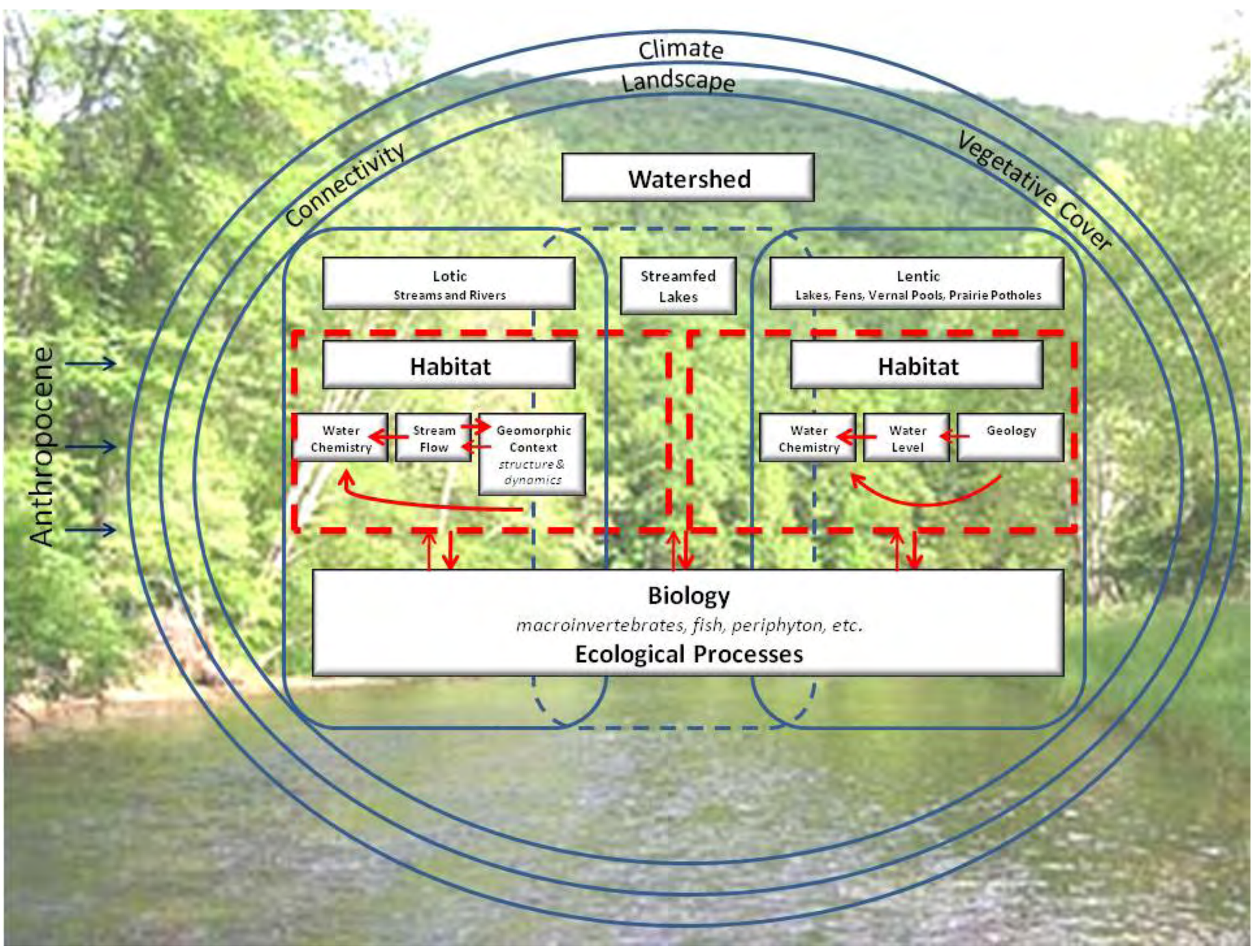
Healthy Watersheds Integrated Assessments Workshop

Advancing the state-of-the science on integrated healthy watersheds assessments and considering the role of green infrastructure in maintaining watershed health and resilience

March 2011



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Appendix A includes a complete list of all persons who attended the workshop and their affiliations and contact information.

Report cover photo credits:

Photo of the Sinnemahoning Creek, an exceptionally high quality watershed in Pennsylvania, provided by US EPA and illustration of draft conceptual model for healthy watersheds integrated assessments developed by workshop participants.

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Acronyms

BMP	Best management practices
CWA	Clean Water Act
DEM	Digital elevation model
DOT	Department of Transportation
DVRPC	Delaware Valley Regional Planning Commission
ELOHA	Ecological Limits of Hydrologic Alteration
EMAP	Environmental Monitoring and Assessment Program
EDU	Ecological drainage unit
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera, Trichoptera
FEMA	Federal Emergency Management Authority
FPZ	Functional process zone
F-TRAC	Florida Forever Tool for Efficient Resource Acquisition and Conservation
GAP	Gap Analysis Program
GDE	groundwater dependent ecosystems
GIS	Geographic information system
HCI	Habitat Condition Index
HUC	Hydrologic unit codes
HWI	Healthy Watersheds Initiative
IBI	Index of biological integrity
INSTAR	INteractive STream Assessment Resource
IWI	Index of Watershed Indicators
LCC	Landscape conservation cooperatives
LID	Low impact development
LiDAR	LIght Detection And Ranging
LWD	Large woody debris
MAIA	Mid-Atlantic Integrated Assessment (MAIA)
mIBI	modified index of biological integrity
MN DNR	Minnesota Department of Natural Resources
NED	National Elevation Dataset
NEPA	National Environmental Protection Act
NFHAP	National Fish Habitat Action Plan

NGO	Nongovernmental organization
NHD	National Hydrography Dataset
NLCD	National Land Cover Dataset
NPDES	National pollutant discharge elimination system
NPS	Nonpoint source
NRCS	Natural Resources Conservation Service
ONRW	Outstanding national resource water
POTW	Publically owned treatment works
ReVA	Regional Vulnerability Assessment
RHA	Reach Habitat Assessment
RPB	Rapid bioassessment
SAB	Science Advisory Board
SARP	Southeast Aquatic Resources Partnership
SIFN	Southern Instream Flow Network
SHC	Strategic habitat conservation
SPARROW	SPAtially Referenced Regressions on Watershed attributes
STORET	STOrage and RETrieval
TITAN	Threshold indicator taxa analysis
TMDL	Total maximum daily load
TNC	The Nature Conservancy
TPL	Trust for Public Land
USDA	United States Department of Agriculture
USGS	Unites States Geological Survey
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
VA DCR	Virginia Department of Conservation and Recreation
VCU	Virginia Commonwealth University
VT ANR	Vermont Agency of Natural Resources
WA DOE	Washington Department of Ecology
WAT	Watershed Assessment Tool
WBD	Watershed Boundary Dataset
WFMIS	Watershed Forest Management Information System

1 Introduction

Purpose of the Workshop

The objective of the Clean Water Act (CWA) is "to restore and maintain the chemical, physical, and biological integrity of the nation's waters." Since enacted in 1972, federal water quality regulations have led to significant reductions in pollutant levels in many impaired lakes, rivers, and streams. Further, significant efforts have been undertaken to restore aquatic ecosystems in our nation's impaired watersheds. Despite these efforts, our aquatic ecosystems are declining nationwide. The rate at which new waters are being listed for water quality impairments exceeds the pace at which restored waters are removed from the list, and restoring impaired waters is costly. In addition to pollution, threats such as loss of habitat and its connectivity, hydrologic alteration, invasive species, and climate change continue to increase. It is clear that a better strategy is needed if we are to achieve all of the objectives of the CWA envisioned by Congress.

The United States Environmental Protection Agency (EPA) is embarking on the new Healthy Watersheds Initiative[1] (HWI), in partnership with others, to protect our remaining healthy watersheds, prevent them from becoming impaired, and accelerate our restoration successes. This initiative will be implemented by using a strategic, systems approach to identify and protect healthy watersheds. Healthy watersheds will be identified through integrated assessments of habitat, biotic communities, water chemistry, and watershed processes such as hydrology, fluvial geomorphology, and natural disturbance regimes. Once healthy watersheds or healthy components of watersheds are identified, then priorities can be set for protection and restoration, with the best chances of recovery being in waters near existing healthy aquatic ecosystems.

The Healthy Watersheds protection approach is based on a key, overarching principle: the integrity of aquatic ecosystems is tightly linked to the watersheds of which they are part. To maintain ecological integrity of aquatic resources, watershed managers need to understand not only the biological, chemical, and physical condition of water bodies, but also critical watershed functional attributes, such as hydrology, geomorphology, and natural disturbance patterns. Programs that protect and restore aquatic ecosystems are most effective when they integrate these dynamics and manage watersheds as systems. Protection and creation of green infrastructure at both local (e.g., rain garden) and landscape (e.g., headwater and riparian corridors) scales is one component of watershed management that is critical for maintaining pre-development hydrologic regimes and habitat, and thus geomorphology, natural disturbance patterns, water quality, and biotic condition.

A number of assessment programs have sought to integrate various measures of ecosystem health into a holistic framework. EPA's Environmental Monitoring and Assessment Program (EMAP) and Mid-Atlantic Integrated Assessment (MAIA) program contributed to an integrated approach by developing tools and the scientific understanding necessary to monitor and assess the nation's ecological resources. EMAP integrated ecologically relevant chemical and physical parameters and landscape indicators with biotic condition assessments. The Heinz Center's State of the Nation's Ecosystems and EPA's Report on the Environment assess a larger list of ecological indicators, including extent and fragmentation of habitat patches on the landscape, patterns of biodiversity, and stream flow modification. These are national-level assessments meant to communicate information to the public and to guide policy and

[1] http://water.epa.gov/polwaste/nps/watershed/index.cfm

decision making. The Healthy Watersheds Initiative contributes to this body of work by providing an integrated assessment framework for comprehensive protection of watersheds.

The purpose of the *Healthy Watersheds Integrated Assessments Workshop* was not to reach consensus on the definition of healthy watersheds; rather, the purpose of the workshop was to advance the state-of-the-science, as well as identify key research needs, on integrated healthy watersheds assessments and to consider the role of green infrastructure in maintaining watershed health and resilience. And while the intent was to initiate a discussion during the workshop on the topic of resilience and how to include concepts of resilience in the assessment of healthy watersheds, the goal was not to reach consensus on the definition of resilience.

A healthy watersheds assessment employs a systems approach that integrates assessments of green infrastructure (i.e., hubs and corridors in the landscape), habitat, biology, water quality, and the key processes that drive their condition: hydrology, fluvial geomorphology, and natural disturbance regimes. States are beginning to conduct these assessments to identify the remaining healthy watersheds and intact components/processes in other watersheds to strategically target resources for protection and restoration. To date, most state approaches integrate these assessment components/processes using indices that are displayed spatially in a geographic information system (GIS). Methods for integrating the individual assessment components/processes are in need of additional research, as are methods for addressing lotic, lentic, and ground water dependent ecosystems in an integrated framework. Many of the approaches discussed at the workshop focused on lotic systems; however, the integration of lotic and lentic systems will be discussed in the post-workshop synthesis paper.

This workshop set out to explore: 1) the relationships among these components/processes and how to design assessments to capture that integration; 2) methods to assess resilience of these healthy watersheds; and 3) how integrated assessments can be practically implemented in state, tribal, or regional programs to meet program needs. Ideas on how to develop state healthy watersheds lists using existing information were also explored and research gaps and data needs were identified.

The desired outcomes of the *Healthy Watersheds Integrated Assessments Workshop* included:

- Improved understanding of watershed resilience and management;
- Improved healthy watersheds assessment conceptual model and understanding of relationships among the assessment components;
- Identification of key gaps in our knowledge and research needs;
- Ideas on how to implement assessments at the state level;
- Ideas on how to better protect healthy watersheds through partnerships; and
- Workshop summary, synthesis paper, and input on revisions to the draft Technical Guide.

Workshop Design

The *Healthy Watersheds Integrated Assessments Workshop* was designed to be similar in organization and format to the Society of Environmental Toxicology and Chemistry (SETAC) Pellston Workshops, where technical experts in a particular subject area are invited to participate and advance cutting-edge technical and policy issues in environmental science. A Pellston-type workshop typically brings together between 40 to 50 technical experts from academia, business, government, and public interest groups. Experts are semi-sequestered for up to a week to facilitate focused discussions and individual and collaborative writing of a draft summary report by the end of the workshop.

To facilitate focused discussions, the size of the *Healthy Watersheds Integrated Assessments Workshop* was limited to about 50 invited attendees. Participation in this workshop was targeted at state and regional technical staff and program managers who are interested in conducting healthy watersheds integrated assessments and protecting healthy watersheds, as well as expert scientists who can contribute to the development of these assessments. In addition to experts drawn from academia, public interest groups, and numerous state and other federal agencies, experts from within EPA also participated in the workshop. See Appendix A for participant list.

The workshop agenda is provided in Appendix B. The workshop included a mix of plenary session presentations and breakout workgroup sessions (with report-outs following each of the breakout workgroup sessions). Additional information regarding the plenary session presentations and breakout workgroup sessions is provided below. The *Healthy Watersheds Integrated Assessments Workshop* did not include on-site writing due to time constraints and the need to first focus on concept development through extensive discussion and brainstorming. Immediately following the workshop, six different writing teams (consisting of workshop participants) were established to co-author a post-workshop synthesis paper on *Healthy Watersheds Integrated Assessments.* A draft outline of the paper is provided in Appendix C. The synthesis paper is expected to be final in spring 2011.

Plenary Session Presentations

Each speaker's presentation slides from the plenary sessions are provided in Attachment 1. Additionally, many of the speakers provided fact sheets, which provide additional information about their programs/projects; those fact sheets are provided in Attachment 2. This workshop proceedings document contains a brief summary of each speaker's talking points from the workshop. Each summary was sent to the speaker for review of accuracy and to allow for additional input to better clarify information. Prior to the workshop, most of the speakers were provided a list of questions to address in their talks and/or to prepare to answer as part of a speaker panel; the questions provided are summarized below:

<u>Examples of State Healthy Watersheds Assessments</u>

- What is the purpose of the assessment approach?
- How can the assessment help to identify healthy watersheds or intact components of other watersheds?
- How are the results of the assessment currently used by natural resource managers?
- What were the limiting factors in your assessments in terms of data availability and methods?

Watershed Resilience

- What indicators are used in the assessment approach and why?
- What methods are used in the assessment approach and why?
- How can these assessments help to maintain healthy watersheds?
- What are the key indicators and methods for assessing watershed resilience?
- How can healthy watersheds be sustained?

Examples of How to Integrate Assessment Components

- Which Healthy Watersheds Assessment Components, or other components, are integrated in the assessment approach?
- What methods are used to integrate the assessment components or address multiple components with one approach?
- How are difficulties, such as different scales, addressed in the assessment?

How to Apply Integrated Assessment Results

- How can Healthy Watersheds Integrated Assessments support what your organization is doing to protect watersheds?
- What is your experience getting different agencies/groups to collaborate and work together on protecting healthy watersheds?

Breakout Workgroup Sessions

The four workgroup topics are presented in four chapters in this report. The topics are presented below, along with a summary of the charge questions. The charge questions helped the workgroups to define the scope of their discussions.

1. Healthy Watershed Resilience

- What are the key indicators for assessing watershed resilience?
- What are the methods for assessing watershed resilience?
- How can healthy watersheds be sustained?

2. Developing Integrated Assessments

Design a healthy watersheds integrated assessment approach that relates key watershed processes and landscape condition to healthy habitat and biota in aquatic ecosystems. The assessment must be implementable at the state scale and by state agencies, with support from outside partners. Consider the following questions when designing your assessment approach:

- What key elements should be included in a healthy watersheds integrated assessment approach and what is the role of green infrastructure?

- Considering readily available data, what are the best indicators for these key elements?
- How should the interactions between key elements affect assessment design?
- What methods are available to simultaneously examine multiple interacting endpoints?
- At what temporal and spatial scales should healthy watersheds integrated assessments be conducted?
- What are the data and indicator gaps that currently limit a state's ability to conduct healthy watersheds integrated assessments?
- What does the final product of the assessment look like (i.e., how will the results be communicated)?

3. Implementation of Healthy Watersheds Assessments

- How can states develop lists of healthy watersheds using existing data?
- How can healthy watersheds assessments be implemented by state agencies within their current program structure?
- In what ways might a state agency consider adapting its program structure to support the implementation of healthy watersheds assessments?
- What kind of cross-agency collaboration is required to successfully implement healthy watersheds assessments?

4. Applications of Healthy Watersheds Assessments

- How can healthy watersheds assessments and the resulting lists of healthy watersheds be used to protect these high quality waters and watersheds within and across a state?
- How can local decision makers use this information to protect healthy watersheds?

Workshop Proceedings

This workshop proceedings document contains a brief summary of each plenary session speaker's talk, as well as notes from each of the breakout groups. Only minor edits were made to combine similar ideas and comments, as well as to exclude unrelated topics, from the breakout groups. The goal of the workshop was to share and listen to ideas, not to reach consensus on any particular topic; therefore, all relevant discussion is included in this document.

Following this Introduction chapter, the remaining chapters of the workshop proceedings document are organized similar to the workshop agenda (Appendix B), as follows:

Chapter 2. Healthy Watersheds Assessments

- Includes agenda topics: Overview of Healthy Watersheds Initiative and Examples of State Healthy Watersheds Assessments

Chapter 3. Watershed Resilience

- Includes agenda topics: Watershed Resilience and Breakout Group Topic 1 (Watershed Resilience)

Chapter 4. Developing Integrated Assessments

- Includes agenda topics: Integrated Assessments, Index Approach, Examples of How to Integrate Assessment Component, and Breakout Group Topic 2 (Developing Integrated Assessments)

Chapter 5. Implementation of Healthy Watersheds Assessments

- Includes agenda topics: Breakout Group Topic 3 (Implementation of Healthy Watersheds Assessments)

Chapter 6. Applications of Healthy Watersheds Assessments

- Includes agenda topics: How to Apply Integrated Assessment Results and Breakout Group Topic 4 (Applications of Healthy Watersheds Assessments)

Chapter 7. Research Needs and Data Gaps

- Includes a list of all research needs and data gaps identified by workshop participants throughout the workshop.

