Utility of National Wetlands Inventory Data for Black Bear Habitat Assessment in Coastal Louisiana

Philip D. Nyland, *School of Forestry, Wildlife, and Fisheries, Louisiana State University Agricultural Center, Baton Rouge, LA 70803*

Richard M. Pace, III, *U.S. Geol. Surv., Biol. Resour. Div., Louisiana Cooperative Fish and Wildlife Research Unit, Louisiana State University, Baton Rouge, LA 70803*

Abstract: Existing landcover maps offer an inexpensive opportunity to conduct large-scale habitat assessments for black bears (*Ursus americanus*), but because cover classes used in these maps may have been developed without consideration for bears, inferring bear food and cover distribution from these maps may be difficult. We evaluated the information content of a habitat map that we constructed using National Wetlands Inventory (NWI) data for a composite home range of 21 radio-tagged adult black bears in coastal Louisiana. Habitat types having potentially different food and cover resources for bears and recognizable from NWI data were deciduous broadleaf forest, bald cypress forest, mixed deciduous broadleaf and bald cypress forest, scrub-shrub wetlands, brackish and fresh marsh, deciduous broadleaf forest spoil, upland hardwood forest, and agriculture. We compared measurements taken from 113 plots in 77 stands distributed among 7 habitat types. We found differences in food indices (density of spring/summer food plants, fall food plants, insect foods) and cover (stem density, canopy cover, vertical profile cover) that indicated our map contained considerable information about the distribution of bear food and cover resources. However, variation in food plant abundance, and the overlapping and patchy distributions of common mast-producing shrubs suggested finer divisions of forest types should be developed. These should include physiognomic characters such as tree density and canopy height.

Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 51:297–310

Habitat assessment programs are viewed as essential components of local and regional bear conservation plans (Schoen 1990). Because black bears range widely and exist in low densities (Pelton 1980), habitat assessment programs must include moderately extensive geographic areas to encompass viable populations. The cost of creating a habitat map over an extensive geographic area can be great (e.g. buying, interpreting, and ground-truthing aerial photographs or satellite images). It may be more cost-effective to use existing habitat inventory data if they can be adapted for bear habitat assessments.

In the southeastern United States, black bears inhabit coastal zones and wetlands in several states (Wooding et al. 1994). Southeastern coastal zones and other areas in the United States are surveyed by the NWI habitat mapping program (U.S. Fish and Wildl. Serv. 1990), which provides readily available data from government sources. Products of the National Wetlands Inventory are designed to meet several needs including locating and identifying wetlands, monitoring habitat change, administrating legislation and regulations, and habitat management (U.S. Fish and Wildl. Serv. 1990) which provides readily available data from government sources. Products of the National Wetlands inventory are designed to meet several needs including locating and identifying wetlands, monitoring habitat change, administrating legislation and regulations, and habitat management (U.S. Fish and Wildl. Serv. 1990). Because NWI is not designed specifically to evaluate the quality of habitat for black bears, there is little guarantee that a NWI map would be useful for black bear habitat assessment. We explored the effectiveness of using NWI data to describe bear habitat quality and distribution in coastal Louisiana. If NWI data are useful in coastal Louisiana, they would offer an inexpensive source of data for other jurisdictions.

This work was funded by the following: United States Forest Service, Southern Forest Experiment Station, Southern Hardwoods Laboratory; Louisiana Cooperative Fish and Wildlife Research Unit; Louisiana Department of Wildlife and Fisheries (LDWF); Riverbend Station, Entergy Corp.; and National Council of the Paper Industry for Air and Stream Improvement, Inc. We thank J. Dixon, R. Harlow, D. Maehr, and J. Wooding for reviewing our food plant list. We are grateful to many LDWF personnel who provided assistance, especially G. Linscombe and N. Kinler. We thank students on the bear crew at LSU, especially R. Wagner, for their efforts. R. Chabreck, T. Dean, A. Lewis, E. Moser, K. Weaver, and J. Wooding provided helpful reviews of this work. In coastal Louisiana, bears live almost solely on private land, and the gracious consent and support of many landowners, hunters, and farmers of Iberia and St. Mary parishes made our work possible.

Methods

Study Area

Our study area encompassed 57,000 ha in Iberia and St. Mary parishes, Louisiana, between Avery Island and Morgan City south of U. S. Highway 90 (Fig. 1) This region comprised forested wetlands, wetland scrub, upland forests, and coastal marshes dissected by sugarcane (*Saccharum officinarum*) fields, petroleum exploration sites, and residential developments. Habitat types are highly interspersed and contain many open water areas, sloughs, bayous, canals, and rivers influenced by salinity gradients and tidal fluctuations (Chabreck 1970). The area has 4 salt domes that rise to elevations >22 m above the deltaic plain (Evans et al. 1983). Salt domes

