USFWS & USGS Future Science Challenges Literature Review
June 10, 2004

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This literature review summarizes 34 documents for the Future Science Challenges Initiative of the USFWS and USGS. All documents are recent publications related to future environmental management challenges, scientific research needs, and societal and institutional organizational responses. The summaries are presented in alphabetical order of authors (with the exception of 2 groups of articles presented together under special Science publication series). A citation list of all documents reviewed is presented at the end of this document.

Akimoto, H. 2003. Global air quality and pollution. Science 302:1716-1719. The impact of global air pollution and it's effect on climate and the environment is a new focus. Global air quality is now having an effect on climate and worldwide ecosystems. In the 1990s nitrogen oxide emissions from Asia surpassed those of North Am and Europe, and will do so for decades. International initiative to mitigate global air pollution requires participation from both developed and developing countries.

Relevance to USGS and FWS mission: USGS has a role as one of the chief scientific organizations of the world to be involved in creating the body of information that documents the phenomena of changing global air quality, and it's effects on climate and ecosystems. The FWS monitors air quality at certain refuges, but it's research concerns are local in nature.

Bricker, O.P. and M.A. Ruggiero. 1998. Toward a national program for monitoring environmental resources. Ecological Applications. 8(2):326-329.

Synopsis: Despite spending hundreds of millions of dollars on environmental monitoring and research each year, the United States does not know the full extent or condition of our natural resources on a national basis, or how they are changing. A fundamental change in our approach to environmental monitoring and related research is needed if we are to meet the challenges facing us in assessing the types and rates of environmental change, and in assuring continued bio-sustainability and biodiversity into the future. Current federal programs are largely piecemeal, intermittent, and short term and don't provide the long-term information necessary to distinguish natural from human-induced effects. This paper presents a conceptual framework for integrating the nation's environmental research and monitoring networks across federal, state, tribal, and local governments and the private sector to enable comprehensive and integrated assessments of natural resources at the regional and national levels. According to the authors, such a framework can help us avoid both unnecessary regulations and serious environmental problems.

Who contributed to this report: The development of this framework was recommended by a panel of experts from across the country convened in 1993 by the

National Science and Technology Council and the National Academy of Sciences to "address the shortcomings of our present environmental monitoring and research programs." It was created by the Council's Environmental Monitoring Team, composed of representatives of 12 federal agencies.

Relevance to FWS/USGS mission: The FWS/USGS monitoring and research efforts would be incorporated into this framework, and we would have access to the monitoring and research of others. Question: Has any action been taken on this network?

Carnegie Commission on Science, Technology and Government. 1997. Federal Environmental Research and Development: Status report with recommendations. Carnegie Commission. 24 pp.

Synopsis: Environmental protection is an issue that cuts across many governmental agencies, therefore environmental research and development programs are highly decentralized, thus very challenging for policymakers. Because environmental decision making will only become more important, it is critical that these programs in the future be well organized, and closely linked to policy making.

Report Recommendations:

- attempt to overcome the inherent fragmentation of the nation's environmental R&D system
- need for effective bridges between scientific information and users of the info
- develop credible environmental indicators such as: measures of atmospheric and oceanic conditions like ozone levels, ecological trends, public health, land-use patterns, and water quality.
- develop an integrated National Environmental Database : use GIS technology to create a unity of information that informs a wide variety of users and policy makers (USGS should do this)
- create an on-line library of National Library of Natural Resources: a national repository of non-partisan, quality controlled information, an expansion of the traditional peer reviewed literature. Could be managed by NOAA or USGS.
- create Regional Natural Resource Science Forums: a mechanism for regional land use issues to be facilitated, mediated among stakeholder groups.

Who contributed to this report: in 1996 a group of experts in the organization of environmental research and development (11 professors, deans, executive directors of professional societies and institutes, and high level DOI appointee).

Relationship to FWS/USGS missions: USGS was specifically indicated as appropriate agency to develop and manage a National Environmental Database, and National on-line Library of Natural Resources. Both agencies should examine ways improve efficiency (reduce fragmentation) in federal environmental research and transfer of scientific information to users. FWS has dual role of science generator and user. Consider the Regional Natural Resource Science Forums as a vehicle to inject regional scientific information into local issues. This could be a mechanism to inform and involve stakeholders at a scale slightly larger than their individual projects for the purpose of distributing scientific information, and more at the scale that resource management agencies want to be heading (ie, end spp mgt occurs at a landscape scale, whereas a housing project is a portion of a landscape).

Chow, J. R. J. Kopp, P. R. Portney. 2003. Energy resources and global development. Science 302:1528-1531.

Synopsis: The primary energy resources used across the world are reviewed, and it is indicated that no form of energy use is without environmental or economic implications. The article predicts that fossil energy resources will remain prevalent as long as they are cheaper in the developed nations, but that developing countries they may skip straight to more modern forms of energy use and distribution, perhaps largely skipping large centralized electrical systems.

Relevance to USGS/FWS missions: Continued use of fossils fuels will extend the duration of conditions leading to global warming, and the coincident environmental changes. In addition, as world demand continues, fossil fuel extraction is likely to continue on FWS lands, and perhaps extend to areas not yet developed for energy production. Both agencies will continue to be involved in predicting the location of fossil fuels (USGS), and managing it's extraction from refuges (FWS). A recent GAO report indicated that FWS does not manage oil and gas production on refuges as assertively as is required by law, or as other federal agencies, and encouraged it to re-examine its policy and improve employee skills in this area.

DOI Strategic Plan. FY2003-2008.

Synopsis: Only the section **Stronger Science** was reviewed to date. It stressed the increasing need for leaders, public, and policy makers to have accurate and timely science-based information. A goal of the DOI over the next 5 years is to ….. '*identify and conduct relevant and current science to help policy officials make conservation and resource decisions.'*

It describes DOI science program as focused on data collection and integration, as well as understanding, modeling, and predicting how multi forces affect natural systems. It indicates that outreach to customers, cooperators, partners, and stakeholders with an interest in science-based information need to help define needs and set priorities. It also indicates a role for traditional or experiential knowledge in determining ecological and socio-economic trends.

It indicates an ongoing need to use integrative approaches and add capabilities in new and different disciplines.

The role of USGS as the principle science bureau was highlighted, and that DOI science priorities will be integrated into the USGS 5-yr strategic plans and annual operation plans.

Keys to implementation are: 1) realistic concrete program goals; 2) measuring progress toward them; 3) holding people accountable for results.

The newly developed Science Code of Conduct will be implemented to assure the DOI science is developed with impartiality, honesty, and availability of info to the public.

There will be bureau-specific guidelines for information quality.

Outreach to customers, partners, policymakers, stakeholders will be stressed to increase effectiveness.

Electronic connections with the public will be built, primarily via Geospatial One-Stop.

Relevance to FWS/USGS missions: These are our marching orders and some new frameworks for doing business, especially the Scientific Code of Conduct, Scientific Peer Review policy, and requirements related to Data Quality Control Act. FWS in particular, when decision making under the ESA "best available science" guidance, will need to balance the requirements in the Data Quality Control Act, and DOI Peer Review policy.

Ecological Society of America. 2004. Ecological Science and Sustainability for a Crowded Planet. 21st Century Vision and Action Plan for the Ecological Society of America. 55 pp.

Synopsis: This report predicts environmental issues will define the 21st century, as will a world with a large human population and ecosystems shaped by human intervention. The science of ecology can and should play an expanded role in managing the planet. To play a bigger role, ecologists will need to form partnerships at scales and in forms not traditionally used.

They should implement action in 3 visionary areas:

1. Informed Decisions: enhance the extent to which decisions are ecologically informed
2. Anticipatory Research: advance innovative ecological research directed at the sustainability of an over-populated planet
3. Cultural Exchange: stimulate cultural change within the science itself that build a forward-looking and international ecology

Specific recommendations for progress in each vision area are presented. Other recommendations are:

1. standardization of data collection, data documentation and data sharing via graduate and professional training of ecologists in a common ecoinformatics

2. a rapid response team of ecological expertise in responding to legislative and executive branch proposals to increase opportunities for ecological knowledge in issues that affect sustainability.
3. a meeting of key leaders in research, management, and business should convene to dev a reward system for ecological researchers and educators.
4. increase global access to ecological knowledge
5. strategies to ease exchange of students, managers and practitioners among institutions in various countries

- By reviewing avail literature they also identified Critical Environmental Issues for Prioritizing Ecological Research (not in order of priority)
- The science of ecosystem services
- Biodiversity, species composition and ecosystem functioning
- Ecological aspects of biochemical cycles
- Ecological implications of climate change
- Ecology and evolution of infectious disease
- Invasive species
- Land use and habitat alteration
- Freshwater resources and coastal environments

Who contributed to this report: The Ecological Society of America developed an action plan to accelerate our progress in addressing the major environmental challenges of our time and increase the contribution of ecological science in the coming decades. The report was produced by an ESA Ecological Visions Committee comprised of 20 society members largely representing academia. They solicited input fr0m numerous groups, governments and NGOs, business, individuals and ESA members.

