in filters due to Route 11 E(4)m-V3. Darker colors represent greater change in filters contributing to overall loss of habitat and biodiversity value.

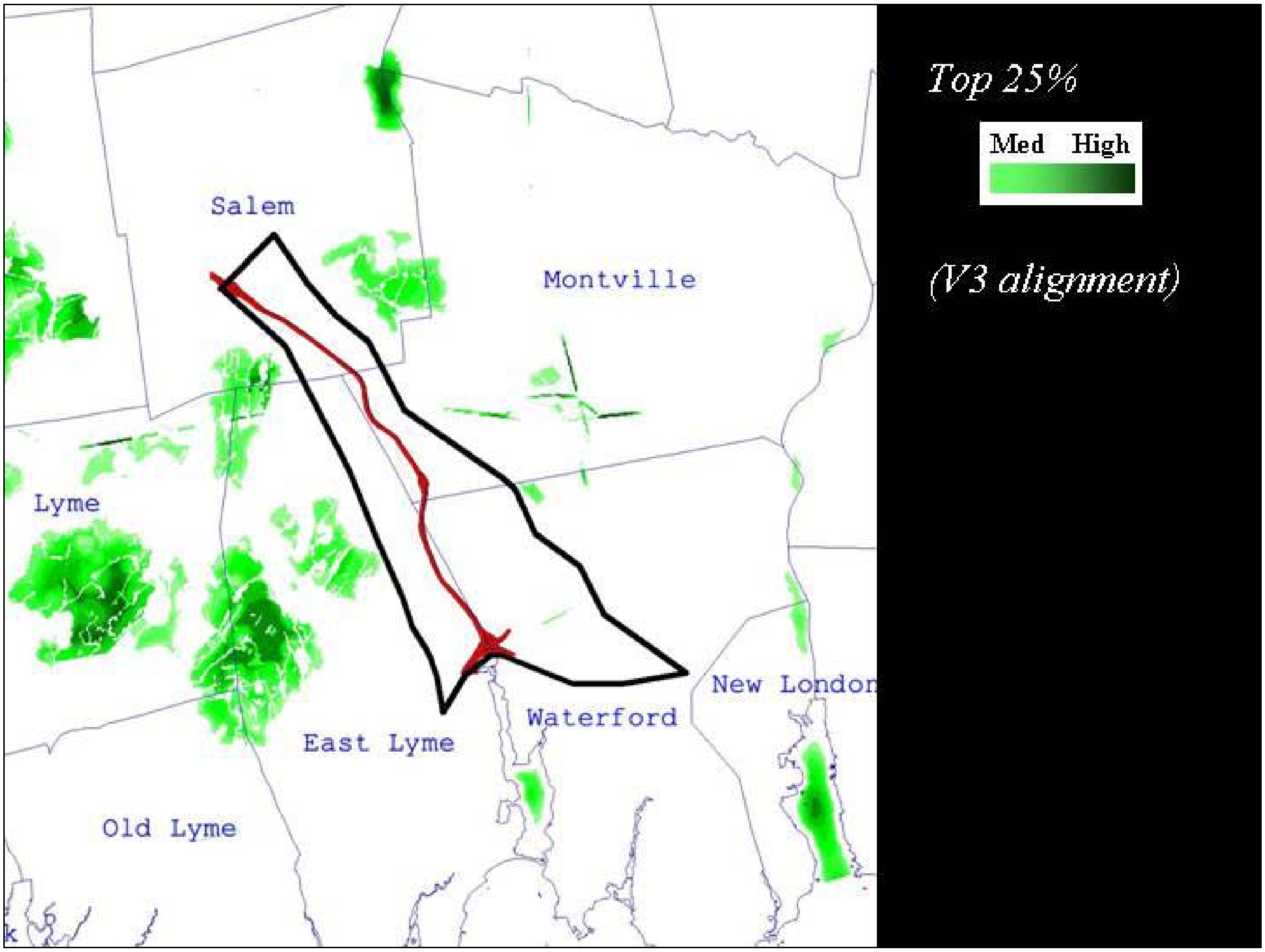

Figure 9. Location of land that is among the best 25% for habitat and biodiversity value within the compensation area for the project. Darker colors represent higher habitat and biodiversity value.