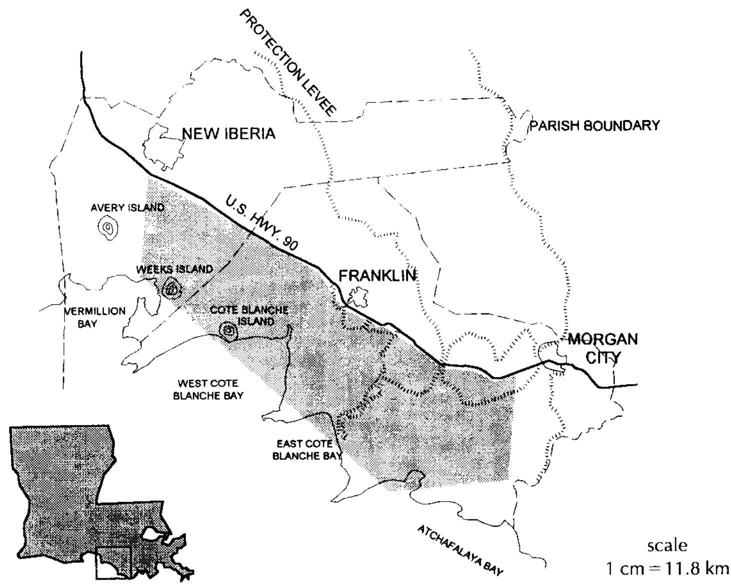


Figure 1. Map of coastal Louisiana study area. Study was confined to shaded area south of US Hwy 90.

have mesic, loamy soils on which are found upland habitats, developments, and agricultural fields.

Habitat and Range Map

We used data from the 1988 NWI project (Natl. Wetlands Res. Ctr. [NWRC], Lafayette, La.). Data were habitat types >0.4 ha interpreted from 1:62,500-scale color infrared photography, digitized and made available for public use (Handley et al. 1992). Interpretation followed a wetland classification system by Cowardin et al. (1979) modified by NWRC personnel to include upland habitat types.

We used NWI data that contained 91 habitat types, which described a few basic vegetation classes with modifiers to reflect small changes in hydrology and salinity that probably have little effect on bear food and cover resource availability (see Nyland 1995 for a complete list of types). We constructed a map for sampling resources pertinent to bears. We subjectively grouped habitat types of similar physiognomic structure and salinity class (Nyland 1995). Grouping produced 15 habitat types including 13 natural vegetation communities (Table 1), a single type for shore and aquatic beds, and a type labeled access that included water, developments, agricultural fields, and barren or scrub uplands. Small-area habitat types were combined with similar ones of larger size, or excluded (each totalling <0.1% of study area) from analysis if not similar to other large-area habitat types (Table 1).

We captured adult black bears and equipped them with radio transmitters to monitor their movements (Nyland 1995). From 21 January 1992 to 27 April 1993,

Table 1. Sampling distribution and after-sampling pooling scheme for habitat type stands >2.88 ha in occupied areas of black bear habitat in coastal Louisiana during summer 1993. Two other types, scrub-shrub spoil (17 ha) and deciduous, evergreen forest (632 ha), were not used in analysis.

NWI Habitat type	*N* Stands	*N* Plots
Brackish marsh (3,230 ha)	3	5
Fresh marsh, flooded (2,800 ha)	4	7
Fresh marsh, tidal (7,253 ha)	2	4
Black bear cover type: MARSH (13,283 ha)	9	16
Brackish scrub-shrub (36 ha)	4	7
Fresh scrub-shrub (1,874 ha)	6	10
Black bear cover type: SCRUB (1,910 ha)	10	17
Deciduous, bald cypress forest (11,587 ha)	10	14
Black bear cover type: MIXED SWAMP (11,587 ha)	10	14
Bald cypress forest (3,680 ha)	11	13
Black bear cover type: CYPRESS (3,680 ha)	11	13
Deciduous forest (8,058 ha)	10	13
Black bear cover type: HDWD SWAMP (8,058 ha)	10	13
Deciduous, bald cypress forest spoil (27 ha)	1	1
Deciduous forest spoil (1,005 ha)	9	13
Black bear cover type: HDWD SPOIL (1,032 ha)	10	14
Upland deciduous forest (34 ha)	9	12
Upland decid. & evergreen forest (516 ha)	4	8
Upland decid. & evergreen for spoil (210 ha)	4	6
Black bear cover type: UPLAND HDWD (760 ha)	17	26
Analysis totals (40,959 ha)	77	113

we collected 437 diurnal telemetry locations from 21 radio-tagged bears in weekly aerial tracking sessions following methods by Gilmer et al. (1981). We constructed 2.54-km buffers around each location and used the union of all buffers as the boundary of occupied habitat. This distance represented the 75th percentile among distances between all pairs of consecutive locations and accounted for normal movements associated with foraging and roaming, but excluded irregularly long excursions.

Resource Sampling

We used ERDAS 7.5 (Erdas, Inc., Atlanta, Ga.) to select 82 sampling stands at random (Table 1); a stand was ≤2.88 ha of contiguous habitat type. A minimum area allowed for errors in locating stands, reduced edge influences, and allowed sampling >1 site per stand. To limit walking distances, we sampled stands <0.8 km from any type labelled access (as determined in the GIS). We used a global positioning system receiver to find (±100 m) sample stands (August et al. 1994). Sites within stands were located ≥60 m from the stand edge and 75 m apart at random cardinal directions. Spoil types were sampled along the stand's long axis, ≥1 m from the edge. Initially, we sampled 2 sites per stand, but we changed to 1 site per stand to sample more experimental units within our time constraints. Because nearly all agriculture in the area is sugarcane, which produces a predictable set of food and cover resources for bears, we excluded agriculture from sampling.