Appendix A. Workshop Participants

- Includes a list of all workshop participants.

Appendix B. Workshop Agenda

- Includes the final workshop agenda.

Appendix C. Outline of Healthy Watersheds Integrated Assessments Workshop Synthesis Document

- Includes an outline of the Healthy Watersheds Integrated Assessments Workshop Synthesis Document

2 Healthy Watersheds Assessments

Background & Overview, Laura Gabanski (US EPA Office of Water)

An overview of the HWI was presented, beginning with a conceptual diagram currently being used to identify the essential ecological attributes: biotic condition, landscape condition, natural disturbance, chemical/physical, ecological processes, and hydrology/geomorphology (Figure 1). The conceptual framework for Healthy Watersheds Integrated Assessments is consistent with these essential ecological attributes. Gabanski stressed the need for a systems approach to protecting healthy watersheds. The approach should include an assessment of habitat, biota, and water quality, plus an assessment of the key processes that drive ecological condition. The Healthy Watersheds systems approach is based on an integrated evaluation of: 1) Landscape Condition, 2) Habitat, 3) Hydrology, 4) Geomorphology, 5) Water Quality, and 6) Biological Integrity. Ecological processes and natural disturbance regimes are addressed in the context of these six categories. One of the key objectives of the *Healthy Watersheds Integrated Assessments Workshop* is to advance the systems approach.

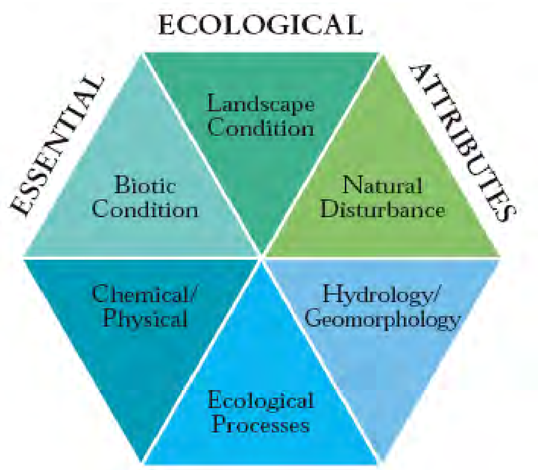

Figure 1 Conceptual diagram for describing ecological condition (from *A Framework for Assessing and Reporting on Ecological Condition.* EPA Science Advisory Board. 2002)

The key characteristics of healthy watersheds include:

- Habitat of sufficient size and connectivity for native aquatic and riparian species.
- Biotic refugia or critical habitat (e.g., deep pools, seeps and springs for survival during droughts).
- Natural hydrology (including flow regime) that supports aquatic species and habitat.
- Natural transport of sediment and stream geomorphology that provides natural habitat.
- Healthy aquatic biological communities.
- Water quality that supports biotic communities and habitat.
- Green infrastructure network of native vegetation in the landscape.
- Functioning natural disturbance regimes (floods, fires).

An integrated assessment approach must be practical, meaning that it must be easy for states to conduct and implement. The integrated assessments should be applicable both to identification and protection of healthy watersheds, as well as to adaptive management of watersheds in need of improvement. Successful implementation of the HWI will require partnerships that inventory healthy watersheds and then protect them at the federal, state, and local levels. These partnerships require coordination across many agencies at varying levels, not just the agencies responsible for water quality. Partnerships with local governments and nongovernmental organizations (NGOs) are also necessary for assessing watersheds. At the federal level, partnerships may involve a variety of agencies (e.g., Department of Interior, Fish and Wildlife, US Forest Service, National Marine Fisheries Service, US Army Corp of Engineers, US Geological Survey, etc.), and work could possibly be coordinated by the Council on Environmental Quality (CEQ). Private industry partners are also welcome. The bottom line is that partnerships are key. For example, EPA is developing a partnership with The Nature Conservancy at both the technical and programmatic levels. EPA's programmatic vision for the HWI is that healthy watersheds are identified and listed by the states and CWA programs are aligned to support the protection, management, and enhancement of healthy watersheds.

The workshop speakers presented examples of their experience with one or more components of the Healthy Watersheds systems approach. Table 1 summarizes which of the Healthy Watersheds components addressed in each speaker's presentation.

Table 1 Healthy Watersheds components and speaker presentations.

	Landscape Condition	Habitat	Hydrology	Geomorphology	Water Quality	Biological Integrity
Bach	✓		✓			
Barnes	✓	✓			✓	
Benson	✓					
Boydstun	✓					
Estep	✓					
Fowler	✓		✓	✓		
Gardner		✓	✓			
Hill	✓				✓	✓
Julius/ Norton						
Kennen			✓			
Kline		✓		✓		
Knight		✓				✓
Linn	✓					
McCall	✓					
McIninch	✓	✓				✓
Pfeifer	✓	✓	✓	✓	✓	✓
Poff/Thorp	✓	✓	✓	✓	✓	✓
Sowa	✓	✓				✓
Stanley	✓		✓			
Whelan	✓	✓	✓		✓	✓

Examples of Healthy Watersheds Assessments

Virginia INteractive STream Assessment Resource, Stephen McIninch, Virginia Commonwealth University

INteractive STream Assessment Resource (INSTAR) is an online geodatabase and decision support tool developed through a partnership between Virginia Commonwealth University (VCU) and state and federal agencies. Probabilistic sampling of stream macroinvertebrates, fishes, and aquatic habitat was used to gather data for INSTAR. This data collection effort resulted in more than 50 metrics of ecological condition, including index of biological integrity (IBI) metrics, rapid habitat metrics, and measures of landscape condition. Other standard metrics, such as stream order and some Rosgen elements, were also considered.

Data were analyzed to determine a set of variables that would reflect a reference condition (virtual stream) specific to physiographic region, stream size, and drainage where appropriate. To analyze the data, INSTAR used nonmetric multi-dimensional scaling, and linear analysis methods. Initial analyses reduced the 50+ metrics to 4-5 key variables that describe distinguishing characteristics of streams (multiple linear regression approach). Variables most closely related to a stream's health, structure, and function were selected and aggregated into an INSTAR virtual site score. Data from all sites were then compared with the virtual score using a similarity index. In order to categorize 'healthy' and 'exceptional' waters, the distribution of INSTAR scores was evaluated. Healthy waters were defined as those with INSTAR scores that were one standard deviation above the mean, and exceptional waters were defined as those with INSTAR scores greater than two standard deviations above the mean. These values correspond to INSTAR scores that are approximately 70% and 80%, respectively, of the reference stream INSTAR score.

One of the limiting factors of the INSTAR approach is the availability of data. In addition, jurisdictional boundaries (e.g., state boundaries) tend to limit model development, because the data sets differ across states and there are limited resources available to expand beyond a single state's boundary.

For more information on INSTAR, visit:
http://instar.vcu.edu/

Use of the Missouri Aquatic Gap Analysis Program Data, Scott Sowa, The Nature Conservancy

Early in an assessment of Aquatic Gap Analysis Program (GAP) data, Sowa determined that Missouri protects clear, cold waters well. However, biodiversity exists in other systems, and the condition and protection of those systems was unclear. This led to an exercise in reserve design that asked the following key questions:

- Which habitats, species, and communities occur within the planning region?
- Where are they and in what condition?
- With respect to establishing reserves, how many, how big, and what configuration?
- How to select among multiple alternatives?

The reserve design process resulted in an analysis of ecological data at varying scales, indicators of ecosystem stress, and land stewardship (specifically public ownership) patterns. This information was compiled for each ecological drainage unit (EDU) in the State of Missouri. Based on this assessment, a representation strategy was developed, resulting in a conservation plan for each EDU. Each plan focuses on conserving two populations of each species found in the EDU and creating an interconnected network of dominant valley segment types.

The results can be used to develop 'dashboards' of information that allow for extensive data exploration and visualization. The process of identifying Conservation Opportunity Areas using these data has provided significant focus on high quality conservation opportunities, an improvement over previous 'blob' approaches that made it difficult to focus restoration work.

Lessons gained from the assessment include understanding the value of a set of guiding principles that provide focus for conservation work, the need for core scientific knowledge to complement available GIS data, the realization that there are many conservation opportunities in 'degraded' lands, and the understanding of how highly valuable targeted results can be.

For more information on the Missouri Aquatic GAP project, visit:
http://www.gap.uidaho.edu/Bulletins/8/bulletin8html/GapBulletin833.html

Puget Sound Water Flow Assessment, Stephen Stanley, Washington Department of Ecology

The Puget Sound region is popular and growing, but this population pressure often results in damage to sensitive ecosystem resources. To reduce this level of damage watershed scientists need to help local decision makers make the correct interpretation and application of watershed research and information.

The Water Flow Assessment tool provides watershed based information on the best areas for protection, restoration and development in the Puget Sound area. The tool assesses watershed processes at the landscape scale and evaluates their degree of impairment and probable effect on the structure and function of aquatic ecosystems. The Washington Department of Ecology (WA DOE) is currently requiring local governments to use these assessments in development planning. They are currently developing solution templates, which provide recommended solutions and actions to address common watershed problems based on assessment results.

An example of how the Water Flow Assessment tool was used by Whatcom and Kitsap Counties was presented. For example, in Kitsap County the assessment was used to prioritize smaller coastal streams that are locally significant, for restoration of processes governing downstream sediment processes impaired by upstream urban development. In Whatcom County the assessment helped prioritize agricultural areas for restoration of processes that govern removal of excess nitrogen from groundwater.

This approach for prioritizing restoration and protection efforts is an improvement over current mitigation and restoration efforts which rely primarily on site conditions and not on the condition of the larger watershed. WA DOE is also working to establish watershed technical teams to assist local governments. WA DOE will provide the assessment framework, and then the technical team will help local governments to correctly apply the results.

For more information on the Puget Sound Water Flow Assessment project, visit:
www.ecy.wa.gov/pubs/1006014.pdf

Maryland Green/Blue Infrastructure, Catherine McCall, Maryland Department of Natural Resources

Growth in the State of Maryland is significant with the state expecting to add an additional million people by 2030. Fortunately, Maryland has a robust program for funding open space maintenance. However, program managers frequently ask, 'How should these funds be focused?' Maryland has conducted multiple assessments to answer this question, and has started to do more with coastal and estuarine systems to improve targeting. This work has involved providing maps and other resources to local groups to help them set priorities. Assessments have been based on combinations of available data for green infrastructure, water quality, endangered species and aquatic life hotspots. Collectively, these assessments have helped to identify targeted ecological areas where the state can focus efforts to maintain open space. The results include a map of the 'best of the best' areas where state effort is focused. NGO partnerships are encouraged in these areas to increase conservation achievements.

Maryland's GreenPrint is an online mapping tool that is used to target and track conservation work at both the landscape and the parcel levels. It is also used to identify and target restoration efforts in the small gaps between high quality areas. To better identify opportunities to protect critical lands for the benefit of coastal habitats and living resources, Maryland is now pulling in 'blue' assessments to complement the green infrastructure efforts already included in the GreenPrint. Maryland's *Blue Infrastructure Near-shore Assessment* is a detailed spatial evaluation of coastal habitat, critical natural resources and associated human uses in the tidal waters and near-shore area of Maryland's coastal zone.

Maryland has also developed a Conservation Scorecards system for all projects. These provide additional accountability for conservation work based on ecologically-defensible criteria. They are used to communicate the value and importance of restoration efforts to elected officials and the public.

For more information about Maryland's programs, visit:
http://greenprint.maryland.gov/
http://dnr.maryland.gov/ccp/bi.asp
http://dnr.maryland.gov/ccp/coastalatlas/estuaries.asp

3 Watershed Resilience

Background & Overview, Doug Norton (US EPA OW) and Susan Julius (US EPA ORD)

The term ‘resilience’ incorporates a number of complex concepts that occur in most resilience definitions. These concepts include disturbance and response, biological community structure, physical structure, natural processes, persistence, and the capacity to maintain functionality. When evaluating resilience in the broadest sense, important factors include the temporal and spatial scales of ecological processes, stress-exposure interactions, social factors that affect ecological resilience, and societal resilience in itself. Managing for resilience also entails understanding critical thresholds for ecological systems in terms of the amount of stress that causes an ecosystem state change and when that state change may occur. Finally, societal resilience or capacity to adapt to changes in climate should also be considered when managing for ecological resilience, because of the pervasive and prolonged nature of the impacts that will occur.

Several studies demonstrate the variable role of resilience concepts in watershed management and potential approaches for assessment. Management strategies that target and favor resilient ecological features are being successfully applied in marine protection areas of the South Pacific. In the North Carolina Blue Ridge ecoregion, on the other hand, some resilience measures would appear to favor the lower quality sites. Hypothetical scenarios of changes in percent coldwater preference Ephemeroptera, Plecoptera, Trichoptera (EPT) taxa were developed to explore the potential effects climatic change may have on reference station quality. Scenarios were of 50 percent loss and 100 percent loss of coldwater EPT taxa across all sites. Results showed that the largest shifts in status occurred at stations classified as mid- to high-quality, whereas those stations classified as fair or poor experienced little or no shifts. This indicates that the highest quality sites may be the most vulnerable to climatic changes, while the lower quality sites may be less vulnerable because the sensitive taxa will already have been extirpated from the lower quality sites. The lower quality sites appear to be more resilient by this measure. This perverse conclusion points to the dangers of managing exclusively for maximum resilience and the need for care to be taken in defining resilience, selecting indicators, and applying resilience findings. This lesson holds for the Healthy Watersheds Initiative since one can infer that broad-scale changes (climate/temperature) that are likely to affect sensitive taxa are, by extension, most likely to affect healthy watersheds. Climate and temperature are not the only broad-scale changes to consider. Population growth and the proportion of anthropogenic cover will also continue to increase (see Attachment 1 for Norton/Julius presentation).

The primary challenge is to understand how to assess and optimize the resilience of our healthy watersheds in light of these ongoing, inevitable changes. Progress has been made in indicator development and comparative assessment techniques. Tools such as Recovery Potential Screening are being used to assess the restorability of impaired watersheds, but could also be adapted to assess resilience of healthy watersheds. Many of this method's indicators of recovery potential address the same ecological, stressor, and social metrics that would be useful for assessing healthy watersheds. A number of state-level assessments have also made progress in measuring and comparing watershed resilience metrics.

As we build a scientific basis that leads to policies that influence resilience, key questions include:

- What are the key indicators and methods for assessing watershed resilience?
- How can healthy watersheds be sustained?
- How well does the HWI hexagon paradigm accommodate resilience concepts?
- How could programs to protect ecosystems in the face of climate change work with programs for healthy watershed protection?
- What can we learn from recovery indicator work that can be translated to HWI assessments?
- Can we develop methodologies for assessing differences in resilience in order to prioritize protection of those valued ecosystems and places that are more likely to persist through increasing pressures (e.g., climate change, development, etc.)?
- How do we manage for resilience?
- Can we predict resilience?

State Case Studies

Florida, Amy Knight, Florida Natural Areas Inventory

The State of Florida's assessment work does not incorporate an explicit focus on resilience, but their program does include aspects of resilience. There is an active land acquisition program in the State of Florida that has historically focused on biodiversity protection. However, the recently adopted Florida Forever Act has added additional aspects (functional wetlands, natural floodplains, and significant surface waters). GIS data were used to help with the development of definitions for these additional aspects and to create models that show each of the aspects as map layers. One of the major challenges was compiling data across 5 water districts that all collect and manage data differently. Climate change considerations were recently incorporated into the Florida Forever Act, but statewide data needed to address this issue are still in the early stages of development. The Florida Natural Areas Inventory is partnering with TNC to develop a coastal-to-inland corridor approach for prioritizing lands to help mitigate the effects of sea level rise.

The Florida Forever Tool for Efficient Resource Acquisition and Conservation (F-TRAC) is a reserve design tool that helps make efficient conservation decisions (i.e., getting the biggest bang for the buck). The tool relies on MARXAN software, which runs site protection scenarios using a series of conservation targets and weights. Florida uses the output to establish protection goals and in budgeting for land acquisition. The output can be used to develop priorities based on single or multiple criteria. In general, the results show that the most efficient protection areas also coincide with areas that are most likely to support resilience.

For more information on Florida Natural Areas Inventory, visit:
www.fnai.org/FlForever.cfm

Louisiana, Jan Boydstun, Louisiana Department of Environmental Quality

The Mississippi River has traditionally been managed for flood control and navigation, and much of the infrastructure was put in place after a major flood in 1927. This disturbance spurred a change in how the river and Louisiana's coastal wetlands were managed. The disconnection between the Mississippi River and coastal wetlands has resulted in loss of nutrients, sediment and fresh waters that are essential for maintaining healthy wetlands. Coastal land loss in Louisiana averages 24 square miles per year, which equates to a patch of land the size of a football field every 20 minutes. This wetland loss has made Louisiana's coastal communities and natural resources less resilient to saltwater intrusion and storm surge. In the wake of Hurricanes Katrina and Rita, the state is working once again to broaden its management framework to include wetland protection and restoration. The state legislature now recognizes the need to combine 'flood protection' and 'wetland restoration' objectives. In 2007, the State created the Office of Coastal Protection and Restoration in order to ensure this high level oversight for coordination of wetland restoration and flow protection in coastal Louisiana. Discussions at the state level have resulted in a new Master Plan. The Master Plan recognizes the need to balance the wide range of critical economic and environmental services that Louisiana provides to the nation and also recognizes the need for public support of the plan.

