U.S. Fish and Wildlife Service

The Parker River Watershed: An Assessment of Recent Trends in Salt Marshes, Their Buffers, and River-Stream Buffer Zones (1985-1999)

National Wetlands Inventory
Northeast Region

The Parker River Watershed: An Assessment of Recent Trends in Salt Marshes, Their Buffers, and River-Stream Buffer Zones (1985-1999)

by

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Contents

Introduction

The Massachusetts Coastal Zone Management Office (MACZM) is developing an environmental monitoring program for the Parker River watershed. Basic information on trends in several natural resources is needed to serve as a baseline for this effort. For example, information on wetland trends, changes in salt marsh and river-stream buffers, and the extent of impervious surfaces is needed. The U.S. Fish and Wildlife Service's National Wetlands Inventory has been analyzing wetland trends since the 1970s and more recently has been evaluating changes in wetland buffers and characterizing the condition of stream buffers for selected watersheds. MACZM contacted the U.S. Fish and Wildlife Service to perform various analyses and in the year 2000 provided funds to the Service's Northeast Region to do this type of work. This report summarizes study findings for the Parker River watershed.

Study Area

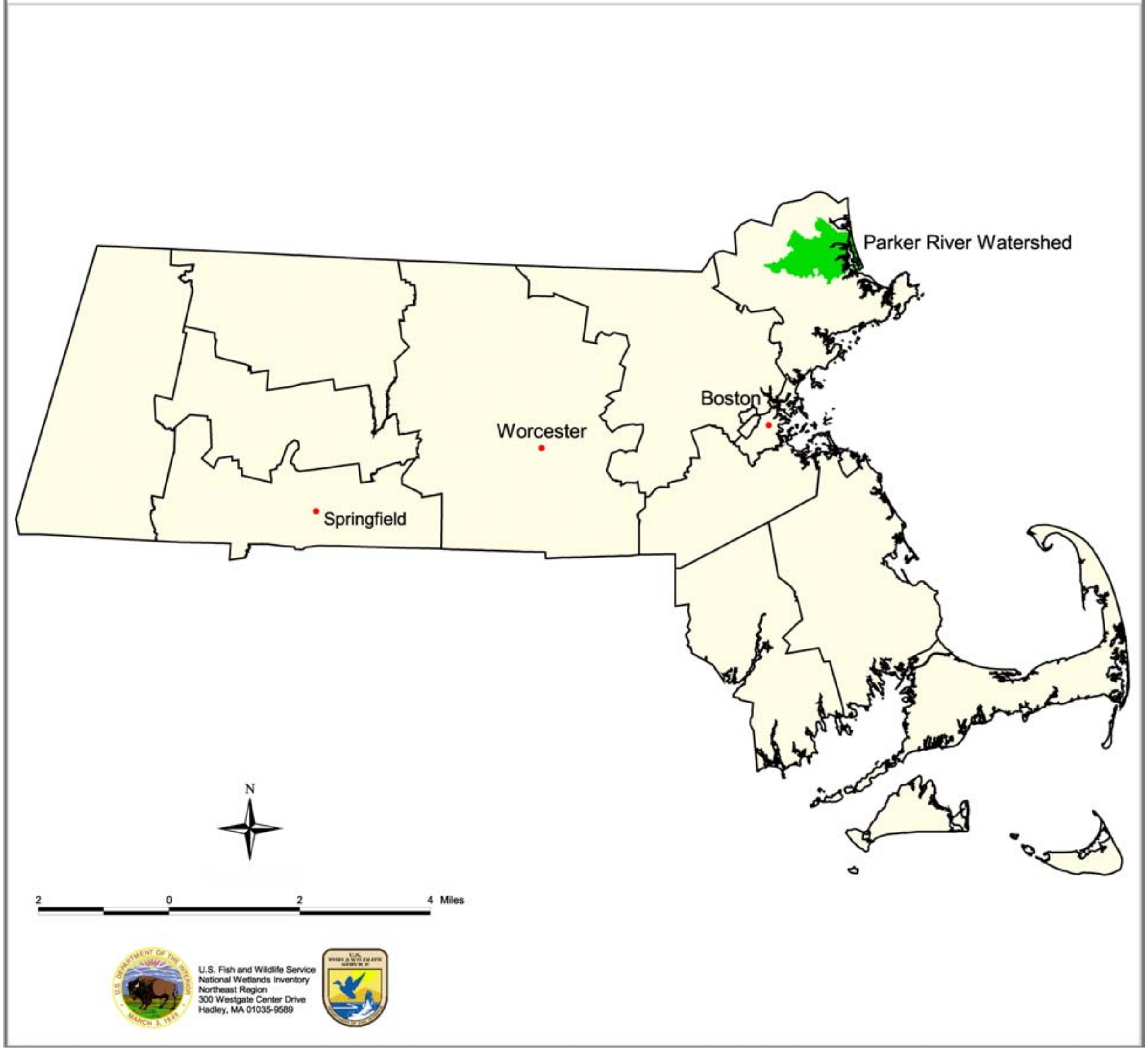
The Parker River Watershed is a relatively small coastal watershed encompassing nearly 80 square-miles in northeastern Massachusetts (Figure 1). It lies between two large watersheds - the Merrimack (to the north) and the Ipswich (to the south). The Parker River Watershed contains extensive salt marshes between Plum Island and the mainland. The watershed appears on the following large-scale (1:25,000) U.S. Geological Survey topographic maps: Newburyport East, Newburyport West, Georgetown, Ipswich, South Groveland, and Haverhill.

Study Objectives

The study involved determining changes in the following features between 1985 and 1999: 1) salt marsh habitats, 2) 100m salt marsh buffers, and 3) 100m freshwater stream buffers (200m corridor along freshwater rivers and streams). The study also included an evaluation of the extent of impervious surfaces associated within mapping units on existing land use/cover maps and application of some natural habitat integrity indices to the watershed. Products from this study were the project summary report and digital data layers for various themes (salt marsh habitat, salt marsh buffers, and freshwater river and stream corridors).

