Final Report

To the EPA Office of Long Island Sound

1. Title

Coastal Riparian Buffers Analysis

EPA Grant Number: LI – 97128801 - 0

2. Grantee Organization and Contact Name:

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3. Public Summary:

Attached as Appendix A.

4. Project Period: 9/30/2005 to 9/30/2007

5. Project Description

Overview

This project looked at land cover and land cover change within watersheds and riparian corridors of coastal Connecticut. Riparian, or streamside, corridors are known to be environmentally important areas critical to stream stability, pollutant removal, and both aquatic and terrestrial wildlife habitat; these areas are also sometimes known as "buffer" areas. Based on the recommendations of the LISS Nonpoint Source and Watershed Work Group, this study was intended to give local officials, researchers, landowners and other interested parties an overview of the status of riparian corridors draining to the Sound, and a feel for land use trends within these areas.

Objectives

The project's objectives were to:

(1) provide an overall picture of the state of riparian areas in the Sound's immediate drainage basin;
(2) develop diagnostic information at the subregional watershed level which LISS, state and local managers can use to direct future efforts, and
(3) create highly accurate information for at least one high priority basin, which can be used as part of local efforts to protect and/or restore riparian areas.

Methods

Connecticut statewide land cover from 2002, and land cover change from 1985-2002, were employed and analyzed to derive a variety of statistics for both entire basins and buffer zones within basins. Basins were characterized for land cover and land cover change at the subregional level of organization, resulting in 167 study units. In addition, within these basins data were compiled for riparian corridors of three different widths: 100 feet, 200 feet, and 300 feet (to either side of the stream). Results are provided in both data table (statistic) format and map format. A fine scale analysis was completed for the three buffer zones of the Niantic Bay watershed. The results have been made available on the Riparian Buffers portion of the CLEAR website in both tabular (PDF) format and an interactive map.

Management Implications

The results are being folded into ongoing CLEAR outreach and educational programs. The statewide buffer characterization is being used within the context of a municipal workshop on coastal habitats being offered by Connecticut Sea Grant and CLEAR's Nonpoint Education for Municipal Officials (NEMO) program. Results have been presented to both the Nonpoint Source and Watershed Work Group and Science and Technical Advisory Committee of the LISS, and also in other scientific meetings and conferences (Section 10). The website will provide complete study results for all managers and researchers interested in using the data. The high resolution analysis is being used by NEMO/Sea Grant Educator Dr. Juliana Barrett and Waterford Environmental Planner Maureen Fitzgerald to conduct educational programs and publications for riparian land owners in the town of Waterford.

6. Activities & Accomplishments

The major tasks of this research project and summarized below are as follows:

1. Determine study area
2. Characterize coastal sub-regional watersheds: land cover and land cover change
3. Characterize riparian areas within coastal sub-regional watersheds
4. Investigate comparative methods and indices
5. Conduct trial fine scale analysis
6. Develop project website

1. Determine study area

The first task was to determine the study area that would be analyzed. For this and many other technical and policy decisions, CLEAR depended upon the advice of a project advisory group, which was drawn from the greater membership of the LISS Nonpoint Source and Watershed Work Group. The advisory group determined that the study area should cover regional basins that cover the Coastal Zone Management Act Section 6217 ("coastal nonpoint program") towns up to Middletown. This excluded the northern Connecticut River towns. Several basins, such as the Connecticut River basin and Housatonic River basin were extremely long and continued too far north. These basins were cut using the sub-regional basin boundaries. The Housatonic and Naugatuck still extended too far north and were cut using the local basin boundaries. The final basins used in analysis are shown below in black in Figure 1 (next page). All basins analyzed are listed in Appendix B. A detailed map with name labels is included in Appendix C.

2. Characterize Coastal Sub-regional Watersheds: Land Cover and Land Cover Change

Statewide analysis was conducted using the medium-resolution Landsat-derived land cover data from the UConn CLEAR *Connecticut's Changing Landscape* (CCL) project, which has developed land cover datasets for 1985, 1990, 1995 and 2002; data for 2006 is in development.

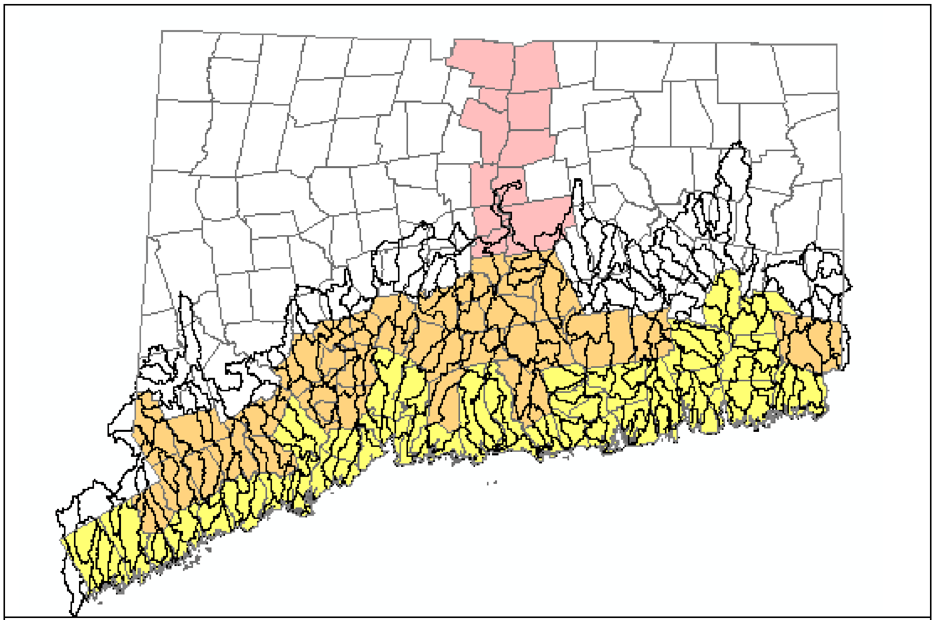


Figure 1. The subset of sub-regional basins used in this analysis are shown with black lines. The 36 coastal zone management towns are yellow. Coastal nonpoint program (6217) towns included in the study are shown in orange; those excluded are in pink.

The 2002 Connecticut land cover was used to characterize the sub-regional basins in the study area. The result is a spreadsheet containing area of each land cover class:

- developed
- turf and grass
- other grasses and agriculture
- deciduous forest
- coniferous forest
- water
- non-forested wetland
- forested wetland
- tidal wetland
- barren
- utility right-of-way

for each sub-regional basin. A map depicting land cover in the sub-regional basins is shown as Figure 2.

