Appendix 2 – Land Use/Land Cover Analyses (1996-2010)

Measuring Land Cover

NOAA's Coastal Change Analysis Program (C-CAP) is a remote sensing program designed to measure the type and extent of land coverage. The program provides standardized data for coastal communities to measure changes to land coverages and usages over time. High resolution data is provided for certain targeted coastal areas, including around Galveston Bay. C-CAP categorizes land cover date into over 20 categories (See Appendix 2, Table 4 for definitions), and which were used for the analyses in this report. Maps 26-29, in this appendix depicts data used from years 1996, 2001, 2006, 2010, respectively.

Changes in land coverage by type as measured over a fifteen year period are summarized in Tables 2 and 3 in this section. Analyses indicate that some minor acreage was converted to land development in both watersheds. There is a similar decline in most other land use categories, such as agricultural lands and vegetated undeveloped lands. As a percentage of the total land over the 15 year period, about 2-3% of the land was converted to developed uses.

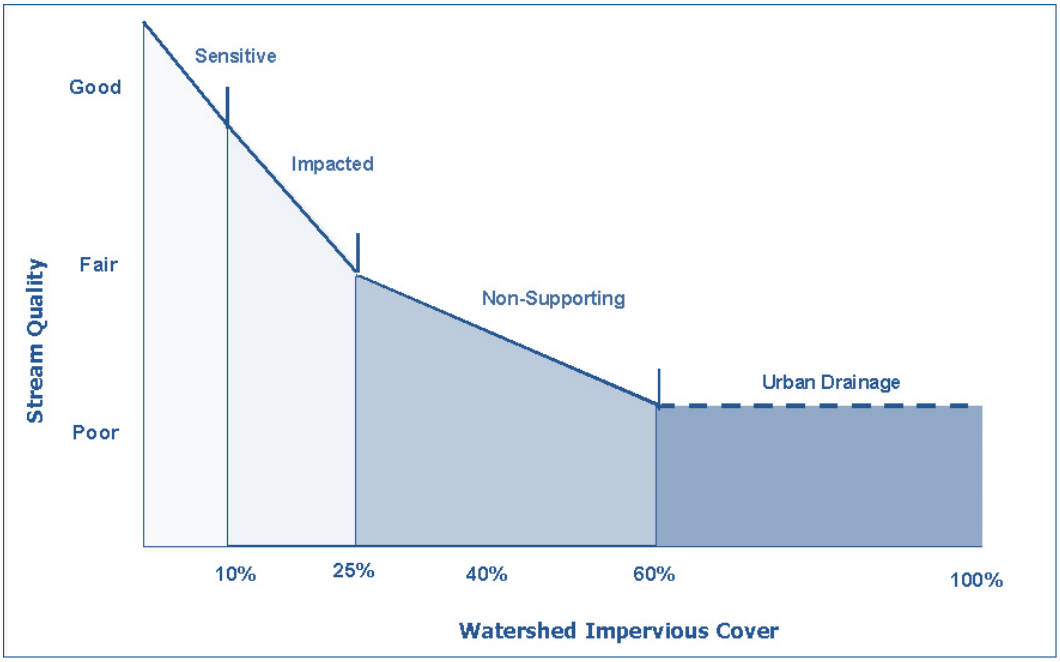
Using C-CAP data, estimates for impervious surface (IS) cover can be made for each subbasin. Ratios of impervious surface cover are defined for each C-CAP land use classification. These values range from under 20% impervious surface cover for 'open space development,' to over 80% for 'high intensity development.' Values for impervious surface cover by land cover/use are in Table 4, definitions.

Highland Bayou and Marchand Bayou are 44% and 68% developed, respectively. Based on the IS cover ratios for each development intensity, impervious surface covers an estimated 16% of Highland Bayou and 21% of Marchand Bayou (Appendix 2, Table 1). Each basin experienced an increase in impervious surface cover, ranging from 2% to 11% increases in 2006 values over 1996 values. In Highland Bayou, this means an additional 85 acres of impervious cover and in Marchand Bayou another 14 acres of impervious cover.