Relevancy to USGS/FWS missions: Visions 1 and 2 have good overlap with our missions, he desire for scientifically informed decisions, and mechanisms to better determine research priorities.

Kim, K. C. and L. Knutson. 1986. Foundations for a National Biological Survey. Assoc. of Systematic Collections. Museum of Natural History, Univ. of Kansas. 215 pp.

Synopsis: this report describes the need for a more complete inventory of the nation's flora and fauna. It indicates that such information is fundamental to the utilization and management of our nation's biota. The essence of the biological survey would be to develop an essential data base of the systematic knowledge of the flora and fauna of a region, thus forming the basic information for understanding ecosystem dynamics and conservation of living diversity. This group provides a plan for getting this work done with a variety of

Who contributed to this report: 26 academics in plant or animal taxonomy or systematics, and directors of several natural history museums, including E.O.Wilson.

Relevance to USGS and FWS mission: Biological surveys have been conducted by various federal government agencies over the decades, but have largely phased out since the 1940s. Is this an area that deserves a renewed effort if we are going to have a more coordinated approach to managing biodiversity? The endangered species scientists of each agency could advise our group on how important this initiative would be.

National Council for Science and the Environment. 2002. Recommendations for Achieving Sustainable Communities: Science and Solutions. National Council for Science and the Environment. 68 pp.

Synopsis: This is the report from the Second National Conference on Science, Policy and the Environment. During the first conference, the concept of "sustainability science" was advanced—"a synthetic, interdisciplinary approach to better understanding the complex interactions between society and nature so that the alarming trend towards increasing vulnerability is reversed." This report documents the recommendations from the second conference on how to apply "sustainability science" to community sustainability, globally and locally. It outlines a holistic approach in which progress is redefined within the context of sustainable development to include five basic elements: environmental protection and restoration, peace and security, economic development, human rights, and supportive national governance. For our purposes, among the most important overarching themes that emerged from examination of eighteen topical areas, as diverse as "Rural Communities," "Remote Sensing," "Federal Government Employees," and "Children's Health," are:

- Science and technology are important and necessary tools for achieving sustainability, but community participation is essential for scientific and technical information to be incorporated into the policymaking process.
- Conserving natural resources, preserving biodiversity and maintaining a clean environment are essential factors for sustaining a healthy human community.
- Exchange of information on sustainability models, programmatic activities and successful projects should be established on an international basis.

Among the most important recommendations that emerged, for our purposes, are:

- Given the importance of science to sustainability, emphasis should be given to developing a science-based understanding of sustainability.
- A crucial aspect of achieving sustainable communities at all levels is the involvement of stakeholders from the inception of the policymaking process.
- Incentive-based policies should be established systematically for the conservation of natural resources.

- Research should be undertaken to create mass balance models with an economic component for forecasting and planning, and for assessment of policy options by manipulating variables to see likely impacts on sustainability.

Who contributed to this report: 575 participants from academia, government, environmental organizations, private business, science organizations, and "others."

Relevance to FWS/USGS missions: Raises the issue of whether the FWS/USGS sees itself as contributing to and benefiting from the national/international effort to define and apply sustainability science. Suggests the need for the FWS/USGS to define sustainability in regard to its conservation mission, i.e., who/what is being "sustained" in our definition of sustainability.

NRC. 2000a. Ecological indicators for the nation. National Academy Press. 180 pp.

Synopsis: This report was generated in response to an EPA request for NRC to conduct a critical evaluation of indicators to monitor ecological change from natural or anthropogenic causes. NRC was also asked to examine what aspects of environmental conditions and trends should be monitored. The current variety of indicators was reviewed, including those used by USGS/NAWQA, DOI/BEST and EPA/EMAP, and others. Ecologic indicators are designed to inform us quickly and easily about environmental conditions too complex to measure individually. The recommended national ecological indicators are in 3 categories:

1. as indicators or the extent and status of the nation's ecosystems: *land cover* and *land use.*
2. as indicators of the nation's ecologic capital: *total species diversity, native species diversity, nutrient runoff,* and *soil organic matter.*
3. as indicators of ecologic functioning or performance: *carbon storage, production capacity, net primary production, lake trophic status, stream oxygen,* and for agricultural ecosystems: *nutrient-use efficiency, nutrient balance.*

Who contributed to this report: A committee of academic ecologists was established that reviewed relevant literature and received presentations on current EPA monitoring programs in about 1998-1999.

Relationship to FWS/USGS missions: This report addresses the needs of agencies involved in adaptative management decision making. It is critical to know which way trends are going and to monitor the consequences of environmental decisions. USGS could play a large role in the development, verification, and implementation of new national ecological indicators. This type of research may not be considered publication quality, as it is monitoring, which could be an institutional barrier to large amounts of indicator status and trends work being conducted by USGS. The NAWQA and BEST programs currently attempts to do this type of work, and its indicators should be compared to the list above, and the projected future information needs. In a sense, the nation currently monitors success or failure at species conservation by the number of spp listed under ESA. But this is not an accurate reflection of the number of spp at risk to extinction. In addition, FWS is increasingly conducting programmatic consultations and HCP's; where types or communities of organisms, rather than individual spp, are managed, sometimes using a non-T&E indicator spp as a monitoring tool.

NRC. 2000b. Grand Challenges in Environmental Science. National Research Council. National Academy Press. 77pp.

Synopsis: A report written for NSF to identify the most important research challenges within environmental sciences for the next 20-30 years, specifically the areas most likely to yield results of major scientific and practical importance if pursued vigorously now. The time frame selected focused on challenges that would take about 10 years to engage successfully, in part to allow for the training of a critical mass of scientists to undertake the necessary projects. After a wide consideration of issues, using methods described below, the committee selected 8 grand challenges. The selection criteria were: probability of significant scientific and practical payoff, large scope, relevance to important environmental issues, feasibility, timeliness, and requirement for multi-disciplinary collaboration. They concluded the needed environmental knowledge for the next generation will depend upon active pursuit of all 8 grand challenges. A focused subset of 4 issues was identified for immediate research investment by NSF and others.

The 8 Grand Challenges (alphabetical order):

1. <u>Biogeochemical Cycles</u> – understand the Earth's major biogeochemical cycles, evaluate how they are perturbed by human activities; determine how they might be stabilized. Research areas are quantifying sources and sinks of nutrient elements; interactions of biogeochemical cycles, assess human perturbations on biogeochemical cycles and their impact on ecosystem functioning, atmospheric chemistry, human activities and a scientific basis for societal decisions about managing these cycles; and exploring technical and institutional approaches to managing anthropogenic perturbations.
2. <u>Biological Diversity and Ecosystem Functioning</u> –understand factors affecting biological diversity and ecosystem structure and functioning, including the role of human activity. Research areas are improved tools for rapid assessment of biodiversity at all scales; producing quantitative, process-based theory of biodiversity at the largest possible variety of spatial and temporal scales; elucidating the relationship between diversity and ecosystem functioning; developing and testing techniques for modifying, creating and managing habitats that can sustain biological diversity, as well as human activities.
3. <u>Climate Variability</u>- increase ability to predict climate variations, from extreme events to decadal time scales; to understand how this variability may change the future, and realistically assess impacts. Research areas are: improve observational capability, extend records of observation back into Earth's history, improve diagnostic process studies, develop increasingly comprehensive models, conduct

integrated impact assessments that take human responses and impacts into account.

4. Hydrologic Forecasting- improve understanding and ability to predict changes in freshwater resources and the environment caused by floods, droughts, sedimentation and contamination. Research areas are: improve understanding of hydrological response to precipitation, surface water generation and transport, environmental stresses on aquatic ecosystems, relationship between landscape changes and sediment fluxes, subsurface transport, and mapping ground water recharge and discharge vulnerability.
5. Infectious Disease and the Environment - understand ecological and evolutionary aspects of infectious diseases; understand interactions among pathogens, hosts/receptors and the environment, thus making it possible to prevent changes in the infectivity and virulence of organisms that threaten plant, animal and human health at population levels. Research areas are: effects of environmental changes as selection agents on pathogen virulence and host resistance; exploring impacts of environmental change on disease etiology, vectors, and toxic organisms; develop new approaches to surveillance and monitoring; improve theoretical models of host-pathogen ecology.
6. Institutions and Resource Use - understand how human use of natural resources is shaped by institutions such as markets, governments, international treaties, and formal and informal sets of rules that are established to govern resource extraction, waste disposal, and other environmentally important activities. Research areas are: documenting the institutions governing critical lands, resources and environments; identify the performance attributes of the institutions governing resources and environments worldwide; conceptualize and assess effects of institutions for managing global commons.
7. Land-Use Dynamics - develop systemic understanding of changes in land uses and land covers critical to ecosystem function and services and human welfare. Research areas are: develop long term regional databases for land use, land covers and related social information; develop spatially explicit land-change theory; link land-change theory to space-based imagery; innovate applications of dynamic spatial simulation techniques.
8. Reinventing the Use of Materials – need a quantitative understanding of global budgets and cycles of materials widely used by humanity and how the life cycle of these materials (from raw material through recycling or disposal) can be modified. Research areas: spatially explicit budgets for key materials; methods for more complete cycling of technological materials; determine how to best utilize materials with unique industrial applications but environmental hazards; understand forces that drive patterns of human consumption of resources; predict possible global scenarios of future industrial development and associated environmental implications.

