



# Methods for Evaluating Wetland Functions

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**PURPOSE:** The purpose of this technical note is to review the major wetland evaluation methods currently in use among wetland professionals and to provide a comprehensive list of these methods for use by field biologists and managers. Method selection can be based on study objectives; amount of time, budget and personnel available; regional or local controversy; and degree of precision and accuracy required.

**REVIEW PROCESS:** A total of 17 methods were reviewed. These methods are widely used and have applicability to the Section 404 review process. The analysis compared the similarities and differences between the variables used to assess wetland functions. Four of the methods reviewed are designed for generalized use: the Habitat Evaluation Procedures (HEP), Habitat Assessment Technique (HAT), Wetland Evaluation Technique (WET), and Ontario Method. These four, and other methods which are more region specific, are listed in Table 1 by author and by their commonly accepted names.

We grouped wetland functions into four broad categories: hydrology/water quality; landscape integrity; fish and wildlife/habitat; and recreation/aesthetic. Each method was reviewed to determine if it addressed the major functional categories and the types of variables used to measure the functions (Table 1.) Three previous reviews of methods addressing different issues may be of use to supplement this review.<sup>1</sup>

No consensus was evident on the numbers of variables used to evaluate wetland functions. The WET addresses the greatest number of variables (94), and HAT, the fewest (3). Collectively, the 17 methods address 300 variables (Table 1). However, the number of variables that three or more methods have in common was 78: hydrology/water quality (16), landscape integrity (31), fish and wildlife/habitat (13), and recreation/aesthetic (18). This smaller list has been compiled into Table 2 and may be useful to evaluators and reviewers of permits to reduce the number of variables included in the analysis. Generally, a greater number of variables will increase time and cost of the analysis. Conversely, too few variables may not provide enough information for sound decision making.

- **Hydrology/water quality.** Fifteen of the methods included variables related to hydrology/water quality (Table 1). Of these methods, three used three or less variables to evaluate this category. The most comprehensive series of variables was contained in WET with 28, although several methods used 12 or more variables.
- **Landscape Integrity.** All of the methods included one or more variables to evaluate landscape integrity. Four methods evaluated this category with four or fewer variables (Table 1). The greatest number of variables was included in HEP with 35.

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<sup>1</sup> See Lonard et al. (1981), Kusler and Riexinger (1986), and Adamus (1989) in the suggested-reading section.

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- **Fish and Wildlife/habitat.** Thirteen methods included one or more variables to evaluate fish and wildlife/habitat (Table 1). HEP used the greatest number of variables at 27. Six used four or less variables to evaluate this category.
- **Recreation/aesthetic.** Thirteen methods included one or more variables to evaluate the recreation/aesthetics category (Table 1). Six used four or less variables. The Wetland Evaluation Guide used the most comprehensive list of variables at 47.