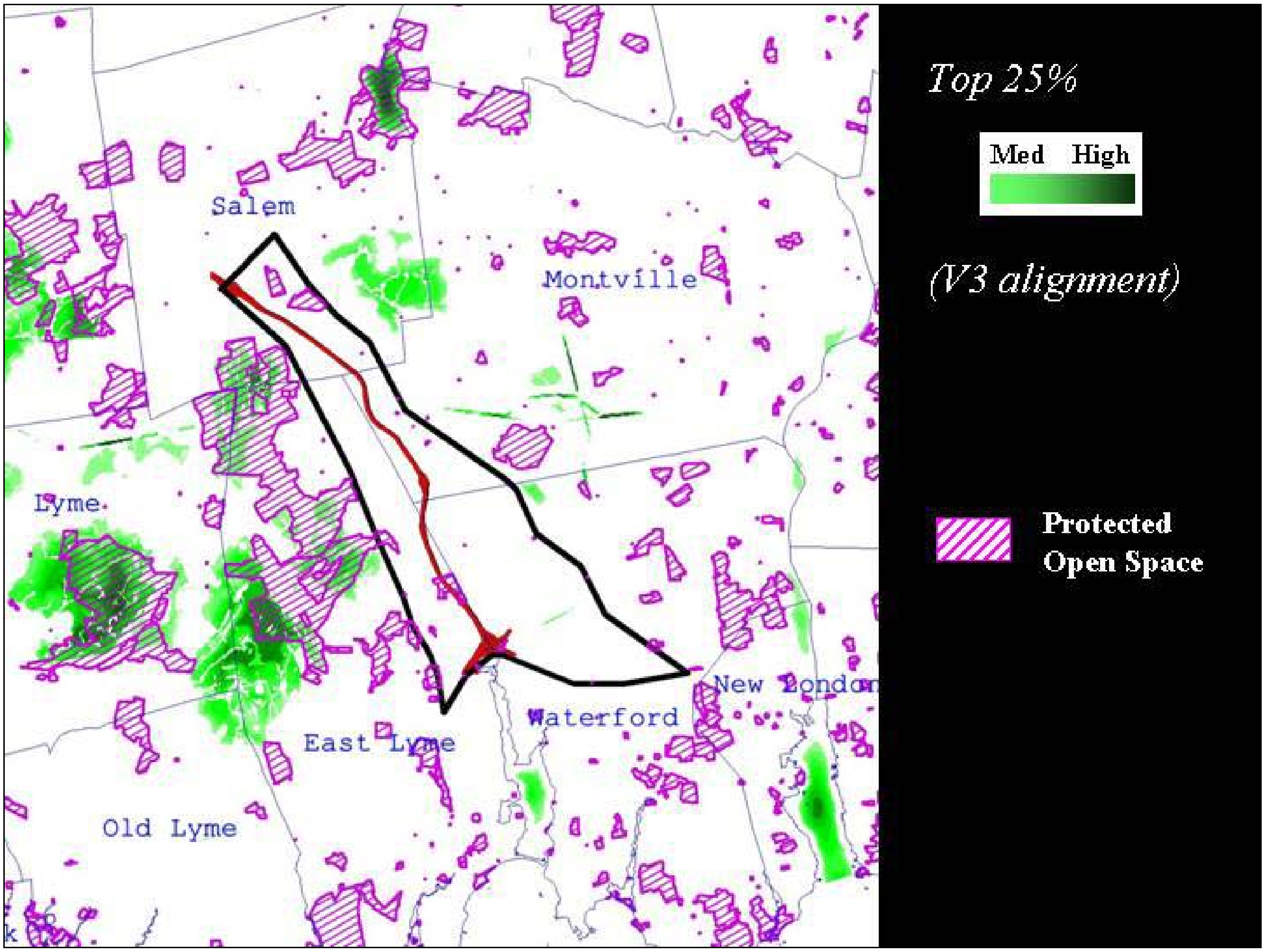

Figure 10. Location of land that is among the best 25% for habitat and biodiversity value and protected open space within the compensation area for the project. Darker colors (green) represent higher habitat and biodiversity value.

Discussion

A simplified CAPS analysis of the proposed Route 11 Extension was conducted using six filters sufficient to characterize and quantify indirect impacts of the proposed highway on habitat and biodiversity value. Although our analyses also predict loss of value due to direct impacts we believe that in this case the CAPS approach is best suited for evaluating indirect impacts.

Using existing GIS data we compiled a land cover map using the standard scenario for development. Existing data on development contains many inaccuracies and lacks classification that would allow full use of the CAPS development classes. However, sensitivity analyses indicate that these development data problems are not likely to have large impacts on the results.