The 4 Immediate Research Investments (alphabetical order):

1. Biological Diversity and Ecosystem Function. Recommendation: develop comprehensive understanding of relationship between ecosystem structure and

function and biodiversity by experimentation, observation and theory focused on: development of knowledge needed to enable the design and management of habitats that can support both human uses and native biota; develop detailed understanding of effects of habitat alteration and loss of biodiversity, especially those species and ecosystems whose disappearance would likely do disproportionate harm to the ability of ecosystems to meet human needs or set in motion the extinction of other species.

2. Hydrologic Forecasting. Recommendation: establish the capacity for detailed, comprehensive hydrologic forecasting, including the ecological consequences of changing water regimes, in each of the primary US climatological and hydrologic regions. Important specific research areas include all those described under Grand Challenge 4.

3. Infectious Disease and the Environment. Recommendation: Develop comprehensive ecological and evolutionary understanding of infectious diseases affecting human, plant and animal health.

4. Land-Use Dynamics. Recommendations: Develop spatially explicit understanding of changes in land uses and land covers and their consequences.

Implementation Issues. Recommendation: NSF, working with other agencies where appropriate, should conduct workshops that include research scientist in academia, the relevant agencies, and private sector, as well the potential users of the research results, to discuss and plan research agendas and address implementation issues.

Who contributed to this report: A committee with broad disciplinary backgrounds comprised of 15 academicians, 1 federal researcher and 1 Carnegie Institute representative met 5 times in 1999 to solicit input, select the most compelling challenges and form its recommendations. They solicited input from the scientific community in 1999 in the form of a 1-pg narrative describing the challenge and suggested responses. Over 200 challenges were nominated by the scientific community (including several individuals of FWS and USGS). Most input came from North America.

Relationship to FWS/USGS missions: This report has high relevancy and practical applicability to the FWS/USGS Future challenges initiative. It provides synthesis of the thinking among the scientific community on the greatest environmental challenges that may have tractable solutions in the near-term, and provides specific recommendations for agencies to prepare themselves scientifically for future action and response. FWS and USGS could choose specific recommendations in this report for implementation.

NRC. 2001a. Future roles and opportunities for the US Geological Survey. National Academy Press. 179 pp.

Synopsis: The recent integration of BRD into the USGS has broadened the USGS mandate beyond the traditional focus on geology, hydrology and geography. Its current mission is to supply information that contributes to the effective mgt of a variety of natural resources. It describes USGS as a vitally important provider and coordinator of information related to critical issues in the natural sciences.

An important mission of the USGS is to provide scientific understanding to support the sound conservation of the nation's biological resources. The factors with the greatest broad-scale effects on biological resources:

- Land use
- Water use
- Non-indigenous species

The challenge for the future is sound management of the earth's ecosystems to maintain biodiversity and ecosystem function. Meeting this objective calls for a greater understanding of how biological systems work, how to stem the loss of habitats, and how to restore and manage ecosystems.

Future research opportunities for USGS revolve around 3 themes:

- Hazards
  - Effective hazard information for communities in high risk environments
  - Hydrologic processes and hazards
  - Wildfires and public policy
- Environment
  - Global climate change
  - Climate variability and water resources
  - Links between geologic processes and human health
  - State of the nation's ecosystems
  - Restoration of aquatic ecosystems
  - Investigations to support wise urban development in the West
- Natural Resources
  - Life cycles of ore materials
  - Geologic frameworks for transition to a methane fuel economy

Specific recommendations:

- *Hazards* - It was suggested that USGS link its hazard and environment research themes. Hazards (fires, floods) are natural occurrences that preserve environmental health.

Global climate change- USGS should play a prominent role in efforts to document man-made changes on climate, as it falls within its expertise and mandate. USGS can contribute to our understanding of global carbon and element cycles, and may be in a unique position of being able to construct the carbon budget of the nation under historic and future land use scenarios. The committee felt that greater USGS participation in global climate change research would help broaden the definition of the problem beyond the current focus on temperature change and atmospheric warming and expand the focus to encompass the range of important issues such as the influence of land use change on climate, the ecosystem services affected.

Climate variability and water resources: USGS should play a major role in determining how climate change will affect water resources.

State of the nation's ecosystems: Encourage interactions among life scientists, geologists, geographers, and experts in surface and groundwater hydrology should address broad questions, such as those posed in the NRC report "Grand Challenges in Environmental Sciences. The USGS has the capability to play a strong role as source of information on ecosystems in the future and:

- Conservation of biodiversity
- Potential effects of climate change
- Invasion and spread of non-native species
- Sustainability of the biosphere

Restoration of aquatic ecosystems – provide technical information to guide and assess aquatic restoration activities, such as the Everglades, CalFed Bay-Delta, and Chesapeake Bay restoration efforts.

Investigations to support wise urban development in the West – because the population in the arid portions of Western US has increased faster than the national population growth rate, complex management problems have arisen. The nation needs an integrated research agenda on sustainable development of the West. The USGS would be "shrinking from its responsibility to provide science for a changing world in response to present and anticipated needs" if it does not embrace this topic.
Who contributed to this report: A committee of 16 academics, corporate and NGO scientists.
Relevance to the USGS/FWS mission: Each of the environmental topics recommended by the NRC for USGS emphasis have direct applications to FWS information needs. It is interesting that a specific region of the US, the West, was recommended in particular for sustainability research. It is also a region of the country that has amongst the most difficult management issues for FWS.

NRC. 2001b. Envisioning the agenda for water resources research in the 21st century. National Academy Press. 61 pp.

Synopsis: Water resource research and dev of last century focused on water quantity, was uncoupled from water quality, and resulted in short-term programs focused on narrow problems. This report addresses water needs for next century and recommends coordination of a water research agenda by creation of a national organization that involves fed and state gov, and all stakeholders. They list 43 water research issues under the broad topical areas of:

1.water availability (enhance supply, limit and control pollution, improve hydrologic measurements, predictions for floods, impact of global climate change on hydrology;

2. water use (understand determinants of water use between competing demands; develop sustainable irrigation strategies; restore aquatic ecosystems; plan for water use in ecologic contex; watershed management.

3. water institutions (develop legal regimes for groundwater management; understand complex governance of water rights; utilize adaptive management; conduct ex post research to evaluate strengths and weakness of past water policies and projects)

In particular they recommended that virtually all future research be conducted with the consideration of water in its ecological role, and the watershed context. And on the whole it is recommended that water research be more organized centrally so that the many institutions involved so not solely focus on their own operational, short term information needs.

Who contributed to this report: With the goal of outlining a roadmap to guide policymakers, the NRC Water Science and Technology Board held a series of meetings in 1998-2000 about the nation's critical water resources issues and research recommendations for the next 20 years.

Relationship to FWS/USGS missions: Many of the 43 specific research recommendations relate directly to the missions of both FWS and USGS, and could be selected for implementation. Probably of highest critical need is for research related to ecological impacts of water use (delivery), and poor water quality on natural resources, and ways to integrate natural resource needs with human needs.

NRC. 2001c. Basic Research opportunities in earth science. National Academy Press. 153 pp.

Synopsis: A series of recommendations for basic research in earth science. Although most of recommendations revolved around the geological sciences, it had a series of recommendations in geobiology that were:

- Prebiotic molecules, origin of life and early evolution
- Biological and environmental controls on species diversity, including ecological and biogeographical selectivity, causes of extinction and survival.
- Response of organisms, communities, and ecosystems to environmental perturbations, including the extreme events in reshaping ecosystems and climate.
- Biogeochemical interactions and cycling among organisms, ecosystems, and the environment, with applications to monitoring and remediating environmental degradation

- Effects of natural and anthropogenic environmental change on the habitability of the earth.

They recommend a major initiative of an Earth Science Natural Laboratory Program with the objective of supporting long-term research at a number of promising sites in the US

Who Contributed to this report: A committee of 14 academics in earth science from various US universities.