#### **RECOMMENDED ADDITIONAL READING:**

- Adamus, P. R. 1989. A review of technical information sources for support of U.S. EPA advanced identification projects. U.S. Environmental Protection Agency Environmental Research Laboratory, Corvallis, OR.
- Adamus, P. R., E. J. Clairain, Jr., R. D. Smith, and R. E. Young. 1987. Wetland evaluation techniques (WET): Volume II: Methodology. Operational Draft Technical Report Y-87. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.
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- Golet, F. C. 1976. Wildlife wetland evaluation model. In: Larson, J.S., ed. Models for assessment of freshwater wetlands. Completion Report 76-5. Water Resource Research Center, University of Massachusetts, Amherst, MA.
- Gosselink, J. and L. Lee. 1987. Cumulative impact assessment in bottomland hardwood forests. U.S. Environmental Protection Agency, Washington, D.C.
- Heeley, R. W., and W. S. Motts. 1976. A model for the evaluation of ground-water resources associated with wetlands. In: Larson, J. S., ed. Models for assessment of freshwater wetlands. Completion Report 76-5. Water Resource Research Center, University of Massachusetts, Amherst, MA.
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- Kusler, J. A., and P. Riexinger (eds). 1986. Proceedings of the national wetland assessment symposium. Association of State Wetland Managers, Albany, NY.
- Lonard, R. I., et al. 1981. Analysis of methodologies for assessing wetlands values. U.S. Water Resources Council, Washington, D.C., and Corps of Engineers, Vicksburg, MS.
- Marble, A. S. and M. Gross. 1984. A method for assessing wetland characteristics and values. *Landscape Plann.* 11: 1-17.
- Municipality of Anchorage. 1991. Anchorage wetlands assessment method. Draft. Anchorage, AK.
- North Carolina Department of Environment, Health, and Natural Resources. 1991. North Carolina wetland rating system manual - second draft. State of North Carolina, Department of Environment, Health, and Natural Resources, Raleigh, NC.
- O'Neil, L. J., Pullen, T. M., and R. L. Schroeder. 1991. A wildlife community habitat evaluation model for bottomland hardwood forests in the Southeastern United States. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, MS.
- Smardon, R. C. and J. C. Fabos. 1975. Assessing visual-cultural values of inland wetlands in Massachusetts. In: Larson, J. S., ed. Models for assessment of freshwater wetlands. Completion Report 76-5. Water Resource Research Center, University of Massachusetts, Amherst, MA.
- Witty, D. R., D. A. Young, and T. Heberlein. 1991. Wetlands evaluation guide. Draft. Prep for Environment Canada.
- U.S. Army Corps of Engineers. 1988. The Minnesota wetland evaluation methodology for the North Central United States. U.S. Army Corps of Engineers, St. Paul District, St. Paul, MN.
- U.S. Fish and Wildlife Service. 1980. Habitat evaluation procedures (HEP) (102-ESM). U.S. Fish and Wildlife Service, Washington, D.C.

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**Table 1**  
**Variables Used for Wetland Evaluation**

Variables	Methodologies																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<b>Hydrology/Water Quality</b>																	
Abundance of cover in stream/river										X							X
Alkalinity												X					
Bacterial concentration			X									X					
Bank stabilization																	X
Bottom water temperature										X		X					
Climate regulation	X											X					
Condition of shoreline													X				
Constriction of wetland												X					
Contribute to groundwater quality	X	X	X				X					X					X
Contribute to groundwater quantity							X										
Contribute to surface water quality	X	X	X						X			X					
Contribute to usable surface water	X																
Dispersal of toxics	X																
Dominant flooding regime												X					
Downstream sensitivity													X				
Erosion control	X	X		X					X				X	X			
Flood damage potential downstream													X				
Flood flow alteration			X									X					
Flood peak flows													X				
Flood protection/control	X			X					X								X
Flood tolerance index																	
Flood water desynchron. and stor.		X															X
Flooding extension and duration											X	X	X				

1 Witty et al., Wetland Eval. Guide.	7 Heeley, Motts, Groundwater Restor.	13 CORPS, WEM.
2 Gosselink, Le, Cum. Ass. of BLH.	8 Cable et al., HAT.	14 Euler et al., Ontario Method.
3 Cooper et al., Intermount Riparian.	9 Marble, Gross, Assess. Wet. Chairs.	15 Hollands, McGee, H&M.
4 Anchorage Assess.	10 USFWS, HEP.	16 Ammann, Stone, NH/CONN Meth.
5 Golet, Freshwater NE.	11 O'Neil et al., BLH.	17 North Carolina Meth.
6 Smardon, Fabos, Vis./cultural Model	12 Adamus, WET II.	