The 1985 and 2002 *Changing Landscape* land cover datasets were used to analyze land cover change. For every basin, the area in acres was calculated for each land cover change class. These include:

- developed before 1985
- turf and grass before 1985
- water
- undeveloped changed to developed between 1985 and 2002
- undeveloped changed to turf and grass between 1985 and 2002

The percent increase in developed land (change to developed between 1985 and 2002 / area that was developed before 1985) was also calculated.

Figure 3 shows an excerpt from the data spreadsheets for land cover and land cover change. The complete spreadsheets are attached as Appendix D, and the tables are also posted on the project website.

Technical GIS methods are provided in Appendix J.

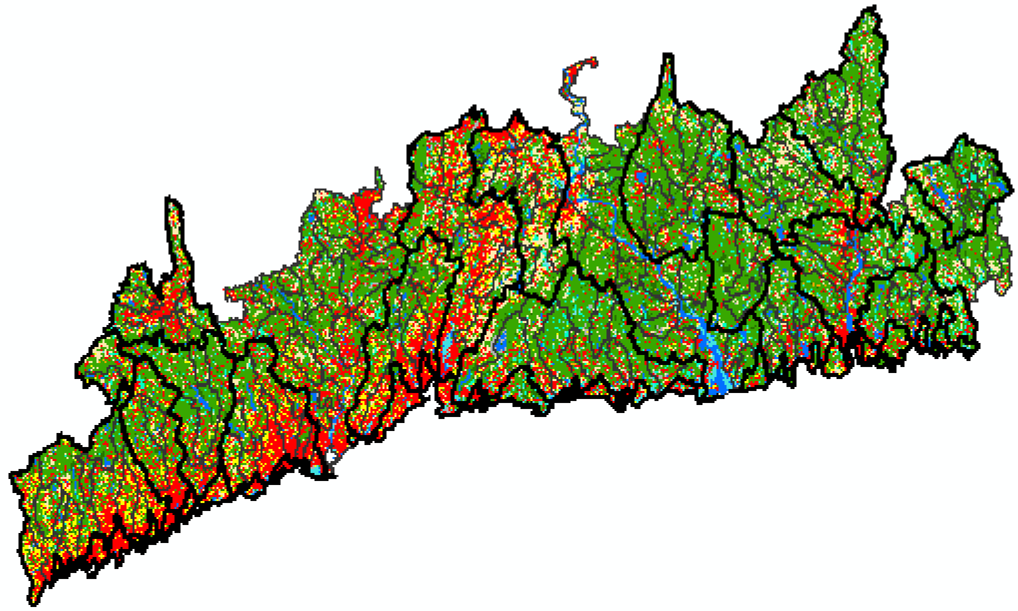


Figure 2. Image of CLEAR land cover data showing subregional (thin black) and regional (thick black) basin outlines

Sub-regional Basin	1001	1002	1003	1004
2002 Land Cover in Acres				
Developed	398.2	263.5	380.5	880.8
Turf/Grass	40.8	29.6	46.4	149.9
Other Grass/ Ag	811.2	805.3	588.2	1678.2
Deciduous Forest	5012.0	5416.6	2016.3	6497.1
Coniferous Forest	307.9	330.0	51.5	213.0
Water	162.3	70.7	10.1	80.9
Non-forested Wetland	72.8	21.6	33.5	279.4
Forested Wetland	496.6	159.2	48.8	661.2
Tidal Wetland	0.0	0.0	0.0	0.0
Barren	37.6	16.0	108.1	149.2
Utility ROW	0.0	0.0	0.0	1.1
Land Cover Change	**(1985-2002) in Acres**			
Dev. before 1985	361.5	232.1	309.4	734.7
Turf/Grass before 1985	35.5	21.6	44.8	153.6
Water	213.2	91.6	12.5	216.8
Undeveloped	6680.3	6722.7	2837.4	9316.3
Other	0.0	0.6	0.3	0.0
Change to Dev.	36.4	30.9	70.3	143.0
Change to Turf/Grass	12.3	13.5	9.2	26.4
Percent Change to Dev.*	10.1%	13.3%	22.7%	19.5%

Figure 3.

Sample of the land cover and land cover change statistics for each sub-regional basin. The complete data table covering all 167 sub-regional basins in included in Appendix D and posted on the project website.

Several other methods of basin-wide land cover characterization were tested and discarded as unhelpful. The investigators experimented with the CLEAR forest fragmentation analysis, which classifies basins based on both amount of forest and heterogeneity of forest. The results of the analysis were that all 167 basins came out to belong to the same class. The conclusion was drawn that the sub-regional basins are too large for this model to provide meaningful information. As an alternative, statistics for forest cover of the sub-regional basins were developed from the overall land cover statistics; forest cover is becoming recognized in the literature as a land cover statistic that is a good indicator of watershed health. The forest cover information is part of the simplified land cover table attached in Appendix E. Figure 4 shows the sub-regional basins colored according to percent forested.

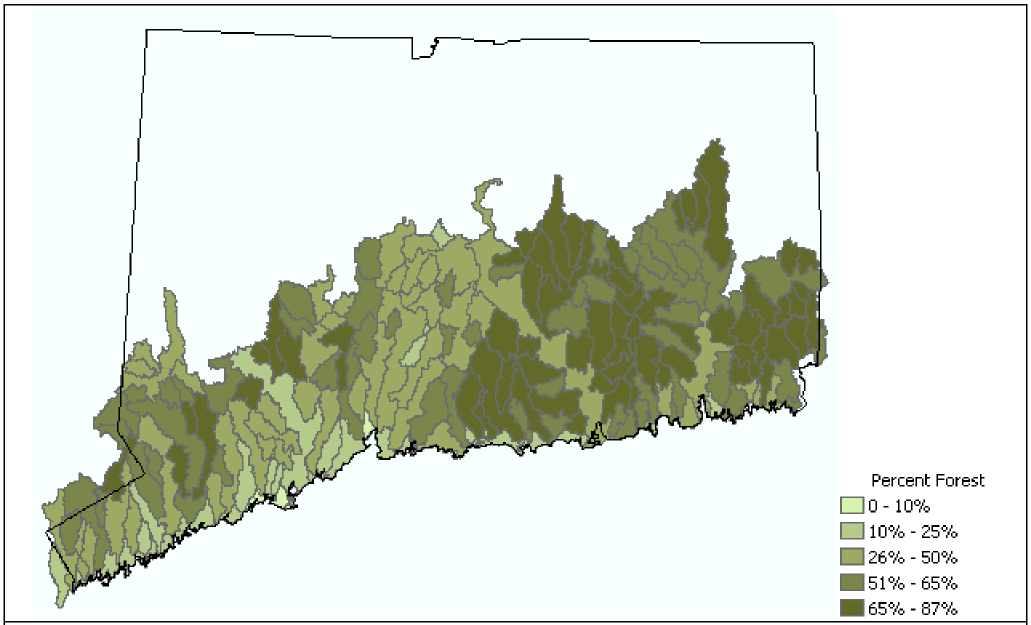


Figure 4. Sub-regional basins colored according to percent forested.

