

# **Improving National Transportation Geospatial Information Workshop New Applications: Environment and Planning**

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Committee on Ecology and Transportation (ADC30)

## **1. *Setting the stage: What are the data information needs to implement the new environmental provisions in SAFETEA-LU.***

A workshop was held at the Keck Center in December 2005 in Washington D.C. to discuss information needs to improve transportation analysis and how existing and additional geospatial data can be used most effectively in vital transportation applications, particularly in light of several new environmental provisions within the current transportation authorization: Safe, Affordable, Flexible, Efficient Transportation Equity Act –A Legacy for Users. Out of these and subsequent discussions, several planning areas were identified for additional discussions. These include:

- Routing/Navigation,
- Corridor Management and Congestion,
- Safety,
- Emergency Management and Security, and
- Environment and Planning
- Asset Management/Maintenance/Construction

This draft white paper will discuss considerations on Environment and Planning, as a starting point for a state DOT advisory group on data information needs. This advisory group will also include GIS experts beyond State DOT's which may have resources, technical expertise or complementary goals where building partnerships maybe mutually beneficial.

In an effort to focus the discussion during the limited time available, this paper will highlight three central themes that seem apparent to each of the new environmental provisions within SAFETEA-LU:

- Environmental Stewardship,
- Environmental Review Process Streamlining
- Accountability/Performance Monitoring.

In an effort to further focus the discussion, this white paper will focus on two sections in SAFETEA-LU which may best advance implementation of the other provisions. Section 6001 requires considerations of the environment at regional and state-wide planning levels. Section 6002 requires efforts to support more effective coordination and simultaneous consideration of individual resource issues during project level analysis where ever possible.

Environmental data at multiple spatial and temporal scales to support project, regional and statewide planning levels seem evident as each planning effort is conducted by three levels of government (local, state and federal) with varying levels of jurisdictions and planning timeframes. As planning and project time and resources are limited, this white paper and the

workshop will attempt to focus on what focused effort might best yield the greatest value to SAFETEA-LU implementation.

## **2. Workshop Objectives**

*This workshop will examine potential benefits and costs of initiatives to improve the national geospatial information infrastructure for transportation. The information from the workshop should serve to inform both the transportation and mapping community on potential strategies for transportation participation in national initiatives in support of regional efforts.*

The specific workshop objectives are:

- a. Investigate the likely applications, benefits and costs to improve a multi-modal surface national transportation (including airports) geospatial information system for the transportation community.
- b. Identify likely users, beneficiaries, and funding sources.
- c. Discuss key data elements for which transportation modes that could be included
- d. Suggest potential roles, mechanisms for sharing data, and approaches to integrate required data for multiple sources
- e. Explore institutional arrangements that could facilitate such an initiative.
- f. Identify the types of questions planners at local, state and federal agencies may need to ask and discuss least-cost approaches to gathering and sharing that data in a manner and within the planning timeframes of the respective agencies.

Highways and streets will likely be dominant because of wider interest and more mature geospatial activities.

## **3. Participating State GIS Staff**

In support of Federal Geographic Data Committee objectives, GIS specialists and users from federal, state and local agencies and organizations who have resources, expertise and needs that may be interested in partnerships toward shared GIS goals are invited to participate in the development of this white paper and/or the December 14, 2007 workshop.

### **The Federal Geographic Data Committee**

The Federal Geographic Data Committee (FGDC) is an interagency committee that promotes the coordinated development, use, sharing, and dissemination of geospatial data on a national basis. This nationwide data publishing effort is known as the [National Spatial Data Infrastructure](#) (NSDI). The NSDI is a physical, organizational, and virtual network designed to enable the development and sharing of this nation's digital geographic information resources. FGDC activities are administered through the FGDC Secretariat, hosted by the [National Geospatial Programs Office](#) (NGPO) of the U.S. Geological Survey. The NGPO oversees other geospatial programs of national importance including The National Map and the Geospatial One-Stop activity.

The Office of Management and Budget (OMB) established the FGDC in 1990 and rechartered the committee in its August 2002 revision of Circular A-16, "Coordination of Geographic Information and Related Spatial Data Activities." The FGDC is a 19 member interagency committee composed of representatives from the Executive Office of the President, and Cabinet level and independent Federal agencies. The Secretary of the Department of the Interior chairs the FGDC, with the Deputy Director for Management, Office of Management and Budget (OMB) as Vice-Chair. Numerous stakeholder organizations participate in FGDC activities representing the interests of state and local government, industry, and professional organizations.