Table 1 (Continued)																	
Variables	Methodologies																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<b>Hydrology/Water Quality (Continued)</b>																	
Flooding frequency													X				
Flow augmentation	X	X										X		X			
Flow retention				X													
Flow stabilization				X										X			
Flow variation			X														
Flow, gradient, deposition												X	X				
Groundwater discharge			X									X					
Groundwater recharge	X		X									X					
Growing degree-days														X			
Heavy metal concentration			X							X							
Hydrologic connection															X		
Hydrologic position															X		
Living filter																	
Measure of D.O.			X							X		X	X				
Nutrient levels	X	X	X	X						X			X	X			
Nutrient removal												X		X			X
Nutrient retention		X										X				X	
Physical char. of stream channel										X						X	
Poorly drained soils-% of wetland																X	
Precipitation rate												X					
Presence of inlets/outlets												X			X		
Presence of springs													X				
Pres./abs. of temp. pools of water										X							
Production exports (organics)			X									X			X		
Recharge to regional aquifer	X		X														
Reduction of tidal impacts	X																
Salinity and conductivity of water										X		X					
Sediment flow stabilization	X		X									X					
Sediment removal																	X

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Table 1 (Continued)																	
Variables	Methodologies																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<b>Hydrology/Water Quality (Continued)</b>																	
Sediment trapping		X	X						X			X	X			X	
Shoreline anchoring												X					X
Slope of watershed above wetland																X	
Storage of agriculture runoff	X																
Storage/recycling of human waste	X																
Streambank shade			X							X						X	
Surface drainage																	X
Surface substrate type												X					
Surface water persistence				X											X		
Suspended solids										X		X					
Toxicant removal																	X
Toxicant retention												X					
Transmissivity of aquifer															X		
Underlying glacial material							X										
Water catchment	X																
Water chemistry					X												
Water conveyance																	X
Water depth										X		X	X		X		
Water detention		X												X			
Water level fluctuation										X					X		
Water quality										X						X	
Water storage																	X
Water temperature										X		X					
Watershed protection	X								X								
Wetland hydroperiod																	X
Wetland outlet restriction																	X
Adjacent to tributary of Great Lakes													X	X			
Buffer zone for natural area										X							X
Contiguity among patches		X								X							X

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Table 1 (Continued)																	
Variables	Methodologies																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<b>Landscape</b>																	
Contiguity to stream/lake		X		X		X							X		X	X	
Contiguity to upland		X										X				X	X
Cover type					X					X		X	X				
Diameter of canopy layer trees										X	X	X					
Diameter/number/condition of snags										X		X					
Dominant wetland class					X								X		X	X	
Ecological age of wetland														X			
Edge bordered by a buffer-%										X						X	
Edge bordered by upland hbtt.-%										X						X	
Edge effect of commun. types				X		X					X	X		X			
Existing disturbance										X		X					
Fetch and exposure												X		X	X		
Fraction of type remaining		X															
Fringe wetland												X					
Gradient												X	X				
Ground cover-%										X	X						
Habitat diversity			X	X						X			X			X	
Internal wetland contrast						X						X		X			
Interspersion of shade												X				X	
Interspersion type					X				X	X	X	X			X	X	
Is area an island?												X					
Landform contrast																X	
Local topography											X	X			X		
Located at extreme limit of range													X				
Location and size of detention areas														X			
Long term stability																X	
Maintainance of biological diversity	X																
Open space or corridors										X			X				

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Table 1 (Continued)																	
Variables	Methodologies																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<b>Landscape (Continued)</b>																	
Open water types				X						X		X		X			
Open water-%															X	X	
Patch size distribution		X															
Position within watershed				X					X			X			X		X
Presence of fen or bog													X	X			
Presence of native prairie												X	X				
Presence of swamp or marsh														X			
Protection of natural shorelines	X																
Proximity to large water bodies										X		X					
Proximity to other wetlands				X	X	X				X		X	X	X	X	X	
Restoration potential/value																	X
Scarcity of type						X						X		X			X
Sensitivity to disturbance				X							X	X					X
Shrub cover-%											X					X	
Size of adjoining lakes and rivers														X			
Size of watershed	X									X		X					X
Size of wetland		X	X	X	X	X		X	X	X		X		X	X	X	
Soils type				X						X		X		X			
Spatial diversity			X							X							
Stand maturity										X	X						
Stream corridor vegetation																	X
Subclass richness					X								X		X		
Surface substrate										X	X						
Surficial geology							X					X			X		
Surrounding habitat types					X					X				X	X		
Tree canopy closure										X	X						
Vegetation class interspersion										X		X	X				
Vegetation community structure				X						X	X						
Vegetation cover-%										X	X	X	X				X



