

Distribution and Abundance of Wetlands in Coastal Texas

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ABSTRACT

Numbers and area of wetlands were estimated in coastal Texas from Galveston Bay south to the Rio Grande during September and November 1992 and January and March 1993 based on a stratified random sample ($n = 1,009$) of 64.8-ha (quarter-section) plots. We estimated seasonal maximums of 125,187 wetlands in January 1993 and 484,760 ha of wetlands in September 1992.

KEYWORDS: Laguna Madre Initiative Area, Texas Mid-coast Initiative Area, quarter-section survey

Coastal Texas is one of the most important wintering areas for waterfowl in North America (Cain, 1988; Texas Mid-coast Initiative Team, 1990). Coastal marshes and adjacent rice prairie lands provide the most important wintering grounds for waterfowl in the Central Flyway (Buller 1964). Additionally, this area provides important habitat for many other groups of water birds. Several threatened or endangered species inhabit this area, including piping plovers (*Charadrius melodus*) and whooping cranes (*Grus americanus*).

We here define a wetland as any area having hydric soils, hydrophytic vegetation, or inundation during any part of the growing season (Cowardin et al. 1979). One of the first steps in managing wetland habitat and water bird populations is to inventory what is currently available (Leopold, 1933). This provides baseline information for monitoring the effects of future wetland management actions or continued wetland destruction (Dahl, 1990). By identifying the abundance of different wetland types, we can at future dates identify types that are being lost most rapidly.

Tacha et al. (1993) estimated numbers and areas of wetlands in the Chenier Plain of Texas (coastal plains east of Houston). Our objectives were to estimate numbers and areas of wetlands (by type), in the coastal plains of Texas west and south of Houston. Area of wetlands in this study refers to surface area of water.

The study area consisted of two initiative areas (Fig. 1), as delineated by the Gulf Coast Joint Venture (1990). The Texas Mid-coast (TMC) Initiative Area occurred

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from the Nueces River north to Galveston Bay and as far inland as rice production occurs. The Laguna Madre (LM) Initiative Area extended from the Nueces River south to the Rio Grande.

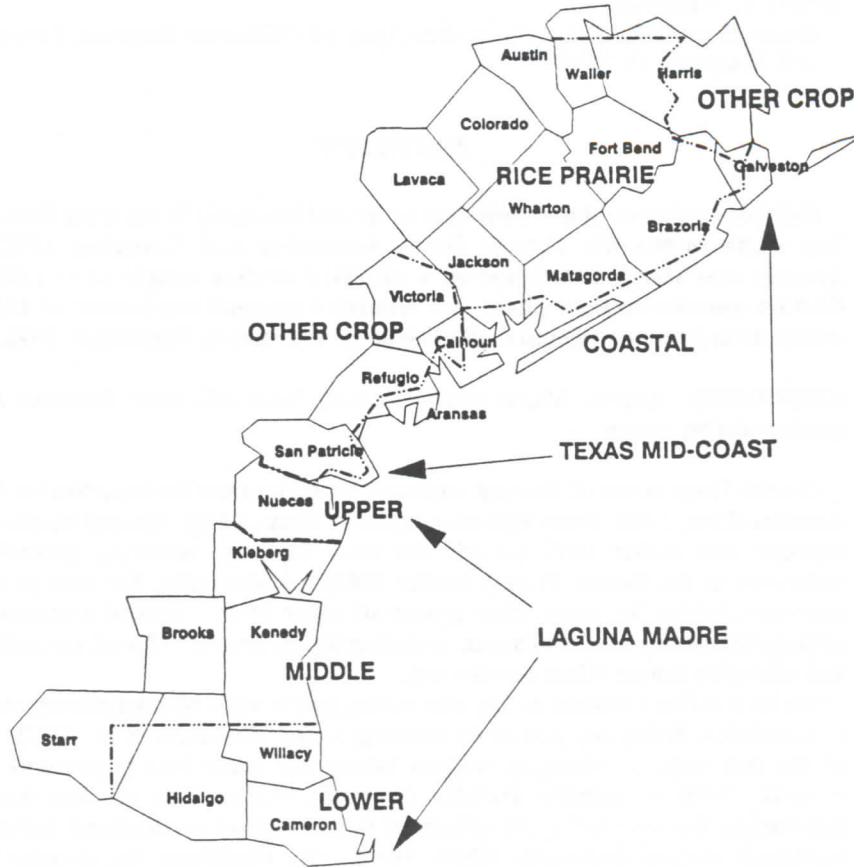


Figure 1. Location of Texas Mid-coast and Laguna Madre initiative areas and strata boundaries for wetland surveys conducted during September and November 1992 and January and March 1993.