Additional background on FGDC is available online: <http://www.fgdc.gov/>

- [What's new at the FGDC?](#)
- [Organization of the FGDC](#)
- [Relationship to other national geospatial initiatives](#)
- [Components of the NSDI](#)

Participation in the development of this white paper and at this workshop is encouraged by planning and GIS specialists with expertise in conducting regional, statewide or nation-wide/system level efforts in infrastructure planning and/or natural resource management. These may include representatives for:

- Local and state agency transportation staff
- Soil and Water Conservation District staff
- Technically trained staff from nongovernmental organizations and industry groups.
  - United Nations Millennium Project – Environmental Sustainability
    - Millenium Project Ecosystem Assessment – North America
  - Heinz Center: State of the Nations – Contracted/Cooperating Staff
  - NatureServe and affiliated Natural Heritage Program staff.
  - The Nature Conservancy – Staff involved in Eco-Regional Assessments
  - National Associations of state and local resource and transportation agency
    - Association of Fish and Wildlife Agency
    - Association of State and Highway Transportation Officials
    - Association of Metropolitan Planning Organizations
    - Association of Regional Councils.
    - National Association of Conservation Districts
- Federal land management agency staff such as
  - US Forest Service – National Forest System Staff
  - National Park staff
  - Bureau of Land Management
  - National Wildlife Refuge
  - Department of Defense (Base/Installations).
- Federal natural resource technical experts
  - U.S. Fish and Wildlife Service
  - Natural Resource Conservation Service
  - Corps of Engineers Regulatory staff – Clean Water Act 404.
  - National Park Service – Inventory & Monitoring Program
  - U.S. Forest – State and Private Forestry

- Other Federal agency which build infrastructure projects or which do large scale planning or monitoring.
  - Department of Defense (Base/Installations)
  - Department of Energy
  - Department of Homeland Security
  - U.S. Customs and Border Patrol
  - NASA – Jet Propulsion Laboratory (Modeling and Data Management Systems Section)

While many of these organization and representatives may not be available to fully participate through out this exercise, they represent a significant network of partners and potential resources which may be able to contribute in some capacity and should be encouraged to engage whenever appropriate. Points of contact will be established with these entities and updated at key milestones or in subsequent application developments either at a national level or regionally.

#### ***4. Application Overviews/Questions/Considerations.***

##### **4.1. How would you describe the use of geospatial technology in the application?**

Geo-spatial data can assist transportation specialists in understanding the ecological implications of an individual transportation project and the cumulative impacts of a larger regional or statewide transportation system on the natural environment. Geo-spatial data can support the design of projects and guide system development that avoids and reduces impacts to the environment.

Specifically, geo-spatial data can be used to prepare ecological assessment for transportation plans to address the following objectives:

- Streamline regulatory compliance through the coordination of multiple conservation and transportation planning objectives to achieve better environmental results.
- Assess status and trends of ecosystem components and their processes important to the health of the ecosystem as needed to assess implications for transportation planning.
- Monitor the impacts of weathering on transportation systems within different climates and environments to facilitate design developments that reduce maintenance costs and lengthen facility life.
- Geo-spatial data can be used to predict species occurrences that can focus species' survey efforts that reduce planning delays and costs.
- Discern ecological relationships to support project design elements that minimize disruptions to ecological processes.
- Monitor the effectiveness of transportation-related mitigation and adaptively manage mitigation to meet desired level of performance.

##### **a. Why is a national or regional context important?**

A national and regional context is important to enhance our understanding of the ecological relationships and the implication of those ecological relationships on transportation planning and project delivery. Plant and animal populations and ecological processes are inter-related and interdependent across the landscape well beyond local, state or even national transportation planning boundaries. Ecological relationships are poorly understood and they can vary widely across the landscape making it difficult to define analysis boundaries.

A national data layer can provide a seamless geographic data layer that local and state transportation planners can use to define the ecological boundaries that are influenced by their respective plan-level activities and can focus coordination with jurisdictions where appropriate. Such a data layer may facilitate understanding of ecological relationships that occur across planning boundaries.

In addition to improving our understanding of the ecological context for regional and statewide planning efforts, a national or regional context can save time, money and effort. Inexpensive and more readily available “coarse” geo-spatial data could be collected at national or multi-state levels to achieve efficiencies of scale and to focus collection of more costly, site specific data as needed to address specific local priorities and to better optimize across competing priorities.

