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ASSESSING THE NATURAL AND BENEFICIAL FUNCTIONS OF FLOODPLAINS:

Issues and Approaches; Future Directions

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Cover Photo from EPA 2002 Wetland Photo Contest and posted to the Web.
http://water.epa.gov/type/wetlands/photocontest2002.cfm
by Dennis Demcheck, *Mississippi/Atchafalaya River Floodplain*
Lake Fausse Point, Louisiana

PREFACE

This report has been prepared to help federal, state and local floodplain management staff, water planners, wetland managers and others assess, protect and restore floodplain "natural and beneficial" functions. It has been prepared, more specifically, to:

(1) Identify and explore user needs for assessment of the natural and beneficial functions.
(2) Describe selected wetland and floodplain methods and techniques, which have been developed to assess such functions and values.
(3) Describe some "lessons learned" with regard to the application of these techniques.
(4) Suggest productive directions for improved future, cooperative federal, state and local assessment efforts.

The report is based upon a number of sources of information and incorporates materials from earlier reports and papers. It is based upon:

(1) A literature review. See bibliography.
(2) A review of floodplain and wetland assessment websites. See list of websites at the end of this paper.
(3) Discussions with a variety of experts in wetland, riparian, river/stream assessment.
(4) Studies by Jon Kusler and the Association of State Wetland Managers dealing with wetland assessment for regulatory purposes. For final reports from these efforts see, e.g., Kusler, J. Report 1. Wetland Assessment for Regulatory Purposes: Assessing Functions and Values. http://aswm.org/pdf_lib/assessing_functions_values.pdf; Kusler, J. Report 2. Wetland Assessment for Regulatory Purposes: Wetland Assessment in the Courts. http://aswm.org/pdf_lib/assessment_courts.pdf; Kusler, J. Report 3. Wetland Assessment for Regulatory Purposes: Integrating Wetland Assessment Into Regulatory Permitting (2004). http://aswm.org/pdf_lib/integrating_assessment_permitting.pdf.
(5) A series of workshops and symposia wholly or in part concerning wetland, riparian and river/stream assessment conducted by the Association of State Wetland Managers in Washington, D.C.; Annapolis, Maryland; Fairlee, Vermont; Albuquerque, New Mexico; and Park City, Utah.

We hope that you will find the report useful and that it will stimulate your own thinking. Please see suggested readings and websites for more detailed discussion of topics.

Sincerely,

Jon Kusler

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EXECUTIVE SUMMARY; RECOMMENDATIONS

There is growing interest at all levels of government in the U.S. and abroad[1] in improved methods to assess floodplain "natural and beneficial" functions including wetlands and other sub-components of floodplains.[2] Such assessments are needed to aid in the implementation of a variety of programs at all levels of government for water resources development, flood loss reduction, wetland and ecosystem protection and restoration, greenway planning, local land use planning, watershed planning and management, infrastructure planning (roads, highways), public land management and other purposes. Congress has established the protection of floodplain natural resources as a national goal for federal water projects and for implementation of the Community Rating System by the Federal Emergency Management Agency.

No overall, widely accepted "model"[3] has been developed to assess floodplain natural and beneficial functions. Rather, assessment models and methods have been developed for specific portions of the floodplain and for specific hydrologic, hydraulic, and ecological processes and functions. Models to date reflect the goals and requirements of specific programs (e.g., flood loss reduction versus habitat protection). They reflect the interests of various disciplines and groups of experts (e.g., hydrologists, geologists, water planners, wetland managers, floodplain managers).

Differing goals and the lack of communication between programs and experts has resulted in a large number of assessment models and limited agreement concerning their use. Nevertheless,

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[1] See generally e.g., WET Ecoservices (South Africa) (2007). http://www.geography.ukzn.ac.za/wetlands/wet-ecoservices.htm; WET-Health (South Africa) (2009). http://www.o5demo.com/ckfinder/userfiles/files/08%20-%20WET%20Health.pdf; Wetland Assessment Techniques Manual for Australian Wetlands (Australia) (2008) http://www.wetlandcare.com.au/Content/articlefiles/248Wetland%20Assessment%20Technique%20Manual%20V3.6sml.pdf (2008); Assessing Floodplain Condition (Wetlands) (Australia) 22(2) (2004) http://ojs.library.unsw.edu.au/index.php/wetlands/article/viewFile/26/22; National Research Programmes on Flood Risk Management Across Europe (Europe) (2007); Landscape Function Analysis (Australia) (2005); Urban Floodplain Management in Europe and America. (Europe, U.S.) (2007) http://www.nofdp.net/data/documents/projects_reports_publications/diploma_theses/diploma_thesis_5_becker_urban_floodplain.pdf; Australia-Wide Assessment of River Health: Queensland AusRivAS Sampling and Processing Manual (Australia) (2002); Australian River Assessment System: Review of Physical River Assessment Methods—A Biological Perspective (Australia) (2002); Living Rivers: Trends and Challenges in Science and Management (Netherlands) (2006); The Status Report on German Floodplains (2010) (Germany) http://www.bfn.de/fileadmin/MDB/documents/themen/wasser/Follner_et%20al%20Abstract%20IAD%20conference.pdf; Economic Assessment of Freshwater, Wetland and Floodplain (FWF) Ecosystem Services (UK) (2010) http://uknea.unep-wcmc.org/LinkClick.aspx?fileticket=lVLEq%2BxAI%2BQ%3D&tabid=82.

[2] In 2007 the Dutch government approved a $3.3 billion strategy for dealing simultaneously with flood threats and ecological issues called Room for the River. http://www.ruimtevoorderivier.nl/meta-navigatie/english.aspx; http://www.npr.org/templates/story/story.php?storyId=18229027 Room for the River will reduce high water levels in the Rhine, Meuse, Waal and Ijssel Rivers. See http://www.riob.org/IMG/pdf/roma_2007_nijland.pdf. These rivers will be given more room at 39 locations, using a variety of strategies by 2015. The Dutch, the Germans, the English and others have underway a variety of efforts to assess river functions and values.

[3] We use the term "model" in this paper to include systematically undertaken natural resource assessments of floodplain areas whether or not pursuant to a formal, named model. Agencies often carry out office and field assessments with varying degrees of specificity for wildlife, flood elevations, vegetation, and other floodplain features for regulatory, EIS, and other purposes without applying a formal assessment "model."

there is also recognition that more integrated, multidisciplinary approaches recognizing hydrologic and ecological connections are needed to simultaneously address multiple goals with common hydrologic underpinnings. Improved dialogue between programs and multi-agency development and testing of models is needed.

A fair amount has been learned about what works and does not work for these assessment models although no overall agreed upon approach has emerged. The types of information, levels of accuracy, geographical scope of the data-gathering, format of the information, and analytical capability needs differ somewhat depending upon the program and program goals. Problems and impediments exist to assessment of functions and values on both a site-specific and area wide basis. Floodplain assessment needs are also evolving. For example, improved methods are needed to assess the hydrologic and ecological changes in floodplains, which may be expected from climate change, how to reduce the adverse flood damage and ecological impacts of such changes, and how to compensate for impacts.

Assessment Models

Some broad categories of assessment models which are described in greater depth below include

—**Assessment models for hydrologic and hydraulic processes.** A number of hydrologic and hydraulic models and methods are available to assess the frequency, depth, erosion potential and other characteristics of coastal and inland flooding. See Part 7 below. These models may be used to produce flood maps and assess the impacts of floodplain modifications upon flood flows. Increasingly sophisticated models can be used to project future hydrologic and hydraulic conditions.

—**Assessment models for wetlands and related ecosystems.** Wetlands often constitute a large portion of coastal and inland floodplain areas and perform many of the most important habitat, flood storage, and pollution control functions of floodplains. More than 40 wetland assessment techniques have been developed to assess wetland functions and/or values including a variety of Hydrogeomorphic and Indices of Biological Integrity models.[4] See Part 7 and Appendix C. Many of these techniques have been developed for use in wetland regulatory contexts.

—**Riparian zone assessment models.** Riparian zones include vegetated areas adjacent to rivers, creeks, streams and coastal areas. These are particularly important for wildlife in semi-arid areas. Scientists have developed a variety of riparian zone assessment methods to evaluate the vegetated corridors. A riparian evaluation methodology developed by the United States Bureau of Land Management in cooperation with the United States Forest Service, "Proper Functioning Condition"[5] is particularly well known. For a review of this and other riparian

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[4] See Bartoldus, C.C. 1999. Comprehensive Review of Wetland Assessment Procedures: A Guide for Wetland Practitioners. Environmental Concern Inc., St. Michaels, MD. See also note 13 below.

[5] See e.g., http://www.mountainvisions.com/Aurora/pfc.html, Proper Functioning Condition, What It Is and What It is Not? National Riparian Service Team.

evaluation models see Thomas Hruby, Developing Rapid Methods for Analyzing Upland Riparian Functions and Values, Washington Department of Ecology, 2009.[6]

—Physical stream assessment models. Rivers and streams also constitute an essential portion of floodplain systems. Scientists have developed a variety of models to assess the functions of rivers, creeks and streams. Models pertain to hydrology/hydraulics, stream stability, channel evolution, the presence or absence of specific types of animals (e.g., salmon, other rare and endangered species), habitat and habitat condition, pollution and other more specific subtopics. See discussion below.

Steps in Assessment

Assessment efforts often employ four general steps:

(1) **Mapping or other identification of the assessment area boundaries.** This is needed to identify the area within which natural and beneficial functions are to be assessed. Hydrologic, hydraulic and ecological modeling methods are available to assist these efforts. The assessment area may be identified based upon frequency of flooding (e.g., 100 year flood, 500 year flood, some other frequency of flooding.). Ecological considerations may also be important in selection of the assessment area and in mapping ecological subzones such as wetlands and habitat of endangered species.

(2) **Preliminary identification of floodplain natural and beneficial functions** including the magnitude of functions. This may involve classification of rivers, streams, riparian areas and wetlands and the identification of floodplain subzones (see below) within a broader assessment area. Stream, wetland and riparian rapid assessment models are useful in evaluating wetland and related floodplain natural and beneficial functions on a preliminary basis. See Appendix F. For a review of riparian evaluation models, see, for example, the efforts of Thomas Hruby of the Washington Department of Ecology.[7]

(3) **More detailed assessment of functions.** This includes mapping or other identification of particular flood and erosion subzones such as flood meander, flood conveyance and flood storage subzones and investigation of their magnitude and other characteristics. It also includes identification and mapping of ecological subzones such as habitat for rare and endangered plant and animal species. Models have been developed not only for wetlands and floodplains but adjacent upland riparian area functions and values. See Part 7 of this report.

(4) **Investigation of the social significance including, in some instances, the monetary "value" of functions.** Assessment methods useful in carrying out this fourth step include both informal, subjective approaches and more formal and quantitative assessment techniques. A combination of informal and more formal techniques (for specific topics and issues) may be needed in a specific context.

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[6] See http://www.springerlink.com/content/01596u44848k65k5/

[7] Hruby, T. Developing Rapid Methods for Analyzing Upland Riparian Functions and Values, Washington Department of Ecology, 2009. http://www.springerlink.com/content/01596u44848k65k5/

Implementation of this fourth step is particularly difficult because it requires not only information concerning long-term hydrology and plant and animal species but information concerning economic value. However, advances have been made in quantifying value. See, for example the work of David Batker and colleagues at Earth Economics[8] and Robert Costanza at Portland State University.[9] See also generally e.g., WET Ecoservices (South Africa) (2007)[10] and Economic Assessment of Freshwater, Wetland and Floodplain (FWF) Ecosystem Services from the UK.[11]

No simple or inexpensive technique has been found to gather site-specific data despite the usefulness of new technologies such as global positioning systems, satellite imagery, low level digital images, and topographic information from LiDAR. Models have incorporated measures to "deduce" hydrology and hydraulics, the capability of wetlands and floodplains to provide habitat for certain plant and animal species, and to capacity of wetlands and floodplains to produce other "goods and services." Models and techniques often use simplifying assumptions and surrogates to reduce the amount of needed data. However, all are subject to margins of error (sometimes large).

Recommendations, Future Efforts[12]

Future efforts to assess natural and beneficial values need to build upon existing models and existing databases and experience. Efforts need to reflect the lessons learned from the last 30 years by federal agencies, states, and others developing and applying assessment models for rivers and streams, inland and coastal wetlands, inland and coastal riparian areas and, in some instances, related upland systems. More specific recommendations include

Make Better Use of Existing Assessment Models and Databases

Better use of existing assessment models and databases could, more specifically, be encouraged and supported by:

(1) Added efforts to tap existing sources of information and expertise on a site-specific and broader geographical basis. Expertise and information can be better tapped by establishing joint databases, converting data (e.g. riparian maps, floodplain maps, wetland maps) to digital formats, establishing multiagency teams for evaluating regulatory permits, holding multi-agency hearings, posting data to the Internet, and taking other measures suggested below.

(2) Establishment of additional internet-based mechanisms for distributing data.

(3) Better matching of user needs with assessment techniques.

[8] See, e.g., http://www.eartheconomics.org/
[9] See http://www.pdx.edu/sustainability/robert-costanza
[10] http://www.geography.ukzn.ac.za/wetlands/wet-ecoservices.htm
[11] http://www.bfn.de/fileadmin/MDB/documents/themen/wasser/Follner_et%20al%20Abstract%20IAD%20conference.pdf
[12] See Part 9 below for more detailed recommendations.

(4) Independent evaluation of the accuracy and cost effectiveness of assessment methods[13] including the pros and cons of individual assessment models and techniques.

(5) Coordination of data-gathering and analysis for one sort of information (e.g., hazards information) with data-gathering and analysis for other types (e.g., habitat functions).

(6) Continued shifting of a portion of the site-specific data-gathering and analysis burden to landowners/developers seeking permits for floodplain alterations.

(7) Cooperative (federal, state, local, academic) preparation of guidance materials for the use of methods such as a floodplain natural and beneficial function assessment manual or handbook reviewing various methods.

(8) Cooperative training for governments, consultants and others in the use of various assessment techniques.

(9) Assessment of floodplain natural and beneficial functions as part of broader, area-wide and upfront land and water planning efforts including stormwater and GIS-based watershed planning and management efforts.

(10) The conduct of additional hydraulic and hydrogeomorphic studies as underpinning for assessments of individual functions.

Developing New Techniques and New Databases

New assessment techniques and databases are also needed. Some priorities include

(1) A holistic identification of the broad range of floodplain management information needs is needed. New multi-objective assessment techniques should then be designed to meet these multiple needs.

(2) Federal agencies along with states, tribes and local governments should better document floodplain natural and beneficial function assessment "user" needs to provide the basis for improved assessment techniques.

(3) More attention should be focused on the development of "intermediate" and "detailed" assessment models and not simply more "rapid" assessment methods.

(4) Joint guidance should be developed by federal agencies and states for describing and evaluating the nonmarket functions and values of floodplains.

[13] See, for example, http://assessmentmethods.nbii.gov/index.jsp?page=gdetail&gid=9 Ecological Assessment Models Data Base. This website lists and describes 90 ecosystem-related modeling approaches and is highly recommended. Many of these "ecological assessment" techniques could be used for assessing floodplains although not originally designed for floodplains.

(5) Improved "red flagging" techniques are needed to identify areas with a high probability of specific natural and beneficial functions and to help prioritize functions and areas needing more specific data-gathering and analysis.

(6) All levels of government should cooperatively develop a variety of types of data to better identify, protect and compensate for damage to floodplain natural and beneficial floodplain functions and values. Some priorities include

> **—flood hazard subzone maps (e.g., erosion areas, zero rise floodways, wave action areas, etc.)**
> **—long-term projections of hydrology such as fluctuations in water levels**
> **—biodiversity/ecological surveys and maps**
> **—updated digital wetland maps**
> **—riparian area maps**
> **—maps for rare and endangered species**
> **—maps of degraded and disconnected floodplain areas with high restoration potential.**

Priority Research Needs

Research needed in this area include the following priorities:

(1) The federal government should in cooperation with the states, local governments, land trusts and academic institutions establish multi-objective floodplain "reference sites" to help document floodplain functions and values and to develop and test assessment methods.

(2) Federal agencies, states, tribes, local governments and others should develop a national statistical survey of floodplain functions and values based on a selected sampling of floodplain natural and beneficial sites as has been done in Germany. Identification of federal and state programs with impacts to those functions should also take place.

(3) Additional basic research is needed that focuses upon the gaps in habitat requirements of various types of floodplain wildlife and the relationship of natural hazards (flooding, erosion) to ecological functions.

(4) A**ssessment models need to be developed to evaluate not only natural resource functions but "social significance" including cultural, historic, health and safety, and other values. Such models may best involve GIS.**

(5) The linking is needed of hydrologic and ecological assessment models at various scales.

(6) The development of a composite set of assessment methods is needed for simultaneous evaluation of interrelated rivers and other waters, wetlands, floodplains and adjacent upland areas.

(7) The development is needed of combined assessment methods which incorporate upfront, generalized inventories with more detailed case-by-case analysis of particular sites and functions, as development or activities are proposed.

PART 1: FLOODPLAIN NATURAL AND BENEFICIAL FUNCTIONS

Part 1 of this report begins with an overview of floodplain natural and beneficial functions. It next describes selected Congressional and federal agency initiatives for protecting floodplain natural and beneficial functions. It also provides examples of natural and beneficial functions which are described in greater depth in Appendix F.

Introduction, Overview of Functions

Floodplains lie principally adjacent to rivers, streams, lakes and estuaries/oceans although other areas are subject to flooding as well.

Floodplains differ from other areas of the landscape in several ways. These differences determine both their natural hazards and their "natural and beneficial" functions.

(1) Floodplains are subject to periodic inundation by coastal storm surges, storm waves, tsunamis, hurricanes, fluctuating groundwater levels, and direct precipitation.

(2) This periodic flooding and related processes of erosion and deposition determine the shape (e.g., often flat), the soils (often alluvial mineral or organic soils), vegetation, and other physical features (e.g., oxbow lakes) of the floodplain.

(3) This periodic flooding combined with other characteristics such as connectivity to waters and organic soils give rise to a variety of natural functions of value to society. These functions are also often referred to as floodplain natural and beneficial functions or natural "goods and services."

(4) Periodic flooding also poses threats to activities located in floodplains such as dwellings, roads, and septic tank/soil absorption systems. Activities located in floodplains may be subject to severe flood and erosion damages and may increase flood and erosion damages on other lands.

Floodplain natural hazards and natural and beneficial functions provide interrelated but somewhat independent bases for planning and managing development and other activities in floodplain areas including "avoidance" of floodplains wherever practical as called for the Floodplain Executive Order 11988 and in EPA's and the Corps of Engineers Clean Water Act Section 404 guidance.

Figure 1. Flooding gives rise to both flood damages and natural and beneficial functions.

Floodplain assessment is needed for formulating protection and restoration policies including compliance with the National Environmental Policy Act. It is also needed to implement various ecosystem protection and restoration initiatives at all levels of government including a "no net loss" standard for wetland functions and/or acreage at the federal level (e.g., the Section 404 program, the Water Resources Development Act of 1991), many state floodplain regulatory, wetland regulatory, wild and scenic river, "public water" and other planning and regulatory statutes, and many local land use and water use plans and ordinances. See Boxes 1 and 2.

Figure 2. Many floodplains are subject to multiple hazards such as unstable soils and liquefaction which caused building collapse here in the Marina District of San Francisco in the Loma Pietra earthquake of 1989. From https://www.geology.ucdavis.edu/iy (U Davis Geology website).

Land and water use polices controlling development in floodplains can simultaneously reduce flood losses while protecting natural and beneficial floodplain functions. For example, a community allocating floodplain areas to greenways and parks may simultaneously reduce flood losses and provide to the community a wide range of habitat, pollution control, recreational and other functions. The community may also qualify for reduced National Flood Insurance Program rates pursuant to the Federal Emergency Management Agency's Community Rating System.

River and Stream Assessment Models: An Overview[14]

The assessments of rivers and streams can include a wide range of applications from water quality measurements and analysis, to evaluating habitat functions and values for fish, amphibians, birds and other wildlife. While many of us think of stream channels and floodplains as being separate features in the landscape, river scientists generally regard the floodplain as part of the river channel and the distinctions they make are how frequent this channel becomes smaller or larger based on the flood discharges it must carry. In the last decade greater attention has been directed towards identifying the connections between the physical forms and processes of streams and their floodplains with important functions such as water quality improvement, and fish, avian and wildlife habitat protection particularly for federal and state species of concern. The growing awareness of the connections between the physical forms of rivers such as channels, floodplains and riparian forests and functioning of dynamic stream processes such as flooding, erosion, deposition, meandering and woody debris recruitment, with the biological, chemical and ecological systems have drawn more professionals into assessing waterways to protect environmental quality and habitat.[15] As a result, river system assessments which were once more a part of a descriptive science are now evolving into the realm of applied science to guide restoration and protection of riverine resources and functions.

[14] The materials concerning "physical stream assessment models" which follow (pages 2-5) were prepared by Ann Riley with the San Francisco Bay Region Water Quality Control Board. Her contribution is much appreciated.

[15] Fischenich, J. C. 2006, "Functional Objectives for Stream Restoration,"EMRRP-SR-2, U.S. Army Corps Research and Development Center, Vicksburg, MS.

Watershed and riverine assessments have added another dimension and emphasis to the field of wetland assessments because they represent environments that are particularly dynamic and dramatic; these abrupt changes in form and condition can represent a healthy functioning ecosystem. Unrestricted flood flows on floodplains are an important part of transporting and rearranging sediment and meanders and creating backwater areas necessary to support the habitat for fish and other aquatic organisms. Landslides, the uprooting, transport and dropping of trees and rootwads in flooodplains and the erosion of stream banks can be critical natural processes which support the fish and wildlife that are dependent on these habitat creating processes.

Rivers have many interacting watershed variables which adjust to these dynamic forces and tend towards rebalancing the river environments. Process-oriented assessments are an important aspect of evaluating floodplain functions and also form the basis of diagnostic assessments used to understand why a river system may be unable to rebalance itself in a reasonable period of time. Management strategies have progressed towards assessing the landscape forms, dynamics and functions of rivers to replace the simpler engineering assessments associated with the past era dominated by single purpose river projects which were often focused on attempting to control the natural dynamics and processes associated with rivers and their floodplains.

The contemporary field of river and floodplain assessment can best be understood by recognizing some of the basic traditions involved in studying rivers. There are several different "schools" of river evaluation and study which produce the common tools in use for the physical evaluation of rivers and floodplains. The first school is known as the **empirical** school and is characterized by applying collected field data from rivers to develop relationships among river and floodplain forms and processes. These assessments can help develop regional or watershed scale relationships among some of the variables making up river systems such as watershed drainage areas, rainfall, river vegetation, channel shapes, and discharges. The assessments can be used as reference information on balanced river environments for application by practitioners of river management and restoration and or provide initial evaluations of how impacted a stream system may be compared to other less impacted areas. The classic paper helping pioneer this school dates to 1953 by Leopold and Maddock.[16] The second school is referred to as the **analytical** school which is the realm most familiar to the hydraulic engineer who uses models of river processes such as continuity, flow resistance and sediment transport to characterize the relationships between discharges, channel slopes, shapes, and sediment transport.[17]

A third school is typically referred to as the study of watershed and **stream evolution models.** These models are composed of sketches recording typical stream and landscape responses over time to changes in sediment supplies, discharges slopes and vegetation. The classic references for this stream evolution school relates back to the work of river scientists Lane, Simmon, Schumm, Harvey and Watson.[18] Channel evolution models are particularly useful for predicting

[16] Leopold, L. B. & T. Maddock JR., 1953 "The Hydraulic geometry of Stream Channels and Some Physiographic Implications," U.S. Geological Survey Professional Paper 252, Washington D.C.

[17] Garcia, M. H. 2008 "Sedimentation Engineering, Processes, Measurements, Modeling and Practice," ASCE Manuals and Reports on Engineering Practice No. 110 American Society of Civil Engineers

[18] Lane, Emory 1955 "The Importance of Fluvial Geomorphology in Hydraulic Engineering," Proceedings of the American Society of Civil Engineers, vol 18 no 745 Hydraulics Division, N.Y.; Schumm, S.A., M.D. Harvey, C Watson, 1984," Incised Channels: Morphology, Dynamics and Control," Water resources Publications, Littleton, Co. ; Simon, A. 1989 "A Model of Channel Response in Distributed Alluvial Channels," Earth Surface Processes and Landforms 14(1): 11-26

how a stream and its floodplain may change over time due to changes made to the watershed. These models capture watershed processes in simple drawings which can be of very practical value in assessing the cause of stream system instabilities.

The use of **river classification** systems can be considered the other developing school of river and floodplain assessment which applies the concept that streams can be grouped into major types of riverine landscapes in order to develop reference data for similar stream types. Rosgen has the most widely applied stream classification system (Rosgen 1994) and another widely known classification system has been developed by Montgomery and Buffington[19] for high gradient environments. The classifications use descriptions of landscape forms to create channel type classifications and the forms may also provide data that informs river processes. This later school produces the most differences of opinion among professionals but will likely continue to evolve as a part of the river assessment management field.

The **stormwater management** field also has developed tools to assess the quality or degradation of watersheds and stream corridors based on the level of watershed land use changes and development. Because of the nationwide stormwater regulatory programs administered by EPA through the Clean Water Act National Discharge Elimination System, states and local governments, assessments conducted to guide and regulate stormwater management are ubiquitous and often entail recording the physical, as well as chemical and biological conditions of stream channels and floodplains. Because of the widespread conduct of stormwater regulatory programs, this focus on assessments to address stormwater is an influential and widespread aspect of riverine assessment. This aspect of stream and river assessment is a "driver" of watershed management activities and projects in many instances. The Center for Watershed Protection has been a significant leader in developing these assessments.[20]

Regulatory programs to protect water quality and fishery habitat are the next evolving area of river and floodplain assessments. NOAA Fisheries and the U.S. Fish and Wildlife Service collaborated on the development of what is called the "RiverRat" assessment to assist Endangered Species Act and Essential Fish Habitat consultation authorities, and review authority under the Fish and Wildlife Coordination Act. The assessment is a web-based system available through the web address[21] and these agencies sponsor trainings on its use. This assessment tool assists any project planner or reviewer to evaluate whether they have the critical information needed for an adequate assessment of a project need or design. The State of California water quality agencies have developed an assessment method which compliments RiverRat in order to improve project planning processes associated with the CWA section 401 state certification of the federal section 404 CWA permits. California broadly defines its authority to protect riverine environments under the state 401 certification process and project proponents use the "Rapid Permit Assessments for Stream Channels and Floodplains" to identify watershed and reach scale influences such as landscape forms, hydrology, land uses, dominant stream processes, status of channel evolution, and plant and animal communities which need to be integrated into plans.[22]

[19] Montgomery, D.R. and J. M. Buffington 1998, "Channel Process, Classification and Response," in R.J. Naiman and R.E. Bilby editors; River Ecology and Management: Lessons from the Pacific Coast Eco Region, Springer, NY

[20] Schueler, T. & H.K. Holland, 2000, The Practice of Watershed Protection, Center For Watershed Protection, Ellicott City, MD.

[21] www.restorationreviw.com

[22] http://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stream_and_wetland_protection.shtml

Assessment models for wetland and riparian areas are discussed in greater depth below and in Part 7.

Natural and Beneficial Functions; Congressional Intent

Box 1
State and Local Programs Needing Natural and Beneficial Functions Data

State and local floodplain programs needing such data include

- State and local floodplain management programs particularly communities enrolled in FEMA's National Flood Insurance Program and Community Rating System;
- State and local water resource and watershed planning efforts;
- State and local public land use management programs;
- Local comprehensive land use planning and management efforts;
- State and local wetland regulatory efforts;
- State and local floodplain regulatory efforts;
- State and local infrastructure planning and construction efforts; and
- State and local post-disaster response and pre-disaster mitigation planning efforts.

Congress and federal agencies have adopted a number of statutes and regulations recognizing the value of floodplain natural and beneficial functions and/or necessitating the assessment of such functions. See below and Appendix A.

Federal Executive Branch and Congressional Actions

The Federal Interagency Floodplain Management Task Force in 1994 set forth a number of national goals for wise use of floodplains for the years 1995 to 2025. The Unified National Program for Floodplain Management report prepared by this Task Force recommended in Goal 2 that the reduction "by at least half of the risks to the natural resources of the nation's floodplains." This report more specifically recommended for all metropolitan areas, the completion of an inventory of "all natural resources, by the year 2000" and for all nonmetropolitan floodplains an inventory of all natural resources by the year 2005." Box 2 reproduces, verbatim, the description of "natural resources of floodplains" described in Appendix B of the 1994 report.

Congress in the National Flood Insurance Act of 1994 also required the Federal Emergency Management Agency (FEMA) to implement a "Community Rating System" program that provides discounts on flood insurance premiums in communities which establish additional floodplain management regulations that exceed the minimum criteria set forth in FEMA's eligibility criteria. 42 U.S.C. § 4022(b). Congress established the community rating system to serve four purposes: See Florida Key Deer v. Paulson, 522 F.3d 1133 (11th Cir. 2008):

(A) to provide incentives for measures that reduce the risk of flood or erosion damage that exceed the criteria set forth in section 4102 of this title and evaluate such measures;
(B) *to encourage adoption of more effective measures that protect natural and beneficial floodplain functions*; (emphasis added)
(C) to encourage floodplain and erosion management; and,
(D) to promote the reduction of Federal flood insurance losses.

