Literature Review for Development of Maryland Wetland Monitoring Strategy: Reviews of Evaluation Methodologies

Kathryn C. Haering and John M. Galbraith
Department of Crop and Soil Environmental Sciences, Virginia Tech

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Introduction and definitions

Wetland assessment has been defined by Kusler (2004a) as "wetland related data-gathering, data analysis, and the presentation of resulting information to regulatory decision makers". Assessment methods directly or indirectly evaluate wetland functions. Some methods also evaluate services.

There is no universally accepted definition of wetland function. Earlier wetland assessment models were developed for help in wildlife management, and many of these evaluated only the habitat function (Kusler, 2004a). Later, models such as the Wetland Evaluation Technique, or WET (Adamus et al., 1987; 1991) assessed habitat, hydrologic and biogeochemical functions as well as "functions" such as recreation and uniqueness/heritage. The Hydrogeomorphic Approach (Smith et al., 1995) and related methods defined functions as ecological processes only.

Federal regulations now define wetland *functions* as the ecological processes that take in a wetland. However, MDE regulations define functions in terms of services. Wetland *services* are defined as "the benefits that human populations derive, directly or indirectly, from ecosystem functions" (Constanza et al., 1997). In some methods and related literature (Bartoldus, 1999, Fennessy et al., 2004), services are referred to as *values*.

Wetland *condition* is evaluated directly in some, but not all, assessment methods. Fennessy et al. (2004) defines condition as "the extent to which a given site departs from full ecological integrity (if at all)". Methods which measure condition generally provide a score which compares wetlands to a wetland with *reference standard condition.* Two definitions for reference standard condition are often used (Sutula et al., 2006):

1. "Culturally unaltered", implying a wetland that has never been affected by human activities, or
2. "Best attainable condition", implying or a wetland with the highest functional state that can be obtained given human alteration of the landscape

Wetland assessment techniques are classified as Levels 1, 2, or 3 based on the scope and detail required to complete the assessment. The U.S. EPA (2006) and MDE Wetlands and Waterways Program (2008) define these levels as follows:

- Level 1 Assessment: Landscape level assessment based on Geographic Information System (GIS) analysis using existing wetland and soil maps, land use and hydrology information. Not a field method, but is often verified by field methods.
- Level 2 Assessment: Rapid assessment based on data collection from easily observable field indicators. A Level 2 assessment usually lasts less than four hours in the field, has relatively simple metrics, and results in a single rating for each wetland. Level 2 assessments would be used most often in permit review and watershed assessments. Should be validated by appropriate Level 3 field methods.
- Level 3 Assessment: Comprehensive assessment involving collection of data from direct measurements and fewer indicators. Used to validate Level 1 and Level 2 assessments and to develop water quality standards.

Since any field method that takes more than 4 hours can technically be defined as "Level 3", the duration and intensity of Level 3 assessments may be highly variable. Level 1 and Level 2 methods should be validated with Level 3 methods which involve long-term, repeated sampling over at least one year to validate an indicator-based rapid assessment.

Objectives

The objectives of Task 2 were to:

a. Determine if the following questions could be answered for the wetland assessment methods in four compilations of methods: Fugro-McClelland East (1993), Bartoldus (1999), Fennessy et al. (2004) and Sutula et al. (2004).

b. Attempt to answer the following questions for at least 15 research studies designated by MDE, plus additional evaluation methods used in other states.

c. Supplement the initial screening as necessary by compiling and reviewing additional information.

The questions were:

1. Y/N. Can the method be used for Clean Water Act ambient condition monitoring in Maryland?
2. Y/N. Can the method be used for improved wetland regulatory monitoring for permit review and mitigation in Maryland?
3. Y/N. Can the method be used for monitoring for watershed planning efforts in Maryland?
4. Y/N. Can the method be used for monitoring of newly restored wetland restoration sites in Maryland?
5. Y/N. Can the method be used for identifying priority preservation areas in Maryland?
6. Y/N. Is the rationale for the method well developed?
7. What is the vegetation or wetland type(s) (Cowardin, NWI, or HGM) as identified by researchers?
8. How were different vegetative communities incorporated into the assessment?
9. Y/N. Is the model is restricted for use in the studied wetland types or does it say it can be used on other types?
10. In what region was the method was developed?
11. Y/N. Is the model restricted for use in the studied region or does it say it can be used in other areas?
12. Y/N. Was the method able to assess the studied function(s)?
13. Y/N. Do the methods adjust scores for sites based on successional stage? Y/N. Are the results supported by or in conflict with other research results?
14. Y/N. Is there a rigorous, valid statistical testing of the method? i.e., was the method validated with an appropriate statistical design or was the study limited to a few sites or limited sampling over time?
15. Y/N. Are the results statistically significant, or accompanied by an explanation for why results are not statistically significant?
16. Are there logistical concerns, such as complex or expensive equipment or supplies needed?
17. Y/N. Are there stated or flaws/limitations for using the method? If so, summarize stated limitations for the method in the paper, not in the table/spreadsheet.
18. How long does it take to conduct the assessment, in the field or office/desktop?
19. How many people are required to assess each site?

Criteria for answering Questions 1 through 5 are outlined below (personal communication, Denise Clearwater):

Question 1. Y/N. Can the method be used for Clean Water Act ambient condition monitoring in Maryland?
Assessment methods for Clean Water Act ambient condition monitoring should evaluate chemical, physical, and biological integrity for designated uses – thus the method should evaluate the full suite of functions and services, and should also evaluate condition (ecological integrity).

Question 2. Can the method be used for improved wetland regulatory monitoring for permit review and mitigation in Maryland?

Assessment methods for improved wetland regulatory monitoring should:

- Evaluates hydrologic, biogeochemical (water quality) and habitat functions.
- Evaluate condition.
- Be able to compare one wetland to another wetland, even if the wetlands are of different types.

Question 3. Y/N. Can the method be used for monitoring for watershed planning efforts in Maryland?
Assessment methods for watershed planning efforts should:

- Evaluate hydrologic, biogeochemical (water quality) and habitat functions.
- Evaluate condition.
- Be able to compare one wetland to another wetland, even if the wetlands are of different types.
- Allow for adjusted scores to highlight wetlands performing specified, preferred functions.

Question 4. Y/N. Can the method be used for monitoring of newly restored wetland restoration sites?
For voluntary wetland restoration sites, an evaluation method should, at the least, determine if the project was built as designed and meet the landowners and projects objectives. Preferably, the method would:

- evaluate surface water and/or groundwater levels
- evaluate vegetation success
- make a visual determination of soil organic matter
- list observable problems

Question 5. Y/N. Can the method be used for identifying priority preservation areas?
Identifying priority preservation areas typically requires a method that evaluates hydrologic, biogeochemical (water quality) and habitat functions. However, local land planners may want to rank certain functions/services higher than others, so in some cases, methods that do not evaluate all the functions above might be suitable.

Because the criteria for some of the questions were similar and/or were flexible, we substituted the following questions:

1. What general categories of functions are evaluated? (For example, hydrologic, biogeochemical/water quality, and habitat.)
2. Are services evaluated?
3. Is condition evaluated *directly*? In other words, is a single score that evaluates the ecological condition of the wetland provided? Although many methods indirectly assess condition, Fennessy et al (2004) notes “Methods best suited to measure condition reflect this by providing a quantitative measure describing where a wetland lies on the continuum ranging from full ecological integrity (i.e., the least impacted or reference condition) to highly degraded (poor condition).” Some methods which measure functions provide a score for each function evaluated, which makes it difficult to rate condition.

4. Can wetlands be compared to one another, even if they are different types?
5. Does the method allow for adjusted scores to highlight wetlands performing specified, preferred functions or services? (These are also known as "Value-added metrics")
6. Does the method evaluate large scale management goals and priorities for land and/or species conservation?
7. Does the method evaluate whether the area can sustain its ecological integrity over time, given current and projected adjacent land use changes?