#### **4.2. What geospatial data would be used in the application?**

Geo-spatial data could be used to link regional conservation planning with individual resource protection that would enable transportation agencies to gain efficiency of scale while improving the overall ecological effectiveness of their conservation efforts. By overlaying regional transportation plans and priority transportation projects, geo-spatial data could be identified to address specific conservation or transportation planning steps.

While the specific types of data may vary by transportation planning units and the environmental condition in and around the planning area, the general types of data could be standardized to meet a general conservation planning approach. A standardized conservation planning or regional ecosystem framework could enable common data types to emerge and facilitate coordination and resource sharing between planning jurisdictions.

##### **What questions do you want to answer?**

To identify the types of data needed for a national or regional geospatial system, consider what questions are commonly asked. Following are a series of questions that may be asked to identify species’ impacts and ecological relationships and how transportation plans and projects may affect those species or influence or disrupt ecological relationships upon which the species and ecosystems depend?

1. What are plant and animal species, natural resources and ecological processes within the planning area?

2. What are the key attributes to determine the status and trends of special status species and other natural resources of interest?
3. What are the key ecological drivers and stressors to those resources in my planning area and how do I prioritize analysis of those drivers and stressors appropriate to the scope and scale of regional and statewide transportation improvement plans and transportation-related and interdependent impacts?
4. How can those impacts be measured in terms and how can those terms be spatially represented to most easily develop and compare transportation scenarios?
5. How can data be organized to support scenario development and comparisons?
6. How do I evaluate impacts at the landscape scale?
7. How do I evaluate effects of transportation projects and systems to ecological processes such as disturbance regimes (flooding, fire, insect cycles) wildlife movement, plant dispersal patterns between ecosystems, patch size, shape and distribution of ecosystems often represented by dominant vegetation.
8. How do I evaluate impacts at the ecosystem scales such as seral stage development, fragmentation of the system, decrease in size of loss of key components such as listed species etc.
9. How do I evaluate impacts to individual resources such as individual species (numbers, distribution, reproduction).
10. How do I develop transportation-appropriate conservation measures to address **landscape** impacts (impacts that cross multiple ecosystems), particularly in light of other non-transportation-related impacts that lie outside of transportation agency jurisdictions?
11. How do I develop transportation-appropriate conservation measures for impacts within a single ecosystem?
12. How do I develop transportation-appropriate conservation measures to address impacts to specific plant and animal species?
13. How do I incorporate conservation measures into the plan and document these efforts so transportation agencies are not expected to make additional contributions that may disrupt timeframes or exceed constrained budgets?
14. How do I predict changes in land use sufficient to address future transportation capacity, safety and environmental concerns?
15. What other agencies and project proponents are working in my area and how do we cooperate to share information and align projects to avoid conflicts?

### **What are examples of data categories used to answer commonly asked questions?**

The seminal text “Landscape Ecology” (Forman & Gordon, 1986) recognized three basic characteristics of a landscape:

- structure – the basic spatial arrangements of ecosystems or elements,
- function – the interactions between spatial elements such as energy flows, species movements and of course,
- change – the alteration of structure and function over time.

Following are data categories commonly considered in geospatial data systems used to describe these ecological characteristics that can support answers to the questions above.

The National Park Service's Inventory and Monitoring Program uses the following terminology in development of their conceptual models: ecological drivers, stressors, and attributes.

**Ecosystem Drivers** are major, naturally occurring forces of change such as climate, fire cycles, biological invasions, hydrologic cycles, and natural disturbance events (e.g., droughts, floods, lightning-caused fires) that have large scale influences on the attributes of natural systems (Leibfreid 2003).

**Stressors** are physical, chemical, or biological disturbance events that result in significant ecological effects and are considered proximate causes of adverse effects on the groups of organisms within the system (Noon et al. 2002). Stressors cause significant changes in the ecological components, patterns and processes in natural systems. Examples include air pollution, exotic pest invasions, water pollution, water withdrawal, pesticide use, timber harvesting, traffic emissions, stream acidification, trampling, poaching, and land-use change.

Ecological effects are the physical, chemical, biological, or functional responses of ecosystems to drivers and stressors.

**Monitoring Attributes** are any living or nonliving feature or process of the environment that can be measured or estimated and that provide insights into the state of the ecosystem. The term Indicator is reserved for a subset of attributes that is particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). Indicators are a selected subset of the physical, chemical, and biological elements and processes of natural systems that are selected to represent the overall health or condition of the system, known or hypothesized effects of stressors, or elements that have important human values. We have identified the following general categories (again, following Young and Sanzone 2002) that establish a framework to identify indicators at multiple spatial and organizational scales.