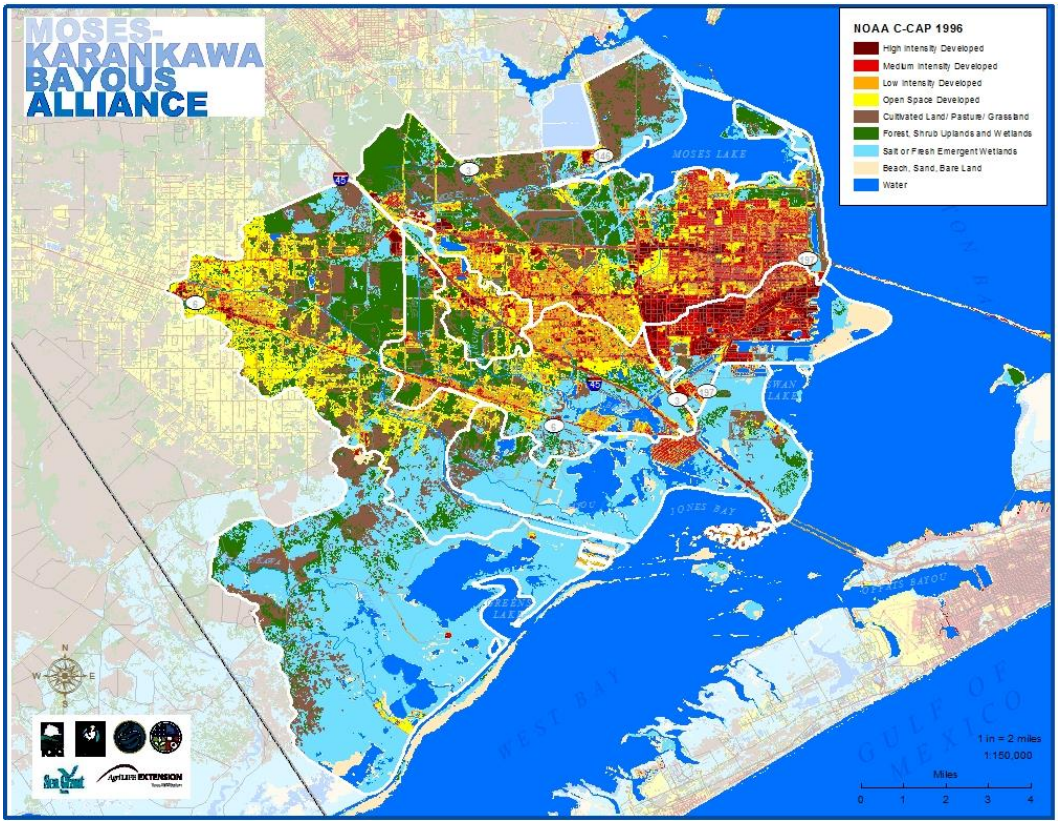
Appendix 2, Table 1. Estimate Impervious Surface (IS) Cover for the Subbasins using NOAA C-CAP Data.

	Highland Bayou	Marchand Bayou
Percent Developed Acres	44%	68%
Percent Impervious Surface Cover	16%	21%