Relevance to USGS and FWS missions: The USGS has a major role in earth science research, and most of the above recommendations have applicability to the mission of FWS.

NRC. 2003. NEON: addressing the Nation's environmental challenges. National Academy Press, Washington, DC.

Synopsis: NEON is a vision for a National Ecological Observatory Network for performance of comprehensive, regional- and continental-scale experimental and observational research on the nation's ecological systems to obtain an in-depth understanding of the environment. It would be conducted via NSF partnerships with appropriate federal, state and local agencies and organizations. Six critical environmental challenges that can only be effectively studied on the regional, continental, or global scale were identified:

1. biodiversity, species composition, and ecosystem function
2. ecological aspects of bio-geochemical cycles
3. ecological implications of climate change
4. ecology and evolution of infectious disease
5. invasive species
6. land use

A NEON research "observatory site" would be developed at multiple strategic locations to address each issue at the broad geographic scales appropriate for that topic. Sufficient funds should be created to assume adequate nationwide networks of observatories for each issue.

The purpose of the research would be to assess ecosystem response and formulate effective environmental policy.

NSF would look for suitable research partners on each topic.

Who Contributed to this Report: NSF tasked NRC to form an ad hoc committee to evaluate which major ecological and environmental issues should be addressed only on a regional or continental scale, and whether the current concept of NEON was optimal to address them, and what effects NEON would have on science and society. The committee hosted a web forum with the scientific community and reviewed the reports of 6 NSF-sponsored workshops on NEON.

Relevance to FWS/USGS Missions: The 6 critical environmental challenges identified by NEON have high overlap with our agencies' missions, and the scale of questions being asked are also appropriate to the scale of our agencies' scientific questions. The proposed research mechanism provides a vehicle if our agencies would choose to be a research partner. There seems like tremendous potential for many our agencies' issues, land resources, research centers, and scientists to play major roles in NEON. For example, the BRD Wildlife Health Center could be a central partner in study of infectious disease, the NAWQ and BEST programs could be major contributors to bio-geochemical cycling issues, and the management decision made by FWS (such as HCPs, large-scale consultation decisions, listing decisions) could be monitored as ecological experiments for studies of land use.

NRC. 1993. A Biological Survey for the Nation. National Academy Press. 205 pp.

Synopsis: The National Research Council is the principal operating agency for the National Academy of Sciences and the National Academy of Engineering. The two academies are established by Congress to advise the Federal Government on scientific and technical matters and to further science and technology and their use for the general welfare in the United States. The NRC is administered by both academies and by the Academy of Science's Institute of Medicine.

In 1993, the NRC was asked by Secretary of the Interior Bruce Babbitt to advise DOI on the formation of a National Biological Survey. NRC assembled a Committee on the Formation of the National Biological Survey that included scientists, people with experience in government and industry, and representatives of public-interest organizations. The Committee's charge was to address in a very short timeframe (March-September 1993) the scientific, functional, information and coordination issues related to the scope and direction of the NBS in the context of the larger national picture—*not* to address whether the NBC should be established or to evaluate DOI's specific proposal for NBS.

The Committee's conclusions and recommendations, as described in this report, were:

- The NBS is a critical step toward assembling a comprehensive assessment of the nation's biological resources, but it cannot by itself meet the full range of needs and objects in scientific research, inventory, and information management that a biological survey for the nation must fulfill.

- The United States, under DOI, should establish a National Partnership for Biological Survey (NPBS) composed of representatives of federal, state and local agencies; museums, academic institutions and private organizations. Its purpose would be to collect, house, assess, and provide access to the scientific information needed to understand the current state of the nation's biological resources (status); how that status is changing (trends); and the causes of the changes.

- The NBS should perform research needed for the management of lands within the jurisdiction of DOI and species for which it has responsibility. It should also ensure, through its own research activities and its leadership role in NPBS, that needed research is performed to fulfill the central purpose envisioned for the NPBS—status, trends, and causes of changes of the nation's biological resources.

- Many of the elements of a NPBS are already in existence in various federal agencies, in all 50 states, in organizations such as The Nature Conservancy and the Smithsonian Institution, in museums, in university, in cooperative programs, among private landholders, Native American groups, the United States' territories and possessions, among individual scientists, in foreign biological sources. What is mission are the mechanisms for horizontal and vertical integration and coordination of the ongoing independent efforts. This would be the work of the NPBS.

- A National Biotic Resource Information System should be developed to make existing information more accessible and to establish mechanisms for efficient, coordinated collection and dissemination of new information. For example, NPBS should promote the development of standard sets of spatial data in such areas as actual vegetation of the United States; should participate in the National Spatial Data Infrastructure; and should promote greater awareness and use of spatial data and technologies, including at the field level.

- Most importantly, the Secretary should establish an NBS office in each state to facilitate joint NBS activities and to provide a communication channel among state agencies, private and individual participants, and federal agencies.

Others who contributed to this report: The Committee worked under the oversight of an ad hoc body, the Commission on the Formation of the National Biological Survey, drawn from the membership of the Commission on Life Sciences and the Commission on Geosciences, Environment and Resources.

Relevance to FWS/USGS missions: As early as 1993, the NRC identified the need to integrate information distribution systems and to prioritize and coordinate biological research activities at multiple levels, across sectors, and across nations; and picked DOI for the job. If the scientific literature we have reviewed to date is representative of the scientific community's current position in regard to environmental science, the call for integrated, coordinated information systems and research has reached a crescendo. Our task is to figure out how we will respond.

NSF. 2003. Complex Environmental Systems: Synthesis for Earth, Life, and Society in the 21st Century. A 10-year outlook for the National Science Foundation. NSF Advisory Committee for Environmental Research and Education. 68 pp.

Synopsis: In this document, the Advisory Committee to the National Science Foundation provides strategic guidance to NSF concerning expansion of its environmental research and education activities, as recommended in reports from the National Science Board (2002) and the National Research Council (2001). NSF's mission is to support basic scientific research, to support research fundamental to engineering processes, and to strengthen science and engineering education at all levels. Its outcomes are to be knowledge, methods, and new technologies that help to solve critical environmental problems. This report assumes a 10-year horizon and focuses on environmental activities that cross NSF's organizational boundaries or that are fundamental to NSF's mission.

The emphasis of this report is that scientists, engineers, technicians, resource managers, and educators must work across disciplines, integrate the information they are gathering, and collaborate to solve environmental problems. These relationships must be long-term, dynamic, and cross regional, national, and international boundaries to address problems at various scales. The authors call this process "environmental synthesis."

The good news is that advances in research instrumentation, data-handling, and methodological capabilities have expanded the horizons of what we can study and understand about the environment. Now the need is to frame interdisciplinary research questions and to merge data, approaches and ideas, across spatial and temporal and across society. The authors argue that what will be required is an ability to think outside the box, to draw upon a diversity of knowledge and skills, and to adapt quickly.

Communication of the scientific information, models and conclusions, between and among researchers, students, educators, resource managers, industrial managers, policy makers and the public, is key to success to meeting complex environmental challenges we face, as well as urgent human needs.

The report divides the environmental research frontiers for NSF for the years 2003-2012 into three, interrelated areas:

1) **Coupled human and natural systems:** land resources and the built-upon environment; human health and the environment; freshwater resources, estuaries and coastal environments; and environmental services and valuation

2) **Coupled biological and physical systems:** understanding the systems, processes and dynamics that shape the physical, chemical, and biological environment from the molecular to the planetary scale, including a) biogeochemical cycles; b) climate variability and change; and c) biodiversity and ecosystem dynamics.

3) **People and technology:** seeking to discover new technologies that protect and improve the environment and also to understand how individuals and institutions interact with the environment and how they use resources and respond to change.

Areas include: a) materials and process development; b) decision making and uncertainty; and c) institutions and environmental systems.

The report recommends expansion and improvements in two key areas of NSF to achieve its research and research application goals and to raise up a new generation of professionals to carry forward its work:

1) **Environmental education:** formal, at all levels, from pre-school to secondary, with more incentives in colleges and community colleges to facilitate environmental research; and informal, through parks, museums, zoos, media to increase public understanding of complex environmental information and decisions.

2) **Infrastructure and technical capacity:** as the quantity and quality of environmental data grows, NSF needs to quickly establish a "cyber infrastructure" in which to archive, integrate, interpret, and communicate this information. Interdisciplinary research will rely on experiments and models to understand environmental problems at multiple scales and to develop scenarios and projects for use in policy making and in practice.