FEMA has been sued in Florida, Oregon, California, Washington and Arizona for inadequately considering the impact of the flood insurance program on rare and endangered species in its flood loss reduction land use standards for local communities. See the 11th Circuit Court of Appeals in Florida Key Deer v. Paulson, 522 F.3d 1133 (11th Cir. 2008). In this case, the court observed (Id at 1142) that "Among the purposes Congress directed FEMA to consider in designing the program (Community rating system) is the protection of "natural and beneficial floodplain functions." Id. § 4022(b)(1)(B). "We find that the language of 42 U.S.C. § 4022(b)(1) provides ample discretion for FEMA to consider listed species." Id. § 4022(b)(1)." Congress also, in the National Flood Insurance Reform Act of 1994, Sec. 562, called for the formation of an Interagency Task Force on Natural and Beneficial Functions of the Floodplain. The duties of this task force included "conducting a study to (A) identify the natural and beneficial functions of the floodplain that reduce flood-related losses; and (B) develop recommendations on how to reduce flood losses by protecting the natural and beneficial functions of the floodplain…." In 2000 this Task Force published a report to Congress: The Natural and Beneficial Functions of Floodplains: Reducing Flood Losses by Protecting and Restoring the Floodplain Environment. This report made eight principal recommendations two of which include the following:

> "Recommendation 1. Develop a national policy on the protection and restoration of the natural and beneficial functions of floodplains as an integral part of all Federal, State, tribal and local government programs, actions, planning, policies, regulations, and grants.
> ….
> Recommendation 4. Focus restoration and protection efforts on those floodplains or portions of floodplains identified as having the greatest flood risks and significant natural and beneficial functions."

Congress has, more recently, in the 2007 Water Resources Development Act, restated a goal of protecting floodplain natural functions in the principles and guidelines for water resources projects. The Water Resources Development Act of 2007 (HR 1495) provides with regard to water resources Principles and Guidelines (Sec. 2031) that " (a) It is the policy of the United States that all water resources projects should reflect national priorities, encourage economic development, and protect the environment by—

> "(1) seeking to maximize sustainable economic development;
> (2) seeking to avoid the unwise use of floodplains and flood-prone areas and minimizing the adverse impacts and vulnerabilities in any case in which a floodplain or flood-prone area must be used; and

(3) *protecting and restoring the functions of natural systems and mitigating any unavoidable damage to natural systems* (emphasis added.)"

This Act requires the Secretary of the Army to "issue revisions…to the principles and guidelines for use by the Secretary in the formulation, evaluation, and implementation of water resources projects" within two years of adoption of the Act.

The Act also (Section 2036) sets forth requirements for "mitigation" plans for mitigation of fish and wildlife and wetlands losses from water projects. It provides, in part, that a mitigation plan for a water resources project shall include, at a minimum—"the criteria for ecological success by which the mitigation will be evaluated and determined to be successful based on replacement of lost functions and values of the habitat, including hydrologic and vegetative characteristics…."

Box 2

"Natural Resources of Floodplains"

Extracted from a Unified National Program for Floodplain Management (1994)

"Floodplains that are relatively undisturbed (or have been restored to a nearly natural state) provide a wide range of benefits to both human and natural systems. These benefits may take many forms: some are static conditions (like providing aesthetic pleasure) and some are active processes (like filtering nutrients). There is some ambiguity over which of these benefits are properly termed "functions", which are "resources", and where the terms overlap. A fairly well accepted (but not necessarily comprehensive) list follows. The resources and functions have been loosely grouped into three categories, and the categories have been labeled according to the primary recipient of the benefit or its relationship to a larger system. That is, "water resources" include those resources and functions of floodplains that are part of or provide a benefit to the hydrologic cycles on the earth's surface and below ground; "biological resources" are floodplain resources and functions that benefit plants and animals; and "societal resources" are floodplain resources and functions that directly benefit human society. Throughout the Unified Program Document, the term "natural resources" is used to refer to any or all of the resources and functions listed here.

WATER RESOURCES

Natural Flood and Erosion Control
-Provide flood storage and conveyance
-Reduce flood velocities
-Reduce flood peaks
-Reduce sedimentation

Water Quality Maintenance
-Filter nutrients and impurities from run-off
-Process organic wastes
-Moderate temperature fluctuations

Groundwater Recharge
-Promote infiltration and aquifer recharge
-Reduce frequency and duration of low surface flows

BIOLOGICAL RESOURCES

Biological Productivity
-Support high rate of plant growth
-Maintain biodiversity
-Maintain integrity of ecosystem

Fish and Wildlife Habitats
-Provide breeding and feeding grounds
-Create and enhance waterfowl habitat
-Protect habitats for rare and endangered species

SOCIETAL RESOURCES

Harvest of Wild and Cultivated Products
-Enhance agricultural lands
-Provide sites for aquaculture
-Restore and enhance forest lands

Recreational Opportunities
-Provide areas for active and passive uses
-Provide open space
-Provide aesthetic pleasure

Areas for Scientific Study and Outdoor Education
-Contain cultural resources (historic and archaeological sites)
-Provide opportunities for environmental and other studies"

Examples of Floodplain Natural and Beneficial Functions

Examples of floodplain natural and beneficial functions (also sometimes called floodplain “natural resources” “floodplain values,” and floodplain “goods and services”) include those listed in Boxes 2 and 3. For more detail description see Appendix F**.** Discussion of individual resources and functions is beyond the scope of this paper.

Box 3
Floodplain Natural and Beneficial Functions
(Natural Resources)

The following is a list of floodplain natural and beneficial functions has been drawn from statutes, ordinances, regulations, and the literature. It is slightly broader than the floodplain "resources" listed in Box 2 but tracks overall with that list. See Appendix F for more detailed description of functions. Floodplains:

Provide flood storage. Many floodplains temporarily store flood waters and reduce flood heights and velocities for downstream lands.

Provide flood conveyance. Many floodplains act as flood conveyance areas, reducing flood heights and velocities at upstream, adjacent and downstream lands.

Reduce wave damage. Some vegetated floodplain areas reduce the force of waves and resulting wave and erosion damage to back lying properties and structures.

Reduce excessive erosion. Many vegetated floodplain areas help moderate erosion by reducing water velocities, binding soil and contributing to the vertical and lateral stability of stream channels (i.e., associated with dynamic equilibrium).

Reduce sediment loadings in lakes, reservoirs, streams, estuaries, coastal systems. Many vegetated floodplains, and the wetlands they contain, reduce the sediment flowing into lakes, streams, and estuaries by intercepting and trapping sediment.

Provide groundwater recharge. Some floodplains provide groundwater recharge although most are discharge areas much of the year.

Provide groundwater discharge. Some floodplains help maintain the base flow of streams and help to reduce ground water levels (which would otherwise flood basements) by providing groundwater discharge.

Produce natural crops. Many types of floodplains and wetlands produce cranberry, blueberry, saltmarsh hay, aquaculture, wild rice, forestry and other natural crops.

Prevent and treat pollution:

- **Prevent pollution from entering water body.** Virtually all types of vegetated floodplains and the wetlands they contain may intercept sediments, nutrients, debris, chemicals, etc. from upland sources before they reach down gradient rivers, streams, lakes, estuaries, oceans, and ground waters.
- **Treat (remove) pollution in water body.** Wetlands located in lakes, streams, estuaries, depressions, and at other locations may remove pollutants from waters.

Provide habitat for fish and shellfish.* Floodplains adjacent to lakes, streams, estuaries, and oceans can provide food chain support, spawning areas, rearing areas, and shelter for fish. Many estuarine wetlands provide shellfish habitat.

Provide habitat for amphibians, reptiles, mammals, and insect species.* Many floodplains and floodplain wetlands provide habitat for a broad range of mammals, reptiles, amphibians, and birds and corridors for migration or movement.

Provide habitat for song birds and other nongame birds.* A broad range of floodplains and wetlands provide habitat for nongame birds important for ecotourism.

Provide habitat for waterfowl.* Many depression, river fringe, lake fringe, coastal and estuarine fringe floodplains and the wetlands they contain, provide food supply, nesting, water etc. for waterfowl.

Provide habitat for rare, endangered and threatened species.* Virtually all types of floodplains may provide food chain support, feeding, nesting, and substrates for endangered and threatened animals and plants.

Maintain carbon stores, sequester carbon, reduce climate change. Many wetlands and floodplains store carbon in carbon-rich wetland soils and trees and vegetation, reducing climate change. Some continue to sequester carbon from the atmosphere.

Provide micro-climate modification. Floodplains, particularly those near cities, may reduce temperatures and reduce air pollution levels.

Provide recreational opportunities and scenic beauty. Many floodplains provide hiking, wildlife viewing and other water and land-based recreational opportunities. Many floodplains have aesthetic value. Scenic beauty when viewed from a car, a path, a structure, or a boat may enhance real estate values, provide recreation, and provide the basis for ecotourism.

Provide historical, archaeological, heritage, cultural opportunities. Some floodplains such as the confluence of the Missouri and Mississippi Rivers (Lewis and Clark Expedition) have historical value; others have archaeological value (shell middens, burial sites).

Provide educational and interpretive opportunities. Many floodplains and the wetlands they contain provide education and research opportunities for schools and universities (K-graduate schools) and government agencies

Provide scientific research opportunities. Schools, universities, resource agencies, and not-for-profit organizations carry out many types of scientific research in floodplains, wetlands and riparian areas.

*These functions/values can be listed separately or together as "habitat" value. They have been listed separately here because they require somewhat different sorts of assessments.

Figure 3. Floodplains vegetation reduced wave heights and erosion in the December, 2004 South Asian Tsunami.

Box 4
Definitions

Terms are used in the following ways in this report:

- **Assessment:** data-gathering and analysis to meet specific goals. Assessment includes, but is not limited to mapping, delineation, natural hazards analysis, ecological analyses, project impact analysis, determination of mitigation needs, the determination of compensation needs (including compensation ratios), and monitoring and enforcement of regulations.
- **Capacity:** the ability of floodplain resources to produce various goods and services of use to society. Capacity depends on flood characteristics, geology, soils, topography, size, hydrologic, biological and chemical processes and other features.
- **Data:** raw information, such as aerial photos, vegetation, topography, and soils not yet analyzed for a specific purpose.
- **Floodplain:** The lowland that borders a river, usually dry but subject to flooding. (Hoyt and Langbein, 1955, p. 12.) For alternative definitions see Geological Survey Water-Supply Paper 1541-A, Methods and Practices of the Geological Survey http://water.usgs.gov/wsc/glossary.html#F which describes the 100-year floodplain as the area subject to a one percent or greater chance of flooding in any given year.
- **Function:** the capacity of a floodplain ecosystem to provide goods and services of value to society. Function also includes the natural processes producing the goods and services. Function is primarily dependent upon natural processes but reflects other features as well (see "capacity" above).
- **Information:** data analyzed for a specific purpose; the results of such analysis.
- **Natural:** in an unaltered or relatively unaltered condition.
- **Opportunity:** the present and reasonably foreseen ability of a floodplain to actually deliver goods or services to society. Opportunity depends on context. For example, a floodplain may have the natural capacity to intercept pollution, but it may not do so because there are no nearby pollution sources.
- **Social significance:** the importance of floodplain/wetland resources to people and not simply the inherent capacity of floodplains to produce goods or services. Assessing social significance requires a shift from examination of the physical characteristics of floodplains alone to determining how functions serve people.
- **Value:** the worth, desirability, utility of floodplain functions. Value includes but is not limited to monetary worth. The term "value" is also sometimes used in the literature as synonymous with "functions" to describe the natural goods and services floodplains provide.

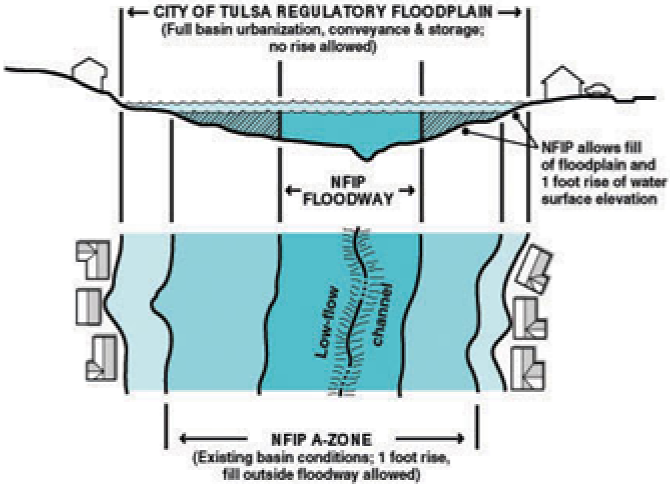

Figure 4. Floodplains both store and convey flood waters. A broad regulatory floodplain like this one from Tulsa can help protect both flood storage and flood conveyance.

Figure 5. Floodplains provide habitat for amphibian, mammal, bird, reptile and other animal species like this spotted salamander. WNC Nature Center website: http://wildwnc.wordpress.com/2010/03/09/take-a-gander-on-southern-appalachias-salamanders/

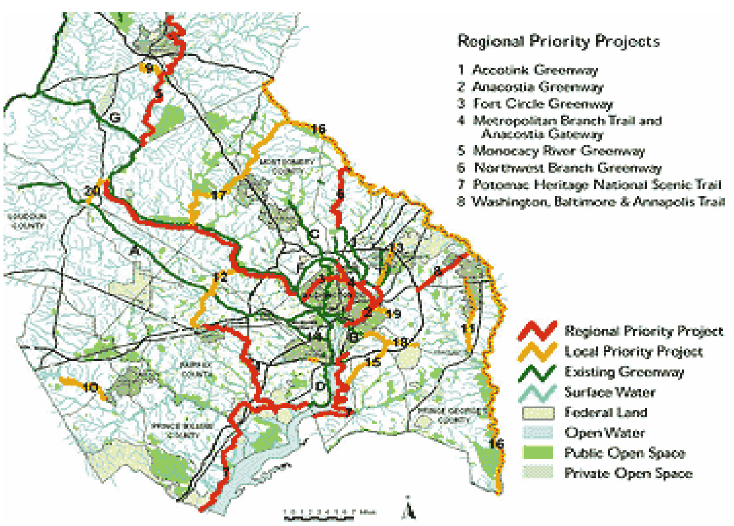

Figure 6. Many cities and metropolitan areas like the metropolitan Washington, D.C. have created greenways and trails to simultaneously achieve flood damage reduction, recreation, and protection of habitat. See Transportation, Community, and System Preservation (TCSP) Program website: http://www.fhwa.dot.gov/tcsp/wdcdflt.html

PART 2:
COMMON STEPS IN ASSESSMENT

Part 2 of this report examines some of the common denominator steps in assessing natural and beneficial functions by floodplain managers, wetland managers, land use planners and other water and land use managers.

As indicated above, no single, overall method or model has been developed to assess floodplain natural and beneficial functions. Rather, floodplain managers, water resources developers, and others have developed and used a variety of methods and models to address floodplain functions and values in specific contexts. These methods and models may be placed into four general categories which also constitute typical steps in assessment:

1. Defining the Assessment Area

The first major step in the assessment of floodplain natural and beneficial functions is definition of the floodplain assessment area. This step may also include classification of areas and identification of hazard and ecological subzones (e.g. floodways, wetlands, riparian zones). The overall assessment area may be the 100-year floodplain or a broader or lesser flood area. Models useful in defining the assessment area include a broad range of flood hazard hydrologic and hydraulic models and methods. They involve, in some instances, not only models for assessment of flood depth and frequency of inundation but velocity, wave heights and erosion potential.

An important consideration in the use of hydrologic and hydraulic-based flood maps to determine an assessment area is the vertical movement and position of stream channels in the landscape. In many areas, stream channels have become deeply incised and vertically disconnected from their natural floodplain. Inundation based flood maps may show a river reach as having little or no 100-year floodplain because, at the time of assessment, the channel was deep enough to contain all flood flows. But due to the fluvial processes which form floodplains, stream channels evolve to form new floodplains or reconnect to their old ones; and care should be taken in the reliance on model outputs which are snapshots of a dynamic system.

Ecological considerations are also relevant to the definition of the assessment area. For example, assessment of the 500-year or even the 1000-year floodplain may be appropriate where much of the floodplain serves as habitat for an endangered plant or animal species.

As a practical matter, the area selected for assessment will often be the “100-year” floodplain because most existing floodplain maps identify the 100-floodplain. However, the assessment area may alternatively, be the 10-year, 50-year, 100-year flood, 500-year or some other frequency of flooding, depending upon the interests of the management agency and the nature of the natural hazards and ecological features.

Sources of flood information helpful in defining the assessment area include

- Topographic information
- FEMA, Corps of Engineers, NRCS, USGS and other flood maps based upon hydrologic modelling
- Air photos, satellite imagery, and maps of historic flooding
- Soil maps showing organic and alluvial soils
- Special feature maps (e.g., erosion maps, floodway maps, maps of areas with floodplain restoration potential)

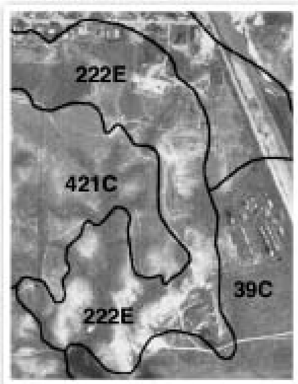

Figure 7. Soils maps can help define the boundaries of the assessment area and provide an identification of functions.

Sources of ecosystem-based information flood information helpful in defining the assessment area may include

- Wetland maps
- Soil maps
- Maps and other sources of information showing endangered or threatened species
- Maps and other sources of information showing areas of biodiversity interest (e.g., "Heritage" Program maps and other sources of information)
- Maps and other sources of information showing invasive species
- Maps and other sources of information showing wildlife corridors and other areas forming ecological connections

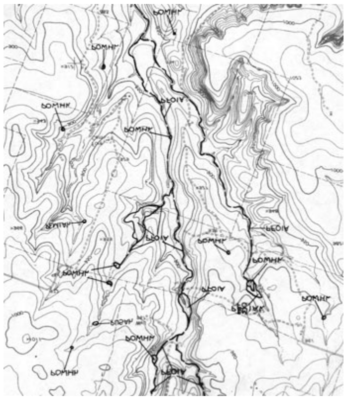

Figure 8. Wetland maps can also help managers identify the assessment area and sub areas. This is a National Wetland Inventory map.

2. **Determining Floodplain Functions on a Preliminary Basis**

The next step in assessing floodplain natural and beneficial functions is often a preliminary identification of floodplain functions within the defined floodplain area. This may involve the classification of natural hazard and ecological sub-zones within the broader floodplain areas to facilitate more specific evaluation of function. See, for example, the Hydrogeomorphic Approach to assessing wetland functions. This assessment method groups wetlands into seven classes: depressional, riverine, mineral flats, organic flats, tidal fringe, lacustrine fringe, and slopes.[23]

[23] See http://el.erdc.usace.army.mil/wetlands/class.html

A variety of models and approaches (e.g. field observations) are available to determine functions on a preliminary basis. Models include wetland assessment models, river and stream assessment models, and riparian assessment models:

—**Wetland Assessment Models.** Many rapid assessment models have been developed or used for assessing wetland functions (and in some instances "values".)[24] Wetlands often constitute a large portion of floodplain areas and perform many of the important habitat, flood storage, and pollution control functions of floodplains. Models for assessing the ability (capacity) of wetlands to produce goods and services on a preliminary basis include the federal WET assessment model and the many state WET-related models. More than 40 wetland "rapid" techniques have been developed to assess wetland functions and/or values.[25] Most of these techniques have been developed for use in wetland regulatory contexts. Experience with these techniques (both positive and negative) also offers important lessons for the development of future broader floodplain assessment approaches. See Appendix C.

Rapid wetland assessment techniques have been useful primarily in providing preliminary analysis of functions (and to a lesser extent) values. However, rapid wetland assessment techniques have not been extensively used in regulatory and other management programs for in depth analysis of functions due to low levels of accuracy and a wide variety of other problems and limitations. These include the failure of many models and techniques to develop much of the critical information needed by decision-makers, high costs, technical expertise needs, and large margins of error. See Appendix C.

—**Assessment of rivers and streams.** Streams also constitute an essential portion of floodplain/riparian systems. Scientists have developed a wide variety of habitat, hydrologic, hydraulic, and geomorphic models to assess the functions and condition of rivers, creeks and streams and related ecosystems.[26] See discussion above of river and stream assessment models.

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[24] For examples of websites describing wetland rapid assessment models see e.g., http://www.environment.gov.au/ssd/publications/ssr/pubs/techniques-ssr161.pdf
An Evaluation Of Wetland Assessment Techniques and Their Applications To Decision-Making (date unknown); http://mtnhp.org/Reports/Level_I.pdf Assessing Wetland Condition With the Use of GIS A Landscape Integrity Model for Montana (2009); Review of Rapid Methods for Assessing Wetland Condition (2004), http://www.epa.gov/owow/wetlands/monitor/RapidMethodReview.pdf; (undated), http://el.erdc.usace.army.mil/emrrp/emris/emrishelp6/models_for_assessment_of_freshwater_wetlands_tools.htm http://water.epa.gov/lawsregs/guidance/wetlands/upload/2004_06_16_wetlands_ELI_Measuring_Mitigation.pdf (2004);

[25] See Bartoldus, C.C. 1999. Comprehensive Review of Wetland Assessment Procedures: A Guide for Wetland Practitioners. Environmental Concern Inc., St. Michaels, MD. See also note 13.

[26] See, e.g., National Rivers and Streams Assessment (2010), http://water.epa.gov/type/rsl/monitoring/riverssurvey/riverssurvey_index.cfm; Stream Visual Assessment Protocol (1998), http://www.nrcs.usda.gov/technical/ecs/aquatic/svapfnl.pdf;
Review of Physical River Assessment Methods: A Biological Perspective (Australian), a review of stream assessment methods used in Australia (2004), http://www.precisioninfo.com/rivers_org/au/archive/?doc_id=6 ;
National Inventory/Survey, Tools for Ecological Assessment (2004), http://www.websitefororg.com/OldWebsites/NPS/CompiledMethodsFrameset.htm;
Stream Corridor Inventory and Assessment Techniques. USDA (2001), http://www.wsi.nrcs.usda.gov/products/W2Q/strm_rst/docs/Stream_Corridor_Inventory_Techniques.pdf;
Stream Corridor Inventory and Assessment Techniques, Technical Supplement 3A (USDA, 2007), http://policy.nrcs.usda.gov/OpenNonWebContent.aspx?content=17820.wba;
http://old.aswm.org/calendar/reconciling/somerville.pdf (2004);

—**Assessment of riparian areas.** A number of models have been developed for assessment of riparian areas.[27] A riparian evaluation methodology developed by the United States Bureau of Land Management in cooperation with the United States Forest Service, Natural Resource Conservation Service, and other agencies—"Proper Functioning Condition"[28]—is well known. See also Thomas Hruby, Developing Rapid Methods for Analyzing Upland Riparian Functions and Values, Washington Department of Ecology, 2009.[29]

Figure 9. Riparian Area in "Proper Functioning Condition. From EPA Nonpoint Success Stories. http://water.epa.gov/polwaste/nps/success319/Section319III_AZ.cfm

3. Determining Floodplain Functions on a More Detailed, Accurate Basis (If Needed)

Determination of floodplain functions on a more detailed, accurate basis is usually not needed for all portions of a floodplain. This step is taken if the preliminary analyses indicate functions, issues, or problems needing more detailed analysis. This step is particularly needed where development is proposed which will substantially affect floodplain functions. Examples of more detailed assessment methods and models are discussed in Part 7 of this paper. More

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Physical Stream Assessment: A Review of Selected Protocols for Use in the Clean Water Act Section 404 Program (2004), http://www.epa.gov/owow/wetlands/pdf/PhysicalStreamAssessmentSep2004Final.pdf;
Ecological Classification of Rivers for Environmental Assessment (undated), http://sitemaker.umich.edu/riverclassproject/home;
National Rivers and Streams Assessment; Field Operations Manual, Measuring the Ecological Condition. (2000), http://www.epa.gov/emap/html/pubs/docs/groupdocs/surfwatr/field/nonws.html;
The Wadeable Streams Assessment: A Collaborative Survey of the Nation's Streams (2010), http://www.epa.gov/owow/streamsurvey/;
National Aquatic Resource Surveys (2010), http://water.epa.gov/type/watersheds/monitoring/nationalsurveys.cfm;

[27] Assessing Range and Riparian Areas, http://www.for.gov.bc.ca/HRA/Publications/pamphlets/Rangeland_Health_Pamphlet1.pdf;
US Forest Service Stream System Technology Center, National Park Service (undated), http://www.stream.fs.fed.us/RelatedWebsites/index.html;
Experts Roundtable, Riparian Restoration Roundtable (undated), http://www.treelink.org/woodnotes/vol1/no1/rrres.htm;
National Wetland Inventory system for mapping riparian areas (2009), http://www.fws.gov/wetlands/_documents/gOther/SystemMappingRiparianAreasWesternUS2009.pdf;
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Stream Assessment in a Regulatory Context (2004), http://old.aswm.org/calendar/reconciling/somerville.pdf;
Physical Stream Assessment: A Review of Selected Protocols for Use in the Clean Water Act Section 404 Program (2004), http://www.epa.gov/owow/wetlands/pdf/PhysicalStreamAssessmentSep2004Final.pdf.

[28] See, e.g., Proper Functioning Condition, What It Is and What It is Not, National Riparian Service Team (2000) http://www.mountainvisions.com/Aurora/pfc.html

[29] http://www.springerlink.com/content/01596u44848k65k5/

detailed models include WEThings and a variety of fish and wildlife assessment models (e.g., HEP) models. They include many GIS-based assessment methods. They include, in some instances, the use of quantitative hydrologic models developed for hydrologic or hydraulic analysis of floodplains such as Corps of Engineers HEC-RAS models to determine flood heights and storage capability.

The need to quantify floodplain functions for floodplain regulatory, water resources development, land management, restoration and other programs has increased greatly in the last two decades due in part to the widespread adoption of a "no net loss" or comparable goal in regulations and land management policies. To implement a no net loss of functions goal requires a quantified estimate of functions before and after changes are made in the floodplain. A quantified estimate of functions is also needed to determine compensation needs and the compliance of mitigation and compensation measures with wetland no net loss goals. In 1989 EPA and the Corps of Engineers adopted a joint memorandum of understanding requiring Clean Water Act Section 404 permit applicants to achieve a goal of "no net loss" of wetland "functions" and "values."[30] Many other federal, state, and local agencies have adopted a "no net loss" of "functions" (and, in many instances, "value") or equivalent goal for wetlands and other water-related areas.

The Army Corps of Engineers and EPA require through their 404(b)(1) guidelines that applicants for Clean Water Act Section 404 permits go through a "sequencing" process. Applicants must

- Avoid wetland and other aquatic ecosystem locations if it is practical to do so. Information must be generated by a project proponent concerning the availability of alternative sites and the practicality of utilizing such sites;
- Mitigate impacts if avoidance is not practical. Information must be available concerning functions and values to determine what mitigation measures may be appropriate; and
- Compensate for losses by restoring, enhancing, creating or in some instances preserving natural functions and values.

Detailed (and preferably) quantitative information is needed to comply with these requirements although often only partially available. Regulators need to know original functions before a project is approved to set goals and procedures for reducing and compensating for impacts. Compliance with mitigation and compensation requirements and the Floodplain and Wetland Executive Orders, the 2007 Water Resources Development Act, the Endangered Species Act and a number of other acts requires information concerning the geographical location of natural and beneficial functions, their magnitude, their sensitivity to disturbance, and, in some instances, their monetary value. See Appendix A.

4. Assessment of "Social Significance," "Worth," "Value"

In some instances, such as for planning federal water resources projects, floodplain managers need to assess not only the ability or capacity of floodplains to produce goods and services but the "opportunity" these goods and services have to meet the needs of society and the broader "social significance" of these functions. Models include

[30] See Memorandum of Agreement Between the Environmental Protection Agency and the Department of the Army Concerning the Determination of Mitigation Under the Clean Water Act Section 404(b)(1) guidelines. Nov. 1989.

—**Models providing economic dollar values for floodplain functions.** A number of economic modeling techniques are available to provide dollar values for floodplain functions including those with limited market values. See discussion below. Congress has required the Corps to provide monetized "cost/benefit" analysis for water projects for many years and some of these efforts to provide dollar values have been more broadly applied. "Social significance" includes but is not limited to economic value. See discussion in Part 6 below.

—**Models providing a "nominal"**[31] **description of functions.** For example, floodplain and functions may be investigated and assigned nominal categories or numbers (e.g., a relative ranking of "good," "middle" and "high") to suggest their relative importance to society without providing quantitative, ratio numbers. See, for example, the WET wetland assessment technique for such an approach.

—**Techniques to qualitatively estimate the "social significance" of functions without providing a quantitative, monetized analysis of functions.** Functions may be qualitatively analyzed to determine who is affected by present or future anticipated changes in functions, how they will be impacted and how much they will be impacted. This can suggest health and safety value, historical and cultural value, education and research value and aesthetic importance to society without detailed economic analysis. A variety of techniques are also available to suggest the "weight" society may place on particular functions in a specific context although none are very precise. See Box 10 and discussion below. We will examine these approaches in greater depth in Parts 5 and 6 of this report.

Box 5
Examples of Floodplain Alterations Which Destroy or Diminish Functions/Values

Common floodplain alterations destroying or diminishing floodplain natural and beneficial functions include

- **Fills for dams, levees, seawalls, road and bridge construction and buildings.** Fills can permanently destroy floodplain natural and beneficial functions if extensive. Even partial fills can have severe impacts on some functions, depending upon the location and configuration of the fills. Fills immediately adjacent to rivers or streams often block flood conveyance; or lead to channel incision. Fills in deep water areas destroy fish habitat; fills in water body outlets destroy connections and pathways between floodplains and adjacent water bodies.

[31] "Nominal" categorization can be used to describe floodplain functions but efforts to determine standard deviation or to apply other mathematical concepts to nominal categorizations are meaningless.