In Louisiana, the state planning agency was abolished in the 1970s because local governments wanted to be in charge of their own zoning and planning processes. A nonprofit organization, the Center for Planning Excellence, currently works with other state and local agencies to provide local planning services to coastal and inland communities and parishes to help them examine how to make their communities more resilient. Other activities in the state include revisions to the Coastal Zone Boundary, work to protect coastal forest ($16 million has been allocated to purchase easements), and other work to provide habitat protection and protection from storm surges. While the coast is a primary focus in Louisiana, inland watersheds have also received attention to protect and restore their healthy and impaired waters and watersheds.

For more information on Louisiana's programs, visit
www.ocpr.louisiana.gov
http://cpex.org/
www.deq.la.gov

Minnesota, Sharon Pfeifer, Minnesota Department of Natural Resources

Minnesota's Department of Natural Resources (MN DNR) is currently merging its Ecological Resources and Waters divisions. The vision of this new division is healthy watersheds throughout the State of Minnesota.

Minnesota is a water-rich state. It has 12,000 lakes, 10 million acres of wetlands, and 96,000 miles of rivers and streams. There are 81 major 8-digit hydrologic units. Planning and management of water resources is fragmented, both among state agencies and among local, regional, and state government.

A number of important initiatives exist that will contribute to future healthy watersheds work:

Significant ecological modeling has been used to identify remaining high quality habitats (natural green infrastructure), but Minnesota's blue infrastructure remains to be assessed. In partnership with the private sector, MN DNR has also examined social and demographic pressures on the conservation of sensitive natural resources.

MN DNR's Watershed Assessment Tool (WAT) provides a systems-focused, comprehensive assessment of the health of the major watersheds and is near completion. The tool is designed to increase land and water managers' awareness of the major components of healthy watersheds: hydrology, connectivity, biology, geomorphology, and water quality. Each of these five components has a different suite of indicators; individual indicator scores are combined to provide an overall score for each of the five components. Overall watershed health is expressed as a score derived from the five component scores.

Minnesota's Sentinel Lakes Program monitors 24 diverse lake types across the state. This research is expected to provide a better understanding of how land use and climate changes impact a host of lake variables and their overall health and resilience.

Two University of Minnesota projects also have implications for healthy watersheds. MN DNR has completed State Climate Action Planning, but it has only considered mitigation strategies. Three university professors have coupled historic regional climate data to global circulation models to investigate climatic effects in eight Minnesota landscape regions. Their research looks at climate change adaptation strategies for biodiversity, including resistance, resilience, and facilitation approaches. For example, a suggested resilience strategy for Minnesota's southwestern region, which is largely farmed, is to buffer any remaining remnant wetlands, protect any wetland complexes, and restrict groundwater withdrawals.

The University of Minnesota is also the lead on preparation of Minnesota's Water Sustainability Framework. This plan will be a 25-year plan to protect, conserve, and enhance the quantity and quality of the state's ground and surface water, and is due to the Legislature in January 2011.

For more information on MN DNR's Watershed Assessment Tool, visit:
http://www.dnr.state.mn.us/watershed_tool/index.html

Breakout Group Topic 1: Healthy Watersheds Resilience

Watershed resilience can be defined as the ability to recover from a disturbance, whereas resistance is the ability to withstand a disturbance. It can be argued that both resistance and resilience are attributes of ecological integrity, and not something separate. However, just because a system is resilient does not mean that it is healthy. A healthy system is not necessarily resilient either. Recovery is something that resilient systems are capable of and recovery implies that a system has already been pushed beyond its threshold for resistance. Therefore, resistance should be addressed first. Different healthy watersheds attributes may have different capacities for resistance and resilience. Maintaining watershed processes may be the best way to ensure resilience.

The components of watershed resilience are pertinent at different spatial and temporal scales and a complete set of indicators of watershed resilience should consider multiple spatial and temporal scales. Considering multiple spatial and temporal scales takes into account a system's natural variability, a necessary parameter to quantify in order to determine if the system is relatively stable over time. Indicators of watershed resilience include connectivity, presence of natural disturbance regimes, presence of refugia, sensitivity to disease (human and non-human), vulnerability to invasion from non-native species, and geobuffering capacity (susceptibility to water and air pollution). The presence of disease resistance, habitat refugia, and various forms of green infrastructure such as natural riparian corridors which provide natural vegetative cover and the connectivity necessary to allow the movement of populations throughout a network of key habitat patches are indications of a resilient watershed.

Resilience can also be considered to be a component of watershed integrity, which can be defined by examining the six essential ecological attributes mentioned in the draft Guide: landscape condition, habitat, biological integrity, water quality, hydroecology, and geomorphology. Levels of nutrients and suspended solids and assemblages of algal populations are indicative of biological and water quality integrity. Counts of fecal bacteria in water samples indicate the sanitary condition of a water body, and how much anthropogenic activities threaten a watershed's integrity. Embeddedness of substrate, sediment sorting distribution, and natural flow regime must also be assessed to determine the integrity of a watershed's habitat, geomorphology, and hydroecology.

Watersheds are sustained in a healthy condition when their socioeconomic characteristics support that condition. Healthy watersheds can be sustained by diverting development pressures toward heavily degraded watersheds through smart growth, preserving open spaces, and limiting new development in healthy watersheds. Continuous monitoring of the watershed's natural condition and the use of field-validated models are imperative to detecting threats to a watershed's health; these practices also make it possible to set minimum stream flow standards that are protective of watershed health. Education and outreach to all stakeholders, including the general public and policy-makers, is also necessary for sustaining watershed health. Incentives can be used to build on many states' inherent desire for preservation from a National Heritage perspective to encourage policies and behaviors which promote watershed health. Leveraging existing programs and regulations, such as antidegradation policies, across a variety of agencies can also help to sustain healthy watersheds.

Some of the key research needs and data gaps identified during this breakout group discussion included: sufficient monitoring to provide a robust set of water flow and channel survey data, making it possible to define baseline conditions; use of water accounting to determine how much water is being used by humans; and quantification of ecosystem services. Monitoring should also provide an understanding of: the natural variability of systems; the effects of natural disturbances, especially climate change, on systems; and surface-groundwater interactions. All of this information should be available in a central data repository.

1. What are the key indicators for assessing watershed resilience?

- Landscape Condition
    - Longitudinal and lateral (floodplain and riparian) connectivity of river systems.
    - Aquatic and terrestrial connectivity – natural connectivity, as well as alterations to connectivity from human disturbance.
    - Distance to refugia – a network of healthy watersheds is needed to support biotic communities.
    - Contiguity of green infrastructure with hubs and corridors.
    - Redundancy and pattern.
    - Patch size and heterogeneity (available from USFS LANDFIRE data).
    - Degree of departure from natural fire regimes.

  - Native vegetation – vegetation can modify other processes, so it is not just a biological component.
  - Percent atypical wetlands (i.e., not the appropriate type for the landscape setting).
  - Wetland buffer – size and condition.
  - Sustainability of wetlands.
  - Erodibility.
- Biological Integrity
  - Index of biotic integrity.
  - Observed/expected species (e.g., River Invertebrate Prediction and Classification System model).
  - Percent coverage of native vegetation.
  - Percent coverage of non-native species.
  - Replication/redundancy of species.
  - Stabilized or increasing aquatic species diversity.
  - Fish community composition over time.
  - Reproductively viable native populations.
  - Species range.
  - Recolonization potential.
- Water Quality
  - Chemical, physical, and biological attributes.
  - Nitrogen, phosphorus, and suspended sediments are three of the most important parameters and influence many processes.
  - In streams, periphyton can be an indicator of nutrient enrichment. Varies based on different natural systems.
  - Trophic state?
  - Bacterial indicators.
- Habitat Assessment
  - Canopy cover over streams (important for trout streams).
  - Cover types, cover shelter, reproductive habitats, feeding habitats.
  - Pool/riffle ratios.
  - Embeddedness of substrate.
  - Channel form.
  - Sinuosity.
  - Replication/redundancy of habitats.
  - Percent of forest cover change.
- Geomorphology
  - Sediment quantity, size, sorting, and distribution.
  - Particle size distribution over time.
  - Floodplain roughness.
  - Geomorphologic capacity – how resistant a system is to substrate bed movement.

    - Natural channel form.
    - Lateral, longitudinal, and cross-sectional dimensions.
    - Entrenchment.
- Hydroecology
    - Natural level of water storage capacity.
    - Watershed yield.
    - Flow regimes and dynamics.
    - Timing and rate of change.
    - Flow duration curves over time.
    - Natural flood/drought cycle (disturbance regime).
    - Groundwater contribution.
    - Hydrologic connectivity.
    - Groundwater/surface water interactions.
    - Water flows, levels, and quantity – surface and subsurface (ice and glacier position also part of water level).
- Stressor-based Indicators
    - Percent deforestation.
    - Rain on snow zones.
    - Percent non-native species.
    - Percent impervious cover in a subwatershed.
    - Road density/road lane-miles.
    - Rural development status and trends in watershed.
    - Road crossings.
    - Change analysis of historic hydric soils.
    - Legacy land uses.
- Programmatic/Social
    - Resistance to disease for human and non-human populations.
    - Existing legal and institutional protection to avoid modification of natural hydrologic variability (flow, stage).
    - Rural development status and trends in watershed.
    - Existing and projected potential land use status and permitted uses of land based on land ownership status (private, tribal, state, local, federal).
    - Potential for future water development projects.
    - Declining number of flood damage claims - if claims are decreasing, the community is making room for the river to flow naturally.
    - Compliance records for publicly owned treatment works (POTWs) and other dischargers.
    - Trends in property valuation and tax assessments (home value is an indicator of water quality in some states).
    - Sonoran Index on Socio-Economic Distress (Sonoran Institute). Provides info on socio-economic components that interact with other elements.

- Others
    - Intact ecosystem function.
    - The amount of energy expended to alter flow of water through watershed.
    - A watershed's response to development pressures.
    - Geological buffering capacity – it determines a watersheds capacity to cope with stressors such as acid rain.
    - Persistence over time of natural conditions.
    - Condition of neighboring watersheds.

Other Considerations

- Recovery is key to resilience and recovery implies watershed process (e.g., hydrologic regimes, sediment regimes, nutrient regimes, etc.).
- Indicators are a measurement; measurements do not define resilience. Ecological and biological processes and functions define resilience. Does the system have functioning processes? How does the system respond to threats? Will the system respond in a resilient way if ecological, biological, and hydrological processes work?
- Watersheds are more resilient (ecologically and financially) when gray infrastructure is decreasing and blue and green infrastructure are increasing.
- Resilience is about comparing to baseline, which most states do not have yet.
- Watersheds have three facets which make them resilient: social/economic, biological, and physical.
- Watershed resilience translates into an ability to endure or recover from natural disaster.
- Systems lose resilience as unnatural infrastructure processes (i.e., flood controls) are added to the system.
- A resilient watershed does not have artificial barriers to movement.
- Proximity to areas of high fire risk, bark beetle outbreak, and other extreme events influences a watershed's resilience.
- High biodiversity is not the same as integrity. Biodiverse systems may not be as resilient because they contain sensitive species; it might be an intermediate level of biodiversity that indicates resilience.
- Is a water body 'impaired' if it is within its natural variability?
- The goal is to identify systems that have high biological integrity and can be managed to maintain this integrity (i.e., resilience).
- Natural range of variation needs to be considered. Variability is natural (e.g., species compositions, flow regimes, habitat heterogeneity, etc.), though some disturbances push a system beyond its ability to recover (e.g., oil spill).
- Resilience is likely highest in places with extreme hydrology. These systems are naturally resistant or resilient to perturbations.
- It is important to look at the kinds of frameworks that are in place to promote resilience.

- EPA's Regional Vulnerability Assessment (ReVA) identified vulnerability indicators. Conductivity, for example, can be an indicator in systems where organisms have adapted to low conductivity. Understanding stressors lets you understand drivers.
- The idea of resilience is system-dependent. There are so many indicators out there. The HWI wants to come up with a more generic list so that it can be used across the country. This needs to happen before developing the site-specific indicators.
- Need to have a variety of indicators at different levels and from different categories. This variety lets you get at different things and find things you might otherwise miss. Linking multiple indicators can allow you to identify some top level indicators.
- Rare stream types with high resilience should also be a focus. These need to be protected from encroachment so that they are not destroyed.
- Need to be careful with term 'resilience' as some of the degraded streams are most resilient, in terms of ability to absorb additional impact.
- Do not let data availability be a barrier to developing an assessment approach. It is important to identify what information is needed, even if it is not available today. There may be funding available to make some of these non-existent data sets available. Need to think long term.
- Some streams may have potential for recovery, but only with human intervention. When we discuss resilience, should human intervention be included? For example, some fish species are not able to return to native habitats because of the presence of dams. Dam removal would be required to allow the system to fully recover.
- Integrity has a regional context. Resilience also has a system specific context. A degraded system may move to a state where resistant species dominate and the system becomes more resilient, but it is not the best of the best anymore.
- Biological indicators need to be addressed in the context of other indicators. 'False positives' (high biotic integrity in poor habitat) are an issue. False positives can be reduced by aggregating indicators to level of stressors.

2. What are the methods for assessing watershed resilience?

- Monitoring
    - Adequate coverage of flow gauging stations to capture whole watersheds.
    - In cases where cost is an issue, pH, temperature, conductivity, and dissolved oxygen are the minimum, most essential, and least costly water quality parameters that can be collected.
    - Long-term water temperature monitoring.
    - Nutrient monitoring.
    - In any given landscape, one could do a course scale inventory based on existing datasets; then install monitoring equipment in places where there are issues.
    - Synthetic aperture radar and satellites could be a good way to look at geomorphic change, although its resolution is not clear enough to use for meter resolution.
    - Remote sensing – measuring impervious surfaces.
    - Compliance records for POTWs and other dischargers.
    - Long-term biological monitoring.

    - Fire frequency (from tree core samples) helps identify regime coupled with forest stand inventory to assess departure of forest conditions from natural state.
    - Remote methods for measuring lake/water levels. (e.g., LIght Detection And Ranging [LiDAR]).
    - Non-scientific methods – economic trends, municipal water use trends, industrial trends.
- Modeling & Analysis
    - Models should be used to explore all potential outcomes. Modeling based on scenarios, especially climate change and land development.
    - Sensitivity analyses are useful methods of measuring watershed resilience, because some systems are adaptive to huge variability.
    - Need to measure effects of impacts – climate change, development, other disturbance.
    - Hydrologic analyses – computing flow duration curves.
    - Trends in property valuation and tax assessments (home value is an indicator of water quality in some states).
    - Targeted research following restoration efforts; helps determine resilience in response to BMPs.
    - Recovery potential screening (an integrated method for overall resilience).
    - ReVA.
    - Natural variability (for any indicator) and whether it is varying within expected range.
    - Proper Functioning Condition Assessment (USFS).
    - Landscape scale assessment (patch size, connectivity, etc.).
    - Hydrogeomorphic analysis.
    - Impact on economics of communities reliant on fish species for income.
    - Sonoran Institute – study resulting in Sonoran Index on Socio-Economic Distress, which provides info on socio-economic components that interact with other elements.

Other Considerations

- Spatial units are not that relevant, as long as consistent, scalable information is used. Key information should drive framework, not spatial units.
- Watershed resilience should be assessed from the perspective of a representative network of watersheds using continual monitoring of multiple variables, ideally on a daily basis, not every 5 or 10 years, with the idea being that intense monitoring will indicate subtle shifts over time.
- Biological samples and measurements may not be representative of the watershed as a whole. Scale is important.
- It is important to monitor species populations of macroinvertebrates, fish, and amphibians and their movement throughout watersheds.
- Watershed resilience can be measured on scales ranging from hydrologic unit codes (HUC) to catchments.
- Caution must be taken not to label a watershed with fewer species as impaired if it has different geomorphology than the watershed to which it is being compared.

- Assessment methods need to be applied consistently in order to make comparisons across geographic units.
- Need measurement methods that examine processes on wide temporal and spatial scales, possibly involving modeling and/or remote sensing in a tiered approach.
- Need to define baseline in order to assess watershed resilience.
- The groundwater-surface water interaction is also critical.
- Different systems respond differently to disturbance and recover in different ways.
- Condition and threat assessments need to be separated out. Threat assessments are indirect. Condition assessments are direct assessments. This distinction needs to be made at a high level.

3. *How can healthy watersheds be sustained?*

- Education & Outreach
  - Educate children.
  - Outreach and advocacy: local, regional, and state government.
  - Educate realtors and land developers. Access to healthy watersheds increases property value.
- Legislation & Policy Incentives
  - State and local policy incentives.
  - Leverage information across federal and state partnerships.
  - EPA and states can help by enforcing existing authorities like antidegradation.
  - Support legislation pertaining to base flow.
  - Smart growth (need to have the right kind of growth policies in place).
  - Designation as outstanding national resource waters (ONRW) - look at both Tier I and Tier II.
  - Prevention-based total maximum daily loads (TMDLs).
  - Incentivize others to use their authority to protect healthy watersheds.
  - Passage of National Fish Habitat Conservation Act (and Action Plan).
  - Land use development based on watershed analysis.
  - Support infrastructure in appropriate areas.
  - Responsible growth management.
  - Enforce engineered mitigation as a result of development (e.g., no change in runoff or pollutants as a result of development).
  - Strengthen wetland mitigation requirements (and in a watershed context).
  - Strengthen in-stream flow laws.
  - Institute laws that protect water rights and water levels.
  - Encourage and pass laws that acknowledge surface and groundwater links.
  - In urban systems, charge stormwater fees based on amount of impervious surface area.
  - Increase incentives for landowners NOT to develop intact watersheds.
  - Increase funding for land conservation and acquisition of easements to protect healthy watersheds.