Relevance to FWS/USGS missions: This report echoes what appears in other pieces of scientific literature reviewed for this project in that it calls for a holistic approach to environmental research that addresses problems at multiple scales and relies on an interdisciplinary approach. It is one of the few to bring up environmental education as a key strategy in addressing professional recruitment, as well as public enlightenment. USGS in particular would probably benefit from determining what has been accomplished by NSF in implementing the recommendations from their Advisory Committee for Environmental Research and Education. Opportunities to link into their "cyberinfrastructure" may prove useful, and both FWS and USGS might participate in the framing of NSF's research questions if we are not already doing so. Their journey of implementing these recommendations in total may be instructive to us as we pursue "Future Challenges." Obviously, we are already headed in the direction of more extensive information-sharing, as evidenced by the recent e-mail from USGS on the availability online of the Nationwide Invertebrate Community Database.

Pew Ocean Commission. 2003. America's Living Oceans: Charting a Course for Sea Change. A Report to a Nation: Recommendation for a New Ocean Policy.

Synopsis: This report recommends a fundamental change in how this nation manages its oceans (and fisheries). It perceives the oceans are at a crisis point caused by a failure in perspective and governance. We have failed to conceive of the oceans as our largest public domain, not recognized how vital they are to the nation's economy, nor the influence of land activities on the ocean. The foundation of current ocean policy is largely derived from coastal zone laws developed in response to local crisis and the nation's first review of ocean policy in the Stratton Commission in 1969. That policy focused on oceans as a frontier with vast resources and most policies were aimed at coordinating development of ocean resources. Calling US ocean governance "in disarray," the hodge podge of ocean laws and programs, and fragmented institutional involvement has not lead to unified, clearly stated goals and measurable objectives in ocean resource management.

Fundamental conclusions are: the status quo is unacceptable; long term economic stability of oceans depends upon ecological stability; A changed perspective is required that oceans need to be treated as a public trust; and governments should exercise its authority with a broad sense of responsibility to all citizens and their long-term interests.

Overall recommendation: A Reformed US Ocean Policy

To achieve that goal there are 5 priority objectives:

7. a principled, unified ocean policy based on protecting ecosystem health and sustainable use.
8. comprehensive, coordinated governance of resources at a scale appropriate to the problem
    1) regional scale for fisheries mgt
    2) watershed level for coastal dev and pollution control
9. restructure fisheries management institutions and reorient fisheries policy to protect and sustain ecosystems
10. protect important habitats and manage coastal development to minimize habitat damage and water quality impairment.
11. control sources of pollution, particularly nutrients

Actions to achieve the above objectives:

Governance for Sustainable Seas

1. enact a National Ocean Policy Act to protect ocean health, integrity and productivity.
2. establish regional ocean ecosystem councils to dev enforceable regional ocean governance plans
3. establish national system of fully protected reserves
4. establish an independent national oceans agency
5. establish a permanent federal interagency oceans council

Restoring America's Fisheries

1. redefine the objective of the American fishery policy to protect marine ecosystems
2. separate conservation and allocation decisions
3. implement ecosystem based planning and marine zoning
4. regulate destructive fishing gear
5. monitor by catch and management plans as a condition of fishing
6. access and allocation planning as a condition of fishing

Preserving Our Coasts

1. develop a plan to address nonpoint source pollution and protect water quality on a watershed basis
2. identify and protect habitat critical for the functioning of coastal ecosystems
3. at all levels of government, manage development and minimize its impact to coastal ecosystems.
4. redirect government support of harmful coastal development toward beneficial activities, including restoration

Cleaning Coastal Waters

1. revise, strengthen pollution laws to focus on nonpoint sources
2. address unabated sources of pollution, such as concentrated animal feedlots and cruise ships.
3. address emerging and nontraditional sources of pollution, such as invasives and noise.
4. strengthen control over toxic pollution

Guiding Sustainable Marine Aquaculture

1. implement new national marine aquaculture policy based on sound conservation principles and standards.
2. set a standard, and provide international leadership, for ecologically sound marine aquaculture.

Science, Education and Funding

1. dev a comprehensive national ocean research and monitoring strategy
2. double funding for basic ocean science and research
3. improve use of existing information by creation of a mechanism or institution of independent oversight of ocean and coastal mgt.
4. broaden ocean education to all levels of society

Who contributed to this report: The Pew Ocean Commission is a bipartisan, independent group of American leaders created to chart this new course for the nation's ocean policy. It organized leaders from the world of science, fishing, conservation, government, education, business, and philanthropy. Scientist summarized the best scientific information, and organized subcommittees that reviewed the *core issues of governance, fishing, pollution, and coastal development, and subtopics of marine aquaculture, invasive species, ocean zoning, climate change, education, and science.* For 2 years the Commission conducted regional meetings, hearings and workshops around the country soliciting input.

Relationship to FWS/USGS missions: The recommendations in this report are largely aimed at reorganizing or creating a new federal agency to undertake ocean management in a centralized manner. The implication could be that DOC and DOI ocean functions could be eliminated, thus significantly changing many of our program areas. However, under the current situation, there are many recommendations for consideration to improve the ecological sustainability of the oceans. Our agencies can contribute to the development of measurable objectives and examine how our jurisdictional interests are contributing to the fragmented management of ocean resources. Our agencies are also involved in many of the fisheries programs and aquaculture technologies that have oceanic implications, and we manage a small number of marine mammals and T&E marine species, and have a large number of coastal and oceanic refuges, many with critical migratory bird and seabird breeding habitats. FWS and NOAA Fisheries currently have many joint management responsibilities under ESA and MMPA.

Stocking, M. A., 2003. Tropical soils and food security: the next 50 years. Science 302: 1356-1359.

Synopsis: This article predicts the ability of tropical soils to contribute to global food security over the next 50 years. It somewhat challenges the assumption that declining soil quality will lead to declines in food production, claiming that local solutions by the local farmer will extend the usefulness of the soils. This article did not have high relevance to our project.

Science. 2003. State of the Planet. A special series, Vol. 302, 14 Nov. 2003-5 Dec, 2003. A four-week series including eight viewpoint articles on topics ranging from population to energy to fisheries to global change. See the complete citation for each article under the individual authors: Cohen, 2003; Jenkins, 2003; Akimoto, 2003; Karl and Trenberth, 2003; Stocking, 2003; Pauly et al; Chow et al; Gleick, 2003.

Cohen, J. E. 2003. Human population: the next half century. Science 302:1172-1175.

Synopsis: Broadstroke predictions of human demographics. By 2050 the human population will have increased by 2-4 billion to 8.9 billion. It will occur largely in less developed regions. It will largely occur in urban areas, and the population will be older. The human species lacks any experience with such rapid growth and large numbers of its own species. The most important demographic event occurred around 1965-70 when the global population growth rate peaked at 2.1%, and then gradually fell to 1.2% by 2002. Global fertility of women fell from 5 children per woman in 1955 to 2.7 currently. By 2000, 64 countries (with 44% of the people) had birth rates below the replacement rate. In 2000, 19 cities had 10 million people or more, and only 4 are in developed countries (Tokoyo, Osaka, LA, NY). The increase of 77 million people per year will primarily occur in 6 countries: India, China, Pakistan, Bangladesh, Nigeria, US (4% in US). Rich regions have annual growth rate of 0.25%, compared to global rate of 1.22%. In rich countries, population density is 23 people/sq km, half the global average. Life expectancy worldwide is expected to rise from 65 (now) to 74 by 2050. For the first time in human history, more than half of all humans will life in a city in the next decade, whereas the rural population will remain flat. The US is expected to receive the most immigrants in the world. Family structure is changing, with the trend of marriage weakening as number of children decreases and prevelance of divorce increases. In 1994 40% of US children did not live with their biological father, and in 1999 33% of births were non-marital.

Relationship to FWS/USGS missions: human populations will continue to displace wild habitats, in US increasing urban growth, non-rural traditions will increase. Traditions of hunting and fishing less likely to be passed to new generations. Nonconsumptive or urbanized resource use likely to increase.

Gleick, P.H. 2003. Global freshwater resources: soft-path solutions for the 21st century. Science 302:1524-1528.

Synopsis: The 20th century water polices that relied on the construction of massive infrastructure in the forms of dams, aqueducts, pipelines, and centralized water treatment plants is described as a "hard-path" approach to solving water problems. The benefits were tremendous, but their were unanticipated environmental consequences and outcome now incompatible with some of this century's natural resource management goals. New challenges are complicating the current approach to solving water problems including: regional and international water conflicts; dependence of many regions on unsustainable groundwater use, climate change; inability to monitor global water balance. The historic response to water needs has been to build infrastructure to store, move or treat water, and underlying assumptions have been that the demand for water will grow. However, during the 1970s and 1980's the fuller economic costs of hard path solutions to water needs were realized (via fuller consideration of environmental and social costs of dams) and construction projects have slowed dramatically. This article proposes a future "soft-path" approach to water policies that encourage small scale decentralized facilities and improved productivity of water rather than increased supplies. Various examples are described in which alternatives to heavy water consumption are being developed for home, industry and agricultural use. Ecological water needs should be quantified and guaranteed by local and national laws. Efforts should be made to quickly transition to comprehensive soft-path water policies.