- **Water level stabilization.** The water levels of most large lakes and many rivers and streams have at least been partially "stabilized" by construction of dams and other outlet control structures. Most large rivers have been dammed for at least a portion of their lengths. Stabilization of water levels may temporarily increase certain values such as fishery but often results in long-term loss of diversity.
- **Water diversions for agricultural, other uses.** Diversions, which are particularly common in the West, may destroy or limit all floodplain natural or beneficial functions, but often have particularly severe impact upon fish and other fauna during low flows.
- **Channelization.** Channelization can also destroy or damage the full range of floodplain functions by lowering water levels, removing wetland soils, and reducing the residence time of water in the floodplain. Functions/values affected include, but are not limited to, flood storage, erosion reduction, pollution control, fisheries, waterfowl, and endangered species.
- **Drainage.** Surface or subsurface drainage can destroy or damage floodplain functions by converting floodplain wetlands and other low-lying floodplain areas into dry land.
- **Pollution.** Toxics, excessive nutrients, debris or other pollutants destroy or damage almost all habitat values. However, flood conveyance, flood storage, and some pollution control functions/values may remain.
- **Sedimentation.** Excessive sedimentation from watershed sources can destroy all values by permanently filling a floodplain. Lesser amounts can also damage or destroy fishery and wildlife functions/values.
- **Groundwater pumping.** Groundwater pumping can destroy many floodplain habitat functions by dewatering a floodplain. Flood storage and conveyance functions may remain.
- **Tree-cutting, vegetation removal.** Tree cutting and other vegetation removal temporarily reduces habitat values, erosion control and wave attenuation functions.
- **Intentional or accidental introduction of exotics species.** Exotics can destroy natural plant and animal habitat, reduce food chain support, and destroy endangered species.

PART 3:
PROGRESS AND PROBLEMS

Part 3 examines progress and problems[32] in assessing floodplain natural and beneficial functions.

Progress

Over the last two decades, considerable progress has been made by federal agencies, states, local governments, tribes, academic institutions, consultants and others in providing the tools, techniques, and information needed to assess floodplain natural and beneficial functions. Progress includes

(1) The scientific information base ("status of the science") pertaining to various natural processes and the habitat requirements of plants and animals has been increased, particularly for wetland and riparian portions of the floodplain.

(2) A great deal of natural resource information useful in assessing natural and beneficial functions and values has been gathered, and, in some instances, digitized. Much has also been made available on the Internet such as

- Flood maps
- Soils maps
- National Wetland Inventory Maps (about 85% of the nation)
- Maps and other sources of information pertaining to rare and endangered species, habitat, areas of special importance for biodiversity
- Color infrared aerial photography
- Rectified, orthophoto imagery, and
- Various types of satellite and other digital imagery.

(3) Advances have been made in data-gathering tools. These have reduced costs and facilitated the analysis of floodplain areas on a time-series basis. They include the use of

- Satellite imagery
- Low level digital imagery
- Global positioning systems (GPS), and
- LiDAR mapping of topography.

(4) Analytical techniques have been improved and made more effective and less costly through the development of

- GIS computer water resources and flood prediction models
- GIS comprehensive planning and watershed planning tools, and
- Other computer-based assessment models and methods.

[32] We offer observations concerning progress and problems based upon our workshops, seminars, and publications.

(5) The pool of experts with botanical, biological, hydrologic and other expertise pertaining to floodplains and components of floodplains such as wetlands has increased. For example, more than 4,000 individuals now belong to the Society of Wetland Scientists. Experts have both general knowledge and, in some instances, specific knowledge with regard to specific floodplain functions.

(6) Many local and regional governments have initiated watershed-based land or land and water planning efforts for pollution control, stormwater management, flood control, water supply or other purposes. These efforts provide hydrologic and, in some instances, other types of information which can be useful in assessing floodplain natural and beneficial values. Examples of such broader efforts include

- Comprehensive land use planning and zoning efforts to determine the most "suitable" or "appropriate" use of land throughout a community or region
- Watershed planning for flood loss reduction, pollution control, water supply, other purposes
- Floodplain management planning including pre and post disaster mitigation planning
- Greenway planning and management efforts
- Highway, sewer, water supply and other infrastructure planning and construction, and
- Floodplain, wetland, coastal zone, shoreland and other regulatory efforts.

These programs are increasingly aided by local, state and federal GIS programs which allow users to “overlay” many types of data.

(7) A variety of rapid and more detailed assessment methods have been developed to assess the "capacity" of floodplains, wetlands, and riparian areas to produce particular goods or services. Some approaches not specifically developed to assess wetlands or floodplains are nontheless useful in doing so. See Part 7 for description of some of these approaches which include but are not limited to

- Instream flow models (fish)
- HEP (birds, other wildlife)
- HGM (overall ecological capacity or functions, condition of systems)
- WEThings (capacity of wetlands to serve as habitat for specific animal species)
- HEC-RAS (hydrology, run-off, flood flows and heights, flood conveyance), and
- Fluvial Geomorphic Assessments (Rosgen and others: steam stability and condition, hydrology).

Problems; Impediments to Assessment

Despite progress, many problems and impediments exist at local, state, or federal levels with assessment of floodplain natural and beneficial values at a scale and degree of accuracy sufficient for detailed, regulation, planning, acquisition, restoration or other on- the-ground management. Examples include

(1) Research efforts and efforts to develop and apply various wetland and other assessment techniques to date have revealed the hydrologic and ecological complexity of wetland and floodplain systems. The hydrogeomorphic processes which form floodplains and wetlands occur at varying spatial and temporal scales. No simple and accurate way has emerged to determine

floodplain hydrologic properties (including long-term flooding or saturation) which determine, in large measure, ecological properties including functions. Similarly, no easy and accurate way has emerged to assess the capacity of floodplain areas to provide habitat for specific types of plant and animal species without time-series, field investigations since plant and animal species at a floodplain site often vary over the seasons and from year to year due to fluctuations in rainfall and floodplain water levels.

(2) Large gaps continue to exist in scientific knowledge pertaining to the hydrologic and ecological niches and ranges of particular plant and animal species and floodplain processes relevant to the assessment of natural and beneficial values including determination of the impacts upon activities upon these values and the adequacy of impact reduction and compensation measures.

(3) Despite the development of certain types of flood, soils, and other types of maps for the nation, much of the detailed time-series ecological information such as hydrologic data and species information for fish, mammals, reptiles, birds, etc. needed for the evaluation of particular floodplain sites is missing and generation of such information is difficult, time consuming, and expensive. As noted above, no easy short-cut methods have been found to provide species-specific and time-series ecological and hydrologic information.

(4) Federal, state and local budgets, staff numbers, and staff expertise are limited. Further cuts in staffing may be expected as efforts are made to balance budgets at all levels of government. This will limit the ability of governmental units at all levels of government to assess natural and beneficial values and require the application of cost-saving and prioritizing mechanisms.

(5) User needs for natural and beneficial data are varied, depending upon the context and management tools. These needs have not been well-documented. Upfront and area wide natural and beneficial functions data is needed for land planning, public land management, and acquisition. More detailed site-specific information is needed for site-specific land use regulation and other types of site-specific management. Yet assessment methods often fail to distinguish these two contexts. Lack of documentation of user needs limits the design and usefulness of assessment approaches.

(6) Efforts to assess particular portions of floodplain ecosystems (e.g., wetland areas) have often ignored other portions of the systems (e.g., aquatic areas, outer floodplain areas), reducing the usefulness of overall efforts and providing only a partial picture of hydrologic and ecosystem functions. In addition, all available funds are sometimes spent evaluating one, limited portion of a system or generating a particular type of data at the expense of other portions.

(7) Progress has been made in developing a variety of "rapid" assessment techniques for particular areas within a floodplain or subzones such as Proper Functioning Condition for riparian areas but most such techniques are not well tested and only partially meet user needs. They often contain simplifying assumptions which undermine their accuracy and often do not reflect basic hydrology.

(8) Natural resource assessment methods have become increasingly complex and often employ special terms and language. They are also increasingly difficult to understand and use by landowners, local governments, not-for-profits, etc. and other decision-makers. Assessment techniques which cannot be used or understood by decision-makers including local land planners, regulators, and others may have limited practical value despite their "scientific" attractiveness.

The Challenge

The challenge in improving assessment of floodplain natural and beneficial values is to (1) make better use of existing information and techniques and build upon the strengths of existing techniques, and, (2) develop new and improved techniques for the future which are understandable and usable by decision-makers. Future directions are explored in greater depth in Part 9 of this report.

PART 4:
USER NEEDS

Part 4 describes selected user needs for natural and beneficial function information.

Efforts over the last two decades to assess wetland and floodplain natural and beneficial functions have revealed that user needs differ somewhat, depending upon the application and context. Any effort to carry out an "on the ground" inventory of natural functions and values should begin with a determination of user needs in the specific context.

Needs of Local and State Land and Water Planners

Most comprehensive land use and watershed management planning takes place at the local level although federal and state managers of public lands also play major planning roles in some contexts. Local land and water use planners need at least generalized "upfront" and "area wide" maps for the floodplain to allow them to develop comprehensive plans and to adopt zoning and other regulations to implement these plans. They also need more detailed natural and beneficial function information where development is proposed in the floodplain. Less detailed information may suffice where they apply a "conservancy" zone approach prohibiting all alterations (except for variances) in the floodplain.

The overall issue in local land use planning is allocating lands throughout a community to their most "suitable" or "appropriate" uses. Information from a broad range of sources may be "overlaid" in such efforts through GIS systems or manually to determine suitability and appropriateness including floodplain natural and beneficial functions.

State planning needs differ somewhat from those of local governments because states do not generally undertake comprehensive land use planning, like local governments. But states often provide information and technical assistance to local governments and require local government land use planning in some instances (e.g., shoreland zoning statutes, coastal zone management statutes, “critical area” statutes, scenic and wild rivers statutes). States are also directly involved in managing public waters, water allocations, pollution control, and public land management. States therefore need both up-front, area wide natural and beneficial functions information and site-specific information for specific areas for water quantity, state floodplain planning and regulations, public water regulation, dam safety, coastal zone management, shoreland zoning, scenic and wild river, critical area, nonpoint pollution control or similar planning and regulatory efforts. These also include state infrastructure development (roads, highways), state land use planning (some states such as Hawaii); and state post disaster recovery and response including mitigation planning.

Needs of Public Land Managers

Almost one half of the Nation’s land is in federal, state, or local public ownership. The federal government alone owns and manages 1/3 of the nation’s lands. These include national parks and monuments, national forests, wildlife refuges, grazing lands, and lands for federal infrastructure such as roads, dikes, and post offices. The federal government also plans and manages major water and flood control projects. State and local public land management efforts include state parks, recreation areas, wildlife areas, and transportation systems.

Public land managers prepare plans and implementation strategies for their lands consistent with specific statutory management goals. For example, U.S. Forest Service land managers prepare plans to achieve the dual goals of forest production and broader resource management including recreation.

Managers need at least generalized up front information concerning floodplain boundaries and natural and beneficial functions such as wetlands, riparian zones, and habitat for endangered species in drafting and implementing public land management plans. They need detailed information where development (roads, bridges, buildings) is proposed. However, information needs vary, depending upon agency statutory goals and the existing and proposed use of the land.

Figure 10. State and local floodplain regulators require flood hazard maps. Most use the flood maps prepared by the Federal Emergency Management Agency.

Needs of Agencies Undertaking Floodplain and Wetland Restoration

At the federal level, the Natural Resources Conservation Service, National Oceanic and Atmospheric Administration, Fish and Wildlife Service, Environmental Protection Agency, Corps of Engineers, Forest Services, Bureau of Land Management and other agencies are increasingly undertaking floodplain and wetland restoration to restore natural floodplain functions, reduce flood and erosion losses from repetitively damaged structures and serve other objectives. States and local governments are also undertaking restoration efforts but typically not at as large scale.

To identify areas in need of restoration, managers at all levels of government need maps and other information showing the location and boundaries of degraded floodplains and wetlands. They also need to know where repetitively flood damaged development is located. They need to know the causes of degradation and what might be done to restore identified areas.
To evaluate the benefits of restoration in a particular place, they need information concerning not only existing but the reasonably anticipated functions of floodplains and wetlands. This requires hydrologic information including present and anticipated future hydrologic conditions. Information concerning both present and future conditions is also needed to evaluate the probability of restoration project success, management needs and management costs.

Managers require biological information to determine existing and reasonably projected ecological functions. To evaluate the practicality of restoration they need estimates of per acre cost for acquisition of fee or easements. Since restoration efforts on private lands usually only involve willing landowners wishing restoration of their lands, managers need information concerning landowner needs and preferences.

Needs of Regulators

Regulators share many floodplain assessment needs such as floodplain and wetland maps with local and state water use planners, public land use managers, and agencies involved with restoration. However, as regulators of private lands, they must also comply with due process, and other legal requirements pertaining to matters such as mapping, application of regulatory criteria to permits and monitoring and enforcement, and other statutory and administrative regulatory requirements. They must keep records so that they are able to defend regulations in court if challenged by landowners.

As discussed above, the information needs of wetland and floodplain regulatory programs have increased in the last two decades due, in part, to the widespread adoption of a “no net loss” or comparable goals in regulations and land management at federal, state, and, to a lesser extent, local levels. The Army Corps of Engineers and EPA require through their 404 (b)(1) guidelines that applicants for Clean Water Act Section 404 permits go through a “sequencing” process that involves avoidance of wetlands and floodplains, impact minimization, and compensation. Compliance with mitigation and compensation requirements and the Floodplain and Wetland Executive Orders, the 2007 Water Resources Development Act, the Endangered Species Act and a number of other acts requires information concerning the geographical location of natural and beneficial functions, their magnitude, their sensitivity to disturbance, and, in some instances, their value.

Regulations typically require that a landowner apply to a regulatory agency for a permit if he or she wishes to undertake regulated activities within a regulated floodplain. Regulators at all levels of government therefore need flood maps (or GIS print-outs serving the purposes of maps) indicating what lands and waters are and are not regulated.

Once an application is received, the regulatory agency typically first evaluates the application in the office. A variety of existing information sources may be used such as flood maps, wetland maps, lists of sites or maps of endangered or threatened species, maps of public lands, topographic maps, soils maps, and watershed studies. Often the regulatory agency also sends the permit application to other resource agencies at federal, state and local levels for comment. Regulatory agencies rarely, themselves, undertake highly systematic assessment of all functions and values for an entire floodplain. This is due to the complexities encountered in analyzing functions/values, limitations upon staff and financial resources, limited time frame, and the need to spend limited funds on other critical information that needs to be carried out such as delineation of floodplain boundaries. The degree of analyses required depends, in large measure, upon the size and type of project and whether any "red flags" are identified early in the regulatory process.

To gather other types of information needed at a proposed development site, regulators typically require that landowners submit various types of information with their permit applications such as a sketch plan of the site and description of the proposed activity, land ownership information, boundaries of the floodplain, boundaries of any wetlands, and proposed impact reduction and compensation measures.

The regulatory agency may carry out one or more field visits to generate additional information concerning soils, vegetation, habitat, land ownership, hazards or other information relevant to permitting criteria. See, for example, Box 6 for factors which are considered by federal Clean Water Act Section 404 staff in evaluating a permit application.

If any special problems or issues are identified ("red flags"), the regulatory agency may hold a public hearing. The agency may also require the landowner to submit additional information or, in some instances, the agency may carry out additional studies. Regulatory agencies use a variety of informal "red flagging," "screening," and "scoping" processes to determine whether significant functions/values may be present at a site. These procedures often involve feedback (for mid-size to larger projects) not only from the permit applicant but other regulatory and resource agencies, not-for-profits, academics and others.

After this is finished, the agency denies, conditionally denies or grants the permit application. The determination of "public interest" for Clean Water Act Section 404 permitting purposes requires the regulatory agency to take into account floodplain functions/values, hazards, impacts, the acceptability of those impacts, the adequacy of mitigation measures, and the adequacy of compensation measures. See Box 6.

Box 6

Factors Considered In a Section 404 "Public Interest Review"

Section 320.4 (a)(l) of the U.S. Army Corps of Engineers Administrative Regulations requires the consideration of the following factors in evaluating a Clean Water Act Section 404 permit:

- Conservation
- Economics
- Aesthetics
- General environmental concerns
- Wetlands
- Historic properties
- Fish and wildlife values
- Flood hazards
- Floodplain values
- Land use
- Navigation
- Shore erosion and accretion
- Recreation
- Water supply and conservation
- Water quality

- Energy needs
- Safety
- Food and fiber production
- Mineral needs
- Consideration of property owners, and, in general, the needs and welfare of the people

Box 7
Floodplain Information Needed By Stage of Regulation

The types of information and the levels of detail and accuracy needed vary, depending upon the stage of a floodplain management program:

1. **Information sufficient for adoption of a floodplain regulatory ordinance.** Local governments usually need floodplain maps prior to adoption of floodplain regulatory ordinances although some have done so with written definitions of the floodplain. Maps typically show floodplain boundaries and flood depths for the 100-year flood. Maps showing floodway and erosion area boundaries may also be needed if local governments wish to adopt floodway or erosion area regulations. However, less detailed data is needed where a local government adopts conservancy zoning. Conservancy zoning limits activities in floodplains to open space activities, subject to variance or special exception procedures.

2. **Information sufficient to "red flag" activities for early rejection of a permit or to identify functions, issues, problems, etc. requiring more detailed studies.** A regulatory agency may "red flag" a permit application or a particular aspect of an application based upon wetland maps, topographic maps, soils maps, and other types of existing information that suggest special functions, values, issues, or problems at a site. The governmental unit may identify such features by not only carrying out fact-finding on their own but referring a permit application to other agencies for comment. An agency may also carry out one or more field visits to identify possible high velocity flow areas, possible wave action areas, possible endangered species areas or other areas of special functions or problems.

3. **Information sufficient to determine whether alternatives exist to the proposed permit activities.** This requires examination of not only the site but adjacent areas and other "alternative" areas to the proposed floodplain activity.

4. **Information to evaluate the sufficiency of the efforts to reduce ecological and hazard losses and to evaluate floodplain restoration, creation, or enhancement plans to compensate for losses.** Additional on-site and off-site information may be needed concerning parcel characteristics, existing and reasonable anticipated future hydrology, and ecosystem characteristics.

5. **Information sufficient for monitoring and enforcement.** Regulatory agencies need time-series information to judge the success of projects and to form the basis for corrective measures if projects fail to meet permit standards and conditions. This information must be gathered and stored in formats sufficient for use in court.

PART 5:
ASSESSING "FUNCTIONS"

Part 5 examines in greater detail the assessment of floodplain natural and beneficial "functions."

Definition of "Function"

The term "function" is broadly used in many statutes, regulations, books and reports to mean the potential of a floodplain to produce goods and services of value to society like those identified in Boxes 2 and 3. However, many scientists use the term "function" in a more restricted sense to mean the natural processes which produce such goods and services. The two definitions of function overlap since the ultimate goal of many efforts to assess processes is to estimate the potential of a floodplain to provide goods and services. See Appendix E for a further discussion of "function."

The term "value" has also often been used broadly in wetland and floodplain contexts in a manner similar to the term "function" to denote goods and services important to society such as flood storage, pollution control and wildlife habitat. The term "value," however, has not been confined to natural processes alone and has been used to refer to historical, aesthetic and other cultural goods and services as well.

The term "value" has also been used more specifically in some contexts to suggest monetary "worth" to society or social significance. We use the term "value" in the present report broadly to mean social significance or worth including but not limited to monetary worth.

Desirability of Objective Fact-Finding

Whatever definition is used for "function" and "value" in an assessment effort, separation of "objective" fact-finding from more subjective determination of societies' preferences is often useful. Physical features of floodplains including natural processes and project impacts can be categorized, studied, described, measured and modeled by scientists, engineers and other experts with a fair amount of objectivity. This is also true for proposed compensation measures. Separation of objective data-gathering from assessment of more subjective factors in analyzing floodplains can facilitate a "meeting of the minds" between resource agencies, the regulatory agency, and a landowner or his or her consultant. Agreeing on "facts" can be an important step in reaching a later agreement on application of policy.

But the objective "facts" that can be measured in the field are not confined to on-site physical, chemical and biological "processes." Objective facts relevant to regulatory permitting and detailed planning and analysis include floodplain size and width, depth of flooding and a wide range of social or cultural characteristics including impacts of proposed changes in floodplains upon landowners, public infrastructure, and the general public. These facts can be, to a greater or lesser degree, objectively measured and described much like natural processes. They are important to the evaluation of the impact of a proposed activity upon floodplain goods and services set forth in statutes and other regulations and the adequacy of various measures to reduce and compensate for impacts to these goods and services. For example, a floodplain serving as a flood storage area may decrease flood heights and resulting damage to existing or potential residential houses by 1 foot, 2 feet, 3 feet, etc. The critical issue from a manager's perspective is not only what is happening hydrologically and hydraulically but how this will affect the flooding of downstream, adjacent and upstream landowners.

Separation of objective fact-finding of “functions” from more subjective analysis of “values” or broader “social significance” is desirable as long as the validity of both assessing natural processes and the relevance of the functions produced by these processes to the needs of people are both recognized.

Floodplain Characteristics Determining Functions

The ability or capacity of a specific floodplain to provide natural and beneficial functions (i.e., goods and services) depends upon a variety of factors outlined in Box 8. Of the various features, hydrology is most important and often the most difficult to evaluate.

Box 8

Floodplain Characteristics Important to the Capacity of Floodplains to Produce Goods and Services (Natural and Beneficial Functions)

- Overall hydrologic and geologic setting including climate, rainfall, topographic form, geology, soils.
- Fluvial processes and geomorphology: the erosion and depositional processes which determine the vertical and lateral position of the water body relative to the floodplain.
- Overall ecological setting including adjacent upland and deepwater habitats.
- On-site hydrologic and hydraulic characteristics including fluctuations in water levels, hydroperiod.
- Water quality, water chemistry (e.g., Ph), nutrients.
- Flora (vegetation): types, diversity of types, condition.
- Fauna (animals): types, diversity of types, condition.
- Persistence, longevity of the floodplain and floodplain features (i.e., will a wetland be here in 10 years?).
- "Connectivity" with other wetlands, waters, upland habitat.
- Size and shape (e.g., edge ratio).
- Existing uses and alterations and restoration potential.
- Presence or absence of buffers.
- Presence or absence of active management measures (e.g., exotic weed control, water level control, fencing of cattle, etc.).

Importance of Floodplain Hydrology

All floodplain functions directly or indirectly depend upon floodplain hydrology, which is a term used here to include the forms and processes associated with watershed hydrology, hydraulics and geomorphology. Floodplain natural hazards are dependent upon the presence of human investments; the size, timing and duration of run-off events; and whether flood flows have the potential to either inundate or erode any property due to site-specific hydraulic or geomorphic conditions. Functions such as flood storage, flood conveyance, groundwater recharge and water supply are directly dependent upon floodplain hydrology. Others, such as wildlife habitat, are indirectly dependent upon floodplain hydrology because hydrology and soils determine vegetation and vegetation determines food supply. It is important, therefore, that assessment of floodplain natural and beneficial functions involve not only analysis of present but reasonably projected future floodplain hydrology including potential impacts of climate change.

It is the "water connection" that distinguishes floodplains from upland systems. The frequency and depth of flooding and saturation, the erosion and deposition of sediments and organic matter, in turn, determine the ecological niches provided by specific floodplains and portions of floodplains. Ecological niches for various plants and animals change somewhat through the seasons and vary from year to year with variations in rainfall and runoff. In addition, hydrology and hydraulics change over time as urbanization and other changes occur in watersheds. For example, peak flows often increase 5-8 times (or more) for small streams in urbanizing watersheds and total run-off may also be substantially altered. This can greatly affect functions.

Unfortunately, it is not possible to accurately determine floodplain hydrology through a single field visit to a site or by examining an air photo or satellite image. Similarly, it is not possible to accurately characterize the capacity of a floodplain to produce certain vegetation or animal/wildlife from a single field visit because both vegetation and animal/wildlife vary seasonally and from year to year in response to changes in water levels. Climate change in many instances will further complicate analysis.

Often the only approach for accurately assessing existing floodplain hydrology is to carry out field studies involving observations over time such as multi-year stream gauging for a river, the use of time-series air photos, or multiple field visits to observe water levels and velocities, plants/wildlife, and other features. But, time series studies are time-consuming and costly. And, they often cannot be carried out in the typical short timeframe of regulatory permitting.

Deducing Floodplain Hydrology from Vegetation, Soils, Other Features

Because of these restraints, floodplain managers use a variety of techniques examined in Part 8 to reduce costs and generate needed data. These include use of techniques to capture whatever hydrologic information is available such as flood elevations. Managers may hold interviews with local engineers, police, hunters, landowners, and others who have made observations (e.g., flood heights) at particular sites. In addition, they may attempt to deduce or imply floodplain hydrology from vegetation, soils, and other observable features. They may, in some instances, extrapolate from known to unknown areas. For example, floodplain managers may use stream flow and ecological information from one study stream in a region to suggest stream flow characteristics and ecological characteristics for another stream.

These techniques can help. Nevertheless, accurately evaluating existing and projecting future floodplain hydrology is difficult and there are often large margins of error.

Models for Assessing Functions

Models and methods for assessing functions may be broadly grouped in three overlapping categories which share characteristics but differ in their foci:

- Models for assessing the potential of floodplains to produce “goods and services”
- Models for assessing floodplain/wetland natural “process” and
- Models for assessing floodplain/wetland “condition.”

We will briefly consider each.

Models for Assessing the Potential of Floodplains to Provide “Goods and Services”

Almost all assessment models may, to a lesser or greater extent, be used to assess the potential of floodplains to produce goods and services. However, some models focus more than others upon the end-result of various floodplain processes and their potential for providing functions of value to people. Goods and services are primarily produced by natural processes but cultural, aesthetic, historical, and recreational factors also play a role.

Models for assessing the potential for providing goods and services help regulatory agencies comply with statutes and administrative regulations, which require them to evaluate the impact of proposed activities upon specific types of goods and services (e.g., flood storage, erosion control, pollution control), the adequacy of impact reduction measures, and the adequacy of compensation measures. See Box 6.

Rapid assessment models for evaluating goods and services may help “target” or “red flag” broader issues, impacts, problems, restoration potential or other features of floodplains in “public interest” regulatory and other management contexts.

In the 1980s and until 1996, much of the national attention in wetland assessment focused upon methods for assessing potential for providing “goods and services.” During this period, the Wetland Evaluation Technique (WET) was developed by the Federal Highway Administration in cooperation with the Corps and other federal agencies. This technique used lists of questions, existing information, limited field observations and professional judgment to guide the user in assessing wetland functions and values. The technique also considered social factors (opportunity and social significance). Many states developed what have been called “baby” WETs in this period. These resemble the national WET model and also focus on goods and services.

Models for assessing goods and services include not only WET but WEThings and a variety of fish and wildlife assessment models (e.g., HEP). They include instream flow models. They include, in some instances, the use of quantitative hydrologic models developed for other purposes but used for wetlands and floodplains such as Corps of Engineers HEC-RAS models to determine flood heights and storage capability. They include the South African WET-

EcoServices model[33] and the UK "National Ecosystem Assessment Working Paper Economic Assessment of Freshwater, Wetland and Floodplain (FWF) Ecosystem Service."[34]

Although useful in some respects, WET and its state counterparts proved to be too subjective and unsatisfactory for determining wetland compensation ratios and for implementing a no net loss goal. In 1996 the Army Corps of Engineers announced development of a new wetland assessment technique—the Hydrogeomorphic Method (HGM). This technique focused upon natural processes and relative ecological condition. With HGM approach, there is no specific evaluation of goods and services nor is there evaluation of opportunity or social significance. Instead, HGM focuses on natural processes alone.

Assessment of goods and services may, like assessment of condition, be carried out with various levels of detail and accuracy including landscape/watershed, intermediate, and detailed levels. Many of the rapid models for evaluating goods and services provide checklists for use in the evaluation process. Assessment involves the examination of wetland and floodplain maps, air photos, soil maps, flood maps, and other existing data combined, in many instances, with some level of field data-gathering. Based upon check lists and both office and field data-gathering, professional judgment is used to determine the goods and services, the possible impact of proposed activities on those goods and services, and the adequacy of compensation measures.

Models for Assessing Floodplain "Natural Processes"

Some assessment techniques such as the HGM focus upon assessment of "natural processes" rather than upon the goods and services produced by such processes. See Appendix D for examples of such processes and their relevance to goods and services. Assessment of "processes" is usually undertaken with the assumption that assessment of processes will also indicate potential to provide goods and services. This assumption may hold true if the full range of processes are investigated.

Unfortunately, models focusing upon processes usually do not assess the full range of processes necessary to produce goods and services. Consider, for example, efforts to evaluate the flood storage functions of a floodplain. Because hydrologic data-gathering is time consuming and expensive, some assessment efforts attempt to evaluate the impact of vegetation on flood storage and largely ignore other factors. But an examination of the vegetation and the "roughness" coefficient provided by vegetation is only one factor relevant to flood storage potential. The depth of the floodplain and its size are often primary considerations.

There are important benefits of a "natural process" focus. Natural processes can be quantitatively measured and this lends objectivity to assessment although objectivity may have limited utility if only limited factors are taken into account. A focus on natural processes also helps managers and private landowners seeking to make changes in the floodplain understand how floodplain/wetland ecological systems "work." And this is important if they are to develop or implement impact reduction or compensation measures.

[33] WET Ecoservices (2007). http://www.geography.ukzn.ac.za/wetlands/wet-ecoservices.htm
[34] http://uknea.unep-wcmc.org/LinkClick.aspx?fileticket=lVLEq%2BxAI%2BQ%3D&tabid=82

Models for Assessing Floodplain "Condition"

In recent years many scientists have shifted their focus from assessment of goods and services per se or natural processes to assessment of relative floodplain/wetland condition measured along a disturbance gradient. The disturbance gradient is defined with the use of "reference" floodplain/wetlands. "Reference" floodplain/wetlands are often defined to include those in a natural condition. But some assessment methods also include wetlands and floodplains with various degrees of disturbance. Flora and fauna and other features are sampled to establish relative condition.

The models focusing on condition overlap with models assessing processes such as HGM. They include the U.S. riparian "Proper Functioning Condition" model and the South African WET-Services model.[35]

Assessment of relative condition with the use of floodplain/wetland reference sites does have advantages. Models assessing ecological condition involve data-gathering and analysis for objective floodplain/wetland characteristics such as the presence or absence of specific types of plants and animals. Reference wetlands and floodplains can be used to suggest goals for protection and restoration of floodplains/wetlands consistent with optimum ecological functioning.

However, assessment models for condition also have the drawback of usually considering only a limited number of assessment factors. The models do not attempt to evaluate the range of end-result goods and services provided to society such as flood storage and pollution control. Nor do they attempt to determine the "opportunity" floodplains have to serve specific functions or the worth to society of those functions.