  - Improve partnering across major federal programs; for example, better collaboration across United States Department of Agriculture (USDA) restoration practices and 319 program.
- Management
  - Facilitate dam removal process.
  - Maintain forest ecosystem fire regimes – add more frequent fire.
  - Work with water appropriation agencies to try to preserve minimum base flows.
  - Preservation-based approaches, such as open space, conservation easements, etc.

Other Considerations

- The key to sustaining healthy watersheds is to sustain natural processes within expected range of variation.
- Cities struggle with regulations and ordinances, because people want to live in 'healthy watersheds' with lawns mown to stream banks.
- Most successful programs have broad stakeholder buy in.
- Need to bring economists and social scientists into healthy watersheds projects. Departments of health, too.
- Climate change presents a challenge. Managing for a cold water stream, for example, where climate change will convert to warm water streams might not be appropriate. Should focus on *processes* that support resilience.
- Agricultural community has to be involved.
- Some people will advocate for doing nothing because nature is inherently resilient.
- Characterize watershed plans as land and water use plans, not just water use plans.
- Need to tie ecosystem services research to HWI.
- Need to quantify economic value of ecosystems to local and regional systems (also need to place a price on degradation).
- The HWI is intended to develop a holistic systems approach of assessment and planning. The outcomes of that could be used for many reasons, and legislation is one possibility. However, if legislation is important and possible, then public education should be prioritized; it is key for building support.
- Need to make sure local governments understand that healthy watersheds benefit them socially and economically. Simplifying and clarifying complex natural resource information is critically important. Local governments appreciate it when the science is made accessible.

4 Developing Integrated Assessments

Background & Overview, Jim Thorp (University of Kansas) and LeRoy Poff (Colorado State University)

To start the discussion of the conceptual basis for evaluating healthy watersheds, Thorp and Poff displayed a diagram depicting a hierarchical arrangement of structural and functional elements of healthy watersheds (Figure 2).

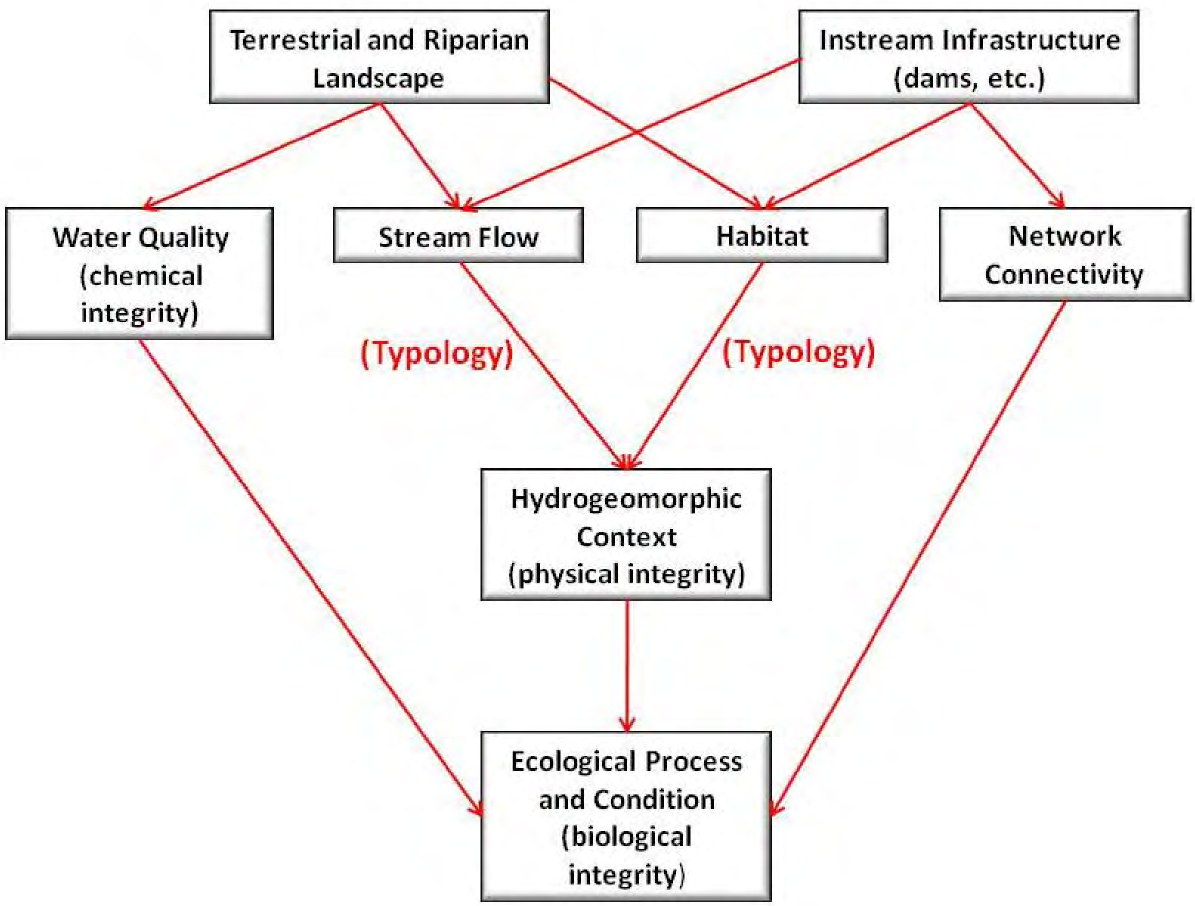

Figure 2 General conceptual design approach for healthy watershed condition assessment

Thorp detailed the process for identifying healthy watersheds and developing programs to maintain them as follows:

1. Identify management needs.
2. Determine management goals.
3. Develop testable questions and hypotheses for each question.
4. Select appropriate spatiotemporal scales for effective management.
5. Select appropriate dependent and independent variables.
6. Conduct geospatial analysis.
7. Select areas for management and sample sites.
8. Employ appropriate sampling techniques and methodologies.
9. Analyze results and test additional hypotheses if appropriate.

Thorp emphasized the need to see effects above and below the targeted management level. He described a management level of statistically delineated hydrogeomorphic patches at the valley level, referred to as functional process zones (FPZ). As such, if the management focus is at the watershed level, assessment stratification and comparison should occur at the FPZ level and data collection should occur at the stream reach level.

Thorp further described his alternative to Vannote's river continuum concept known as the Riverine Ecosystem Synthesis (Thorp et al. 2006, 2008) that interprets FPZs in a riverine ecosystem synthesis framework. Each FPZ has characteristic structure, function, and services it provides. FPZs are repeatable from headwaters to the mouth of river systems, but are only partially predictable in location, especially between ecoregions. More hydrogeomorphically complex patches, which can occur anywhere along a river gradient, support higher biodiversity and more complex food webs. Ecosystem structure and function, the amount of ecosystem services provided, and the cost/benefit ratio of rehabilitation are directly related to the FPZ structure of a river. Thorp and fellow authors present 17 model tenets which link FPZ structure to various aspects of riverine landscape structure and function in their 2008 book, *The Riverine Ecosystem Synthesis*. Once the system, spatial variables, and sampling design have been selected, this conceptual model can guide management.

A computer program which minimizes human bias by allowing FPZs to self-emerge statistically has been developed by the laboratories of Thorp and Joe Flotemersch (US EPA Office of Research and Development) in the USA and Martin Thoms (University of New England) in Australia. This GIS-based analysis typically uses 14 hydrogeomorphic variables in 10-km segments along the course of a river. The primary GIS layers are digital elevation model (DEM) data along with precipitation and geology layers; aerial or satellite images are also incorporated to identify channel structure. Multivariate cluster analysis is used to group segments with similar hydrogeomorphic character (i.e., functional process zones). Ground-truthing of groups is recommended for a subset of river segments as a background check. Once identified, FPZs serve as a key driver of ecological assessment strategies and sample design, being used to address questions such as how to stratify sampling, how to interpret ecosystem structure, and how to undertake rehabilitation. FPZs also can be used to predict the ecosystem services provided by each segment. An understanding of ecosystem services is critical for getting public buy-in for the HWI. Overall, the program provides a cost-effective, rapid way of analyzing watersheds, ranging in size from small to very large, that would be prohibitive to study using field techniques like Rosgen stream classification.

Poff circled back to the healthy watersheds framework for his portion of the presentation to consider the integration of indicators into a healthy watersheds concept. In order to measure watershed aquatic ecosystem condition, it is necessary to think about how systems function. Biological integrity is the endpoint of interest for healthy watersheds and lends itself to endpoint metrics the public cares about. A good starting point for states to develop techniques to measure biological integrity across territories is a coarse GIS analysis of riparian land use because it allows them to infer water quality without making measurements. While chemical integrity has historically been a fundamental feature of EPA and state programs, components of physical integrity, including water and materials flow across landscapes, stream flow regime and water levels, and habitat structure ranging from grain size to larger geomorphology, is just beginning to be addressed. As such, physical integrity consists of both habitat structure and dynamics.

Habitat dynamics control evolutionary adaption and ecological processes and thus drive biological integrity. Natural stream flow is a key habitat dynamic in riverine systems. It varies along the length of a river, regionally from place to place, and across seasons because of climate and geology. High flows which connect the river to its floodplain serve an ecological function unique from that served by stable base flows. Different adaptations are expected of organisms inhabiting systems with highly variable flow regimes than in stable groundwater-based systems, because natural variation sets a reference condition to which species and communities are adjusted. The magnitude, frequency, duration, and timing of extremes and how quickly flows change are important variables to consider. But a focus on flow regime alone is inadequate to capture habitat dynamics, because the effect of flow on stream organisms is often mediated by the habitat structure. For example, a stream channel in a narrow mountain canyon experiences a much harsher disturbance from high flows than a nearby channel in an alluvial valley, where the energy from high flows can be dissipated on the adjacent floodplain.

A focus on stream flow regime and water quantity issues is underrepresented in analyses of ecosystem integrity; EPA has no regulations in this area. However, states which have begun to incorporate flow regime data into ecosystem analyses face the next step of interpreting their analyses and managing water bodies differentially. Characterizing flow regimes across the landscape is a real research need, one that requires increased modeling effort. It will also be necessary to account for surface water modifications in ecosystem analyses, as most flow regimes today are no longer natural, and to consider the integration of groundwater and surface water.

The corollary to the principle that natural flow regime drives biologic integrity is that flow alteration impairs biological integrity. The question of how much flow alteration is too much to sustain a functioning ecosystem is one that is being confronted not just in the U.S., but globally. How do we develop scientifically justifiable guidelines for managing flow regimes where data are sparse or non-existent? The scientific process for flow regime assessment starts with developing a hydrologic foundation for the region of interest, probably via modeling. Again, there are different ecological expectations for different geomorphologies. Taking hydrologic alterations into consideration, deviations from natural conditions can be determined, and the larger the deviation in ecologically relevant components of flow (e.g., magnitude, timing), the greater the expected biological impairment relative to reference. The social part of this process comes into play as communities of stakeholders are asked to determine, 'what are acceptable or desirable ecologic conditions?' This feeds into what standards for healthy watersheds might be. Once standards are developed, monitoring would be necessary to obtain feedback on their implementation. Over time, an efficient flow framework is economically efficient.

The Ecological Limits of Hydrologic Alteration (ELOHA) model provides hydrogeomorphic context for healthy watersheds. Connectivity and redundancy of important habitat types should be used to establish healthy watershed networks. Habitats that are hydrologically connected, sharing the same flow path of a river, have high potential for recolonization post disturbance. In watersheds which are hydrologically decoupled, protecting functionally similar habitats allows the habitat type to persist through disturbance up to a regional scale.

Highlighting again the place of healthy watersheds and watershed assessments in the conceptual model, watersheds need to be stratified by flow regime type in order to capture the dynamic variation that sets our expectation of ecological condition. A healthy watershed has intact water quality, biodiversity, flow regime, connectivity and redundancy. Networks of healthy watersheds will become especially important in land management strategies as climate change moves across the landscape and places new stress on spatially isolated habitats. We need to be visionary about what needs to be done to make the HWI successful in order for natural systems to persist as we know them in the face of climate change.

Examples of How to Integrate Assessment Components

Virginia Watershed Integrity Model, Rick Hill, Virginia Department of Conservation and Recreation

Virginia has developed and is applying numerous assessments and models to identify conservation priorities. One such model is the Virginia Watershed Integrity Model. This model is an index approach to assessing healthy watersheds. The model integrates the following resource assessments: the INSTAR; a modified index of biological integrity (mIBI); nonpoint source pollutant loadings for sediment, phosphorus, and nitrogen from the state's 305(b) and 303(d) integrated report; and the Virginia Vulnerability Model, developed to map predicted population growth and serve as an indicator for impervious cover.

This hydrologic unit scale model compliments instream assessment methods, such as the Interactive Stream Assessment Resource (INSTAR) and it is available for the entire state. The Natural Heritage Program within the Virginia Department of Conservation and Recreation (VA DCR) began the development of the Virginia Conservation Lands Needs Assessment, a suite of seven GIS models focused on green infrastructure. The assessment identifies ecological cores and landscape areas, and has been used to conduct the vulnerability assessment. Although INSTAR, which is an instream multi-metric assessment tool that considers physical condition, habitat, fish communities, and macroinvertebrate health, provides a basis for classifying and identifying aquatic ecological health in Virginia's water bodies, the watershed integrity model provides a tool for integrating green and blue data layers.

The objective of the Virginia Watershed Integrity Model was to identify the relative value of lands as they contribute to water quality and watershed integrity in the context of the Chesapeake Bay Directive, which sought to identify areas where retention and expansion of forests is needed. GIS data layers incorporated into the model include mIBI, INSTAR, erodible soils, slope, forest fragmentation, impervious surface, SPAtially Referenced Regressions on Watershed attributes (SPARROW) or data from the Division of Soil and Water, and stream density. Model results are being used for state and interstate watershed planning, integrating conservation into existing programs, providing conservation-based planning assistance to local governments, and leveraging and coordinating natural resource management programs. In this way, VA DCR has been able to build support for a healthy waters initiative by tapping into the state administration's land conservation priority.

For more information on the Virginia Watershed Integrity Model, visit: http://www.dcr.virginia.gov/natural_heritage/vclnawater.shtml

Hydrology and Groundwater Dependent Ecosystems and the Active River Area, Leslie Bach, The Nature Conservancy

An example of how to integrate healthy watershed assessment components was presented that focused on two different approaches, the Active River Area and management of groundwater dependent ecosystems (GDEs).

The active river area is defined to include floodplains, terraces, meander belts, riparian wetlands, and material contribution areas. Assessing rivers using the active river area approach means looking at places through the lens of processes (both ecological and physical) in order to see how resilient they are. Considering the natural characteristics of the active river area and the surrounding land use allows for identification of restoration and protection priorities. It builds a framework which is useful at the regional, watershed, and reach scales.

Groundwater-dependent ecosystems include wetlands, rivers, lakes, springs and other ecosystems that depend on groundwater for some, or all, of their water needs. Both groundwater quantity and groundwater quality (temperature and chemistry) are important to GDEs. The Nature Conservancy is developing tools and strategies for identifying and mapping GDEs, describing their essential ecological attributes, and evaluating their threats, and is using that information to develop management, policy, protection, and restoration strategies. At the regional or watershed scale, TNC has developed methods for identifying GDEs and mapping threats using existing datasets. The presentation provided an example that described mapping groundwater-dependent wetlands utilizing the National Wetlands Inventory, and supplementing it with information such as the organic content of soils and proximity to springs In another example, from the Upper Klamath Basin of Oregon, TNC overlaid a map of GDEs with a map of water quality threats to identify GDEs for which more information is needed. TNC has also developed a Groundwater Assessment Methods Guide, which provides guidance for incorporating the groundwater needs of ecosystems into local and watershed plans. The guide walks through the same steps of identifying GDEs, defining essential ecological attributes, describing key processes, and developing conceptual models. It includes "decision trees" that can be used to determine the groundwater dependence of water bodies. It is a technically robust, yet simple to use guide to a watershed-based conservation approach. Finally, the concept of Environmental Water Requirements (EWRs) is emerging in GDE management and conservation. EWRs describe the amount, timing, and quality of water needed to sustain GDEs.

For more information on The Nature Conservancy's Groundwater-Dependent Ecosystems work, visit: http://conserveonline.org/workspaces/gde/documents/all.html.

Vermont Geomorphic and Habitat Assessments, Mike Kline, Vermont Agency of Natural Resources

The Vermont Agency of Natural Resources (VT ANR) undertook a study of the state's fluvial geomorphology originally to make a case for considering measures other than stream channelization for flood control after the state was hit with a series of floods in the 1990s.

Vermont's Stream Geomorphic Assessment Program, which was begun with the intent to characterize past channel adjustments in order to predict future channel adjustments and understand what stressors drive the dynamic equilibrium toward which streams will be managed, is comprised of three phases:

- Phase I considers aspects of watersheds and valley segments: modifications to riparian, floodplain, and channel geometry and habitats, as well as surrounding land use.
- Phase II considers reaches: departure from natural geomorphic and habitat conditions, current and anticipated channel adjustments as the river evolves to its dynamic equilibrium, and reach sensitivity, which indicates adjustment rates.
- Phase III considers sites: hydraulics and sediment transport.