Relationship to FWS/USGS missions: Natural resource needs have become increasingly considered in water project planning as various environmental laws (NEPA, ESA) have forced consideration of project impacts, and have played a role in the trend away from hard path water policies toward soft path policies. As long as these laws are in place this trend is likely to continue. To solidify this situation, information could be gathered to more fully quantify ecological water needs (i.e., aquatic resource flow needs, water quality requirements, etc., for various flora and fauna) in order to seek their "guarantee" in local and national laws as suggested by the author.

Jenkins, M. 2003. Prospects for Biodiversity. Science 302:1175-1177.

Synopsis: assuming no radical transformation of human behavior, we can expect important changes in biodiversity (lower) and ecosystem services by 2050. Global surface temp will be 1-2 degree C higher, and atmospheric CO_2 will be 100-200 ppm higher. The effects will occur via habitat conversion, exploitation of wild resources, and impacts of introduced species. Extinction rates will increase, for example, BirdLife International predicts 350 spp of birds might become extinct by 2050, or 3.5% of world avifauna. Mammals and freshwater fishes may have higher extinction rates, but data for them is less complete. The land: because the harvest of marine resources is now at or past peak, terrestrial ecosystems will bear burden of production for humans, primarily in the tropics. Forest cover may stabilize or expand, as urbanization removes marginally productive land out of agriculture. Wild lands will be impoverished, and populations of many species will survive only with intervention or in heavily managed areas. Aquatic ecosystems: marine ecosystems will have lost many top predators, and coastal systems will be extremely challenged by development, anoxia, siltation, eutrophication, and aquaculture. Loss of freshwater biodiversity may continue to occur even faster than terrestrial or marine, as has been the trend for the past 30 years. Conservationists have struggled to demonstrate any increased material benefits to humans of intact or wild systems over largely anthropogenic ones. Even in regard to indirect ecological services, such as carbon sequesteration, regulation of water flow, and soil retention, it seems there are few cases in which these cannot be provided by managed, generally low diversity systems.

Relationship to FWS/USGS missions: Species listings are going to increase and successful conservation of T&E spp will require more land acquisition and direct intervention management. Ecosystem conversion will heavily favor invasive or generalist spp. The need for scientific knowledge and skill in small population conservation, conservation genetics, invasive species management will increase dramatically. The ESA is likely to be challenged and/or reformed as societal choices become increasingly difficult to conserve T&E spp. Scientific information may not support arguments to maintain natural systems to preserve ecosystem functions. Human perception of what is “natural biodiversity” will continue to change as local and global extinctions continue.

Karl, T. and K. Trenberth. 2003. Modern global climate change. Science 302:1719-1723.

Synopsis: Modern climate change is dominated by human influences, which are now large enough to exceed the bounds of natural variability. The main way humans alter global climate is by interference with natural flows of energy through changes in atmospheric composition, not by the actual generation of heat in energy use. On a global scale, a 1% change in energy flows, which is the order of the estimated change to date, dominates all other direct influences humans have on climate. Global changes in atmospheric composition occur from anthropogenic emissions of greenhouse gases, such as carbon dioxide that result from burning of fossil fuels, trapping outgoing radiation in the earth’s atmosphere from going on out to space, thus warming the planet. Rates of climate change remain uncertain, although they are likely to be manifest in important and tangible ways like: changes in extreme temperature and precipitation, decreases in season and perennial snow and ice extent, and sea level rise. Manmade climate change is now likely to continue for many centuries.

Relationship to FWS/USGS missions: Global warming can be expected to produce uncertainty in the persistence of habitats, changes in the timing of natural phenomena (blooms, precip, etc,) and distribution and abundances of flora and fauna. The number of potential influences in profound. A single example is that delivery of water via the California water project may be severely impacted if precipitation in the Sierra Nevada Mountains shifts to an increased amount of rain instead of snow, because the water storage and delivery system was primarily designed to capture and deliver spring snowmelt rather than winter rains. Species and habitat conservation planning will slowly be turned on its ear, and there will be tremendous need for adaptive management skills.

A second lesson illuminated by the issue of global warming is the role of scientific information in the decision-making process. The scientific data regarding global warming is remarkably simple, clear, and unambiguous. By looking at a single graph, the average person can see the relationship that exists between atmospheric carbon dioxide and annual mean global temperature, and the information is compelling. The data even describes a measurement familiar to everyone – temperature. However, despite the fact this phenomenon was detected almost immediately, and in a short period of time was described with general agreement among the scientific community, decision-making and political processes in place to respond to this scientific information are not yet responding with science-based decisions. This illustrates the limits to the usefulness of scientific information for decision makers.

Pauly, D., J. Alder, E. Vennerr, V. Christensen, P. Tyedmers, R. Watson. 2003. The future of fisheries. Science 302:1359-1361.

Synopsis: Analysis of global fisheries is limited as most research focuses on local, species- specific fisheries, which limits development of long-term scenarios. Extrapolating current trends implies expansion of bottom fisheries into deeper waters, impacts to biodiversity, declining global catches. Various management scenarios were examined.

Relationship to FWS/USGS missions: this article had few specifics of use for our purposes beyond the prediction that current trends in heavy sea harvesting will contribute to lowered marine biodiversity.

Science. 2003. 302:1861; 1906-1929. Tragedy of the commons? A special issue. Nine review and viewpoint articles that commemorate Hardin's essay, "The Tradegy of the Commons", and look at trends in the management of common resources in the 35 years since the essays publication. See the complete citations for each article under the individual authors: Kennedy, 2003; Sugden et al, 2003; Rosegrant and Cline, 2003; Mascie-Taylor and Karim, 2003; Dietz, et. al, 2003; Pretty 2003, Adams et al; 2003; Hasselmann et al, 2003; Watson, 2003; Houck, 2003.

Synopsis: All articles in this issue reference the essay "Tragedy of the Commons" by Garret Hardin that appeared in Science in 1968. Hardin drew attention to two human factors driving environmental change: 1) increasing demand for natural resources and environmental services, driven by human population growth and per capita resource consumption; and 2) the ways humans organize themselves to extract environmental resources (i.e., institutional arrangements) and to eject effluents into the environment. He argued that humankind was doomed to overexploit commonly held resources unless the growth of world populations was controlled and these resources were under either private or government control.

Synopsis of each article in this special issue of Science appears below. The article by Dietz, Ostrom and Stern provides a review/overview of the problem of governing the commons; the other articles offer viewpoints on various aspects of the issue.

Sugden, A., C. Ash, B. Hanson, and J. Smith. Introduction: Where do we go from here? Science. 2003. 302: 1906.

Science has a central and urgent part to play in addressing the depletion and damage to critical resources we all share. Options other than forced population control are available.

Dietz, T., E. Ostrom, and P.C. Stern. The struggle to govern the commons. Science. 2003. 302:1907-1912.

Synopsis: Citing the decline in ocean fisheries as an example, the authors contend that advanced technologies for resource use have exacerbated the problems Hardin identified to an unparalleled degree globally; but they disagree that his alternatives for addressing these problems are our only options. They argue that sustaining the earth's ability to support diverse life, including quality of life for humans, will always be a struggle because it involves making tough decisions under uncertainty, complexity, and significant biophysical constraints, as well as conflicting human values and interests. With these challenges to successful governing of the commons in mind, they examine artifacts of an "emerging science of human-environment interactions, sometimes called human ecology or the 'second science'" to clarify the characteristics of institutional arrangements that facilitate or undermine sustainable use of environmental resources.

Highlights of their findings on the requirements for governing the commons:

1. One size does not fit all. Successful commons governance requires that rules evolve.

2. Environmental governance is research-dependent, relying upon trustworthy information about the stocks, flows and processes within the resource systems being governed and about the human activities affecting those systems.
3. Research must be comprehensive and holistic, looking at the resource issue at all levels, including the local level, to ensure that international or national decisions and policies don't overlook important information known regionally or locally.
4. Research information must be of the highest quality scientifically, but also must be translated into a user-friendly language and format for decision-makers, making use of meaningful summary indicators to characterize environmental conditions or human activities
5. Research information must address the issue of uncertainty that is the result of the unpredictability of human-biophysical systems and the fact that science is never complete. Decision-makers need information that characterizes the types and magnitudes of uncertainty and the nature and extent of scientific disagreement.
6. Research information must address individual and social values and the effects of decisions on various valued outcomes. Some values, such as biodiversity, are particularly difficult to monitor and measure, but we must look for ways to do so
7. Recognize that conflict is inherent in environmental choices, and provide for conflict resolution in the very design of resource institutions
8. Induce rule compliance at all levels of society using informal to formal mechanisms and applying modest sanctions on first offenders, gradually increasing severity of sanctions.
9. Whether formal or informal, those who enforce rules must be seen as effective and legitimate by resource users or resistance and evasion will overwhelm enforcement. Command and control is not effective if government lacks the will or the resources to protect "protected" areas. Command and control is more effective at preventing prohibited behaviors than it is at innovating new behaviors or technologies to protect a resource.
10. Tradable environmental allowances (TEAs) are not a cure-all, but they have proven to be an important tool in gaining compliance.
11. Physical and technological infrastructure is essential to setting resource use limits, reducing waste, and to determining the degree to which resource conditions and human behavior can be monitored.
12. To be successful, institutions that govern the commons must be ready to adapt and change, a lesson of adaptive management research.
13. Analytic deliberation that involves scientists, resource users, and interested publics, and involves analysis of research information gathered about resource systems and human-resource system interactions is critical to governing the commons.
14. Institutional arrangements that are redundant and nested in many layers of government are preferable to centralized government control in protecting natural resources.
15. A multiplicity of rules generated by a mixture of institutional types, from hierarchies to markets, will help with information dissemination, development of incentives, monitoring of resource use, and inducing compliance.