We also added the following question:

8. Is the method Level 1 (landscape), Level 2 (rapid field) or Level 3 (comprehensive field)?

Fennessy et al. (2007) defines a rapid (Level 2) assessment as taking no more than two people a half day total in the field and requiring no more than another half day of office preparation and data analysis to obtain a result. We used these criteria to distinguish between Level 2 and Level 3 assessments. Assessment methods that typically require between 4-8 hours (1/2 to 1 day) in the field are labeled Level 2/3 in Table 2.

Part A: Reviewing Compilations

Introduction

For Part 2a, we determined whether the questions above could be adequately answered by the four methods compilations: Fugro-McClelland East (1993), Bartoldus (1999), Fennessy et al. (2004) and Sutula et al. (2004). We also supplemented the information given in the compilations with information from Adamus (1992), Kusler (2004a and 2006) and Fennessy et al. (2007)

Although the compilations provided a basic overview of many methods, we were not able to answer all the questions for the methods described in the compilations for several reasons:

- The compilations generally did not contain detailed information on field data collection, data analysis, and statistical evaluation.
- The compilations often did not supply detailed information on which indicators were used for functions and services for each method.
- The compilations did not usually summarize the original research on which each method was based.
- There was very little information available on some of the methods.
- The version of the method reviewed was not always the latest available, even in the newer compilations.

A more detailed study of selected methods will thus be provided in Part 2B of this report We determined that we could answer the following questions for most of the methods listed in the compilations:

1. What general categories of functions are evaluated? (For example, hydrologic, biogeochemical/water quality, and habitat.)
2. Are services evaluated?
3. Is condition evaluated?
4. Can wetlands be compared to one another, even if they are different types?
5. Is the method Level 1 (landscape), Level 2 (rapid field) or Level 3 (comprehensive field)? [When different estimated times to complete the method were given in two or more compilations, we used the estimated time given in Fennessy et al. (2004; 2007).]
6. In what region was the method was developed?
7. Is the model restricted for use in the studied physiographic region or does it say it can be used in other areas?
8. Are there stated or flaws/limitations for using the method? (Note: this was answered in the text rather than Table 2)
9. How long does it take to conduct the assessment, in the field or office/desktop? [Again, when different estimated times to complete the method were given in two or more compilations, we used the estimated time given in Fennessy et al. (2004; 2007).]

Compilation overview

We reviewed 37 methods from the four compilations (Table 1). Fugro-McClelland East (1993) reviewed 12 wetland assessment methods for their suitability for landscape level assessment. Several of the methods reviewed have been superseded by newer methods and/or appear to never have been used extensively. Bartoldus (1999) reviewed 40 assessment methods in detail, including the current MDE method. Again, several methods are outdated or appear never to have been used extensively. Fennessy et al. (2004) briefly reviewed 16 assessment methods, including the current MDE method, in a survey of rapid assessment methods and chose seven methods to review in detail. (Fennessy et al., however, did not interview MDE regarding its method.) The methods selected were those that (a) measured condition (b) were truly rapid (c) were on-site assessments and (d) were verifiable through level 3 assessment. The study was updated in Fennessy et al. (2007), and one of the seven "rapid" methods (the Penn State Stressor Checklist) was eliminated because it was not truly rapid. Sutula et al. (2004) described the development of the California Rapid Assessment Method (CRAM), and explained decisions that may need to be made while developing other rapid assessment methods.

Table 1. List of methods reviewed in this report with associated references.

Method	Reviewed by	References
Avian Richness Evaluation Method	Bartoldus, 1999	Adamus, P.R. 1993a. User's Manual: Avian Richness Evaluation Method (AREM) for lowland wetlands of the Colorado Plateau. EPA/600/R-93/240. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.
CRAM - California Rapid Assessment Method	Sutula et al., 2004	Collins, J., E. Stein, M. Sutula, 2004. Draft California Rapid Assessment Method for Wetlands (Version 2.0). San Francisco Estuary Institute and the Southern California Coastal Water Research Project, Westminster, CA.
Delaware Rapid Assessment Protocol	Fennessy et al., 2004	Jacobs, A. D. 2003. Delaware Rapid Assessment Procedure, Version 1.2. Delaware Department of Natural Resources and Environmental Control. Dover, DE. **Note:** this has apparently been superseded by: Jacobs, A.D. 2005. Delaware Rapid Assessment Procedure, Version 2.0. Delaware Department of Natural Resources and Environmental Control, Dover, DE.
Descriptive Approach	Bartoldus, 1999	U.S. Army Corps of Engineers. 1995. The highway methodology workbook supplement. Wetland functions and values: A descriptive approach. U.S. Army Corps of Engineers, New England Division. NENEP-360-1-30a. Available on-line at http://www.nae.usace.army.mil/reg/hwsplmnt.pdf
Evaluation for Planned Wetlands (EPW)	Bartoldus, 1999	Bartoldus, C.C., E.W. Garbisch, and M.L. Kraus. 1994. Evaluation for Planned Wetlands (EPW). Environmental Concern Inc., St. Michaels, MD. Bartoldus, C. C. 1994. EPW: A procedure for the functional assessment of planned wetlands. Water, Air and Soil Pollution, 77:533-541.
Florida Wetland Quality Index	Bartoldus, 1999; Fennessy et al., 2004	Lodge, T.E., H.O. Hillestad, S.W. Carney, and R.B. Darling. 1995. Wetland Quality Index (WQI): A method for determining compensatory mitigation requirements for ecologically impacted wetlands. Proceedings of the American Society of Civil Engineers South Florida Section Annual Meeting, Sept 22-23, 1995, Miami, FL.
Florida Wetland Rapid Assessment Procedure	Bartoldus, 1999; Fennessy et al., 2004	Miller, R.E., Jr. and B.E. Gunsalus. 1999. Wetland Rapid Assessment Procedure. Technical Publication REG-001. Natural Resource Management Division, Regulation Department, South Florida Water Management District, West Palm Beach, FL. Available on-line at: http://www.sfwmd.gov/org/reg/nrm/wrap99.htm

Table 1 (continued). List of methods reviewed in this report with associated references.

Method	Reviewed by	References
Habitat Assessment Technique (HAT)	Fugro-McClelland East, 1993; Bartoldus, 1999	Cable, T.T., V. Brack, Jr., and V.R. Holmes. 1989. Simplified method for wetland habitat assessment. Environmental Management 13:207-213
Habitat Evaluation Procedure (HEP)	Fugro-McClelland East, 1993; Bartoldus, 1999	USFWS. 1980. Habitat Evaluation Procedure manual. 102 ESM. U.S. Fish and Wildlife Service, Washington, DC. Available on-line at: http://www.fws.gov/policy/ESMindex.html USFWS. 1981. Standards for the development of Habitat Suitability Index models. 103 ESM. U.S. Fish and Wildlife Service, Washington, DC.
Hydrogeomorphic Approach (HGM)	Bartoldus, 1999	Smith, R.D., A. Ammann, C. Bartoldus, and M.M. Brinson. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. Wetlands Research Program Technical Report WRP-DE-9. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS.
Index of Biological Integrity (IBI)	Bartoldus, 1999	Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6(6): 21-27. Karr, J.R. and E.W. Chu. 1997. Biological monitoring and assessment: Using multimetric indexes effectively. EPA 235-R97-001. University of Washington, Seattle, WA. Danielson, T.J. 1998. Wetland bioassessment fact sheets. EPA 843-F-001. U.S. Environmental Protection Agency. Office of Wetlands, Oceans, and Watersheds, Wetlands Division, Washington, D.C.
Interim HGM (HGM Light)	Bartoldus, 1999	Whited, M. 1997. The NRCS interim hydrogeomorphic approach to functional assessment: what should it entail? USDA Natural Resources Conservation Service, Washington, DC. Available on-line at: ftp://ftp-fc.sc.egov.usda.gov/WLI/1212OldWLIfromUSGS/wli/WAIS1.htm
Larson-Golet Method	Fugro-McClelland East, 1993; Bartoldus, 1999	Larson, J.S. (ed). 1976. Models for assessment of freshwater wetlands. Publication No. 32, Water Resources Research Center, University of Massachusetts, Amherst, MA. Golet, F.C. 1976. Wildlife wetland evaluation model. p. 13-34 *In* Larson, J.S. (ed). Models for assessment of freshwater wetlands. Publication No. 32, Water Resources Research Center, University of Massachusetts, Amherst, MA. Golet, F.C., and J.S. Larson. 1974. Classification of freshwater wetlands in the glaciated Northeast. Resource Publication 116, U.S. Fish and Wildlife Service, Washington, D.C.