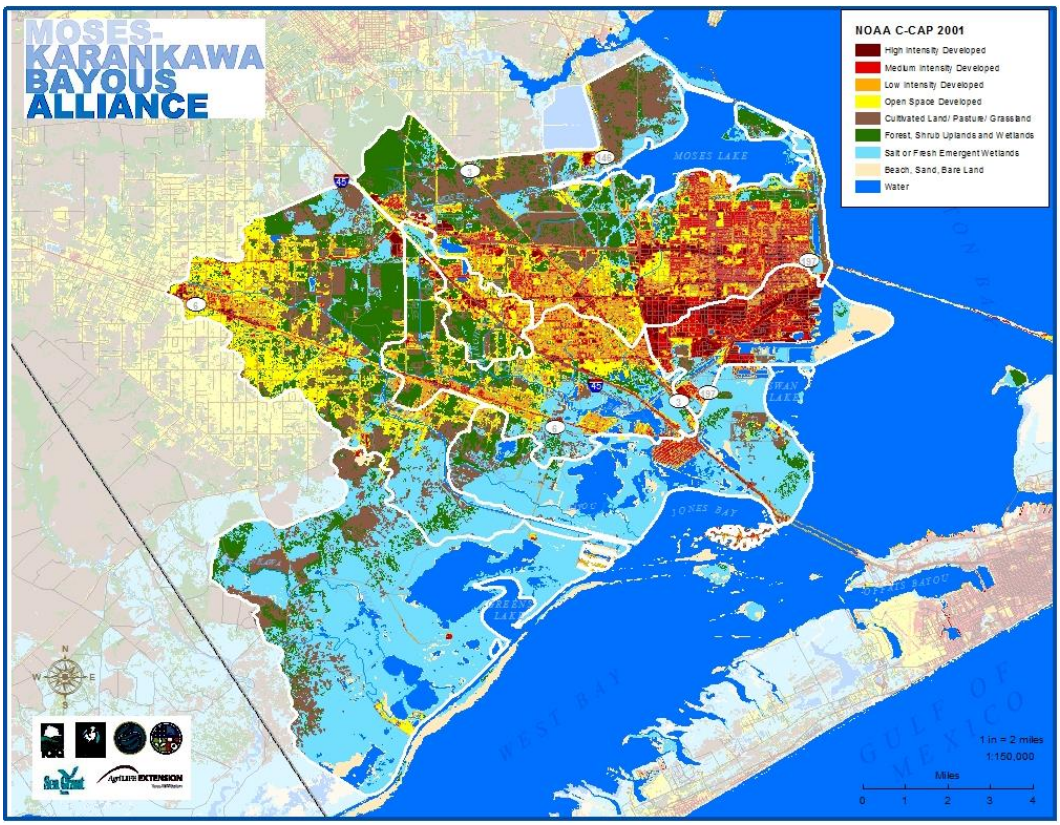
Stream habitat quality declines rapidly as impervious surface increases in the surrounding watershed. Figure 1 shows that above 25% imperviousness, stream quality indicators rapidly become non-supporting. Even with as low as 10% imperviousness, stream quality is significantly impacted. This model suggests we will get a better bang for our buck if we preserve those sensitive watersheds that have less than 25% imperviousness, and especially those that have less than 10% imperviousness.



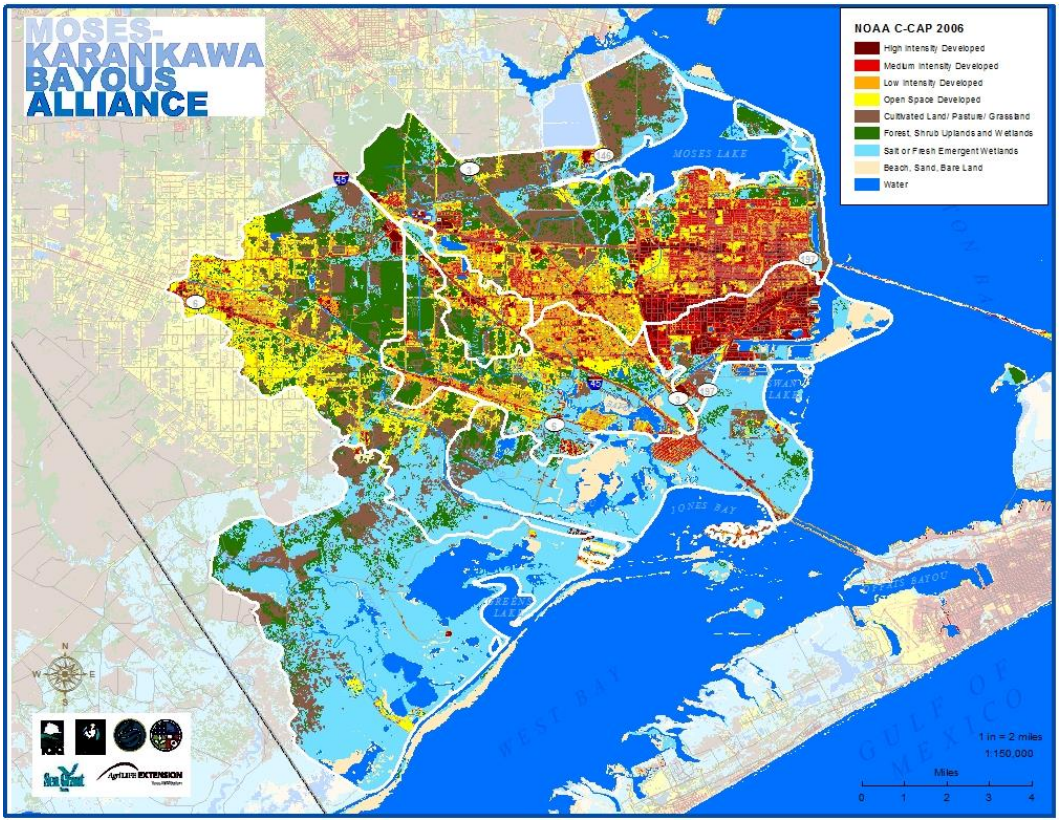
Appendix 2, Figure 1. Stream quality impacts by percent impervious cover in a watershed. Watershed Impervious Cover Model. Source: Stormwater Management Resource Center.