Figure 1

General Location of the Parker River Watershed
in Massachussetts



Methods

The study relied on conventional photointerpretation and geographic information system processing to develop the required data. The foundation for the trends analyses was aerial photographs from 1985 and 1999. Aerial photography was 1:25,000 color infrared acquired in July 1985 and in September 1999 when foliage was on the trees. This photography is well-suited for distinguishing among plant communities, but is less useful for differentiating wetlands from uplands. Since the focus of the interpretation was changes in salt marshes and in vegetated status of the 100m buffer around these marshes and along freshwater streams, the photos were acceptable, while they would be inadequate for detailed mapping of forested and shrub wetlands.

Salt Marsh Habitat and Buffer Trends

Comparison of the aerial photos allowed detection of changes in salt marshes and a 100m buffer zone around them. A digital transfer scope (DTS) was used to map the current status and analyze the recent trends in these resource areas. The DTS allows simultaneous examination of aerial photos (in stereo) and digital data for a given area. Consequently, the DTS was used to update and enhance existing MassGIS digital wetland data for the Parker River Watershed and to record changes in salt marshes. Wetland types used in this study followed the classification used to map wetlands under the state's Wetland Conservancy Program (e.g., low marsh, high marsh, and brackish marsh), with the following attributes added: vegetated panne, open water panne, Phragmites-dominated marsh, and ditched salt marsh. ArcInfo and ArcView were used to analyze the data and to generate maps and statistics. For evaluation of changes in the salt marsh buffer, the Anderson et al. system (1976) was used to describe the 1985 and 1999 condition of the buffer. Digital data layers were created for 1985 salt marsh, 1999 salt marsh, 1985 salt marsh buffer, and 1999 salt marsh buffer.

River-Stream Buffer Zone Trends

Aerial photointerpretation using the DTS was also the technique employed to detect and record changes in the 100m buffer zone around freshwater rivers and streams. MassGIS hydrography data (1:5000) were used to delineate the presence of rivers and streams. The freshwater-estuary boundary was revised based on our study. A 100m buffer was then established around the freshwater river and stream channels through ArcInfo software, making sure to not overlap with the salt marsh buffer. The condition of the buffer zone was determined for each time period (1985 and 1999) through photointerpretation using the DTS. The buffer was classified according to Anderson et al. (1976) with some modifications for more detailed categorization. Classification included the following categories: large turf area, residential (single family, multiple-low density, multiple-medium density, multiple-high density), commercial development, light industry, highway, railroad, airport, institutional/government facility, recreation, golf course, cropland, pasture, idle field, farmstead/farm building, herbaceous cover (old field), shrubland, mixed rangeland, deciduous forested upland, evergreen forested upland, mixed forested upland, open water, natural lake and pond, manmade reservoir and impoundment, bay and cove, deciduous forested wetland, emergent wetland, scrub-shrub wetland, salt marsh, beach and river bank, sandy area, bare and exposed rock, sand and gravel mining, transitional land (land under development, intended use unknown), and barren and sparsely vegetated area. ArcInfo and ArcView were used for data analysis and producing maps and statistics. Digital data layers were created for 1985 stream buffer and 1999 stream buffer.

Natural Habitat Integrity Indices

To aid in assessing the overall ecological condition of watersheds, the Northeast Region of the U.S. Fish and Wildlife Service has developed a set of largely remotely sensed “natural habitat integrity” indices (formerly referred to as “ecological integrity indices”). The variables for these indices are derived mainly through air photointerpretation coupled with knowledge of the historical extent of wetlands and open waterbodies. They are coarse-filter variables for assessing the overall condition of watersheds. They are intended to augment, not supplant, other more rigorous, fine-filter approaches for describing the ecological condition of watersheds (e.g., indices of biological integrity for macroinvertebrates and fish and the extent and distribution of invasive species) and for examining human impacts on the natural world.

To date, the Service has created ten indices that can be used to characterize the habitat condition of a watershed. Six indices address natural habitat extent (i.e., the amount of natural habitat occurring in the watershed and along wetlands and waterbodies): natural cover, river-stream corridor integrity, vegetated wetland buffer integrity, pond and lake buffer integrity, wetland extent, and standing waterbody extent. Three indices emphasize human-induced alterations to streams and wetlands. These “stream and wetland disturbance indices” address dammed stream flowage, channelized stream flowage, and wetland disturbance. The nine specific indices may be combined into a single, composite index called “remotely sensed natural habitat integrity index” for the watershed. All indices have a maximum value of 1.0 and a minimum value of zero. For the habitat extent indices, the higher the value is the more habitat available. For the disturbance indices, the higher the value is the more disturbance. For the remotely sensed natural habitat integrity index, all indices are weighted, with the disturbance indices subtracted from the habitat extent indices to yield an overall “natural habitat integrity” score for the watershed.

“Natural habitats” are defined as areas where significant human activity is limited to nature observation, hunting, fishing, or timber harvest, and where vegetation is allowed to grow for many years without annual introduction of chemicals or annual harvesting of vegetation or fruits and berries for commercial purposes. Natural habitats are essentially plant communities represented by “natural” vegetation such as forests, meadows, shrub thickets, and vegetated wetlands. They are not developed sites (e.g., impervious surfaces, lawns, turf, cropland, pastures, mowed hayfields, or commercial cranberry bogs). Managed forests are included as natural habitat, whereas orchards and vineyards are not. Natural vegetation does not imply that substantial groundcover must be present, but simply that the communities reflect the vegetation that is capable of growth and reproduction in accordance with site characteristics (e.g., sand dunes and beaches).

For the Parker River Watershed study, we calculated three natural habitat integrity indices using data derived from this study and existing land use/cover data. Index values were determined for two years - 1985 and 1999 - for the entire watershed and for each subbasin. Two of the ten existing indices were evaluated - natural cover integrity and river-stream corridor integrity, while the third index - the salt marsh buffer integrity - was created especially for this project. The former index was computed from existing MassGIS land use/cover data and our updates for the watershed, while the latter two indices was determined from the new data we created. Each index is briefly described below.