Table 1 (continued). List of methods reviewed in this report with associated references.

Method	Reviewed by	References
Massachusetts Coastal Zone Management Method	Fennessy et al., 2004	Hicks, A. L. and B. K. Carlisle. 1998. Rapid habitat assessment of wetlands. Macro-invertebrate survey version: Brief description and methodology. Massachusetts Coastal Zone Management Wetland Assessment Program, Amherst, MA.
MNRAM - Minnesota Routine Assessment Method	Bartoldus, 1999; Fennessy et al., 2004; Fugro-McClelland East, 1993 (earlier version)	Minnesota Board of Water and Soil Resources. 2003. Minnesota Routine Assessment Method for Evaluating Wetland Functions (MNRAM) Version 3.0. Minnesota Board of Water and Soil Resources, St. Paul, MN. **Note:** Fugro-McClelland East (1993) lists the Minnesota method as WEM (similar to WET), with the following reference*:* 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.
Montana Wetland Assessment Method	Bartoldus, 1999; Fennessy et al., 2004	Berglund, J. 1999. Montana wetland assessment method. Montana Department of Transportation and Morrison-Maierle, Inc., Helena, MT
New Hampshire Coastal Method	Bartoldus, 1999; Fennessy et al., 2004	Cook, R.A., A.J. Lindley Stone, and A.P. Ammann. 1993. Method for the evaluation and inventory of vegetated tidal marshes in New Hampshire. Audubon Society of New Hampshire, Concord, NH.
New Hampshire/Connecticut Method	Bartoldus, 1999; Fugro-McClelland East, 1993 Fennessy et al, 2004; (lists only NH method)	Ammann, A.P. and A. Lindley Stone. 1991. Method for the comparative evaluation of nontidal wetlands in New Hampshire. NHDES-WRD-1991-3. New Hampshire Department of Environmental Services, Concord, NH. Ammann, A.P., R.W. Frazen, and J.L. Johnson. 1986. Method for the evaluation of inland wetlands in Connecticut. DEP Bulletin No. 9. Connecticut Department of Environmental Protection, Hartford, CT.
North Carolina Coastal Region Evaluation of Wetland Significance (NC-CREWS)	Bartoldus, 1999	Sutter, L.A. and J.R. Wuenscher. 1996. NC-CREWS: A wetland functional assessment procedure for the North Carolina coastal area (Draft). Division of Coastal Management, North Carolina Department of Environment and Natural Resources, Raleigh, NC
North Carolina Guidance - Guidance for Rating the Values of Wetlands in North Carolina	Bartoldus, 1999	North Carolina Department of Environment and Natural Resources. 1995. Guidance for rating the values of wetlands in North Carolina. Raleigh, NC.

Table 1 (continued). List of methods reviewed in this report with associated references.

Method	Reviewed by	References
Ohio Rapid Assessment Method (ORAM)	Fennessy et al., 2004	Mack, J.J. 2001. Ohio rapid assessment method for wetlands v. 5.0: User's Manual and Forms. Ohio EPA Technical Report WET/2001-1. Ohio Environmental Protection Agency Division of Surface Water, Columbus, OH.
Ontario Wetland Evaluation Guide	Fugro-McClelland East, 1993	Bond, W.K., K.W. Cox, T. Heberlein, E.W. Manning, D.R. Witty, and D.A. Young. 1992. Wetland evaluation guide: Final report of the 'wetlands are not wastelands' project. Sustaining Wetlands Issues Paper No. 1992-1. North American Wetlands Conservation Council (Canada). Ottawa, Ontario.
Ontario Wetland Evaluation System	Fugro-McClelland East, 1993	Euler, D.L., F.T. Carreriro, G.B. McCullough, G.B. Snell, V. Glooschenko, and R.H. Spurr. 1983. An evaluation system for wetlands of Ontario south of the Precambrian Shield. Ontario Minstry of Natural Resources and Canadian Wildlife Service, Ontario Region. **Note:** This has apparently been superseded by**:** Ontario Ministry of Natural Resources. 1993. Ontario Wetland Evaluation System Southern Manual. NEST Technical Manual TM-002.
Oregon Freshwater Wetland Assessment Methodology (OFWAM)	Bartoldus, 1999; Fennessey et al., 2004	Roth, E., R. Olsen, P. Snow, and R. Sumner. 1996. Oregon freshwater wetland assessment methodology. Wetlands Program, Oregon Division of State Lands, Salem, OR.
Penn State Stressor Checklist	Fennessy et al., 2004	Brooks, R.P., D.H. Wardrop, and J.A. Bishop. 2002. Watershed-based protection for wetlands in Pennsylvania: Levels 1 & 2 - Synoptic maps and rapid field assessments. Report No. 2002-1. Penn State Cooperative Wetlands Center, University Park, PA.
Process for Assessing Proper Functioning Condition (PFC)	Bartoldus, 1999	Prichard, D., H. Barrett, J. Cagney, R. Clark, J. Fogg, K. Gebhart, P.L. Hansen, B. Mitchell, and D. Tippy. 1993. Riparian area management: Process for assessing proper functioning condition. TR 1737-9 (Revised 1998). Bureau of Land Management BLM/SC/ST-93/003+1737+REV95+REV98, Service Center, CO. Prichard, D., C. Bridges, R. Krapf, S. Leonard, and W. Hagenbuck. 1994. Riparian area management: Process for assessing proper functioning condition for lentic riparian-wetland areas. TR 1737-11. Bureau of Land Management, BLM/SC/ST-94/008+1737, Service Center, CO

Table 1 (continued). List of methods reviewed in this report with associated references.

Method	Reviewed by	References
Rapid Assessment Procedure (Hollands-Magee)	Bartoldus, 1999, Fugro-McClelland East, 1993 (earlier version)	Magee, D.W. 1998. A rapid procedure for assessing wetland functional capacity. Normandeau Associates, Bedford, NH. Association of State Wetland Managers, Berne, NY. ***Note:*** The precursor to this method is listed in both Bartoldus (1999) and Fugro-McClelland East (1993) as Hollands, G.G., and D.W. Magee. 1985. A method for assessing the functions of wetlands. Pages 108-118. *In* J. Kusler and P. Riexinger (eds.), Proceedings of the National Wetland Assessment Symposium. Association of Wetland Managers, Berne, NY.
Synoptic Approach	Fugro-McClelland East, 1993; Bartoldus, 1999	Liebowitz, Scott G., B.S. Abbruzzese, P.S. Adamus, L.E. Huges, and J.T. Irish, 1992. A synoptic approach to cumulative impact methodology. EPA-600-R92-167. U.S. Environmental Protection Agency Environmental Research Laboratory, Corvallis, OR. Abbruzzese, B., and S.G. Leibowitz. 1997. A synoptic approach for assessing cumulative impacts to wetlands. Environmental Management 21(3):457-475
VIMS method	Bartoldus, 1999; Fennessy et al., 2004	Bradshaw, J.G. 1991. A technique for the functional assessment of nontidal wetlands in the Coastal Plain of Virginia. Special Report No. 315 in Applied Marine Science and Ocean Engineering. Virginia Institute of Marine Science, College of William and Mary, Gloucester Point, VA.
Washington State Wetland Rating System - Eastern	Fennessy et al., 2004	Hruby, Thomas. 2004. Washington State wetland rating system for eastern Washington. Revised and annotated version. Ecology Publication # 04-06-15. Washington State Department of Ecology, Olympia, WA.
Washington State Wetland Rating System - Western	Fennessy et al., 2004; Bartoldus, 1999 (earlier version)	Hruby, Thomas. 2004. Washington State wetland rating system for western Washington. Ecology Publication # 04-06-025. Washington State Department of Ecology, Olympia, WA. **Note:** This is listed in Bartoldus (1999) as the Washington State Wetland Function Assessment Method (Hruby, T., T. Granger, K. Brunner, S. Cooke, K. Dublanica, R. Gersib, L. Reinelt, K. Richter, D. Sheldon, A. Wald, and F. Weinmann. 1998. Methods for assessing wetland functions. Volume I: Riverine and depressional wetlands in the lowlands of Western Washington. Washington State Department Department of Ecology Publication #98-106, and Hruby, T. and T. Granger. 1998. Methods for assessing wetland functions. Volume II: Procedures for collecting data in the lowlands of Western Washington. Washington State Department of Ecology Publication #98-107.)