The study area encompassed 24 Texas counties covering 5,504,389 ha. The region consisted of sandy plains and coastal prairie in the south and coastal marsh and rice production to the north. Farming and ranching were prevalent throughout. Major agricultural crops were sorghum, cotton, rice, and corn (Tex. Agric. Stat. Serv., 1992).

Topography was nearly level in >95% of the area, with an increase in elevation

of 0.2-0.6 m km⁻¹ from the coast inland (Westfall, 1975; Laguna Madre Initiative Team, 1990). Elevation ranged from sea level to 122 m above sea level. Soils were somewhat poorly drained, with a surface layer of fine sandy loam above several layers of clay and sandy clay to a depth of 2 m (Westfall, 1975; Lehman, 1984).

Climate classification for the TMC area is subtropical humid, noted for warm summers (Larkin and Bomar, 1983). Average annual high and low temperatures, respectively, are 28 and 13°C. Average annual precipitation ranges from 133 cm in the north to 87 cm in the south (Nat. Fibers Inf. Cent., 1987). Climate is classified as semiarid in the LM area, with frequent droughts in the region (Norwine and Bingham, 1986). Annual rainfall ranges from 80 cm in the north to 55 cm in the south (Larkin and Bomar, 1983), and annual evaporation rates exceed 175 cm. The average annual high and low temperatures are 30 and 16°C, respectively. Climatic conditions during this study were normal (i.e., temperatures and precipitation were near average).

The coastal zone in the TMC is primarily located in the Louisianian estuarine and marine province (Cowardin et al., 1979). This area is characterized by relatively extensive marshes and well-developed barrier islands, with a small tidal range. The LM area is primarily located in the West Indian Estuarine and Marine Province (Cowardin et al., 1979). This province is characterized by a shoreline that is predominantly low-lying limestone with calcareous sands and marls and a small tidal range.

METHODS

The TMC Initiative Area was divided into three strata: rice prairie, coastal, and other crop (Fig. 1). The LM Initiative Area was also divided into three strata: upper, middle, and lower. Strata were based on land practices and major physiographic regions. Descriptions of strata can be found in Anderson (1994) and Muehl (1994).

In 1992-93, we used map coordinates to randomly select 600 and 409 64.8-ha plots (hereafter referred to as quarter-sections) in the TMC and LM Initiative Areas, respectively. Logistics limited our sample size to near 1,000. In the TMC area, Coastal, Rice Prairie, and Other Crop strata were allocated 273, 241, and 86 quarter-sections, respectively. In the LM area, Upper, Middle, and Lower strata were allocated 136, 46, and 227 quarter-sections, respectively. Total quarter-sections in the study area numbered 82,275. The breakdown by strata were coastal (5,486), rice prairie (38,131), lower (10,150), middle (15,208), other crop (10,150), and upper (3,150).

After quarter-sections were randomly selected within strata, trespass permission was obtained or the area was replaced with another random sample. Quarter-sections were surveyed if wetlands or wetland basins occurred. Similar stratified random sample surveys of quarter-sections have been conducted in the Dakotas (Stewart and Kantrud, 1972; Brewster et al., 1976) and Oklahoma (Heitmeyer, 1980).

All wetland classification occurred during two-week survey periods in 1992-93. Surveys were conducted 19 September to 3 October, 21 November to 5 December, 2 to 16 January, and 20 March to 3 April.

All quarter-sections were visited once per survey period. Surveys did not include

national wildlife refuge lands with large expanses of coastal marsh, large bays, the Laguna Madre, or island habitats because ground surveys were impractical and wetland areas were better documented on these public lands.

All wetlands and deep-water habitats observed on quarter-sections were classified according to Cowardin et al. (1979), but seasonally flooded basins or flats (e.g., sheet-water on cropland or pastures) were also incorporated (Martin et al., 1953) into the classification system. Both wetlands and deep-water habitats were considered to be wetlands for classification and discussion purposes. System, subsystem, class, and subclass were recorded for each wetland. Wetlands were classified during each survey period.

Wetland size was determined following methods of Millar (1973). To distinguish between organic and mud subclasses we determined if soil was organic in the field. Soil was considered to be organic if the top 5 cm under the litter layer was estimated to contain at least 1/6 (by volume) rubbed fiber (Soil Conservation Service, 1975).

Special modifiers were recorded and placed into one of three categories: farmed, manmade, and natural. Wetlands were considered natural if no earth-work had been conducted in them. Wetlands that had fences in them or cattle grazing on them were considered natural. Wetlands were considered manmade if they had any of the following Cowardin et al. (1979) modifiers: excavated, impounded, diked, or artificial.