16. Sound science is necessary for commons governance, but not sufficient in and of itself.

Relevance to FWS/USGS missions: Both agencies are involved in governing the commons, so the findings 1-16 all have relevance. The findings on how we should gather, use and disseminate research findings are important for USGS. FWS might consider how to institutionalize conflict resolution organizationally, perhaps relying more on mediated outcomes. FWS is cited as an example of successful conflict resolution through a participatory process with the Corps of Engineers, local landowners, environmental groups and academics from several disciplines in resulting the Mississippi River and its tributaries. Both agencies are challenged to address scientific uncertainties and to add research on societal values into day-to-day operations, while recognizing that the latter invites internal criticism that they are departing from "pure" science in so doing.

Kennedy, D. Sustainability and the commons. Science. 2003. 302: 1861.

Synopsis: Defines the global commons as those critical resources we all must share: climate, soil, air, water, energy resources, food, fisheries, and biodiversity. Decades of depletion of these resources have led to the terms "sustainability" and "sustainability science." The author argues that modern definition of sustainability—that with respect to the total of values taken from the environment, the average welfare of the successor generation will be as high or higher than that of the current generation—doesn't take into account issues such as equity or expectations based on historical rates of improvement. We must define sustainability to know exactly how science can contribute. We are having some successes on resource problems at small scales, but less at large scales. The author poses the question: "Can scientific evidence successfully overcome social, economic, and political resistance?"

Relevance to FWS/USGS missions: As conservation organizations, we may define values of nature differently than others, i.e., timber-harvesting is as much a value taken from nature as is birdwatching. A key to overcoming social, economic and political resistance mentioned by Kennedy is to recognize our biases, our paradigm of nature, and to respect other paradigms.

Pretty, J. Social capital and the collective management of resources. Science. 2003. 302: 1912-1914.

Synopsis: While acknowledging the incontrovertible evidence of harm being done to water, land and atmospheric resources by humans, the author rejects the paradigm that has influenced many policy makers and environmentalists, i.e., that to prevent further harm we must manage collective resources by "mutual coercion mutually agreed upon" (Hardin, 1968). Pretty proposes a third way to achieve sustainability, the use of "social capital" (social bonds and norms in communities), which he argues has shown itself to be a successful approach to long-term resource management at local levels and is more humane in accommodating the needs of the poor. His thesis is that "given good knowledge about local resources, appropriate institutional, social and economic conditions; and processes that encourage careful deliberation, communities can work together collectively to use natural resources sustainably over the long term." Social capital manifests itself in four features:

1) relations of trust (lubricate cooperation, reduce the cost of monitoring behavior; take time to build)
2) reciprocity and exchanges (increases trust, refers to exchanges of goods or knowledge or continuing relations over time)
3) common rules, norms and sanctions (the rules of the game, which give individuals confidence to invest in the collective good and knowledge that those who break the rules will be punished)
4) connectedness in networks and groups (bonding among people with mutual objectives, bridging between those groups and other groups with different views, linking of groups to government and other agencies to gain access to their resources or to influence their policies).

Some 400,000 to 500,000 such groups have emerged at the local levels since the early 1990s, benefiting the collective resources issues they are formed to address, while simultaneously improving economic and social wellbeing in the community. Evidence suggests that social capital could be a prerequisite for long-term improvement in natural resources. Regulations and economic incentives are important, but without changes in social norms, people revert to old ways when incentives or regulations are not there. Social capital must be included as a strategy with other strategies that make up for its shortcomings, such as lack of access to the latest science that might contradict locally held beliefs on resource status; or needs of local groups for support from higher level authorities in the form of regulations or laws. Social capital's successes have been at the local to regional level. The challenge is to apply its principles to national and global issues.

Relevance to FWS/USGS mission: The ecosystem approach and its spin-off projects are examples of leveraging social capital to achieve conservation success. Consideration might be given to how apply the concept across organizational programs within our agencies, across agencies, across disciplines, across countries.

Adams, W.M., D. Brockington, J. Dyson, and S. Vira. Managing tragedies. Understanding conflict over common pool resources. Science. 2003. 302: 1915-1915-1919.

Synopsis: Conflicts over the management of commonly held resources are not simply about material interests between stakeholders. According to the authors, history shows that the origins of conflict lie in the perceptions of the stakeholders, in the way they define or frame the problem cognitively. The knowledge that stakeholders, including scientists and policy makers, use to define a natural resource problem fall into three categories: 1) knowledge of the empirical context, i.e., personal experience, inference from similar events elsewhere, empirical or theoretical formal research; 2) beliefs, myths and ideas, i.e., religious beliefs or moral convictions, received wisdom about theory; and 3) knowledge of laws and institutions, the presence or absence of which shapes the stakeholders' views on what options are available to respond to problems.

Policy conflict arises because differences in knowledge and understanding between stakeholders frame their perceptions of resource use problems as well as possible solutions to these problems. Thus, policy dialogue needs to be structured so that differences in knowledge, understanding, ideas, and beliefs in the public arena are recognized. Doing so is likely to improve the effectiveness of negotiations and the trust level between stakeholders by enabling them to understand the plurality of views that exist in the context of resource use and management.

Relevance to FWS/USGS mission: Numerous examples of conflict over resource management in play at this moment in time could be traced back to the different cognitive perceptions of FWS/USGS and other stakeholders, including conflicts with environmental groups. This article opens up the possibility that creating an institutionalized program of conflict resolution that gets at these differences could be of value for us and other resource management agencies.

McMichael, A.J., C.D. Butler, and C. Folke. New visions for addressing sustainability. Science. 2033. 302:1919-1920.

Synopsis: Sustainability is defined as transforming our ways of living to maximize the chances that environmental and social conditions will indefinitely support human security, well-being, and health. Study of the subject is motivated by the steadily accruing evidence that humankind is jeopardizing its own existence by living beyond Earth's means, thereby changing atmospheric composition and depleting biodiversity, soil fertility, ocean fisheries and supplies of fresh water.

Among the reasons that we have failed to achieve a collective vision about how to address achieve sustainability is the failure of four key scientific disciplines to engage interactively on the subject: demography, economics, ecology and epidemiology. The authors argue that all four disciplines are central to the subject of sustainability, but share a limited ability to appreciate that the fate of human populations depends on the biosphere's capacity to provide a continued flow of goods and services. This limitation is a by-product of long-standing Western scientific thought that humankind is separate from the natural world and is its master.

The authors argue that sustainability should be at the top of our research agendas. They recommend that we pursue “sustainability science” and the “science of human-environment interactions” in an inter-disciplinary fashion, working with existing interdisciplinary societies and research networks and creating interdisciplinary centers for such studies that will allow scientists to think and work outside of disciplinary constraints.

Relevance to FWS/USGS mission: This is another call for a holistic approach to science that moves beyond disciplinary constraints to look at the biggest picture of the earth. Within our agencies, there are scientists who are actively engaged in carrying out their missions within the context of the bigger picture. The FWS Asheville, NC Field Office is a key player in the Man in the Biosphere initiative, for example. Consideration might be given to how to institutionalize this larger world view across the FWS and USGS so that we can be both contributors to and beneficiaries of the emerging sustainability science.

Mascie-Taylor, C.G. and E. Karim. The burden of chronic disease. Science. 2003. 302:1921-1922.

Synopsis: International health initiatives are targeted at conditions that cause high mortality (AIDS, tuberculosis, vaccine-preventable diseases), but disease and injury attributable to undernutrition, poor water supply, poor sanitation, and inadequate hygiene are having a huge impact in shortening lives in both rich and poor nations. Soil-transmitted diseases need more attention. In developing nations, an accessible and good quality healthcare system is the pressing need, while in industrial nations, public health education and promoting healthy lifestyles is needed.