The high cost of field sampling typically requires the use of a small number of indicators of condition and a relatively small number of samples. But efforts to use a small number of indicators and simplifying assumptions for highly complex and variable wetland and floodplain systems results in inaccuracy. It is also difficult to find undisturbed "reference" floodplains and wetlands in urban and highly altered rural settings due to pollution, modifications in hydrologic and sediment regimes, and widespread invasive species.

There is also, as yet, only partial agreement concerning what overall wetland or floodplain characteristics are to be measured in determining ecological "condition" at federal, state and local levels. The relative "condition" of wetlands and floodplains may be compared in terms of a number of different characteristics. For example, relative condition can be compared in terms of the amounts of toxics, nutrients, or sediment found in floodplains in an absolute sense or in comparison to a pre-determined standard (i.e., a state water quality standard). Relative floodplain condition can also be compared in terms of biology including the degree of "naturalness" of plant and animal communities ("ecological" condition). Relative condition can be compared in terms of the capacity of floodplains to perform specific hydrologic functions (e.g., storage of flood waters). The various measures for relative condition do not necessarily coincide with one

[35] WET-Health (South Africa), 2009, http://www.o5demo.com/ckfinder/userfiles/files/08%20-%20WET%20Health.pdf

another. For example, the flood storage and pollution control functions of a floodplain may be high even though the indicators of relative ecological condition are low.

In urban settings, ecological condition is often a poor surrogate for the full range of hydrologic goods and services. Some of the heavily impacted floodplains have the greatest hydrologic goods and services and the greatest restoration potential. It is here that assessment models which reflect both condition and the full range of goods and services are most needed.

There is also, as yet, little agreement on how information concerning relative ecological condition is to be used in regulatory permitting at all levels of government including the establishment and implementation of water quality standards. It may be argued, on the one hand, that the most disturbed floodplains should receive **the greatest regulatory protection** to prevent further degradation. These include many urban floodplains and floodplains in highly altered (e.g., agricultural) rural landscapes. It may also be argued that floodplains with the greatest disturbance should also be **given highest priority for restoration** because of their degraded condition and because, quantitatively, the greatest restoration benefits in terms of goods and services may be derived from restoring such floodplains.

On the other hand, it may also be argued that floodplains with the most disturbances should receive the **least regulatory protection** because there are fewer remaining services to protect. Restoration is often most difficult and costly. Developers in urban settings often seek permits for fill and drainage of wetland or storm water discharge into wetlands using this argument. Wetland legislation was proposed but not adopted in a number of sessions of Congress in the early to mid-1990s (H.R. 1330) would have classified wetlands to remove protection for the most highly altered wetlands.

Examples of assessment methods/models addressing wholly or in part relative condition include various state IBI approaches, HGM models, the Rosgen stream assessment approach, and BLM's "proper functioning condition" procedure. They include many "condition" assessment approaches under development by states with funding from the EPA's Wetland Division for the 2011 National Assessment

EPA is conducting a cooperative EPA/state national assessment of wetland "condition" in 2011. This assessment with be based upon a statistical sample of wetlands. It will parallel similar EPA/state efforts to evaluate the condition of rivers, streams, lakes and the oceans. According to EPA, the "survey will be designed to provide regional and national estimates of the ecological integrity and biological condition of wetlands". The process of designing and conducting the survey is also intended to help build state and tribal capacity to monitor and analyze wetland condition while promoting collaboration across jurisdictional boundaries.

EPA is making available to the states Clean Water Act Section 106 funds to inventory wetlands as part of the 2011 national assessment. EPA is, with the states, in the process of developing wetland condition assessment criteria and procedures for the 2011 assessment including the indicators of condition, assessment protocols, monitoring needs over time, and other particulars.

EPA efforts to encourage the states to assess wetland biological condition are not new. EPA has worked extensively with states to help them develop wetland bioassessment and biological criteria (biocriteria). In May of 2001 it released 19 “State of the Science” reports addressing biocriteria. EPA in the spring of 2000 released a wetland monitoring strategy. EPA has suggested that states undertake assessment of wetland condition at three levels as described above. EPA has indicated that the 2011 condition assessment will utilize a “probability-based sample design” that will result in estimates of condition for populations of wetlands.

Assessment of Social Significance Including, In Some Instances, Monetary Value

Floodplain managers may need to assess not only the ability or capacity of a floodplain to perform specific functions but also to relate these functions to the needs of society. “Social significance” refers to the importance of floodplains to people. Assessing the social significance of floodplain functions requires simultaneous consideration of floodplain capacity and the needs of people. Social significance includes but is broader than economic value alone. It includes health and safety, aesthetics, and broader cultural features with or without economic valuation.

Assessment of social significance will be discussed next in Part 6.

PART 6:
ASSESSING "SOCIAL SIGNIFICANCE"

Part 6 examines issues and approaches for assessing the "social significance" of floodplain functions.

Overview

"Social significance" refers not simply to the inherent capacity of floodplains to provide "functions" to produce "goods or services" but the importance of these functions or goods and services to society in a variety of ways—economically, aesthetically, culturally, historically, etc.

Evaluation of social significance is (arguably) needed to carry out environmental impact review pursuant to the National Environmental Policy Act since impact on people is part of environmental impact. Social significance is relevant to a determination of the "public interest" by the Army Corps of Engineers and EPA for a Clean Water Act Section 404 permit. See Box 6. It is also needed by federal agencies to make environmental equity determinations required by the Environmental Equity Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations (1994). State and local regulators need social significance information to apply "public interest" criteria in state and local regulations.

Evaluation of social significance requires the simultaneous consideration of capacity, opportunity, and the needs of the people who may benefit or suffer costs from resource decisions. Assessing social significance requires a shift from examination of the physical characteristics of floodplains to determining how they will impact specific groups and individuals.

Social significance depends upon not only present importance but potential future importance to groups and individuals. For example, for an urbanizing area, the social significance of a floodplain requires consideration of not only present but future populations.

If a proposed activity poses a threat to public safety, even limited impact on the resource may be unacceptable. For example, even a small amount of damage to a floodplain wetland may be unacceptable where the wetland helps protect the water supply of several million people (e.g. a wetland in the Catskills helping to protect the New York water supply).

In an ideal world, assessment of floodplain functions would involve quantitative evaluation of natural and beneficial functions (using real, "ratio" numbers), the impacts of specific project proposals on such functions/values, and the economic and broader social impacts of proposals on society. For example, a quantified assessment of flood storage would suggest how much flood storage a floodplain/wetland would provide for a selected flood (e.g., 100-year flood), what individual or cumulative impact a fill might provide on this storage, how much this would affect downstream flood heights and velocities, and what this would mean in terms of flood damages to both existing and potential development. In an ideal world, this information might be translated into a cost/benefit economic analysis showing not only total monetized benefits and costs for a project but who would benefit and incur costs. Economic models might be used to quantify the economic "value" of particular goods or services provided to society.

Of course, this is not an ideal world. For a variety of scientific, budgetary and other reasons it is difficult to provide even a qualitative evaluation of functions for a specific floodplain much less highly quantitative information on costs and benefits of functions for an entire floodplain or all the floodplains within a geographical region.

Carrying Out a Monetized Assessment of "Value"

Congress, in the Flood Control Act of 1936, required the Corps of Engineers to conduct a cost/benefit analysis for water projects. The Corps of Engineers has done so for more than seventy years. The Corps has, for much of this time, followed "principles and standards" or "principles and guidelines" for evaluating the cost/benefit of water projects. The benefits of a proposed project must exceed costs over time. All costs and benefits of a project are to be evaluated. This is very difficult, however, because all projects have benefits and costs to which it is difficult to assign dollar values. This includes "residual" flood hazards after construction of a dike, levee, dam, or drainage channel. It also includes a broad range of environmental functions such as habitat for rare and endangered species or pollution control.

The 2007 Water Resources Development Act more specifically requires federal agencies to develop updated standards and criteria for water projects which reflect floodplain natural resources. See discussion in Part 1 of this paper.

The benefits and costs of floodplain natural and beneficial functions are typically not priced in the market and may, therefore, be poorly reflected in water project analysis. In addition, economists have no sound, broadly agreed upon techniques for valuing the flood damages "avoided." For example how are the dollar values of flood damages avoided to be calculated when a floodplain management agency creates a greenway as part of a flood control project? Is the water resource planner to assume that without the creation of the greenway/floodway the area would be completely developed? Partially developed? What sorts of development would occur? High density residential? Low density residential? Flood vulnerable commercial or industrial development? Commercial or industrial development with floodproofing?

Monetized assessment of functions is more difficult for some functions than for others. For example, if a specific floodplain reduces downstream flood heights by 1 foot by storing flood waters, an economic analysis could be done to indicate the benefits of reduce flood heights to structures by using flood stage (elevation) versus damage curves. A dollar figure might be assigned to this reduction in flood damage. Assigning economic numbers to other types of "values" such as aesthetic and cultural values is more difficult although some economic models attempt to measure them by visitor days, enhancement in adjacent land values, and other techniques.[36]

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[36] See King, D.M. & M.J. Mazzota. 2000. Economic Evaluation website available at http://www.ecosystemvaluation.org/

Because of the time and expense involved, full-fledged economic studies of natural and beneficial functions are rare except for federal water projects where economic analyses are routinely carried out. For example, the Corps of Engineers calculated the economic flood-loss reduction benefits of both structural and nonstructural measures for the Charles River. Based upon this analysis, the Corps ultimately decided based upon the economic analyses to acquire many of the watershed wetlands rather than construct a dam.

The Corps has also attempted to economically quantify economic benefits of Corps restoration projects. Economic studies can suggest before and after economic costs and values for restoring floodplains. For example the economic value of a restored floodplain for providing fish, shellfish, flood storage or other functional values in comparison with an unrestored floodplain may be provided.

Because of uncertainties in assigning dollar values to avoidance of flood damage or to the protection of habitat and other functions, water resource planners may over-estimate the benefits and underestimate the costs of structural flood control measures. Consider, for example, the dilemma facing a water resource planner for an area with many existing flood prone residential structures. The planner can assign with fair certainty a dollar value for the benefits and costs of a levee or dam for reducing future flood damages to the individual residences and public infrastructure serving the residences. The planner may also project benefits for residential "in filling" of the flood prone area. In contrast, the planner proceeds with great uncertainty in projecting the costs and benefits of preventing development from occurring in areas through public acquisition, regulation, or other approaches. This does not mean that the benefits and costs are less real, only that they are difficult to accurately project and require making a variety of assumptions concerning future growth. And, the water resource planner in the past has often sided with what is relatively certain and can be most accurately measured.

Despite problems in applying cost/benefit analyses to nonmarket functions and values, even approximate cost/benefit analysis can be helpful to the water resource planner. Cost benefit analyses can be used to discount the present value and costs of a project over time. Cost benefit analyses can identify spillovers which need to be taken into account in project planning. Cost benefit analyses can help the water resource planner understand the social context of projects including the environmental impact.

Progress has been made in monetizing the value of floodplain, wetland and riparian area functions. See the work of Dennis King, et. al. from the University of Maryland[37] for examples of nonmarket valuation tools available to the floodplain manager interested in monetized evaluation of nonmarket goods and services such as[38]

> "Contingent valuation. Surveys are used to help respondents estimate personnel willingness to pay for nonmarket goods or services like clean beaches or healthy corals.
>
> Travel cost. Survey or observation uses to calculate the value of a recreational experience. An example would consider how much visitors are willing to pay for access to a resource, considering travel time, fuel, lodging and entry fees.

[37] Id.
[38] Id.

> Hedonic pricing. Market transactions are compared for goods or services that differ primarily because of the influence of the nonmarket good or service of interest. For example, sales prices of similar homes could be compared where some overlook a healthy saltmarsh and others do not. This comparison could estimate the value of the saltmarsh to the market value of the homes that surround it.
>
> Benefit transfer. Estimates of value derived from a study of one area can be adapted for use in another area. For example, the value of sportfishing that will result from the restoration fisheries in northern California can be estimated using studies of similar fisheries in Oregon."

See also the useful efforts to provide science-based economic analysis and attach value to natural resource capital including the monetization of value of wetlands and other natural systems of David Batker and colleagues at Earth Economics (a not-for-profit located in Tacoma, Washington)[39] and Robert Costanza at Portland State University.[40] See also WET-Ecoservices a South African (2007) project[41] and Economic Assessment of Freshwater, Wetland and Floodplain (FWF) Ecosystem Services, a UK project.[42]

Alternatives in Assessing Social Significance

If full-blown economic analyses to determine economic value is not practical or possible, what can be done to evaluate "social significance?"

It has been argued by some scientists that Section 404 regulators should ignore social significance altogether because social significance is hard to evaluate and it is easier for wetland or floodplain managers to focus in assessment on natural processes alone, which are (more or less) measurable. Most of the recent wetland models such as HGM and IBI models have not attempted to evaluate the value of goods and services to people, although there are exceptions.

Several rationales have been offered for omitting consideration altogether of social significance and focusing on natural processes. Assessment of social significance is more subjective and less subject to quantification than assessment of natural processes alone. Natural processes can be more or less "objectively" studied and described. It is difficult to quantify social significance. A focus on measurable natural processes or condition can also help floodplain managers understand natural systems and the impacts of proposed projects. It can help a regulator determine the adequacy of impact reduction and compensation measures.

But can a Section 404 "public interest" review take place without relating natural processes and goods and services to "public?" Can "environmental impact" be assessed without also considering the impact on people as well as other aspects of the environment?

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[39] See, e.g., http://www.eartheconomics.org/
[40] See http://www.pdx.edu/sustainability/robert-costanza
[41] http://www.geography.ukzn.ac.za/wetlands/wet-ecoservices.htm
[42] Economic Assessment of Freshwater, Wetland and Floodplain (FWF) Ecosystem Services (UK), (2010), http://uknea.unep-wcmc.org/LinkClick.aspx?fileticket=lVLEq%2BxAI%2BQ%3D&tabid=82

Without procedures for considering the public interest, regulators and managers are left to their own highly subjective devices for considering social significance.

There are alternatives to economic analyses in determining social significance which stop short of either ignoring “value” altogether or conducting a full scale economic analysis. These include assessments which evaluate the relative value of floodplain functions using nominal scale numbers, efforts which evaluate the “opportunity” functions have to actually provide goods and services, efforts which examine “who benefits and who pays for changes in functions,” and other efforts to evaluate the “weight” society places on functions. Each of these will be discussed briefly.

Evaluating Capacity, Value Using “Nominal” Numbers

Given the difficulties encountered with providing a quantitative monetary analysis of floodplain functions, including the weight which society attaches to these functions, a number of assessment models have been developed for rating relative value of floodplain/wetland functions using "nominal" numbers.[43] With a nominal scale approach, relative scores and weights may be provided for floodplain/wetland functions based upon professional judgment but there is no fixed interval between numbers. For example, a floodplain rated a 2 for flood storage on a nominal scale of 1 to 10 might have twice as much, ten times as much, or only slightly more flood storage capability than a floodplain rated a 1. In contrast a floodplain rated a 2 on a "ratio" scale would have twice as much flood storage as a floodplain rated a 1.

Some government agency staff, landowners and consultants have supported the use of numeric rating schemes to provide estimates of relative importance or simple, "bottom line" numbers for impact analysis or determining mitigation needs even when they have known that such numbers are more or less arbitrary. Nominal scale numbers can provide some estimation of weight or probability of importance. Advocates argue that it is useful to determine how “relatively” important a particular function or floodplain may be and this is the best that can be done.

But, there are problems with nominal rating schemes and they must be used with care if at all:

(1) They may mislead landowners, developers, members of the public, legislators and others who do not understand nominal versus ratio[44] numbers. Nominal numbers often quickly develop a life of their own (i.e., the public believes that "figures don’t lie," particularly if they are developed by scientists).

(2) Nominal or ordinal ratings can, because of their subjectivity, be easily manipulated by the individual carrying out the rating.

(3) Nominal scale numbers provide limited actual guidance for the design of mitigation measures and compensatory mitigation. Consider a proposed fill for an acre of inland marsh.

[43] See Hollands, G.G., and D.W. Magee. 1985. "A Method for Assessing the Functions of Wetlands," pp. 108-118 *in* J. Kusler and P. Riexinger (eds.), Proceedings of the National Wetland Assessment Symposium (1985), Association of State Wetland Managers, Berne, NY.

[44] The interval between “ratio” scale numbers is fixed—2 is 1 more than 1; 3 is 2 more than 1 and so forth. Almost all measurement in the physical sciences in done on ratio scales.

> If "no net loss" of function is to occur, a regulator must know what impact this fill will have in terms of loss of flood storage. It is not very useful to know simply that "some" loss of flood storage will occur for the design of specific mitigation or compensation measures or that a floodplain ranks 2 on a nominal scale. What does a nominal rating of 2 mean—1 acre foot, 2 acre feet, 3 acre feet of flood storage etc.?

Efforts to "add" and “subtract” functions and values using even ratio scale numbers create further problems because some functions and values although quantitative are wholly or partially contradictory: if a floodplain serves one function it cannot serve another. For example, dense floodplain vegetation helps slow floodwater, increasing flood retention and storage. But dense vegetation may also trap sediment resulting in rapid filling of a floodplain (sometimes many feet of sediment in a single flood event) and the destruction of flood storage, pollution removal, and other floodplain functions. So, flood storage and sediment retention value may, over time, be contradictory and cannot be added in assessment.

Contradictions between sediment trapping and flood storage, pollution control, and other valuable functions are dramatic and obvious. But there are many more subtle contradictions such as differences between functions which favor maintenance of open water (fisheries, waterfowl) versus functions such as pollution removal, which favor dense vegetation.

Evaluating “Opportunity”—The Ability of a Floodplain To Actually Perform Certain Functions

Some assessment models such as the WET model and some GIS models evaluate the “opportunity” wetlands or floodplains have in a particular context to actually perform certain functions for specific individuals or groups. Opportunity pertains to the ability or capability of a floodplain area to actually deliver certain goods or services to the public. For example, a natural floodplain in a rural, wilderness setting may have considerable natural ability or "capacity" to remove pollutants from a river, but there may be few pollutants to remove in such a setting. A similar floodplain in an urban area may actually remove large amounts of pollutants from watershed development. This floodplain has present "opportunity" to provide significant pollution control or recreation and may have even greater future "opportunity" as more development occurs in the area.

Evaluation of present and future "opportunity" is important to decision-makers attempting to determine which floodplain areas or functions are of greatest value or worth to society, in the “public interest,” or in the most need of protection, restoration, or management.

Opportunity depends upon a number of interrelated factors which are outlined in Box 9.

Opportunity and capacity overlap. For example, the capacity of a floodplain to provide fisheries habitat depends, in part, upon present and future connectivity to other waters. A floodplain with no connectivity has no fisheries "capacity." Opportunity also depends upon connectivity because a wetland or floodplain cut off from adjacent waters has no opportunity to provide fish spawning grounds or food for fish in adjacent waters and for the people who may catch them.

Box 9
Determining "Opportunity": Relevant Factors

- "Capacity"
- Hydrologic and ecological context
- Land use
- Existing and potential watershed "problems" such as pollution, flooding, habitat degradation, etc. which may be addressed by protecting/restoring floodplain natural and beneficial functions
- Location
- "Connectivity", fragmentation
- Accessibility to the public

It is difficult to evaluate opportunity because needs change over time as well as the ability of specific floodplains to meet those needs. Opportunity can best be evaluated through land and water use inventories and planning methods which consider not only present capacity but the relationship of floodplains to existing and potential needs and problems. Geographic information systems are particularly useful in evaluating and projecting such relationships, in defining present and future needs, and suggesting the ability of specific floodplains to meet needs.

Evaluating Who Benefits and Who Pays

Social significance depends, in part, upon who benefits and who "pays" (i.e. suffers costs), how they are benefited or suffer costs, and how much they benefit or suffer costs. A subjective, unquantitative assessment of who benefits and pays has limitations but, nevertheless, can shed light on the "public interest" when an alteration is proposed to floodplain natural and beneficial functions:

(1) **What is the nature of the interest or interests involved?** Floodplain functions and changes in those functions provide specific individuals and groups with goods and services which affect society in different ways and have varying levels of importance to society. Characterizing the nature of the interests can help determine importance to society. For example, a floodplain that stores flood waters, reducing downstream flash flooding would have "health and safety" implications. Similarly a floodway that conveys flood waters without significant increase in flood heights will help prevent "nuisances." Still other floodplains provide important cultural or aesthetic functions.

(2) **Who benefits and who suffers costs?** Even a generalized analysis of "who" benefits and who suffers costs for floodplain functions or changes in these functions can be useful in evaluating the social significance of floodplain functions in a specific context. It can help a floodplain agency determine the geographical scope of floodplain functions and the impacts of proposed changes on those functions. It is also relevant to determinations of "social equity" and "social justice." For example, an urban floodplain may be particularly important to urban minorities.

(3) **How many benefit and suffer costs?** Knowing "how many" will benefit or suffer costs can help a floodplain agency determine what will provide "the greatest good for the greatest number?" For example, a wetland in the Catskills which helps protect the water supply for New York City may provide benefits to 8 million plus people, while another wetland in northern New York may provide present day pollution control benefits to a much smaller number of individuals.[45]

Assessing the "Weight" Society Attaches to Various Functions

Social significance depends, in part, upon the weight society attaches to particular functions and changes in functions. Determination of weight is not easy. However, some sense of "weight" may be gained through a number of approaches outlined in Box 10 below.

Box 10

Approaches for Determining the "Weight" Society Attaches to Various Functions in Specific Contexts

Examples of approaches not involving monetized assessments available to floodplain management agencies for estimating the weight society attaches to particular functions including changes in functions include the following. All approaches are subject to limitations.

1. **Floodplain management agencies can solicit responses concerning value and weight of value by issuing notices and holding public hearings.**

A. *Notices.* Notices and opportunity for comment are a broadly used technique to solicit feedback from the public concerning public preferences. Regulatory agencies often provide notices of permit applications to the public, interest groups, adjacent landowners, and others. The resulting comments are then analyzed.

B. *Public hearings.* Public hearings are also broadly used to solicit feedback from the public concerning proposed permits, plans and policies.

2. **Floodplain management agencies can use general knowledge to estimate value and weight of value.** An agency does not need an independent poll to determine that landowners do not want adjacent floodplain occupants to pollute their wells. Agencies can and do use their common sense and general knowledge (newspapers, T.V., interaction with interest groups, interaction with the public) to recognize values held by the public.

[45] It is to be noted, however, that the pollution control function of a wetland in the Adirondacks may become increasingly important over time as development occurs.

3. **Floodplain management agencies can, in some instances, refer to existing statutes, ordinances, or other legislative acts to determine what legislative bodies or executives believe to be important and the weight attached to particular functions or changes in functions.** For example, agencies can determine the consistency of a permit with the goals set forth by Congress in the Endangered Species Act, the Clean Water Act, and other acts and regulations. See Florida Key Deer v. Paulson, in which the 11th Cir. Court of Appeals observed that (522 F.3d 1133, 1138 (11th Cir. 2008)) that "The plain intent of Congress in enacting this statute was to halt and reverse the trend toward species extinction, whatever the cost." Tenn. Valley Auth., 437 U.S. at 184, 98 S.Ct. 2279. In short, the preservation of endangered species was to be considered "the highest of priorities." Id. at 194, 98 S.Ct. 2279."

4. **Floodplain management agencies can consult locally adopted plans and regulations; they can also work with planning agencies to gain feedback from a broad range of groups and organizations concerning protection, restoration and development proposals through the use of planning processes.** For example, the Lane County Regional Planning Agency undertook a detailed wetland assessment process and prepared a wetland plan for West Eugene, Oregon. The agency used assessment and planning processes to gain feedback from various groups and individuals concerning wetland functions and what wetlands should be protected. Techniques used included one-on-one consultations, questionnaires, and public workshops. The plan was ultimately submitted to the electorate for approval and is now used as the basis for regulatory permitting.

5. **Floodplain management agencies can, with the help of their attorneys, determine private legal rights relevant to value.** For example, private landowners owning lands adjacent to a stream have a variety of legal rights such as reciprocal "riparian rights" to surface waters. These landowners also have a right to use their property without unreasonable interference by other riparian landowners.

6. **Floodplain management agencies can poll a statistical sample of users with regard to preferences.** This is rare but is sometimes done. For example, a fish and wildlife agency may poll a sample of hunters with regard to proposed dates for beginning a hunting season.

7. **Floodplain management agencies can, in some instances, subject the question of value and weight of value directly to elected officials for determination.** For example, a local floodplain regulatory agency may submit a proposed by-law change, "special exception," "variance" to a town, city or county council or board of adjustment for a vote to determine how the legislative body feels about protecting specific functions or areas.

8. **Floodplain management agencies can subject the question of value to appointed executive commissions or committees.** Quite often local regulators submit proposed permit applications to appointed soil and water conservation boards and conservation commissions for comment.

9. **Floodplain management agencies can, in some instances, subject the question of value to direct vote by the public.** At the local level, proposed floodplain zoning regulations and amendments may be placed on voting ballets for direct vote. Or, local land or water use plans with floodplain components may be subjected to direct vote. Proposed local bond issues for floodplain management measures may also be put before voters. This isn't a quick process, but it can provide direct public feedback.

Experience suggests that if floodplain management agencies wish to gain feedback concerning value and “weight" of value from interest groups, commissions, academics, and the public, the agencies need to provide target groups with information concerning the resource that may be lost and who will be affected. They must, then, provide a comment period, hearing, or other mechanism for soliciting and allowing feedback. This is best achieved in a planning process rather than on an individual permit basis where it is very difficult to consider cumulative impacts.

PART 7:
RAPID AND MORE DETAILED ASSESSMENT TECHNIQUES

Part 7 provides examples of two categories of assessment techniques and methods developed over the last several decades and applied to wetlands, rivers and streams, and riparian areas by wetland managers, floodplain managers, public land use managers, regulators and others. [46] These include

—**Rapid and, in many instances, generalized assessments.** These assessment techniques and methods address, on a preliminary basis, the capacity of floodplain areas to provide natural and beneficial functions. Such techniques can be used to provide an unquantified, overview of functions. They can also help the user determine whether a more detailed analysis is needed, and to design more detailed analyses (if one is needed). These techniques are based primarily upon existing information, a single field visit and professional judgment.

—**More detailed (and, in some instances) quantitative assessment.** Specific hydrologic and hydraulic models can provide more detailed and accurate determination of flood subzones and the impact of activities on floodplain hydrology and hydraulics. Similarly, more detailed ecological assessment approaches can provide more information concerning ecological functions, the impacts of activities on those functions, and the adequacy of impact reduction and compensation techniques.

It is difficult to compare the various methods because they have different uses and different strengths and weaknesses. For example, broad-based mapping approaches may be sufficient for community wide planning and the adoption of conservancy zoning but they lack accuracy and detail needed for evaluating the impact of specific activities at particular sites and designing impact reduction and compensation measures.

It is often best where development is proposed with significant impact on floodplain functions to combine a preliminary overview survey with the use of more specific models to assess functions and values at specific sites. To make such an approach practical (due to limitations on budgets, staff, time) various "sorting," "red flagging," "screening" and other approaches must be used to selectively determine whether more detailed analysis is needed and, if so, which functions, values, issues and problems need more detailed analysis. See Part 8 of this paper. More detailed analysis can then follow if needed.

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[46] The following summary of approaches draws upon a wide range of sources and materials. Selected references are provided in the text. See also Appendix G, suggested readings and websites.

Examples of Rapid (Preliminary) Assessment Methods

Rapid Wetland Assessment Methods. A relatively large number of rapid assessment methods have been developed to assess wetland functions/values using various lists of questions and matrix analyses. See, e.g., Larson, J.S. (ed.). 1976. Models for Assessment of Freshwater Wetlands, Publication No. 32, Water Resources Research Center, University of Massachusetts, Amherst, MA. WET and WET2 were the first broad scale wetland assessment approaches developed to evaluate the range of functions/values for specific wetlands in a regulatory context. See Adamus, P.R. et al. 1987. Wetland Evaluation Technique (WET), Technical Report Y-87, Volume II. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, MS. WET was designed to evaluate 11 functions/values and the impact of proposed activities upon a number of targeted animal species. Wetlands are qualitatively evaluated through the use of a series of questions which must be answered by the assessor. This creates a matrix. Capacity, opportunity, and social significance are considered. A somewhat similar approach with numerical scores and weights was developed by Hollands/Magee. See Hollands, G.G., and D.W. Magee. 1985. "A Method for Assessing the Functions of Wetlands," pp. 108-118 *in* J. Kusler and P. Riexinger (eds.), Proceedings of the National Wetland Assessment Symposium (1985), Association of State Wetland Managers, Berne, NY.

Many similar matrices analysis models were subsequently developed in Connecticut, New Hampshire, Maryland, Wisconsin, Oregon, Minnesota, Ontario) based upon the Larson, WET, and Hollands/Magee approaches. See e.g., U.S. Army Corps of Engineers. 1988. The Minnesota Wetland Evaluation Methodology for the North Central United States. Minnesota Wetland Evaluation Methodology Task Force and U.S. Army Corps of Engineers, St. Paul District; NY; Ammann, A.P. and A.L. 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; Euler, D.L. et al. 1983. An Evaluation System for Wetlands of Ontario South of the Precambrian Shield. Ontario Ministry of Natural Resources and Canadian Wildlife Service, Ontario, Canada.

With some of these matrix approaches (e.g., WET), wetlands are simply rated as high, medium, and low with regard to specific functions and values. With others (e.g. Hollands, Magee) "nominal" (non interval) numeric scores are assigned to specific functions and values. Some approaches then weigh function scores to provide overall scores by function or wetland.

WET and similar matrices analysis approaches were used quite extensively in the late 1980s and early 1990s by consultants and by some state, federal and local regulatory agencies for not only regulatory permitting, but assessment of wetlands for planning purposes (Advanced I.D.s, Special Area Management). Use has diminished over time, however, because these procedures are relatively time consuming and complicated and have proven inadequate for numerically evaluating with real, “ratio” numbers the adequacy of impact reduction and compensation measures including compensation ratios. In addition, the accuracy of these evaluations is often limited by simplifications, assumptions and the failure to consider all of the relevant factors. Nevertheless, some elements of these approaches such as lists of functions, lists of "red flag" issues, and bibliographies continue to be used.