<u>3. Characterize riparian areas within coastal subregional watersheds</u>

Buffer widths: The advisory group decided that it would be most beneficial to analyze three different buffer widths: 100 feet, 200 feet and 300 feet. Although relevant for town regulations, buffer widths less than 100 feet wide were not appropriate for this analysis because each pixel in the land cover is a 100 foot by 100 foot square. To analyze an area smaller than a single pixel, then would be an inappropriate use of the land cover data.

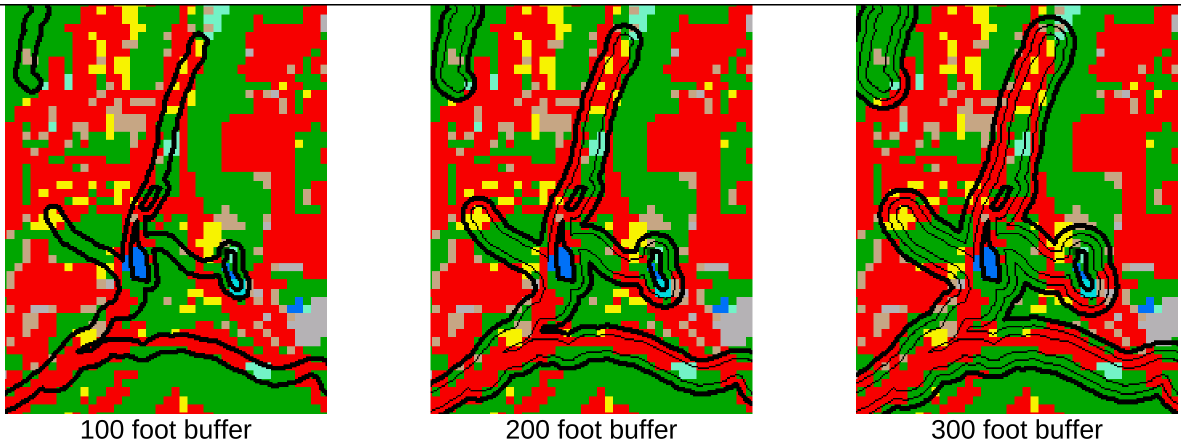


Figure 5. Close-up showing the relationship of the riparian corridor study widths to the 30-meter land cover data.

Buffer definition: The advisory group determined that streams, waterbody shorelines and tidal wetlands all should be included in the area to be buffered, rather than only streams. For example, along the coast tidal wetlands are treated as a unit rather than performing the analysis on either side of the tidal creeks; with the latter interpretation, the area within the buffer would consist entirely of tidal marsh, and not tell the researcher anything about incursions of development into the marsh.

It was difficult to find consistent data layers to create the “to be buffered” file. Inconsistent data layers result in missing areas, like donut holes, that were then treated in the analysis as an island (see Figure 6 for an example). An island is considered land and would thus incorrectly buffered. All cases of these donut holes were removed via hand digitizing, and the final “to be buffered” file was a continuous line of streams, waterbody shores and tidal wetland edges. The final product then consisted of seamless buffered polygons with 100 feet, 200 feet and 300 feet distances from the “to be buffered” features. This is a data layer that may be of use to researchers and others beyond the immediate focus of this study (Figure 7).

Technical GIS methods are provided in Appendix J.

Imagery shown with rivers (blue).	Imagery with rivers (blue) and tidal wetlands (green).	Result where no gaps are present between rivers (blue) and tidal wetlands (green).

Figure 6. Example of the inconsistent data between tidal wetlands and watercourses that needed to be fixed before buffering.

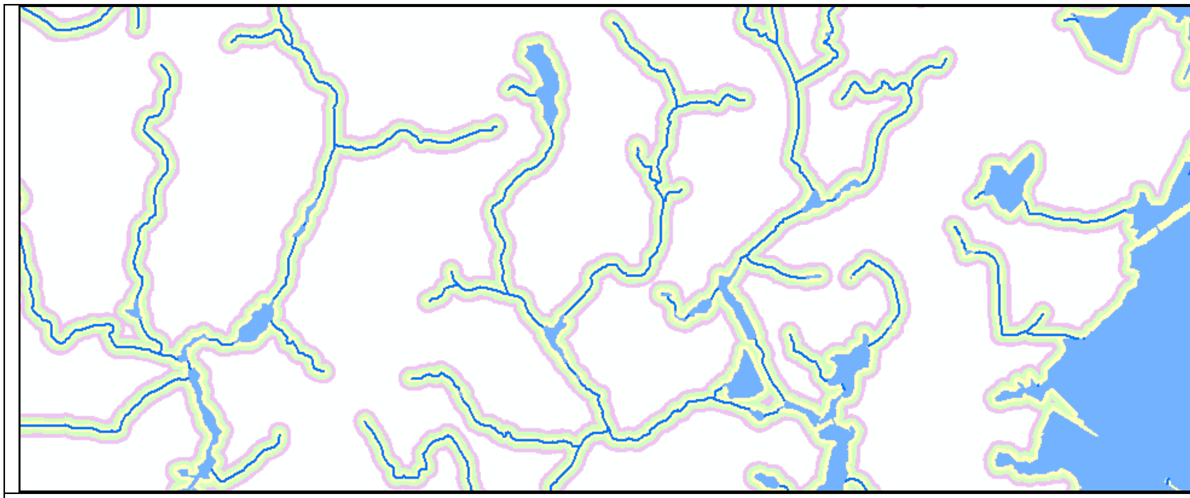


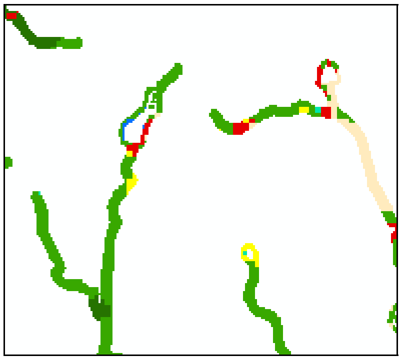
Figure 7. Continuous, seamless buffer polygons of 100 feet (yellow), 200 feet (green) and 300 feet (purple) were created in order to do the land cover analysis. Significant data fusion and hand digitizing were required. Creation of this data may have uses for other researchers and managers.

