Research Summary

The Status of Connecticut's Coastal Riparian Corridors

Overview

This project, conducted by the UConn Center for Land Use Education and Research (CLEAR) in 2005 and 2006 for the Long Island Sound Study (LISS) National Estuary Program, 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 (and are sometimes called this within this report), but are not to be confused with regulatory review zones, which are often also called buffers.

This study constitutes the first coast-wide assessment of Connecticut's coastal riparian areas, and to the investigators' knowledge is the first study of its kind in the U.S. The results are intended to give local officials, researchers, educators, landowners and others a general feel for the status of watersheds and riparian corridors draining to the Sound, the land use trends within these areas during the 1985 – 2002 time period, and the implications of this information for the health of Connecticut's coastal water resources.

Methods

Geographic scope and framework

An advisory committee drawn from the LISS Watersheds and Nonpoint Source Work Group assisted CLEAR researchers with determining the major parameters of the study. The watershed unit chosen as the basis for study was the subregional basin, which is small enough for land cover statistics to be meaningful, but large enough to be a practical unit of management. The study area chosen captures all subregional basins that intersect both the coastal towns (as defined by the Coastal Zone Management program) and the "coastal nonpoint source" towns (as defined by the Coastal Nonpoint Program), with the exception of towns in the far northern Connecticut and Housatonic watersheds. The final study area contains 167 distinct subregional basins that cover, approximately, the southern half of the state, (Figure 1).

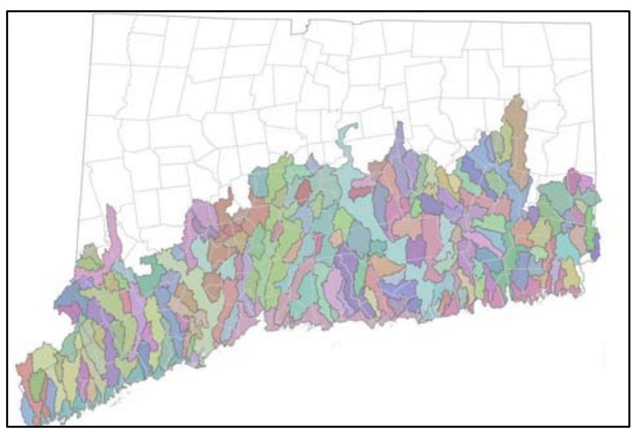


Figure 1. Study area, showing the 167 subregional basin study units.

Analysis window

In order to conduct the study, CLEAR researchers created a seamless, continuous "object to be buffered" GIS data layer (Figure 2). This turned out to be an unexpectedly complicated task, due to inconsistencies and overlaps between the many data sets used to determine watercourses, wetlands, and waterbodies, especially along the immediate coastline. The advisory committee decided that this "to be buffered" feature would include wetlands and waterbodies contiguous with the stream lines. For example, along the coast the riparian areas studied would begin at the outer edge of the tidal wetlands, not at the stream edge. This provides a more complete picture of development pressures infringing on water resources. Inland wetlands and small waterbodies not directly connected to the stream lines as determined by the state data layers were not included in this study.

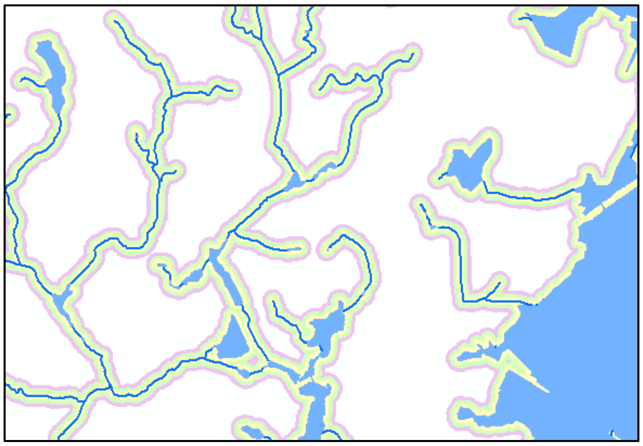


Figure 2. Continuous, seamless buffer polygons of 100 feet (yellow), 200 feet (green) and 300 feet (purple) were created in order to do the land cover analysis.