The Natural Cover Index (I_{NC}) is derived from a simple percentage of the watershed that is wooded (e.g., upland forests or shrub thickets and forested or scrub-shrub wetlands) and "natural" open land (e.g., emergent wetlands or "old fields;" but not cropland, hayfields, lawns, turf, or pastures). These areas are lands supporting "natural vegetation" and they exclude open water of ponds, rivers, lakes, streams, and coastal bays.

> $\mathbf{I_{NC} = A_{NV}/A_W}$, where A_{NV} (area in natural vegetation) equals the area of the watershed's land surface in "natural" vegetation and A_W is the area of "watershed" excluding open water.

The River-Stream Corridor Integrity Index (I_{RSCI}) was derived by considering the condition of the stream corridor around perennial freshwater rivers and streams:

> $\mathbf{I_{RSCI} = A_{VC}/A_{TC}}$, where A_{VC} (vegetated river-stream corridor area) is the area of the river-stream corridor that is colonized by "natural vegetation" and A_{TC} (total river-stream corridor area) is the total area of the river-stream corridor.

A 200-meter (656 feet) corridor (100m on each side of the river or stream) was evaluated. To compute total river-stream length, the centerlines of river polygons are used to derive river length and this was added to stream length (from linear data). Also note that these corridors include impounded sections of rivers and streams, so that a continuous river or stream corridor is evaluated. The centerlines of these polygons were used to determine stream length. For this watershed, the index was applied to freshwater portion of the Parker River and its tributaries.

The Salt Marsh Buffer Integrity Index (I_{SMB}) is a measure of the condition of the buffer zone within a specified distance (e.g., 100m) of mapped salt marshes:

> $\mathbf{I_{SMB} = A_{VB}/A_{TB}}$, where A_{VB} (area of vegetated buffer) is the area of the salt marsh buffer zone that is in natural vegetation cover and A_{TB} is the total area of the buffer zone.

While the buffer zone may include open water, this buffer index focused on land areas that may support free-standing vegetation.

Impervious Surface Coverage Estimates

The MassGIS data for land use/cover in the Parker River Watershed includes 27 categories (Table 1). Each of these categories may contain impervious surface. To estimate the percent of impervious surface in each land use/cover type, the MACZM randomly selected up to 15 polygons (mapping units). A total of 274 mapping units were analyzed (see Table 1) equating to nearly 13 percent of the watershed polygons. Within each polygon, random points were evaluated on the 1999 aerial photography using the DTS to determine whether or not the point was located on an impervious surface. From these data, the percent of impervious surface was calculated. The results represent an estimate of the percent of impervious surface within each type of mapping unit.

Table 1. Land use/cover categories for the Parker River Watershed from MassGIS.

Land Use/Cove Category	**No. of Polygons**	**Average Size** (acres)	**No. of Polygons Sampled**
Cropland	132	16.9	15
Pasture	106	7.4	15
Forest	386	41.9	15
Wetland	92	14.8	15
Mining	8	9.9	8
Open Land	132	11.5	15
Participatory Recreation	30	5.9	14
Spectator Recreation	1	1.3	1
Water Recreation	5	18.7	5
Multi-Family Residential	13	4.6	13
<1/4-acre Residential	7	6.4	7
1/4-1/2-acre Residential	116	16.7	15
>1/2-acre Residential	737	6.1	17
Salt Marsh	73	83.8	15
Commercial	71	4.6	15
Industrial	74	6.9	15
Urban Open	32	2.8	5
Transportation	14	33.3	9
Waste Disposal	10	7.5	10
Water	34	6.5	15
Golf Course	10	25.5	4
Marina	2	4.3	2
Urban Public	30	5.6	8
Transportation Facility	15	3.0	6
Cemeteries	11	9.9	2
Orchard	4	5.9	4
Nurseries	17	5.9	11

Results

Wetland and Coastal Features Acreage Summary

The extent of wetlands and other coastal features (e.g., barrier beach/dune system) for the Parker River Watershed is given in Table 2 and displayed in Figure 2. Wetlands comprised about 30 percent of the watershed (excluding open water). Salt and brackish marshes were more abundant than freshwater wetlands (8,810 acres vs. 6,486 acres or 1.36:1.00). Nearly 56 percent of the salt marshes were ditched. Only 43 acres of Phragmites marsh were identified in the estuarine zone of the watershed.

Table 2. Acreage of wetlands and coastal features for the Parker River Watershed. (Note: 1999 data for salt and brackish marshes from this study; 1985 data for other wetlands and coastal features from MassGIS).

General Category	Specific Type	1985 Acres	
Coastal Features*	Barrier Beach System	181.6	
	Barrier Beach-Coastal Beach/Dune	899.3	
	Barrier Beach-Marsh	0.9	
	Barrier Beach-Open Water		0.3
	Barrier Beach-Shrub Swamp	9.9	
	Barrier Beach-Wooded Swamp	26.9	
	Coastal Bank Bluff or Sea Cliff	35.2	
	Coastal Beach	23.5	
	Coastal Dune	2.9	
	Tidal Flat	250.2	
	Rocky Intertidal	1.9	
	Subtotal	1,432.6	
Salt and Brackish Marshes	Brackish Marsh	421.9	
	Ditched Salt Marsh	4,647.0	
	High Salt Marsh	2,054.5	
	Low Salt Marsh	602.8	
	Open Water Panne	388.7	
	Vegetated Panne	652.0	
	Phragmites Marsh	43.3	
	Subtotal	8,810.2	
Freshwater Wetlands	Bog	14.4	
	Shallow Marsh	1,032.9	
	Deep Marsh	268.9	
	Shrub Swamp	811.4	
	Coniferous Wooded Swamp	10.7	
	Deciduous Wooded Swamp	4,031.7	
	Mixed Wooded Swamp	316.1	
	Subtotal	6,486.1	

*Includes some wetland types.