**Table 1 (Continued)**

Variables	Methodologies																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<b>Landscape (Continued)</b>																	
Vegetation density										X	X				X	X	
Vegetation diversity			X			X				X		X					
Vegetation type										X		X	X	X			
Vegetation-water interspersion										X		X				X	
Vegetative species richness										X					X		
Vegetative width										X		X					
Waterbody diversity						X										X	
Watershed position			X														
Water/cover ratio															X		
Wetland bordering open water-%										X					X		
Wetland class richness					X								X		X	X	
Wetland morphology																X	
Wetland type	X			X	X	X						X	X	X			
Wetland types within a wetland-#										X				X			
Width of wetland										X			X			X	
Wildlife access to other wetlands																X	
<b>Wildlife/Habitat</b>																	
Abund. of aquatic insects/inverts			X							X		X					
Biological control	X																
Bird species richness		X								X							
Breeding bird diversity				X						X							
Breed. hbtt. for endan. plants/ anim.														X			
Breed./feed. hbtt. for signif. species														X			
Dominance of robust emergents				X						X			X	X			
Identifiable guilds			X														
Mast production by trees										X	X						
Migration habitat	X			X									X				

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Table 1 (Continued)																	
Variables	Methodologies																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<b>Wildlife/Habitat (Continued)</b>																	
Migration or feed. hbtt. for T&E spp.														X			
Nursery habitat	X																
Plant productivity												X					
Presence of coldwater fish species													X				
Presence/absence of indicator spp.		X								X							
Proportion of wildlife food plants										X					X		
Quality of spawning substrate										X			X				
Quality habitat for plants and animals	X									X							
Rare/threat. endan. plants/animals	X	X		X								X	X	X	X	X	X
Scarcity of spawning habitat										X			X				
Significant habitat for aquatic life										X							X
Significant habitat for birds				X						X		X					
Significant habitat for crustaceans	X									X							
Significant habitat for fish		X	X	X						X		X					
Significant habitat for mammals	X									X							
Significant habitat for sport fish	X									X		X					
Significant habitat for wildlife	X	X	X							X		X					X
Significant waterfowl habitat	X									X		X	X	X			
Sig. habitat for reptiles/amphibians	X									X							
Sig. hbtt. for fish spawning/rearing										X			X	X		X	
Sig. nest. hbtt-colonial waterbirds										X				X			
Species diversity								X		X		X					
Submerged or emergent vegetat.-%										X							X
Total area of pond or lake										X							X
Unique fisheries															X		

Table 1 (Continued)																	
Variables	Methodologies																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<b>Wildlife/Habitat (Continued)</b>																	
Uniqueness of species								X				X					
Unusual abundance of plants/animals	X											X					
Water dependent terr. organisms		X										X					
Waterbird migration populations	X			X								X		X			
Wetland depend. aquatic organisms		X										X					
Wetland plant communities-#				X						X							
Winter cover provided										X				X			
Winter fish kills													X				
Wintering habitat										X		X	X	X			
<b>Recreation/Aesthetics</b>																	
Absence of human disturbance										X				X			
Access to navigable waters													X		X	X	
Access to stream/pond/lake																X	
Add to visual diversity of area	X															X	
Adjacent development										X			X				
Adjacent to public lands													X				
Aesthetic quality																	X
Aids groundwater recharge regulation													X				
Ambient quality							X										
Amount of original wetland filled-%																	X
Archaeol./paleon. resources	X												X				X
Area dominated by flowering trees-%																	X
Audio qualities	X									X							
Barriers to anadrom. fish (ie. dams)																	X
Boating opportunities	X													X			
Commercial harvest (hunt, trap, fish)	X												X	X			