We used 4 different sampling units at each site. We recorded ocular estimates of horizontal cover (%) of each taxa within the groundstory (plant ≤0.25 m in height) in 4 0.5-m radius plots, located at cardinal directions 5 m from the center of the site. In spoil types <5 m wide, groundstory plots were placed at 2.5-m intervals in a random direction along the stand's major axis. Plots in which groundstory was under water were categorized as 0% cover. In a 2.5-m radius plot, we counted low shrubs and perennials 0.25- to 1.0-m high. In a 5-m radius plot, we made the following stem counts: high shrubs and perennials (1–3-m high), sapling trees and woody vines (<10-cm dbh and >3-m tall), and pole trees (10- to 25-cm dbh and >3-m tall). We assessed vertical cover (%) by viewing a 2- × 0.5-m profile screen (constructed of alternate red and white 0.5- × 0.5-m cloth panels) at cardinal directions 5 m from the center of the site. We counted insect nests, logs, and stumps >10-cm diameter and 0.5-m long (coarse woody debris) in the 5-m radius plot, and we used these counts to index colonial and wood-boring insect foods. Basal area of overstory trees >25-cm dbh and >3-m tall was measured with a 2-factor metric prism (Hays et al. 1981). We assessed canopy cover (%) in cardinal directions 5 m from the center of the site using a spherical densiometer (Hays et al. 1981). We visited stands at random to sample vegetation throughout phenological development. Sampling was terminated for a habitat type when no new species were encountered for all strata after sampling 3 consecutive sites (Mace 1985). Latin names of plants follow Radford et al. (1968).

Analysis

We assumed all plants contributed to cover, whereas only a few provide food. We categorized plants according to type of food (herbage, soft mast, or hard mast) and season of production (spring/summer, 1 Apr–31 Jul; fall, 1 Aug–31 Nov; or both; Nyland 1995). We pooled taxa within food groups to obtain percent cover of groundstory foods in each 0.5-m radius plot, then averaged the 4 plots to calculate cover (%) of each food group for a site. We summed stem counts within food groups and within low shrub, high shrub, sapling, and pole strata for each site. We summed basal areas of trees within food groups for each site. We pooled basal areas of overstory trees that produce soft mast. To assess cover, we summed stem counts from all plants within each of low shrub, high shrub, sapling, and pole strata to get total stems in each stratum for each site. For canopy cover and vertical cover, we averaged the 4 measurements within each site. When 2 sites were measured, we averaged measurements across sites to compute stand averages.

We pooled habitat types that had similar species composition and encompassed <7% of the study area (Table 1) into 7 types: brackish and fresh marsh (MARSH), scrub-shrub wetlands (SCRUB), deciduous and bald cypress forest (MIXED

SWAMP), bald cypress forest (CYPRESS), deciduous forest (HDWD SWAMP), deciduous forest spoil (HDWD SPOIL), and upland hardwood forest (UPLAND HDWD). We performed analyses only on these 7 types. We excluded data collected from scrub-shrub spoil and deciduous and evergreen forests from our analyses because they accounted for little land area (<650 ha).

We tested for differences in cover of groundstory plant foods and stem densities of food and all plants in low and high shrub strata among the pooled habitat types. We excluded marsh when testing for differences in density of trees and overstory vines. We used ranks of stand averages in 1-way ANOVAs to test for differences among habitat types in plant food and cover in each stratum. In each case, we used variance estimates for measurements among habitat types having equal variances in stand ranks according to Levine's method ($P > 0.01$; Milliken and Johnson 1984) to construct conservative mean square error terms to test habitat types with unequal variances. Least-square-mean comparisons were used to examine differences between habitat-type pairs if overall differences were detected. Insect nests and potential dens were classed as present or absent, whereas coarse woody debris counts were grouped as 0–3, 4–7, and >7 per plot. We tested for differences in classes of insect nests, potential dens, and coarse woody debris density among all habitat types using Fisher's exact Chi-square analysis (Agresti 1990). Cover, volume, and density data for each habitat type are reported in ha-equivalents for significant food and cover component tests. Unless otherwise noted, we assumed a Type I error rate of 5%.

We used multivariate displays to summarize relative food and cover conditions among habitat types. First, we determined the abundance of 8 important food plants across strata: summer foods including summer vines (pepper vine *[Ampelopsis arborea]* and poison ivy *[Toxicodendron radicans]*), greenbriars (*Smilax* spp.), and *Rubus* spp; durable, multi-seasonal food plants including hollies (*Ilex* spp.) and palmetto (*Sabal minor*); and fall food plants including grapes (*Vitis* spp.), tupelo (*Nyssa* spp.) and oaks (*Quercus* spp.) and hickories (*Carya* spp.). We averaged sites within stands and then averaged stand averages within habitat types to produce food production indices. Similarly, we used the average stem densities within vegetation sampling strata and among habitat types for those measurements found to differ among types. Using these 2 multivariate sets, we plotted Chernoff faces (Chernoff 1973) to illustrate the relative similarities and differences in habitat quality among habitat types. In each Chernoff face, the dimension or shape of a specific facial feature changes with the relative value of a particular habitat component. Thus, at a glance, one sees a summary of the relative similarity or differences among habitat types under study.

