Written Public Comments on the
Strategic Plan for the U.S. Climate Change Science Program
Chapter 10: Ecosystems (pp 112-120)
Comments Submitted 11 November 2002 through 18 January 2003
Collation dated 21 January 2003

Page 112, Chapter 10: Much like the Land Use chapter, this section did not provide much in the way of specific knowledge that would be gained. The focus was on defining requirements, maps, and databases.

MARK R. ABBOTT, OREGON STATE UNIVERSITY

Page 112, Chapter 10: The 'Ecosystems' chapter does a good job of covering the traditional issues of climate change and ecosystems. The three driving questions can be roughly paraphrased as addressing the 'feedbacks' between ecosystems and the rest of the Earth system, the impacts of global change on ecosystems, and lastly, the possible management responses to both mitigate global change and to adapt to the seemingly inevitable and ongoing global change. I was able to find almost all of the 'key' words that define the current issues in ecosystems and climate change science, such as climate variability, nutrients, disease, multiple scales, multiple stresses and others. Yet, although this is a good beginning, I think the chapter can be improved. My concerns can all be grouped under the heading of a 'lack of dominant, over-arching research themes', that define the most pressing research uncertainties. For example, the atmospheric scientists have focused on cloud physics and precipitation simulation as among their dominant concerns. Likewise, I believe there are similar themes that need a concerted research focus to move global change ecosystem science ahead rapidly.

The primary concern of the UNFCCC is "dangerous interference" with the climate system (defined broadly as that rate of change which will allow ecosystems to adapt naturally to climate change) (http://unfccc.int/). I believe the key, missing ingredient from Chapter 10 is a focus on the rate of change of both climate and ecosystems. Such a focus provides a powerful organizing principle to help prioritize the bewildering array of possible research directions. Most of our accumulated science presumes a non-changing world. Although we've learned much about disturbance, succession, rates of growth and other realms of ecosystem dynamics, we know little about how ecosystems change from one condition or state to a totally different one under a rapidly changing climate.

Consider the elements of 'rate of change'. Climate variability, especially in the interannual (ENSO) and interdecadal (PDO, NAO) timeframes becomes of paramount importance. Associated with climate variability is the frequency of 'extreme events'. It is widely hypothesized that the more rapid the rate of change, the greater will be the frequency of extreme events. Studies of extreme events quickly lead to the frequency distribution of disturbances, such as drought, flood, infestation, disease and others. It has also been hypothesized that the more rapid the rate of climate change, the more likely will the biosphere, via massive disturbances, become a large source of carbon to the atmosphere. We do, however, know that the biosphere has a large buffering capacity. From the longevity of forests to lags in biogeochemical cycles to the adaptability of physiological mechanisms, the biosphere has the capability of absorbing or 'damping' much of the intrinsic variability in the weather. What will this intrinsic buffering capacity withstand?

Thus, a sub-theme to 'rate of change' is that of ecosystem buffering capacity. There are several processes contributing to this buffering capacity, of which we have precious little knowledge. Among the most critical are questions of rate of growth and successional change. After a disturbance, such as a fire, how rapidly do ecosystems regain carbon? What species or functional groups will control ecosystem change. The mechanisms controlling rates of response can be organized into a) physiological, b) biogeochemical, c) demographic, and d) ecological interactions. For example:

- Physiological
    - How adaptive are physiological responses of vegetation to rising CO_2 levels?
    - Do respiration-temperature curves shift with rising average temperatures?
- Biogeochemical
    - What controls the rate of nutrient supply to a recovering or changing ecosystem, including natural nitrogen fixation?
    - What are the exchanges of carbon between upland and aquatic ecosystems, especially in riverine and high-latitude ecosystems?
- Demographic
    - What controls migration rates of species under a rapidly changing climate?
    - Will invasive, early-successional species migrate most rapidly and invade communities with endemic, poorly migrating, late-successional species?
    - Will species migrations increase the risks of species extinctions?
- Ecological Interactions
    - Do more species buffer or protect the ecosystem both from the intensity of a disturbance, as well as from slow rates of recovery after a disturbance?
    - What is the relationship between functional diversity and species diversity?
    - Which functional groups will dominate in the ensuing successional communities?
    - What is the role of herbivores and their predators in governing the rate and character of ecological succession following disturbance, and hence the carbon balance ecological functioning of the ecosystem?
    - What functional groups or species will migrate the most rapidly and what impacts will they have on the ecosystems that they invade?
- Human- ecological interactions
    - How do we partition human-induced from climate-induced carbon source/sink patterns?

In addition to the ecological science issues are a series of methodological issues that must be addressed.

- How do we construct detailed spatial histories of land-use change and management?
- How can land-use and management histories best be assimilated into ecological models?
- Ecological models are rapidly approaching supercomputer demands. Do we have the computer infrastructure to accommodate these models?
- How can we reduce uncertainties in scaling ecological models from landscape to regional and national scales?
- Databases are best developed for industrialized nations. How do we develop the databases to extend high-quality ecological simulations from the National to continental and global scales?
- How do we foster integration among primary research communities representing ecosystems, water resources and atmospheric dynamics?

RON NEILSON, USDA

Page 112, Chapter 10: The term scientific term “ecosystems” is not correctly used; I suggest changing it to “ecological systems.” The reason for this suggested change is that ecosystem has a technical meaning of one level in the ecological hierarchy (individual, population, species, community, ecosystem, biome) whereas "ecological system" is a general term.

Overview comment 2: The chapter does not build upon the extensive work that went into the USGCRP.