Seasonal estimates of wetlands were calculated using SAS (SAS, 1988). Mean area of each wetland type within sample quarter-sections in each stratum were multiplied by the area of each stratum, and the totals were added to give study area estimates. Standard errors associated with estimates of wetlands were calculated following procedures for weighted pooled stratified random samples (Kish, 1965).

RESULTS AND DISCUSSION

We classified 77 subclasses of wetlands in the study area. We estimated 125,187 wetlands in January 1993 (Table 1). Palustrine and lacustrine wetlands were also most abundant in January at 95,628 and 4,687, respectively. Estuarine wetland numbers peaked in September 1992 at 13,289 and riverine wetlands in November at 16,471.

Total wetland area (area of surface water) peaked in September 1992 at 484,760 ha (Table 2). Estuarine and palustrine wetland area also peaked in September at 145,768 ha and 249,291 ha, respectively. Lacustrine wetland area was highest in January 1993 (97,079 ha) and riverine area was highest in November 1992 (12,689 ha).

Wetland estimates derived from Landsat imagery (Gilmer et al., 1988) or aerial photographs (Cowardin et al. 1981) are often subject to error. Small wetlands (≤ 0.5 ha) and those obscured by dense forest or brush cover may not be visible on aerial photographs (Leibowitz et al., 1991). Additionally, a wetland may be misclassified, sites identified as wetlands may be non-wetlands, and others may be overlooked. Wetlands are sufficiently dynamic that a 1-time survey often result in an improper classification. In general, these errors were not problems for our ground surveys. Our information provides a valuable data base for evaluating and implementing wetland management strategies in this region.

Table 1. Total estimated numbers and standard errors (SE)† of wetlands in the Texas Mid-coast and Laguna Madre initiative areas of coastal Texas during September and November 1992 and January and March 1993 quarter-section surveys.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Estuarine	13,289	1,565	11,820	1,465	11,661	1,514	11,010	1,427
Intertidal	8,005	1,124	6,493	983	6,345	1,065	5,815	934
Aquatic-bed	1,794	463	1,794	464	1,096	388	897	368
Algal	371	143	371	143	142	62	173	71
Manmade	52	52	52	52	52	52	52	52
Rooted vascular	1,423	408	1,423	408	989	383	725	361
Manmade	0	0	0	0	0	0	118	118
Emergent	3,322	514	2,741	460	2,395	510	2,103	409
Nonpersistent	201	94	121	56	0	0	118	118
Persistent	3,121	505	2,117	394	2,394	510	1,985	392
Manmade	452	218	504	223	366	189	228	105
Reef	40	28	40	28	60	35	40	28
Mollusk	40	28	40	28	60	35	40	28
Rocky shore	20	20	40	28	40	28	20	20
Rubble	20	20	40	28	40	28	20	20
Manmade	20	20	40	28	40	28	20	20
Scrub-shrub	233	79	112	62	52	52	112	112
Broad-leaved	141	53	20	20	52	52	112	112
Needle-leaved	92	59	92	56	0	0	0	0
Streambed	535	258	80	49	337	202	219	162
Mud	515	257	80	49	337	202	219	162
Manmade	178	126	60	45	60	45	198	161
Organic	20	20	0	0	0	0	0	0

Table 1. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Unconsolidated shore	2,061	572	1,685	509	2,366	578	2,423	543
Cobble-gravel	331	331	331	331	371	332	351	331
Mud	1,226	459	1,030	383	1,570	467	1,547	423
Manmade	391	332	411	333	569	369	411	333
Organic	141	60	100	53	221	71	241	74
Manmade	40	40	40	40	20	20	20	40
Sand	345	86	224	72	204	70	284	85
Manmade	60	45	60	45	60	45	60	45
Subtidal	5,284	864	5,327	865	5,316	854	5,195	857
Aquatic-bed	771	157	711	154	524	123	518	130
Algal	176	92	124	76	72	55	144	78
Manmade	104	73	104	73	52	52	103	73
Floating vascular	0	0	0	0	52	52	0	0
Manmade	0	0	0	0	52	52	0	0
Rooted vascular	595	128	587	134	400	98	374	104
Manmade	75	57	75	57	43	31	75	57
Reef	20	20	20	20	20	20	20	20
Mollusk	20	20	20	20	20	20	20	20
Rock bottom	43	31	23	23	23	23	23	23
Bedrock	23	23	23	23	23	23	23	23
Rubble	20	20	0	0	0	0	0	0
Manmade	20	20	0	0	0	0	0	0
Unconsolidated bottom	4,449	849	4,573	851	4,697	844	4,634	846
Cobble-gravel	23	23	23	23	46	33	230	23