Qualitative Analysis Of Wetland Functions/Values. The U.S. Army Corps of Engineers. 1995. The Highway Methodology Workbook Supplement, Wetland Functions and Values, A Descriptive Approach, NEDEP-360-1-30a, New England Division's descriptive approach is quite different from other assessment approaches and retreats from the attempt to assign numerical scores to functions and values. It is more qualitative and it is the only approach which has been developed primarily by regulators. It was developed in a region of the country (Northeast) where there has been extensive experimentation with WET, Hollands/Magee, and other approaches. It is based upon much of what has proven to be "workable" on individual permits.

This approach uses a multidisciplinary regulatory team (applicant's consultant, Corps of Engineers staff, and State and Federal agency staff) to evaluate the impact of project proposals upon 13 wetland functions and values including groundwater recharge/discharge, flood flow alteration, fish and shellfish habitat, sediment/toxicant and pathogen retention, nutrient removal/retention/transformation, production export, sediment/shoreline stabilization, wildlife habitat, recreation, education/scientific value, uniqueness/heritage, visual quality/aesthetics, and threatened or endangered species habitat.

The document setting forth the assessment method recommends that the project consultant first seek guidance from the U.S. Army Corps of Engineers, then evaluate the wetlands. The team will either be a party to this effort directly or review work products and offer comments.

The evaluation is to be a qualitative description of the physical characteristics of the wetlands including a determination of the "principal" functions and values exhibited. The method rejects "numerical" methods unless the data is available to support the analysis. It prohibits the arbitrary weighing of wetland functions and the ranking of dissimilar functions. The guide provides a simple evaluation form and calls for attachments such as a sketch of a wetland in relation to the impact area and surrounding landscape and an inventory of vegetation and potential wildlife species. It calls for a graphical approach to wetland evaluation.

The document provides an example of "considerations" that were taken into account for a New Hampshire highway project.

The approach ties into regulatory processes and can be used in conjunction with comment and notice and hearings. It is flexible and depends upon discussion and negotiation. It uses a hierarchical, sorting approach to first determine relevant functions and then to focus on those factors in greater depth. It asks for graphic, qualitative analysis from a project proponent which can be understood by all members of a team. It relies on professional judgment and does not attempt to rigorously separate policy from fact. It considers a broad range of functions such as recreation, heritage, education, and archaeological values.

Area Wide Assessment Of Functions/Values Through The Synoptic Approach, Various GIS Approaches. The U.S. Environmental Protection Agency has proposed a landscape level "synoptic" approach to wetland assessment. This approach looks at wetland position in the landscape and overall landscape features to help evaluate wetland functions/values and threats to wetlands. See Abbruzzese, B., S.G. Leibowitz, and R. Sumner. 1990. Application of the Synoptic Approach to Wetland Designation: A Case Study Approach, EPA/600/3-90/072, U.S. EPA Environmental Research Lab, Corvallis, OR. See

http://cfpub.epa.gov/si/si_public_record_Report.cfm?dirEntryId=31920&CFID=36332389&CFTOKEN=18608368&jsessionid=5a30c5241678969d45de91a97f64633e6f15
The synoptic approach does not attempt to evaluate the functions/values of individual wetlands. The synoptic approach is broad brush. Other federal level "landscape" level approaches using GIS developed by federal agencies include USGS Ecosystem Modeling. See http://www.nwrc.usgs.gov/about/sab/decision.htm and NOAA functional evaluation of tidal and freshwater wetlands. See
http://proceedings.esri.com/library/userconf/proc00/professional/papers/pap661/p661.htm

A variety of state approaches utilizing GIS to provide landscape level analyses have been developed in Arkansas, Florida, Wisconsin, New Jersey, Virginia, North Carolina, Michigan, Delaware, Montana, New York, New Hampshire, Missouri, Kansas, Colorado, and elsewhere. See, e.g.,
http://www.awag.org/2004%20Conference/Track%203/Murray_AWAG1.pdf;
http://proceedings.esri.com/library/userconf/proc00/professional/papers/pap305/p305.htm;
http://assessmentmethods.nbii.gov/index.jsp?page=mdetail&mid=45;
http://dnr.wi.gov/wetlands/methods.html;
http://dnr.wi.gov/wetlands/documents/070228_MLWAP_FINAL_REPORT.pdf;
http://el.erdc.usace.army.mil/emrrp/emris/emrishelp6/watershed_based_wetland_assessment_method_for_the_new_jersey_pinelands_tools.htm;
http://www.rougeriver.com/wetlands/pdfs/wetassessmentprofile.pdf;
http://dcm2.enr.state.nc.us/wetlands/nccrews.htm;
http://www.delawareestuary.org/science_projects_wetland_assessment.asp;
http://mtnhp.org/Reports/Level_I.pdf; http://mtnhp.org/Reports/Level_I.pdf;
http://www.horizonsystems.com/nhdplus/applications/NHDPlus_Jberner_application_Paper_May_2009.pdf;
http://des.nh.gov/organization/divisions/water/wmb/swqa/2008/documents/appendix_36_l1_wet.pdf; http://mtnhp.org/plants/reports/whitewater_Assessment.pdf;
http://www.cpcb.ku.edu/datalibrary/assets/library/KBSreports/KBSRept142_wetlflood.pdf.;
http://cnhpblog.blogspot.com/2010/10/2010-north-platte-wetland-assessment.html.
These consider soils, topography, location, and other factors. GIS models have been used in regulatory permitting in North Carolina and Maryland, but not as a complete substitute for case-by-case, on the ground analyses.

Wetland Landscape Characterization, USFWS. Ralph Tiner with the US Fish and Wildlife Service has developed a set of "keys" for characterizing wetland functions on a preliminary basis based upon wetland characteristics observable on National Wetland Inventory Maps. See http://assessmentmethods.nbii.gov/index.jsp?page=gdetail&gid=9 Ecological Assessment Models Data Base. See more specifically
http://library.fws.gov/wetlands/dichotomouskeys0903.pdf for more detailed description of landscape analysis keys. The Service has applied these keys on a demonstration project basis. See National Wetland Inventory http://www.fws.gov/wetlands/. See Dichotomous Keys LLWW Classification; Wetland Characterization and Preliminary Assessment of Wetland Functions for the Delaware and Catskill Watersheds of the New York City Water Supply System. *R.W. Tiner and J. Stewart. 2004;* Wetland Characterization and Preliminary Assessment of Wetland Functions for the Croton Watershed of the New York City Water Supply System. *R.W.Tiner, C.W. Polzen, and B. J. McClain. 2004;* Watershed-based Wetland Characterization for Maryland's Nanticoke River and Coastal Bays Watersheds: A Preliminary Assessment Report.

R.W. Tiner and others. 2000. http://www.fws.gov/wetlands/_documents/gOther/WatershedbasedWetlandCharacterizationMarylandsNanticokeRiverWatershed.pdf; Watershed-based Wetland Characterizations for Delaware's Nanticoke River Watershed: A Preliminary Assessment Report. *R.W. Tiner and others. 2001.* http://library.fws.gov/wetlands/DEnanticoke01.pdf. *See also* Enhancing Wetlands Inventory Data for Watershed-based Wetland Characterizations and Preliminary Assessments of Wetland Functions. *R.W. Tiner. 2002;* Remotely-sensed Natural Habitat Integrity Indices for Assessing the General Ecological Condition of Watersheds. *R.W. Tiner. 2002;* Watershed-based Wetland Planning and Evaluation. A Collection of Papers from the Wetland Millennium Event *(August 6-12, 2000; Quebec City, Quebec, Canada).* http://www.aswm.org/propub/pubs/pdf/tiner_2002_wshed.pdf Wetland Characterization Study and Preliminary Assessment of Wetland Functions for the Casco Bay Watershed, Southern Maine. *by R.W. Tiner and others. 1999. U.S. Fish and Wildlife Service, Region 5, Hadley, MA;* Wetland Characterization and Preliminary Assessment of Wetland Functions for the Boyds Corner and West Branch Sub-basins of the Croton Watershed, New York *by R. Tiner, S. Schaller, and M. Starr. 1999.*

Proper Functioning Condition (PFC), Bureau of Land Management.
http://www.mountainvisions.com/Aurora/pfc.html. See also http://www.waterboards.ca.gov/mywaterquality/monitoring_council/collaboration_network/docs/pfc_read091610.pdf "Helpful Readings on PFC; ftp://ftp.blm.gov/pub/nstc/techrefs/Final%20TR%201737-11.pdf Process for Assessing Proper Functioning Condition for Lentic Riparian-Wetland Areas.

This methodology has been developed by the Bureau of Land Management in cooperation with the U.S. Fish and Wildlife Service, Natural Resources Conservation Service, National Park Service and a variety of other federal agencies to assess the physical functioning of riparian and wetland areas. The method uses check lists, existing information, and limited field studies to evaluate the existing condition of a riparian-wetland area and the potential for restoration if degraded ("capability" and "potential"). It can provide information on whether a riparian-wetland area is physically functioning in a manner which will allow the maintenance or recovery of desired values, e.g., fish habitat, neotropical birds, or forage, over time. It can identify "at risk" systems in need of restoration efforts and help establish restoration priorities.

The term "Proper Functioning Condition" (PFC) is used to describe both the assessment process, and a defined, on-the-ground condition of a riparian-wetland area. The PFC assesses the physical functioning and condition of riparian-wetland areas through consideration of hydrology, vegetation, and soil/landform attributes. It has been quite extensively tested in the field. It is designed to help determine whether a riparian-wetland area will withstand the energies of a 25 to 30-year flood event.

However, PFC is not intended as a replacement for inventory or monitoring protocols designed to yield more detailed information on the "biology" of the plants and animals dependent on the riparian-wetland area. To obtain a picture of riparian-wetland area health, including the biological side, one must have information on both physical status, provided through the PRC assessment, and biological habitat quality. Neither will provide a complete picture when analyzed in isolation. In most cases proper functioning condition will be a prerequisite to achieving and maintaining habitat quality.

Developing Methods for Analyzing Upland Riparian Functions and Values. Tom Hruby and colleagues at the Washington Department of Ecology are in the process of developing a rapid method for analyzing upland riparian functions and values. Their recommendations are set forth in a paper: see Developing Rapid Methods for Analyzing Upland Riparian Functions and Values. http://www.springerlink.com/content/01596u44848k65k5/ Environmental Management Vol. 43, Number 6 (2009). This paper provides a framework for addressing assessment of riparian functions and values and not simply riparian condition. It summarizes earlier papers and reports attempting to assess riparian functions and values. It contains an up-to-date bibliography of papers and reports addressing the assessment of riparian functions and values. This paper builds upon the extensive Washington Department of Ecology experience in assessing wetland ecosystems. It raises and discusses major issues in assessing riparian functions and values and regulating riparian areas including

—Defining the riparian zone;
—Defining the waterward boundary of a riparian area;
—Defining the upland boundary of a riparian area;
—Classifying riparian areas;
—Developing structure for the assessment, metrices, and calibration;
—Selecting functions and indicators including the three major groups of functions: (l) hydrologic, (improving water quality), and (2) habitat and maintaining food webs;
—Selecting riparian areas with special characteristics;
—Selecting and calibrating indicators.

The paper also contains a useful variety of assessment forms.

Hruby and his colleagues have developed a second paper on a related subject. See Hruby, T. Calculating Credits and Debits for Compensatory Mitigation in Wetlands of Western Washington, Operational Draft (2011), Washington Department of Ecology Publication no. 10-06-011. http://www.ecy.wa.gov/pubs/1006011.pdf.

Collaborative EPA and State National Wetland Assessment. See http://water.epa.gov/type/wetlands/assessment/survey/index.cfm. EPA is conducting a cooperative EPA/state national assessment of wetland "condition" in 2011. This assessment is based upon a statistical sample of wetlands throughout the nation. It will parallel similar EPA/state efforts to evaluate the condition of rivers, streams, lakes and the oceans. The process of designing and conducting the survey is also intended to help build state and tribal capacity to monitor and analyze wetland condition while promoting collaboration across jurisdictional boundaries."

EPA has suggested that states undertake assessment of wetland condition at three levels:

- Landscape level to understand watershed condition impacting wetlands (remote sensing, existing GIS layers, landscape profiling),
- Rapid assessment to scope likely problems and useful parameters (sub-sample of landscape level, hydrogeologic setting, land uses and stressors, and
- Site specific (quantitative methods) to understand wetland condition including subsample of rapid assessment level, bioassessment methods, and hydrologic measures.

Examples of Techniques Providing More Detailed and, In Some Instances, Quantitative Analysis of Selected Functions

Assessment of overall ecological processes through HGM. See http://el.erdc.usace.army.mil/wetlands/hgmhp.html; http://el.erdc.usace.army.mil/wetlands/class.html The HGM wetland assessment method was formally proposed by the U.S. Army Corps of Engineers and other federal agencies for use on Section 404 regulatory permits in 1997 (see work plan published in the Federal Register, August 16, 1997). See a "procedural" HGM document: Smith, D., A. Ammann, C. Bartoldus, and M. Brinson. 1995. An Approach for Assessing Wetland Functions Using Hydrogeomorphic Classification, Reference Wetlands, and Functional Indices, U.S. Army Corps of Engineers, Waterways Experiment Station, Wetlands Research Program Technical Report WRP-DE-9. More documents are in publication or in preparation.

HGM was designed to help regulators assess wetlands overall ecological condition and to establish compensation ratios. This approach has a number of significant and interesting features in comparison with earlier rapid wetland assessment approaches. It requires classification of wetlands by hydrogeomorphic setting (classes and subclasses), the establishment of profiles of classes through reference sites, and evaluation of wetland "functions." It shifts analysis from the end result—function/value—to the underlying biological, chemical, and other processes. This shift in emphasis encourages users to understand "how wetlands work" and facilitates analysis of the "changes" which projects may cause in wetlands.

However, the technique is complicated and time consuming. It is represented as a "rapid" assessment technique but cannot be quickly undertaken without prior subclass guidebook development and perhaps selection of regional reference sites. It develops only a portion of the information needed for analysis of functions/values and other factors for regulatory permitting. It does not consider "opportunity" or "social significance." The relationships between functions and functions/values have not been clarified. It does not provide species-specific information such as identification of rare and endangered species.

The practicality of this approach for routine permitting activities remains to be seen. It has received limited use in regulatory contexts to date and questions remain concerning its application. However, both the regulatory classification system and the establishment of "reference" sites hold potential for improving assessment of not only wetland functions/values but those of related aquatic and floodplain/riparian ecosystems. Regional subclass guidebooks are useful in helping regulatory agencies evaluate capacity and the impact of activities upon capacity.

Hydrologic and Hydraulic Models (e.g., HEC-RAS, TR 20, TR 55, others). For HEC-RAS see http://www.hec.usace.army.mil/software/hec-ras/ Hydrologic and hydraulic models can be used to predict run-off, flood conveyance and storage areas, floodplain boundaries and elevations, flow velocities, and other hydrologic and hydraulic features. Such models are based upon stream gauging, rainfall records, snow pack records, and other sources of precipitation information combined with topographical, channel cross-section, soils, vegetative cover, and land use information. These models provide quantified, "real number" outputs. These models do not evaluate social significance. But, they can be used to determine the impact of various activities including land use changes on flood heights at specific locations. And this information can be used to predict damages to homes, factories, commercial establishments, agricultural structures, and other structures. Hydrologic and hydraulic flood models are increasingly combined with GIS models to help predict future hydrology.

Computerized flood models can be used to compute the quantity of run-off from a defined watershed area based upon rainfall, slope, area, and other factors. See, for example, NRCS, Win TR-20 computer program for Project Formulation Hydrology http://www.wsi.nrcs.usda.gov/products/w2q/h&h/tools_models/WinTR20.html and TR-55 Urban Hydrology for Small Watersheds, http://www.cpesc.org/reference/tr55.pdf; WinTR55. http://www.wsi.nrcs.usda.gov/products/w2q/h&h/tools_models/wintr55.html

The computer program HEC-2, "Water Surface Profiles," has been widely used by engineers in hydrologic studies to determine floodplains and floodways and the effects of fills, culverts, bridges, and other obstructions upon water surface elevations. See, e.g., http://www.hec.usace.army.mil/software/legacysoftware/hec2/hec2.htm; U.S. Army Corps of Engineers, Hydrologic Engineering Center, Floodway Determination Using Computer Program HEC-2 (l988); U.S. Army Corps of Engineers, Hydrologic Engineering Center, Training Document No. 26, Computing Water Surface Profiles With HEC-2 on a Personal Computer (l992). See also, Chow, V.T., Open Channel Hydraulics, McGraw-Hill Book Company, New York, 1959; Chow, V.T., Handbook of Applied Hydrology, McGraw-Hill, New York, New York.

Hydrologic information generated by these models includes depth of water, water velocities, and frequency of flooding. This information is useful in evaluating floodplain functions/values since all functions/values depend, in part, upon water regime. They can be more specifically used to determine flood conveyance and flood storage potential for a floodplain. They can be used to determine flood and erosion threats at a site and the impact of proposed activities upon those threats. They can be used to evaluate the adequacy of project impact reduction and compensation measures.

Data-gathering to apply these models is often expensive since detailed topographic and hydrologic (e.g., steam gauging) information is needed. However, use of Global Positioning Systems (GPS), LiDAR, and other technologies is reducing cost. In addition, hydrologic information gathered for floodplain management, stormwater management, and other purposes can be used for assessment of natural and beneficial functions.

Habitat Evaluation With HEP. See HEP (Habitat Evaluation Procedures), See http://www.fort.usgs.gov/products/software/hep/;
http://el.erdc.usace.army.mil/emrrp/tools/exhep.html
U.S. Fish and Wildlife Evaluation Procedures (HEP) Handbook, U.S. Fish and Wildlife Service (1980), http://www.fws.gov/policy/esmindex.html. Washington, D.C., See also http://www.fort.usgs.gov/products/software/hep/.

With HEP, agencies can use a combination of field observations and various inferential (deductive) models to determine the capacity of particular environments to serve as habitat for fish, amphibian, mammal, or other species or assemblages of species. These models can be used not only to determine functions but to help establish water quality standards, to enforce such standards, and to assist monitoring efforts. These models do not evaluate opportunity or social significance.

HEP procedures have been in use since the mid-l970s. Both a short version and long version of HEP have been developed. A team of biologists uses U.S. Fish and Wildlife Service publications which contain "habitat suitability" models which provide a list of habitat features that should be measured for indicator species. The team visits a wetland/floodplain and measures or estimates habitat structural features that are believed to indicate the density of at least five animal species at a site. The team arrives at a habitat suitability score for each species. These scores (1=most suitable, 0=least suitable) are then pooled to give an overall score which is multiplied by acreage.

HEP is the most widely used of the habitat rapid assessment methods with documentation in the literature but is limited by the relatively small number of supporting models for floodplain species. At least three trained evaluators with hours to weeks of time per wetland are needed. The accuracy of the habitat characterization depends upon selected indicator species. Accuracy also depends upon conditions encountered at a site at the time of evaluation which may vary greatly from year to year with seasonal and longer term fluctuations in rainfall and vegetation.

This is the only rapid assessment method with relatively long-term efforts to validate models with actual field observation of species. Results have been somewhat mixed.

This is a relatively "rapid" method but only estimates habitat value among the many potential wetland values and requires considerable time and expertise. It is therefore not suitable for the routine permits.

For examples of HEP models see HEP (Habitat Evaluation Procedures), U.S. Fish and Wildlife Service. 1980. Habitat Evaluation Procedures (HEP) Manual (102ESM), U.S. Fish and Wildlife Service, Washington, D.C.; Cable, T.T., V. Brack, Jr., and V.R. Holmes. 1989. "Simplified Method for Wetland Assessment", Environmental Management 13, 207-213; Whitlock, A.L, N. Jarman, J.A. Medina, and J. Larson. 1995. WEThings. The Environmental Institute, University of Massachusetts; Adamus, P.R. and K. Brandt, Impacts on Quality of Inland Wetlands of the United States: A Survey of Indicators, Techniques, and Applications of Community-level Biomonitoring Data. EPA/600/3-90. Office of Research and Development, U.S. Environmental Protection Agency, Washington, D.C. (l990); Davis, W.S., and T.P. Simon (eds.) Biological Assessment and Criteria. Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL. (1995).

Assessing Habitat Potential With WEThings. See Whitlock, A.L, N. Jarman, J.A. Medina, and J. Larson. 1995. The Environmental Institute, University of Massachusetts.

This method, like HEP, HES, and the instream flow models, focuses on the evaluation of habitat for wetland-dependent amphibians, reptiles and mammals. The method is based on an extensive literature review of measurable habitat characteristics conducted for 22 amphibian, 15 reptile, and 22 mammal species, many of which are listed as rare, threatened, or endangered in at least one of the six New England states. The models may be used individually or combined into a software package that provides a composite habitat predicting model for all species. The method use field data collection and analysis of data to evaluate and predict potential habitat.

Strengths of this approach include: 1) it focuses with specificity upon particular species and recognizes the importance of information relating to specific species in regulatory permitting; 2) it includes excellent references; and 3) it can be used relatively quickly by relatively untrained users.

Weaknesses include these aspects: 1) it is limited in its use to a small number of species; 2) it has not had extensive field validation or testing; and 3) it is relatively time-consuming.

Assessing Stream Stability Using River/Stream Hydrologic/Geomorphic Assessment Approaches. Agencies can use several models to evaluate the fluvial processes, gemorphology and equilibrium condition of streams to help determine functions/values and restoration and management needs. The models evaluate the condition of streams in terms of stability versus natural streams in terms of stream slope and form. These approaches are increasingly used to determine possible erosion, channel evolution, flooding and other problems, the impact of activities upon these, natural processes, and the adequacy of compensation measure**.** See D. Rosgen, Applied River Morphology, Wildland Hydrology, Pagosa Springs, Colorado (l997); L.B.Leopold, A View of the River, Harvard University Press, Cambridge, Massachusetts (1994).

Evaluating Restoration Potential, Identifying Restoration Sites. A number of models have been developed to help identify potential wetland restoration sites and to evaluate the restoration potential and needs of wetlands and related floodplains and aquatic ecosystems. See for example, C. Bartoldus, E.W. Garbish and M. Kraus, Wetland Replacement Evaluation Procedure, Environmental Concern, St. Michaels, Maryland (1994) which recommends a procedure for calculating differences between the wetland to be impacted and replacement wetland in terms of six functions and 82 determinants. These functions include shoreline bank erosion control, sediment stabilization, water quality, wildlife, fish, and uniqueness/heritage.
For other guidance concerning evaluation of restoration potential see Bureau of Land Management, Riparian Area Management, Process for Assessing Proper Functioning Condition, U.S. Department of Interior, Bureau of Land Management, Service Center, Denver, Colorado (1993, 1995); Dave Rosgen, Applied River Morphology, Wildland Hydrology, Pagosa Springs, Colorado (1997); C.R. Brown, F.O. Stayner, C.L. Page, C.A. Aulback-Smith, Toward No Net Loss, A Methodology for Identifying Potential Wetland Mitigation Sites Using a Geographic Information System, South Carolina Water Resources Commission Report No. 178, USEPA Report No. EPA904-R-94-001 (1993); and the HGM approach described below.

Assessment of Related Habitat Functioning and In Some Instances Broader Ecological Integrity Through the Use Of Indices of Biological Integrity. See http://water.epa.gov/type/wetlands/assessment/fact5.cfm; http://www.cbr.washington.edu/salmonweb/bibi/biomonitor.html; http://en.wikipedia.org/wiki/Index_of_biological_integrity; http://www.mnwhep.org/id46.html.

Quite a number of efforts are underway across the nation to develop models for measuring the biological integrity and relative biological condition of wetlands, rivers, streams and estuary areas. These efforts involve information gathering for particular types of plant and animal species for a range of similar sites with various levels of anthropogenic impacts. Information gathering typically pertains to not only plants and animals but to hydrogeomorphic setting. “Reference” sites are identified with no or little disturbance; a suite of similar sites representing various levels of disturbance may also be identified. Plants, insects, amphibians, birds and other forms of life are compared at the various sites. Indicator species are identified which can be used to compare the relative condition of sites. Quantitative indices are also typically developed which allow the comparison of sites.

These biological surveys and indices have a number of important uses. First, the biological information gathered on-site of a proposed activity can be used to determine whether there are endangered species at the site and the impact of a proposed activity at the site upon fish and wildlife. Biological information is also proving somewhat useful as a surrogate for the types and magnitudes of other floodplain functions (e.g., food chain support, pollution control.) Indices can also be used to establish water quality standards. For example, such standards can specify that water quality and other features (e.g. depth, vegetation) cannot be degraded to the point that there will be a loss of specific indicator species in a wetland, lake, or stretch of stream. Alternatively, standards can specify that water quality and other features must be restored to the point that the water body will again support specific indicator species. Emergence of indicator species will indicate success.

Despite the promise of biological indices, development of such indices is proving difficult and time consuming. It is also difficult to develop accurate indices to characterize whole wetlands or floodplains because there are often many ecological zones within a single wetland and these zones shift by season and over a period of years as precipitation varies. Finally, the correspondence between biological integrity and many other wetland functions/values such as flood storage, flood conveyance, erosion control, natural crop production is yet to be demonstrated.

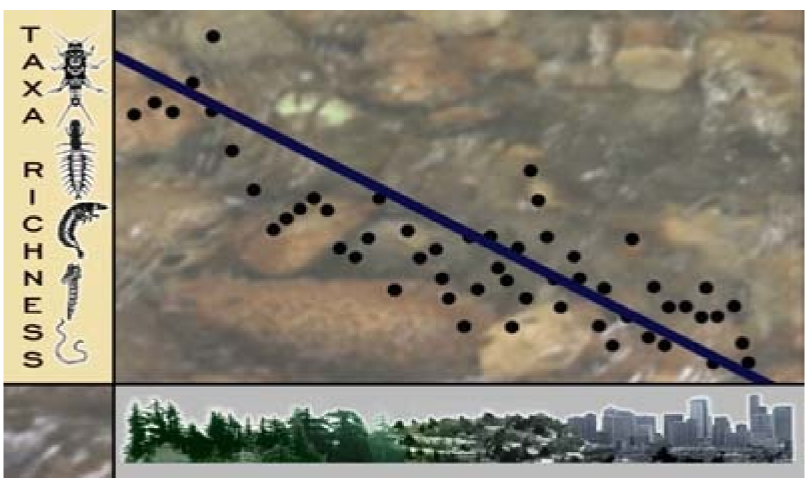

Figure 10. Graph showing taxa richness vs. degree of human disturbance (http://www.cbr.washington.edu/salmonweb/)

PART 8:
COPING WITH LIMITED BUDGETS, SMALL STAFFS, AND LIMITED EXPERTISE

Introduction

Part 8 examines strategies for generating natural and beneficial functions information when agencies have limited budgets, staff and expertise.

Experience over the last two decades suggests that it is difficult and expensive to produce information with sufficient accuracy and detail to allow site-specific analysis of floodplain natural resources for planning, regulatory and other purposes. Only a small portion of this information is typically available "upfront" and only a portion can be gained from existing topographic, soils, wetland, floodplain and other maps or from air photos and satellite imagery. It is often difficult, time-consuming, and expensive to generate even the most “essential” information much less the broad range of information which may be desirable to provide accurate evaluation of functions for multi-objective water resources planning and similar purposes.

Government agencies have available a number of strategies for coping with limited budgets, staffs and expertise.

Require Landowners to Develop Much of the Required Information for Mid-sized and Larger Projects

Floodplain and wetland regulatory agencies typically rely upon landowners and their consultants to develop much of the required information for regulatory permitting. Floodplain assessment for regulatory purposes at the federal level typically involves two critical sets of actors—the regulator and the regulated. Much of the actual assessment (boundary delineation, hazards, impacts, functions/values, restoration potential) is typically carried out by private landowners and their consultants.

This means that landowners and their consultants must be involved in the assessment process and guidance for floodplain assessment must be provided for the landowner and his or her consultant. Guidance should be written in simple, understandable terms and be provided at reasonable costs to landowners and developers. Training and education and technical assistance are needed.

Use Presumptions

Some wetland and floodplain programs use “presumptions” to help evaluate wetland and floodplain functions. The presumptions shift the information gathering burden to someone wishing to damage or destroy a wetland or floodplain to show that a wetland does not provide specified functions.

For example, the Massachusetts wetland and floodplain regulatory program establishes a series of presumptions for specific categories of wetlands and wetland functions. See 310 CMR: Department of Environmental Protection. Program regulations provide, in part, for “Bordering Vegetated Wetlands (Wet Meadows, Marshes, Swamps and Bogs”:

> 410 CMR 10.55(1) “(1) Preamble. Bordering Vegetated Wetlands are likely to be significant to public or private water supply, to ground water supply, to flood control, to storm damage prevention, to prevention of pollution, to the protection of fisheries and to wildlife habitat.”

The Massachusetts regulations further provide a rebuttable presumption:

> 410 CMR 10.55(3) “Presumption. Where a proposed activity involves the removing, filling, dredging or altering of a Bordering Vegetated Wetland, the issuing authority shall presume that such area is significant to the interests specified in 310 CMR 10.55(1). This presumption is rebuttable and may be overcome upon a clear showing that the Bordering Vegetated Wetland does not play a role in the protection of said interests. In the event that the presumption is deemed to have been overcome, the issuing authority shall make a determination to this effect, setting forth its grounds (Form 6).”

Use “Red Flagging,” “Yellow Flagging,” “Focusing,” “Screening,” “Scoping,” and Other “Filtering” Mechanisms

Regulatory agencies have broadly used various formal and informal “red flagging,” “yellow flagging,” “filtering,” and “scoping” procedures to evaluate and make rapid decisions on permit applications based upon natural hazards, readily identified impacts on functions or values, or other special issues and problems.

With such an approach, data-gathering is progressively focused on more specific functions/values or issues or problems likely for a particular activity and floodplain area (e.g., potential blockage of flood flows).