- Landscape Condition (landscape pattern and composition);
- Biotic (stand) condition (structure, species composition, community diversity);
- Abiotic (stand) condition (chemical and physical characteristics; e.g., nutrient concentrations, trace chemicals, and soil and atmospheric characteristics).

### **Geomorphology**

- Landforms: plateaus, plains, valleys, mountains, chasms, small islands, floodplains.
- Hydrography: lakes, rivers, swamps, aquifers,
- Soils / Substrate: depth, structure, texture, composition
- Geographic position such as relief, aspect, elevation.
- Land/sea interface: marine, coastal, tidal influence zones

**Climate:** Climate data can characterize the distribution of flora and fauna. The structural characteristics of habitat and may regulate critical life functions such as breeding, feeding and sheltering that in turn may influence a species range or breeding success. Climate change can influence species movement and distribution.

- Average monthly/daily temperatures (high/lows)
- Average monthly/daily precipitation.
- Average monthly/daily humidity levels
- Solar exposure

**Native Plant Communities:** Biotic communities broadly defined as forests, grasslands, desert shrub, tundra and their seral stages.

**Flora:** Special status plant species protected by regulation such as those listed under the Endangered Species Act or of interest to planners, and their key habitat and life cycles.

**Fauna:** Special status animal species protected by regulation or of interest to planners and their range maps, migration patterns, key habitat types or niches.

**Species of interest** may include the following:

**Migratory Birds:** Executive Order 13186 directs each Federal agency taking actions having or likely to have a negative impact on migratory bird populations to work with the U.S. Fish and Wildlife Service to develop an agreement to conserve those birds. The protocols developed by this consultation are intended to guide future agency regulatory actions and policy decisions; renewal of permits, contracts or other agreements; and the creation of or revisions to land management plans. In addition to avoiding or minimizing impacts to migratory bird populations, agencies will be expected to take reasonable steps that include restoring and enhancing habitat, preventing or abating pollution affecting birds, and incorporating migratory bird conservation into agency planning processes whenever possible.

In addition to requiring consultation with the Service and consideration of migratory bird conservation for agency actions, the Executive Order also:

- Establishes a Council for the Conservation of Migratory Birds to assist agencies in implementing the order. Composed of administrators from the Departments of the Interior, State, Commerce, Agriculture, Transportation, Defense and the Environmental Protection Agency, the council will also serve as a clearinghouse to share the latest migratory bird information with Federal agencies.
- Directs agencies to ensure that environmental analyses of proposed Federal actions required by the National Environmental Policy Act evaluate the effects of those actions on migratory birds.
- Requires agencies, within the scope of their regular activities, to control the spread and establishment in the wild of exotic animals and plants that may harm migratory birds and their habitat.
- Requires agencies to provide advance notice of any action that may result in the take of migratory birds, or to report annually to the Service on the numbers of

each species taken during the conduct of any agency action. Agencies are directed to avoid the take of any species identified by the Service as being of particular concern, and to consult with the Service to set out guidelines for any actions resulting in take.

**Invasive species:** is defined as a species that is

- non-native (or alien) to the ecosystem under consideration and
- whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

Invasive species can be plants, animals, and other organisms (e.g., microbes). Human actions are the primary means of invasive species introductions.

Additional information is available on an applicable [Executive Order 13112](http://www.invasivespeciesinfo.gov/laws/execorder.shtml)  
<http://www.invasivespeciesinfo.gov/laws/execorder.shtml>

**Disturbance Regimes:** An event that causes significant change in the normal pattern in an ecosystem. These might include fire, pest outbreak, flooding, and hurricanes which can mold a landscape or distribution of species or elements over time such as days or years. Disruptions to disturbance regimes may influence an ecosystem function or an element's occurrence.

Disturbance regimes may include data that may assist planners in understanding impacts layers may characterize elements that shape an ecosystem such as their severity, the frequency and season of occurrence spatial pattern with which they occur, the season in which they occur, their spatial pattern and whether they burn subsurface in the ground, on the surface, or in the crowns of trees.

#### **4.3. What is the organizational structure of the application?**

Geo-spatial data may be most useful when organized in a spatially explicit manner that allows qualitative and quantitative analysis. Data structures that express a continuum and hierarchical relationships may facilitate scenario development. If data organized in a database or other structure that facilitates transportation planning, it may be useful to examine how that structure could be linked to a spatial structure or converted to spatially explicit applications that can be overlaid to various transportation scenarios. As individual resource components, like individual transportation projects, are part of a much larger ecosystem and transportation system, the considerations of an individual natural resource or transportation project is often relative to the larger system dynamics.