Table 1 (continued). List of methods reviewed in this report with associated references.

Method	Reviewed by	References
WET - Wetland Evaluation Technique	Fugro-McClelland East, 1993; Bartoldus, 1999	Adamus, P. R., E. J. Clairain Jr., R. D. Smith, and R. E. Young. 1987. Wetland Evaluation Technique (WET). Volume II. Methodology. Report # FHWA-IP-88-029. Federal Highway Administration, Office of Implementation. McLean, VA Adamus, P.R., L.T. Stockwell, E.J. Clairain, M.E. Morrow, L.D. Rozas, and R.D. Smith. 1991. Wetland Evaluation Technique (WET). Volume I. Literature review and evaluation rationale. Technical Report WRP-DE-2. U.S. Army Engineers Waterways Experiment Station, Vicksburg, MS.
WEThings	Bartoldus, 1999	Whitlock, A.L., N.M. Jarman, J.A. Medina, and J.S. Larson. 1994a. WEThings: Wetland Habitat Indicators for nongame species. Volume I. TEI Publication 94-1. The Environmental Institute, University of Massachusetts, Amherst, MA Whitlock, A.L., N.M. Jarman, and J.S. Larson. 1994b. WEThings: Wetland Habitat Indicators for nongame species. Volume II. TEI Publication 94-2. The Environmental Institute, University of Massachusetts, Amherst, MA.
Wetland Value Assessment (WVA)	Bartoldus, 1999	Environmental Work Group. 1998. Wetland value assessment methodology and community models. Report of the Coastal Wetlands Planning, Protection, and Restoration Act Technical Committee, U.S. Fish and Wildlife Service, Lafayette, LA Louisiana Department of Natural Resources. 1994. Habitat assessment models for fresh swamp and bottomland hardwoods within the Louisiana Coastal Zone. Louisiana Department of Natural Resources, Baton Rouge, LA.
Wildlife Community Habitat Evaluation (WCHE)	Bartoldus, 1999	Schroeder, R.L. 1996a. Wildlife community habitat evaluation: A model for deciduous palustrine forested wetlands in Maryland. Technical Report WRP-DE-14, US Army Engineer Waterways Experiment Station, Vicksburg, MS
Wildlife Habitat Appraisal Procedure (WHAP)	Bartoldus, 1999	Frye, R. 1995. Wildlife Habitat Appraisal Procedure (WHAP). Texas Parks and Wildlife Department, Austin, TX.
Wisconsin Rapid Assessment Method (WIRAM)	Bartoldus, 1999; Fennessy et al., 2004; Fugro-McClelland East, 1993 (earlier version)	Wisconsin Department of Natural Resources. 1992. Rapid assessment methodology for evaluating wetland functional values. Wisconsin Department of Natural Resources, Madison, WI. **Note:** Fugro-McClelland East (1993) lists the Wisconsin method as WEM (similar to WET), with the following reference: US Army Corps of Engineers. 1983. Wetland evaluation methodology. Prepared for Wisconsin Department of Natural Resources, Bureau of Water Regulation and Zoning. U.S. Army Corps of Engineers, Rock Island, IL.

We eliminated some methods from the review process for various reasons:

- The New England Freshwater Wetlands Invertebrate Biomonitoring Protocol (Hicks, 1997) reviewed in Bartoldus (1999) was eliminated because it was a subset of the Index of Biological Integrity method.
- The Maine Tidal Method (Bryan et al., 1997) and the Narragansett Bay Method (Lipsky, 1997), which were listed separately in Bartoldus (1999) were eliminated because they were so similar to the New Hampshire Coastal Method.
- We eliminated the Pennsylvania Modified 1980 Habitat Evaluation Procedure (Palmer et al., 1993) and the Pennsylvania Wildlife Habitat Assessment and Management System (Palmer et al., 1993), both reviewed in Bartoldus (1999), because they were both versions of the Habitat Evaluation Procedure (HEP).
- We eliminated the Regulatory Assessment Method that was reviewed in Bartoldus (1999) but was never published. It appears to be a precursor to Kusler (2004b), which compiles recommendations for developing assessment methods.
- We also eliminated the Indicator Value Assessment (Hruby et al., 1995) that was reviewed in Bartoldus (1999) because it appears to be a tool for planning methods tool rather than an actual model.
- Since the Rapid Assessment method is an improved version of the Hollands-Magee method (Bartoldus, 1999), we did not review the Hollands-Magee method that was reviewed in both Fugro-McClelland East (1993) and Bartoldus (1999) separately.
- We eliminated the New Jersey Watershed Method (Zampella et al., 1994) reviewed in Bartoldus (1999) because it was a Level 1 demonstration project that was never used and/or revised, and the method author recommended revision prior to implementation.
- Two studies reviewed in Fugro-McClelland East (1993) were not reviewed because they did not appear to be assessment methods. The Croonquist and Brooks study (1991) that was reviewed in Fugro-McClelland East (1993) was a research project that assessed the effects of human activities on bird and mammal communities of wetlands and associated riparian areas in Pennsylvania. The Palustrine-Emergent Conceptual Model (Rosen et al., 1995: cited in the compilation as Rosen et al., 1993, but apparently never published as such) was described in Rosen et al. (1995) as a conceptual framework that could be used in the development of an assessment method for prairie potholes.

Results of compilation review

Results from the review of the compilations are presented in two parts. First:

1. A list of methods we reviewed sorted by assessment level with both a brief description and the associated limitations (if stated in the compilations).
2. An alphabetical tabular comparison of the wetland assessment methods from the compilations (Table 2). This summarizes answers to the specific questions about each method.

Level 1 methods

North Carolina Coastal Region Evaluation of Wetland Significance (NC-CREWS)
Reviewed in Bartoldus, 1999
Summary: This is a GIS-based landscape level method that predicts the relative ecological significance of wetlands at the watershed level.
Limitations: Not appropriate for small projects. Does not evaluate services. No upper limit on opportunity values for functions.

Synoptic Approach
Reviewed in Fugro-McClelland East, 1993; Bartoldus, 1999
Summary: The Synoptic Approach is a Level 1 method that uses watershed maps to evaluate natural functions (habitat, water quality and hydrologic), services, functional loss, and restoration potential of wetlands in a large geographic area. Individual wetlands are not ranked.
Limitations: Cannot rate or compare individual wetlands. Months to years required to develop and complete assessment.