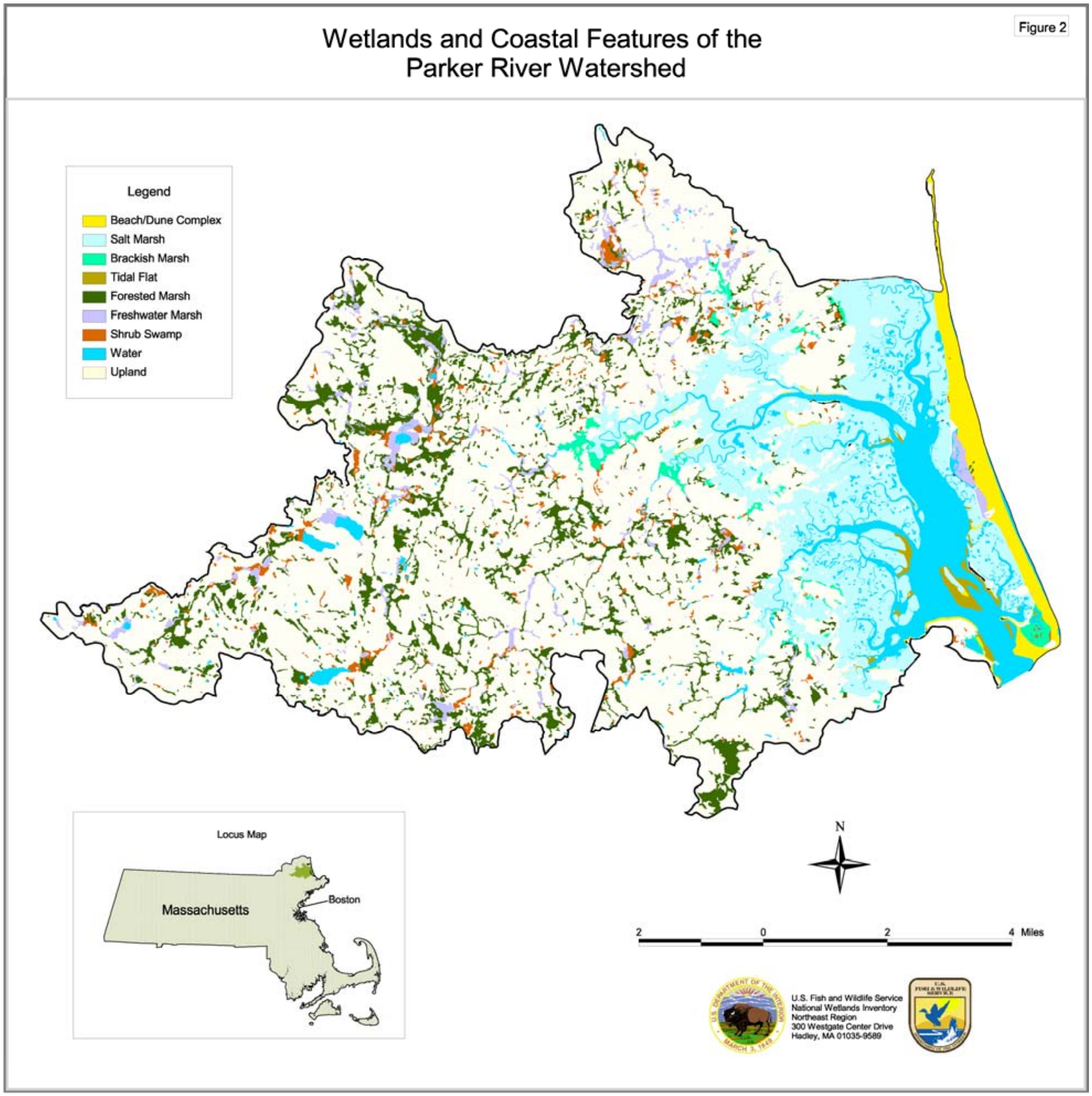


Figure 2
Wetlands and Coastal Features of the
Parker River Watershed
Legend
Beach/Dune Complex
Salt Marsh
Brackish Marsh
Tidal Flat
Forested Marsh
Freshwater Marsh
Shrub Swamp
Water
Upland
Locus Map
Massachusetts
Boston
N
2 0 2 4 Miles
U.S. Fish and Wildlife Service
National Wetlands Inventory
Northeast Region
300 Westgate Center Drive
Hadley, MA 01035-9589

Salt Marsh Habitat Trends

Salt marshes are among the most highly regarded wetlands in the state. They are closely regulated throughout Massachusetts and are, therefore, among the best protected habitats. Consequently, little change was anticipated between 1985 and 1999 and the results confirmed this.

Only 17.4 acres of changes were identified. Most of the changes involved marsh pannes (depressions that may be vegetated or not): 1) 9.3 acres of open water pannes in 1985 were vegetated pannes in 1999, 2) 5.2 acres of vegetated pannes in 1985 were open water pannes in 1999, 3) 0.8 acres of high salt marsh in 1985 was classified as low salt marsh in 1999, and 4) 2.1 acres of brackish marsh in 1985 were mapped as Phragmites marsh in 1999. The changes in pannes may be due to the differences in the amplitude of recent tides more than to a successional change in vegetation. No salt or brackish marsh was lost to development between 1985 and 1999.

Salt Marsh Buffer Trends

The 100m buffer zone around salt marshes of the Parker River watershed amounted to 3,873 acres. The condition of this zone has an important effect on the quality of the salt marsh, especially as fish and wildlife habitat. The more natural vegetation in this zone, the more beneficial to wildlife.

Table 3 summarizes the condition of this buffer in 1999 and recent trends (also see Figure 3). Seventy-five percent of the buffer was “naturally” vegetated, with most of this being forested (over 2,000 acres or 53% of total buffer) and 14 percent having other upland vegetation. Various types of development occupied 11 percent of the buffer (with over half of this being residential housing), whereas agriculture affected 7 percent.