Results

We counted 119 taxa at 121 sites across 82 stands. We used 113 plots from 77 stands to test differences in food and cover resources among habitat types (Table 1). Based on our seasonal food group and strata category combinations, food plants

Table 2. Cover (%) (S.E.), density (stems/ha) (S.E.), basal area (m^2/ha) (S.E.), frequency (number of stands where present), and distribution of the most common food plants found in 7 cover types in coastal Louisiana black bear habitat. Taxa are listed by occurrence in ground cover (<0.25 m), shrub and sub-canopy (0.25 m < height <3 m, diameter <25 cm), and canopy strata (height >3m, diam. >25 cm). Scientific names from Radford et al. (1968).

	Marsh (*N* = 9)		Scrub (*N* = 10)		Mixed Swamp (*N* = 10)		Cypress (*N* = 11)		Hardwood Swamp (*N* = 10)		Hardwood Spoil (*N* = 10)		Upland Hardwood (*N* = 17)	
Groundstory	Freq	% Cover	Freq.	% Cover	Freq.	% Cover	Freq.	% Cover	Freq.	% Cover	Freq.	% Cover	Freq.	% Cover
Ampelopsis arborea	0	0	0	0	1	28	0	0	2	2 (1.5)	2	1 (0.1)	5	4 (1.1)
Poaceae, Cyperaceae	4	27 (21.1)	6	7 (2.6)	5	6 (3.8)	5	6 (3.6)	6	3 (1.0)	4	10 (8.3)	8	13 (7.2)
Rubus spp.	0	0	0	0	1	8	1	9	2	11 (0.7)	9	7 (1.6)	15	4 (1)
Smilax spp.	0	0	0	0	1	0	0	0	2	9	1	5	6	0 (0.1)
Toxicodendron radicans	0	0	0	0	1	3	0	0	0	0		130	8	9 (3.6)
Vitis spp.	0	0	0	0	0	0	0	0	0	0	1	2	9	3 (1.1)
Shrub, sub-canopy	Freq	Density	Freq.	Density	Freq.	Density	Freq.	Density	Freq.	Density	Freq.	Density	Freq.	Density
Ampelopsis arborea	0	0	0	0	4	1940 (1561)	0	0	4	1971 (706)	4	1320 (435)	8	2488 (695)
Celtis laevigata	0	0	0	0	3	212 (149)	0	0	1	254	3	611 (265)	4	354 (248)
Ilex vomitoria	0	0	4	1079 (217)	1	381	0	0	0	0	4	9851 (3645)	15	5912 (2207)
Myrica cerifera	0	0	8	1819 (560)	3	2053 (629)	5	1994 (669)	5	1613 (813)	5	355 (109)	5	1919 (807)
Persea borbonia	0	0	4	461 (111)	1	1082	2	635 (508)	3	254 (73)	2	858 (604)	3	1674 (884)
Poaceae, Cyperaceae	1	2.1M[a] (2.0M)	8	2.1M (1.4M)	4	11863 (3762)	6	9435 (2214)	6	0.3M (0.2M)	3	2842 (1153)	5	9029 (5405)
Rubus spp.	0	0	0	0	3	3474 (1949)	1	2416	2	12810 (11475)	8	6820 (2245)	12	14043 (4434)
Sabal minor	0	0	5	599 (300)	7	559 (205)	2	667 (477)	5	787 (315)	4	748 (198)	5	598 (229)
Sambucus canadensis	1	5083	0	0	2	954 (446)	0	0	1	381	5	1933 (883)	11	4060 (1482)
Smilax spp.	0	0	1	191	2	1527 (1145)	1	508	0	0	3	1441 (531)	10	1328 (249)
Toxicodendron radicans	0	0	0	0	1	827	1	508	0	0	1	2670	4	4802 (4336)
Vitis spp.	0	0	0	0	1	763	0	0	1	127	2	1240 (668)	10	1341 (461)
Canopy	Freq	Basal area	Freq.	Basal area	Freq.	Basal area	Freq.	Basal area	Freq.	Basal area	Freq.	Basal area	Freq.	Basal area
Celtis laevigata	0	0	0	0	0	0	0	0	1	1.0	2	5 (1.0)	5	2 (0.5)
Nyssa spp.	0	0	0	0	2	13 (2.5)	8	12	0	0	0	0	0	0
Quercus nigra	0	0	0	0	1	1	0	0	0	0	0	0	8	3 (0.9)
Quercus virginiana	0	0	3	3 (1)	1	1	0	0	0	0	1	2	7	6 (1.9)

a. M = million

occurred in all strata but with considerable variation among habitat types (Table 2). Typical lower strata (groundstory to high shrub) mast producers were vines, *Rubus* spp., elderberry (*Sambucus canadensis*), palmetto, wax myrtle (*Myrica cerifera*) and hollies. Upper strata (sapling to overstory) mast producers included vines, hollies, tupelos, oaks, and wax myrtle.

Foods

We found no differences among habitat types in cover of spring/summer, groundstory herbage; density of spring/summer, low shrub herbage; or density of spring/summer, high shrub herbage (Table 3). However, spring/summer, groundstory soft mast differed among habitat types (Table 3). Spring/summer, groundstory soft mast was highest in HDWD SPOIL (10 ± 3%) and UPLAND HDWD (9 ± 2%), present but variable in MIXED SWAMP (4 ± 4%) and HDWD SWAMP (3 ± 2%), and was absent or nearly so from MARSH and CYPRESS (both 1 ± 1%). Fall, groundstory soft mast also differed among habitat types (Table 3), being highest in HDWD SPOIL (7 ± 2%) and UPLAND HDWD (6 ± 1%), moderate in HDWD SWAMP (3 ± 2%), and absent or nearly so from MARSH (0 ± 0) and CYPRESS and MIXED SWAMP (both 1 ± 1%).