Methods which combine Level 1 with Level 2 or 3

Ontario Wetland Evaluation Guide (combines Level 1 with either Level 2 or 3 evaluations, depending on user needs)
Reviewed in Fugro-McClelland East, 1993
Summary: The Ontario Wetland Evaluation Guide was designed to evaluate seven functions and services in three categories: life support (regulation/absorption, ecosystem health) social/cultural (aesthetic/recreation, cultural/psychological) and production (both natural and commercial). The method involves a decision tree which includes three stages, each requiring progressively more input from the user.
Limitations: Very time consuming, especially at later stages. Functions/services are different from those used in most other wetland assessment methods.

Penn State Stressor Checklist – 2002 version (combines Level 1 and Level 2 methods)
Reviewed in Fennessy et al., 2004
Summary: The Penn State Stressor Checklist combines a Level 1 landscape assessment with a Level 2 field assessment. It is an inventory of stressors at a site with adjustments for surrounding buffer areas. According to Fennessy et al. (2004), newer versions of the method will not require a landscape level assessment.
Limitations: Does not evaluate services. Assumes wetland is in good condition unless stressors are visible, which may not account for non-point source stressors.

Process for Assessing Proper Functioning Condition (PFC) (combines Level 1 and Level 2 methods)
Reviewed in Bartoldus, 1999
Summary: The Process for Assessing Proper Functioning Condition was designed by the U.S. Bureau of Land Management in order to evaluate whether of riparian-wetland areas on BLM-managed lands are functioning properly. Proper functioning condition is defined as follows (Bartoldus, 1999): "Riparian-wetland areas are functioning properly when adequate vegetation, landform, or large woody debris is present to dissipate stream energy associated with high water flows, thereby reducing erosion and improving water quality; filter sediment, capture bedload, and aid floodplain development; improve flood-water retention and ground-water recharge; develop root masses that stabilize streambanks against cutting action; develop diverse ponding, and channel characteristics to provide the habitat and the water depth, duration, and temperature necessary for fish production, waterfowl breeding, and other uses; and support greater biodiversity."
Limitations: The method is designed to assess riparian-wetland areas, not individual sites.

VIMS method (combines Level 1 and Level 2/3 methods)
Reviewed in Bartoldus, 1999; Fennessy et al., 2004
Summary: The VIMS method is primarily designed to assess wetlands on the basis of their opportunity to perform flood storage and storm flow modification, nutrient retention and transformation, sediment and toxicant trapping, sediment stabilization, wildlife habitat, aquatic habitat, public use, and other factors. It is mainly a desktop method.

Limitations: Opportunity is a large factor in scoring. No upper limit on opportunity values for functions. No overall score calculated for site.

WET - Wetland Evaluation Technique (combination of Level 1 and Level 3)
Reviewed in Fugro-McClelland East, 1993; Bartoldus, 1999
Summary: WET assesses habitat, hydrologic and biogeochemical functions as well as services such as recreation and uniqueness/heritage. The method involves three levels of evaluation, each requiring progressively more input from the user. WET uses "high/middle/low" ranking but no overall ranking,
Limitations: Time-consuming (according to Kusler, 2004a). May not be sensitive enough to distinguish differences between wetlands.

Level 2 methods

Avian Richness Evaluation Method

Reviewed in: Bartoldus, 1999

Summary: This Avian Richness Evaluation Method estimates number and species of birds in wetlands and riparian areas in the Colorado Plateau area of western Colorado, eastern Utah, and southwestern Wyoming. Information can then be input into the associated computer program to determine to determine how suitable each area is for specific species habitat.

Limitations: Evaluates habitat potential only. No direct evaluation of hydrological and biogeochemical functions.

California Rapid Assessment Method (CRAM)

Reviewed in Sutula et al., 2004

Summary: The California Rapid Assessment Method evaluates landscape context, hydrology, physical structure, and biotic structure as compared to undisturbed reference wetlands in order to assess ecological condition. Wetlands are evaluated by HGM class and cannot be compared between classes. A stressor checklist is included, but is scored independently.

Limitations: Does not measure services. Requires model for each type of wetland.

Delaware Rapid Assessment Protocol

Reviewed in Fennessy et al., 2004

Summary: This is a rapid assessment method evaluates wetland condition based on the presence or absence of stressors that affect hydrology, habitat, biogeochemical cycling, and the surrounding landscape. Function is inferred based on whether stressors are present or not.

Limitations: Does not evaluate services. Assumes wetland is in good condition unless stressors are visible, which may not account for non-point source stressors.

Descriptive Approach

Reviewed in: Bartoldus, 1999

Summary: The Descriptive Approach was developed by the Corps of Engineers New England Division, and is a very rapid qualitative evaluation of the presence or absence of 13 functions and values, including ground water recharge/discharge; flood flow alteration; fish and shellfish habitat; sediment/toxicant/pathogen retention; nutrient removal, retention, and transformation; production export; sediment and shoreline stabilization; wildlife habitat; recreation; educational or scientific value; uniqueness/heritage; visual quality/aesthetics; and threatened or endangered species habitat. Functions and values are evaluated using best professional judgment. Wetlands within the region can be directly compared to each other.

Limitations: Some subjective decisions required. No upper limit on opportunity values for functions. Bartoldus (1999) notes that upper limits on opportunity levels must be defined to make certain that the wetland will have the capacity to provide the measured function. For example, a wetland which receives high nutrient input has a high

opportunity for nutrient removal, but may not have the capacity to remove all nutrients entering the wetland.

Evaluation for Planned Wetlands (EPW)

Reviewed in Bartoldus, 1999

Summary: The Evaluation for Planned Wetlands is a rapid procedure for evaluating function and services when comparing planned wetlands to other wetlands, but can also be used in restoration, permit review, or watershed inventor. It evaluates five functions: shoreline bank erosion control, sediment stabilization, water quality, wildlife habitat, and fish habitat; plus one service: uniqueness/heritage. It has some features of HGM but does not use a reference standard.

Limitations: Cannot directly compare wetlands from different classes (e.g., tidal vs. non-tidal, or non-tidal stream/river vs. non-tidal pond/lake.) Limited number of functions/services evaluated.

Florida Wetland Rapid Assessment Procedure

Reviewed in Bartoldus, 1999; Fennessy et al., 2004

Summary: The Florida Rapid Wetland Assessment procedure was designed to evaluate freshwater wetlands that were created, enhanced, preserved, or restored by the South Florida Water Management District. It evaluates six functions: wildlife utilization; overstory/shrub canopy of desirable species; wetland vegetative ground cover of desirable species; adjacent upland/wetland buffer; field indicators of wetland hydrology; and water quality input and treatment.

Limitations: Scores weighted towards wildlife habitat. Many variables require subjective judgment.

Massachusetts Coastal Zone Management Method

Reviewed in Fennessy et al., 2004

Summary: This is a rapid assessment method was primarily designed to evaluate macroinvertebrate habitat, but includes landscape features and stressors that would affect habitat. It results in a single score that can be used to evaluate condition.

Limitations: Stressors caused by human activities are combined into one category.

Minnesota Routine Assessment Method (MNRAM)

Reviewed in Bartoldus, 1999; Fennessy et al., 2004; Fugro-McClelland East, 1993 (earlier version)

Summary: MNRAM evaluates 12 hydrologic, biochemical and habitat functions, as well as services, relative to reference wetlands. A computer program is used to score each function.

Limitations: Can only directly compare wetlands of same type. Does not directly evaluate condition. May require GIS to answer some questions. No upper limit on opportunity values for functions.

Montana Wetland Assessment Method

Reviewed in Bartoldus, 1999; Fennessy et al., 2004

Summary: The Montana Wetland Assessment Method was specifically developed to find wetlands which provide unique and valuable functions or services. Evaluates 12 hydrologic, biochemical and habitat functions, and also evaluates services. It provides a single score that can represent condition.
Limitations: No upper limit on opportunity values for functions.