From 1985 to 1999, the salt marsh buffer zone experienced increases in residential development (34%), commercial/industrial development (14%), and sand/gravel mining (19%) at the expense of deciduous upland forest (45%), transitional land (21%; actually land in the early stages of development in 1985), fields (17%), and cropland (15%). These changes, however, accounted for only 1.8 percent of the buffer.

Table 3. Status and recent trends in the 100m salt marsh buffer zone 1985-1999. (Note: + indicates a gain in acreage and - indicates a loss.)

Land Cover/Use (code)	1999 Acreage	Recent Acreage Change (% change)
Large Turf Area >0.25 acres (100)	22.4	+1.6 (8)
Single Family Residential <1 acre (111)	23.5	+3.5 (18)
Multiple Residential, Low Density (1101)	56.7	+9.8 (21)
Multiple Residential, Medium Density (1102)	139.4	+10.5 (8)
Commercial Development (120)	16.3	+5.4 (50)
Light Industry (132)	9.6	+9.0 (1500)
Highway (141)	58.7	0 (0)
Railroad (143)	35.7	0 (0)
Airport (144)	0.6	0 (0)
Institutional/Government Facility (180)	3.6	+0.5 (16)
Recreation (190)	38.8	0 (0)
Golf Course (191)	12.6	0 (0)
Cropland (211)	146.2	-10.5 (7)
Pasture (212)	128.6	-0.8 (1)
Idle Field (213)	0.9	0 (0)
Farmstead/Farm Building (240)	11.9	+7.8 (190)
Herbaceous Cover (310)	179.5	-11.9 (6)
Shrubland (320)	115.3	+0.4 (<1)
Mixed Rangeland (330)	228.7	+7.2 (3)
Deciduous Forested Upland (410)	1,930.3	-31.5 (2)
Evergreen Forested Upland (420)	2.8	0 (0)
Mixed Forested Upland (430)	110.6	0 (0)
Open Water (510)	19.2	0 (0)
Natural Lake and Pond (520)	20.5	0 (0)
Manmade Reservoir and Impoundment (530)	2.4	0 (0)
Bay and Cove (540)	73.7	0 (0)
Deciduous Forested Wetland (610)	115.5	0 (0)
Emergent Wetland (620)	43.7	0 (0)
Scrub-Shrub Wetland (623)	67.2	0 (0)
Salt Marsh (624)*	89.7	0 (0)
Beach and River Bank (720)	54.3	0 (0)
Sandy Area (730)	16.9	0 (0)
Bare and Exposed Rock (740)	1.9	0 (0)
Sand and Gravel Mining (753)	13.4	+13.4 (all gain)
Transitional Land (760)	33.8	-15.0 (31)
Barren and Sparsely Vegetated Area (770)	48.2	-0.5 (1)

*Salt marsh occurring in Parker River salt marsh buffer zone based on the boundary line for the watershed; this acreage lies outside of the watershed but adjacent to the Parker River salt marshes.