Most mast-producing shrubs that we encountered produce fruit during both spring/summer and fall. Consequently, differences among habitat types were nearly identical across seasons (Table 3, Fig. 2). Patterns of abundance were the same for low and high shrubs, with UPLAND HDWD having the highest densities, HDWD SPOIL a distant second, and all other habitat types much lower and not different from each other (Fig. 2).

Table 3. Results of ANOVA's testing for differences among 7 habitat types measured in coastal Louisiana black bear habitat during summer 1993. Habitat components measured included indices of food plant abundance in different vegetation strata. Types were MARSH, SCRUB, MIXED SWAMP, CYPRESS, HDWD SWAMP, HDWD SPOIL, UPLAND HDWD.

Resource	Type	Habitat types	*df*	F	*P*
Groundstory	herbage	all	6,70	0.47	0.828
	summer, soft mast	all	6,53	14.40	<0.001
	fall, soft mast	all	6,53	13.98	<0.001
Low shrub	herbage	all	6,70	1.70	0.134
	summer, soft mast	all	6,62	17.00	<0.001
	fall, soft mast	all	6,62	19.95	<0.001
High shrub	herbage	all	6,70	1.72	0.129
	summer, soft mast	all	6,70	10.26	<0.001
	fall, soft mast	all	6,70	9.90	<0.001
Sapling	summer, softmast	ABM[a]	5,62	1.74	0.140
	fall, soft mast	ABM	5,62	2.05	0.084
Pole	summer, soft mast	ABM	5,43	1.59	0.183
	fall, soft mast	ABM	5,53	5.28	0.001
Overstory	all soft	ABM	5,62	4.64	0.001
	hard mast	ABM	5,43	4.15	0.004

a. ABM= All habitat types except MARSH included in test.

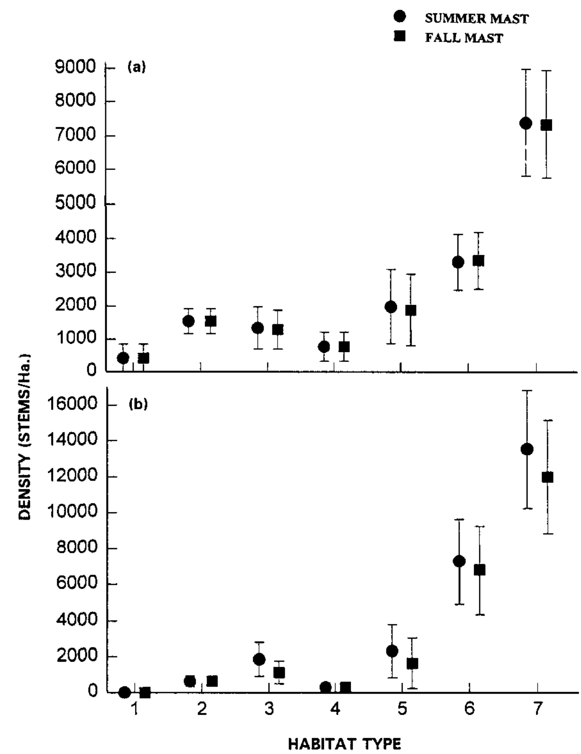


Figure 2. Mean and interval estimates ($\alpha = 0.05$) of high shrub (a) and low shrub (b) densities for plants that potentially produce sping/summer or fall soft mast in 7 habitat types identified from NWI data and found in an area of coastal Louisiana known to be occupied by black bears during summer 1993. [1 = MARSH, 2 = SCRUB, 3 = MIXED SWAMP, 4 = CYPRESS, 5 = HDWD SWAMP, 6 = HDWD SPOIL, 7 = UPLAND HDWD]

We found no differences among density of spring/summer, soft-mast saplings; fall, soft-mast saplings; or spring/summer, soft-mast pole trees. However, density of fall, soft-mast trees differed among forested types for sapling and pole trees (Table 3). Fall, soft-mast pole trees were densest in CYPRESS (504 ± 129 stems/ha), moderately high in MIXED SWAMP (115 ± 54 stems/ha) and UPLAND HDWD (97 ± 36 stems/ha), low in SCRUB (45 ± 23 stems/ha), HDWD SPOIL (25 ± 17 stems/ha) and not encountered in HDWD SWAMP. Basal area differed for both soft- and hard-mast trees in the overstory (Table 3). CYPRESS had the largest basal area of soft-mass trees (9.8 ± 3 m^2/ha), while the other habitat types were similar ($P > 0.05$) in mean basal area, ranging from 3.1 ± 1.7 m^2/ha for MIXED SWAMP to 0.1 ± 0.1 m^2/ha from SCRUB. Hard-mast overstory basal area, primarily oaks, hickory (*Carya tomentosa*), and pecan (*Carya illinoensis*), was highest in UPLAND HDWD (4.8 ± 1.1 m^2/ha) and never >1m^2/ha for other habitat types.