In addition to converting data to spatially-explicit structures, the ability to convert spatial data to numerical databases may facilitate quantification of individual impacts and cumulative impacts of regional or statewide plan.

#### **4.4. What would be potential benefits or improvements from improved national geospatial data?**

Increased understanding of the ecological relationships and the implication of those ecological relationships can improve transportation designs that minimize impacts to the environment, reduce mitigation costs and project delivery delays due to environmental impacts.

#### **4.5. Case Studies – Critical Considerations.**

I am broadly requesting 1-2 page case studies of projects that integrated conservation and transportation planning goals together. I will work with contributors to review the case studies and select only 4-5 of them to deliver a 10-15 minute presentation during the workshop. Those selected to deliver a case study will be offered a registration waiver they can use or give to someone else!

Following are a range of case studies that utilize different approaches based upon the transportation and environmental workload and needs. These are only examples and I do not have a commitment from anyone involved in these efforts to deliver a case study. If you can draft a 1-2 page summary on these or others efforts, please send them to me:  
joseph\_burns@fws.gov

**Ecosystem Approach:** **Colorado - Short Grass Prairie.**

**Landscape Scale Batch Programmatic:** **Oregon - Oregon Bridges**

Oregon DOT utilized a rapid assessment across multiple ecosystems at a coarse state-wide level and at finer watershed/individual project level to optimize streamlining with individual project level protection.

**Species Approach:** **Ohio – Indiana Bat.**

Ohio DOT utilized a single species approach across an entire state. This species home range can span multiple states where winter hibernacula may be one state and the summer roosting and location of maternity colonies in another state.

**Integrated Planning Approach:**

Plan first, data second:

Maryland -Green Infrastructure/MATE Process  
North Carolina -

Data first, plan second:

Florida  
Efficient Transportation Decision Making

Example of a case study outline

1. Issue:
  - What are desired outcomes or objectives?
  - What timeframes were involved?
  - Who are key constituencies and how were they engaged?

2. How was geospatial data utilized?
  - What questions did you need to answer?
  - How were issues of scope and scale addressed?
  - Did ecological data offer insight or value to non-ecological questions?
3. How would things have been better (for transportation) if better national data development took place?
  - What information did you need?
  - What development really enables increased benefits?
  - How did you handle unknowns?
  - How could ecological data be better collected to benefit a wide range of socio-economic-cultural values?

## **5. What barriers exist to achieving geo-spatial data improvements?**

There are a variety of barriers for improving national geo-spatial data.

- Existing data has been collected differently for varying purposes with varying levels of precision. This makes spatial data difficult to use to answer broader questions or to apply to other projects.
- Availability and type of metadata is limited, reducing the ability to apply specific data to broader applications.
- Data on private land is often proprietary limiting the ability to understand landscape level implications or future trends.
- Data sharing across jurisdictions may be legally limited.
- Data sharing may be logistically difficult to availability of staff to transfer data, or inability of data systems to communicate with each other.

## **6. Next Steps**

- White paper – Incorporate discussions into white paper.
- Circular – Finalize white paper into circular.

## **Appendices**

## ***Program Schedule, Revised***

- 8:30 -10:00            Workshop Welcome and Objectives
- 10:15 -11:30:        Overview of the Breakout Session Application Topics
- Emergency management and security
  - Safety
  - Corridor management and congestion
  - Routing and navigation
  - Environment and Planning
  - Asset management/maintenance/construction
- 11:30 - 2:30            Pick up lunch and go to breakouts.

During the breakout sessions, Environment Application Leader will discuss any critical additions or deletions participants may have from the Overview that may aid discussions of the selected case studies. The case studies are designed to illustrate issues raised in the white paper and to focus the discussion on one or two key opportunities that can be adapted into next steps. Each case study will offer a 15 minute overview with the following elements”

1.     Issue:
  - What are desired outcomes or objectives?
  - What timeframes were involved?Who are key constituencies and how were they engaged?
  
2.     How was geospatial data utilized?
  - What questions did you need to answer?
  - How were issues of scope and scale addressed?
  - Did ecological data offer insight or value to non-ecological questions?
  
4.    How would things have been better (for transportation) if better national data development took place?
  - What information did you need?
  - What development really enables increased benefits?
  - How did you handle unknowns?
  - How could ecological data be better collected to benefit a wide range of socio-economic-cultural values?