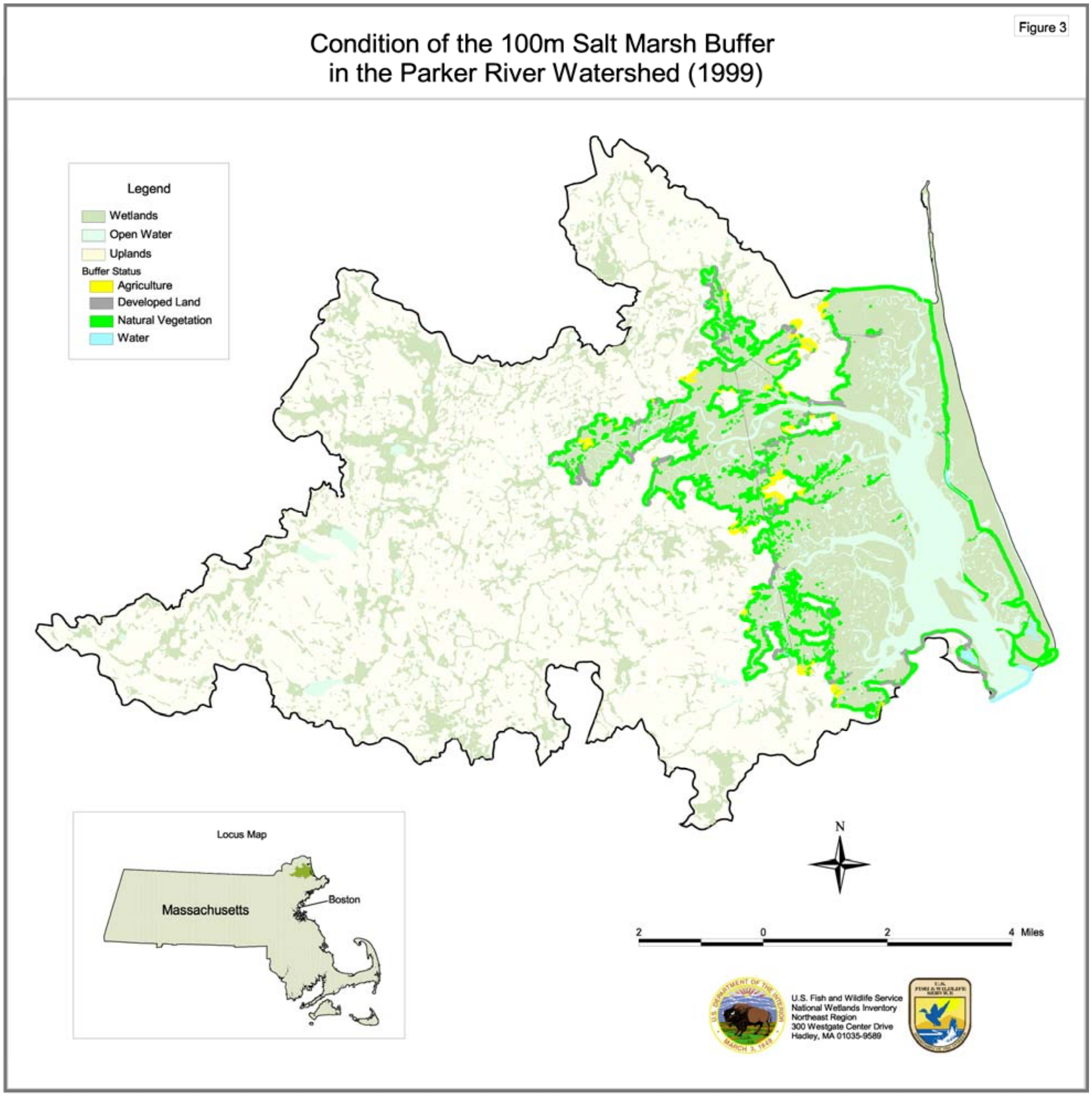


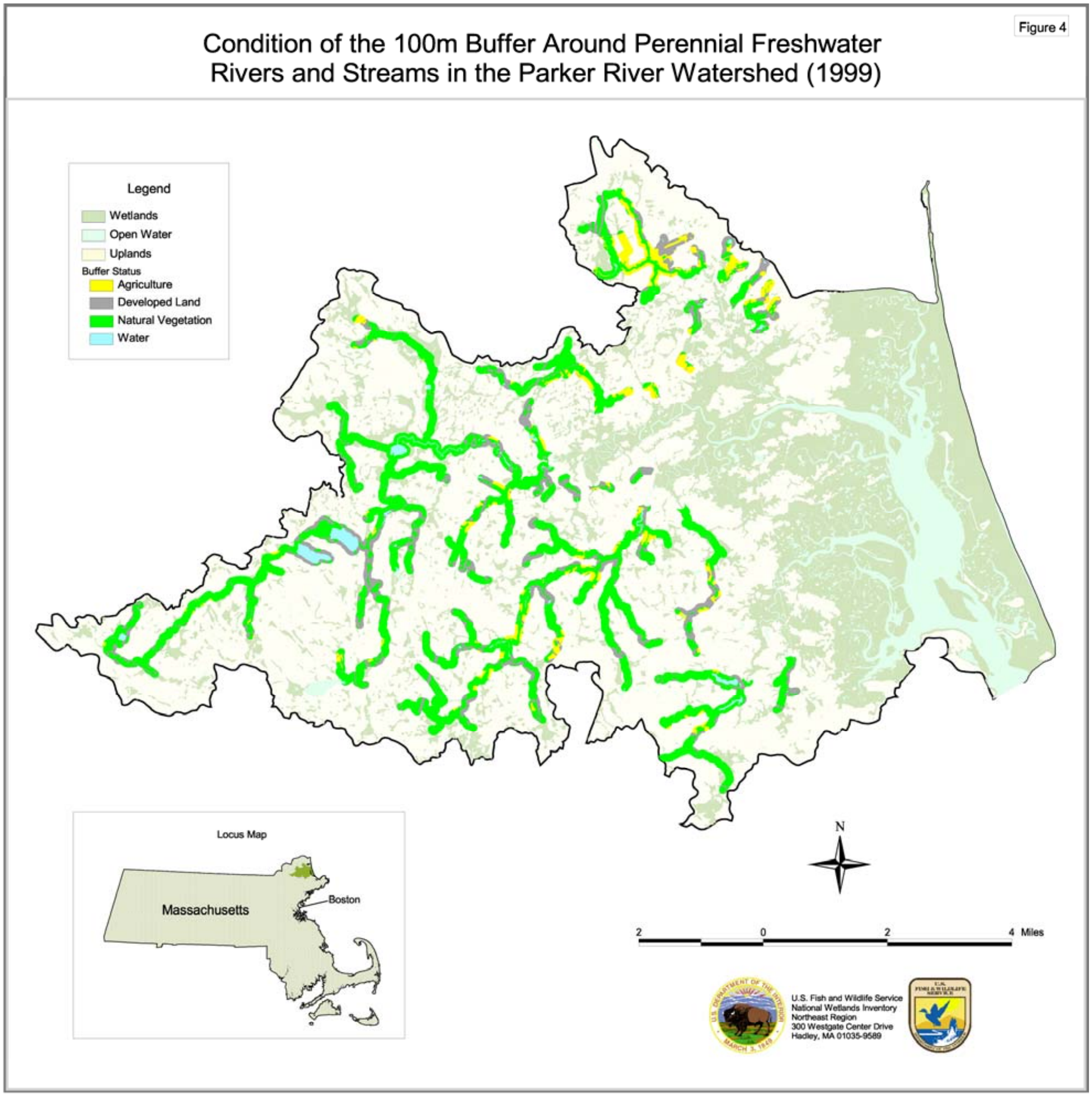
Figure 3
Condition of the 100m Salt Marsh Buffer
in the Parker River Watershed (1999)
Legend
Wetlands
Open Water
Uplands
Buffer Status
Agriculture
Developed Land
Natural Vegetation
Water
Locus Map
Massachusetts
Boston
N
2
0
2
4 Miles
U.S. Fish and Wildlife Service
National Wetlands Inventory
Northeast Region
300 Westgate Center Drive
Hadley, MA 01035-9589

River-Stream Buffer Zone Trends

The 100m buffer around freshwater perennial rivers and streams totaled 7,472 acres (Table 4; see Figure 4). Of this, 70 percent was "naturally" vegetated, 18 percent developed (non-agricultural), 9 percent agricultural development, and 3 percent open water in 1999. A total of 317 acres changed from 1985 to 1999. This change amounts to about 4 percent of the buffer zone. Most of the change was increases in residential development (70% of the gain) and light industry (26%) mainly at the expense of upland forests and fields (72% of the loss).