Bedform heterogeneity, substrate retention, and lateral/longitudinal connectivity are maximized when sediment load and hydrologic load are in equilibrium. Therefore, hydrologic and sediment load indicators are assessed as the primary controlling factors influencing equilibrium, hydraulic geometry, and stream power. As part of the assessment, changes in channel, floodplain, and valley characteristics are assessed to understand how depth, slope, and boundary resistance influence hydraulic geometry, stream power, and the sorting and distribution of sediment and organic material. Alteration of hydrologic, sediment, and large woody debris (LWD) regimes cause departures in the size, quantity, sorting, and distribution of materials instream. Channelization has converted many depositional streams into transport streams, reducing the resiliency of their riparian habitats. In Vermont, 73.5% of streams in disequilibrium lacked access to their floodplains.

VT ANR was not satisfied with EPA's link to fluvial processes and geomorphology in its rapid bioassessment (RPB) method, so VT ANR integrated its Stream Geomorphic Assessment Program with Reach Habitat Assessments (RHAs), which are now conducted simultaneously in the field. The habitat assessments evaluate river and riparian components of cover, feeding, and reproductive habitat as created and maintained by the physical regimes of hydrology, sediment, large woody debris, and organic material. Reach scale rapid assessments are used to infer smaller scale forms and processes. The integration of the two assessments took the form of linking habitat quality to large and mid-scale physical processes. The analysis of key life cycle requirements for organisms in this context provides the opportunity to evaluate and address a broader range of possible stressors. Parameters assessed by several variables in the RHAs include key ecological processes, aquatic life cycle requirements, habitat types and habitat complexity. In several cases, LWD links variables to stressors, departures from natural regimes of physical processes, and their treatable causes. LWD has a notably reduced presence in the incised stage of channel evolution. The integration of the two assessments was intended to push the limit of the scientific community's understanding of the effects that changes in stream corridor or land use ultimately have on population composition and distribution, eutrophication, and water table elevations. This study did find that EPT species richness rebounded as a channel evolves back toward equilibrium. However, it is difficult to draw further conclusions from the integrated assessment, because 1) fish and macroinvertebrate studies were originally designed to control for physical variables in order to focus on the impact of pollutants, 2) geomorphic data indicates physical form and process on a much larger scale than biological data does, and 3) summary metrics may obscure relationships in the data.

For more information on the Vermont Rivers Program, visit:
www.vtwaterquality.org/rivers/htm.

Nationwide Landscape Disturbance Index for NFHAP, Gary Whelan, Michigan Department of Natural Resources

The purpose of the national assessment of rivers undertaken for the National Fish Habitat Action Plan (NFHAP) was to estimate relative habitat condition in all river habitats of the United States using national landscape level data collected in a uniform and consistent manner. This information will be used by the NFHAP board and its partnerships to better inform the use of their limited capital for the protection, rehabilitation and improvement of the nation's fish habitat. The national river assessment is one of a group of fish habitat assessments being conducted that includes assessments for lakes and reservoirs, coastal waters, and separate analyses for Alaska and Hawaii. Due to differences in data availability for Alaska and Hawaii, a risk index system in which scores representing the degree of landscape disturbance for major landscape stress classes were compiled to determine cumulative risk index values for each watershed unit in these states. For the 48 contiguous United States, fisheries data from federal and state single pass electrofishing data was used to refine weighting of habitat disturbance axes to allow the development of a Habitat Condition Index (HCI). A range of regional fish community indicators were plotted against thirteen anthropogenic stress variables which were then analyzed using threshold indicator taxa analysis (TITAN) to define condition response relationships and thresholds that defined habitat condition scores. Based on these condition response relationships, habitat condition scores were assigned to each river reach in the lower 48 states. The stressor with the lowest score within each stressor axis was used and assumed to be most limiting to the fish community indicator of interest. The habitat condition score in a reach was computed separately for each of the applicable fish community indicators. The average condition score across all fish community indicators in a reach is its HCI. Scores were mapped for every river reach in the lower 48 states using National Hydrograph Dataset Plus (NHD+) which allows the user to control how information is aggregated and disarticulated. The next steps moving forward from this initial analysis will be to: complete the lakes and reservoir analysis; incorporate hydrologic data; incorporate improved connectivity measures; refine the stressor set; decrease the bias in the fish data by increasing data from central plains; move the Hawaii and Alaska assessment from a risk based to habitat condition analysis and incorporate higher resolution river maps; include new violation data on national pollutant discharge elimination system (NPDES) permits; incorporate 303(d) list data; refine the connections between the river and coastal assessments; and have habitat scores ground truthed by regional fisheries experts.

For more information on NFHAP, visit:
http://fishhabitat.org/
http://fishhabclimate.org/

Breakout Group Topic 2: Developing Integrated Assessments

The first step needed in a healthy watersheds integrated assessment approach is a user needs and program assessment to determine who will be using the assessment results and for what applications the results will be used. To enhance assessment results, there are existing sets of raw data from which information that is useful to local land-use planners can be derived. States will be able to use integrated assessment results to inform residents of the valuable natural resources located in their communities. Information should be available in a GIS database through an interface that is accessible to all stakeholders. The feasibility of healthy watersheds assessments is dependent upon funding and political support. Disparate groups, including state, federal, tribal, and watershed groups, all of whom have have vested interests in this initiative, need to be convened to ensure that integrated watersheds assessments are value-added rather than duplicative of other assessments.

The second step toward an integrated watershed assessment approach is to develop a conceptual model. Overall, the current hexagon diagram of healthy watersheds elements is fairly comprehensive. However, sub-elements which should not be overlooked include thermal regime, sediment regime, woody debris regime, flow regime, invasive species, and connectivity and the rates of change over time in the processes which govern the condition of these elements. Stratification within the conceptual model might be done using topography, soils, geology, flow regime, vegetation, sediment transport, and hydrology elements. Interactions between elements can be captured in process-based habitat assessments that consider temporal and spatial scales above and below the scale of interest for management. The diagram LeRoy Poff presented could be adapted to fit the healthy watersheds concept with modifications to include climate and lentic systems on a larger spatial scale. While assessing one system type, wetlands, for example, it is important to consider its connections to other water bodies in both the lotic and lentic systems of its watershed. Modeling is an important step for filling data gaps, especially with respect to time scales; current watershed conditions may be reflecting the effects of historic anthropogenic activities.

Third, a framework for assessing watershed health needs to be developed; a tiered framework would be ideal. A screening level, such as landscape disturbance, could be followed by a more detailed approach using indicators to assess watershed health based on threshold stress-response levels. The detailed assessment could emphasize a state's areas of strongest expertise and thus vary between states as long as standards for healthy watersheds are consistent and comparable between states and integrated assessments are incorporated into the state watershed planning process. It was suggested that assessments be conducted every five years and start at a HUC-12 spatial scale, beginning with watersheds which have been influenced by development in the last hundred years. Although assessment should occur on multiple scales, findings should be presented to end-users at a scale appropriate to their needs.

Lastly, an examination of the available existing expertise and data should be undertaken. Data gaps identified here included the following: landscape-scale biological data, geomorphological data (in state assessments), tracking for conservation projects, water use and stream flow data, historic data for model calibration, and the natural variability of systems. Some data gaps merely reflect a lack of communication between agencies, whereas others reflect a need to improve understanding of stressor-response relationships for various indicators, including how cultural processes affect landscapes and the green infrastructure-blue infrastructure nexus. The need to "map" stakeholders and jurisdictions with respect to watersheds was identified as an information gap.

1. ***What key elements should be included in a healthy watersheds integrated assessment approach and what is the role of green infrastructure?***

- It was mentioned that a systems approach must:
    - Have the goal of ensuring restoration and protection of key ecological patterns and processes that sustain biodiversity;
    - Simultaneously address multiple key threats and systems level targets;
    - Integrate multiple relevant conservation strategies, including policies, land and water management, education and outreach, protection, and economic incentives;
    - Ultimately seek to have desired ecological conditions and proactively restore or sustain them through all of the relevant socioeconomic domains; and
    - Be implemented across most or the entire relevant geography.
- Goal setting process should be included as a key element. We need to be clear on what we are assessing and why.
- Classification/Stratification System
    - We need to classify watersheds, not water bodies. There are already watershed classifications out there based on climatic regimes, precipitation, etc.
    - Working with groupings of watersheds, identify indicators for healthy watersheds specific to each stratum.
    - Urban watersheds do not have chemical, physical, and biological integrity. However, we need to protect healthy components even in highly urbanized areas. Few whole watersheds are pristine.
    - We can basically define a healthy watershed based on the absence of human disturbance. Therefore, identify those areas of least disturbance and use those areas to characterize geomorphology, water quality, etc.; and use this information as healthy watersheds indicators.
    - Arraying watersheds across a human disturbance gradient can be helpful. Understanding the manageable things that are causing different levels of disturbance lets states do something about it. Then look at range of natural variation.
- Evaluation of Natural Range of Variation of System Processes
    - Understanding the range of variability should be part of assessment.
    - Sediment regime alteration can be measured with other indicators. Information can then be used to identify green infrastructure that supports sediment attenuation.
    - Woody debris regime is also important.
    - Hydrologic regime is extremely important.
    - Predictive models exist for predicting natural flow regimes. Although gages do not exist everywhere, we can use these tools to characterize natural flow regimes.
    - EPA should develop a framework that allows flexibility for states to use data for which they have expertise to identify healthy watersheds.
    - Assessment method needs to have capacity to consider future changes (e.g., climate change).

- Multiple Scales and Levels of Detail
  - Watershed characteristics, including causal agents affecting waters.
  - Basic physical elements (e.g., soils, geology, precipitation, etc.).
  - Representativeness – regional things like climate, geography, geology, etc.
  - Within-watershed elements, like habitat structure.
  - A disturbance index is just a screening level and ranking tool. States will have to develop a screening tool first. Multivariate indexes can then be decomposed to get at the details for individual watersheds and areas.
  - Pennsylvania identifies water quantity, quality, habitats, biotic communities, ecosystem services, etc. at three different levels – stream, active river area, and watershed.
- Include designated use attainment, as it helps communicate to the public the intended use of these waters.
- Biotic assessments – animals and plants.
- Green Infrastructure
  - Green infrastructure is beyond low impact development (LID); it's more about a network of green infrastructure built around hubs and corridors. The assessments should look at gains/losses, as well as fragmentation (less fragmented is better).
  - Should assess absence, presence, and connectivity of green infrastructure under present conditions; and assess how it relates to biological, physical, chemical integrity of aquatic systems.
  - Green infrastructure is important to understand links to other watersheds. Also, it provides framework for strategic investment in fragmented corridors, and could be used to create a healthy patch size. Rise above single watersheds to networks of watersheds.
  - Not all green is the same. GIS exercise may give a different answer than ground observation. Forested areas (green infrastructure) in GIS might show high quality habitat, but then stream assessment shows a poor quality stream.
  - Historically, green infrastructure studies have looked at presence/absence, not quality, of vegetation. We could use the expected vegetation in classification and observed vegetation in assessment.
  - Metrics used in Florida include the land use intensity continuum and landscape integrity, which may be captured in connectivity, and includes fragmentation.

2. Considering readily available data, what are the best indicators for these key elements?

- General Considerations
  - Hierarchical stratification by physical differences among watersheds is important.
  - Hydrogeomorphic context will affect what we consider to be healthy or having integrity.
  - Multimetric indices can compound the problem of using the wrong indicators. Multimetric indices can be dangerous.
  - The process of indicators selection is important, but the indicators must be widely interpretable. Patch configuration, for example, is not interpretable by local planners.
  - Distribution of system types is an indicator of health. Doing it piece by piece leads you to miss the interactions.

- Landscape Condition
    - Land cover.
    - Percent impervious surface.
    - Forest condition.
- Connectivity
    - Road density.
    - Stream connectivity. Need to know natural vs. current fragmentation of system. Road crossing generally available and can provide good information.
    - Encroachments in channel, corridor, and floodplain.
- Hydrology
    - Flow duration curves based on daily data and annual hydrographs. Calculated at the pour point of a watershed. Also need an estimate of historic reference condition and current condition.
    - Estimates of recharge. Using readily available data for precipitation and geology, can use USGS regressions to estimate recharge.
    - Surface storage and groundwater discharge. Can evaluate hydric soils and land cover data to establish historic condition. This gets at amount of change. Can use thermal color IR to look at upwelling (in streams).
- Biology
    - Biotic integrity, such as fish composition size/structure. Need to know historical and current. Keep in mind that some healthy waters may not have a biotic community. In Alaska, there are healthy systems that naturally do not have a biotic community.
    - Type and number of invasive species.
    - Submerged aquatic vegetation (some information available via aerial photos).
- Geomorphology
    - Want to know if stream is moving/migrating at expected rate over time.
    - Channel stability, channelization, etc.
    - Sedimentation rates for lakes and bottom form changes.
    - Material Recruitment. Organic material, woody debris, sediment loading rates. De-snagging data are available from historical navigation projects.
- Water Quality
    - Known impairments, including extent, number, and type of sources. Much of this information is available nationally in EPA databases.
    - Tidal systems. Data could provide insights in intertidal zone. Need to understand changes in salinity.
    - Temperature (min, max, mean monthly, historic vs. current).
    - Dissolved oxygen (min, max, mean, monthly % saturation, historic vs. current).
    - Nutrients.
    - Conductivity.
    - Designated Use.

- Social Indicators
    - Would provide a good understanding of risk/vulnerability, as well as help to identify opportunities for support.
    - Percent protected land.
    - Jurisdictional complexity.
    - Land ownership complexity.
    - Existence of watershed plans.
    - TMDLs.
    - Economic data.
    - Population.
    - Water rights data.
    - Recreational use patterns.
    - Valued ecological attributes.
    - Iconic value assessment.
    - Aesthetics.
    - Cultural relevance/importance.

3. How should the interactions between key elements affect assessment design?

- Tiered assessments.
- Coordinated assessments of different system types.
- Decision science has a lot of tools for integrating indicators.
- Keep connectivity in mind for various assessments.
- Make sure assessments are designed with enough attention paid to finer scales to ensure that we are confident in the connections.
- One of the groups reviewed a diagram from Poff's presentation for ideas for the creation of a new schematic that depicts a healthy watersheds integrated assessment approach. The schematic is presented in Figure 3.

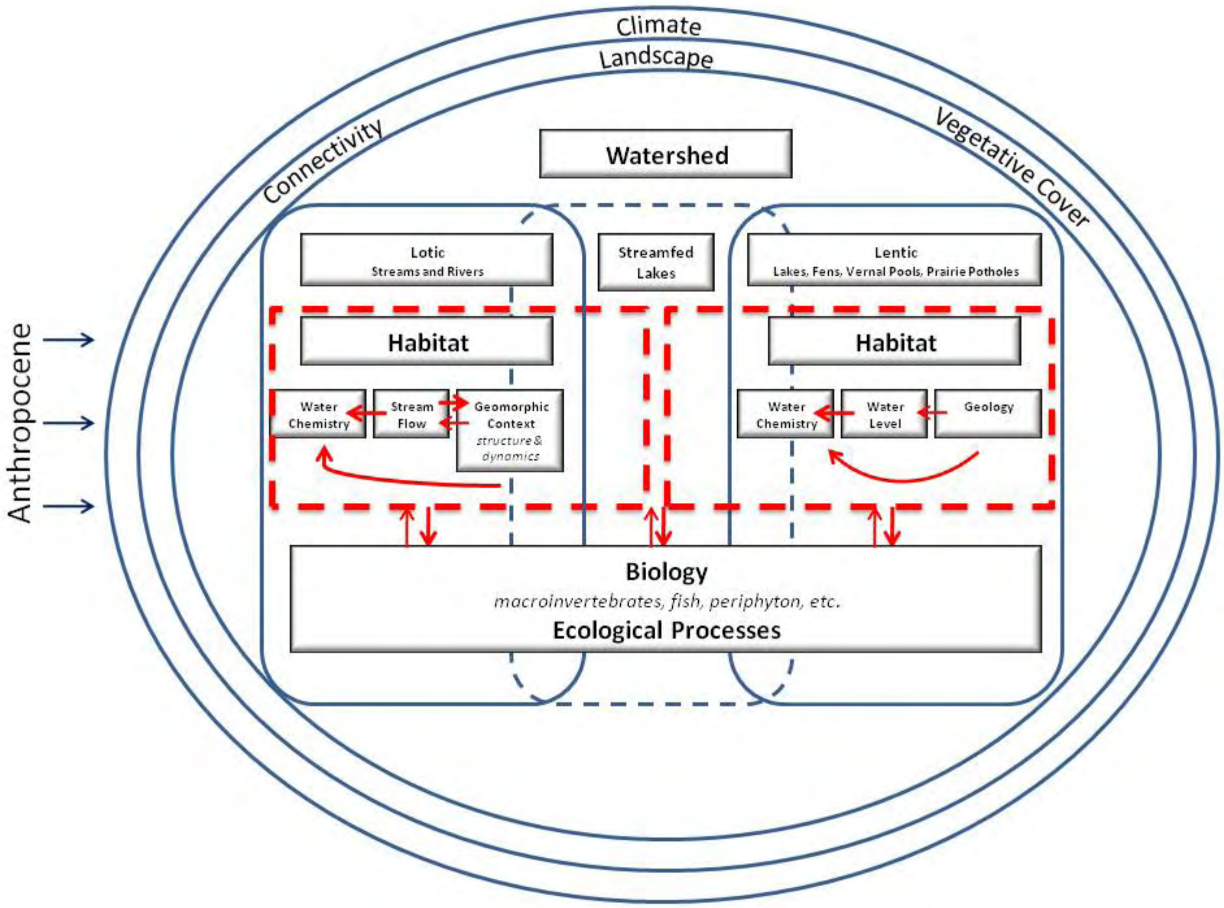

Figure 3 Conceptual Model for Healthy Watersheds Integrated Assessments

4. What methods are available to simultaneously examine multiple interacting endpoints?

- EPA's Science Advisory Board (SAB) framework (Essential Ecological Attributes) is the most comprehensive framework out there. The framework is an excellent tool for assessing multiple interacting endpoints. However, the SAB framework needs to be modified for the HWI, as it has a strong lotic focus.
- One of the struggles in the development of the Technical Guide was to identify an assessment process that is gold-plated. We need to identify a reasonable framework for a generalized approach rather than try to all agree on THE best approach.
- Once identified, we need to be able to prioritize high quality areas.
- Massachusetts is doing a lot of work to identify stressor-response relationships: characterizing different indicators, stressor by stressor, attempting to identify numeric thresholds for impervious cover, etc. Once you understand these relationships, you can start identifying watersheds below these thresholds as candidate healthy watersheds. Can then validate with more detailed biological data. This keeps it relatively simple, rather than combining many indicators into a complicated index that is difficult to communicate.
- We need a system for weighting components.