In addition to mapping developed land we characterized the undeveloped portion of the landscape using a simplified natural community classification. Terrestrial communities were classified generally as deciduous forest, coniferous forest and powerline shrubland. The quality of existing wetlands data allowed us to compile a more detailed map of wetland and aquatic communities (See Appendix A).

Results of the analyses using the standard scenario were converted to acres using the mean habitat and biodiversity value for the best 25 percent of natural community patches in the project compensation area. We assume that land to be protected as compensation for the loss of habitat and biodiversity value will be selected from the most valuable natural community patches (Fig. 9). If this is true, then the number of compensation acres calculated via our analyses would be about equal in value to that lost in the creation of the highway.

It is not our role to suggest or determine whether one-to-one or some other ratio of compensation is appropriate for the loss of habitat and biodiversity value. For purposes of quantifying the predicted loss of value we calculated that total impacts (direct and indirect) would be roughly equivalent to 686 acres of high quality habitat (best 25 percent within the compensation area). Taken alone, the indirect impacts of the highway on habitat and biodiversity value would be approximately equivalent to 539 acres of high quality habitat. Information on the predicted loss of value broken out by natural community is presented in Tables 3 and 4. Our analyses predict that the loss of value in wetland and aquatic habitats would be roughly equivalent to 139 acres of high quality wetland/aquatic habitat within the compensation area (with indirect impacts roughly equivalent to 112 acres).

It is important to note that those areas identified as high quality habitat in our analysis (Fig. 9) were valued as such because they were imbedded in relatively intact landscapes. Areas targeted for compensation based on this analysis will only retain their value if they remain in functionally intact landscapes over time. This is especially important to consider for wetland and aquatic systems. We recommend against "cherry picking" high quality habitats from around the compensation area and suggest instead that compensation efforts be focused on protecting functional landscapes that contain a mix of high quality wetland, aquatic and terrestrial communities. Targeting high quality habitat adjacent to protected open space (Fig. 10) is another strategy for maintaining the value of compensation areas over time.

Appendix A: Final land cover classes

Developed land
- Developed (commercial/industrial/residential)
- Agriculture/Barren land

Roads
- Expressway
- Primary highway
- Secondary highway
- Light-duty road
- Unpaved road
- Wildlife underpass (on Route 11 extension)
- Railroads

Forests
- Deciduous forest
- Coniferous forest
- Forested wetland

Nonforested uplands
- Powerline shrubland

Wetlands & Aquatic[*]
- Non-forested wetland (includes tidal wetlands)
- Farmed wetland (hydric soils in agriculture)
- Headwater (intermittent) stream
- Perennial stream
- River (includes tidal rivers)
- Pond and lake

[*]Forested wetlands are listed under “Forests”

Appendix B: Land cover codes and Crosswalk

Crosswalk of road classes (Conn. DEP → CAPS)

Conn DEP	code	CAPS	Comments
Hway prim	101	Expressway	expressway = 1 (Route 11, 95, and 395 delineated by hand)
Hway prim	102	Primary highway	
Rest area	103	Secondary highway	
Hway secon	103	Secondary highway	
Local road	104	Light duty road	
Minor road	105	Unpaved	
Railroads	106	Railroad	
—	110	Wildlife underpass	Digitized as passages.shp

Crosswalk of land cover classes (2002 land cover → CAPS)

code	2002 landcover	code	CAPS	Comments
1	Developed	11	Developed	
2	Turf & grass	11	Developed	
3	Other grasses & agriculture	15	Agriculture/Barren Land Farmed wetland	 with hydric soils
4	Deciduous forest	31	Deciduous forest	
5	Coniferous forest	32	Coniferous forest	
6	Water	62	Perennial stream/river	delineation
6	Water	71	Pond and lake	
7	Non-forested wetland	51	Nonforested wetland	also from soils
8	Forested wetland	33	Forested wetland	also from soils
9	Tidal wetland	51	Nonforested wetland	
10	Barren land	11	Agriculture/Barren Land	
11	Utility right-of-way	41	Powerline shrubland	