Land cover data

Land cover analysis was conducted using medium-resolution satellite-derived land cover data from CLEAR's *Connecticut's Changing Landscape* project, which has created land cover datasets for 1985, 1990, 1995 and 2002; data for 2006 is in development. The 167 subregional basins were characterized for land cover and land cover change, and within these basins land cover and land cover change data were compiled for riparian corridors of three widths: 100 feet, 200 feet, and 300 feet to either side of the stream (Figure 3). Since the land cover data is in the form of 100 foot by 100 foot pixels, the 100 foot corridor analysis involves a very small sample size, which the researchers feel approaches the limit of appropriate use of medium resolution data; however, since the 100 foot corridor encompasses the regulated review zone in most Connecticut towns, the advisory committee thought it worth investigating.

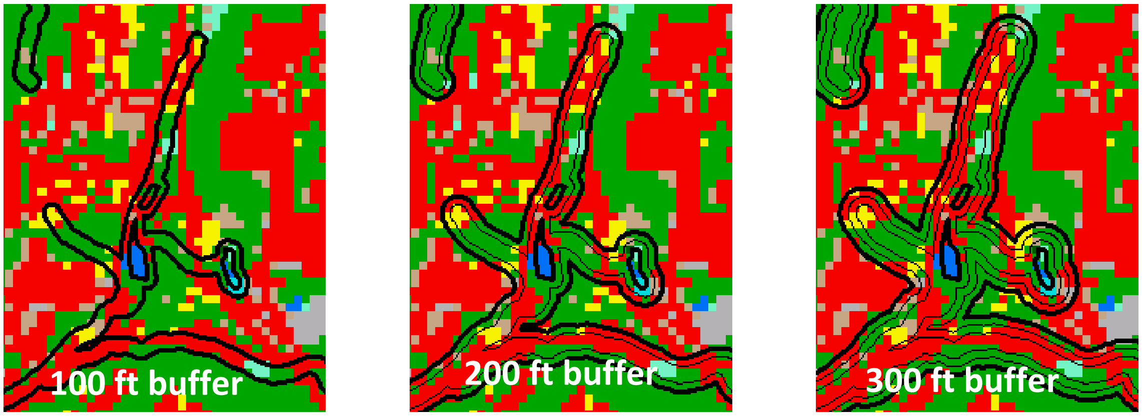


Figure 3. Close-up showing the relationship of the riparian corridor study widths to the 30-meter (100 foot square pixel) satellite-derived land cover data.

In order to simplify the land cover change results, the standard CLEAR 11-class land cover data was condensed into three categories (other than water). "Simplified" land cover classes are:

- **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 a producer, rather than a mediator, of pollutants.
- **NON-VEGETATION, or DEVELOPED,** consisted of the developed and barren classes.

Land cover was measured as area (acres or square miles) and as percent of the unit of interest. Land cover change was measured in several ways, which are summarized in Table 1. Not all measures were used for all analyses, nor are all the results contained in this paper; complete data tables are posted on the project website (see last page).

Table 1. Various methods of looking at land cover change used in this study.

Measure of land cover change	unit	calculation	significance
Absolute change	acres	(acres lc^{02} – acres lc^{85})	Allows aggregation of total areal change across basins
Relative change	percent	(% lc^{02} - % lc^{85})	Allows comparison between basins; relates to land cover indicators
Relative rate of change	percent	(acres lc^{02} – acres lc^{85}) / acres lc^{85}	Gives feel for how quickly land cover is changing relative to 1985 baseline, within and between basins

Research Results

<u>Land cover status, 2002</u>

Results presented here focus on two land cover classes: developed land and natural vegetation. The 2002 average percent developed land for the entire study area was 21.1%, slightly higher than the 18.7% statewide average found in the *Connecticut's Changing Landscape* study. This might be expected, since Connecticut's coastal towns are more heavily developed than the state average. This basin-wide average was higher that the averages for all three buffer widths, which showed decreasing amounts of development as proximity to the waterways increased, with the 100 foot buffer at 16.8% (Figure 4a).

The status of natural vegetation tells much the same story (Figure 4b). The highest percentage of natural vegetation was found within the 100 foot corridor (68.5%), with decreasing coverage in the 200 foot and 300 foot corridor, respectively; all three buffer zone figures were appreciably higher than the overall basin average for natural vegetation (59.1%). Increases in development and decreases in vegetation are not "mirror images" of each other due to land cover changes to and from the "other vegetation" category (not discussed in this paper, please see website for complete datasets).

Taken together, these results provide circumstantial but compelling evidence that Connecticut's tidal wetlands and inland wetlands and watercourses land use regulations are having an impact on the intensity of development in riparian corridors.