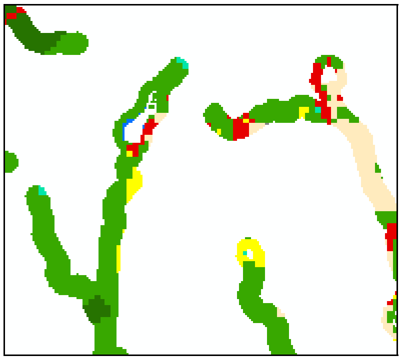
Buffer area characterization, acreage: After the buffer areas were created, statistics were calculated for each basin using the buffer areas. These include total area (acres) of the basin, total water area (acres) for the basin, and for each of the 100 foot, 200 foot and 300 foot buffer zones: acres outside buffers and water, buffer area (acres), percent of basin in buffer only and percent of basin in buffer and water (Figure 8 provides an example). See Appendix F.

			100ft				200ft				300ft			
Sub-regional Basin	Total Area (acres)	Water Area (acres)	Acres Outside Buffer & Water	Buffer Area (acres)	Percent of Basin in Buffer Only	Percent of Basin in Buffer & Water	Acres Outside Buffer & Water	Buffer Area (acres)	Percent of Basin in Buffer Only	Percent of Basin in Buffer & Water	Acres Outside Buffer & Water	Buffer Area (acres)	Percent of Basin in Buffer Only	Percent of Basin in Buffer & Water
1001	7339.3	141.4	6720.1	477.8	6.5%	8.4%	6253.7	944.2	12.9%	14.8%	5798.0	1399.9	19.1%	21.0%
1002	7113.1	63.8	6477.5	571.7	8.0%	8.9%	5843.0	1127.8	15.9%	17.9%	5386.3	1663.0	23.4%	24.3%
1003	3283.9	1.3	3042.5	240.1	7.3%	7.4%	2669.0	471.6	14.4%	18.7%	2589.4	693.2	21.1%	21.1%
1004	10590.9	80.6	9403.7	1106.6	10.4%	11.2%	8279.6	2167.0	20.5%	21.8%	7348.8	3161.5	29.9%	30.6%
2000	27389.6	1357.6	22929.0	3103.1	11.3%	16.3%	21303.6	5940.7	21.7%	22.2%	17446.4	8585.7	31.3%	36.3%

Figure 8. Example of spreadsheet statistics for the 100ft, 200ft and 300ft buffer zones by basin. See Appendix F for entire dataset.

Buffer area characterization, land cover and land cover change: The land cover data was clipped so that a GIS file existed of land cover within the 100 foot buffer zone, land cover within the 200 foot buffer zone and land cover within the 300 foot buffer zone (Figure 9).


100 foot buffer


200 foot buffer

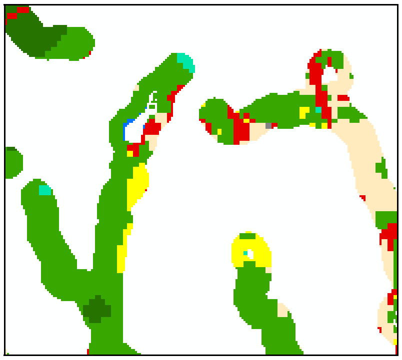

300 foot buffer

Figure 9. Sample of the land cover data within each buffer zone.

The land cover and land cover change data for the 100 foot and 300 foot buffer zones were summarized by basin to characterize the status of coastal riparian areas. Complete data tables were done for both the 100 and 300 foot buffer zones. The results, in very large spreadsheets, are posted on the website and contained in Appendices G and H.

In order to somewhat simplify the results for the purposes of characterizing the riparian areas, the CLEAR land cover data was condensed into three categories (other than water). This "simplified land cover" was as follows:

- **NATURAL VEGETATION** consisted of the deciduous forest, coniferous forest, forested wetlands, non-forested wetlands, and tidal wetlands classes. This class was seen as the most environmentally desirable condition of a riparian area.
- **OTHER VEGETATION** consisted of the turf and grass and "other grasses and agriculture" classes. This class was seen as of intermediate environmental value, since it was vegetated but likely associated with developed land, and possibly producing pollutant problems if the lawn or field was treated with chemicals and fertilizer.
- **NON-VEGETATION** consisted of the developed and barren classes.

Technical GIS methods are provided in Appendix J.

4. Investigate comparative methods and indices

To compare subregional basins, the investigators measured land cover change not only in acres, but in "percentage of 1985 natural vegetation lost by 2002," a metric that normalized for differences in basin size. This simple metric also allowed us to compare relative difference not only in land cover change between basins, but between the 100 foot and 300 foot buffer zones. An arbitrary "top 25" list was created for both buffer widths, showing the basins that had experienced the most rapid relative loss of riparian vegetative cover. Results are shown in Section 8 of this report.

In addition, all 167 basins were analyzed using a combined basin-wide/buffer zone metric that was developed by Goetz et al. (2003) for the Chesapeake Bay region. Goetz found that the best predictor of stream health, as determined by an intensive county field sampling program, was an index that combined basin-wide impervious cover and tree cover within the 100 foot buffer. We applied this index to the current study, using CLEAR data of percent impervious cover as derived from the Impervious Surface Analysis Tool (ISAT) and our percent of "natural vegetation" as previously described. The index was calculated using the following values, from the Goetz study:

Percent Impervious Surface	Percent natural vegetation	"Health"
<= 6	>= 0.65	Excellent
<= 10	>= 0.60	Good
<= 25	>= 0.40	Fair
> 25	< 0.40	Poor
> 10	< 0.60	Fair/Poor
		Other

Results are shown in Section 8 of this report.

5. Conduct trial fine scale analysis

The Niantic Bay watershed was selected primarily because it is a coastal basin that is receiving a variety of CLEAR education efforts.