- 2:30pm-3:00pm        Break
- 3:00pm-4:00pm        Reports from Discussion Breakouts
- 4:00pm-5:00pm        Conclusions and Next Steps

## **Outline Preliminary Program**

### **Cover**

Graphic

Workshop Title *Improving National Transportation Geospatial Information Workshop*

Dates December 14, 2007

Location The National Academies Keck Center, Washington, DC

Organizer Transportation Research Board Geographic Information Science and Applications Committee

Cosponsors Statewide Transportation Data and Information Systems Committee, National Transportation Data Requirements and Programs Committee and Critical Transportation Infrastructure Protection Committee

Sponsor Federal Highway Administration

URL: [www.trb.org/conferences/2007/Geospatial](http://www.trb.org/conferences/2007/Geospatial)

### **National Park Service - National Framework for Inventory & Monitoring**

<http://science.nature.nps.gov/im/monitor/NationalFramework.cfm>

The National Park Service has implemented a strategy designed to institutionalize natural resource inventory and monitoring on a programmatic basis throughout the agency. The effort was undertaken to ensure that more than 270 park units with significant natural resources possess the resource information needed for effective, science-based managerial decision-making and resource protection. The national strategy consists of a framework having three major components: (1) completion of basic resource inventories upon which monitoring efforts can be based; (2) creation of experimental Prototype Monitoring Programs to evaluate alternative monitoring designs and strategies; and (3) implementation of operational monitoring of critical parameters (i.e. "vital signs") in all natural resource parks.

### **National and Regional Oversight**

Natural resource inventory and monitoring activities by the National Park Service are carried out under the direction of the Associate Director for Natural Resource Stewardship and Science. National level program coordination and management is provided by a National Inventory and Monitoring Program Manager, the National Monitoring Program Leader, and other staff who are aligned administratively with the Office of Inventory, Monitoring and Evaluation in the Natural Resource Program Center. The Inventory and Monitoring Program at the Washington Office level involves staff and funding from all offices and divisions of the Natural Resource Program Center, including the following NRPC divisions that provide guidance, technical support and funding to the I & M networks: [Air Resources](#), [Biological Resources](#), [Geologic Resources](#), and [Water Resources](#).

Five long-term programmatic goals for the Servicewide Inventory and Monitoring Program were established in the early 1990s to comply with legal requirements, fully implement NPS policy, and guide management:

- Establish natural resource inventory and monitoring as a standard practice throughout the National Park system that transcends traditional program, activity, and funding boundaries.
- Inventory the natural resources and park ecosystems under National Park Service stewardship to determine their nature and status.
- Monitor park ecosystems to better understand their dynamic nature and condition and to provide reference points for comparisons with other, altered environments.
- Integrate natural resource inventory and monitoring information into National Park Service planning, management, and decision making.
- Share National Park Service accomplishments and information with other natural resource organizations and form partnerships for attaining common goals and objectives.

Program coordination and oversight at the regional level is provided by a full-time Regional Inventory and Monitoring Coordinator who reports to the region's senior natural resource staff member or other regional staff person designated by the Regional Director. Regional I&M Coordinators are responsible for providing day-to-day coordination between parks, the regional office, and the National Inventory and Monitoring Program.

### **Natural Resource Program Center**

The Natural Resource Program Center is comprised of three offices and five divisions of the Washington Office of the NPS, and is part of the Natural Resource Stewardship and Science Directorate. The five divisions in the NRPC, [Air Resources](#), [Biological Resource Management](#), Environmental Quality, [Geologic Resources](#), and [Water Resources](#), provide technical support, scientific expertise, and funding to parks to assist with the following park stewardship functions:

- coordinating resource inventory and monitoring activities;
- implementing technical resource management solutions;
- funding resource management projects and implementation;
- acting as a national clearinghouse and distribution hub for resource management information;
- facilitating resource management partnerships and training;
- interpreting resource management policy, regulations, and permitting; and
- supporting resource management planning, research, and policy development.