Relevance to FWS/USGS mission: Relevant in that it suggests a holistic approach to all that we do, including actively promoting healthy lifestyles among our own employees through policies and programs. Also relevant in that disease is related to poverty, poverty is related to war, war is related to FWS/USGS budget cuts. The world is one big ecosystem.

Hasselmann, K. M. Latif, G. Hooss, C. Azar, O. Edenhoger, C.C. Jaeger, O.M. Johannessen, C. Kemfert, M. Welp, and A. Wokaun. The challenge of long-term climate change. Science. 2003. 302:1923-1925.

Synopsis: To avoid major long-term climate change, average per capita greenhouse gas emissions from developed countries must be reduced to a small fraction of the present levels within one or two centuries. The 1997 Kyoto Protocol, while a historic first step toward reversing the trend of continually increasing emissions, will have a negligible impact on future global warming. Binding commitments to meet short-term emission-reduction targets must go hand-in-hand with clearly defined strategies to achieve substantially more stringent reductions in the longer term.

To avoid predicted temperature increases of 4-9 degrees centigrade and a sea level rise of 3 to 8 meters in the second half of this millennium that will be driven by expanding populations of the developing world, we need to find affordable new technologies. Promising leads are solar, thermal, or photovoltaic energy in combination with hydrogen technology; carbon sequestration in geological formations or the ocean; advanced nuclear fission; and nuclear fusion. The goal of long-term climate policy must be to influence business investments, research, education and public perceptions such that stringent emission-reduction targets, although not attainable today, become acceptable at a later time.

Science can assist the development of long-term climate policies by providing detailed analyses of the technological options and their implications for national economies and global development. The Intergovernmental Panel on Climate Change has played a pivotal role in the climate debate by presenting authoritative reviews of the state of science and on climate change impact, mitigation, and policy. Climate negotiators need scientific analyses of the implications of alternative climate policy regimes for individual signatories to the United Nations Framework Convention on Climate Change.

Relevance to FWS/USGS missions: Impacts at the level of wildlife conservation are not addressed in this piece, although they are in a general way in the article by Watson (2003) that follows. This article addresses a longer timeframe than our committee is presently addressing. Nevertheless, the question arises, whether either FWS or USGS are involved even tangentially in discussions on implications of climate change for our missions.

Watson, R.T. Climate change: the political situation. Science. 2003. 302:1925-1926.

Synopsis: Human-induced climate change is one of the most important environmental issues facing society worldwide. Changes in the earth's climate are projected to adversely affect socioeconomic systems (water, agriculture, forestry, and fisheries), terrestrial and aquatic ecological systems, and human health. Although the near-term challenge for most industrialized countries is to achieve their targets under the Kyoto Protocol (5 to 10 percent reductions relative to the levels emitted in 1990), the long-term challenge is to meet the objectives of Article 2 of the United Nationals Framework Convention on Climate Change, which calls for reductions to 5 to 10 percent of current emissions.

Although the United States currently emits ~25 percent of global emissions of greenhouse gases, the United States has publicly stated that it will not ratify the Kyoto Protocol because:

1) there are scientific uncertainties about projected human-induced changes to climate from greenhouse gas emissions;

2) high compliance costs would hurt the U.S. economy;
3) it is unfair because India and China are not obligated to reduced their emissions;
4) it will not be effective because developing countries are not obligated to reduce their emissions and that is where most of the projected growth in greenhouse gas emissions over the next 100 years will come from.

Watson counters each of these arguments and points out that the United States' unwillingness to sign the Kyoto Protocol will discourage other major developing countries from limiting their emissions and industrialized nations from agreeing to further reductions beyond the Kyoto accord. One encouraging sign is that about half of the U.S. states have enacted climate protection measures of their own and the U.S. Congress is considering initiatives to reduce greenhouse gas emissions. In addition, some companies are voluntarily undertaking actions to reduce emissions and improve the energy efficiency of their products. Watson calls for the United States to sign the Kyoto Protocol and to set longer-term emission-reduction targets as well. He calls it an opportunity to modernize energy systems and to enhance competitiveness in a globalized world.

Relevance to FWS/USGS missions: We have already shown that we can be players in this arena through carbon sequestration on national wildlife refuges. The question arises as to how far and wide we have extended this initiative and what we project as benefits that will accrue in the short and long terms.

Rosegrant, M. W. and S.A. Cline. Global food security: challenges and policies. Science. 2003. 302:1917-1918.

Synopsis: The term "food security" refers to the concern that there will be global food shortages due to an inability of agricultural production to keep up with population demands. Issues affecting food security include HIV/AIDS, which takes food producers out of the economy in countries such as Africa; and climate change, which could result in adverse rainfall conditions for crop production. The authors claim that among the policy and investment reforms needed to ensure global food security is natural resources management. They write, "Agroecological approaches that seek to manage landscapes for both agricultural production and ecosystem services are another way of improving agricultural productivity." Citing the successes of the agroecological approach, they call for pilot programs to work out how to mobilize private investment in such things as biodiversity reserves and habitat improvements and to develop systems of payment for ecosystem services.

Relevance to FWS/USGS missions: At first glance, this subject seems far removed from either agency's mission. Yet some of the infrastructure that the authors recommend be built to ensure food security may already be in place at the local level in the Private Lands programs and other landowner-incentive efforts.

Houck, O. Tales from a troubled marriage: science and law in environmental policy. Science. 2003. 302:1926-1929.

Synopsis: This essay explores the history of the uneasy, 30+year relationship between science and law in environmental policy. It considers the debate over which of the two environmental policy should be based on and how it should be implemented. It concludes that environmental policy based on standards set by scientists has not proven successful, and that scientists have other, more important roles to play.

According to author, prior to the advent of environmental statutes in the 1960s, civil law provided the avenue for redress for environmental harm, but it proved inadequate to the challenge. Civil law failed because science could not make the required proof of harm with the specificity that the law requires.

In the 1960s, public environmental statutes addressed the problem by setting standards of performance that bypassed the rigors of causation and proof. Scientists were relied upon to set the standards. The Water Quality Act, NEPA, the Clearn Water Act, RCRA, CERCLA, TOSCA, FIFRA and the Safe Drinking Water Act are all examples of first-wave environmental law where scientists set the standards. All these laws have failed in large measure to achieve their intent (he claims that a good rule of thumb is that no environmental law achieves more than 50 percent of what it set out to do) because: 1) science isn't dispositive, i.e., doesn't settle things once and for all, by its very nature can be challenged; 2) environmental policy faces public resistance unparalleled in public law because of costs involved, its intrusive nature in people's lives, and the embarrassment involved in public exposure of environmental wrongdoing. When challenged, science failed to provide the proofs in public law, as it had in civil law.

Congress addressed this problem in public law by adopting the standard of "Best Available Technology" or BAT, for environmental discharges. BAT has been amazingly successful as a "just do it" policy that doesn't rely on scientists to set the standards. Its weakness is in how the scope of a proposal is defined, which can lead to a lack of an alternative technology and a failure of BAT to protect the environment.

The result has been that today, all approaches to environmental policy are needed to protect the environment – engineering, science, tort actions, public law, and economic and market incentives. Science still plays a lead role, which is to:

1) sound the alarm on environmental dangers;
2) provide a rationale for the requirement of BAT;
3) provide a safety net by identifying substances so noxious that they need to be completely phased out; and identifying levels still dangerous to humans even after BAT is applied;

4) set absolute standards under the ESA above which no further impacts will be allowed;
5) oversee restoration after damage has been done.

With so much power and so much riding on the opinion of scientists, four cautions are given to scientists:

1) Beware of the lure to return to standards set by science, which will always be subject to challenge as arbitrary and capricious, face crippling political pressure, and produce little abatement.
2) Be wary of the call for “good science,” which can be a way for opponents to manipulate scientific findings they don’t like by insisting on peer review.
3) Be aware that, even with scientists, money talks; and with scientists, following the money is harder to do, thus the public will probably never find out that the science was bought and paid for;
4) Beware the lure of the safe, apolitical life. Given the importance of environmental problems today, we cannot afford for scientists to sit it out.

Relevance to FWS/USGS missions: This article in its entirety deserves careful consideration. It looks at the big picture of where we have been and where we ought not to go again in setting environmental policy. DOI and FWS are used as examples several times in this article. FWS is commended for the “no jeopardy” standard of the ESA, which is seen as a “just do it” policy. DOI is criticized for considering peer review of all science-based agency decisions in the name of “good science.” Finally, the success of Zoo Atlanta director (and FWS partner) Terry Maple and other scientists in preventing the repeal or amendment of several environmental laws in the 1990s under the Contract with America is a powerful statement of why scientists must not “sit it out” where environmental policy is concerned.

Future Challenges Literature Review

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