Table 1. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Mud	4,326	848	4,398	849	4,458	840	4,438	844
Manmade	2,217	380	2,313	37724	2,177	357	2,073	352
Organic	40	28	92	59	164	81	112	62
Manmade	0	0	52	52	104	73	52	52
Sand	60	35	60	35	80	40	60	35
Lacustrine	3,775	1,216	4,538	1,254	4,687	1,282	4,189	1,256
Limnetic	1,047	566	1,047	566	1,047	566	1,047	566
Rock bottom	158	158	158	158	158	158	158	158
Rubble	158	158	158	158	158	158	158	158
Manmade	158	158	158	158	158	158	158	158
Unconsolidated bottom	889	544	889	544	889	544	889	544
Mud	889	544	889	544	889	544	889	544
Manmade	889	544	889	544	889	544	889	544
Littoral	2,728	760	3,491	821	3,640	834	3,142	792
Aquatic-bed	949	358	791	322	336	200	495	255
Algal	0	0	0	0	0	0	158	158
Floating vascular	751	321	573	279	158	158	276	197
Manmade	40	28	20	20	0	0	0	0
Rooted vascular	198	161	218	161	178	123	60	35
Manmade	198	161	218	161	40	28	60	35
Emergent	0	0	0	0	118	118	118	118
Nonpersistent	0	0	0	0	118	118	118	118
Rock bottom	495	475	495	475	495	475	495	475
Bedrock	475	475	475	475	475	475	475	475

Table 1. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Manmade	475	475	475	475	475	475	475	475
Rubble	20	20	20	20	20	20	20	20
Manmade	20	20	20	20	20	20	20	20
Rocky shore	0	0	0	0	158	158	158	158
Rubble	0	0	0	0	158	158	158	158
Unconsolidated bottom	772	310	990	351	1,485	443	1,209	385
Cobble-gravel	222	139	222	139	222	139	222	139
Manmade	222	139	222	139	222	139	222	139
Mud	432	191	650	251	1,145	370	869	298
Manmade	222	139	380	186	737	290	619	246
Sand	118	118	118	118	118	118	118	118
Manmade	118	118	118	118	118	118	118	118
Unconsolidated shore	512	367	1,214	484	1,047	458	667	399
Mud	0	0	0	0	331	331	20	20
Organic	512	367	1,214	484	716	317	647	399
Farmed	354	331	1,056	459	558	276	647	398
Manmade	158	158	158	158	158	158	0	0
Palustrine	40,893	3,780	64,551	5,238	95,628	9,234	88,353	7,194
Aquatic-bed	4,885	891	4,073	830	3,037	696	4,718	1,257
Algal	1,001	427	843	397	1,015	468	1,636	578
Manmade	553	244	394	186	567	261	799	478
Floating vascular	1,970	671	1,771	653	869	430	2,014	936
Manmade	1,303	504	967	499	552	368	1,519	777

Table 1. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
	Rooted vascular	1,913	430	1,458	350	1,153	299	1,067
Manmade	1,464	376	1,128	318	782	259	817	266
Emergent	14,615	1,747	17,695	1,902	18,091	1,863	25,596	2,528
Nonpersistent	1,542	576	2,039	664	3,619	913	6,469	1,041
Farmed	0	0	0	0	0	0	316	222
Manmade	1,108	470	1,188	415	2,353	677	4,689	911
Persistent	13,073	1,592	15,655	1,715	14,472	1,529	19,127	2,133
Farmed	5,997	1,087	4,136	783	2,891	672	2,928	961
Manmade	4,003	717	4,849	794	5,346	843	8,617	1,233
Forested	434	253	1,424	557	1,286	486	1,502	568
Broad-leaved deciduous	434	253	1,404	556	1,266	159	1,502	568
Manmade	158	158	475	273	178	159	751	404
Dead	0	0	20	20	20	20	0	0
Manmade	0	0	20	20	20	20	0	0
Rock bottom	0	0	20	20	20	20	20	20
Bedrock	0	0	20	20	20	20	20	20
Manmade	0	0	20	20	20	20	20	20
Scrub-shrub	3,484	1,075	5,027	1,359	4,912	1,255	6,368	1,311
Broad-leaved deciduous	3,172	1,057	4,710	1,346	4,734	1,249	6,011	1,258
Manmade	705	503	1,234	622	1,200	474	2,063	586
Broad-leaved evergreen	0	0	0	0	0	0	158	158
Dead	138	121	158	121	158	121	158	121
Needle-leaved evergreen	158	158	158	158	20	20	40	28
Manmade	158	158	158	158	20	20	40	28