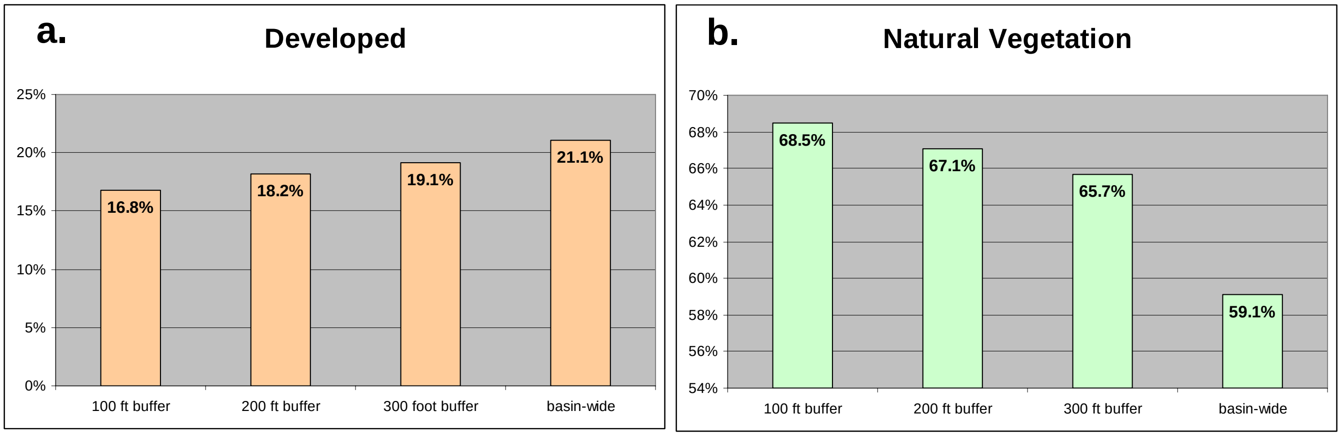


Figure 4. 2002 land cover status. (a) percent of developed land increased with width of riparian corridor and was highest basin-wide. (b) natural vegetation (forest and wetlands) was appreciably higher in the riparian corridors than in the basins overall, and increased with proximity to the stream

The status of riparian corridors for individual basins is summarized in Figure 5, which shows the percent of natural vegetation within the 100 foot (left) and 300 foot (right) buffer zones, symbolized by a color ramp in increments of 20% coverage (note: the entire basin is colored for the purposes of legibility of the map). The color gradations of the map are not related to any specific land cover thresholds, since the literature linking watershed or waterway health to riparian cover alone is not robust (please see Comparative Metrics section).

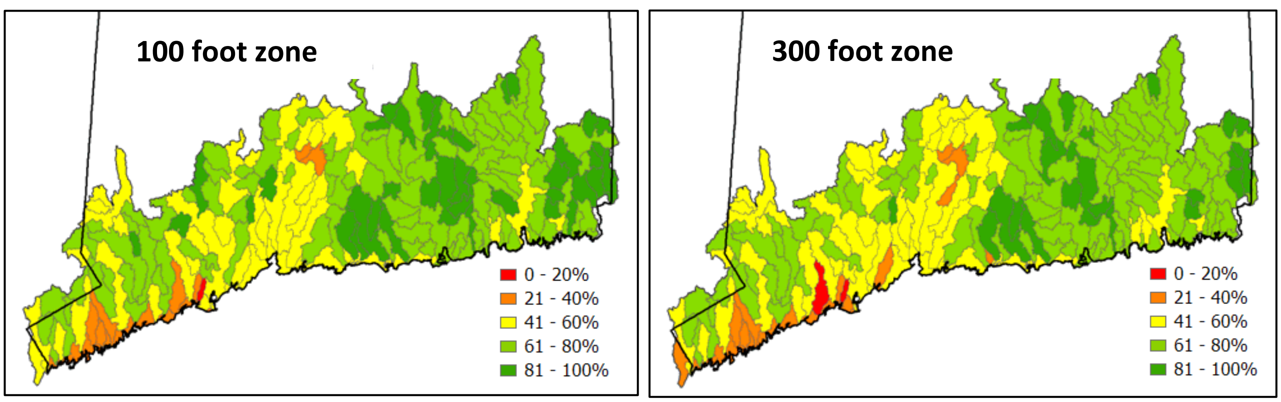


Figure 5. Amount of natural vegetation within the 100 foot (left) and 300 foot (right) riparian corridors in 2002, depicted by coloring in the entire basin.