Combine Broad, Generalized, Upfront Data-gathering With Selective Site-Specific Surveys

Due to limited budgets and time-frames for processing permits, floodplain managers have found it necessary to combine generalized "upfront" data-gathering (e.g., use of existing topographic, soils, floodplain, wetland maps) with site-specific surveys on a case-by-case basis as needed (e.g., more detailed floodplain delineation, analysis of project impacts on flood flows).

When floodplain regulations were first adopted at federal, state, and local levels in the early 1970s, it was broadly hoped by regulators that floodplain boundary maps and other types of assessments could be developed with sufficient accuracy and detail on a community-wide, state, or regional basis to replace on-site delineation of boundaries or assessment of functions and values at the time permit applications are submitted. A great deal of money was spent preparing detailed floodplain maps in some localities.

But, field experience has indicated that maps and assessments, even those with considerable detail have often not proven sufficient to make a "final" determination of floodplain and subzone boundaries, ecological functions/values, and other features for a number of reasons:

- Floodplains are extremely dynamic and it is difficult, in advance, to determine natural fluctuations in water levels and resulting changes in flora and fauna over time.
- There are many changes in floodplains and floodplain water regimes due to the activities of man and it is difficult to anticipate these changes.
- Many mapping efforts were carried out to meet narrow agency missions and often provide only a portion of needed information. For example, flood information and maps are available for the floodplains of most major rivers, lakes, and estuarine areas in the Nation. But, ecological information is often limited or missing.
- There are physical limitations in representing the entire floodplain and more specific subzones within a floodplain (e.g., wetlands) with enough precision on a map (e.g., the width of a pencil line may be 10-25 feet) to determine precise boundaries.

Use Surrogates

Because of lack of detailed data on most floodplains and the complexity and dynamic nature of wetland, floodplain, and riparian systems, scientists have attempted, over the last 30 years, to find various “indicators” or surrogates to suggest broader functions, functional values, and socio-economic values. Search for surrogates has at times been characterized as a search for ecological “canaries.” The “canary” refers to the success of coal miners in the 19th century in using canaries as a cheap and easy way to detect lethal or dangerous levels of methane gas in coal mines.

The search for ecological “canaries” is not new. And, a variety of “canaries” have been postulated. For example, in the 1970s wetland scientists postulated that wildlife habitat values could be used as a surrogate or indicator of all wetland functions and values. But, wildlife habitat values have proven of only limited value in indicating flood storage, flood conveyance, erosion control, and pollution control potential. And, habitat value for one type of wildlife (e.g., ducks, fish) has quite often not proven a good indicator for other wildlife.

Similarly, wetland vegetation has been broadly used as a surrogate for wetland functions and values in determining the “success” of wetland restoration or creation projects. But, experience with restoration and creation suggests that restoration or creation of certain types of wetland vegetation for a short period of time (usually a year or two) may be a relatively poor indicator of long-term vegetation and also a relatively poor indicator of long-term functions (e.g., flood storage, flood conveyance) including habitat functions.

Attempts to use habitat as an indicator of other wetland characteristics have proven particularly tenuous in urban areas. For example, an urban wetland with little or no habitat value due to pollution, high rates of sedimentation, no vegetation, and limited wildlife may, nevertheless, be subject to deep and high velocity flood hazards and may play important flood storage or conveyance roles. Such a wetland is not a good development site, despite the limited habitat value. Any characterization of the wetland for development based solely on habitat value would be misleading.

Finally, many floodplains with limited present functions may have high restoration potential—e.g., a coastal wetland behind a dike; a partially drained and farmed wetland. Assessment based upon use of "existing conditions" alone will understate long use potential.

This is not to suggest that indicators or surrogates are not useful or that the search for indicators is invalid. The discovery of good surrogates or indicators is key to low cost and more accurate assessment approaches. But experience to date with efforts to find easily applied indicators is not very encouraging and future efforts should be subject to careful field testing.

Make Simplifications; Omit Consideration of Some Factors

Rapid assessment methods typically focus upon a limited number of key variables and do not attempt to consider all factors relevant to various functions or production of goods and services. For example, most rapid assessment approaches do not consider the future hydrology of a proposed development site because it is difficult to predict future conditions. Similarly, most approaches focus upon on-site conditions and do not consider off-site ecological context such as predator/prey relationships.

Simplifications are necessary for practical reasons. But simplifications also often result in inaccurate and unacceptable assessments. Box 11 provides a brief description of some simplifications, tradeoffs, and compromises in assessment.

Box 11
Examples of Simplifications, Tradeoffs

Given limited dollars, staff, and time frames, the following sorts of simplifications, and tradeoffs have often been made in assessment approaches. Note, this list is not exhaustive and only provides examples.

Degree of accuracy. Less accurate approaches such as "office" surveys based upon existing data, limited or no field information gathering, and professional judgment are typically less expensive and more "do-able" than more intensive approaches involving extensive field data-gathering. However, inaccurate assessments may be misleading, lack adequate factual support, and fail to achieve floodplain assessment goals such protection of rare and endangered species.

Precision (scale). Less precise approaches such as small scale mapping are (in general) also less expensive and more do-able than large scale efforts. But, they too may not achieve assessment goals because they fail to show important subzones (e.g., small wetlands) or important functions (e.g., pollution control).

Geographical scope. Geographically comprehensive surveys are more expensive than site-specific analyses. But geographically comprehensive approaches are often needed for land and water planning, land use management, and watershed planning.

Number and type of simplifying assumptions. Approaches with many simplifying assumptions are typically less expensive than approaches which consider a broader range of factors, but are often less accurate. Simplifications may include

- Consider only on-site factors versus on-site and off-site factors.
- Consider only physical, natural resource functions in assessment in contrast with cultural features.
- Consider only natural processes versus natural processes, opportunity, and social significance.

Remote sensing versus field observations. Use of remote sensing (air photos, digital imagery) is typically less expensive than field studies, but it also does not provide certain types critical information such as endangered plant and animal species which are not visible from the air and can only be gathered through field surveys.

Landowners playing greater or lesser roles in assessment. Placing greater data-gathering burdens on landowners is less expensive for a regulatory agency but often results in less objective information and more landowner complaints.

Faced with cost/benefit tradeoffs, management agencies have often opted for rather generalized upfront mapping and evaluation and concentrated most of their funds on site-by-site analysis as permit applications are submitted.

Box 12 summarizes a variety of additional strategies and techniques for coping with limited budgets, staffs and expertise.

Box 12

Additional Strategies and Techniques for Coping With Limited Budgets, Small Staffs, and Limited Staff Expertise

1. Use a decision-making process which bases decisions, to the extent possible, upon known and relatively certain information and avoid the necessity of making difficult assessments and decisions based upon problematic assessments. For example, permits for activities in floodplains may be rejected on the following grounds before an expensive, time-consuming and error-prone effort is made to analyze specific floodplain functions or functions and values:

- Failure to demonstrate water dependency,
- Failure to demonstrate that alternative sites are not available,
- Problems with natural hazards and/or impact of proposed activity upon natural hazards,
- Inconsistency with other regulations,
- Inadequate proof of ownership, ownership problems, and
- Documented, special resource characteristics (e.g., endangered species).

2. Utilize assessment approaches which progressively narrow the issues and areas that need detailed analysis through various "red flagging" or other filtering mechanisms. Such approaches may first determine whether particular functions, hazards, other problems or values may exist at a site and, second, whether there may be significant impacts on society if these are damaged or destroyed. If so, more detailed analyses may then be conducted. Such red flagging or filtering may use a variety of sources of information:

- Information supplied by landowners/developers seeking permits,
- Office analysis of permit applications and use of existing data,
- Consultations with other regulatory and resource agencies,
- Field visits,
- Public notices and analysis of comments, and
- Public hearing and analysis of comments.

3. Tap the scientific and other knowledge and expertise available in other regulatory and resource agencies (floodplain, coastal zone, soil conservation, etc.) the academic community, interest groups, and among landowners. Techniques may include

- Provide notices and solicit comments from a broad range of groups,
- Undertake joint permit processing,
- Hold public hearings,
- Form commissions and work groups (e.g., HGM A-Teams, Conservation Commissions), and
- Hold workshops.

4. Use existing data and information and remote sensing.
Examples of existing data and remote sensing include

- National Wetland Inventory
- Flood, soils, topographic, geologic, endangered species and other maps and lists, and
- Air photos, satellite imagery, low level digital imagery.

5. Group or classify floodplains and wetlands (e.g., the US Fish and Wildlife Wetland Categorization approaches to suggest functions, values, HGM.)

6. Use sampling techniques rather assess all area floodplains. Note, this is only useful for certain types of assessment such as characterizing floodplain condition in a region or state. See EPA river, stream, wetland assessment.

8. Tie-in floodplain assessment to broader resource assessment and management efforts such as hydrologic modeling for water supply, wetland management, stormwater management, etc. Share costs and data**.**

PART 9:
FUTURE DIRECTIONS

Part 9 suggests future directions for assessing floodplain natural and beneficial functions. It begins with overall recommendations for actions by various levels of government. This is followed by more specific suggestions for better use of existing data and assessment methods and databases. It then suggests the development of new methods and new databases. Part 9 concludes with some priority research needs.

The Need for Cooperative Approaches

Improving the assessment of floodplain natural and beneficial functions at federal, state, tribal and local levels of government is complicated by the complexity of floodplain systems, the cost of gathering hydrologic and ecological information, the need for technical expertise, and budgetary restraints at all levels of government. However, much progress has been made in developing data and important lessons pertaining to models learned in the last two decades. A considerable amount of useful map and digital information is now available on the internet. Strengthened assessment, protection and restoration efforts need federal, state, tribal, local government, and landowner/consultant cooperation. Suggested roles are described below.

—Federal agencies. Federal agencies need to take the lead in assessing floodplain natural and beneficial functions including the USFWS, NOAA, EPA, NRCS, USGS, FEMA, US Army Corps of Engineers, BLM, the Bureau of Reclamation and the US Forest Service. More specifically, the Corps of Engineers, Bureau of Reclamation, and other agencies need to better incorporate assessment of floodplain natural and beneficial functions into water project planning. Federal agencies need to adopt updated “Principles and Guidelines” for water projects which even the playing field for nonstructural flood loss reduction projects.

Congress should continue to fund federal and federal-contracted flood mapping but with more flexibility and larger roles for the states, tribes, and local governments in the design of flood mapping efforts and studies. Future conditions should be reflected in such mapping. Erosion areas, floodways, and other special hazard areas should be identified. FEMA needs to better incorporate assessment and protection of natural and beneficial functions into its Community Rating System for local governments and its standards and guidelines for local floodplain management programs. Better control of fills in floodplain should be a high priority along with protection of endangered species. FEMA also needs to encourage states and local governments to incorporate assessment and protection of natural and beneficial functions into pre-disaster and post disaster flood mitigation planning.

Federal land management agencies such as BLM and the Forest Service need to better incorporate assessment, protection, and restoration of floodplain natural and beneficial functions into federal land planning and management. The Army Corps of Engineers, EPA, Fish and Wildlife Service and the Marine Fisheries Service need to better incorporate consideration of floodplain natural and beneficial functions into Section 404 permitting and into NEPA analysis. The Fish and Wildlife Service needs to continue to prepare and update National Wetland Inventory maps and digital databases. Federal agencies need to carry out cooperate research of assessment methods with the states and tribes and provide training in the use of various assessment techniques.

—State/Tribal Roles. States, tribes, local governments and the private sector also need to play significant roles. States need to provide technical assistance to local government floodplain regulatory and management efforts including assistance in assessing, mapping, protecting and restoring floodplain natural and beneficial functions. States and tribes need to directly regulate wetlands and floodplain if local governments are unwilling to do so. States and tribes need to be more involved in establishing standards for federal or cooperative federal/state/tribal mapping of floodplains. They need to work with the National Wetland Inventory to complete and update digital wetland maps and other USGS digital products. They need to identify rare and endangered species habitat and areas of special biological diversity (e.g., Heritage Programs). They need to help local governments undertake inventories and prepare zoning maps showing floodplains including those not mapped by FEMA and other federal agencies. State and tribal water and pollution control agencies need to adopt water quality standards for floodplains and wetlands.

—Local governments. Local governments need to integrate assessment, protection and restoration of floodplain natural and beneficial functions into local zoning, subdivision controls, and building codes. Local governments wishing to protect and restore floodplain natural and beneficial functions can begin with the use of existing data to identify and determine the magnitude and other characteristics of floodplain natural and beneficial functions. Such existing maps and other existing information may include but are not limited to:

- Flood hazard boundary maps
- Floodway maps
- Wave velocity and erosion area maps
- National Wetland Inventory maps, other wetland maps
- Soils maps
- Topographic maps
- Satellite imagery, other digital imagery
- Air photos (color, color IR, orthophotos,), and
- Identification of areas of biodiversity and endangered and threatened species by state Heritage Programs, Fish and Wildlife agency studies, land trust studies.

These maps and other sources of information can be used to identify on a preliminary basis floodplain areas with flood storage, flood conveyance, erosion control, pollution control, carbon storage and other functions. A governmental unit may also use one of the broad-brush assessment approaches described in Part 7 to suggest probable functions such as the Wetland Landscape Characterization approach developed by Ralph Tiner for the USFWS or the Qualitative Analysis Of Wetland Functions/Values The Highway Methodology Workbook Supplement, Wetland Functions and Values, A Descriptive Approach.

A local government may use preliminary information to adopt floodplain zoning regulations for the floodplain as a whole. It can help gather more detailed information to provide the basis for and more specific and stringent floodplain regulations for wetlands, riparian areas, endangered species habitat, floodways, coastal erosion areas and other ecological and hazard subzone portions of the floodplain.

In most instances, it will not be possible for any level of government to provide a detailed, upfront assessment of functions for all floodplains within a local government, region or state due to the high cost of detailed assessments, scientific uncertainties, and the dynamic nature of floodplains including changing hydrology due to watershed changes. In such situations, preliminary analyses can suggest the probability or likelihood that certain functions and values do or do not exist at a site or for a reach of floodplain and whether these may be threatened by floodplain activities. Focused information gathering can then be undertaken as needed.

—Landowners/consultants. As described in Part 8 above, landowners and their consultants now often carry out much of the detailed data-gathering for floodplain areas. This should continue. Local governments and other local governmental should more specifically require that landowners and their consultants seeking floodplain permits undertake identification of ecological subzones within or adjacent to a project area such as wetlands, habitat for endangered plants and animals, and other areas with special ecological, recreation, historic, or cultural potential. Modeling of future hydrologic and ecological conditions is particularly important where watershed hydrology is changing and where major activities are proposed for the watershed and floodplain since long-term hydrology is critical to many natural and beneficial functions. The assessment model used will depend upon the functions. For example, an IBI model, HEP, WEThings, or another "habitat" model may used to assess impacts of wildlife or fish; a hydrologic model such as HEC-RAS may be used to determine flood storage and impact on flood conveyance.

Making Better Use of Existing Assessment Models, Databases

Recommendations for helping governmental units at federal, state, tribal, and local levels make better use of existing assessment models and databases include

(1) Because of the high cost of data-gathering and the need for time-series hydrologic and ecological data, **added efforts should be made to tap available sources of expertise and information on a site-specific and broader geographical basis.** Expertise and information can be better tapped by establishing joint databases, converting data (e.g. riparian maps, floodplain maps, wetland maps) to digital formats, establishing multiagency teams for evaluating regulatory permits, holding hearings, posting data to specific Internet webpages, and taking other measures suggested below.

(2) **Mechanisms for distributing information should be improved.** For example, many types of floodplain-related natural and beneficial functions information needs, over time, to be converted to digital formats and posted on specific webpages. Wetland maps or digital data should be supplied to floodplain managers and floodplain maps to wetland managers.

(3) **Additional use of existing wetland, riparian zone, and aquatic system assessment models developed to date may be encouraged by better defining user needs, and matching user needs with assessment techniques.** These techniques should include not only techniques specifically designed for assessing floodplain natural and beneficial functions but others useful in assessment of such functions (e.g., habitat models) but developed for broader use. Guidance should be provided to users concerning the pros and

cons of various techniques. Techniques often need to be combined including rapid, preliminary assessments and more detailed, site-specific assessments (as needed).

(4) **Federal agencies, states, local governments, not-for-profits and academic institutions should cooperatively test the accuracy and cost-effectiveness of assessment methods used for specific purposes and report their findings on the Internet.**[47]

(5) **Federal and state agencies, not-for-profits, and academic institutions should cooperatively prepare guidance materials with regard to the use of assessment methods such as a floodplain natural and beneficial function assessment manual or handbook reviewing various methods.**[48] These groups should also provide cooperative training for local governments, consultants and others**.**

(6) **Data-gathering and analysis for one sort of needed data (e.g., hazards information) should be coordinated with data-gathering for other types (e.g., habitat functions).** Both site-specific and geographically broader floodplain assessments need to be carried out by multi-objective teams including biologists, botanists, hydrologists, water resources planners, geologists and others.

(7) **A portion of the site-specific data-gathering and analysis burden** should continue to be shifted to landowners/developers. This is particularly true for mid-sized and large projects with substantial floodplain impacts.

(8) **Cooperative (federal, state, local, academic) preparation of guidance materials is needed for the use of assessment methods such as a floodplain natural and beneficial function assessment manual or handbook reviewing various methods.**

(9) **Cooperative training is needed for governments, consultants, and others in the use of various assessment techniques.**

(10) **Floodplain natural and beneficial functions and values can be assessed as part of broader, area-wide and upfront land and water planning efforts** including GIS-based stormwater and watershed planning and management efforts. Such broader assessments can address not only floodplain "capacity" but, in some situations, opportunity and social significance.

(11) **Hydraulic and hydrogeomorphic studies are needed to provide the underpinnings for functional assessment efforts.** Assessment of present and reasonably anticipated hydrology is needed including “connectivity” and “maintenance of variability in “flow

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[47] For example, federal agencies adopted HGM in 1997 to improve Clean Water Act Section 404 regulatory assessments. However, it has not been widely used in intended regulatory contexts. Why not? What lessons have been learned?

[48] See, for example, Ecological Assessment Models Data Base, http://assessmentmethods.nbii.gov/index.jsp?page=gdetail&gid=9. This website lists and describes 90 ecosystem-related modeling approaches and is highly recommended. Many of these “ecological assessment” techniques could be used for assessing floodplains although not originally designed for floodplains.

regimen."[49] Assessments need to be conducted at sufficient "spatial scale" to take into account dynamic processes such as erosion and deposition.[50] Projection of future hydrologic conditions is particularly important where watershed hydrology is changing and where major activities are proposed for the watershed and floodplains.

New Techniques and New Information Gathering

Some priority recommendations for new techniques and new information gathering include the following points:

(1) In developing new techniques for evaluating floodplains, agencies should take a **holistic look at floodplain management information needs—**natural and beneficial functions, natural hazards, property ownership, and others—to identify common denominators in needs and to provide improved bases for multi-objective data-gathering.

(2) Federal agencies (FEMA, EPA, NPS) along with the states, tribes, and local governments **should better investigate and document floodplain natural and beneficial function assessment "user needs"** for various types of users since the types of information, scales, accuracy and other assessment needs differ considerably and there has been limited documentation of such needs to date. Such a "user needs survey" could help design future methods and techniques.

(3) **More attention should be placed upon the development of "intermediate" and "detailed" assessment models and not simply more "rapid" assessment methods.** Improved intermediate and detailed assessment models are needed for both natural hazard and ecologically-based functions.

(4) Federal agencies and states need to jointly develop guidance for describing and **evaluating the nonmarket functions and values of floodplains** including the monetary valuation of functions protected by nonstructural flood loss reduction approaches.

(5) **Improved "red flagging" techniques should be developed to identify areas with a high probability of specific natural and beneficial functions and to help prioritize functions and areas needing more specific data-gathering and analysis.**

(6) **With regard to the creation of new or additional data, government agencies at all levels need over time to develop a wide variety of types of data to aid their efforts to protect natural and beneficial values and reduce flood losses.** Some of the highest priority include flood hazard subzone maps (e.g. zero rise floodways, erosion and wave zone maps), basic hydrologic information, updated wetland maps, riparian area maps, maps for rare and endangered species, updated topographic maps.

[49] See Opperman, J., R. Luster, B. Mckenney, M. Roberts, & A. Meadows. "Ecologically Functional Floodplains: Connectivity, Flow Regieme, and Scale", J. Amer. W. Res. Association, April 2010.
[50] Id.

(7) **Federal agencies, states, and local governments should identify degraded floodplain areas with high restoration potential.** These include areas which may be restored by removing fills, culverts, and other impediments to flows, clearing repetitively flood damaged structures, operating dams and other water control structures to mimic natural fluctuations in flow, and reestablishing river/stream stability and meander. Surveys of degraded floodplains can help assess functions and prioritize restoration projects.

Priority Research Needs

Research is needed in these priority areas:

(1) The federal government should in cooperation with the states, local governments, land trusts and academic institutions establish a **multi-objective system of floodplain "reference sites."** Sites should be established on a regional basis representing various functions and levels of disturbance to provide "profiles" on various floodplain functions and values, help guide long-term monitoring and restoration efforts, and test assessment models for accuracy and cost effectiveness.

(2) **Looking to the future, federal agencies should, in cooperation with the states, tribes and local governments conduct a national "statistical" survey of floodplains.** This survey would include a sampling of floodplain sites on a national basis. It would evaluate the natural and beneficial functions provided by the floodplains and the condition of these functions. The impact of federal and state programs upon floodplain functions should also be evaluated as was done for wetlands in the "Goldstein" report. See Goldstein, Impact of Federal Programs on Wetlands -Vol. 1 (1994). http://old.aswm.org/fwp/historical_interest/ifpw1.pdf; Impact of Federal Programs on Wetlands-Vol. 2 (1994). http://www.doi.gov/oepc/wetlands2/index.html

(3) Additional, **basic research should be carried out pertaining to the gaps in habitat requirements** of various types of floodplain vegetation and wildlife. There are presently many gaps in scientific knowledge concerning habitat requirements and natural hazards such as the need for flooding and fluctuating water levels.

(4) Improved assessment models are needed to **address "social significance"** (including cultural, historic, health and safety, and other values) **as well as floodplain functional capacity.** Capacity, opportunity and social significance are all relevant to the determination of the "public interest" and the "suitability" and "appropriateness" of activities at floodplain versus upland sites. See Part 6.

(5) **Federal agencies and states need to link hydrologic and ecological models for assessment at various scales.** Models should be developed to predict and reflect long-term hydrology and ecological condition. Such models can also permit the development and analysis of alternative water and land use management, development and restoration strategies. For example, flood models predicting flood frequency and heights need to be linked to ecological models for instream flows for various species of fish and wildlife.

Linking hydrologic and ecological models has been done by the state of Vermont in its river and floodplain management program.[51]

(6) **A composite set of assessment methods is needed for simultaneous evaluation of rivers and other waters, wetlands, floodplains and adjacent upland areas** to determine whether "alternative" locations outside of the floodplain exist for activities proposed for the floodplain, the overall most suitable locations for various activities, and to reduce and compensate for impacts. Such composite assessment methods are needed for water resources development, land planning, watershed planning, and other purposes.

(7) **Combined assessment methods should be developed which incorporate upfront, generalized inventories with more detailed case-by-case analysis of particular sites and functions, as development or activities are proposed.**

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[51] See Geomorphic Assessment of Rivers and Streams in Vermont (2007), http://www.anr.state.vt.us/dec//waterq/rivers/htm/rv_geoassess.htm;
The Vermont Agency of Natural Resources Reach Habitat Assessment (2008), http://www.anr.state.vt.us/dec//waterq/rivers/docs/rv_RHAProtocolReport.pdf

APPENDIX A: FEDERAL LEGISLATION/EXECUTIVE ORDERS NEEDING FLOODPLAIN NATURAL AND BENEFICIAL FUNCTIONS INFORMATION FOR IMPLEMENTATION

Congress has adopted a variety of environmental programs which, under certain circumstances, need natural and beneficial functions information for implementation. Some examples are described below:

National Environmental Policy Act (1969) 42 USC 4321 et. seq. This act establishes a "national policy" to **"**encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; to enrich the understanding of the ecological systems and natural resources important to the Nation; and to establish a Council on Environmental Quality." Pursuant to this act federal agencies must evaluate the impact of their actions on the environment. Information pertaining to the type, location, and magnitude of floodplain natural and beneficial functions is needed to help agencies evaluate and reduce floodplain environmental impacts and determine the adequacy of impact reduction and compensation measures.

National Flood Insurance Program (1968, amendments) 42 USC 4106 et seq. This act establishes a national flood plain insurance and management program. Pursuant to this act, the Federal Emergency Management Agency has promulgated guidelines for floodplain regulation by states and local government. Local governments failing to adopt and enforce regulations meeting FEMA standards face loss of National Flood Insurance. As part of this program, Congress and FEMA have established a Community Rating System which provides reduced flood insurance rates for communities adopting floodplain regulations which go beyond FEMA minimum standards. More than 900 communities are participating in the Community Rating System. Section 4012 of National Flood Insurance Act states a number of goals which include

> (A) to provide incentives for measures that reduce the risk of flood or erosion damage….
> (B*) to encourage adoption of more effective measures that protect natural and beneficial floodplain functions;*
> (C) to encourage floodplain and erosion management; and
> (D) to promote the reduction of Federal flood insurance losses." (emphasis added)

The federal courts have held that FEMA must consider rare and endangered species in implementing these provisions. In Deer v. Paulson, 522 F.3d 1133 (11th Cir. 2008) the 11th Circuit Court of Appeals sustained an injunction prohibiting FEMA from issuing flood insurance for new development in endangered species listed habitats (here Key Deer) in Monroe County Florida. The Court held that FEMA had not, pursuant to these broad criteria for community programs and the Endangered Species Act, undertaken an adequate program to conserve endangered or threatened species. Information pertaining to floodplain natural and beneficial functions would help FEMA and communities comply with the Endangered Species Act.

Clean Water Act (1972 and amendments). (1972, 1977) 33 U.S.C. 1251 et seq. The Clean Water Act establishes a comprehensive federal, state, Tribal, and local program for the control of pollution and to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The Corps of Engineers, EPA, and some states regulate discharges of fill and other material into waters of the U.S. pursuant to Section 404 of this Act. Protection of wetlands and other aquatic ecosystems including no net loss of functions and values is one goal. Information pertaining to floodplain natural and beneficial functions is needed to achieve this goal. 33 CFR Part 320 Section 320.4 provides, in part:

"Wetlands considered to perform functions important to the public interest include

> **(iii)** Wetlands the destruction or alteration of which would affect detrimentally natural drainage characteristics, sedimentation patterns, salinity distribution, flushing characteristics, current patterns, or other environmental characteristics;
> **(iv)** Wetlands which are significant in shielding other areas from wave action, erosion, or storm damage. Such wetlands are often associated with barrier beaches, islands, reefs and bars;
> **(v)** Wetlands which serve as valuable storage areas for storm and flood waters."

Water Resources Development Act of 2007. (2007) Title 33 USC 2283. This comprehensive act authorizes the Army Corps of Engineers to undertake a wide variety of water resources development projects. Impacts on Fish and Wildlife are to be evaluated and mitigated. The U.S. Army Corps of Engineers is to establish revised principles and standards for "protecting and restoring the functions of natural systems and mitigating any unavoidable damage to natural systems." Information pertaining to floodplain natural and beneficial functions will help the Corps and other agencies achieve this goal.

The Act also (Section 2036) sets forth requirements for "mitigation" plans for mitigation of fish and wildlife and wetlands losses from water projects.

Endangered Species Act (1973). 16 U.S.C. §1531 et seq. This act protects threatened and endangered plants and animals and their habitats. Federal agencies, in consultation with the U.S. Fish and Wildlife Service and/or the NOAA Fisheries Service are to ensure that actions they authorize, fund, or carry out are not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat of such species. The law prohibits any action that causes a "taking" of any listed species of endangered fish or wildlife. Likewise, import, export, interstate, and foreign commerce of listed species are all generally prohibited. Several courts have held that FEMA must enforce the Endangered Species Act in implementing the National Flood Insurance program. See http://www.epa.gov/lawsregs/laws/esa.html. Information pertaining to the type, location, numbers, habitat requirements and other features of rare, endangered and threatened species will help agencies achieve this goal.

Disaster Assistance Act. (2000). 42 U.S.C. 5121-5207 Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended by Public Law 106-390 (2000) and other legislation provides communities with funds to carry out pre and post disaster planning and mitigation of flood impacts. Opportunities often arise after flood disasters to protect and restore floodplain natural and beneficial functions. For example, more than 26,000 structures were removed from the floodplain along the Mississippi and its tributaries after the “Great” flood of 1993.

Executive Order 11988. Floodplain Management (1977). This Executive order was adopted by President Carter in 1977. It requires federal agencies to avoid activities in the floodplain and to undertake flood hazard mitigation measures if activities in the floodplain are to be undertaken.

Executive Order 11900. Protection of Wetlands (1977). This Executive order was also adopted by President Carter in 1997. It directs federal agencies to avoid activities in wetlands and to mitigate impacts if they must locate activities in wetlands. The executive order No. 11990 May 24, l977, 42 F.R. 26961 provides in part:

> Section 1. (a) Each agency shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; and (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.
>
> Sec. 5. In carrying out the activities described in Section I of this Order, each agency shall consider factors relevant to a proposal's effect on the survival and quality of the wetlands. Among these factors are “(a) public health, safety, and welfare, including water supply, quality, recharge and discharge; pollution; flood and storm hazards; and sediment and erosion…”

APPENDIX B: ACRONYMS

This report uses the following acronyms:

EPA: United States Environmental Protection Agency
BLM**:** United States Bureau of Land Management
GIS: Geographic Information System. A "geo-referenced" information storage and analytical system, usually computerized
HEP: Habitat Evaluation Procedure. This is a wildlife assessment procedure developed by the U.S. Fish and Wildlife Service.
HEC: Hydrologic Engineering Center, U.S. Army Corps of Engineers. This Center has developed a series of hydrologic and hydraulic assessment techniques which are broadly used to identify and assess floodplain flood hazards.
HGM: Hydrogeomorphic Assessment Method. This method is being developed by the U.S. Army Corps of Engineers in cooperation with other agencies.
IBI: Index of Biological Integrity. This is a reference standard of biological health and condition, developed in accordance with various biological indicator assessment approaches collectively referred to in this report as IBI assessment approaches.
NPS: National Park Service
NRCS: the United States Department of Agriculture Natural Resources Conservation Service
USFWS**:** United States Fish and Wildlife Service
USGS**:** United States Geological Survey.
USACE**:** United States Army Corps of Engineers.
WET: Wetland Evaluation Technique. This is a rapid wetland assessment approach that was developed by the Federal Highway Administration in cooperation with the U.S. Army Corps of Engineers and other agencies in the l980s.