Table 1. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Unconsolidated bottom	12,256	2,065	13,984	2,185	15,029	2,355	12,748	2,020
Cobble-gravel	262	174	262	174	420	325	443	326
Manmade	262	174	28	28	420	325	443	326
Mud	10,102	1,865	11,790	2,035	12,231	2,121	10,361	1,793
Manmade	7,415	1,471	8,871	1,660	9,312	1,723	7,617	1,317
Organic	822	336	1,198	419	1,645	531	1,092	392
Farmed	0	0	0	0	118	118	0	0
Manmade	591	264	968	364	965	340	861	332
Sand	1,070	447	733	318	733	318	851	353
Manmade	1,010	446	693	316	693	316	831	352
Unconsolidated shore	5,215	1,313	22,328	2,581	53,253	8,108	31,403	5,386
Cobble-gravel	80	63	0	0	0	0	0	0
Manmade	80	63	0	0	0	0	0	0
Mud	2,197	860	4,337	1,225	7,927	3,633	3,664	1,027
Farmed	52	52	158	158	158	158	158	158
Manmade	615	292	1,723	667	5,986	3,544	2,198	678
Organic	1,115	635	15,031	2,073	43,530	6,154	29,101	5,008
Farmed	677	592	13,780	1,965	36,207	4,967	24,905	4,173
Manmade	60	60	555	277	5,877	3,614	4,018	2,883
Sand	316	199	198	125	259	138	515	257
Manmade	178	160	40	28	80	63	219	164
Vegetated	1,507	514	2,762	742	1,536	732	4,123	1,145
Farmed	0	0	0	0	23	23	0	0
Manmade	820	326	411	231	223	168	1,200	485

Table 1. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Riverine	9,577	1,134	16,471	1,463	13,211	1,282	11,508	1,195
Intermittent	3,426	753	9,264	1,215	6,331	982	4,508	844
Streambed	3,426	753	9,624	1,215	6,331	982	4,508	844
Bedrock	20	20	0	0	0	0	0	0
Mud	2,790	670	7,017	1,069	5,005	847	3,875	799
Manmade	2,295	577	5,751	996	3,878	764	2,946	2,108
Organic	279	166	909	342	296	198	434	253
Manmade	239	163	731	302	296	198	434	253
Sand	20	20	377	226	397	227	178	159
Manmade	20	20	178	159	178	159	20	20
Vegetated	316	223	1,321	440	633	386	20	20
Manmade	316	223	1,163	823	633	386	20	20
Lower perennial	5,419	821	5,916	864	6,126	877	5,988	865
Aquatic-bed	595	262	397	205	198	128	357	203
Algal	0	0	0	0	20	20	20	20
Manmade	0	0	0	0	20	20	20	20
Floating vascular	475	256	337	202	158	125	158	125
Manmade	475	256	337	202	158	125	158	125
Rooted vascular	121	56	60	35	20	20	20	20
Manmade	80	40	20	20	20	20	20	20
Emergent	158	158	0	0	0	0	158	158
Nonpersistent	158	158	0	0	0	0	158	158
Manmade	0	0	0	0	0	0	158	158
Unconsolidated bottom	4,665	769	5,519	842	5,927	868	5,473	832

Table 1. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Cobble-gravel	0	0	118	118	118	118	118	118
Manmade	0	0	118	118	118	118	118	118
Mud	3,999	716	4,938	802	5,346	830	4,891	791
Manmade	2,641	593	3,170	663	3,420	683	3,262	666
Organic	507	224	305	177	305	177	305	177
Manmade	326	157	124	76	124	76	124	76
Sand	158	158	158	158	158	158	158	158
Tidal	575	357	773	307	595	280	854	324
Unconsolidated bottom	417	229	733	303	417	229	676	281
Mud	417	229	615	279	417	229	676	281
Manmade	178	159	198	160	178	159	240	163
Organic	0	0	118	118	0	0	0	0
Manmade	0	0	118	118	0	0	0	0
Unconsolidated shore	158	158	40	28	178	160	178	160
Mud	158	158	40	28	20	20	20	20
Manmade	158	158	0	0	20	20	20	20
Organic	0	0	0	0	158	158	158	158
Upper perennial	158	158	158	158	158	158	158	158
Unconsolidated bottom	158	158	158	158	158	158	158	158
Cobble-gravel	158	158	158	158	158	158	158	158
Totals	67,534	4,759	97,380	6,246	125,187	9,789	115,060	7,828

†SE was derived from variance estimates calculated following procedures for weighted pooled stratified random samples from Kish (1965).