<u>Land cover change, 1985 – 2002</u>

From 1985 – 2002, the entire study area gained over 364,000 acres of developed land (about 569 square miles), and lost well over a million acres (about 1696 square miles) of natural vegetation. Within the riparian buffer areas, increases in development and losses of natural vegetation increased with increasing buffer width in terms of absolute change (acreage), which would be expected. As shown in Table 2, total acreage lost of natural vegetation within the 300 foot riparian corridor was over 11,500 acres, about 18 square miles. Over 9,600 acres (15 square miles) of development were added.

TABLE 2. Land cover change 1985-2002: total acres	100 ft	200 ft	300 ft	Study area
Developed land	2688 ac.	5961 ac.	9689 ac.	364,300 ac
Natural vegetation	- 2435 ac.	- 6567 ac.	- 11529ac.	1,085,165 ac.

Relative land cover change, as represented by change in the percentage of a given land cover during the 17-year period (Table 1, second row), was also calculated and is summarized in Table 3. Relative increase in development from 1985 – 2002 increased with riparian corridor width, and was highest for the entire study area (2.6%, similar to the statewide figure of 2.4% determined by the *Changing Landscape* study). Loss of natural vegetation was lowest in the 100 foot zone (-1.6%), increased in the 200 foot zone (-2.2%), increased again in the 300 foot zone (-2.6%), and was highest for the study area (-3.7%). As noted in Methods, these figures might be influenced by the relatively larger errors incurred as corridor width narrows, due to the fewer number of land cover pixels sampled. However, the data appear to show a trend demonstrating a protective effect of Connecticut's watercourse and wetlands laws. This supports the 2002 land cover data presented in Figure 4.

TABLE 3. Land cover change 1985-2002: percent of study area	100 ft	200 ft	300 ft	Study area
Developed land	1.7%	2.0%	2.2%	2.6%
Natural vegetation	- 1.6%	- 2.2%	- 2.6%	-3.7%

Individual basin status: comparative land cover metrics

Scientific studies relating land cover to waterway or watershed health are fairly new in the literature. The most robust group of studies in this area relates impervious cover to the quality of the receiving waterway. In recent years, several studies have demonstrated a strong relationship between forest cover and/or tree canopy in a watershed and the health of the waterways comprising the watershed. Studies looking specifically at land cover in riparian areas as an index are few. (Note: references are not included in this paper but key references are posted on the website). Thus, this part of the CLEAR study is largely speculative.

We used all three of these land cover metrics – forest cover, riparian cover and impervious cover – within the context of two mapping exercises aimed at providing insight into the health of Connecticut's coastal watersheds. First, we looked at percent forest, basin-wide (Figure 6). Since the literature mostly cites "forest cover," we used the original CLEAR forest land cover classes, rather than our more inclusive "natural vegetation" class. The dark green color, representing