#### **(1) Basic Resource Inventories**

The first major component of the NPS national inventory and monitoring framework is a set of 12 core natural resource inventory data sets needed to effectively manage a park's resources. The minimal information required by all parks includes the following 12 data sets that include a variety of biotic and abiotic ecosystem components:

- [Natural Resource Bibliography](#)
- [Base Cartographic Data](#)
- [Geology Map](#)

- [Soils Map](#)
- [Climate Data](#)
- [Air Quality](#)
- [Location of Air Quality Monitoring Stations](#)
- [Water Body Location and Classification](#)
- [Water Quality Data](#)
- [Vegetation map](#)
- [Documented Species List of Vertebrates and Vascular Plants](#)
- [Species Distribution and Status of Vertebrates and Vascular Plants](#)

## **(2) Prototype Monitoring Programs**

The second component of the NPS national inventory and monitoring framework is a series of eleven "prototype" monitoring programs that were selected in the early 1990s as experiments to learn how to monitor different kinds of natural resources. The prototype monitoring parks worked with USGS scientists and funding to design and implement long-term ecological monitoring. All prototypes are now nested within one of the 32 monitoring networks described below, and most of them are now fully integrated with their respective networks. The eleven prototype programs included:

- Channel Islands National Park
- Great Smoky Mountains National Park
- Shenandoah National Park
- Cape Cod National Seashore
- Denali National Park and Preserve
- Great Plains Prairie Cluster (6 small parks in the Midwest Region)
- Virgin Islands-Southern Florida Cluster (3 parks in the Caribbean)
- Olympic National Park
- North Cascades National Park Service Complex
- Mammoth Cave National Park
- Northern Colorado Plateau Cluster (5 parks on the Colorado Plateau)

The current vision of the prototype monitoring programs is that within the NPS, there should be a few parks with greater funding and staffing levels that serve as monitoring Research and Development sites. These prototype monitoring programs, which may also receive funding and scientific expertise from USGS scientists, are expected to develop and test sampling protocols and provide technical assistance and mentoring to other parks within their network and nationwide.

By nature of these enhanced funding and staffing levels and USGS involvement, most prototypes are able to conduct a level of monitoring that is more comprehensive and intensive than what other parks can undertake. All prototypes are nested within one of the 32 monitoring networks, and the main distinction between the prototypes and other parks within their network is a greater emphasis on protocol development and technical support that will benefit all parks in the network, as well as other parks outside of the network. In addition to the initial emphasis on protocol development, there is a long-term role for the prototypes in developing and testing

new approaches to data analysis and synthesis, reporting of monitoring results, and in providing mentoring and training to others.

### **(3) Vital Signs Monitoring Networks**

The third component of the NPS national framework for inventory and monitoring consists of more than 270 parks with significant natural resources that have been grouped into 32 I & M networks linked by geography and shared natural resource characteristics. The network organization will facilitate collaboration, information sharing, and economies of scale in natural resource inventory and monitoring. Each of the 32 park networks is guided by a Board of Directors (usually comprised of park superintendents and the regional and network coordinators) who specify desired outcomes, evaluate performance for the monitoring program, and promote accountability. The level of funding available through the Natural Resource Challenge will not allow comprehensive monitoring in all parks, but will provide a minimum infrastructure for initiating natural resource monitoring in all parks that can be built upon in the future.

Parks within each of the 32 networks work together and share funding and professional staff to plan, design, and implement an integrated long-term monitoring program. The complex task of developing a network monitoring program requires a front-end investment in planning and design to ensure that monitoring will meet the most critical information needs of each park and produce scientifically credible data that is accessible to managers and researchers in a timely manner. The investment in planning and design also ensures that monitoring will build upon existing information and understanding of park ecosystems and make maximum use of leveraging and partnerships with other agencies and academia.

[View the Map of the 32 networks and the parks in each network.](#)

[Download a list of parks in each network.](#)

[Download a list of coordinators and data managers for each network.](#)

[Download a list of abbreviations for all NPS park units.](#)

A monitoring program requires professional-level staff who can analyze data, interpret data, prepare reports, and provide the information in a useable format to park managers, scientists, and other interested parties. However, it is currently unrealistic that every park will be able to obtain funding to hire a full professional staff, including as an example a botanist, wildlife biologist, hydrologist, geologist, soil scientist, data manager, etc. The vision behind the vital signs monitoring program is to provide each network of parks with consistent annual funding and approximately 5 to 7 FTEs to develop a core, long-term program. Each network could then leverage these core resources with existing personnel, funding from other sources, and partnerships with other agencies and organizations, to build a single, integrated monitoring program that best addresses the needs of the parks in that network. The integrated program would monitor the condition of physical and biological resources including air quality, water quality, geological resources, weather, fire effects, threatened and endangered species, exotic

species, and other flora and fauna. The offices of the Natural Resource Program Center, including the divisions of Air Resources, Biological Resource Management, Geologic Resources, and Water Resources, are coordinating efforts to provide funding and technical support to park networks for developing these integrated monitoring programs.