Table 4. Status and recent trends in the100m freshwater river-stream buffer zone 1985-1999. (Note: + indicates a gain in acreage and - indicates a loss.)

Land Cover/Use (mapping code)	**1999 Acreage**	**Recent Acreage Change (% change)**
Large Turf Area >0.25 acres (100)	41.1	-36.3 (47)
Single Family Residential <1 acre (111)	75.0	+4.1 (6)
Multiple Residential, Low Density (1101)	112.8	+26.7 (31)
Multiple Residential, Medium Density (1102)	461.6	+149.6 (48)
Multiple Residential, High Density (1103)	114.6	+42.6 (59)
Retail Sales/Wholesale/Professional Services (121)	42.2	+5.9 (16)
Light Industry (132)	142.7	+81.8 (134)
Heavy Industry (133)	3.6	+3.3 (1100)
Transportation/Communication (140)	7.6	0 (0)
Highway (141)	176.5	0 (0)
Utilities (150)	31.9	0 (0)
Other Urban or Built-up Land (170)	43.7	0 (0)
Institutional/Government Facility (180)	1.7	0 (0)
Recreation (190)	23.8	0 (0)
Golf Course (191)	22.3	0 (0)
Cropland (211)	408.5	-22.3 (5)
Pasture (212)	109.0	-0.5 (<1)
Idle Field (213)	169.1	+0.5 (<1)
Orchards/Nurseries (220)	3.5	0 (0)
Farmstead/Farm Building (240)	3.3	0 (0)
Herbaceous Cover (310)	2.5	0 (0)
Mixed Rangeland (330)	40.0	-74.6 (65)
Deciduous Forested Upland (410)	2,587.3	-153.7 (6)
Open Water (510)	238.2	+2.7 (1)
Bay and Cove (540)	0.4	0 (0)
Deciduous Forested Wetland (610)	1,341.2	0 (0)
Emergent Wetland (620)	910.6	0 (0)
Scrub-Shrub Wetland (623)	346.4	0 (0)
Salt Marsh (624)	2.5	0 (0)
Sand and Gravel Mining (753)	6.8	0 (0)
Transitional Land (760)	1.7	-30.0 (95)



Condition of the 100m Buffer Around Perennial Freshwater Rivers and Streams in the Parker River Watershed (1999)

Selected Natural Habitat Integrity Indices (1985-1999)

Three natural habitat integrity indices were calculated for the Parker River Watershed: natural cover index, river-stream corridor integrity index, and salt marsh buffer integrity index (Table 5). These indices present a picture of the extent of "natural habitat" remaining in these locations. The indices were calculated for two time periods (1985 and 1999) to reveal changes in these features. Figure 5 shows the general extent of natural vegetation and developed lands for the Parker River Watershed.

In 1985, about 73 percent of the watershed was covered with "natural vegetation" (37,789 acres). By 1999, development had eliminated 6 percent of this vegetation, leaving about 69 percent of the watershed in "natural vegetation" (35,514 acres). The condition of the river-stream corridor followed a similar path of conversion of "natural vegetation," with a 4 percent reduction during that time period (5,459 acres in 1985 to 5,231 acres in 1999). The salt marsh buffer was more stable with only a 1 percent change in the "natural vegetation" (2,919 acres in 1985 to 2,883 acres in 1999). The high values of these indices suggest that the Parker River watershed is in relatively good condition. More developed areas would have index values that are much lower. There was, however, a 6 percent change in natural vegetation within the watershed over the 14-year study interval. Additional monitoring of these indices can track the effect of development on the wildlife habitat which could provide valuable information for natural resource managers and planners.

Table 5. Selected natural habitat integrity indices for the Parker River Watershed in 1985 and 1999.

Index	**1985 score**	**1999 score**
Natural Cover (for entire watershed)	0.73	0.69
100m River-Stream Corridor Integrity	0.75	0.72
100m Salt Marsh Buffer Integrity	0.78	0.77