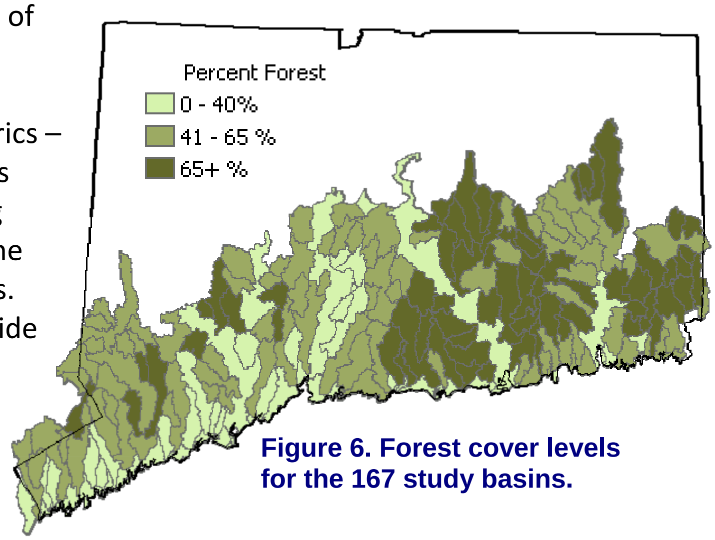
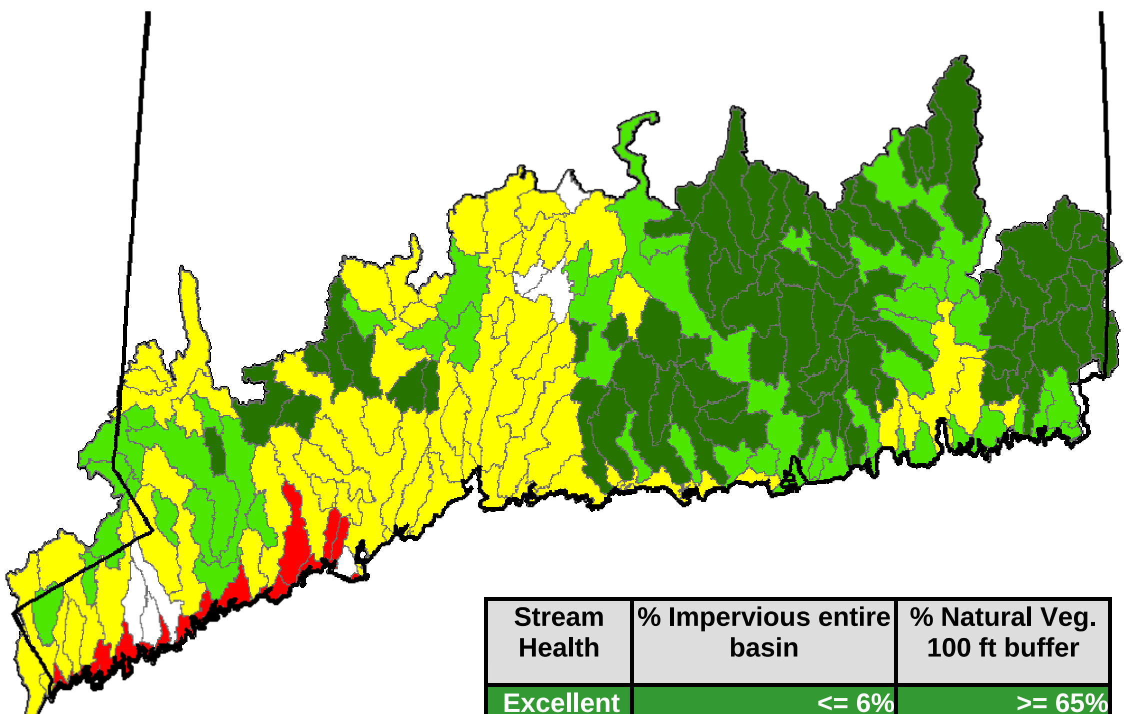


Figure 6. Forest cover levels for the 167 study basins.

forested cover of 65% or greater, is based on (the few) studies that suggest 65% forest cover as the minimum needed for a healthy aquatic invertebrate community. The 40% break is based on the recommendation of the American Forests organization that urban areas set a goal of at least 40% forest cover (this goal is based on a number of factors, not solely research).

In our second exercise, all 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 intensive multi-parameter stream sampling, was a land cover index that combined basin-wide impervious cover with tree cover within the 100 foot buffer. We adapted this index to the current study, using CLEAR data for impervious cover derived from the Impervious Surface Analysis Tool (ISAT), and percent of "natural vegetation" cover class as determined in this study. The index values, taken from the Goetz study, appear below in Figure 7. The resulting analysis is not strikingly different from the forest cover map in Figure 6, but appears to further highlight an East/West dividing line in predicted stream quality. Although this analysis is based on one study, the thoroughness of that study and the inclusion of the well-documented indicator of impervious cover suggest that this analysis is perhaps the most reliable of the two attempted.

Figure 7. A combined watershed/riparian zone metric developed in a Chesapeake Bay region study (below) was applied to the study data as a predictor of stream health.



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

Individual basin status: relative rate of land cover change

To assess the relative rates of land cover change between basins, the investigators measured land cover change from 1985 to 2002, as compared to 1985 levels. This appears in the third row of Table 1 as "relative rate of change," calculated as:
$[(acres\ lc^{02} – acres\ lc^{85}) / acres\ lc^{85}]$.

An arbitrary "top 25" map was created for both 100 foot and 300 foot buffer widths, showing the basins that had experienced the most rapid relative loss of riparian natural vegetative cover. These basins are depicted in Figure 8 with blue (100 foot) and orange (300 foot) cross-hatching. A majority of the basins score in the top 25 for both corridor widths. The range for the top 25 basins was 5.6% - 11.2% relative decrease in the 100 foot zone, and 7.2% - 13.4% relative decrease in the 300 foot zone.