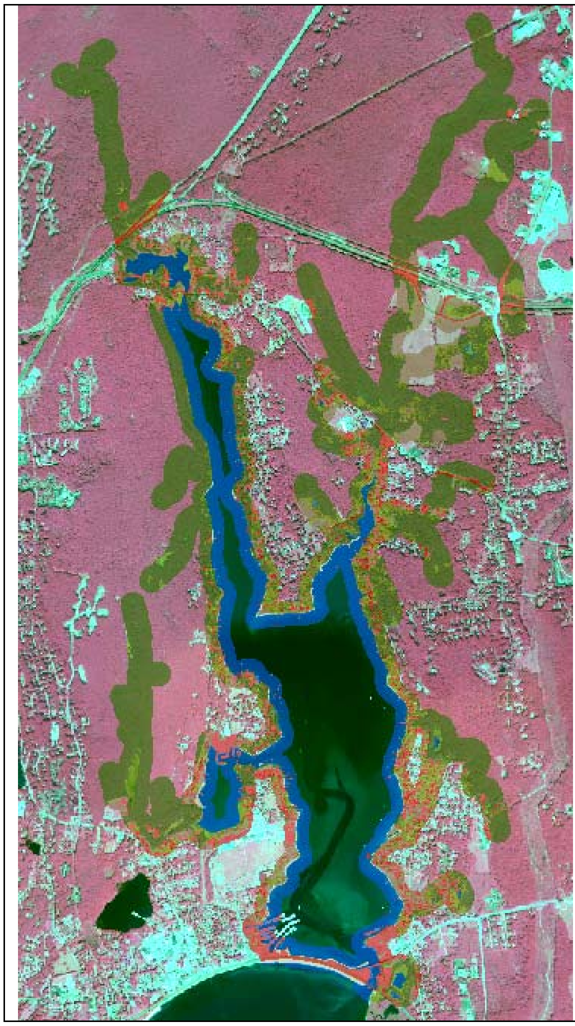
Coastal, high resolution ADS40 aerial imagery was used for the detailed analysis. This pilot represents the first time that CLEAR researchers have used this quality of imagery and in this manner.

A software called eCognition was used. eCognition groups like pixels together as objects and the objects are used in further analysis. A number of iterations were required to find a way to use the software with the new dataset. The high resolution data is very complex and had very large file sizes. See Appendix J for complete methods.

We were interested in analyzing the buffer zone within the Niantic. When the "to be buffered" file was viewed with the high-resolution, aerial imagery, there were many inconsistencies. This is because the DEP water data was created from the USGS topographic maps. Because of the discrepancy, the "to be buffered" polyline was modified for the Niantic Bay watershed. The 300 foot buffer was then created and used to isolate only land cover within the buffer. Extensive hand editing cleaned up the data.

A classification of the 300ft buffer zone contained six land cover categories: developed, water, sand, forest, field and other vegetation (Figure 10). Figure 11 demonstrates how the land cover classification differs from a land use map. Notice the detail present in a land cover map that is not part of a land use map.

Figure 10. The high resolution classification shown with the high resolution imagery (pinks and cyans).



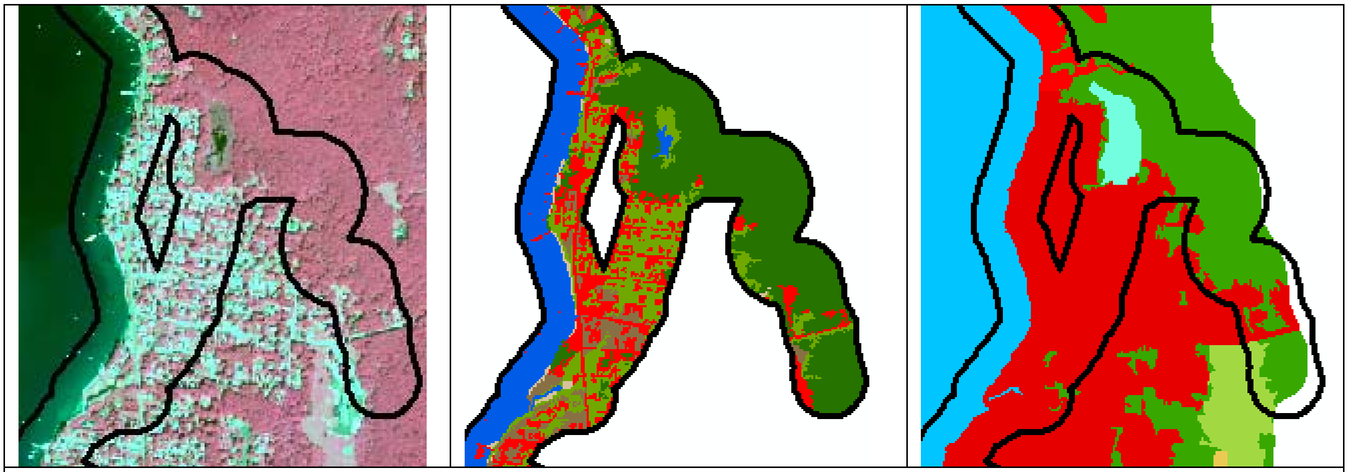


Figure 11. The 300ft buffer zone over imagery (left). The land cover classification created in this study (center). An existing land use classification (right).

Summary information about the land cover within the three buffer zones of the Niantic Bay watershed is shown in Table 1. Figure 12 demonstrates that, for the 100ft zone, most of the buffer zone is forested. “Other vegetation” is the second most common class and developed is third. When the classes are grouped into vegetation and non-vegetation, the percentages are almost equivalent for all buffer zones (Table 2).

Table 1. Niantic bay land cover statistics for the three buffer zones.

		100 foot		200 foot		300 foot	
	Class	**Acres**	**Percent**	**Acres**	**Percent**	**Acres**	**Percent**
	Developed	66.3	11.6%	141.8	13.1%	209.6	13.5%
	Forest	365.9	63.9%	684.5	63.1%	981.6	63.0%
	Other Veg.	85.4	14.9%	152.4	14.0%	207.6	13.3%
	Field/grass	43.3	7.6%	92.7	8.5%	142.1	9.1%
	Sand	11.5	2.0%	14.0	1.3%	16.1	1.0%

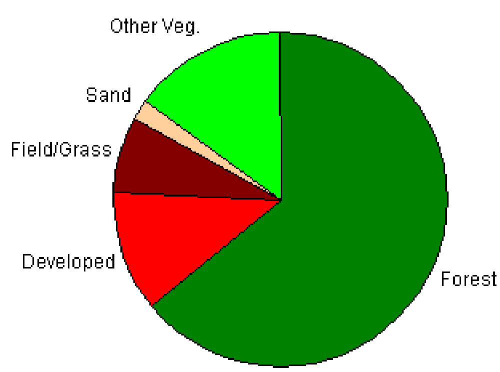


Figure 12. Graphic representation for the 100 foot buffer data shown in Table 1.

Table 2. Vegetation is a combination of forest, field and other vegetation classes. Non-vegetation is the same as the developed class.