North Carolina Guidance - Guidance for Rating the Values of Wetlands in North Carolina
Reviewed in Bartoldus, 1999
Summary: The North Carolina Guidance assesses the following functions: water storage, bank and shoreline stabilization, pollutant removal, wildlife habitat. It also assesses services such as recreational and educational value. It can directly compare all freshwater wetlands.
Limitations: The method produces an overall score, but recreational/educational values are included in that score, so it does not directly assess condition. No upper limit on opportunity values for functions.

Ohio Rapid Assessment Method (ORAM) - 2001 version
Reviewed in Fennessy et al., 2004
Summary: ORAM is a rapid assessment method which evaluates condition by rating wetlands on habitat connectivity, average buffer width, percent of wetland with buffer, buffer condition, water sources, hydroperiod, hydrologic connectivity, physical patch types, topographic complexity, organic matter accumulation, biotic patch types, vertical structure, interspersion and zonation, native plant species richness, and percent invasive plant species. The method adds points for rare wetland types.
Limitations: None stated in compilations.

Washington State Wetland Rating System – Eastern
Reviewed in Fennessy et al., 2004
Summary: The Eastern version of the Washington State Wetland Rating System Method assesses wetlands for (1) functions performed and (2) special characteristics. It evaluates wetlands based on HGM type. Extra points are awarded for rare wetland types.
Limitations: Does not measure condition. Some wetlands are rated higher based on opportunity. Function score is doubled for wetlands which have the opportunity to perform a certain functions.

Washington State Wetland Rating System - Western
Reviewed in Fennessy et al., 2004; Bartoldus, 1999 (earlier version)
Summary: The Western version of the Washington State Wetland Rating System Method assesses wetlands based on (1) sensitivity to disturbance (2) rarity, and (3) functions performed. Extra points are awarded for rare species, rare wetland types, and "irreplaceable areas".
Limitations: Some wetlands are rated higher based on opportunity.

Wetland Value Assessment (WVA)
Reviewed in Bartoldus, 1999.

Summary: The Wetland Value Assessment method was designed to assess habitat quantity and quality in Coastal Louisiana fresh, salt, and brackish wetlands. It was adapted from HEP.
Limitations: Evaluates habitat potential only. No direct evaluation of hydrological and biogeochemical functions.

WEThings (can be Level 2 or Level 3, depending on wetland complexity)
Reviewed in Bartoldus, 1999
Summary: WEThings is a computer program developed to evaluate wildlife habitat potential in New England wetlands for impact assessment and resource management. It Measures habitat suitability for several species of amphibians, reptiles, and mammals, and can be used with WET.
Limitations: Evaluates habitat potential for a limited number of species only. No direct evaluation of hydrological and biogeochemical functions.

Wildlife Community Habitat Evaluation (WCHE) (Can be either Level 2 or Level 3 depending on user needs)
Reviewed in Bartoldus, 1999
Summary: The Wildlife Community Habitat Evaluation was developed to evaluate wildlife habitat potential in deciduous palustrine forested wetlands in Maryland. It measures habitat suitability for birds, reptiles and amphibians and can be used with WET.
Limitations: Evaluates habitat potential only. No direct evaluation of hydrological and biogeochemical functions.

Wisconsin Rapid Assessment Method (WIRAM)
Reviewed in Bartoldus, 1999; Fennessy et al., 2004; Fugro-McClelland East, 1993 (earlier version)
Summary: WIRAM evaluates the ability of a wetland following functions and services: floral diversity; wildlife habitat; fishery habitat; flood/stormwater attenuation; water quality protection; shoreline protection; groundwater; and aesthetics/recreation/education. Sites are then rated low, medium, high, exceptional, or N/A for each function or service.
Limitations: No overall score for site. No upper limit on opportunity values for functions

Level 2 methods that require model development before use

Hydrogeomorphic Approach (HGM)

Reviewed in Bartoldus, 1999

Summary: The Hydrogeomorphic Approach measures wetland hydrologic, biogeochemical, and habitat functional capacity by comparing wetlands within regional subclasses to reference wetlands of the same subclass.

Limitations: Complicated, time consuming, expensive. Does not directly evaluate condition because no overall score is calculated. Does not evaluate services.

Interim HGM (HGM Light)

Reviewed in Bartoldus, 1999

Summary: Interim HGM is used by the NRCS. It is based on the HGM Approach, but models are calibrated using best professional judgment and literature values rather than reference wetlands. (Note that HGM models may be developed from the Interim HGM models after they are calibrated using reference wetlands.)

Limitations:

Model development is time-consuming. Does not address services. Does not directly evaluate condition because no overall score is calculated.

Rapid Assessment Procedure (improved Hollands-Magee)

Reviewed in Bartoldus, 1999, Fugro-McClelland East, 1993 (earlier version)

Summary: The Rapid Assessment Procedure is an improved version of the Hollands-Magee method. It is both (1) a specific assessment procedure for assessing functions in wetlands in glaciated areas of the U.S. Northeast and Midwest and (2) a template for developing procedures for other areas. The method measures both functions and services with numerical ranking. It has some features of HGM but does not use a reference standard.

Limitations: Depends on expertise of users so can be biased. Time consuming, and requires expertise in geology/hydrology/botany/ecology. Uses ordinal values in mathematical calculations.

Level 3 methods:

Florida Wetland Quality Index
Reviewed in Bartoldus, 1999; Fennessy et al., 2004
Summary: The Florida Wetland Quality Index was designed to evaluate wetland mitigation areas. It assesses 17 hydrologic, biogeochemical and habitat functions, but its primary focus is wildlife habitat.
Limitations: Designed for mitigation sites so might not be suitable for some natural wetlands. Scores weighted towards wildlife habitat.

Habitat Assessment Technique (HAT)
Reviewed in Fugro-McClelland East, 1993; Bartoldus, 1999
Summary: The Habitat Assessment Technique assesses bird habitat in wetlands and other areas. It requires direct species surveys with at least three visits.
Limitations: Evaluates habitat potential only. No direct evaluation of hydrological and biogeochemical functions. A model must be developed for each state.

Habitat Evaluation Procedure (HEP)
Reviewed in Fugro-McClelland East, 1993; Bartoldus, 1999
Summary: The Habitat Evaluation Procedures assesses habitat potential for wildlife, fish, invertebrates for wetlands and other landscapes based on structural features. It requires a model for each species and type of wetland being evaluated, and site visits to confirm the model. It can directly compare habitats within the range of the species being evaluated.
Limitations: Evaluates habitat potential only. No direct evaluation of hydrological and biogeochemical functions.

IBI - Index of Biological Integrity
Reviewed in Bartoldus, 1999
Summary: The Index of Biological Integrity evaluates biological condition using data on plant and animal habitat and hydrology. Sites with various levels of disturbance are compared to a reference site, and then indicator species are used to assess condition.
Limitations: Time consuming and expensive. Difficult to create index that is accurate in every season/year. Cannot directly compare different habitats within a region or similar habitats across regions. Biological integrity does not necessarily relate to other functions and services such as flood storage, etc.

Larson-Golet Method
Reviewed in Fugro-McClelland East, 1993; Bartoldus, 1999
Summary: The Larson-Golet method was one of the first relatively rapid assessment methods. It assesses wildlife, groundwater potential and visual/cultural value. It was used to develop several newer assessment methods.
Limitations: Measures only a limited number of functions or services. Some of the assumptions that the method is based on are outdated

New Hampshire Coastal Method

Reviewed in Bartoldus, 1999; Fennessy et al., 2004

Summary: The New Hampshire Coastal Method evaluates hydrologic, biogeochemical, and habitat functions, and several services. According to Fennessy et al., 2004, this method does not directly evaluate condition. However, it does provide a score for ecological integrity, which we feel is equivalent to condition.

Limitations: Time-consuming (according to Kusler, 2004a). Does not provide overall score for each wetland.