As can be seen in Figure 8, there appear to be two major "hot spots" of clustered basins with high relative riparian vegetation loss. The first is in southeastern Connecticut, in the stretch of shoreline from East Lyme to Stonington; this cluster includes the Latimer Brook, Pattagansett River, Niantic River, Great Brook, Mystic River, Jordan Brook and lower Thames River basins. The second cluster is in the region draining to the Bridgeport area of the western coastline, and includes the Pequonnock River, Booth Hill Brook, Indian River and lower Housatonic systems. As can be seen in the inset, which shows the same type of relative change metric calculated at the town level as part of *Connecticut's Changing Landscape* project, there appears to be a correlation (as one would expect) between the state's most rapidly developing towns and its most rapidly de-vegetated riparian corridors.

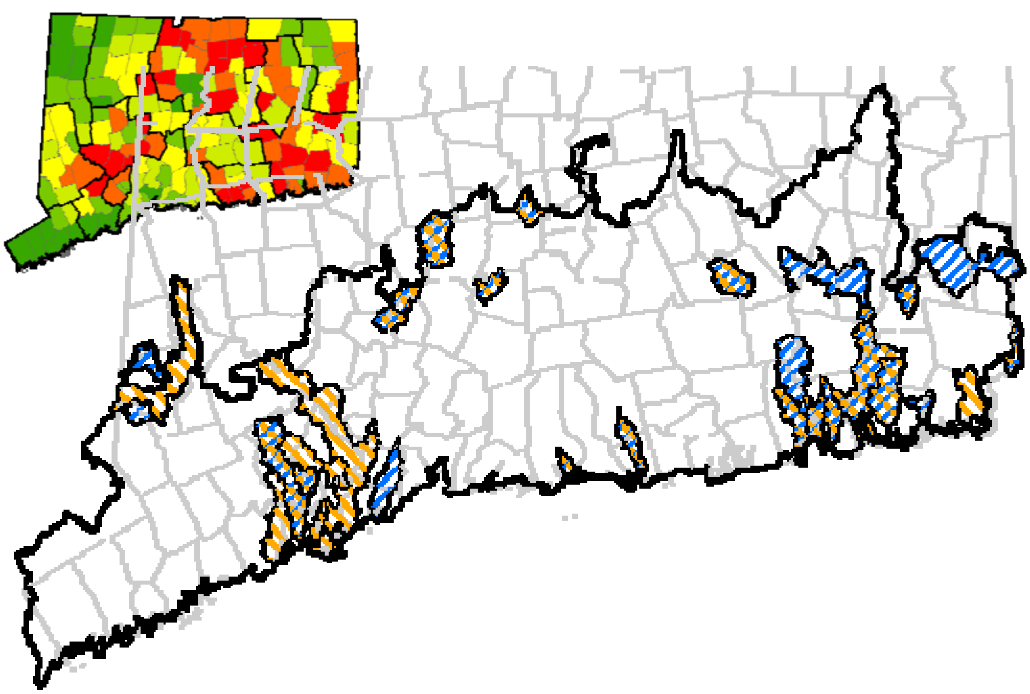


Figure 8. Cross-hatched basins are in the top 25 for relative rate of loss of natural vegetation from 1985-2002 in the 100 foot (blue) and 300 foot (orange) riparian corridors. Inset shows the corresponding statewide "hot spot" map of fastest developing towns, from the CLEAR *Changing Landscape* study (most rapid relative increases in development are depicted by "warm" colors).

Conclusions

This study constitutes the first geographically extensive, coast-wide assessment of the land cover status of coastal riparian areas in Connecticut. The objective of the study was to develop a "triage-type" overview that would allow federal, state and local land managers, researches and others to assess the status of the state's coastal riparian areas, and compare basins both in terms of current status and change over the last 15-20 years.

The study has accomplished that goal. Land cover status and land cover change of both the basins overall and various widths of riparian corridor have been compared with each other, and with statewide averages. These analyses appear to present strong evidence that the wetlands and watercourse regulations in Connecticut are having a measurable effect in protecting riparian areas. Overall watershed condition, as indicated by land cover metrics, has been estimated. Basins with the most rapid relative loss of riparian vegetative cover have been identified. 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 of the research project.

In the near future, CLEAR researchers plan to expand this study using the 2006 land cover data, apply the analysis to the whole state, and use a new GIS tool to investigate riparian status and change relative to stream/watershed order.

Complete data tables, various charts and maps, links to other references and an interactive web mapping page showing project results in visual format are available at the project website at:

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

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