APPENDIX C: LESSONS LEARNED FROM WETLAND ASSESSMENT; APPLICATION TO FLOODPLAINS

Introduction

Wetland assessment methods are relevant to floodplain assessment in three ways:

- Wetlands and floodplains share the same group of functions, values and natural hazards although not in the same proportions.
- Wetlands constitute an important and (often) large component of floodplain systems. Therefore, wetland assessment approaches have direct applicability to the assessment of floodplain natural and beneficial functions at many sites.
- A great deal of experience has been gained with wetland assessment over the last two decades. This experience offers important lessons, both negative and positive, for floodplain assessment efforts.

Efforts to Date to Develop Wetland Functional Assessment Models

In the last two decades no topic in wetland management has spawned more reports or papers than assessment of wetland functions and, to a lesser extent, values. See Bibliography and Websites below for a partial listing. Since 1990 with the advent of the "no net loss" goal, emphasis in wetland regulatory programs at the federal level has shifted from either/or decision-making (either you are in a wetland and don't get a permit or you are out of a wetland and get a permit) to the conditional granting of permits subject to mitigation and restoration of functions and values and/or acreage. Qualitative and/or quantitative assessment of functions/values for the original wetland area (which will be impacted) and the replacement or restored wetlands are needed for such determinations. Floodplains share similar needs involving impact reduction and compensation.

Despite extensive efforts, however, to develop workable and practical wetland rapid functional assessment models, no "silver bullet" for such models has been found and no model is broadly applied in regulatory and other efforts. Why?

The answer is that assessment of wetland functions and values involves a variety of conceptual issues which are not easily resolved (i.e., definition of "function" and "value"). In addition detailed, accurate site-specific assessment of functions/values is factually complicated and often requires data (e.g., long-term hydrology) which is rarely available at the scale and degree of accuracy needed and cannot be easily or cheaply generated. Efforts to assess wetland functions also incorporate a variety of simplifying assumptions which undermine their accuracy. It is particularly difficult to develop the information needed within the limited time-frames and budgets of individual permit decisions.

Unfortunately, rapid wetland methods have often not met planners and regulators needs and the short cuts and simplifications have greatly reduced the accuracy of the assessment method results even if one agrees with the underlying definitions and assumptions. The low level of accuracy has been unacceptable to regulators and landowners.

It hasn’t taken long for agencies to lose confidence in assessment methods when the results when applied to a particular permit just don’t make any sense or can be generated more quickly with a "little common sense." Often regulatory agencies have found that a quick field visit to a wetland and discussion with the landowner/consultant and other resource agencies provides a more accurate, focused, and common sense evaluation of functions than use of a more formal and time consuming “rapid” assessment method.

Important Lessons from Efforts to Develop and Apply Rapid Wetland Assessment Methods

Some lessons learned from wetland assessment efforts with applicability to floodplain assessment include

(1) There is no both simple and accurate way to rapidly assess wetland functions and values. This is also proving true for broader floodplain areas. Accurate functional assessment is difficult, time consuming, and expensive. Time-series, on the ground hydrologic, hydraulic, and ecological information is needed. Wetland rapid assessment models have often proven of limited value except when they are viewed as preliminary and are followed with more detailed assessment (where necessary).

(2) Rapid wetland assessment methods looking at on-site parameters alone and without considering broader ecological and hydrologic context are subject to large margins of error because many wetland functions and values depend upon such broader context and wetland functions/values change over time as changes occur in watershed hydrology. This will also be true for floodplains.

(3) Evaluation of present and reasonably anticipated hydrology is key to assessment of wetland functions and to the success of impact reduction and compensation measures. This will also be true for floodplain efforts. Local and state watershed studies are important to both wetland and floodplain assessment.

(4) Wetland agencies have found that information gathering on wetlands must often involve the landowners/consultants, local governments, state and federal agencies, particularly for larger projects. There is not enough money and time for any singe level of government to go it alone. This will be also true for floodplains. Collaborative information gathering can distribute the costs and build consensus among regulatory and commenting agencies about relevant facts (e.g., Is a site subject to severe flooding? Is an endangered species present?).

(5) There has been an emphasis in the last twenty years upon the development of “rapid” wetland assessment methods with little attention to “intermediate” or “detailed” assessment efforts. Improved intermediate and detailed assessment models are also needed in both wetland and broader floodplain contexts.

(6) Because of budgetary and staff expertise limitations, wetland assessment has increasingly required the use of sorting procedures (e.g., “red flagging”), with various feedback loops to determine, early on, the issues and problems at a site and whether more detailed studies are needed. Floodplain assessment will have similar needs.

(7) Wetland regulators typically sequence information gathering to get the easy information first which may provide the basis for a rapid “no” to a permit application. A similar approach is appropriate for floodplains. For example, a rapid “no” may be appropriate if alternatives exist for a proposed activity in the floodplain. A rapid “no” may also be appropriate for a proposed fill is in a floodway, where a septic tank system is proposed for a saturated area where such a system will not work, or for a site which serves as habitat for endangered species. A “no” may be rational and legally defensible in quite a broad range of contexts without efforts to determine the full range of functions.

(8) Floodplain “capacity,” “opportunity” and “social significance” are (arguably) all relevant to determination of the “public interest” in allowing or denying a permit application. Most recent wetland methods (e.g., HGM, IBI models) only evaluate capacity. This limits their usefulness because wetland losses involve more than loss of wetland function and replacement of function at some other portion of a watershed. Replacing capacity at some other portion of a watershed will not replace loss of landscape level function. Improved methods need to be developed to evaluate opportunity and broader context for both wetlands and broader floodplains.

(9) Users of various wetland assessment methods have often found themselves lost in the unacknowledged assumptions contained in the methods. This will also be a problem for future floodplains methods. Scientists developing floodplain assessment methods need to carefully spell out assumptions.

(10) Wetland assessment methods have not been understood by landowners and the public, limiting their use. This will also be true for floodplain assessment methods as these methods become more complex and technical. Manuals need to be written with as much simplicity as possible. Training is needed.

In summary, efforts over the last several decades to develop rapid and more detailed assessment methods for wetlands offer important lessons for assessment of broader floodplains. Federal, state, local or tribal entities developing floodplain assessment methods should carefully examine these experiences.

APPENDIX D:
WETLAND "FUNCTIONS" AS "PROCESSES"

(From Smith et al., 1995. An Approach for Assessing Wetland Functions Using Hydrogeomorphic Classification, Reference Wetlands, and Functional Indices)

Functions Related to Hydrologic Processes	**Benefits, Products, and Services Resulting from the Wetland Function**
Short-Term Storage of Surface Water: the temporary storage of surface water for short periods.	Onsite: Replenish soil moisture, import/export materials, conduit for organisms. Offsite: Reduce downstream peak discharge and volume and help maintain and improve water quality.
Long-Tern Storage of Surface Water: the temporary storage of surface water for long periods.	Onsite: Provide habitat and maintain physical and biogeochemical processes. Offsite: Reduce dissolved and particulate loading and help maintain and improve surface water quality.
Storage of Subsurface Water: the storage of subsurface water.	Onsite: Maintain biogeochemical processes. Offsite: Recharge surficial aquifers and maintain baseflow and seasonal flow in streams.
Moderation of Groundwater Flow or Discharge: the moderation of groundwater flow or groundwater discharge.	Onsite: Maintain habitat. Offsite: Maintain groundwater storage, baseflow, seasonal flows, and surface water temperatures.
Dissipation of Energy: the reduction of energy in moving water at the land/water interface.	Onsite: Contribute to nutrient capital of ecosystem Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.
Functions Related to Biogeochemical Processes	**Benefits, Products, and Services Resulting from the Wetland Functions**
Cycling of Nutrients: the conversion of elements from one form to another through abiotic and biotic processes.	Onsite: Contributes to nutrient capital or ecosystem.
Removal of Elements and Compounds: the removal of nutrients, contaminants, or other elements and compounds on a short-term or long-term basis through burial, incorporation into biomass, or biochemical reactions.	Onsite: Contributes to nutrients capital of ecosystem. Contaminants are removed, or rendered innocuous. Offsite: Reduced downstream loading helps to maintain or improve surface water quality.

Retention of Particulates: the retention of organic and inorganic particulates on a short-term or long-term basis through physical processes.	Onsite: Contributes to nutrient capital or ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.
Export of Organic Carbon: the export of dissolved or particulate organic carbon.	Onsite: Enhances decomposition and mobilization of metals. Offsite: Supports aquatic food webs and downstream biogeochemical processes.
Functions Related to Habitat	**Benefits, Goods and Services Resulting from the Wetland Function**
Maintenance of Plant and Animal Communities: the maintenance of plant and animal community that is characteristic with respect to species composition, abundance, and age structure.	Onsite: Maintain habitat for plants and animals (e.g., endangered species and critical habitats), for rest and agriculture products, and aesthetic, recreational, and educational opportunities. Offsite: Maintain corridors between habitat islands and landscape/regional biodiversity.

APPENDIX E: DEFINITION OF "FUNCTION"

There is quite broad agreement among floodplain, wetland and riparian managers concerning the overall categories of goods and services provided by floodplains and, to a lesser extent, the natural processes producing such goods and services. See Boxes 2 and 3 and Appendix F. However, there is limited agreement concerning the formal definition of the term “function.” Statutes, regulations, and many papers, books and reports use the term function to mean “goods and services.” Many others and many scientists use the term function to mean “natural processes.”

Differences in how the term function is defined are important. For example, regulations of the Clean Water Act Section 404 program require that regulatory permits not result in net loss of wetland “function” and “value.” Permit applicants are to minimize (mitigate) project impacts upon functions and values and compensate for impacts which cannot be minimized. The definition of “function,” therefore, determines what is to be protected, mitigated and compensated. But, protecting a natural process such denitrification is not the same as protecting a floodplain pollution control “function.” The later depend not only upon single natural processes but upon multiple natural processes and a broad range of additional factors such vegetation, connectivity of the floodplain with adjacent waters, existing use, and condition.

What difference does it make whether “functions” are defined as the natural processes producing goods and services or the goods and services themselves? The use of the term “function” to mean the natural processes producing goods and services rather than the goods and services themselves makes little difference in terms of what ultimately gets assessed, mitigated and compensated if the natural processes investigated are sufficiently broad so that they also act as an accurate predictor of goods and services. Unfortunately this is not true for many rapid assessment models developed to date because the models fail to consider many relevant natural processes and are based upon broad and only partially validated assumptions with regard to the relationship between individual processes and goods and services.

Part of the confusion in the use of “function” and “value” has been the multiple dictionary meanings of the terms "function" and "value." Both terms may be used as both nouns and verbs (See Webster, 2nd Edition). For example, a floodplain can be said to be characterized by certain on-site "functions" (noun) such as atmospheric gas exchange. A floodplain also "functions" (verb) to retard and store flood waters. Similarly, a floodplain may be characterized as possessing a certain "value" (noun) such as an economic value of $10,000 for forestry production. But, members of society may also "value" (verb) a floodplain for birding, pollution control, or other purposes.

To further complicate matters, a "function" (noun) such as the storage of flood waters can be (and often has been) characterized as a "value" because it is valuable to society. Conversely, a floodplain "value" such as flood water retention may perform certain off-site flood loss reduction "functions" for downstream landowners and society. Confusing enough?

It is not surprising that legislators, the public, agency staff, scientists, and others have used the terms *function* and *value* somewhat interchangeably in statutes, regulations, ordinances, articles, books, and newspapers.

It is also not surprising that scientists in developing methods for assessing "functions" or "values" have wished to more precisely define functions. For example, the HGM procedural guide (Smith et al., 1995) defines functions as the "normal or characteristic activities that take place in wetland ecosystems or simply the things that wetlands do." Unfortunately, this definition is also ambiguously broad although it is clear from the report as a whole that the authors use the term *functions* to mean natural processes.

Use of the term *function* to refer only to natural processes leaves a void in terminology for the combinations of natural processes and other floodplain characteristics (size, topography) which make a floodplain valuable to society. What are these to be called? A New Hampshire wetland assessment method used the term "functional value" to describe such composite characteristics. The HGM approach suggested the term "valuable function" (Smith et al., 1995). I have suggested in earlier papers the compound term “function/value” for the lack of a better term.

Continued use of the term “function” to refer to both end-product goods and services and the collection of natural processes which produce such goods and services is less than ideal but is consistent with the broad existing use of the term “function” in books, reports, statutes, regulations and general polices. The noun "function" appropriately describes the collection of natural processes which produce the goods and services as well as the goods and services produced by floodplain processes such as pollution control, flood storage, and production of fish.

If the term “function” is to be used to apply only to natural process, scientists should make clear that they are not attempting to subtly redefine the scope of Section 404 and similar project review in evaluating “functions” and that there are factors other than natural processes needing evaluation as well. See Box 6. Narrowing the concept of “net loss of function” to apply only to changes in selected natural processes has significant policy implications which deserve open public debate and review and perhaps public rule-making. It should be decided based upon sound public policy considering a broad range of factors.

Further, if the term “function” is to be narrowly used in scientific contexts to refer only to natural processes, scientists should make clear that natural processes encompass only a portion of what floodplains and wetlands “do.” As suggested above, what floodplains and wetlands do, in even a narrow natural resource sense, depends upon size, shape, location, surrounding land uses, and other factors not simply floodplain onsite physical (chemical, biological, other) processes. On the other hand, if scientists wish to select a single term to describe natural processes, why not simply call them “natural processes”?

APPENDIX F: FUNCTIONS/VALUES OF WETLAND/FLOODPLAIN/RIPARIAN AREAS

This appendix provides an overview of some of the naturally occurring "goods and services," which floodplains and wetlands provide to society. This list is derived from various wetland, floodplain and riparian area regulatory statutes, administrative regulations, ordinances, and publications. This list focuses on the end-products (functions/values) of value to society. Habitat functions have been subdivided into a number of categories with resulting overlap because there are many types of important habitat with somewhat different assessment needs.

1. HYDROLOGICALLY-BASED FUNCTIONS/VALUES

Function/value:
Provide flood storage by storing and slowly releasing flood waters.

Value: Reduce flood heights and velocities and flood damages, protect health and safety, prevent nuisances, reduce the economic impacts of flooding.

General discussion: Flood storage has been recognized as a floodplain and wetland function/value for many years although there are only a small number of papers and reports dealing specifically with natural flood storage. Storage has proven difficult to evaluate on a case-by-case basis because the flood storage capability of a floodplain or wetland depends not only upon the size, configuration, and elevation of the outlet of the floodplain or wetland but the vertical and lateral connectivity of the drainage network with the surrounding topography. Flood storage also depends upon antecedent hydrologic and hydraulic conditions including ground and surface water levels. Further, the importance of a given amount of flood storage on downstream water levels depends upon the synchronization and desynchronization of flood flows from multiple sources reaching a particular area at a particular point in time. Flood storage is, to some extent, susceptible to quantitative evaluation if adequate time and money are available for detailed topographic mapping and flood flow analysis (e.g., HEC—RAS model).

Features determining whether floodplain may serve function/value:

- Size of floodplain and surrounding depression
- Antecedent ground water and surface water conditions
- Size (magnitude) of flood
- Configuration of floodplain/wetland topographic depression (includes not only floodplain or wetland but surrounding "lip"
- Outlet size, depth
- Vegetation type and density
- Dams, dikes, levees, flood warning and other flood reduction measures.

Floodplain/wetland types: Riverine floodplains serve primary storage roles but vernal pools, pothole wetlands, other isolated or semi-isolated wetlands and estuarine wetlands may also play important storage roles in some contexts.

Difficulty in evaluation: Quantitative evaluation with HEC-RAS or other hydrologic/hydraulic and geomorphic models is possible but time consuming and expensive.

Sources of useful information: FEMA and other flood maps, National Wetland Inventory maps, stream gauge records, other water level records, topographic maps, of hydrologic and hydraulic models.

Some features to look for suggesting floodplain may serve flood storage function:

- Large floodplain in deep topographic depression with restricted floodplain outlet. FEMA or other flood maps showing deep inundation for floodplain.
- Physical evidence of deep flooding.
- Lack of stream channel incision (little or no evidence of bed and back erosion)
- Much of the watershed is developed, much is impermeable surface.
- Floodplains/wetlands are rare or relatively rare in a watershed.
- Significant topography in a watershed with resulting steep hydrograph.

Sources of expertise: Local floodplain management agency, state floodplain management agency, U.S. Army Corps of Engineers, FEMA, USGS, NRCS, U.S. Bureau of Reclamation.

Measures to reduce project impacts on function:

- Protect topographic configuration of floodplain/wetland and surrounding depression from filling, grading, drainage.
- Protect outlet elevation.
- Prevent channelization, ditching, filling which increases runoff and channel incision.
- Prevent cutting of floodplain vegetation.

On-site restoration/creation/enhancement potential: Often technically possible to restore storage through removal of fills, revegetation, excavation, restoring or raising elevation of outlet.

Off-site restoration/creation and mitigation bank potential: It is technically possible to provide offsite flood storage benefits for downstream individuals and properties if off-site mitigation is provided upstream on the same river or stream. A shift to another location or stream will shift flooding to different landowners.

Function/value: ***Convey flood waters.***

Value: Reduce flood heights and velocities at upstream, adjacent, and downstream points. Protect health and safety. Prevent nuisances. Reduce economic damages and losses.

General discussion: Flood conveyance is a function broadly recognized in floodplain management for over 30 years. It is a function that is also subject to quantitative evaluation through "backwater models" such as HEC-RAS. The calculation of flood conveyance requires the calculation of a flood discharge (Q) and flood heights for a specific frequency of flood based upon the flood discharge, valley profile and stream valley cross section. Backwater computations can be carried out to calculate increases in flood heights which would occur if a floodplain/wetland or portion of a floodplain/wetland was filled, leveed or otherwise blocked. Geomorphic studies may determine aggradational zones where sediment deposition (e.g., at delta areas) is creating backwater conditions and the blockage of ice flows. Documentation of this function may be particularly important in addressing "taking" issues for regulations because it is one of the few functions subject to clear "nuisance" implications and quantitative evaluation.

Features determining whether floodplain may serve function/value:

- Overall hydrologic regime (the quantity of flood waters for particular sizes or frequencies of floods which can be expected to flow through a valley cross section).
- Position of natural or anthropogenic fills, levees, other obstructions in relationship to channel.
- Topographic configuration of the floodplain.
- Vegetation (in general, more vegetation results in less conveyance capacity).
- Soils (erodibility).

Floodplain/wetland types: Riverine.
Difficulty in evaluation: Moderate, subject to availability of funds.
Sources of useful information: Topographic maps (stream gradient, topography), air photos (vegetation), FEMA and other federal and state agency flood and floodway maps, National Wetland Inventory maps (vegetation, location), and stream gauging records.
Some features to look for suggesting floodplain may serve a flood conveyance function:

- Floodplain/wetland is in a FEMA, Corps of Engineers, USGS, NRCS, state or local mapped floodway.
- Floodplain/wetland is in or adjacent to a river or stream with history of deep, high velocity inundation.
- Floodplain/wetland in or adjacent to a river or stream with documented "flashy" hydrologic characteristics (indicated by stream gauging, flood maps, other flood data).
- Floodplain/wetland in or adjacent to a river or stream in an urban or urbanizing area with much impermeable surface and substantial drainage area.
- Floodplain/wetland in or adjacent to a river or stream in an area of steep topography.
- Floodplain/wetland is covered with large stones and gravel (indicates high velocity flows).
- Narrow valley cross section with floodplain/wetland occupying much of the cross section.
- Substantial, low-lying development now suffering severe flood losses or susceptible to losses.

Sources of expertise/data: FEMA local floodplain management agency; state floodplain management or water resources agency; Corps of Engineers, USGS, NRCS, U.S. Bureau of Reclamation, Tennessee Valley Authority, and other agencies with flood loss reduction mission.
Measures to reduce project impacts on function:

- Locate fills as far from the center of a river or stream as possible.
- Contour any fills, channelization, other alterations to compensate for loss of hydraulic conveyance.

On-site restoration/creation/enhancement potential: Hydraulic conveyance capacity may be restored in some instances through on-site grading, excavation, shaping of conveyance area, etc.
Off-site restoration/creation or mitigation bank potential: Any effort to recreate or restore hydraulic conveyance on other streams or at other locations on a stream will often result in increased flood damages to upstream, adjacent, and downstream properties at the original site although it may reduce damage at the site of the restoration.

Function/value:
Induce waves to break before reaching shore, reduce force of water.

Value: Reduce wave damage.
General discussion: Waves for a 100 year flood may add 3-15 feet or more to standing water flood elevations along major rivers, streams, lakes, and coastal areas. Waves have large kinetic energy and often not only damage but destroy houses, roads, and other structures. They can also erode foundations and pilings (resulting in building collapse), roads, lawns, parking lots, agricultural fields, etc.

Large waves are generated where there is a combination of (1) high winds (particularly common in hurricanes and "northeasters" along the coast), (2) wide "fetch" (width of open water), and (3) at least moderate water depths.

Vegetated floodplains/wetlands can help reduce wave and erosion damage by (1) causing waves to "break" at offshore locations, and (2) binding and holding the soil.

The Federal Emergency Management Agency has identified high velocity wave zones on some coastal flood hazard maps and requires protection of mangroves in local coastal floodplain regulations where mangroves reduce flood damages.
Features determining whether floodplain may serve function/value:
- Intensity of wind velocities (e.g., hurricane prone area).
- Whether a floodplain/wetland is adjacent to a major water body.
- Size/width of floodplain/wetland.
- Depth of water in the floodplain; bottom topography.
- Vegetation type, density, height.

Floodplain/wetland types: Coastal, estuarine fringe, some lake (Great Lakes) and river fringe (Mississippi River) floodplains.
Difficulty in evaluation: Moderate.
Sources of useful existing information: FEMA flood maps, historic flood records, topographic maps, water resource maps, bathymetric maps, air photos (water body characteristics, floodplain characteristics)
Some features to look for suggesting floodplain may serve wave attenuation function:
- FEMA or other maps showing wave action areas.
- Maps or other records of past wave action, wave damage.
- Floodplain/wetland adjacent to a water body with high wind and deep flood history, large width (fetch), and at least moderate near-shore depths.
- Floodplain/wetland with thick wetland vegetation (e.g., mangroves, other trees).
- Existing or potential back lying development subject to flood/erosion damage, **Sources of expertise:** FEMA, Corps of Engineers, USGS, NRCS, local floodplain management agency, state floodplain management agency, and Soil and Water Conservation District.

Measures to reduce project impacts on function:
- Restore dunes, beaches.
- Allow natural revegetation to occur or replant vegetation where disturbed.
- Install compensatory wave reduction and erosion control measures such as sea walls

On-site restoration/creation/enhancement potential: Restoration of dunes, **r**eplanting of trees and other vegetation can, over time, restore on-site wave retardation and erosion potential.

Off-site restoration/creation or mitigation bank potential: Off-site restoration of a dune, wetland, floodplain forest can reduce flood and erosion damage at the sites of such restoration. But, it is not usually possible to protect the same back lying properties and individuals by a restoration/creation project or mitigation bank some distance from an original damage site.

Function/value: ***Reduce erosion by slowing velocity of water and by binding soil.***

Value: Reduce erosion property losses, ecological damage, and sedimentation of lakes, streams, reservoirs, estuaries, and wetlands**.**

General discussion: A properly functioning floodplain is indicative of a stream channel in dynamic equilibrium where channel meander and slope, and subsequent erosive force of the flowing water are in balance with the sediment supply and erosion resistive qualities of the channel boundaries. An equilibrium channel is one where stream power is evenly distributed and erosion is minimized (Leopold, 1994). Vegetated floodplains and wetlands reduce erosion in a broad range of contexts by slowing the velocity of waters and binding the soil. Sediment is deposited where water velocities are reduced, forming natural levees.

Features determining whether floodplain may serve function/value:

- Velocity of water at a site.
- The equilibrium condition of the stream channel.
- Duration of flooding.
- Topography
- Susceptibility of soils to erosion.
- Vegetation types, densities, condition.
- Sediment loading in water body.

Floodplain/wetland types: Primarily river and river fringe (river bed, stream bank, floodplain), but also some lake fringe, coastal and estuarine fringe. Often the portion of a floodplain nearest the channel is most susceptible to erosion.

Difficulty in evaluating: Moderate.

Sources of information: Topographic maps, fluvial geomorphic studies, FEMA and other floodplain and floodway maps, soil maps, and air photos.

Some features to look for suggesting floodplain may serve erosion control function:

- Degree of stream channelization (i.e., altered stream channel meander and slope).
- Bank erosion, other erosion of stream channel, banks, outer floodplain areas.
- Large gravel, boulders in floodplain/wetland (indicates high velocity flows).
- Floodplain/wetlands in or adjacent to high velocity stream.
- Floodplain/wetlands in "wave action" zones along lakes, rivers, estuaries, and coasts.

Sources of expertise: NRCS, USGS, Corps of Engineers, resource agencies, floodplain management agencies, soil conservation groups and organizations (e.g., Soil Conservation Districts), academics.

Measures to reduce project impacts on function:

- Accommodate dynamic equilibrium stream channel conditions by minimizing encroachment within the meander belt width of the stream.
- Allow natural revegetation to occur.
- Replant erosion-prone areas.
- Restore dunes.
- Contour fills and other alterations to reduce water velocities.

On-site restoration/creation/enhancement potential: Replanting of trees and other vegetation or natural revegetation can, over time, help restore onsite erosion control capacity. It is also important to restore channel and floodplain geometry associated with equilibrium conditions.
Off-site restoration/creation or mitigation bank potential: It is difficult to protect the same back lying properties and individuals by a restoration/creation project some distance from an original site although erosion control may be provided for new sites.

Function/value: ***Recharge ground water.***

Value: Maintain and enhance quantity and quality of ground water supplies for domestic, commercial, industrial, agricultural, wildlife protection and other purposes; maintain base flow of rivers and streams.
General discussion: In general, wetlands and floodplains are not recharge areas. But, some lake fringe and river fringe wetlands and other seasonally flooded wetlands and floodplains may recharge ground water at least a portion of a year or function as both discharge and recharge areas.
Features determining whether the floodplain will serve function/value:

- Floodplain/wetland water levels higher than wetland/floodplain ground water levels.
- Substantial yearly fluctuations in ground and surface water levels.
- High porosity and permeability of wetland/floodplain soils.
- Whether the bottom of a wetland/floodplain is "sealed" by organics, silt.

Floodplain/wetland types: Some riverine and depressional wetlands/floodplains act simultaneously as recharge and discharge areas (discharge on side, recharge on other) or act as recharge areas a portion of the year when water elevations exceed ground water elevations due to precipitation or surface runoff.
Difficulty in evaluating: May be difficult, time-consuming, and expensive to determine ground water flow regimes.
Sources of information: Topographic maps; water level records for floodplain, adjacent areas; well logs, other records of ground water levels.
Some features to look for suggesting floodplain may serve to recharge groundwater:

- Wetland/floodplain has inlet but no outlet.
- Seasonal fluctuations in wetland/floodplain water levels (particularly, long-term fluctuations).
- Sand or gravel substrate.

Sources of expertise: USGS, NRCS, state water supply agencies, state geologic agencies, other resource agencies, academics.
Measures to reduce project impacts on function:

- Maintain natural fluctuations in wetland/floodplain water levels.
- Where water levels are controlled, make sure wetland/floodplain water levels continue to exceed adjacent ground water levels at least a portion of the year.

On-site restoration/creation/enhancement potential: It is technically possible to create both wetland/floodplain and upland recharge areas although it has often proven difficult to maintain natural infiltration capacity because the bottoms of detention/recharge areas tend to "seal" with organics and sediment.

Off-site restoration/creation or mitigation bank potential: See on-site above. It is theoretically possible to locate recharge wetlands/floodplains at some distance from the original wetland/floodplain if recharge of a regional aquifer is involved.

Function/value:
Discharge ground water.

Value: Prevent damaging increases in ground water levels, basement flooding; maintain floodplain/wetland river and stream base flows.

General discussion: Many depressional, slope, lake, estuarine, and river fringe floodplain/wetlands are ground water discharge areas much of the year. If a floodplain/wetland is filled or covered with impermeable surface (e.g., a parking lot), this may block ground water discharge, increasingly ground water levels in the surrounding landscape and causing flood and saturation problems for basements, foundations, and septic tank/soil absorption fields.

Features determining whether floodplain will serve function/value:

- Wetland/floodplain surface water elevation is higher than groundwater elevation in nearby areas.
- Permeable wetland/floodplain soils.

Floodplain/wetland types: Montane, riverine and some lake, coastal and estuarine fringe.

Difficulty in evaluating: Moderate. Discharge may be directly observed in some instances (e.g., springs in wetland/floodplain).

Sources of information: Topographic maps, well logs, USGS water resource maps and papers.

Some features to look for suggesting floodplain may serve as ground water discharge area:

- Springs.
- Flooding of basements due to high ground water levels.
- Rivers, creeks, streams with strong base flows.
- Onsite septic tank/ soil absorption fields fail to work properly.

Sources of expertise: USGS, state geologic and water resource agencies.

Measures to reduce project impacts on function:

- Minimize fills, paving which decrease natural discharge.

On-site restoration/creation potential: Ground water discharge may be restored by removal of fills.

Off-site restoration/creation or mitigation bank potential: Ground water discharge may be restored at another site. However, it is unlikely that the same ecological communities and properties will benefit.

2. ECOLOGICALLY BASED FUNCTIONS/VALUES

Function/value:
Provide natural crops.

Value: Produce natural crops of commercial and recreational value such as cranberries, blueberries, salt marsh hay, timber, and wild rice.