New Hampshire/Connecticut Methods

Reviewed in Bartoldus, 1999; Fennessy et al, 2004; Fugro-McClelland East, 1993

Summary: The New Hampshire and Connecticut methods are very similar, with slight regional adjustments for each method. Both methods assess hydrologic, biogeochemical, and habitat functions, plus services. Evaluation of both functions and services results in a numerical score output that can be used to compare wetlands.

Limitations: Time-consuming (according to Kusler, 2004a). No upper limit on opportunity values for functions. Uses ordinal values in mathematical calculations.

Ontario Wetland Evaluation System

Reviewed in Fugro-McClelland East, 1993

Summary: The Ontario Wetland Evaluation System addresses hydrologic, biogeochemical, and habitat functions, along with services such as recreation, aesthetics, educational value, etc. It is similar to the Rapid Assessment (improved Hollands-Magee) method.

Limitations: Depends on expertise of users so can be biased. Time consuming. Uses ordinal values in mathematical calculations.

Oregon Freshwater Wetland Assessment Methodology (OFWAM)

Reviewed in Bartoldus, 1999; Fennessy et al., 2004

Summary: OFWAM evaluates 9 functions and services: wildlife habitat; fish habitat; water quality; hydrologic control; sensitivity to impact; enhancement potential; education; recreation; and aesthetic quality. It allows for increased scores for wetlands performing preferred functions or services.

Limitations: Time-consuming (according to Kusler, 2004a). Some questions are not clearly defined. May result in higher scores for larger or wetter wetlands. No upper limit on opportunity values for functions.

Wildlife Habitat Appraisal Procedure (WHAP)

Reviewed in Bartoldus, 1999

Summary: The Wildlife Habitat Appraisal Procedure is a procedure for assessing wildlife habitat in wetlands, bottomlands, and uplands in Texas. It evaluates vegetative cover and other habitat elements as well as protected/endangered species.

Limitations: Evaluates habitat potential only. No direct evaluation of hydrological and biogeochemical functions.

Tabular comparison of wetland assessment methods

Table 2. Comparison of wetland assessment methods from compilations.

Method	*Compilation*	*Which categories of functions are evaluated?*	*Are services evaluated?*	*Is condition evaluated directly?*	*Can method compare wetlands of different classes/types?*	*Level 1, 2, or 3?*	*Region in which method was developed*	*Can it be used in other areas?*	*How long does it take (either in field or in office)?*
Avian Richness Evaluation Method	Bartoldus, 1999	Bird habitat	No	No	Yes	Level 2	Colorado Plateau	Not as is	2 hours in field after wetland delineation plus additional time for plus data entry
California Rapid Assessment Method (CRAM)	Sutula et al., 2004	Hydrologic, biogeochemical, habitat	No	Yes	Wetlands can only be compared within regional subclasses	Level 2	California	Not as is	2.1 ± 0.9 hours (for two people)
Delaware Rapid Assessment Protocol	Fennessy et al., 2004	Effects of stressors on hydrologic, biogeochemical, habitat functions	No	Yes	No, because scoring is different for different subclasses	Level 2	Delaware	Not as is	<1/2 day
Descriptive Approach	Bartoldus, 1999	Hydrologic, biogeochemical, habitat	Yes	No	Yes	Level 2	New England	Not as is	2 hours per 1 acre site
Evaluation for Planned Wetlands (EPW)	Bartoldus, 1999	Hydrologic, biogeochemical, habitat	Yes	No	Can only compare wetlands of same general type (tidal, non-tidal stream/river, non-tidal pond/lake)	Level 2	National method	National method	1 hour per 1 acre site in field plus variable amounts of office time.

Table 2 (continued). Comparison of wetland assessment methods from compilations.

Method	*Compilation*	*Which categories of functions are evaluated?*	*Are services evaluated?*	*Is condition evaluated directly?*	*Can method compare wetlands of different classes/types?*	*Level 1, 2, or 3?*	*Region in which method was developed*	*Can it be used in other areas?*	*How long does it take (either in field or in office)?*
Florida Wetland Quality Index	Bartoldus, 1999; Fennessy et al., 2004	Hydrologic, biogeochemical, habitat	No	No	Yes, but only within the Everglades	Level 3	Florida Everglades	Not as is	1 day or more
Florida Wetland Rapid Assessment Procedure	Bartoldus, 1999; Fennessy et al., 2004	Hydrologic, biogeochemical, habitat	No	Yes	No	Level 2	Freshwater wetlands in Florida	Not as is	<1 day
Habitat Assessment Technique (HAT)	Fugro-McClelland East, 1993; Bartoldus, 1999	Bird habitat	No	No	Yes	Level 3 after model development	National method	Models must be developed for each state	Requires at least 3 visits of 1 hour per 1 acre site after breeding bird numbers for state are compiled.
Habitat Evaluation Procedure (HEP)	Fugro-McClelland East, 1993 (HEP only); Bartoldus, 1999	Wildlife habitat	No	No	Yes	Level 3 after model development (possibly Level 2 if site is very simple)	National method	Models must be developed for each species	1 day or more for 1 acre site.
Hydrogeomorphic Approach (HGM)	Bartoldus, 1999	Hydrologic, biogeochemical, habitat	No	No	Wetlands can only be compared within regional subclasses	Level 2 after model development. U.S. EPA (2006) considers this to be a Level 3 method.	National method	Models must be developed for each regional subclass	2 months or more to develop model, then 1-2 hours per 1 acre site for assessment.

Table 2 (continued). Comparison of wetland assessment methods from compilations.

Method	*Compilation*	*Which categories of functions are evaluated?*	*Are services evaluated?*	*Is condition evaluated directly?*	*Can method compare wetlands of different classes/types?*	*Level 1, 2, or 3?*	*Region in which method was developed*	*Can it be used in other areas?*	*How long does it take (either in field or in office)?*
Index of Biological Integrity (IBI)	Bartoldus, 1999	Biological condition	No	Yes	Wetlands can only be compared if they are similar habitat types within the same geographic region.	Level 3 after model development	National method	Model must be developed for each state	2 months or more to develop model, then 4 hours field and 4 hours lab per site.
Interim HGM (HGM Light)	Bartoldus, 1999	Hydrologic, biogeochemical, habitat	No	No	Wetlands can only be compared within regional subclasses	Level 2 after model development	National method	Models must be developed for each regional subclass	1 month or more to develop model, then 1-2 hours per 1 acre site for assessment.
Larson-Golet Method	Fugro-McClelland East, 1993; Bartoldus, 1999	Wildlife habitat, groundwater potential	"Visual-cultural" only	No	Yes	Level 3	Freshwater non-tidal wetlands in glaciated Northeast U.S.	Not as is	9-18 hours
Massachusetts Coastal Zone Management Method	Fennessy et al., 2004	Designed to evaluate macroinvertebrate habitat	No	Yes	Method has two versions - tidal and non-tidal: wetlands cannot be compared across versions.	Level 2	Tidal and non-tidal wetlands in Massachusetts	Not as is	1/2 day

Table 2 (continued). Comparison of wetland assessment methods from compilations.