- Region 1 is doing a multivariate version of threshold indicator taxa analysis as a healthy watersheds pilot project.
- Need to snap all data to NHD reaches. This will make integration of data much easier.
- Data mining. Correlation analysis is required with a data mining approach. Should not just compile everything possible. Need to understand representation of variables.
- Need to build in quality assurance/quality control of available data.
- Tier 1 analysis would use just existing data (no new data).
- The Recovery Potential Screening web site will include web links to data sources. This could be useful way to access data.
- Aerial photo interpretation - Historical aerial photos highly useful and accessible.
- GAP analysis techniques.
- Hydrogeomorphic analysis.
- The point of multimetric indices is to integrate. No single disturbance variable seems to correspond very well with measures of biological integrity. However, there is a correspondence between general human disturbance and biological integrity. We do not have a complete understanding of the most important stressors. We first need to do a screening, not use just a few indicators.

5. At what temporal and spatial scales should healthy watersheds integrated assessments be conducted?

- Spatial grain and extent always comes into play. A nested set of scales allows you to roll up information from small to large scales.
- Need to look at one scale above and one scale below.
- Nested assessments are important, and they should include an evaluation of neighborhood effects (it is important to look up and down stream).
- Multiple scales, but need to consider ecoregions.
- Could stratify watersheds based on physiograhic region, gradient, and size.
- There is a big difference in recovery time between different species. This can obscure more rapid recovery of ecosystems. This is the temporal scale issue.
- We should identify at which levels various assessment tools work best at scales from the HUC-8 down to the site level.
- Healthy watersheds are primarily small watersheds, so differences in state data collection methods may not be a huge issue.
- Are there levels that do not have methodologies?
- Should be at a scale appropriate to the end users. Vermont works at local, reach scale because this is the level where decisions are made, while Kansas works at the watershed scale, which is just a combination of stream reaches. Maryland looks at parcel-level opportunities within a watershed framework (bottom-up vs. top-down).
- In Vermont, we get opposite results from our geomorphic data and our biological data in terms of describing ecological condition. Maybe these are scale issues that occur during the assessments.

- We need to consider backward looking timeframe (legacy of watershed) as well as forward looking (future impacts/climate change). And there is a great deal of historical data that can be used to assist with this. For the future, a timeframe of 50 years would be good.
- Scale will need to vary across the country. This means that the model/methods need to be repeatable at different scales.
- HUC-12 may be a good starting point, but site scale assessment will need to be finer.
- The assessment should be done at a scale that informs local decision making.
- We need to consider management boundaries, too, because they are difficult to change. Socio-political boundaries need to be considered realistically.

6. ***What are the data and indicator gaps that currently limit a state's ability to conduct healthy watersheds integrated assessments?***

- Many states lack geomorphological data.
- Baseline water quality data.
- STOrage and RETrieval (STORET) and other data management systems are not user-friendly.
- Lack of data analysis is another problem (in some cases, we are data rich, but information poor).
- Information on water use and hydrology.
- Historic data to assess natural variability.
- Assessments on how landscape scale impairments affect wildlife.
- Need to improve understanding of dose-response relationships for every indicator and process.

7. ***What does the final product of the assessment look like (i.e., how will the results be communicated)?***

- The purpose of the assessment is to support state level decisions, then hand data to local governments without telling them exactly what to do.
- Once an assessment methodology is established, it will be important to feed results down to the local level, because many decisions are made at the local level, but many towns that have healthy watersheds do not realize that they do.
- Watershed groups can use assessments to prioritize conservation and restoration.
- The end user of the data can be variable as long as it is presented to said user in a manner specific to him/her and the scientific baseline is strong.
- Online mapping and decision support tools.
- Also need public-friendly versions of assessment products (e.g., report cards).
- Electronic communication methods are more flexible.
- Guidance to local communities on how to use assessment information in land use plans, etc.
- Public meetings are important.
- An interactive web site that is navigable by public. The web site ought to provide data – not just a synthesis of watershed quality. Also, it should not be redundant with other online data sources; anything online needs to provide added value.
- It needs to be made clear how the assessment/results fit within current state/local work.

5 Implementation of Healthy Watersheds Assessments

Breakout Group Topic 3: Implementation of Healthy Watersheds Assessments

In their current structure, state agencies use lists to identify unhealthy watersheds. Several points of caution were made for developing healthy watersheds lists. For one, healthy watersheds assessments should integrate assessment of biotic, abiotic, and socioeconomic characteristics. Healthy watershed lists based on current data alone will not be accurate. It is also important to consider how healthy watersheds lists would be perceived by the public: designating some watersheds as healthy may spark interest among state residents to relocate from unhealthy to healthy watersheds, increasing development pressure there; communities may also fear that their capacity for economic growth will be limited if healthy watersheds fall within their jurisdictions. Should these cautions be addressed, existing water quantity and quality data could be used as a starting point for identifying healthy watersheds; adding additional screening layers to this could create a tiered classification approach.

States can introduce healthy watersheds assessments into their current program structures if they are able to identify a lead individual or group that can get administrators of their programs to buy into a shared healthy watersheds vision before drilling down into implementation. State governors are in a good political position to show a commitment to this initiative; a signatory document could also help make such a commitment more concrete. The same buy-in for this initiative is also needed from federal programs. The CWA 319 and 604(b) planning programs, for example, could be adapted to expand their foci from water quality restoration to include other aspects of watershed health. There is a need to communicate the point that protecting healthy watersheds is more cost-effective than restoring impaired watersheds.

The data needed to conduct integrated watershed assessments would originate from what are separate programs in most current state government structures. Such structural barriers and potential methods for dealing with them should be identified in a national inventory so that cross-agency collaboration can be used to take advantage of existing data and funding sources and communication pathways. Rather than work in ’program silos’, the work should be organized around a decision process and on ’information supply chain’ should be created to channel integrated watershed assessments through the hands of scientists developing them to the decision-makers who will use them.

EPA could support a team of experts to provide the technical assistance states would need to conduct integrated watershed assessments. The resulting national datasets would fill many of the current data gaps and could be compiled into an interactive map that has links to individual watershed assessments. An associated clearinghouse for documents and screening tools related to this initiative should be publicly available online in a format that is understandable and highlights the aspects of healthy watersheds that pertain to the values that are important to various audiences. Lastly, EPA should provide guidance through the Regions on what methods states can use to collect data and how to use those methods for integrated watershed assessments and set goals for the implementation of those assessments to help achieve consistency and comparability across states. Innovative program-based incentives that reward desired behaviors and punish undesired behaviors can also be used to move the healthy watersheds initiative forward. Lack of national program measures related to healthy watersheds is a potential barrier, as states are less likely to put resources towards programs without mandatory reporting.

1. How can states develop lists of healthy watersheds using existing data?

- EPA can get the process started by suggesting an approach for states to use to develop lists of healthy watersheds. Over time, states can add additional data and assessment components to the process.
- Potential approach: 1) Define a healthy watershed; 2) Create classification system; 3) Conduct threat assessment (start with NFHAP); 4) Perform condition assessment (SAB framework); 5) Stakeholder input/public outreach.
- States already have information that can be used to develop lists of healthy watersheds. In many cases, states already know which systems are good from the 305(b) assessment process. They just have not done a good job of conveying this information to the public. This is not the primary focus (the focus is on impaired waters); people would have to wade through state 305(b) reports to find this information. In the absence of additional assessments or data, each state's 305(b) assessment and reporting process is a good starting point for developing lists of healthy watersheds. The 305(b) reports identify ONRWs and other water bodies that fully meet all designated uses. However, just because a water body is meeting designated uses does not mean it is healthy. Meeting designated uses is just an interim goal in the CWA and the ultimate goal is chemical, physical, and biological integrity. Reference condition is way up the ladder. Healthy watersheds should be those that are in reference condition. It is important to recognize that 305(b) assessments are water quality focused. For healthy watersheds, we need to move beyond assessments that focus solely on water quality standards and designated uses. Some states are starting to use more than just water chemistry for 305(b) assessments. Expanding the 305(b) reporting to include additional information about the watersheds and describing how it affects the water body would be helpful for healthy watersheds assessments.
- The tiered aquatic life use approach is a useful approach based on functional response in ecology. It is based on the expected response of invertebrates instream to anthropogenic activity. This might be a useful approach to help develop lists of healthy watersheds.
- There are many existing data sets that can be used to help develop lists of healthy watersheds (e.g., land use/land cover). We need to compile information from existing assessments, and start with that. Examples include: NFHAP, HUC-12 attributes library (in development), state heritage programs, Wildlife Action Plans, etc.
- Kansas has been developing a list of reference streams by using a disturbance index to find the streams least subject to human development activities. Initial threat assessment was conducted, hydrologic, geologic, water quality, and biological assessments were incorporated. This is a start to identifying healthy watersheds.
- Look at existing lists of protected areas.
- Use existing sets of reference sites by ecoregion.

Other Considerations:

- Consider potential unintended consequences of a healthy watersheds list. For example, it may increase development pressure in healthy watersheds (no one wants to live in an 'unhealthy watershed'). The list may create a perverse incentive to classify watersheds as healthy that are not. The reverse is true as well, as some communities, farmers, and developers do not want extra protection (some local stakeholders view listings as states locking up waters and land). There is also a danger of incorrect classification with limited data. Also, consider the challenge in communicating the assessment work to the public; we currently have trouble communicating the 305(b) assessment work to the public.

- Without appropriate level of introduction, the public may resist healthy watersheds lists.
- One agency needs to own the healthy watersheds list; however, other agencies should be allowed to provide data/input.
- Ensure that state agencies are cross-communicating so that everyone has a similar understanding of what a healthy watershed is. Convene the various agencies and organizations to come to consensus on this.
- States do not work at a watershed level; perhaps a regional (watershed-based) group should oversee the development of the lists.
- Allow for public input/comment in identification of healthy watersheds.
- NGOs and the private sector also need to be part of the conversation.
- Existing regional meetings (e.g., New England Association of Environmental Biologists) could have healthy watersheds sessions to help bring people together and get things going.
- These need to be more than just lists of clean watersheds. They need to be full assessments of all watersheds, clean and dirty.
- EPA should avoid casting HWI as only looking at clean areas. The HWI should not be just about finding clean spots. This is an opportunity to take a systematic look at everything in the watershed. It will be more valuable if it is framed as a true look at watersheds in a broad sense. This will help inform protection and restoration.
- States need to focus resources on required programs, which leaves little to no resources for voluntary programs. If funding were made available for healthy watersheds assessments and lists, states would be more likely to implement such a program. Still, voluntary programs have limited success. EPA should mimic effective Federal programs (that work) to get something done with healthy watersheds. The NPDES program works because it is backed by legislation and funding. In the absence of healthy watersheds regulations, incentives may be an option.
- If healthy watersheds becomes a priority, but is not backed with additional (new) funding, states will need to stop doing something else. It will be important to communicate cost-effectiveness of healthy watersheds approach to inform the realignment of Federal and state budgets.

2. ***How can healthy watersheds assessments be implemented by state agencies within their current program structure?***

- Antidegradation is a regulatory mechanism with which to start.
- States can start healthy watersheds assessments by screening for threats/ stressors.
  - For example, the State of Connecticut used GIS analysis to screen for healthy water bodies. They did not have much data on geomorphology or stream flow. So, they used indirect measurements, like diversions and dams to determine flow regimes; they also used land cover and imperviousness data. Following that screening level examination, 30 small watersheds were selected to sample for macroinvertebrates and fish, as well as temperature and some water chemistry. This was funded through a 104(b) grant.
  - As another example, the State of Pennsylvania is working on a hydroecological study, which will identify hydrologically-impaired water bodies; this could be used as a first screening for healthy watersheds.

- Bioassessment programs have been designed to be efficient, simple, cost-effective. Could be another good starting point.
- Do not assume that a state has to do the assessment itself. States can reach out to partners.
- The nonpoint source (NPS) program and 319 funding support watershed-scale assessments; this could be a starting point. 319 may be a good "home" for this program. NPS program guidelines could be expanded to include flexibility for healthy watershed planning and protection. EPA has generally been hands off in directing states on the use of 319 funding. Perhaps EPA could encourage states to use a portion of 319 funding to conduct healthy watersheds assessment. Some states have indicated that they will not use 319 funding for protection since there are no requirements related to protection measures. States do not get 'credit' for protection; and there are no measures for protection. EPA should consider changing its guidelines and adding performance measures to encourage the healthy watersheds approach.
- Regional meetings of states, facilitated by EPA regional offices, could be effective in moving the HWI forward. The Southeast Aquatic Resources Partnership (SARP) has been working with 14 states very successfully. This kind of regional organization can be very useful.

Other Considerations:

- The HWI needs dedicated funding, technical assistance, regulatory backing, and outreach. We need to convince upper management to allocate resources to both impaired AND healthy waters. It is more cost effective to protect, rather than restore. Also, we need to communicate other benefits of healthy watersheds assessments. Protecting things like geomorphology and hydrology also helps reduce typical pollution problems like sediment loading, temperature, nutrients, etc.
- 604(b) funding is a great source for healthy watersheds funding. The 303(e) planning process can be useful and linked with 604(b) funding.
- State revolving funds could be used creatively for HWI projects.
- In some states, water is owned; it is not a state resource. For example, 83% of water in the State of Colorado is owned by the agricultural community. It is essential to involve this stakeholder group. USDA and United States Forest Service (USFS) programs are important for this. Ducks Unlimited is another important partner. The Natural Resources Conservation Service (NRCS) is an incredible funding source.

3. In what ways might a state agency consider adapting its program structure to support the implementation of healthy watersheds assessments?

- The HWI needs a champion – a lead agency and a lead person. The state water pollution control agencies may need to be the lead in order to do this work under the CWA. Each state agency should also create a Healthy Watersheds Coordinator. The lead agency and coordinator are not necessarily the ones doing all of the work; rather, they coordinate and facilitate the work.
- There is a need for communication first within EPA regions. Then, the regions should convene the states to start dialogues about healthy watersheds.
- State agencies need to develop more partnerships to get the work done. A state cannot own and manage everything. Success with the flow work in New England is partly due to involvement of Fish and Wildlife agencies.

- Establish work groups across divisions and agencies. A dedicated council, board, or team could create consensus or buy-in. The group of people put together to work on this would have to cover all of the areas of expertise in the healthy watersheds diagram.
- Probabilistic monitoring program does not adequately identify or characterize healthy waters. Since probabilistic monitoring program is already required and funded, it would be nice if it could be modified to provide this additional information.

Other Considerations:

- We need to link HWI to other funded initiatives and large aquatic ecosystem efforts (Great Lakes Restoration Initiative, Mississippi River Basin Initiative, Chesapeake Bay Program, etc.) to encourage states to work together and share ideas. Those existing initiatives can be good vehicles for advancing the HWI efforts. Fish Habitat Partnerships could provide a similar mechanism.
- 'Inreach' (educating people within your agency) is equally as important as outreach. Technical staff definitely see benefits of this, but management staff are less likely to be supportive. We need to emphasize that we are not abandoning old things, but just placing a new emphasis on healthy watersheds. Target your outreach efforts to those who care. We are not going to reach everyone. Reach the most influential people first. They will help you push it along. Also, we need to start at top – legislature, governor, etc. State initiatives work well coming from the top. Florida Department of Environmental Protection had a 'springs' initiative that started at the head of DEP and was given to a task force of nonprofits and experts. Governors have the ability to tell state agencies to work together.
- Consider the role of the public in conducting assessments, or at least collecting data for the assessments. Public volunteers are willing and able to help if provided with proper training and equipment. This also gives the public a sense of ownership of the watershed. The State of Connecticut has used volunteer monitoring of macroinvertebrates as an affirmative that a water body is not impaired; they provide a checklist of good macroinvertebrates and ask the volunteers to complete the list and send a few samples to the Connecticut Department of Environmental Protection to confirm their identification. Some states have cut volunteer monitoring programs due to data quality issues. Volunteer programs require funding in order to be successful or collect data of appropriate quality. States need to provide training, equipment, and guidance.

4. What kind of cross-agency collaboration is required to successfully implement healthy watersheds assessments?

- One of the best ways to foster cross-agency collaborations is for EPA to have a HWI website with all of this workshop information available.
- Examples of agencies that need to be involved: Departments of Fish & Game, Departments of Natural Resources, Departments of Environmental Conservation, Departments of Commerce, Governor's Offices, universities, professional organizations (e.g., American Water Resources Association, Fish and Wildlife associations), NGOs, etc. Although it does get complex when there are multiple agencies involved, greater input and buy-in will result in greater support and success. And it is not just representation that is important; you need knowledgeable leadership at the table.