Density of coarse woody debris varied among habitat types ($\chi^2 = 39.36$, 12 *df*, $P < 0.001$), but insect nest presence did not ($\chi^2 = 11.57$, 6 *df*, $P = 0.072$). Mean density of coarse woody debris was highest in UPLAND HDWD (2,210 ± 357 logs/ha) and ranged from 1,197 to 1,655 logs/ha in other types except MARSH, which contained no coarse woody debris.

Cover

Cover provided by shrubs and sub-canopy trees differed among habitat types (Tables 3, 4). MARSH and SCRUB had high (>10^6 stems/ha) low shrub and substantial high shrub densities. SCRUB tended to obscure vision more than MARSH, and SCRUB offered some small trees. Consequently, SCRUB had the highest profile cover among types. SWAMP had modest amounts of shrub cover (high, low, and profile) and modest overstory cover. MIXED SWAMP and CYPRESS SWAMP seemed to offer abundant overhead, but less obscuring cover. HDWD SWAMP, UPLAND HDWD, and HDWD SPOIL had modest overhead cover and lower shrub densities, but these provided abundant horizontal cover.

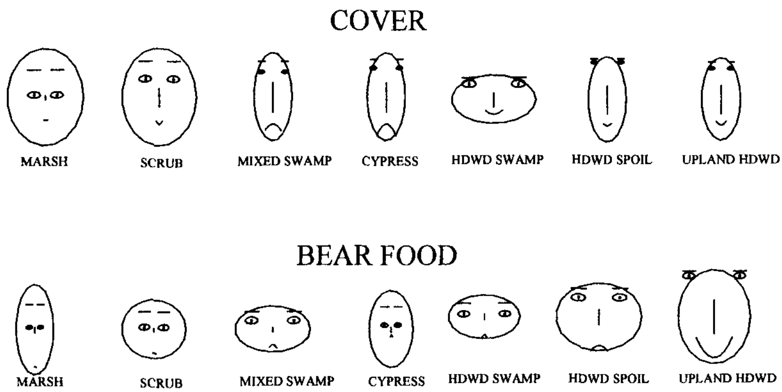
Food and Cover Indices

Despite high variability in the amounts of food and cover variables within habitat types, differences among types were common. Chernoff faces reflected the relative availability in food and cover resources (Fig. 3). For example, a large-faced, big-mouthed, long-nosed, eyes-at-the-top-of-his-head, smiling face depicts UPLAND HDWD. Relative to those face features, UPLAND HDWD had the second most abundant hollies and the highest counts of grapes, *Rubus, Smilax*, and hard mast. A gaunt, mealy-mouthed face represented MARSH, which offered few food plants. For

Table 4. Average cover measurements (± s.e.) in different vegetation strata among 7 habitat types measured in coastal Louisiana black bear habitat during summer 1993. Types were MARSH, SCRUB, MIXED SWAMP, CYPRESS, HDWD SWAMP, HDWD SPOIL, UPLAND HDWD.

Habitat type	Low shrub density (1,000 stems/ha)	High shrub density (1,000 stems/ha)	Sapling density (100 stems/ha)	Pole density (stems/ha)	Profile cover (%)	Overstory basal area (m^2/ha)
MARSH	1810 ± 1520	60.5 ± 20.5	0± 0	0± 0	54 ± 9	0 ± 0
SCRUB	1730 ± 1120	58.1 ± 38.2	7.3 ± 2.3	146 ± 41	67 ± 6	1.4 ± 0.5
MIXED SWAMP	64 ± 16.2	5.5 ± 1.4	11.1 ± 2.2	579 ± 100	48 ± 6	14.4 ± 1.8
CYPRESS	66 ± 16.2	6.7 ± 4.1	15.7 ± 5.4	700 ± 125	44 ± 4	18.4 ± 3.6
HDWD SWAMP	217 ± 65.4	129 ± 83.2	16.7 ± 4.9	522 ± 98	60 ± 6	6.6 ± 1.8
HDWD SPOIL	48 ± 13.2	8.9 ± 1.7	26.4 ± 9.2	739 ± 146	61 ± 5	7.2 ± 1.8
UPLAND HDWD	40 ± 6.8	14.8 ± 2.5	19.1 ± 2.7	356 ± 65	64 ± 4	9.2 ± 1.5
ANOVA Tests	all	all	ABM[a]	ABM	all	ABM
F-value	3.90	5.01	2.54	6.41	2.45	9.05
df	6,70	6,70	5,62	5,62	6,70	5,62
P	0.002	<0.001	0.037	<0.001	0.033	<0.001

a. ABM = All habitat types except MARSH included in test.



KEY

FACIAL FEATURE	Face Area	Face Shape	Nose Length	Mouth Location	Mouth Curvature	Mouth Width	Eye Location	Eye Separation
COVER MEASUREMENT	Low Shrub Density	High Shrub Density	Canopy Cover	Constant (not used)	Vertical Profile	Overstory Basal Area	Sapling Density	Pole Density
FOOD MEASUREMENT	Hollies	Palmetto	Rubus	Tupelo	Hard Mast	Grape	Smilax	Summer Vines

Figure 3. Chernoff faces depicting relative availability of food and cover resource sets among 7 habitat types identified from NWI data and found in an area of coastal Louisiana known to be occupied by black bears. Facial features (e.g., nose) increase with increasing values of each habitat component.

cover, faces representing MARSH and SCRUB were clearly similar except for nose length, which reflected appreciable canopy cover present in SCRUB but absent in MARSH.