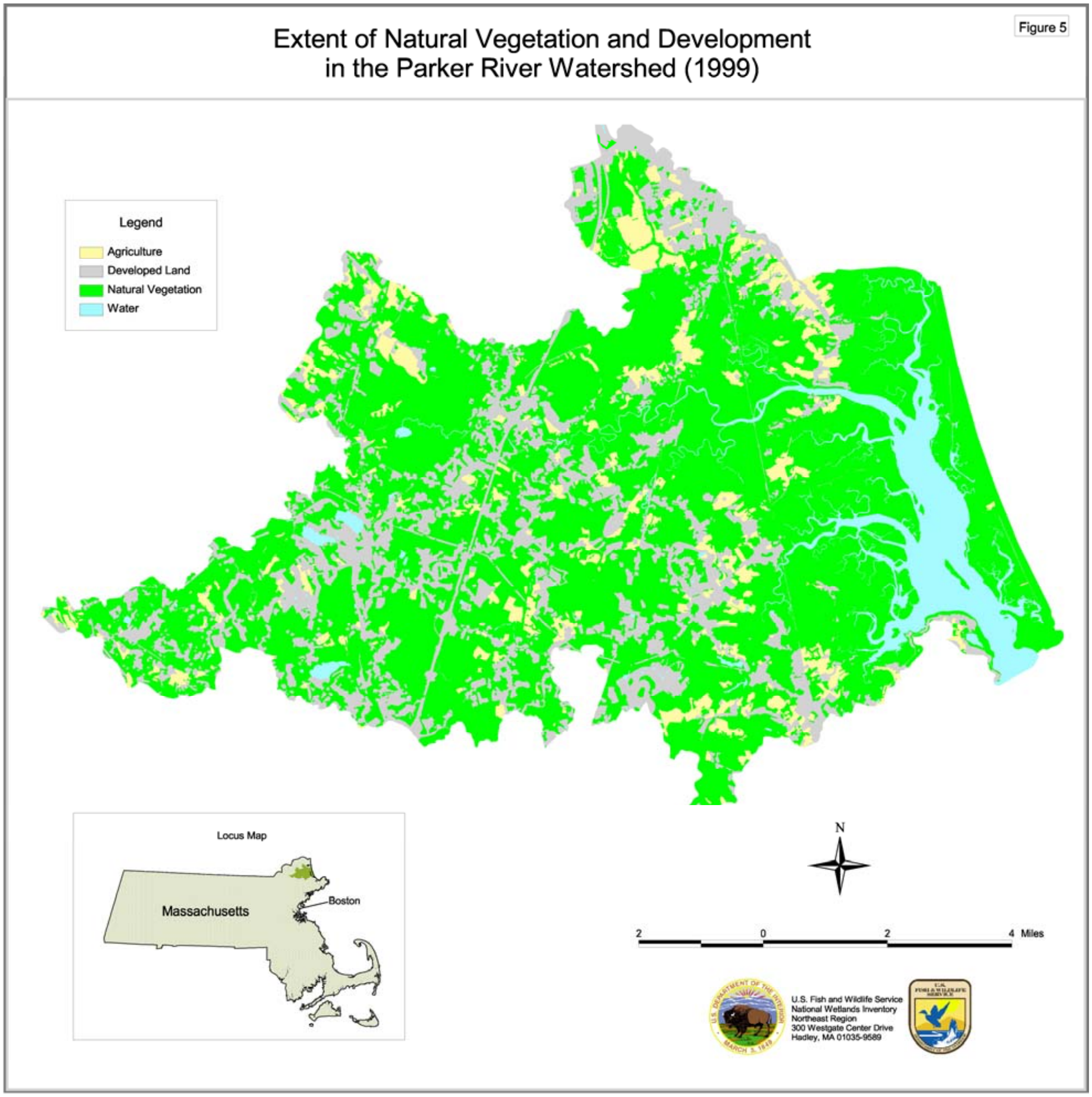


Figure 5
Extent of Natural Vegetation and Development
in the Parker River Watershed (1999)
Legend
Agriculture
Developed Land
Natural Vegetation
Water
Locus Map
Massachusetts
Boston
N
2
0
2
4 Miles
U.S. Fish and Wildlife Service
National Wetlands Inventory
Northeast Region
300 Westgate Center Drive
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Impervious Surfaces Coverage Estimates

Estimated percent of impervious surface for each land use/cover mapping category is presented in Table 6. The estimates vary in reliability. An indication of the reliability of the estimate is reflected by the variance which is represented here as a percent of the mean. The lower the variance is the more reliable the estimate. In general, when the variance is 20 percent of the mean or less, the estimate is considered reliable.

More than half of the categories had reliable estimates of impervious cover and most of these represented developed lands (e.g., residential, commercial, and industrial development) where impervious surfaces were expected to represent a significant proportion of the mapping unit. The marina category was 90 percent impervious surface, while transportation facility was second-ranked in impervious surface coverage with 73 percent. Commercial and industrial development had 64 and 55 percent coverage by impervious surfaces. Small-lot residential development (<1/4-acre) and multi-family residential closely followed with 54 and 47 percent, respectively. Natural areas such as salt marshes, other wetlands and forests had low impervious surface values of 3, 6, and 8 percent respectively, yet variances were less reliable for the latter two types. Evaluation of additional sample points within the polygons and sampling of more polygons would likely reduce the variance for those categories with higher variances as long as mapping interpretation was consistent.

Table 6. Land use/cover categories for the Parker River watershed from MassGIS and estimates of impervious surface within each category.

Land Use/Cove Category	**No. of Polygons Sampled/Total Polygons**	**No. of Points Sampled**	**% Impervious (mean)**	**Variance (as % of mean)**
Cropland	15/132	200	9.0	29.0
Pasture	15/106	135	8.0	41.3
Forest	15/386	440	7.8	25.5
Wetland	15/92	315	5.5	43.3
Mining	8/8	105	6.7	28.6
Open Land	15/132	105	4.7	21.0
Participatory Recreation	14/30	135	6.4	14.0*
Spectator Recreation	1/1	5	0.0	0.0*
Water Recreation	5/55	85	12.0	26.7
Multi-Family Residential	13/13	100	46.9	10.8*
<1/4-acre Residential	7/7	70	54.3	4.2*
1/4-1/2-acre Residential	15/116	300	30.5	13.6*
>1/2-acre Residential	15/737	170	30.4	14.2*
Salt Marsh	15/73	460	2.9	12.1*
Commercial	15/71	115	64.0	5.8*
Industrial	15/74	105	54.7	11.7*
Urban Open	5/32	25	4.0	20.0*

Transportation	9/14	155	35.9	28.3
Waste Disposal	10/10	110	21.8	14.9*
Water	15/34	150	2.9	36.7
Golf Course	4/10	85	5.0	3.7*
Marina	2/2	15	90.0	2.2*
Urban Public	8/30	50	48.8	20.8
Transportation Facility	6/15	30	73.3	8.0*
Cemeteries	2/11	40	28.3	0.2*
Orchard	4/4	40	10.0	40.0
Nurseries	11/17	100	17.4	29.6

Conclusion

Changes in the Parker River salt marshes between 1985 and 1999 were negligible. The 100m buffer around these marshes remained in relatively good condition with 75 percent in “natural” vegetation. Overall, the watershed appeared to be in good shape with “natural” vegetation covering 69 percent of the watershed. However, from 1985 to 1999, development had reduced the amount of the natural vegetation in the watershed from 73 percent to 69 percent. While the river-stream buffer also remained in good condition with 72 percent in “natural” vegetation, substantial conversion of forests and fields to development recently took place in this zone. The naturally vegetated stream and river buffer zones are important travel corridors for local wildlife and vital filters for buffering stream water quality from adverse impacts associated with upland development (e.g., Castelle et al. 1994). Based on the results of this study, natural resource managers and planners may be advised to place more attention on conserving these natural resources.

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