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Table 1 (Continued)																	
Variables	Methodologies																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<b>Recreation/Aesthetics (Continued)</b>																	
Commercial uses (rice, peat)	X													X			
Contribute to local/regional economy	X													X			
Contribute to urban flood protection	X																
Direct alteration												X					
Distance from urban population	X											X		X			
Distance to education facility	X			X								X		X		X	
Distance to roads										X		X	X				
Dominant land use																X	
Dominant land use above wetland																X	
Ease of access	X			X			X						X	X	X	X	
Economic value																	X
Educational use	X			X		X						X	X	X			X
Enhance crop production	X													X			
Enhance development values	X																
Enhance urban water quality	X																
Existing alterations													X				
Fisheries management area																	
General appearance of wetland																X	
Handicap access																X	
Hazards limiting public use																X	
Historical area/buildings																X	
Important sightseeing locale	X												X				
Interpretive program	X			X										X			
Land use along river/stream														X			
Land use in watershed														X			
Land use patterns (general)													X				
Landscape distinctness														X			

Table 1 (Continued)																	
Variables	Methodologies																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<b>Recreation/Aesthetics (Continued)</b>																	
Level of human activity in upland																	X
Level of human activity in wetland										X							X
Local significance																	X
Location (public/private land)	X			X								X	X	X	X		
National natural landmark																	X
Noise level at viewing locales																	X
Number of visitors	X																
Occupied buildings along edge-#																	X
Occurrence of mineral, gas, oil	X																
Odors present at viewing locales																	X
Offroad parking for buses/cars																	X
Open space function	X			X									X				
Opportunity for noncommercial use	X																
Part in pattern of settlement	X																
Part of heritage of region	X											X	X				
Photographic opportunity	X																
Plant alteration (ie. mowing)-%																	X
Policies/programs to conserve area	X											X					
Pollution													X				
Presence of harvestable resources	X											X					
Presence of mill pond																	X
Pres. of nature pres. or wildl. mgmt.																	X
Project benefits	X																
Proximity to tribal lands													X				
Proximity to wild and scenic river													X				
Public roads/railroad crossings-#																	X
Recreation diversity			X														

<b>Table 1 (Concluded)</b>																	
<b>Variables</b>	<b>Methodologies</b>																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<b>Recreation/Aesthetics (Continued)</b>																	
Recreation experience (general)			X									X					X
Regulated by state or COE													X				
Scarcity of type						X							X		X		
Site of special public interest	X											X					
Source of forage	X																
Source of water for crop irrigation	X															X	
Source of water for livestock	X																
Source of waterfowl for consumption	X													X			
Sport hunting/fishing	X	X												X		X	
Student safety																X	
Tactile quality	X																
Tourism or recreation attraction	X																
Traditional use area	X																
Unique regional resource	X											X	X				
Unusual geol. or structural features														X		X	
Use for domestic water supply	X											X				X	
Use for scientific research	X			X		X						X	X	X		X	
Use for sewage treatment	X											X					
Use of water for industry	X																
Utilized for cultural events	X																
Visibility from highway	X																
Visibility of open water																X	
Visual diversity													X				
Visual dominance	X					X											
Watchable wildlife	X															X	
Wells that serve public												X				X	
Winter recreation	X													X			

**Table 2**  
**Variables Used for Wetland Evaluation Appearing Three or More Times in the Literature**

Variables	Methodologies																	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
<b>Hydrology/Water Quality</b>																		
Contribute to groundwater quality	X	X	X				X					X					X	
Contribute to surface water quality	X	X	X						X			X						
Erosion control	X	X		X					X				X	X				
Flood protection/control	X			X					X								X	
Flooding extension and duration											X	X	X					
Flow augmentation	X	X										X		X				
Groundwater recharge	X		X									X						
Measure of D.O.			X							X		X	X					
Nutrient levels	X	X	X	X						X			X	X				
Nutrient removal												X		X			X	
Nutrient retention		X										X					X	
Production exports (organics)			X									X			X			
Sediment flow stabilization	X		X									X						
Sediment trapping		X	X						X			X	X				X	
Streambank shade			X							X							X	
Water depth										X		X	X		X			
<b>Landscape</b>																		
Contiguity among patches		X								X								X
Contiguity to stream/lake		X		X		X							X		X	X		
Contiguity to upland		X										X				X	X	
Cover type					X					X		X	X					
Diameter of canopy layer trees										X	X	X						
Dominant wetland class					X								X		X	X		
Edge effect of commun. types				X		X					X	X		X				