### **Northeast Temperate Network – An example**

Development of conceptual models is an important step in the design of the Vital Signs Monitoring Program for each network. The need for this key step is based on lessons learned about monitoring program designs from the NPS experience with its prototype parks program, and from many other monitoring programs. These lessons demonstrate that monitoring efforts are based on some underlying understanding of how the ecosystem in question works. Conceptual models play several useful roles in monitoring program design, including:

- Conceptualizing ecosystem function and structure (cumulative, holistic, multi-scale);
- Identifying major stressors, attributes affected, impacts, and indicators at a broad level;
- Aid in identifying "vital signs" to detect ecological health changes;
- Formalizing current understanding of the context and scope of the ecological processes important in the area of interest;
- Expanding our consideration across traditional discipline boundaries, fostering integration of biotic and abiotic information;
- Facilitating communication among scientists from different disciplines, between scientists and managers, and between managers and the public.

In the development of the NETN Vital Signs Monitoring Program, we have chosen to generally follow examples from Noon, et al. (2002) to draft the diagrammatic conceptual models and accompany these models with narratives that describe the details of the interactions among the components. These models identify ecosystem processes/functions that are integrated with structural/compositional attributes and predict biodiversity responses.

We are taking a hierarchical approach to model development starting with a general model for the key ecological systems located in the NETN. The general model identifies the key ecological communities within parks and the natural and anthropogenic stressors that influence those systems. A model is then developed for each of the ecological systems that more specifically integrates the drivers, stressors, and attributes that may influence that specific system. Under each general ecosystem model a series of specific ecological models are then developed that focus the key disturbances and stressors, and identify specific attributes of the ecological system. Finally, sub-models of specific components of a system are modeled to identify the important interactions within a specific component of the larger system.

The goals of these conceptual models are to:

- Synthesize understanding of ecosystem dynamics;
- Provide a firm conceptual foundation for identifying monitoring indicators;

- Identify and illustrate relationships among indicators and key system processes;
- Provide a clear means of illustrating major subsystems and system components and their interactions;
- Facilitate communications on system dynamics and the vital signs monitoring program among network staff, managers, technical and non-technical audiences;
- Identify areas where knowledge is inadequate and further research is needed;
- Describe and illustrate alternative hypotheses about key processes or system dynamics

The NETN conceptual models use the Environmental Protection Agency (EPA) Framework of Essential Ecological Categories (Young and Sanzone 2002) adapted to fit into the NPS Vital Signs monitoring development program. We use the following terminology in developing conceptual models for the Northeast Temperate Network:

**Ecosystem Drivers** are major, naturally occurring forces of change such as climate, fire cycles, biological invasions, hydrologic cycles, and natural disturbance events (e.g., droughts, floods, lightning-caused fires) that have large scale influences on the attributes of natural systems (Leibfreid 2003). We have divided ecosystem drivers in to following categories:

- Natural disturbance regimes (fires, floods, insect infestations, wind);
- Ecological processes (energy and material flows);
- Physical Processes (Hydrology and geomorphology surface and groundwater flows, channel characteristics, sediment and material transport);
- Climate (Temperature, precipitation).

**Stressors** are physical, chemical, or biological disturbance events that result in significant ecological effects and are considered proximate causes of adverse effects on the groups of organisms within the system (Noon et al. 2002). Stressors cause significant changes in the ecological components, patterns and processes in natural systems. Examples include air pollution, exotic pest invasions, water pollution, water withdrawal, pesticide use, timber harvesting, traffic emissions, stream acidification, trampling, poaching, and land-use change.

Ecological effects are the physical, chemical, biological, or functional responses of ecosystems to drivers and stressors.

**Monitoring Attributes** are any living or nonliving feature or process of the environment that can be measured or estimated and that provide insights into the state of the ecosystem. The term Indicator is reserved for a subset of attributes that is particularly information-rich in the sense that their values are somehow indicative of the quality, health, or integrity of the larger ecological system to which they belong (Noon 2002). Indicators are a selected subset of the physical, chemical, and biological elements and processes of natural systems that are selected to represent the overall health or condition of the system, known or hypothesized effects of stressors, or elements that have important human values. We have identified the following general categories (again, following Young and Sanzone 2002) that establish a framework to identify indicators at multiple spatial and organizational scales.

- Landscape Condition (landscape pattern and composition);
- Biotic (stand) condition (structure, species composition, community diversity);
- Abiotic (stand) condition (chemical and physical characteristics; e.g., nutrient concentrations, trace chemicals, and soil and atmospheric characteristics).