- Other key organizations that can help gain support for HWI include: Western States Governors Council, Environmental Council of the States, and Association of State and Interstate Water Pollution Control Administrators.
- Some state governments are structured in a way that does not facilitate healthy watersheds work. In some states, two different agencies deal with regulatory and assessment. For the HWI, these agencies must talk to each other. Some states will resist these efforts, because pulling together is burdensome.
- Even though water pollution control agencies may need to be the lead in the HWI, natural resource agencies could take a lead role in conducting the assessments.

Other Considerations:

- EPA should not have the power to 'disapprove' of a methodology like it would with a 303(d) listing methodology. EPA should have more of an advisory/technical assistance role. EPA should engage in conversation if a methodology is heading in the wrong direction.

6 Applications of Healthy Watersheds Assessments

Examples of Applications of Integrated Assessment Results

Dave Fowler, Milwaukee Metropolitan Sewerage District/**Association of Floodplain Managers**

The watershed approach to flood management prevents flood damage more cost-effectively than acquiring structures in order to move them out of harms way, prevents coastal areas from internalizing benefits and externalizing risks, balances regulatory and non-regulatory approaches, and is more effective than trying to use geopolitical boundaries and current regulatory structures that do not consider floods from a watershed perspective. A watershed management strategy includes encouraging the collection of biologic and geomorphic data needed to make management decisions, using financial incentives and disincentives to encourage local governments to adopt watershed management strategies, and emphasizing sustainability in pre- and post-disaster mitigation. A municipality using a watershed management strategy may make financial investments upstream in order to protect its own assets. By contrast, current management policies show communities how to build as safely as possible in floodplains rather than discouraging development in floodplains, and mitigation is not required for alterations in hydrology and geomorphology due to development in floodplains despite the fact that development reduces the ability of floodplains to perform their natural functions. The Water Quality Initiative undertaken in Milwaukee from 2001 through 2007 piloted watershed-based resource management in the Sewerage District with a walleye restoration project to help build public support for the new management strategy. The Initiative also includes local government leaders and other stakeholders serving on its citizen advisory committee in its decision-making process.

For more information about the Milwaukee Metropolitan Sewerage District, visit:
http://v3.mmsd.com/

For more information about the Association of Floodplain Managers, visit:
http://www.floods.org/

Christopher Linn, Delaware Valley Regional Planning Commission

Delaware Valley Regional Planning Commission (DVRPC) has integrated healthy watersheds concepts into transportation systems planning at the metropolitan scale. The resource management strategy that results from this integration protects interactions between aquatic and terrestrial resources, creates a vision for green infrastructure, and proactively protects healthy resources through transportation and land use planning. The Delaware Valley region is home to a lot of suburban and urban development, and, consequently, impaired streams. Most watersheds identified as high value are forested. Because so many of the region's resources are threatened by growth and development, significant investments have been made in conservation. It is intended that the integrated conservation and planning strategy will assess impacts of transportation on conservation beyond a project's right of way, with a focus on maintaining biodiversity and a healthy hydrologic cycle. Another goal of the project is to minimize conflicts between transportation infrastructure and green infrastructure. Using the blue-green connection and protecting aquatic resources as a guiding principle, DVRPC developed the Green Infrastructure Screening Tool to quantify potential impacts of transportation projects on healthy ecosystems. The screening tool integrates GIS data layers showing physical resources (i.e., wetlands, forest lands, floodplains, ecological priorities, conservation priorities, and high-value habitat areas as defined by local, regional and state planning activities. The final output maps quantify the relative value of resources for the entire region. The screening tool then uses these resource scores to calculate and compare the potential impact of future transportation projects on aquatic and terrestrial resources. The screening tool is useful to local, county, state, and federal governments both for long-term, non-regulatory planning and for bringing transportation projects through the National Environmental Protection Act (NEPA) process.

For more information about the Delaware Valley Regional Planning Commission, visit:
http://www.dvrpc.org/

Lindsay Gardner,* Southeast Aquatic Resource Partnership/*Southern Instream Flow Network

The SARP and Southern Instream Flow Network (SIFN) are applying healthy watersheds assessments and other science-based resources to the implementation of protective instream flow policies in 15 southern states. SARP unites 21 organizations representing 14 states to protect, conserve, and restore aquatic resources. SARP is using the regional conservation priorities it has identified from habitat assessments in its Southeast Aquatic Habitat Plan, including protective instream flow policy, to guide its work. As published in its 2008 strategy document, the five Southern Instream Flow Research Agenda priorities are: 1) regional river classification, 2) flow alteration assessment, 3) compilation of regional aquatic data, 4) ecological responses to flow alteration hypotheses, and 5) field studies to confirm ecology-flow relationships. SIFN has leveraged a three-year, multistate conservation grant to make progress on the second priority with studies beginning to map impervious surface cover, water consumption, and dam storage capacity as well as flow alteration assessment following the ELOHA model. Progress has also been made on the third priority in that SIFN has documented states' baseline conservation resources, which is helping to identify and address data and funding gaps many SARP members face.

For more information on SARP and SIFN, visit:
www.southeastaquatics.net/program/sifn/

Martina Barnes, United States Forest Service

The USFS has been applying healthy watersheds assessments to provide source protection for water supplies. Three examples of their work include: the Forests, Water, and People project; the Trust for Public Land's (TPL) Source Water Stewardship Project; and USFS's effort to develop a watershed condition class framework.

The Forests, Water, and People project was run in the Northeast and Midwest United States to emphasize the forest-to-faucet connection for decision makers, because conserving forests around drinking water supplies is a low-cost strategy for minimizing supply contamination. USFS' Northeast region encompasses 540 watersheds in 20 states. It is 40% forested and provides water for about half the nation's population. The GIS analysis done by USFS overlaid four core data layers: the ability of the natural ecosystem to produce clean water, the number of water consumers supported by surface water supplies in the area, the percentage of unprotected (i.e., privately owned) forest present, and development pressure depicted in terms of expected housing density increase by 2030. The resulting map of development pressure on privately-owned forests important for drinking water supply will guide USFS' national assessment conservation priorities. The index of ability to produce clean water has also been used in some State Forest Resource Assessments to describe water quality and priority areas.

Furthermore, the Forests, Water and People project identified regionally important watersheds for drinking water supplies that were then further analyzed using the Watershed Forest Management Information System (WFMIS) software. In the WFMIS application, priority watersheds from Forests, Water and People were further analyzed to manage forests for the water supplies of Bridgeport and Hartford, CT, Boston and Springfield, MA, and Portland, ME. Lastly, TPL conducted refined analysis on conservation priority forests in its Source Water Stewardship Project using the USFS Forests, Water and People project results as a baseline.

TPL selected the Lower Meramec River in Missouri for the Source Water Stewardship Project based on a variety of factors, including its ranking in Forests, Water and People, its ability to provide clean water, habitat, and recreation, and the availability of demonstration site(s) in the watershed. TPL mapped conservation priority indices and restoration priority indices for the watershed. Volunteer experts were divided into committees to create action plans and make site-specific recommendations. The plans' components include voluntary, place-based strategies, as well as regulatory and enforcement ideas. The local steering committee developed a brochure for use by local governments, water suppliers, and conservation groups to assist in the implementation of the recommendations and action plans.

The watershed condition class framework is a project currently underway in order to achieve the U.S. Secretary of Agriculture's core management objective of restoring watershed health in national forests. Currently, priority watershed areas are being identified. The six-step framework is set up to classify watershed condition, prioritize watersheds for restoration, develop watershed action plans, implement integrated projects, track restoration accomplishments, and finally monitor and verify watershed conditions for watershed reclassification. Watershed condition indicators in use include water quality, water quantity, aquatic habitat, aquatic biota, riparian/wetland vegetation, rangeland vegetation, terrestrial invasive species, roads and trails, soils, fire regime, forest cover, and forest health. All national forests are expected to complete 6th level HUC condition classifications by March 31, 2011.

For more information on USFS programs, visit:
www.forest-to-faucet.org/
www.na.fs.fed.us/watershed/fwp_preview.shtm
www.tpl.org/tier3_cd.cfm?content_item_id=14411&folder_id=1985
www.forest-to-faucet.org/pdf/WFMIS-overview.pdf

Bob Benson, The Nature Conservancy

In the last 10 years, TNC has shifted its strategic emphasis from its traditional approach of buying or otherwise conserving parcels of land at the local level to a broader, landscape scale approach that focuses on whole-system strategy to achieve conservation goals. TNC supports the HWI because it embodies the landscape scale, whole-system approach. TNC already is working with the HWI in several ways. TNC is working with EPA to use policy and program guidance (e.g., CWA 319, CWA 404 mitigation requirements) to support a landscape-scale conservation. TNC is working with EPA on technical tools, such as ELOHA and the Groundwater Dependent Ecosystem assessment tool, to support system-wide assessment and planning. TNC is working with EPA to facilitate the healthy watershed approach in the field, working through TNC's 50 state chapters. TNC sees these mutually supportive efforts as groundwork for a possible national healthy watershed partnership between the Conservancy and EPA.

Benson offered three observations from TNC's perspective with respect to applying integrated assessments to the HWI. First, consider the HWI as an overarching framework for sustainable watersheds, rather than simply a tool to assess 'clean' water resources. Use the HWI to support conservation planning at the broad systems level in large aquatic landscapes. Second, leverage existing programs that address conservation needs in large aquatic ecosystems such as the Chesapeake Bay, the Great Lakes, and the Gulf of Mexico. Vast resources are poured into EPA programs addressing these three systems, which make these programs ideal places to develop strategic approaches, apply data, and leverage funds to support the HWI. Lastly, in order to successfully move from data assessment to conservation action, it is essential to examine the systemic factors that affect stakeholders' decisions and their ability to move forward. These factors, the 'drivers and barriers' controlling stakeholders' decision-making processes, vary from place to place and may include information, organizational culture, regulations, resources, and technical data (or lack thereof). Knowing the drivers behind stakeholders' decisions can help EPA to develop appropriate incentives for the HWI. Identifying systemic barriers which prevent stakeholders from effectively implementing healthy watershed programs can help define essential government actions to support the HWI. EPA is well situated to analyze driver-barrier factors at the national and regional levels, with help from TNC and others. States should also do so at the local level.

For more information on The Nature Conservancy, visit:
http://www.nature.org/

Megan Estep, United States Fish and Wildlife Service

The United States Fish and Wildlife Service's (USFWS) landscape conservation cooperatives (LCCs) are based on a business model termed strategic habitat conservation (SHC). The concept of LCCs was developed to facilitate SHC, a species-focused adaptive management model. SHC allows the identification of factors affecting the species of concern, models changes in those factors, develops plans to manage the factors, and evaluates the implementation of the plans. The USFWS realized that national wildlife refuges and fish hatcheries are small in the context of landscapes. How do migratory birds and anadramous fish, for example, really benefit from these small, isolated islands of habitat? The USFWS decided to improve its conservation strategy and pursue the LCC concept. USFWS defines LCCs as management-science partnerships that inform integrated resource management actions addressing climate change and other stressors within and across landscapes. They will link science and conservation delivery. LCCs are true cooperatives, formed and directed by land, water, wildlife, and cultural resource managers and interested public and private organizations. Federal, state, tribal, local government and non-governmental management organizations are all invited as partners in their development. LCCs are a useful management strategy because they cross state and regional boundaries. Currently, USFWS is primarily working in great northern plains and prairie potholes with the Bureau of Reclamation. LCCs can be used to implement HWI goals because they allow partners such as state agencies, universities, and federal agencies to collaborate to achieve strategic landscape-scale conservation.

For more information on USFWS' landscape conservation cooperatives, visit:
http://www.fws.gov/science/SHC/lcc.html

Jonathan Kennen, United States Geological Survey

The USGS Water Smart Initiative provides stakeholders with data to address two questions: 1) Does the nation have enough freshwater to meet human and ecological needs? and 2) Will this water be present to meet future needs? USGS' National Water Census (part of the initiative) focuses on defining water budgets by both generating and delivering information needed for water accounting. Such information includes precipitation, runoff, baseflow, evapotranspiration, recharge, and surface storage. Maintaining water budgets allows for broad-based accountability of water and water systems, especially when the information that goes into developing these budgets is publicly available on the internet at a relevant scale through a user-driven interface. USGS plans to use stratified random sampling and regression models to estimate water use across the nation. The development of water use models will be informed by land use. Ultimately, the goal for water use is to make it possible to trace the path of water from the point of withdrawal to the return of flow. It is anticipated that water budgeting will strategically push the expansion of groundwater programs. USGS is implementing focused water availability assessments in three areas where competition for water use is high: the Colorado River, Delaware River, and the Apalachicola Chattahoochee and Flint Rivers. These assessments will integrate water quality, water use, groundwater, ecological flow, precipitation, climate change and potentially population and economic data with input from local, state, and regional stakeholders. Data will be integrated from relevant national, state, and private databases over a three-year timeframe. USGS plans to provide state water resource agencies with grants on the order of $250,000 to support water use data collection for water availability assessments. The National Water Census is expected to address some of the data gaps the HWI faces. Additionally, many of the attributes measured in the National Water Census are indicative of whether or not a watershed is healthy.

For more information on USGS' National Water Census, visit:
http://water.usgs.gov/wsi/

Breakout Group Topic 4: Applications of Healthy Watersheds Assessments

In order to use integrated assessment results to protect healthy watersheds, states need to maintain and improve current monitoring programs, strengthen existing regulations, and conduct outreach to the public. However, integrated assessment results should not be used in a way that is perceived as regulatory oversight. The application of integrated assessment results should be value-added and create synergy with other state land and water management programs, such as support for green infrastructure, smart growth, antidegradation policies, NPDES permits, TMDLs, NEPA decisions, and protection of drinking water, groundwater, wetlands, and minimum stream flows. Green infrastructure is an especially opportune area in which to create synergy with healthy watersheds projects, because it is one route of access to SRF funds. The results of integrated assessments can also be used to incentivize behaviors that are protective of watershed health. In addition, the healthy watersheds initiative can serve as a focal point for collaboration across states.

If communicated concisely using visual presentations, healthy watershed assessments can be used not only to influence state and comprehensive watershed plans, but also to influence local water plans and water quality plans if they are presented to planning and zoning boards and other individuals who make land and water use decisions, such as where to locate easements. Public safety and economic benefits of healthy watersheds, which resonate outside environmentally-conscious communities, should be highlighted in data presented to these decision-makers. For example, the consistency of an integrated watersheds assessment approach would create a predictable and cost-effective environment for land developers. Through programs such as Nonpoint Source Education for Municipal Officials (NEMO), states can assist municipalities in implementing plans and ordinances that promote the healthy watersheds initiative. Integrated watershed assessments should be considered as snapshots of current conditions and be followed with subsequent tracking. Integrated watershed assessments data should be publicly available; one suggested format was an atlas with data overlays that end-users can look at to see how development will influence watersheds. Leaders of the healthy watersheds initiative should also take advantage of conventional as well as social media outlets to capitalize on the positive message of the healthy watersheds initiative to get diverse public stakeholders to embrace a systems perspective of natural environments.

1. How can healthy watersheds assessments and the resulting lists of healthy watersheds be used to protect these high quality waters and watersheds within and across a state?

- Build bridges to regulatory processes. Provide justification for need to strengthen existing state regulations and develop new state regulations (e.g., instream flows, channel management rights, fishing regulations, etc.).
- Identify areas to purchase for preservation.
- Help land trusts to focus land protection efforts on critical areas within a watershed that maintain connectivity.
- Influence land management.
- Support green infrastructure planning and conservation development.
- Prioritize riparian management and help with selection of rivers to be added to National Rivers Programs.
- Provide justification to target resources to protecting unique resources (e.g., natural area designations).
- Support for adoption of Outstanding/Exception Resource Water designations.
- Inform antidegradation (Tier I and Tier II waters could be related to healthy watersheds).
- Increase focus on need for continued monitoring. Also, focus monitoring in areas that were not on states' radars.
- Help guide the design of water quality monitoring programs, which are not traditionally linked to watershed assessments.
- Help drive/focus other Federal programs (e.g., Farm Bill, Environmental Quality Incentives Program, NRCS).
- Inform decision making in the 404 and 401 processes.
- Could expedite the permit review/approval process for development (would already know which areas need protecting and which are okay for development).
- State revolving funds, TMDL programs, performance partnership agreements, NPDES stormwater permits could have special provisions if in a healthy watershed.
- Give a watershed more statutory significance.
- Inform the 604(b) continuous planning process.
- EPA's Supplemental Environmental Projects can be targeted in watersheds on healthy watersheds lists.

Other Considerations:

- The assessment and results must be impartial - just science-based facts.
- Lists help with education and outreach, because they make abstract concepts concrete.
- Healthy watersheds lists may have backlash if perceived as regulatory. Private lands will be affected.
- We need to provide incentives to communities who can protect river corridors.
- We should provide developers with incentives to conduct demonstration projects of low impact development and green infrastructure.
- EPA/states should reserve a portion of implementation funding for the protection of healthy watersheds.
- Interstate cooperation and collaboration is important.
- Continued healthy watersheds assessment can help to evaluate progress and assess whether or not best management practices (BMPs) are effective (long term assessment tool).
- Linking healthy watersheds to geographic programs (e.g., Great Lakes, Chesapeake Bay, etc) could result in more traction in the short-term.
- Alternatives analysis can be very effective in some situations. Show people what will happen if resources are not protected.

2. How can local decision makers use this information to protect healthy watersheds?

- Inform the development of municipal/county master and water plans.
- Inform decisions regarding development and zoning.
- Assist with regional water quality management planning (as required by CWA Section 208).
- Promote existing or start new land acquisition programs.
- Justification to develop and enforce ordinances to keep watersheds healthy.
- Conduct comprehensive corridor planning and protection.
- Inform decisions regarding transportation, sewage, and flood control (all of which are issues that are priorities to local governments).
- Petition for ONRW designations, which results in more protective water quality standards. ONRW designations are more successful when initiated locally.