Discussion

A previous, coarse-scale evaluation found areas of coastal Louisiana and coastal areas in other southeastern states to have significant amounts of good bear habitat (Rudis and Tansey 1995) and recommended finer-scale mapping for more complete assessment. In coastal Louisiana, bear habitat comprises several easily recognized vegetation associations, including marshes, forested wetlands, uplands, and spoil habitat types. Grouping NWI data into 7 categories of vegetative cover, 2 non-vegetative types (developed sites and waterways) and agriculture produced a habitat map of coastal Louisiana that conveyed considerable information concerning the distribution and quantity of food and cover resources available to bears.

Forested wetlands were the major habitats that provided seasonal foods and year-round cover to bears within this region. However, forested wetlands provided lower overall quantities of food plants and cover than UPLAND HDWD or forested spoil banks, which were rare (3% of the composite home range of monitored bears)

MARSH provided abundant cover <1 m, little cover >1 m, and almost no mast or insect foods. Therefore, bears probably used several habitat types to fulfill dietary needs. For example, only wax myrtle, redbay (*Persea borbonia*), grasses (Poaceae), sedges (Cyperaceae), and palmetto were common in all forested wetlands, but most common plant foods were absent from at least 1 type of forested wetland. Peppervine, *Rubus* spp., and grapes were particularly abundant in the shrub strata of HDWD SWAMP but absent from SCRUB. In contrast, yaupon holly (*Ilex vomitoria*), poison ivy, and greenbriars were absent from HDWD SWAMP but present in the shrub strata of other forested wetlands. The abundance of overstory live oaks (*Quercus virginiana*) in forested wetlands was highest in SCRUB and absent from MIXED SWAMP. Overstory tupelo (*Nyssa* spp.) abundance in forested wetlands was highest in CYPRESS and MIXED SWAMP but absent from SCRUB and HDWD SWAMP (Table 3).

Differences in the distribution of common plant foods among forested wetlands suggested that interspersion of habitat types is an important element of coastal Louisiana bear habitat. Interspersion of habitat types as a means of habitat diversity is a common element of black bear habitat in other coastal areas (Landers et al. 1979, Abler 1985, Hellgren and Vaughan 1988, Hellgren et al. 1991, Smith 1985). Several components of bear habitat in coastal Louisiana were similar to coastal North Carolina and Virginia (Landers et al. 1979, Hellgren and Vaughan 1988, Hellgren et al. 1991), and other wetland regions of the southeastern United States. Forested wetlands in coastal Louisiana provided moderate quantities of seasonal fruits and hard mast, potential for animal foods, and escape cover. HDWD SWAMP had moderate overstory volume, dense shrub understory that provided good vertical profile cover, and seasonal berry crops such as holly, palmetto, and wax myrtle. High stocking and volume of pole and overstory tupelo trees in large contiguous flooded stands of CYPRESS and MIXED SWAMP provided fall mast and escape cover. SCRUB provided good vertical profile cover and adequate cover for ground dens (Johnson and Pelton 1981, Weaver et al. 1990); however, food resources were moderate, which contrasts with abundant food described for scrub lands in coastal North Carolina and Virginia (Landers et al. 1979, Hellgren et al. 1991).

Seasonal food and cover resources were different between forested wetland and forested spoil and uplands. Overall, food and cover in UPLAND HDWD and HDWD SPOIL were higher than in forested wetlands. Abundant food and cover resources in UPLAND HDWD may explain high concentrations of bears on Weeks Island (R. M. Pace, unpubl. data). Developments on salt domes occasionally provide bears with high-energy garbage foods, yet are juxtaposed with high-quality UPLAND HDWD. Although bears inhabiting Weeks Island benefit from its high food density, these resources are unavailable to most bears within the study area.

Two major questions arose concerning the effectiveness of NWI data for bear habitat assessment in the Southeast. First, do habitat types identified in NWI data represent different sets of resources available to bears? If so, does the resource set associated with a given habitat type convey information about the relative quality or seasonal importance of that habitat type? We believe the answers to both questions are yes. However, raw NWI data sets contained many habitat designations that account for small changes in hydrology and salinity (Handley 1992). These fine distinctions may be important for other uses of these data, but they complicate large-scale assessment projects needed for bear conservation. Many hydrological modifiers found in NWI data were most evident among marsh types. We believe that these convey little information about food and cover resources for bears. Our habitat map conveyed considerable information about the relative availability, juxtaposition, and interspersion of resource sets for bears. Other workers have focused on dominant vegetation types to assess bear habitat quality. For example, Mykytka and Pelton (1990) used 12 vegetation associations to examine bear habitat use patterns in north Florida. Our coalescence of 91 habitat types to 15 (excluding agriculture, development, and open water) and then to 9 (7 evaluated plus access and agriculture) may have reduced the information content of our map, but we could distinguish very different resource sets represented by these habitat types. To depict habitat types that are biologically relevant to bears, modifiers that embellish dominant vegetation associations with geomorphological or structural features such as slope, stand age, or level of stocking would be useful but are not currently available in NWI data.