Table 2. Total estimated hectares and standard errors (SE) of wetlands in the Texas Mid-coast and Laguna Madre initiative areas of coastal Texas during September and November 1992 and January and March 1993 quarter-section surveys.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Estuarine	145,768	13,597	112,089	11,485	98,542	11,077	105,070	11,521
Intertidal	106,695	12,664	74,354	10,441	61,192	10,101	68,753	10,544
Aquatic-bed	31,461	8,270	27,895	7,952	20,356	7,673	15,130	6,829
Algal	4,957	1,809	3,408	1,185	1,067	759	2,967	2,879
Manmade	11	11	11	11	11	11	11	11
Rooted vascular	26,504	7,985	24,487	7,805	19,289	7,640	12,163	6,078
Manmade	0	0	0	0	0	0	13	13
Emergent	50,828	5,606	32,692	4,408	17,697	3,135	23,227	3,710
Nonpersistent	1,970	790	1,420	917	0	0	875	875
Persistent	48,858	5,528	31,272	4,326	17,697	3,135	22,352	3,606
Manmade	278	164	258	143	91	44	201	141
Reef	67	58	67	58	97	64	83	61
Mollusk	67	58	67	58	97	64	83	61
Rocky shore	144	144	71	69	220	166	94	94
Rubble	144	144	68	68	68	68	94	94
Manmade	144	144	68	68	68	68	94	94
Scrub-shrub	2,983	1,296	166	108	6	6	365	280
Broad-leaved deciduous	2,822	1,290	91	91	6	6	365	280
Needle-leaved evergreen	161	145	75	59	0	0	0	0
Streambed	87	42	15	9	43	24	68	42
Mud	86	42	15	9	43	24	68	42
Manmade	35	24	11	7	12	9	36	27
Organic	1	1	0	0	0	0	0	0

Table 2. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Unconsolidated shore	21,125	6,770	13,448	4,720	22,772	5,340	29,786	6,408
Cobble-gravel	4,402	4,267	4,265	4,265	4,371	4,265	4,316	4,265
Mud	10,774	4,957	6,588	1,818	12,445	2,673	16,799	4,201
Manmade	467	313	1,106	634	991	525	947	667
Organic	2,978	1,434	1,120	690	4,171	1,665	6,339	2,197
Manmade	696	696	177	177	58	58	338	338
Sand	2,971	1,132	1,476	653	1,785	820	2,332	1,076
Manmade	0	0	74	52	74	52	74	52
Subtidal	39,074	4,775	37,735	4,712	37,349	4,676	36,318	4,637
Aquatic-bed	12,173	2,780	11,081	2,659	9,875	2,574	9,105	2,601
Algal	1,401	982	591	556	591	591	944	645
Manmade	36	25	36	25	19	19	36	25
Floating vascular	0	0	0	0	4	4	0	0
Manmade	0	0	0	0	4	4	0	0
Rooted vascular	10,773	2,608	10,490	2,607	9,279	2,519	8,161	2,527
Manmade	14	11	14	11	556	546	14	11
Reef	18	18	18	18	18	18	18	18
Mollusk	18	18	18	18	18	18	18	18
Rock bottom	1,146	811	600	600	600	600	600	600
Bedrock	600	600	600	600	600	600	600	600
Rubble	546	546	0	0	0	0	0	0
Manmade	546	546	0	0	0	0	0	0
Unconsolidated bottom	25,736	3,865	26,036	3,888	26,850	3,891	26,595	3,862
Cobble-gravel	450	450	450	450	1,049	747	450	450

Table 2. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
	Mud	24,003	3,796	24,202	3,819	23,612	3,744	24,273
Manmade	7,689	2,035	8,348	2,124	5,764	1,690	4,819	1,427
Organic	390	310	480	323	989	588	977	592
Manmade	0	0	90	90	107	92	90	90
Sand	894	627	894	627	1,200	696	894	627
Lacustrine	80,262	19,743	95,046	20,982	97,079	21,113	87,930	20,283
Limnetic	23,264	11,576	23,264	11,576	23,264	11,576	23,264	11,576
Rock bottom	7,537	7,537	7,537	7,537	7,537	7,537	7,537	7,537
Rubble	7,537	7,537	7,537	7,537	7,537	7,537	7,537	7,537
Manmade	7,537	7,537	7,537	7,537	7,537	7,537	7,537	7,537
Unconsolidated bottom	15,727	8,812	15,727	8,812	15,730	8,812	15,727	8,812
Mud	15,727	8,812	15,727	8,812	15,730	8,813	15,727	8,812
Manmade	15,727	8,812	15,727	8,812	15,730	8,813	15,727	8,812
Littoral	56,998	15,269	71,782	16,888	73,812	16,952	64,666	15,814
Aquatic-bed	27,459	11,870	22,913	11,501	9,951	7,834	11,171	6,586
Algal	0	0	0	0	0	0	3,406	3,406
Floating vascular	20,147	10,173	14,365	8,614	7,691	7,691	6,848	5,626
Manmade	1,250	975	917	917	0	0	0	0
Rooted vascular	7,312	6,185	8,548	7,667	2,260	1,491	917	538
Manmade	7,312	6,185	8,548	7,667	694	490	917	538
Emergent	0	0	0	0	953	953	953	953
Nonpersistent	0	0	0	0	953	953	953	953
Rock bottom	703	648	703	648	703	648	703	648
Bedrock	646	646	646	646	646	646	646	646