Method	*Compilation*	*Which categories of functions are evaluated?*	*Are services evaluated?*	*Is condition evaluated directly?*	*Can method compare wetlands of different classes/types?*	*Level 1, 2, or 3?*	*Region in which method was developed*	*Can it be used in other areas?*	*How long does it take (either in field or in office)?*
Minnesota Routine Assessment Method (MNRAM)	Bartoldus, 1999; Fennessy et al., 2004; Fugro-McClelland East, 1993 (earlier version)	Hydrologic, biogeochemical, habitat	Yes	No	No	Level 2	Freshwater wetlands in Minnesota	Not as is	1/2 day
Montana Wetland Assessment Method	Bartoldus, 1999; Fennessy et al., 2004	Hydrologic, biogeochemical, habitat	Yes	Yes	Yes	Level 2	Freshwater wetlands in Montana	Not as is. Parts of this method were used to develop CRAM.	1/2 day
New Hampshire Coastal Method	Bartoldus, 1999; Fennessy et al., 2004	Hydrologic, biogeochemical, habitat	Yes	Yes - as ecological integrity.	Tidal wetlands only	Level 3	Tidal wetlands in New Hampshire	Not as is. Has been adapted for use in Maine and Rhode Island	More than 1 day
New Hampshire/ Connecticut method	Bartoldus, 1999; Fugro-McClelland East, 1993; Fennessy et al., 2004	Hydrologic, biogeochemical, habitat	Yes	Possibly, if adapted to area	Possibly, if adapted to area	Level 3	Non-tidal wetlands in New Hampshire and Connecticut	Not as is. Used as a template for OFWAM method; portions were adapted for VIMS method.	More than 1 day

Table 2 (continued). Comparison of wetland assessment methods from compilations.

Method	*Compilation*	*Which categories of functions are evaluated?*	*Are services evaluated?*	*Is condition evaluated directly?*	*Can method compare wetlands of different classes/types?*	*Level 1, 2, or 3?*	*Region in which method was developed*	*Can it be used in other areas?*	*How long does it take (either in field or in office)?*
North Carolina Coastal Region Evaluation of Wetland Significance (NC-CREWS)	Bartoldus, 1999	Hydrologic, biogeochemical, habitat - on landscape level.	No	Yes - as overall ecological significance	Yes	Level 1	Tidal and non-tidal wetlands in coastal North Carolina	Not as is	Approx. 3-9 days per watershed
North Carolina Guidance (Guidance for Rating the Values of Wetlands in North Carolina	Bartoldus, 1999	Hydrologic, biogeochemical, habitat	Yes	No	Yes (freshwater only)	Level 2	Freshwater wetlands in North Carolina	Not as is	Approx. 1 hour per 1 acre site in field.
Ohio Rapid Assessment Method (ORAM)	Fennessy et al., 2004	Hydrologic, habitat	Extra points are awarded for rare wetland types.	Yes	Yes	Level 2	Ohio	Not as is. Parts of this method were used to develop CRAM.	1/2 day
Ontario Wetland Evaluation Guide	Fugro-McClelland East, 1993	Hydrologic, biogeochemical, habitat	Yes	Unclear	Unclear	Level 1, 2, or 3 depending on user needs	Ontario	Possibly in glaciated areas of the U.S. if adapted	Not directly stated, but appears to be more than 1 day.
Ontario Wetland Evaluation System	Fugro-McClelland East, 1993	Hydrologic, biogeochemical, habitat	Yes	Unclear	Yes	Level 3	Ontario	Not as is	"Hours to days" (Adamus, 1992)

Table 2 (continued). Comparison of wetland assessment methods from compilations.

Method	*Compilation*	*Which categories of functions are evaluated?*	*Are services evaluated?*	*Is condition evaluated directly?*	*Can method compare wetlands of different classes/types?*	*Level 1, 2, or 3?*	*Region in which method was developed*	*Can it be used in other areas?*	*How long does it take (either in field or in office)?*
Oregon Freshwater Wetland Assessment Methodology (OFWAM)	Bartoldus, 1999; Fennessy et al., 2004	Hydrologic, biogeochemical, habitat	Yes	No	Yes	Level 3	Freshwater wetlands in Oregon	Not as is. Parts of this method were used to develop ORAM.	More than 1 day
Penn State Stressor Checklist	Fennessy et al., 2004	Effects of stressors on hydrologic, biogeochemical, habitat functions	No	Yes	Yes	Combination of Level 1 and Level 2	Freshwater wetlands in Pennsylvania	Not as is. Parts of this method were used to develop CRAM.	More than 1/2 day
Process for Assessing Proper Functioning Condition	Bartoldus, 1999	Hydrologic, biogeochemical, habitat	No	Yes	Yes, but within riparian-wetland areas only.	Combination of Level 1 and Level 2	Riparian-wetland areas managed by U.S. BLM	Yes, but some portions will require regional adaptation.	Approx. 8-24 hours for each study area
Rapid Assessment Procedure (Hollands-Magee)	Bartoldus, 1999, Fugro-McClelland East, 1993 (earlier version)	Hydrologic, biogeochemical, habitat	Yes - depending on regional model.	No	No. Can only directly compare wetland from the same regional class.	Level 2 after model development	Glaciated Northeast and Midwest U.S.	Yes, if adapted. This method was used to develop the MDE method.	1-2 hours/site after model development
Synoptic Approach	Fugro-McClelland East, 1993; Bartoldus, 1999	Hydrologic, biogeochemical, habitat	Yes	Unclear	Can only compare geographic areas - not individual wetlands.	Level 1	National method	National method	Several months per geographic area

Table 2 (continued). Comparison of wetland assessment methods from compilations.

Method	*Compilation*	*Which categories of functions are evaluated?*	*Are services evaluated?*	*Is condition evaluated directly?*	*Can method compare wetlands of different classes/types?*	*Level 1, 2, or 3?*	*Region in which method was developed*	*Can it be used in other areas?*	*How long does it take (either in field or in office)?*
VIMS Method	Bartoldus, 1999; Fennessy et al., 2004	Hydrologic, biogeochemical, habitat	Yes	No	Yes	Combination of Level 1 and Levels 2/3	Virginia Coastal Plain	Not as is	Over 1 day
Washington State Wetland Rating System - Eastern	Fennessy et al., 2004	Hydrologic, biogeochemical, habitat	Extra points are awarded for rare wetland types.	No	No. Wetlands can only be compared by HGM class.	Level 2	Eastern Washington State	Not as is	1/2 day
Washington State Wetland Rating System - Western	Fennessy et al., 2004; Bartoldus, 1999 (earlier version)	Hydrologic, habitat	Extra points are awarded for rare species, rare wetland types, etc.	Yes	Yes	Level 2	Western Washington State	Not as is	1/2 day
WET: Wetland Evaluation Technique	Fugro-McClelland East, 1993; Bartoldus, 1999	Hydrologic, biogeochemical, habitat	Yes	No	Yes	Combination of Level 1 and Level 3	National method	Yes, if adapted. This method was used to develop part of the VIMS method.	Approx. 14-42 hours.
WEThings	Bartoldus, 1999	Habitat	No	No	Yes	Level 2 or 3 - depending on wetland complexity	New England	Possibly, if similar species are present.	1-2 hours per wildlife cover type.

Table 2 (continued). Comparison of wetland assessment methods from compilations.

Method	*Compilation*	*Which categories of functions are evaluated?*	*Are services evaluated?*	*Is condition evaluated directly?*	*Can method compare wetlands of different classes/types?*	*Level 1, 2, or 3?*	*Region in which method was developed*	*Can it be used in other areas?*	*How long does it take (either in field or in office)?*
Wetland Value Assessment (WVA)	Bartoldus, 1999	Habitat	No	No	No, except for restoration projects	Level 2	Coastal Louisiana	Not as is	1 hour per 1 acre site.
Wildlife Community Habitat Evaluation (WCHE)	Bartoldus, 1999	Habitat	No	No	Can only compare deciduous palustrine forested wetlands within Maryland.	Level 2 or 3 depending on user needs	Maryland	Not as is	Variable depending on user needs
Wildlife Habitat Appraisal Procedure (WHAP)	Bartoldus, 1999	Habitat	No	No	Yes	Level 3	Texas	Not as is	8 hours per study area
Wisconsin Rapid Assessment Method (WIRAM)	Bartoldus, 1999; Fennessy et al., 2004; Fugro-McClelland East, 1993 (earlier version)	Hydrologic, biogeochemical, habitat	Yes	No	Yes	Level 2/3	Wisconsin	Not as is. Was used to develop MNRAM.	1 day

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