Features determining whether floodplain may serve function/value:

- Water salinity (almost all natural crops except for salt marsh hay are in found in freshwater floodplains and wetlands).
- Water quality, pollution types and levels.
- Water depths and velocities, hydroperiod.
- Soil.
- Vegetation type, density, condition.
- Presence or absence of exotic plant species.

Floodplain/wetland types: Many types, but primarily seasonally flooded freshwater floodplains and wetlands.

Difficulty in evaluating: Easy to moderate. There are many types of natural crops with differing requirements.

Sources of information: Soil surveys, National Wetland Inventory maps (vegetation), air photos, and topographic maps.

Some features to look for suggesting floodplain may serve natural crop function:

- Visible evidence of cranberry, blueberry, wild rice salt marsh hay, forests or other natural crops.
- Area has history of wild crop production.
- Soils favorable for natural crop production.

Sources of expertise: Natural Resources Conservation Service, U.S. Forest Service, groups and organizations representing various agricultural groups, environmental not-for-profits, academics.

Measures to reduce project impacts on functions:

- Maintain natural hydrologic regime
- Control exotic species.
- Replant disturbed areas with natural crops.

On-site restoration/creation potential: Moderate to good if hydrology is intact. Regrading, replanting may be necessary.

Off-site restoration/creation or mitigation bank potential: Possible at another location but there may be a shifting of benefits and costs.

Function/value: ***Prevent and treat pollution.***

Value: Prevent and treat pollution in lakes, streams, estuaries, coastal water, ground waters, etc.
General discussion: Many wetlands and floodplains serve two related functions:

- Prevent pollution from entering water bodies. Wetlands and vegetated floodplains intercept and trap debris, toxics, nutrients, and other pollutants which would otherwise reach water bodies from upland sources by slowing the velocity of water, causing sediment to drop out, and providing an opportunity for chemical transformations in soils and water.
- Treat (remove) pollution in water bodies. Wetlands (and some frequently flooded floodplain areas) in water bodies or inundated by fluctuating water levels from adjacent water bodies (tides, floods) may also, in many instances, remove pollutants which have already reached water bodies. For example, riverine floodplains and wetlands may slow river velocities, causing precipitation of sediments and attached pollutants. Lake fringe wetlands may buffer lakes from upland sediment and pollution and may also, to some extent, remove pollutants in lakes.

Features determining whether floodplain will serve function/value:

- Overall flow regimes, quantity of water (dilution factor), water velocity, whether natural aeration is taking place (rapids, waterfalls).
- Temperature.
- Detention times.
- Sediment regime.
- Type of vegetation, density, condition.
- Soils.
- Location of wetland/floodplain in relationship to other water bodies.
- Vertical and lateral connectivity to other water bodies.
- Existing or reasonably anticipated pollution sources which may be intercepted or "treated" by wetland, riparian area, broader floodplain.

Floodplain/wetland types: All floodplain/wetland types may help prevent pollution for upland sources reaching water bodies if they lie between the pollution sources and the water bodies. Lake fringe, estuarine and coastal fringe, and riverine wetlands may also remove pollutants from water bodies to a greater or lesser extent.
Difficulty in evaluating: Moderate because highly variable.
Sources of information: NWI maps (water regimes, vegetation), topographic maps (water flows), soils maps, fluvial geomorphic studies, air photos (vegetation, flow regimes, land uses), and land use plans (future development).
Some features to look for suggesting floodplain may serve pollution control function:

- Floodplain or wetland in an area (agricultural, urban, other) with much pollution or high pollution potential.
- Vegetated floodplain areas which lie between an existing or potential pollution source (e.g., nutrients, sediment, toxics) and a water body used for water supply, swimming, other purposes.
- Sediment deposition visible in a wetland or floodplain area.

Sources of expertise: NRCS, EPA, Corps of Engineers, USGS, state pollution control agencies, other regulatory and resource agencies, environmental not-for-profits, land trusts, and academics.
Measures to reduce project impacts on function:

- Protect natural vegetation
- Do not allow drainage, channelization or other measures which decrease water detention time in floodplain/wetland.

- Require replanting of vegetation where natural revegetation may not occur.
- Create artificial detention areas to compensate for loss of natural detention areas.

On-site restoration/creation/enhancement potential: On-site measures may be undertaken to compensate for loss of pollution buffering or treatment potential such as replanting of vegetation, installation of detention and sedimentation ponds, and construction of upland vegetated buffers.

Off-site restoration/creation or mitigation bank potential: Restoration at another site will usually not protect the same water body and the same individuals and properties. However, it may be possible to create wetlands on the floodplain off-site in some instances to provide pollution buffers for the same water body (e.g., destruction of a wetland along a portion of a lake and restoration or creation of a wetland at another location on the lake) or to help treat water in the same water body (e.g., creation of a wetland in the same stream but in a different section).

Function/value: ***Provide habitat for fish and shellfish.***

Value: Provide fish and shellfish for commercial fisheries, food, recreational fishing, and food chain support for other wildlife.

General discussion: The importance of coastal and estuarine wetlands and floodplains to estuarine and oceanic fish and shellfish are two of the most broadly recognized wetland and floodplain functions/values. The importance of freshwater wetlands to northern pike spawning and other fish is also well-recognized. Riverine and other periodically flooded floodplain areas provide fish habitat and food sources. Storage of sediment and woody materials in stream channels maintains important cover habitats. Functioning floodplains reduce the erosive scour of instream habitat features.

Features determining whether floodplains will serve function/value:

- Vertical and lateral connectivity between floodplain and adjacent waters.
- Depth of water.
- Salinity.
- Water quality
- Velocity.
- Temperature.
- Substrate, soil.
- Presence or absence of riffles, pools, other structures.
- Presence or absence of invasive species.
- Water quality (including sediments).

Floodplains/wetlands types: Primarily wetlands and floodplains adjacent to lakes, streams, estuaries, or the ocean with adjacent open water.

Difficulty in evaluating: Moderate to good.

Sources of information: NWI maps (size, water regime, salinity, vegetation type), soils maps, topographic maps, fluvial geomorphic studies, fisheries and shellfish studies, instream flow studies.

Some features to look for suggesting floodplain may serve fish and shellfish habitat function:

- Observed fish or shellfish.
- Observed spawning areas.
- Floodplain/wetland is adjacent to and vertically/laterally connected to a water body with fish/shellfish.

- Adequate depth and size for fish or shellfish.
- Good water quality.

Sources of expertise: U.S. Fish and Wildlife Service, National Marine Fisheries Service, commercial and private fisherman and shell fishermen, resource agencies, and academics.

Measures to reduce project impacts on function:

- Protect low flows sufficient for target species.
- Insure that connection between floodplain/wetland and adjacent waters is maintained (essential to passage of fish, food chain support,
- Maintain equilibrium stream conditions.
- Require that public and private landowners revegetate e river banks to reduce erosion and sedimentation.
- Minimize tree cutting adjacent to wetland and water body to maintain water quality and temperatures.
- Prevent pollution.

On-site restoration/creation/enhancement potential: On-site restoration is sometimes possible involving control of pollution and sediment, restoration of stream banks and stream bank vegetation, restoration of meanders, creation of riffles and pools.

Off-site restoration/creation or mitigation bank potential: Off-site restoration or creation or use of a mitigation bank on another water body will not compensate for destruction of fish or shellfish in the original water body. Different individuals and properties will benefit and suffer burdens.

Function/value:
Provide habitat for amphibian, reptile, mammal and insect species.

Value: provide biodiversity in landscape, protect rare and endangered species, provide research and educational opportunities.

General discussion: Wetlands and floodplains provide critical habitat for a broad array of amphibian, reptile, mammal, and insect species. Functions/values depend not only upon floodplain characteristics but relationship to uplands, other wetlands and floodplains, and open water bodies because most amphibians, mammals, and reptiles spend only a portion of their time in wetlands and floodplains.

Features determining whether floodplain will serve function/value:

- Connectivity with other waters.
- Vegetation types, density.
- Size of wetland/floodplain.
- Water quality.
- Relationship of wetland/floodplain to other wetlands, floodplains, water bodies, and upland habitat, availability of corridors and passageways between wetland or floodplain and other habitat.
- Presence or absence of buffers.
- Salinity.
- Sediment regimes.
- Water level fluctuations.

Floodplain/wetland types: All types of wetlands and floodplains may provide valuable habitat (depending upon the circumstances) for reptiles, birds, amphibians, mammals and insects although habitat requirements differ.

Difficulty in evaluating: Depends. Difficult to assess presence or absence of many species because they occupy the floodplain only a portion of the year, are seen only at night, and their habitat requirements are not well known..
Sources of information: NWI maps soils maps, topographic maps, various mammal, reptile, amphibian, and insect surveys like those carried out by state Heritage programs. .
Some features to look for suggesting floodplain may serve fish and shellfish habitat function:

- Directly observed amphibians, reptiles, mammals, insects or observed signs (e.g., tracks, scat, egg cases or pupa shells).
- Wetlands/floodplains/riparian areas are rare in locality or region.
- Wetland/floodplain type is rare.
- Wetlands/floodplains adjacent to parks, refuges, other public lands.
- Wetlands/floodplains adjacent to large undeveloped private tracks.
- Wetland/floodplains with significant open water or adjacent to a lake, river, or stream with open water (otter, beaver).
- Undisturbed wetlands/floodplains.

Sources of expertise: Academics, resource agencies, environmental not-for-profit organizations.
Measures to reduce project impacts on function: Varied, depending upon the situation and type of wildlife.

- Maintain wetland/floodplain open water connections and connections to upland wildlife corridors.
- Require erosion control and sediment control measures such as detention areas and grass strips to reduce sediment and pollutant contributions.
- Fence.

On-site restoration/creation/enhancement potential: Varied, depending upon the species. Often on-site restoration potential is poor in an urbanizing context for animal species which require not only floodplain but undisturbed upland habitat and adequate connecting pathways.
Off-site restoration/creation or mitigation bank potential: Varied. Off-site restoration/creation or mitigation bank potential may be better than on-site where the original floodplain is in the midst of a large subdivision, road project, etc. However, different individuals and properties will benefit and suffer costs.

Function/value:
Provide habitat for waterfowl.

(Note, this overlaps with other types of habitat.)

Value: Provide hunting opportunities, food sources for people, bird watching.
General discussion: Waterfowl nesting, resting and feeding were some of the first, widely recognized functions of wetlands and floodplain areas. Floodplains and wetlands may be important nesting and feeding areas. The prairie pothole wetlands and other wetlands in various "flyways" are particularly important. Because they fly from wetland to wetland, waterfowl can make use of many types of isolated and semi-isolated wetlands not usable for other forms of wildlife dependent upon ground pathways.
Features determining whether floodplain will serve function/value:

- Size of wetland and floodplain.
- Presence of open water in wetland or floodplain or adjacent to open water in a lake, river, stream, estuary, or ocean.

- Types, densities, and condition of wetland and floodplain vegetation.
- Water quality.
- Salinity.
- Food chain support, availability of nearby sources of food (e.g., corn fields).
- Presence or absence of buffers (nesting, resting areas).
- Predators: types, numbers.

Floodplain/wetland types: Principally lakefringe, river fringe, ocean and estuarine fringe.
Difficulty in evaluating: Moderate.
Sources of existing information: NWI maps (water regime, vegetation, size, substrate, relationship to other waters), soil maps, topographic maps, land cover maps, waterfowl inventories and special maps.
Some features to look for suggesting floodplain may serve as waterfowl habitat:

- Waterfowl directly observed.
- Wetland or floodplain with open water or adjacent to a lake, river, or stream with open water.
- Wetland or floodplain in "flyway".
- Wetlands and floodplains adjacent to parks, refuges, other protected public lands.

Sources of expertise: FWS, NMFS, NRCS, state wildlife agencies, groups representing waterfowl hunters, duck clubs, resource agencies, environmental not-for-profits, and academics.
Measures to reduce project impacts on function:

- Use (e.g., agriculture) wetlands/floodplains only during periods when not used by waterfowl.
- Install nesting boxes; create nesting islands.
- Fence wetlands and floodplains.
- Protect wetlands and floodplains from pesticides, nutrients, and sediment through control of applications and the use of buffer strips.
- Provide nearby upland food sources.

On-site restoration/creation/enhancement potential: Often quite good if adequate land and funds are available to excavate upland areas, use dredging, dynamite or other measures to create open water, control exotic plant species.
Off-site restoration/creation or mitigation bank potential: Also often quite good since ducks can fly from one site to another. However, different individuals and properties will, to some extent, benefit and suffer burdens.

Function/value: ***Provide habitat for various song birds, other nongame birds.***

(Note, this overlaps with other types of habitat but has been set forth separately because "birding" and ecotourism have become such important services in some areas of the country.)

Value: Ecotourism, recreation, education, research.

General discussion: Bird watching has become a widespread activity in the last 20 years with bird watchers now outnumbering hunters in some areas. Bird watching is important in many local economics. A great deal of bird watching takes place in wetlands, floodplains, and riparian areas due to the large numbers of waterfowl and other water birds and many upland species which feed in these areas.

Features determining whether floodplain will serve function/value: A broad range of physical processes and cultural features affect the bird habitat and bird watching potential of floodplains/wetlands:

- Vegetation types, conditions, densities.
- Water quality, degree of disturbance.
- Adjacent upland and deepwater habitat.
- Other wildlife including food sources, predators.
- Presence of absence of public access.
- Rareness of wetlands/floodplains in the region.
- Rareness of wetland/floodplain type in region.
- Adjacency of wetland/floodplain to trails, roads, parks, refuges, sanctuaries.

Floodplain/wetland types: Many types or wetlands/floodplains and subzones within floodplains serve specific bird habitat needs.

Difficulty in evaluating: Difficult to evaluate based upon one-time visits since birds are too small to be seen on air photos and birds often use wetlands only a portion of a time.

Sources of information: NWI maps (wetland types, vegetation, substrate, proximity to other waters, overall water regime), air photos (vegetation), local birding clubs, field observations

Some features to look for suggesting floodplain may serve as bird habitat and as bird watching areas:

- Nongame species of birds observed.
- Floodplain meets habitat requirements for specific types of birds.
- Wetland/floodplain is well known in a region for bird watching.
- Floodplain is located in flyway.
- Wetland/floodplain is relatively undisturbed.
- Wetland/floodplain has open water (water birds).
- Rareness of wetlands/floodplains in the region.
- Favorable adjacent upland and deepwater habitat.
- Adjacency of wetland/floodplain to trails, roads, parks, refuges, and sanctuaries.
- Absence or presence of public access including boardwalks and trails.

Sources of expertise: USFWS, schools, universities, environmental not-for-profits, land trusts, resource agencies, and museums.

Measures to reduce project impacts on function:

- Protect natural vegetation.
- Require upland screening of fills and structures to protect aesthetic values.
- Install nesting boxes.
- Maintain connectivity between open waters and wetland/floodplain.

On-site restoration/creation/enhancement potential: Variable. It is often difficult to create the conditions needed for very specific bird species or suits of species.
Off-site restoration/creation or mitigation bank potential: See on-site.

Function/value:
Provide habitat for endangered or threatened species of plants and animals.

(Note, this overlaps with other habitat categories but has been set forth separately because of the great interest in endangered or threatened species and various programs directed to such species).
Value: Heritage value, protect gene pools, ecotourism, bird and animal watching, research, education.
General discussion: An estimated 35-80% of endangered or threatened plant or animal species live in or are dependent upon wetlands. An even high percentage of threatened plant and animal species in arid or semi-arid regions live in riparian areas. Some animal species spend their entire lives in wetlands or riparian areas. However, most occupy wetlands or riparian areas only a portion of the time. Therefore adjacency of upland and deep water habitat and the connections between floodplains and these other habitats are important. Connections are also important to provide refuge during droughts and periods of fluctuating water levels. Because of the sensitivity of many of these species and their narrow ecological niches, it is particularly important to protect broader water regimes and adjacent upland habitat.
Features determining whether floodplain will serve function/value: A large number of features are relevant to ability of wetlands/floodplains to provide habitat for rare, threatened or endangered plant or animal species.

- Vegetation.
- Water depth, velocity, quantity.
- Salinity.
- Water temperature.
- Buffers present or absent, condition.
- Soils.
- Substrate.
- Size.
- Adjacent upland and aquatic habitat; connections with broader habitat.
- Rarity of wetland/floodplains and wetland/floodplain types

Floodplain/wetland types: All types may be important. Many endangered plant and animal species are located in rare wetland and floodplain types such as bogs, vernal pools, and saline ponds.
Difficulty in evaluating: Difficult due to the large number of floodplain habitat and niches of different endangered species and because endangered and threatened species are usually difficult to locate and observe due to small numbers.
Sources of information: State Heritage Programs, NWI maps (overall vegetation, water regime, substrate, connections with other wetlands), air photos (vegetation), lists of sites in federal inventories, state inventories, land trusts.

Some features to look for suggesting floodplain may serve as habitat for rare or endangered species:

- Observed rare, endangered or threatened species in a floodplain or similar wetlands/floodplains
- Wetlands/floodplains are rare in a locality, region, or state.
- Wetland/floodplain type is rare in a locality, region, or state.
- Rare/endangered species found in similar habitat.
- Floodplain meets habitat requirements of specific types of endangered species.

Sources of expertise: State heritage programs, environmental not-for-profits, and academics.
Measures to reduce project impacts on function:

- Maintain buffers,
- Pprovide detention basins to reduce pollution, undertake or other measures to protect water quality.
- Fence.
- Control exotic species.

On-site restoration/creation/enhancement potential: Often low given the very narrow habitat requirements of most endangered species.
Off-site restoration/creation or mitigation bank potential: Also low given the very narrow habitat requirements of most endangered species including, in many instances, the need for adjacent upland and/or aquatic habitat as well as wetland/floodplain habitat.

3. ATMOSPHERICALLY BASED FUNCTION/VALUES

Function/value:
Maintain carbon stores, sequester carbon in order to reduce climate change.

Value: Reduce climate change and the damage caused by climate chance due to increased temperatures, changes in precipitation, sea level rise.
General discussion: Wetlands and some floodplains store and sequester carbon thereby potentially reducing climate change. Many wetlands contain large stores of carbon and provide continued sequestering of carbon. However, wetlands also produce methane which may offset carbon sequestering benefits.
Features determining whether floodplain will serve function/value:

- Type of wetland/floodplain (e.g., mangroves and other coastal wetlands may be particularly important carbon sequesters while producing limited methane.)
- Depth and volume of organic soils
- Size of wetland/floodplain.
- Type of wetland/floodplain.
- Vegetation.
- Climate.

Floodplain/wetland types: All types. However, some types may be particularly important as carbon sinks such as estuarine wetlands, delta wetlands, mangroves, peatlands, and tundra.
Difficulty in evaluating: Difficult on a site by site basis.

Sources of information: NWI maps, other maps and surveys pertaining to wetland size, water regime, vegetation, substrate. Soils maps, climatological data (temperatures).

Some features to look for suggesting floodplain may store significant amounts of carbon:

- High organic content of soils.
- Deep carbon rich soils.
- Large floodplain size.
- Large standing crop of trees
- Many wetlands in flood plain.

Sources of expertise: Academics, resource agencies.

Measures to reduce project impacts on function: Control drainage, fills, burning.

On-site restoration/creation potential: It will often be very difficult to restore wetland/floodplain carbon stores once carbon is returned to the atmosphere by drainage, burning. However, restoration of wetlands and floodplains may help.

Off-site restoration/creation or mitigation bank potential: Creation of a wetland/floodplain carbon bank might compensate for carbon or methane releases at an original site where floodplains or wetlands are destroyed. .

Function/value:
Modify micro-climate by cooling air (or preventing temperature rises), increasingly circulation due to differential pressure gradients, increasing evaporation and local humidity, etc.

Value: Cool air in urban area, reduce health problems, reduce the costs of air conditioning.

General discussion: Wetlands and floodplains in urban areas along with other open spaces may moderate temperatures and increase air circulation patterns.

Features determining whether floodplain will serve function/value:

- Location in relationship to urban areas.
- Size.
- Configuration (shape).
- Vegetation types, condition.
- Presence or absence of open water.

Floodplain/wetland types: All types of wetlands/floodplains and vegetated open space.

Difficulty in evaluating: Moderate. However there are no agreed-upon procedures.

Sources of information: Floodplain maps, NWI maps (wetland size, location, type, vegetation, open water, other wetlands and waters), detailed climatological data, and topographic maps, air photos.

Some features to look for suggesting floodplain may serve to modify micro climate:

- Location adjacent to an urban area.
- Floodplain heavily vegetated.
- Floodplain large.

Sources of expertise: Academics, resource agencies.

Measures to reduce project impacts on function:

- Maintain vegetated open space.
- Replant vegetation where natural revegetation is insufficient.

On-site restoration/creation/enhancement potential: Moderate to good.

Off-site restoration/creation or mitigation bank potential: Moderate although different individuals and groups will accrue benefits/suffer costs by removal of vegetation/open space at one location and establishment at another.

4. CULTURALLY AND ENVIRONMENTALLY BASED FUNCTIONS/VALUES (Humans more significantly enter the picture).

Function/value:
Provide recreation and ecotourism opportunities and experiences.

Value: Provide recreation, promote health, provide ecotourism opportunities, provide economic benefits.

General discussion: Recreation is among the most important uses of wetlands/floodplains to society. It includes both water-based recreation such as fishing, canoeing, boating (in some instances) and land-based recreation such as bird watching, nature watching, jogging along trails, etc.

Features determining whether floodplain will serve function/value: A broad range of floodplain physical processes and other characteristics determine the potential of a floodplain area for various recreational uses such as canoeing, boating, birding, hiking). Such characteristics and processes include but are not limited to:

- Floodplain type.
- Vegetation.
- Size.
- Presence or absence of open water (boating, canoeing).
- Bird species (bird watching).
- Animal species including endangered species (wildlife watching).
- Fish species (fishing).
- Waterfowl species (hunting).
- Rarity of wetlands/floodplains in a state or region.
- Rarity of wetland/floodplain type in a locality, state.
- Presence or absence of public access.
- Adjacency to other waters.
- Adjacency to roads, bike paths, etc.
- Adjacency to parks, refuges, sanctuaries.

Floodplain/wetland types: Many types have recreational and ecotourism potential. Floodplains/wetlands adjacent to lake, river, and estuarine/coastal waters are most important for water-based recreation.

Difficulty in evaluating: Moderate. There are many types of recreation. Recreation functions/values are not based upon ecological considerations alone. For example, accessibility and location are relevant.

Sources of information:

Some features to look for suggesting floodplain may serve as recreation area:

- Observed use of wetlands/floodplains by canoeists, birders, etc.
- Adjacency to other waters.
- Public access through roads, trails, boat launching sites, public waters.
- Proximity to urban centers.
- Size.

- High water quality (swimming, boating, wildlife).
- Rarity of wetlands/floodplain in state region.
- Rarity of wetland/floodplain type in locality, state.
- Open water (relevant to canoeing, fishing).
- Bird species important for bird watching.
- Animal species including endangered species important for wildlife watching.
- Fish species important for fishing.
- Waterfowl (hunting).

Sources of expertise: FWS, NPS, state park and recreation agencies at all levels of government, environmental not-for-profits and land trusts.

Measures to reduce project impacts on function:

- Maintain connectivity between floodplain and open water.
- Require protection of floodplain vegetation.
- Require revegetation of denuded areas.
- Require screening of upland areas to fills protect aesthetic values.

Restoration/creation/enhancement potential: Moderate but variable, depending upon the types of recreation and impacts.

Off-site restoration/creation or mitigation bank potential: Off-site potential is variable in part because of the many different types of recreation. However, in general, different individuals or populations will benefit.

<u>Function/values</u>:
<u>Provide historical, archaeological, heritage, aesthetic opportunities and experiences</u>.

Value: Provide heritage, cultural, educational, research, tourism, and aesthetic functions and values.

General discussion: Some wetlands and floodplains have important historical or archaeological value. Well known examples include the confluence of the Mississippi River and the Missouri where Lewis and Clark began their westward journeys, the Concord Marshes, and the Everglades. Many others have heritage and cultural value for biodiversity, rare and endangered species, and open space.

Features determining whether floodplain will serve function/value:
A broad range of ecological processes are relevant. However, value does not derive from ecological processes alone. Some relevant features include

- Historical use of floodplain (e.g., shell mounds).
- Aesthetic features including vegetation, open water, and edge ratio.
- Size of wetland/floodplain.
- Wildlife.
- Diversity of plants/animals.
- Public access.
- Adjacency to parks, historical monuments, sanctuaries, preserves.

Floodplain/wetland types: Many types (not dependent upon natural resource characteristics alone).

Difficulty in evaluating: Moderate (depends).

Sources of information: Lists and maps of archaeological sites, historical sites, heritage sites, historical parks, etc.
Some features to look for suggesting floodplain may serve historical, archaeological, aesthetic function:

- Shell mounds.
- Historical markers.
- Adjacency to historic, archaeological park.
- Rarity of wetlands/floodplains, wetland/floodplain types.
- Biodiversity.
- Presence of endangered or threatened species.

Sources of expertise: NPS, schools, universities, environmental not-for-profits, land trusts, resource agencies, and museums.
Measures to reduce project impacts on function: Varied, depending upon functions/values and impacts. Adopt tight regulations, create buffers, require setbacks, construct boardwalks to reduce impacts on sensitive areas..
On-site restoration/creation/enhancement potential: Poor to impossible. It is impossible to create a historic or archaeological site although some restoration may be possible.
Off-site restoration/creation or mitigation bank potential: See offsite above**.**

Function/value: ***Provide education and interpretation opportunities*****.**

Value: Educate students at all levels.
General discussion: Many types of education and nature "interpretation" are carried out in wetlands and floodplains at K-12, college and adult education levels. These range from observation of frogs and birds to sophisticated restoration projects by university faculty and students. Many trails and boardwalks and interpretative centers have been constructed in or adjacent to floodplains/wetlands.
Features determining whether floodplain will serve function/value: A broad range of physical processes give rise to various characteristics important to education. Some include

- Vegetation type
- Wildlife including biodiversity.
- Presence of endangered, threatened, or rare plants or animals.
- Degree of alteration or disturbance.
- Rarity of wetlands/floodplains in the locality, region.
- Rarity of wetland/floodplain type.
- Proximity to schools, urban centers.
- Public access, ease of access.
- Presence or absence of boardwalks, trails.

Floodplain/wetland types: All types.
Difficulty in evaluating: Moderately difficult to evaluate education and interpretation potential since education and interpretation needs are diverse.
Sources of information: Floodplain maps, NWI maps (size, vegetation, water regime), maps of public lands, lists of interpretative trails and centers, rare and endangered species maps.
Some features to look for suggesting floodplain may serve educational function:

- Experiments going on in a wetland/floodplain.
- Wetland/floodplain is habitat for rare or endangered species.

- Wetland/floodplain is in or adjacent to parks, refuges, or marine/estuarine sanctuaries.
- Wetland/floodplain readily accessible to the public by canoe.
- Schools and colleges nearby. Boardwalks, trails, interpretative facilities in or near a wetland/floodplain.
- Wetlands/floodplains rare in locality, state, or region.
- Wetland/floodplains unaltered, in "natural" condition.

Sources of expertise: Schools, universities, environmental not-for-profits, land trusts, resource agencies, and museums.
Measures to reduce project impacts on function: Varied, depending upon type of education, interpretation needs and interests Adopt tight regulations, create buffers, require setbacks, construct boardwalks and trails to reduce damage from foot traffic.
On-site restoration/creation/enhancement potential: Varied. There are many successful examples of wetland and floodplain restoration sites being used for education and interpretation (e.g., Tifft Farms, Buffalo; Hackensack Meadowlands; South Platte).
Off-site restoration/creation or mitigation bank potential: See on-site above.

Function/value: ***Provide scientific research opportunities.***

Value: Advance scientific knowledge; improve understanding of natural systems; educate students at all levels.
General discussion: Scientific research is carried out in rivers and streams, floodplains, wetlands, and riparian areas by schools, universities, resource agencies, and not-for-profit organizations.
Features determining whether floodplain will serve function/value: A broad range of floodplain characteristics may be important to research (which is highly varied):

- Vegetation type and wildlife including biodiversity.
- Presence of endangered, threatened, or rare plants or animals.
- Degree of alteration, disturbance, condition.
- Rarity of wetland/floodplain type.
- Rarity of wetlands/floodplains in the locality, region.
- Ownership (public or private).
- Proximity to schools, urban centers.
- Proximity to public lands such as parks, refuges, and sanctuaries.
- Public access, ease of access.
- Presence of absence of boardwalks, trails.
- Previous studies (establishing baseline conditions).

Floodplain/wetland types: All types.
Difficulty in evaluating: Moderate due to many potential types of research.
Sources of information: Floodplain maps, NWI maps, maps of endangered or threatened species, maps or lists of "natural" areas, soils maps.
Some features to look for suggesting floodplain may serve scientific research function:

- Visible evidence of ongoing experiments.
- Boardwalks, research interpretative facilities in or near floodplain.
- Wetland/floodplain is in or adjacent to parks, refuges, or marine sanctuaries.
- Public trails near wetland/floodplain or wetland/floodplain readily accessible Schools, colleges nearby.

- Wetland/floodplain type rare in a locality, state, or region.

Sources of expertise: Resource agencies, schools, universities, environmental not-for-profits, land trusts, museums.

Measures to reduce project impacts on function: Varied by type of wetland and research type. Adopt tight regulations, create buffers, require setbacks, construct boardwalks and trails.

On-site restoration/creation/enhancement potential: Traditionally quite poor because most researchers have wanted to work with undisturbed or relatively undisturbed floodplains. However, there are exceptions such as the Des Plaines River restoration site. And, more researchers are becoming interested in altered systems.

Off-site restoration/creation or mitigation bank potential: Poor to moderate. Most researchers seek undisturbed or relatively undisturbed wetlands.

APPENDIX G: SUGGESTED READINGS AND WEBSITES

(Please note, not all suggested readings and websites are cited in this paper. Please also note that in the last decade, many newspapers and reports and articles have been posted to the Internet although they are also available in hard copy. We have included these in our listing of websites although many could also be listed as books, reports, or articles.

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