Table 2. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Manmade	646	646	646	646	646	646	646	646
Rubble	58	58	58	58	58	58	58	58
Manmade	58	58	58	58	58	58	58	58
Rocky shore	0	0	0	0	357	357	357	357
Rubble	0	0	0	0	357	357	357	357
Unconsolidated bottom	22,164	8,010	28,842	9,731	45,270	12,997	38,366	12,260
Cobble-gravel	6,224	3,933	6,224	3,933	6,224	3,933	6,224	3,933
Manmade	6,224	3,933	6,224	3,933	6,224	3,933	6,224	3,933
Mud	14,758	6,530	21,463	8,514	37,864	12,121	30,961	11,349
Manmade	10,429	6,019	13,069	6,421	26,924	10,273	21,185	8,272
Sand	1,181	1,181	1,181	1,181	1,181	1,181	1,181	1,181
Manmade	1,181	1,181	1,181	1,181	1,181	1,181	1,181	1,181
Unconsolidated shore	6,672	5,341	19,325	7,867	16,708	7,765	13,117	7,614
Mud	0	0	0	0	5,174	5,174	238	238
Organic	6,672	5,341	19,325	7,869	11,534	5,790	12,879	7,610
Farmed	5,360	5,177	18,012	7,765	10,221	5,648	12,879	1,125
Manmade	1,312	1,312	1,312	1,312	1,313	1,313	0	0
Palustrine	249,291	37,601	158,928	25,310	142,324	20,347	127,046	16,209
Aquatic-bed	5,082	1,307	4,180	1,252	2,669	774	4,644	1,692
Algal	213	80	156	57	194	78	476	236
Manmade	184	76	127	51	164	73	420	234
Floating vascular	1,330	806	1,732	1,006	289	203	2,102	1,326
Manmade	1,020	781	1,443	987	19	10	1,823	1,305

Table 2. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Rooted vascular	3,539	1,035	2,292	748	2,186	745	2,066	730
Manmade	2,844	967	1,610	663	1,570	664	1,657	670
Emergent	217,176	36,084	106,681	21,272	95,501	19,756	79,775	14,621
Nonpersistent	1,726	1,149	1,366	572	3,174	1,440	5,631	3,030
Farmed	0	0	0	0	0	0	2,894	2,810
Manmade	1,228	1,097	593	390	2,306	1,350	1,710	1,062
Persistent	217,176	37,778	106,681	21,272	92,317	19,730	74,144	14,367
Farmed	48,580	5,525	73,107	19,321	57,733	18,082	21,099	8,958
Manmade	15,280	6,640	14,428	5,461	13,500	5,501	16,391	5,627
Forested	6,756	4,778	16,788	10,960	5,668	3,629	7,453	4,116
Broad-leaved deciduous	6,756	4,778	16,785	10,960	5,665	3,629	7,453	4,116
Manmade	22	22	10,108	10,053	32	29	3,335	2,538
Dead	0	0	3	3	3	3	0	0
Manmade	0	0	3	3	3	3	0	0
Rock bottom	0	0	1	1	1	1	2	2
Bedrock	0	0	1	1	1	1	2	2
Manmade	0	0	1	1	1	1	2	2
Scrub-shrub	8,057	5,671	7,765	4,952	3,696	1,085	5,762	1,355
Broad-leaved deciduous	2,420	958	2,860	997	3,574	1,083	5,207	1,306
Manmade	328	238	1,469	640	394	167	736	377
Broad-leaved evergreen	0	0	0	0	0	0	11	11
Dead	46	37	51	39	64	44	64	44
Needle-leaved evergreen	5,591	5,591	4,854	4,854	58	58	480	368
Manmade	5,591	5,591	4,854	4,854	58	58	480	368