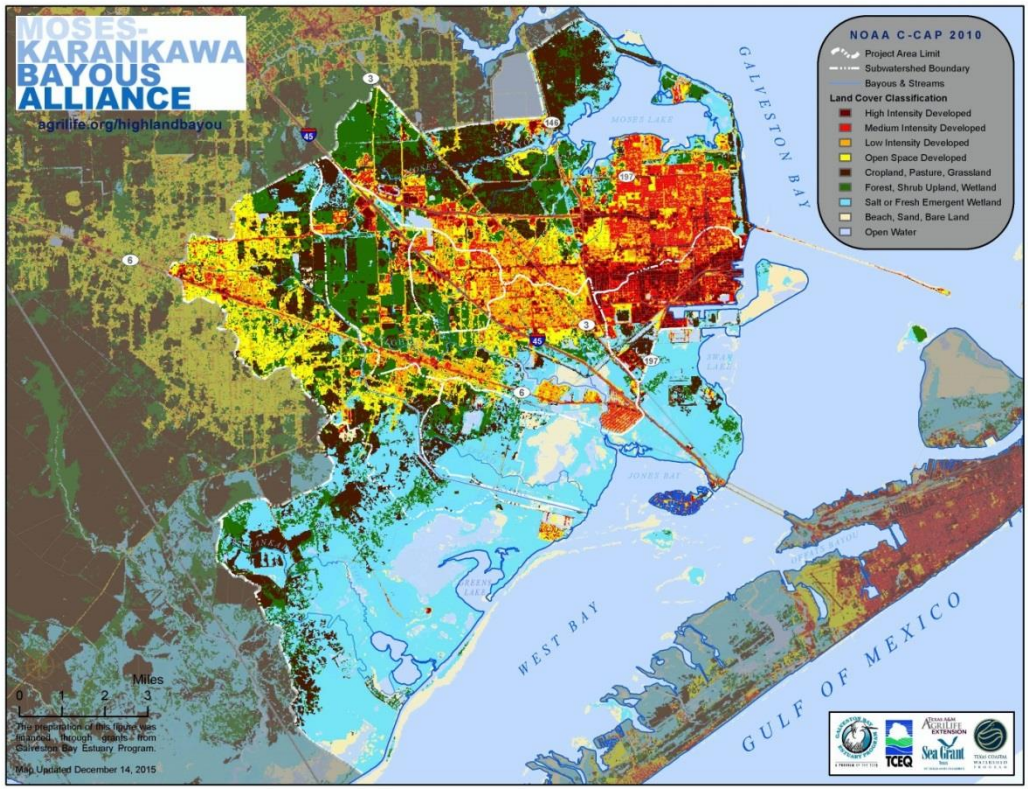
Map- 26. NOAA Coastal Change Analysis Program (C-CAP) for the entire Highland Bayou Coastal Basin Study Area, 1996.



Map- 27. NOAA C-CAP for the entire Highland Bayou Coastal Basin Study Area, 2001.



Map- 28. NOAA C-CAP for the entire Highland Bayou Coastal Basin Study Area, 2006.