Other Considerations:

- Important considerations for delivering and communicating results of healthy watersheds assessments to local decision makers:
    - Provide short, flashy reports with concise, powerful messages.
        - Make all data available for those who want it (e.g., Healthy Watersheds Atlases)
    - Information (new and updated) needs to be made readily available in short time spans.
    - Visual aids are really effective at getting points across. Visuals should include maps, both electronic and paper.
    - Watershed tours (get local officials in the watershed and on the water).

    - Present results in context of public safety (e.g., floodplain protection) and economics (i.e., ecosystem services).
    - Consider role of the internet, including social media (e.g., Facebook).
    - Consider the role of media:
        - Get local decision makers in front of the media.
        - Public service announcements, public radio series, etc.
- Informing local decision makers gives scientific support for decisions they would want to make anyway.
- Outreach has to be repetitive because officials turn over.
- In many cases, even when information is made available, local governments often do not know how to use information or who to call to ask how to use it. This needs to be addressed.
- Engage hunters and fishers in order to gain increased local support. However, targeted message is key; hunting and fishing community may not understand nitrogen loading, but they understand rainbow trout, connectivity, etc.
- Placing basic information online and in the hands of the public can facilitate local conversations about resource protection.

7 Research Needs and Data Gaps

As research needs and data gaps were identified throughout the workshop, they were captured for inclusion in a summary of all needs and gaps. The following lists include all of the needs and gaps identified during the workshop. The synthesis paper to be developed in spring 2011 will include a refined list, categorization, and more in-depth summary of research needs and data gaps.

The following is a summary of research needs (RN) and data gaps (DG) identified during the workshop:

- Guidance on how to define baseline/reference for healthy watersheds assessments (RN, DG)
- Better understanding of natural variability in biotic/abiotic variables, including flow (RN, DG)
- How to effectively deploy flow gages to cover missing areas (RN)
- Appropriate coverage of flow gages (DG)
- Better monitoring following disturbances (DG)
- Central, GIS-based data repository (DG)
- Better understanding of climate-effects on indicators (RN)
- More channel surveys (DG)
- Better understanding of surface-groundwater interactions (RN)
- Understanding and quantification of non-human (natural) water uses (RN)
- Monetary valuation of ecosystem services (RN, DG)
- Summary of what other countries are doing to protect healthy watersheds (RN)
- Definition of resilience (RN)
- Explanation of how resilience fits into healthy watersheds (RN)
- Guidance on how to maintain/protect the components of healthy watersheds (RN)
- Better understanding of how ecosystems respond (recovery and adaptation) to disturbances (RN)
- Refinement of existing and development of additional regional hydrographs (DG)
- Approaches for conservation (RN)
- Guidance for the design of biomonitoring approaches that pick up on the integrity of physical processes and hydrogeomorphic components of habitat (RN)
- Better understanding of linkages between ecological health and socioeconomic factors (RN)
- Better understanding of the natural variation in response variables (assessing this using a consistent basis across the country would be highly valuable) (RN)
- The study of climatological effects on systems and indicators (RN)
- Additional assessments of climate change on hydrology (RN)
- LIDAR data (DG)

The following are additional needs identified during the workshop:

- Better communication of HWI within EPA and to each state water agency.
- Create a document clearinghouse where all states can see what others are doing.

- Create a logo for the HWI.
- Antidegradation policy needs to work better.
- Better integration of ground water and surface water programs.
- Implementation of Federal guidance on the Coastal Zone Act Reauthorization Amendments could protect healthy watersheds.
- Should carry over healthy watersheds concepts into impaired waters program too. Bringing all these tools together would help move all water quality programs forward.
- EPA should develop an inventory of all applicable funding sources to support healthy watersheds assessments and protection.
    - For example, half of the fluvial geomorphic assessments conducted in Vermont were paid for by pre-disaster funds from Federal Emergency Management Authority (FEMA). Millions of dollars are available for geomorphic assessments through this program.
- Need to engage FEMA, the floodplain agency of the country.
- Link conservation of aquatic resources to drinking water supply and source water.
- Need training on the ‘systems approach’ for the state level.
- Need a more systematic assessment of how each state is structured so we can identify how best to integrate healthy watersheds program into states.
- Need regional trainings. This will also help states that did not attend the workshop.
- The way of the future is through technology. Natural resource field is really behind in technology. HWI should have a strong technology component.
- Would be helpful if EPA assembled a national inventory of data that could be used for the assessments. Also, EPA could develop a portal where people have access to assessment approaches and derived data (already starting this via the HWI web site).
- It might be helpful for EPA to conduct a generic healthy watersheds assessment at the national scale. There is a lot of variation across states, but it could help to jump start the initiative.
- EPA can gain more support for protection through more education and outreach to the public, particularly through showing the economic value of protecting vs. restoring degraded systems.
- EPA needs to highlight the value added by the healthy watersheds program.
- EPA needs to conduct/fund pilot tests; it is important to demonstrate that the outputs are credible and useful.
- There is a Department of Transportation (DOT) liaison currently at EPA. This person is looking for ways to use EPA information and products to assist with DOT planning. Healthy watersheds could be one of those tools – it could be plugged directly into a national process.
- Having an EPA representative on each of the 17 fish habitat partnerships can help with healthy watersheds implementation since fish habitat partnerships already have buy-in from states.
- Convene a group of experts and establish a systematic process to identify indicators (and stressors) of resilience.
- Tools for forecasting projections for population growth, increase in impervious cover, and fragmentation need to be developed in order to assess healthy watersheds.
- Develop tools for understanding where growth may or may not be appropriate.

- Develop a set of low cost but high return indicators that capture most of the process information for watershed for little money (i.e. obtaining 90% of the information for 10% of the cost).
- Encourage the development of riparian protection programs such as Federal Wild and Scenic River or State Natural Rivers Programs and provide funding support for these programs to help keep systems intact.
- Develop a database of existing conservation projects for healthy watersheds (e.g., protected lands, mitigation banks, conservation easements, etc.).

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Appendix A. Workshop Participants

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Last Name	First Name	Organization
Abele	Ralph	US EPA Region 1
Akers	Paulette	Kentucky Division of Water
Angelo	Bob	Kansas Department of Health and the Environment
Bach	Leslie	The Nature Conservancy
Barnes	Martina	US Forest Service
Bellucci	Chris	Connecticut Department of Environmental Protection
Benson	Bob	The Nature Conservancy
Best	Elly	US EPA Office of Research and Development
Blake	Laura	The Cadmus Group, Inc.
Bledsoe	Brian	Colorado State University
Boydstun	Jan	Louisiana Department of Environmental Quality
Cianciola	Elisabeth	The Cadmus Group, Inc.
Colaiacomo	Erika	Montana Natural Heritage Program
Detenbeck	Naomi	US EPA Office of Research and Development
Dlugolecki	Laura	US EPA Office of Water
Estep	Megan	US Fish & Wildlife Service
Estes	Christopher	Association of Fish & Wildlife Agencies
Flotemersch	Joe	US EPA Office of Research and Development
Fontenot	Brian	US EPA Region 6
Fowler	Dave	Milwaukee Metropolitan Sewerage District /ASFM
Franklin	Abraham	New Mexico Environment Department
Gabanski	Laura	US EPA Office of Water
Galloway	Walt	US EPA Office of Research and Development
Gardner	Lindsay	Southeast Aquatic Resources Partnership
Godfrey	Corey	The Cadmus Group, Inc.
Hartranft	Jeff	Pennsylvania Department of Environmental Protection
Hill	Rick	Virginia Department of Conservation and Recreation
Julius	Susan	US EPA Office of Research and Development
Kennen	Jonathan	US Geological Survey
King	Ryan	Baylor University
Kline	Mike	Vermont Agency of Natural Resources
Knight	Amy	Florida Natural Areas Inventory
Linn	Christopher	Delaware Valley Regional Planning Commission

Last Name	**First Name**	**Organization**
Maxted	Jeff	The Cadmus Group, Inc.
McCall	Catherine	Maryland Department of Natural Resources
McInich	Stephen	Virginia Commonwealth University
Medley	Leah	US EPA Region 7
Morgan	Ken	Colorado Division of Wildlife
Nicholson	Matt	US EPA Region 3
Norton	Doug	US EPA Office of Water
Novak	Rachel	US EPA Office of Research and Development
Pfeifer	Sharon	Minnesota Department of Natural Resources
Poff	LeRoy	Colorado State University
Sowa	Scott	The Nature Conservancy
Stanley	Stephen	Washington Department of Ecology
Ten Brink	Marilyn	US EPA Office of Research and Development
Thorp	Jim	University of Kansas
Walsh	Ted	New Hampshire Department of Environmental Services
Weitman	Dov	US EPA Office of Water
Whelan	Gary	Michigan Department of Natural Resources
Wireman	Mike	US EPA Region 8

Appendix B. Workshop Agenda

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HEALTHY WATERSHEDS INTEGRATED ASSESSMENTS WORKSHOP

November 2 – 4, 2010

YMCA of the Rockies

Estes Park, Colorado

AGENDA

DAY 1: Tuesday, November 2, 2010

7:00	BREAKFAST (Aspen Dining Hall)
7:30 – 8:00	Participant Check-In (East Portal/Bible Point Room in Emerald Mountain Lodge)
8:00 – 8:15	Welcome & Opening Remarks *(Denise Keehner,* Director of EPA's Office of Wetlands, Oceans & Watersheds*)*
8:15 – 8:30	Logistics, Workshop Goals and Structure, and Review of Day 1 Agenda (*EPA and Cadmus*)
8:30 – 9:15	Overview of Healthy Watersheds Initiative (*Laura Gabanski, EPA*)
9:15 – 10:15	Examples of State Healthy Watersheds Assessments Stephen McIninch, VCU, Virginia INteractive STream Assessment Resource (10 min) Scott Sowa, TNC, Missouri Aquatic GAP (10 min) Stephen Stanley, Washington Department of Ecology, Puget Sound Example (10 min) Catherine McCall, MD DNR, Maryland Green/Blue Infrastructure Example (10 min) Question & Answer (20 min)
10:15 – 10:30	BREAK
10:30 – 11:45	Watershed Resilience Doug Norton & Susan Julius, EPA, Overview of Watershed Resilience (20 min) Amy Knight, FL, state example/perspective (10 min) Jan Boydstun, LA, state example/perspective (10 min) Sharon Pfeifer, MN, state example/perspective (10 min) Panel Discussion (25 min): • What are the key indicators and methods for assessing watershed resilience? • How can healthy watersheds be sustained?
11:45 – 1:00	LUNCH (Aspen Dining Hall)
1:00 – 1:15	Charge to Breakout Groups for Topic 1 (Watershed Resilience)
1:15 – 4:00	Breakout Group Topic 1: Watershed Resilience 1. What are the key indicators for assessing watershed resilience? 2. What are the methods for assessing watershed resilience? 3. How can healthy watersheds be sustained?
4:00 – 4:45	Reconvene for Group Reports on Topic 1 (Healthy Watershed Resilience)
4:45	END OF DAY 1
5:00	DINNER (Aspen Dining Hall)
6:30	Social Gathering (meet in Emerald Mountain Lodge common area)

DAY 2: Wednesday, November 3, 2010

7:00	BREAKFAST (Aspen Dining Hall)
8:00 – 8:15	Recap of Day 1 and Review of Day 2 Agenda (*Cadmus*)
8:15 – 9:30	Integrated Assessments LeRoy Poff & Jim Thorp, Conceptual Model Overview (45 min) Question & Answer (30 min)
9:30 – 10:00	Index Approach Rick Hill, VA DCR, Virginia Watershed Integrity Model (20 min) Question & Answer (10 min)
10:00 – 10:15	BREAK
10:15 – 11:30	Examples of How to Integrate Assessment Components Leslie Bach, TNC, Hydrology and groundwater dependent ecosystems and the Active River Area (20 min) Mike Kline, Vermont geomorphic and habitat assessments (15 min) Gary Whelan, Nationwide landscape disturbance index for NFHAP (15 min) Question & Answer (25 min)
11:30 – 11:45	Charge to Breakout Groups for Topic 2 (Developing Integrated Assessments)
11:45 – 1:00	LUNCH (Aspen Dining Hall)
1:00 – 4:00	Breakout Group Topic 2: Developing Integrated Assessments Design a healthy watersheds integrated assessment approach that relates key watershed processes and landscape condition to healthy habitat and biota in aquatic ecosystems. The assessment must be implementable at the state scale and by state agencies, with support from outside partners. Consider the following questions when designing your assessment approach: 1. What key elements should be included in a healthy watersheds integrated assessment approach and what is the role of green infrastructure? 2. Considering readily available data, what are the best indicators for these key elements? 3. How should the interactions between key elements affect assessment design? 4. What methods are available to simultaneously examine multiple interacting endpoints? 5. At what temporal and spatial scales should healthy watersheds integrated assessments be conducted? 6. What are the data and indicator gaps that currently limit a state's ability to conduct healthy watersheds integrated assessments? 7. What does the final product of the assessment look like (i.e., how will the results be communicated)?
4:00 – 4:45	Reconvene for Group Reports on Topic 2 (Developing Integrated Assessments)
4:45	END OF DAY 2
5:00	DINNER (Aspen Dining Hall)
6:30	Social Gathering (meet in Emerald Mountain Lodge common area)

DAY 3: Thursday, November 4, 2010

7:00	BREAKFAST (Aspen Dining Hall)
8:00 – 8:15	Recap of Day 2and Review of Day 3 Agenda (*Cadmus*)
8:15 – 8:30	Charge to Breakout Groups for Topic 3 (Implementation of Healthy Watersheds Assessments)
8:30 – 11:00	Breakout Group Topic 3: Implementation of Healthy Watersheds Assessments 1. How can states develop lists of healthy watersheds using existing data? 2. How can healthy watersheds assessments be implemented by state agencies within their current program structure? 3. In what ways might a state agency consider adapting its program structure to support the implementation of healthy watersheds assessments? 4. What kind of cross-agency collaboration is required to successfully implement healthy watersheds assessments?
11:00 – 11:45	Reconvene for Group Reports on Topic 3 (Implementation of Healthy Watersheds Assessments)
11:45 – 1:00	LUNCH (Aspen Dining Hall)
1:00 – 2:10	How to Apply Integrated Assessment Results Dave Fowler, Milwaukee Metropolitan Sewerage District/ASFM (10 min) Christopher Linn, Delaware Valley Regional Planning Commission (5 min) Lindsay Gardner, SARP, Southeastern Instream Flow Network (5 min) Martina Barnes, USFS, Drinking Water Project; related TPL projects (10 min) Bob Benson, TNC, Landscape Scale Conservation (5 min) Megan Estep, US FWS, National Landscape Conservation Cooperative (5 min) Jonathan Kennen, USGS, Water Census (5 min) Panel Discussion (25 min): • How can healthy watersheds integrated assessments support what your organization is doing to protect watersheds? • What is your experience getting different agencies/groups to collaborate and work together on protecting healthy watersheds?
2:10 – 2:15	Charge to Breakout Groups for Topic 4 (Applications of Healthy Watersheds Assessments)
2:15 – 3:30	Breakout Group Topic 4: Applications of Healthy Watersheds Assessments 1. How can healthy watersheds assessments and the resulting lists of healthy watersheds be used to protect these high quality waters and watersheds within and across a state? 2. How can local decision makers use this information to protect healthy watersheds?
3:30 – 3:45	BREAK
3:45 – 4:30	Reconvene for Group Reports on Topic 4 (Applications of Healthy Watersheds Assessments)
4:30 – 4:45	Closing Remarks & Next Steps (*EPA*)
4:45	END OF WORKSHOP
5:00	DINNER (Aspen Dining Hall)

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Appendix C. Outline of Healthy Watersheds Integrated Assessments Workshop Synthesis Document

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1. Background

- Motivation behind the Healthy Watersheds Initiative
- Why Integrated Assessments are important
- Brief description of the workshop

Contributors: Laura Gabanski, Naomi Detenbeck, Cadmus

2. Conceptual Model

- The essential elements of a healthy, functioning watershed.
- The relationships between these elements and their role in supporting watershed resiliency.
- Options for relating elements and processes at different temporal and spatial scales.

Contributors: LeRoy Poff, Jim Thorp, Stephen Stanley, Bob Angelo

3. Watershed Resilience

- The key indicators and methods for assessing watershed resilience.
- Options for sustaining healthy watersheds.

Contributors: Doug Norton, Susan Julius, Marilyn Ten Brink, Christopher Estes

4. Integrated Assessment Approaches

- Indicators for the essential elements of a healthy watershed.
- Methods for incorporating element relationships and multiple interacting endpoints into the assessment approach.
- Methods for scaling (temporal and spatial) between indicators.
- Communicating the results of the integrated assessment.

Contributors: Leslie Bach, Stephen Stanley, Gary Whelan, Mike Kline, Ted Walsh

5. Applications and Synergy across Programs

- Implementing healthy watersheds assessments within current program structures and opportunities for adapting programs to support development of healthy watersheds lists.
- Cross-agency collaboration in the implementation of healthy watersheds assessments.
- Using healthy watersheds lists to support state and local implementation of conservation and protection programs.

Contributors: Bob Benson, Mike Kline, Ralph Abele, Megan Estep, Ted Walsh, Marilyn Ten Brink, LeRoy Poff, Christopher Estes

6. Research Needs and Data Gaps

- The data and indicator gaps that are currently limiting the development of healthy watersheds integrated assessments.

Contributors: Naomi Detenbeck, Joe Flotemersch, Elly Best, Susan Julius