1 Witty et al., Wetland Eval. Guide.	7 Heeley, Motts, Groundwater Restor.	13 CORPS, WEM.
2 Gosselink, Le, Cum. Ass. of BLH.	8 Cable et al., HAT.	14 Euler et al., Ontario Method.
3 Cooper et al., Intermount Riparian.	9 Marble, Gross, Assess. Wet. Chairs.	15 Hollands, McGee, H&M.
4 Anchorage Assess.	10 USFWS, HEP.	16 Ammann, Stone, NH/CONN Meth.
5 Golet, Freshwater NE.	11 O'Neil et al., BLH.	17 North Carolina Meth.
6 Smardon, Fabos, Vis./cultural Model	12 Adamus, WET II.	

<b>Table 2 (Continued)</b>																	
<b>Variables</b>	<b>Methodologies</b>																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
<b>Landscape (Continued)</b>																	
Fetch and exposure												X		X	X		
Habitat diversity			X	X						X			X			X	
Internal wetland contrast						X						X		X			
Interspersion type					X				X	X	X	X			X	X	
Local topography											X	X			X		
Open water types				X						X		X		X			
Position within watershed				X					X			X			X		X
Proximity to other wetlands				X	X	X				X		X	X	X	X	X	
Scarcity of type						X						X		X			X
Sensitivity to disturbance				X							X	X					X
Size of watershed	X									X		X					X
Size of wetland		X	X	X	X	X		X	X	X		X		X	X	X	
Soils type				X						X		X		X			
Subclass richness					X								X		X		
Surficial geology							X					X			X		
Surrounding habitat types					X					X				X	X		
Vegetation class interspersion										X		X	X				
Vegetation community structure				X						X	X						
Vegetation cover-%										X	X	X	X				X
Vegetation diversity			X			X				X		X					
Vegetation type										X		X	X	X			
Wetland class richness					X								X		X	X	
Wetland type	X			X	X	X						X	X	X			
Width of wetland										X			X				X
<b>Wildlife/Habitat</b>																	
Abund. of aquatic insects/inverts			X							X		X					
Dominance of robust emergents				X						X			X	X			
Migration habitat	X			X								X					



<b>Table 2 (Concluded)</b>																	
<b>Variables</b>	<b>Methodologies</b>																
	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>12</b>	<b>13</b>	<b>14</b>	<b>15</b>	<b>16</b>	<b>17</b>
<b>Wildlife/Habitat (Continued)</b>																	
Rare/threat. endan. plants/animals	X	X		X								X	X	X	X	X	X
Significant habitat for birds				X						X		X					
Significant habitat for fish		X	X	X						X		X					
Significant habitat for sport fish	X									X		X					
Significant habitat for wildlife	X	X	X							X		X					X
Significant waterfowl habitat	X									X		X	X	X			
Sig. hbtt. for fish spawning/rearing										X			X	X			X
Species diversity								X		X		X					
Waterbird migration populations	X			X								X		X			
Wintering habitat										X		X	X	X			
<b>Recreation/Aesthetics</b>																	
Access to navigable waters													X		X	X	
Archaeol./paleon. resources	X											X					X
Commercial harvest (hunt, trap, fish)	X											X		X			
Distance from urban population	X											X		X			
Distance to education facility	X			X								X		X			X
Distance to roads										X		X	X				
Ease of access	X			X			X						X	X	X	X	
Educational use	X			X		X						X	X	X			X
Interpretive program	X			X										X			
Location (public/private land)	X			X								X	X	X	X		
Open space function	X			X									X				
Part of heritage of region	X											X	X				
Recreation experience (general)			X									X					X
Scarcity of type						X							X		X		
Sport hunting/fishing	X	X												X			X
Unique regional resource	X											X	X				
Use for domestic water supply	X											X					X
Use for scientific research	X			X		X						X	X	X			X

(Sheet 3 of 3)