Table 2. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
	Unconsolidated bottom	8,917	2,165	9,472	2,183	93	85	102
Cobble-gravel	50	43	50	43	93	85	102	86
Manmade	50	43	50	43	91	44	102	86
Mud	6,098	1,502	6,439	1,509	7,820	2,082	5,437	1,196
Manmade	5,207	1,457	5,753	1,488	7,129	2,067	4,784	1,170
Organic	1,568	1,054	1,836	1,076	2,174	1,127	1,784	1,075
Farmed	0	0	0	0	338	338	0	0
Manmade	1,414	1,047	1,683	1,069	1,678	1,068	1,630	1,068
Sand	1,202	706	1,146	703	1,167	704	1,147	703
Manmade	1,099	702	1,049	699	1,049	699	1,071	699
Unconsolidated shore	1,576	383	12,674	2,309	23,534	3,434	20,941	3,385
Cobble-gravel	7	5	0	0	0	0	0	0
Manmade	7	5	0	0	0	0	0	0
Mud	389	163	1,577	699	1,234	435	2,682	1,212
Farmed	15	15	28	28	28	28	2	2
Manmade	206	121	937	636	797	371	2,336	1,191
Organic	664	268	9,493	1,943	21,913	3,411	16,017	2,879
Farmed	236	148	9,127	1,941	20,891	3,389	15,710	2,879
Manmade	282	170	113	69	431	211	280	182
Sand	62	34	74	47	122	72	168	103
Manmade	41	31	45	43	29	27	53	38
Vegetated	453	187	1,531	790	265	122	2,073	1,060
Farmed	0	0	0	0	52	52	0	0
Manmade	280	152	33	20	45	33	164	76

Table 2. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Riverine	9,439	2,399	12,689	2,704	12,202	2,559	10,551	2,247
Intermittent	281	67	2,788	1,527	2,986	1,439	519	119
Streambed	281	67	2,788	1,527	2,968	1,439	519	119
Bedrock	3	3	0	0	0	0	0	0
Mud	214	55	2,306	1,516	2,602	1,414	473	117
Manmade	193	54	720	208	911	336	410	113
Organic	38	23	123	47	28	19	29	20
Manmade	35	22	110	45	28	19	29	20
Sand	1	1	82	70	305	274	16	15
Manmade	1	1	70	70	273	272	1	1
Vegetated	25	22	106	106	50	30	1	1
Manmade	25	22	106	106	50	30	1	1
Lower perennial	6,413	1,579	6,445	1,574	6,566	1,575	6,541	1,575
Aquatic-bed	424	282	146	83	95	73	119	77
Algal	0	0	0	0	8	8	32	29
Manmade	0	0	0	0	8	8	4	4
Floating vascular	390	282	132	83	82	72	82	72
Manmade	390	282	132	83	82	72	82	72
Rooted vascular	33	16	14	8	5	5	5	5
Manmade	24	24	4	4	5	5	5	5
Emergent	42	42	0	0	0	0	63	63
Nonpersistent	42	42	0	0	0	0	63	63
Manmade	0	0	0	0	0	0	63	63
Unconsolidated bottom	5,947	1,554	6,299	2,004	6,972	1,573	6,359	1,572

Table 2. Continued.

System Subsystem Class Subclass Special modifiers	Sep		Nov		Jan		Mar	
	Estimate	SE	Estimate	SE	Estimate	SE	Estimate	SE
Cobble-gravel	0	0	201	201	201	201	201	201
Manmade	0	0	201	201	201	201	201	201
Mud	5,509	1,533	5,957	1,558	6,130	1,966	6,018	1,558
Manmade	2,836	984	2,653	874	2,829	878	2,757	876
Organic	388	226	91	48	91	48	91	48
Manmade	343	222	44	31	45	29	45	29
Sand	50	50	50	50	50	50	50	50
Tidal	1,936	1,629	2,648	1,400	1,841	1,207	2,863	1,398
Unconsolidated bottom	1,398	1,098	2,643	1,400	1,812	1,207	2,654	1,397
Mud	1,398	1,098	2,632	1,400	1,812	1,207	2,654	1,397
Manmade	1,084	1,078	1,788	1,288	1,084	1,078	1,855	1,289
Organic	0	0	11	11	0	0	0	0
Manmade	0	0	11	11	0	0	0	0
Unconsolidated shore	538	538	4	4	29	29	29	29
Mud	538	538	4	4	1	1	1	1
Manmade	538	538	0	0	1	1	1	1
Organic	0	0	0	0	28	28	28	28
Upper perennial	809	809	809	809	809	809	809	809
Unconsolidated bottom	809	809	809	809	809	809	809	809
Cobble-gravel	809	809	809	809	809	809	809	809
Totals	484,760	45,804	378,752	36,724	350,147	34,521	330,597	30,906

†SE was derived from variance estimates calculated following procedures for weighted pooled stratified random samples from Kish (1965).

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