Crosswalk CAPS Housatonic parameterizations → Rt 11 parameterizaions

code	CAPS	code	RT11	Parameterization
11-14		11	Developed	as high-density residential
15	Agriculture	15	Agriculture	
21	Expressway	101	Expressway	
22	Primary highway	102	Primary highway	
23	Secondary highway	103	Secondary highway	
24	Light-duty road	104	Light-duty road	
25	Unpaved road	105	Unpaved road	
26	Railroad	106	Railroad	
		110	Wildlife underpass	New type – treat as unpaved road
141	Mixed transitional forest	31	Deciduous forest	
151	Temperate conifer forest	32	Coniferous forest	
191	Deciduous/mixed coniferous forest	33	Forested wetland	
214	Powerline shrubland	41	Powerline shrubland	
311 / 341	Emergent marsh / shrub swamp	51	Nonforested wetland	take mean
311 / 341	Emergent marsh / shrub swamp	52	Farm wetland	take mean
371 / 372	Pond / lake	71	Pond and lake	
351 / 355 / 358	High/medium/low-gradient headwater stream	61	Headwater stream	Use medium gradient.
352 / 353 / 356 / 357 / 359 /361	1-3 order stream	62	Perennial stream	Use medium 1-2
362 / 363 / 364	4-5 order stream	63	River	Use low 5th

Appendix C: CAPS Filter Parameterizations for Wetland Communities

The following filters were used to characterize wetland communities:

- Patch area
- Core area
- Connectedness
- Edge effects
- Road intensity
- Development intensity

The parameters presented here were devised by expert teams of biologists during all-day meetings at UMass in November 2000 and February 2001. Explanations of these filters are available at:
http://www.umass.edu/landeco/research/caps/documents/filters.doc

Forests (Forested wetlands)

Patch area (weight = 1)
No parameters required.

Core area (weight = 1)
Uses 75th percentile from Edge Effects filter, below.

Connectedness (weight = 1)
Spread value = 5 km
Costs:
Developed land cover:

20	Developed land
10	Agricultural
200	Expressway
150	Primary highway
100	Secondary highway
50	Light duty road
20	Unpaved road
20	Wildlife underpass
50	Railroad

Natural land cover:

1	Forests
5	Powerline shrubland
4	Non-forested and farmed wetlands
30	Streams and rivers
50	Pond and lake

Edge effects (weight = 1)
Edge effect categories:

0	no edge effect
1	d_{50} = 15 m, d_s = 3 m
2	d_{50} = 100 m, d_s = 20 m
3	d_{50} = 200 m, d_s = 40 m
4	d_{50} = 400 m, d_s = 80 m
5	d_{50} = 800 m, d_s = 160 m

Edge effect category for each land cover class:
Developed land cover:

4	Developed

3 Agricultural
4 Expressway
4 Primary highway
4 Secondary highway
3 Light duty road
2 Unpaved road
2 Wildlife underpass
3 Railroad

Natural land cover:
0 Forests
2 Grasslands
1 Non-forested and farmed wetlands
1 Streams and rivers
2 Lakes

Road intensity (weight = 1)
Logistic distance scaling parameters: $d_{50} = 1000$; $d_s = 200$
Development class weights:
20 Expressway
10 Primary highway
7 Secondary highway
4 Light duty road
1 Unpaved road and wildlife underpass
3 Railroad

Development intensity (weight = 2)
Logistic distance scaling parameters: $d_{50} = 1000$; $d_s = 200$
Development class weights:
15 Development
5 Agricultural

Palustrine (Nonforested Wetland and Pond and Lake)

Patch area (weight = 1)
No parameters required.

Connectedness (weight = 6)
Spread value = 2 km
Costs:
Developed land cover:
30 Development
10 Agricultural
100 Expressway
75 Primary highway
50 Secondary highway
30 Light duty road
20 Unpaved road and wildlife underpass
100 Railroad

Natural land cover:
6 Forests
4 Powerline shrubland

1 Non-forested and farmed wetlands
2 Streams and rivers
1 Pond and lake

Edge effects (weight = 2)
Edge effect categories:
0 no edge effect
2 d_{50} = 50 m, d_s = 10 m
3 d_{50} = 100 m, d_s = 20 m
4 d_{50} = 200 m, d_s = 40 m
5 d_{50} = 400 m, d_s = 80 m
Edge effect category for each land cover class:
Developed land cover:
4 Developed
4 Agricultural
5 Expressway
5 Primary highway
4 Secondary highway
3 Light duty road
2 Unpaved road and wildlife underpass
3 Railroad

Natural land cover:
0 all natural communities

Road intensity (weight = 2)
Logistic distance scaling parameters: d_{50} = 1000; d_s = 200
Development class weights:
10 Expressway
7 Primary highway
5 Secondary highway
3 Light duty road
1 Unpaved road and wildlife underpass
5 Railroad

Development intensity (weight = 2)
Logistic distance scaling parameters: d_{50} = 1000; d_s = 200
Development class weights:
1 Developed
3 Agricultural