Class	100 foot		200 foot		300 foot	
	Acres	Percent	Acres	Percent	Acres	Percent
Vegetation	494.6	57.5%	929.6	57.6%	1331.4	57.6%
Non-vegetation	365.9	42.5%	684.5	42.4%	981.6	42.4%

6. Develop project website

A project website was developed as part of the CLEAR Research pages, and contains the following broad chapters:

- *About:* project overview, objectives, sponsor
- *Methods:* nontechnical and technical methods
- *Interactive map:* ArcIMS interactive mapping site where users can explore project results over the internet without GIS software
- *Results:* complete results provided in tabular form with illustrative charts and maps
- *More on riparian buffers*: links to other sites, including the LISS-sponsored riparian buffer toolbox website

http://clear.uconn.edu/projects/riparian_buffer/index.htm

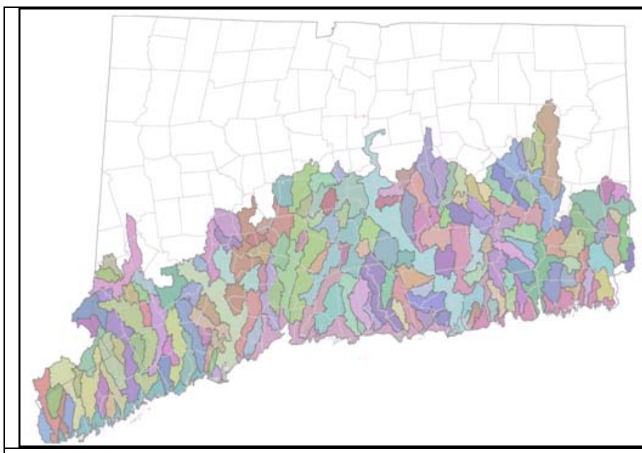


Figure 13. 167 basins in the study area.

8. Summary of Findings:

Basin characterization

One hundred sixty seven sub-regional basins in Connecticut were assessed (Figure 13) (Appendix B and C). For each basin, a variety of land cover and land cover change data was created (Appendix D and E).

A goal of the study was to act as a screening tool to determine which basins could benefit from future efforts. The wealth of data created could be used in many ways. The overall average of percent increase in development is 2.6%, compared to the statewide *Changing Landscape* data of a 2.4% increase.

A simple histogram chart (Figure 14) shows the range and distribution of increases in development for all study basins between 1985 and 2002.

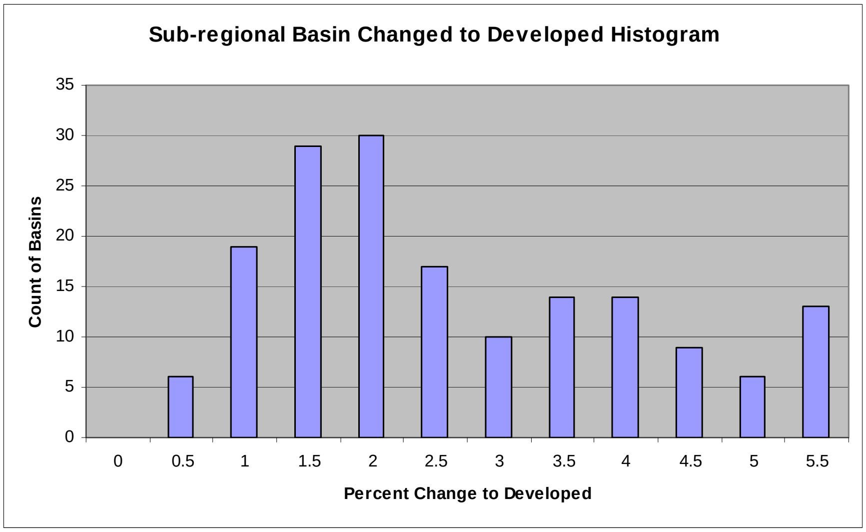


Figure 14. Histogram showing range and distribution of percent increase in development for all study basins between 1985 and 2002.

The overall average of forest cover in 2002 for the 167 study basins was 55.6%, compared to a statewide average of 59.3% forest cover in 2002.

<u>Buffer characterization</u>

To assess buffers, a dataset was created that was comprised of a seamless, continuous line of streams and waterbody shorelines. Three buffer zones were created: 100 foot, 200 foot and 300 foot (Appendix F). Land cover and land cover change data were created and analyzed for the 100 foot and 300 foot buffer zones of each basin (Appendix G, H). The data can be used for many different analyses, and is available for download on the project website.

The focus of this research was on the loss of "natural vegetation" – basically, forests and wetlands, as defined by simplified land cover data. A higher percentage of natural vegetation loss identifies basins that could warrant further attention. The histogram in Figure 15 shows the distribution and range of percent change of natural vegetation in the 100 foot and 300 foot zones. Generally, basins with a decrease in natural vegetation have experienced development. Basins with an increase in natural vegetation have gained wetlands at the expensive of water. The increase is not due to a loss of development. Figure 16 shows total acreage lost within these zones, as well as the total increase in developed acreage.

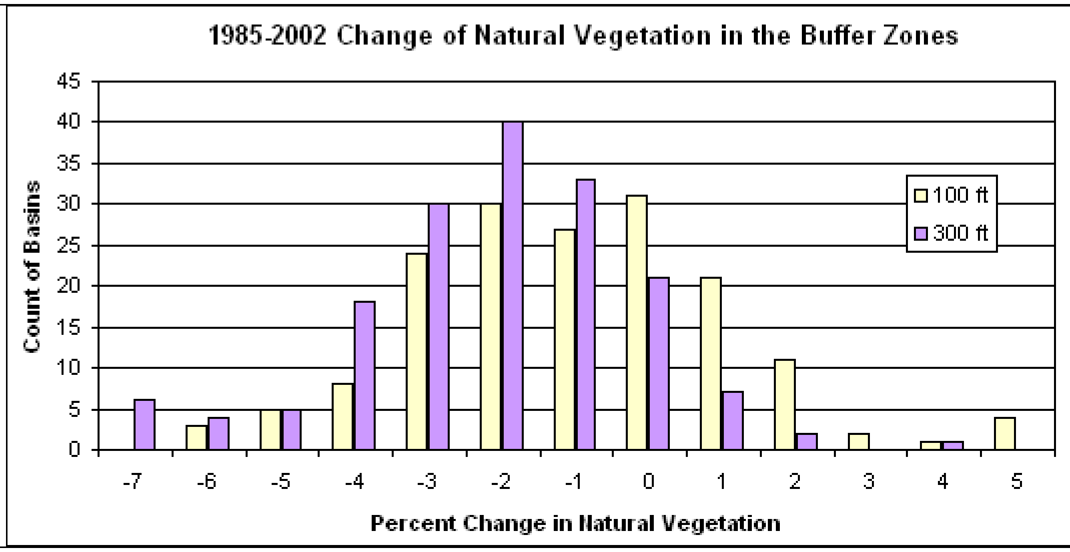


Figure 15. Distribution and percent change of natural vegetation in the 100 foot and 300 foot zones.