Map- 29. NOAA C-CAP for the entire Highland Bayou Coastal Basin Study Area, 2010.

Appendix 2, Table 2. Summary of NOAA C-CAP for Highland Bayou Subbasin, Years 1996-2010.

Highland Bayou	1996		2001		2006		2010	15 yr. net change
	Acres	% change	Acres	% change	Acres	% change	Acres	
Developed, High Intensity	357	1.3%	361	12.1%	405	2.1%	413	15.9%
Developed, Medium Intensity	1058	1.5%	1074	5.1%	1128	4.2%	1175	11.1%
Developed, Low Intensity	1982	1.0%	2001	2.5%	2052	2.3%	2099	5.9%
Developed, Open Space	1532	0.3%	1538	3.2%	1587	2.2%	1623	5.9%
Total Developed Lands	**4929**	**0.9%**	**4974**	**4.0%**	**5172**	**2.7%**	**5310**	**7.7%**
Cultivated Crops	6	0.0%	6	3.4%	7	0.0%	7	3.4%
Pasture/ Hay	731	-0.9%	725	-5.4%	686	-1.2%	677	-7.3%
Grassland/ Herbaceous	638	1.3%	646	4.6%	676	-3.5%	652	2.3%
Total Agricultural Lands	**1375**	**0.1%**	**1377**	**-0.6%**	**1368**	**-2.3%**	**1336**	**-2.8%**
Deciduous Forest	608	-1.2%	600	-6.3%	563	-4.1%	540	-11.2%
Evergreen Forest	582	-5.8%	548	-0.9%	543	-3.1%	526	-9.6%
Mixed Forest	215	-2.9%	209	-8.4%	191	-8.7%	175	-18.8%
Scrub/ Shrub	550	1.4%	558	-11.3%	495	-5.5%	467	-15.0%
Total Vegetated Undeveloped Lands	**1955**	**-2.0%**	**1915**	**-6.4%**	**1792**	**-4.7%**	**1708**	**-12.6%**
Palustrine Forested Wetland	937	0.1%	938	-2.6%	914	-1.3%	902	-3.7%
Palustrine Scrub/ Scrub Wetland	355	-0.5%	354	-4.5%	338	-3.2%	327	-8.1%
Palustrine Emergent Wetland	991	0.8%	999	-2.5%	974	0.3%	977	-1.4%
Estuarine Forested Wetland	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Estuarine Scrub/ Shrub Wetland	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Estuarine Emergent Wetland	699	1.2%	708	-1.8%	695	-1.1%	688	-1.6%
Total Palustrine Wetlands	**2283**	**0.3%**	**2290**	**-2.8%**	**2226**	**-0.9%**	**2206**	**-3.4%**
Total Estuarine Wetlands	**699**	**1.2%**	**708**	**-1.8%**	**695**	**-1.1%**	**688**	**-1.6%**
Unconsolidated Shore	216	0.0%	216	50.4%	325	-0.3%	324	50.0%
Barren Land	30	-77.8%	7	-20.0%	5	0.0%	5	-82.2%
Total Beach/ Bare Lands	**246**	**-9.5%**	**223**	**48.3%**	**331**	**-0.3%**	**330**	**33.9%**
Open Water	599	0.1%	600	-16.2%	503	1.2%	509	-15.0%
Palustrine Aquatic Bed	6	0.0%	6	3.4%	7	0.0%	7	3.4%
Estuarine Aquatic Bed	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Total Open Water	**606**	**0.1%**	**606**	**-16.0%**	**510**	**1.2%**	**516**	**-14.8%**
Sum Check	**12,093**		**12,093**		**12,093**		**12,093**	

Appendix 2, Table 3. Summary of NOAA C-CAP for Marchand Bayou Subbasin, Years 1996-2010.