Although NWI data were useful to assess differences in available tree foods and cover, overlapping and patchy distributions of common mast-producing shrubs suggested finer divisions of plant associations should be developed. Amendments to NWI data that include mapping associated uplands, better discrimination among forest wetland types, and addition of physiognomic characters such as tree density and canopy height might prove useful for future habitat assessment projects.

Literature Cited

Abler, W. A. 1985. Bear population dynamics on a study area in southeast Georgia. Ga. Dep. Nat. Resour., Atlanta. Final Rep. Proj. W37 LII. 91pp.

Agresti, A. 1990. Categorical data analysis. Wiley and Sons, Inc., New York, N.Y. 558pp.

August, P., J. Michaud, C. Labash, and C. Smith. 1994. GPS for environmental applications: accuracy and precision of locational data. Photogramm. Eng. Remote Sensing. 60:41–45.

Chabreck, R. H. 1970. Marsh zones and vegetative types in the Louisiana coastal marshes. Ph.D. Thesis, La. State Univ., Baton Rouge. 113pp.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Dep. Int., Fish and Wildl. Serv., Washington, D.C. 103pp.

Evans, D. L., P. Y. Burns, N. E. Linnartz, and C. J. Robinson. 1983. Forest habitat regions of Louisiana. School of For., Wildl. and Fish., La. State Univ. Agric. Ctr., Baton Rouge. 23pp.

Gilmer, D. S., L. M. Cowardin, R. L. Duval, L. M. Mechlin, C. W. Shaiffer, and V. B. Kuechle. 1981. Procedures for the use of aircraft in wildlife biotelemetry studies. U.S. Dep. Int., Fish and Wildl. Serv. Resour. Publ. 140. 19pp.

Handley, L. R., M. J. Fuhrmann, and J. H. Blackmon, Jr. 1992. A verification of the accuracy of the 1988 National Wetlands Inventory habitat maps. Page 16 *in* L. N. May, Jr., ed. Proc. Workshop on Remote Sensing and Geographical Info. Systems for Coastal Manage. in La. Stennis Space Ctr., Miss.

Hays, R. L., C. Summers, and W. Seitz. 1981. Estimating wildlife habitat variables. U.S. Dep. Int., Fish and Wildl. Serv., Washington, D.C. FWS/OBS-81/47. 111pp.

Hellgren, E. C. and M. R. Vaughan. 1988. Seasonal food habits of black bears in Great Dismal Swamp, Virginia-North Carolina. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 42:295–305.

———, ———, and D. F. Stauffer. 1991. Microhabitat use by black bears in a southeastern wetland. J. Wildl. Manage. 55:442–448.

Johnson, K. G. and M. R. Pelton. 1981. Selection and availability of dens for black bears in Tennessee. J. Wildl. Manage. 45:111–119.

Landers, J. L., R. J. Hamilton, A. S. Johnson, and R. L. Marchinton. 1979. Foods and habitat of black bears in southeastern North Carolina. J. Wildl. Manage. 43:143–153.

Mace, R. D. 1985. Analysis of grizzly bear habitat in the Bob Marshall Wilderness, Montana. Pages 136–149 *in* G. P. Contreras and K. E. Evans, eds. Proc. Grizzly Bear Habitat Symp. U.S. Dep. Agric., For. Serv. Intermountain Res. Sta., Missoula, Mont.

Milliken L. D., and D. M. Johnson. 1984. Analysis of messy data. Wadsworth, Inc., Lifetime Learning Publ., Belmont, Calif. 473pp.

Mykytka, J. M., and M. R. Pelton. 1990. Management strategies for Florida black bears based on home range habitat composition. Internatl. Conf. Bear Res. and Manage. 8:161–167.

Nyland, P. D. 1995. Black bear habitat relationships in coastal Louisiana. M.S. Thesis. La. State Univ., Baton Rouge. 76pp.

Pelton, M. R. 1982. Black bear. Pages 504–514 *in* J. A. Chapman and G. A. Feldhamer, eds. Wild mammals of North America: biology, management, and economics. John Hopkins Univ. Press, Baltimore, Md.

Rudis, V. A. and J. B. Tansey. 1995. Regional assessment of remote forests and black bear habitat from forest resource surveys. J. Wildl. Manage. 59:170–180.

Radford, A. E., H. E. Ahles, and C. R. Bell. 1968. Manual of the vascular flora of the Carolinas. Univ. N.C., Chapel Hill. 1183pp.

Schoen, J. W. 1990. Bear habitat management: a review and future perspective. Internatl. Conf. Bear Res. and Manage. 8:143–154.

Smith, T. R. 1985. Ecology of black bears in a bottomland hardwood forest in eastern Arkansas. Ph.D. Thesis, Univ. Tenn., Knoxville. 209pp.

U.S. Fish and Wildlife Service. 1990. Photo interpretation conventions for the National Wetlands Inventory. U.S. Dep. Int., Fish and Wildl. Serv., St. Petersburg, Fla. 45pp.

Weaver, K. M., D. K. Tabberer, L. U. Moore, Jr., G. A. Chandler, J. C. Posey, and M. R. Pelton. 1990. Bottomland hardwood forest management for black bears in Louisiana. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 44:342–350.

Wooding, J. B., J. A. Cox and M. R. Pelton. 1994. Distribution of black bears in the southeastern coastal plain. Proc. Annu. Conf. Southeast. Assoc. Fish and Wildl. Agencies 48:270–275.