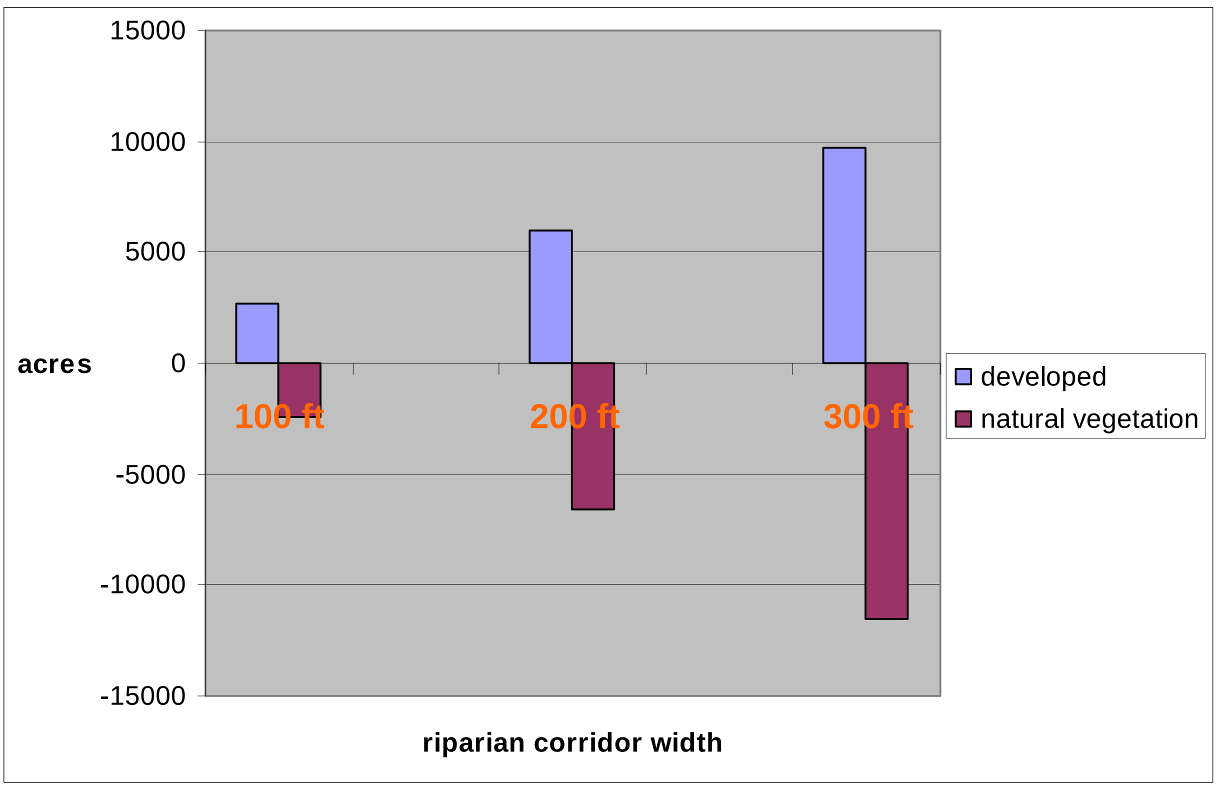


Figure 16. Total acreage lost within each buffer zone and the increase in developed acreage.

Of further interest is comparing natural vegetation loss in the 100 foot and 300 foot zones. Table 3 shows both the percent increase in developed land and the percent loss of natural vegetation during the 1985-2002 period. As can be seen, gains in developed land and losses in natural vegetative cover both increase with increasing buffer width. (The reason why the two figures are not mirror images of each other, by the way, is due to changes between the natural vegetation and "other vegetation" category). It is possible that this trend is due in some way to the fact that the 100 foot buffer width is "pushing the limits" of the 100 foot pixel data, and that the results become more accurate with an increasing sample size, i.e., an increasing buffer width area. However, it could also be evidence of the salutary effect of Connecticut's tidal wetlands and inland wetlands and watercourses laws, showing that percent losses of natural riparian vegetation decrease as one approaches the stream.

Table 3. Percent increase in developed land and the percent loss of natural vegetation during the 1985 to 2002 time period.

Average of 167 study basins	100 ft	200 ft	300 ft
Increase in developed category	1.7%	2.0%	2.2%
Decrease in natural vegetation category	- 1.6%	- 2.2%	- 2.6%

Comparative Methods and Indices

The following map shows the 25 sub-regional basins with the largest relative rate of loss of natural vegetation (acres in 2002 – acres in 1985, divided by acres in 1985). These basins are shown in Figure 17 in the 100 foot zone (blue cross-hatches) and 300 foot zone (orange cross-hatches). The percentage loss ranged from 5.6% to 11.2% in the 100 foot zone, and from 7.2% to 13.4% in the 300 foot zone. This map shows the "hot spots" that might be worthy of state and local attention, particularly the East Lyme – Stonington coastal corridor, and in the watersheds draining to Bridgeport Harbor.

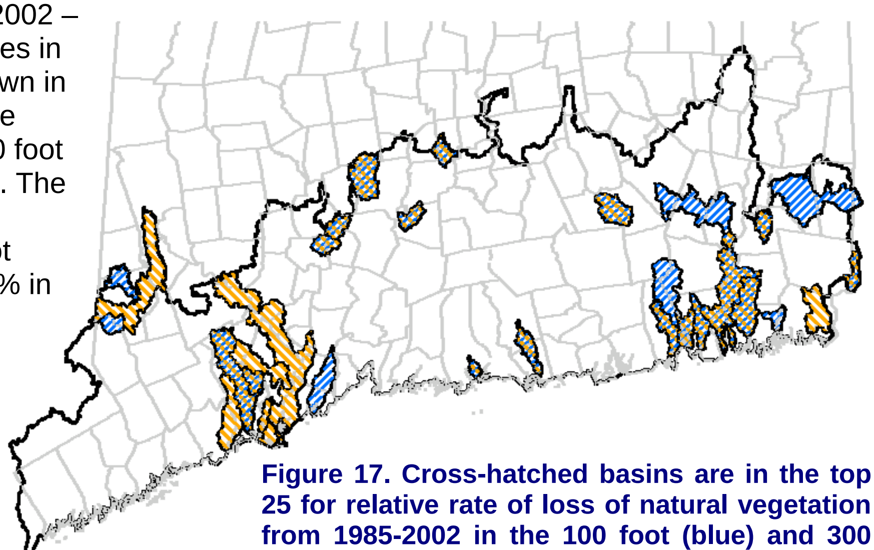
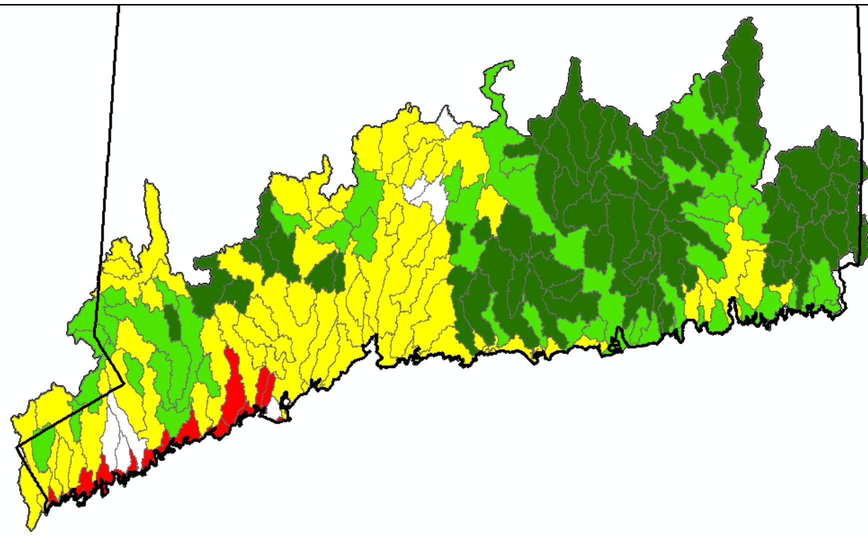