Marchand Bayou	1996		2001		2006		2010	15 yr. net change
	Acres	% change	Acres	% change	Acres	% change	Acres	
Developed, High Intensity	113	1.3%	115	15.3%	132	0.7%	133	17.6%
Developed, Medium Intensity	337	0.1%	338	12.2%	379	0.3%	380	12.6%
Developed, Low Intensity	595	0.0%	596	4.6%	623	0.2%	625	4.9%
Developed, Open Space	503	0.0%	503	2.9%	517	0.5%	520	3.4%
Total Developed Lands	**1549**	**0.1%**	**1551**	**6.5%**	**1652**	**0.4%**	**1658**	**7.0%**
Cultivated Crops	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Pasture/ Hay	183	0.0%	183	-28.0%	131	-1.2%	130	-28.9%
Grassland/ Herbaceous	89	0.0%	89	-18.4%	73	3.7%	75	-15.4%
Total Agricultural Lands	**272**	**0.0%**	**272**	**-24.8%**	**204**	**0.5%**	**205**	**-24.4%**
Deciduous Forest	152	0.0%	152	-2.0%	149	0.0%	149	-2.0%
Evergreen Forest	121	0.0%	121	-3.4%	117	6.1%	124	2.5%
Mixed Forest	27	0.0%	27	-3.3%	26	0.0%	26	-3.3%
Scrub/ Shrub	104	0.0%	104	-21.0%	82	-14.9%	70	-32.7%
Total Vegetated Undeveloped Lands	**404**	**0.0%**	**404**	**-7.4%**	**375**	**-1.4%**	**369**	**-8.6%**
Palustrine Forested Wetland	126	0.0%	126	-1.6%	124	11.0%	138	9.2%
Palustrine Scrub/ Scrub Wetland	47	0.0%	47	-0.9%	47	-33.1%	31	-33.8%
Palustrine Emergent Wetland	16	0.0%	16	-6.8%	15	0.0%	15	-6.8%
Estuarine Forested Wetland	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Estuarine Scrub/ Shrub Wetland	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Estuarine Emergent Wetland	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Total Palustrine Wetlands	**190**	**0.0%**	**190**	**-1.9%**	**186**	**-1.1%**	**184**	**-2.9%**
Total Estuarine Wetlands	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**	**0**	**0.0%**
Unconsolidated Shore	6	0.0%	6	0.0%	6	0.0%	6	0.0%
Barren Land	2	-100.0%	0	0.0%	0	0.0%	0	-90.0%
Total Beach/ Bare Lands	**8**	**-27.1%**	**6**	**3.7%**	**6**	**0.0%**	**6**	**-24.4%**
Open Water	30	0.0%	30	0.0%	30	0.0%	30	0.0%
Palustrine Aquatic Bed	2	0.0%	2	0.0%	2	0.0%	2	0.0%
Estuarine Aquatic Bed	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Total Open Water	**32**	**0.0%**	**32**	**0.0%**	**32**	**0.0%**	**32**	**0.0%**
Sum Check	**2,455**		**2,455**		**2,455**		**2,455**	

Appendix 2, Table 4. Legend for Land Cover Types for Coastal Change Analysis Program.

High Intensity Developed	areas where people reside or work in relatively high numbers. Examples include apartment complexes, row houses and commercial and industrial uses. Impervious Surfaces account for 80-100% of total cover.
Medium Intensity Developed	areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50-79% of the total cover. These area most commonly include single-family housing units
Low Intensity Developed	areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20-49% of the total cover. These areas most commonly include single- family housing units
Open Space Developed	areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single0family housing units, parks, golf courses, and vegetation planting in developed settings for recreation, erosion control, or aesthetic purposes.
Cultivated Land	areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.
Pasture/ Hay	areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation
Grassland	areas dominated by grammoid or herbaceous vegetation, generally greater than 80% of total vegetation. These areas are not subject to intensive management such as tilling, but can be utilized for grazing
Deciduous Forest	areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
Evergreen Forest	areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree special maintain their leaves all year. Canopy is never without green foliage.
Mixed Forest	areas dominated by trees generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
Scrub/Shrub	areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions
Forested Wetland	areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water
Scrub/Shrub Wetland	areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water
Emergent Wetland	areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water
Beach; Bare Land	areas of sand, gravel pits, and other accumulations of earthen material. Generally, vegetation account for less than 15% of total cover.
Water; Aquatic Beds	areas of open water, generally with less than 25% cover of vegetation or soil.