Figure 17. Cross-hatched basins are in the top 25 for relative rate of loss of natural vegetation from 1985-2002 in the 100 foot (blue) and 300 foot (orange) riparian corridors.

As noted in Section 6, all 167 basins were analyzed using a combined basin-wide/buffer zone metric that was developed by Goetz et al. (2003) for the Chesapeake Bay region. Goetz found that the best predictor of stream health, as determined by an intensive county field sampling program, was an index that combined basin-wide impervious cover and tree cover within the 100 foot buffer. We applied this index to the current study, using CLEAR data of percent impervious cover as derived from the Impervious Surface Analysis Tool (ISAT) and our percent of "natural vegetation" as previously described. The results are shown in Figure 18. They illustrate the need for protection and preventative measures along the eastern half of the state, and for remedial measures in the western half.



Stream Health	% Impervious entire basin	% Natural Veg. 100 ft riparian buffer
Excellent	<= 6%	>= 65%
Good	<=10%	>=60%
Fair	10-25%	40-60%
Poor	>25%	<40%

Figure 18. Results of a metric by Geotz et al. (2003) that combines percent imperviousness for the entire basin and percent of natural vegetation in the 100 foot buffer.

<u>Fine Scale Analysis</u>

The final classification is acceptable but the methodology needs further refinement before it should be repeated. The segmentation parameters with ADS40 imagery should be scrutinized so that the output segments can better account for shadows. The primary emphasis was the distinction between developed and non-developed areas. Leaf-on imagery and tree canopy made this extremely difficult.

9. Conclusions

This study constitutes the first statewide assessment of the land cover status of coastal riparian areas. As far as the authors know, it is the first study of its kind in the nation. The objective of the study was to develop a "triage"-type overview that would allow federal, state and local land managers and researches to comparatively assess the status of the riparian areas, and the changes that have been occurring over the last 15-20 years.

The study has accomplished that goal. The land cover characterization of the 167 subregional basins was very similar to the statewide average; this was not a surprise, as the study area ended up covering about half of the entire state of Connecticut. Within the riparian buffer areas, increases in development and losses of natural vegetation increased with increasing buffer width, both in terms of acreage (expected) and in relative terms as depicted by percent changes of 2002 over 1985 levels (not expected). The relative loss of natural vegetation was smallest in the 100 foot zone (1.6% loss), increased in the 200 foot zone (2.2%), and increased again in the 300 foot zone (2.6%). This could partly be due to relatively larger errors incurred in the 100 foot width, but is more likely evidence that Connecticut's watercourse and wetlands laws are having at least some effect in retarding deforestation along riverbanks and wetlands.

"Hot spot" areas where relatively forested riparian zones are quickly losing natural vegetation were identified, with the largest concentration of these being, as expected, in southeastern Connecticut in the stretch of shoreline from East Lyme to Stonington. This is consistent with the *Connecticut's Changing Landscape* study, which showed that area of the state to be experiencing some of the most rapid expansion of development in the state.

The literature on land cover indicators is plentiful in the area of impervious cover and its relationship to stream health. It is less robust but growing in the area of forest cover and its relationship to watershed health, and there are only a few studies that relate riparian zone cover to watershed or stream health. One of the most thorough, conducted in the Chesapeake Bay region, shows that the best predictor of stream quality is a combined indicator of overall basin imperviousness and forest cover within the 100 foot buffer zone. The 167 coastal basins of Connecticut were assessed using these criteria, and the resulting map provides a striking East/West dividing line in predicted stream quality, at approximately the westernmost extent of the greater Connecticut River drainage area.

Finally, in addition to meeting the original objectives, this project has produced data that should be useful to managers and researchers beyond the original scope. First, creating the seamless watercourse, waterbody and wetland "to be buffered" polygon was a considerable technical feat, and this data layer may be of further use to other researchers and managers. Second, the land cover and land cover change data contained in the many project spreadsheets comprise a large body of data that this study has only begun to mine. Last, the results of this study, mostly in map form, are already being incorporated into CLEAR outreach programs for municipal officials. The high resolution dataset for the Niantic watershed, although not as promising as the investigators had hoped, will likely be used by the Waterford Planning Office for education of local riparian land owners.

10. Presentations/Publications/Outreach

The results of this study will continue to be presented in various formats, and articles are planned to be written. At the time of this report, presentations have been made to the following groups:

- Long Island Sound Study Watersheds and Nonpoint Source Work Group
- Long Island Sound Study Scientific and Technical Advisory Committee
- Connecticut Conference on Natural Resources
- Connecticut Riverfront Protection Act Working Group

As noted, the results are being folded into ongoing CLEAR outreach programs, and the website will be up and running as of 2/15/08, and advertised to various list-serves and email groups.

Appendix A. Public Summary

Appendix B. List of Basins Analyzed

Appendix C. Map of All Basins Analyzed

Appendix D. By Basin: 2002 Land Cover and 1985-2002 Land Cover Change

Appendix E. By Basin: Simplified Land Cover Including Forest Cover Statistics

Appendix F. Buffer Zones: Statistics By Basin

Appendix G. 100 Foot Buffer Zone: Land Cover and Change

Appendix H. 300 Foot Buffer Zone: Land Cover and Change

Appendix I. Focus on Natural Vegetation

Appendix J. Technical GIS methods.