VIRGINIA DALE, ORNL

Page 112, Chapter 10: I suggest that this Chapter be completely re-written because little is said about the issue of the response of ecosystems to climate forcing. Most of the discussion in Chapter 10 is centered around “feedbacks”. Understanding of feedback mechanisms is certainly a critical need but equally critical is the need for research on the response of population to climate variability and climate change. Without a solid understanding of the response of populations to physical forcing, or of the response of ecosystems to a different set of predator-prey and competitive interactions that may result from differences in physical forcing, we will be unable to make wise decisions about harvesting natural resources. Thus, the ecosystem discussion as a whole is very imbalanced. At every juncture in the planning document where “feedbacks” are mentioned, another sentence must be added that states the need for better understanding of how physical forcing affects population dynamics and productivity of resource populations. I would be happy to contribute towards a re-write of this section.

BILL PETERSON, NOAA/FISHERIES

Page 112, Chapter 10: The smaller scale feedbacks are omitted in this chapter. An example of feedback on the microbial ecology and activity should be considered. While greenhouse gases may change often it is the microbial component that is the driver for the changes in greenhouse gas flux from the soil. Research has examined the large scale change on gas flux but often black box the processes in the soil. If we are to advance the science there must be an integration of the scientific disciplines. This program could advance the science by encouraging these activities.

Second Overview Comment: Feedbacks on nutrient cycling should be considered in both agricultural and native ecosystems. Altered nutrient cycles as a result of climate change or increased carbon sequestration will change ecosystem responses or may shift ecosystems.

CHUCK RICE, KANSAS STATE UNIVERSITY

Page 112, Chapter 10: OVC 1. The Ecosystems (Chapter 10) embraces many of the major research issues facing the ecological community. The chapter recognizes (but does not pose specifics) the importance of interacting with the social science community and dealing with research efforts related to land use change and carbon sciences.

OVC 2. There needs to be a recognition that ecosystem processes and structure need to be addressed across a gradient of human dominated ecosystems, from the natural, more pristine ecosystems to the urban-industrial landscapes near megacities. This range of ecosystems are needed to better address the feedbacks to global change, including climate change; to evaluate the effects global change will have on ecosystems and the associated societal impact; and for the development of mitigation or adaptive strategies to these changes.

OVC 3. The research plan needs to also provide a clearer strategy for building an integrated framework to incorporate human dimension science within the ecosystem research agenda. This is needed to better understand the factors affecting changes in the carbon and nitrogen cycles, affects on atmospheric chemistry, changes in disturbance regimes, and allocation of natural resources such as water, soil, and land.

OVC 4. Development of ecological forecasting so that scenarios of ecosystem changes can be developed and evaluated would be a useful goal. This would be an important consideration in the development of sustainability strategies for ecosystem functioning and for societal well-being.

DENNIS OJIMA, COLORADO STATE UNIVERSITY

Page 112, Chapter 10: Ecosystem structure and boundaries are shaped by climate change, and the availability and value of living resources can be greatly impacted. Marine ecosystems are especially vulnerable to the effects of climate change. Living marine resources are known to fluctuate in response to interannual to centennial variability in large-scale climate, leading to social and economic dislocations of the fishing industry and the communities it supports.

A number of examples exist where commercial fish populations have been greatly altered by climate change on time scales that upset the social, economic, and ecological integrity of major fisheries. A famous example is the sudden decline of the California sardine in the 1940s, documented in John Steinbeck's Cannery Row. We now recognize that a shift to cooler ocean conditions off the US west coast was a major factor in the reduction in sardine available to the fishery. Since the 1970s, warmer conditions and management have combined to bring this stock back to levels that allowed the revival of a commercial fishery. Studies indicate this is part of a natural climate fluctuation that has modified the California sardine, and many other fish populations worldwide for centuries. A number of fish stocks in other regions - including Japan, South America, Africa - display what appears to be a synchronous boom-bust cycle, suggesting that global fish populations are responding to large-scale climate fluctuations.

Pacific salmon stocks also respond to climate variability. The same warmer conditions that support the sardine appear to impede the growth and survival of west coast salmon, but enhance Alaska salmon production. This apparent contradiction suggests that different ecosystems respond regionally to global climate signals, so it is incumbent to understand the interaction of climate variability with local physical and biological conditions to forecast how individual marine populations will respond to future climate change.

FRANKLIN SCHWING, NOAA/NMFS

Page 112, Chapter 10: **Research on climate change impacts and mitigation strategies for America's valuable public lands and water should be a priority.**

Chapter 10 of the draft Strategic Plan focuses on ecosystem research needs, but fails to mention a key area of research that needs to be conducted, which is research on climate change impacts on our nation's public lands and waters. Approximately 30 percent of America's land is public land that is managed by federal agencies such as the National Park Service, U.S. Forest Service, Fish and Wildlife Service, and National Oceanic and Atmospheric Administration. These agencies are legally charged with protecting natural and cultural resources from harm, including mitigating the impacts of climate change.

For example, four million acres of spruce forests in Alaska are dead or dying due to spruce bark beetle infestation, a problem that will only worsen because of climate change. Warming rivers and streams at Yosemite National Park could devastate whitefish, brook trout, and Chinook salmon populations.

In addition to studying climate change impacts, agencies need to study the effectiveness and feasibility of various mitigation measures including:

- Establishing corridors between wildlife habitats to facilitate expected plant and animal migrations due to climate change-induced habitat loss.
- Increasing emphasis and consideration of new measures to protect endangered species and their critical habitats, to safeguard those plants and animals most at risk from climate change damage.
- Increasing natural control of exotic species to curb anticipated spread of pests and other invasive plants and animals.
- Establishing no-take zones at marine sanctuaries to reduce impacts on already stressed marine wildlife populations.

- Reassessing the boundaries of national forests and parks, wildlife refuges, and national marine sanctuaries to ensure that borders are adequate to protect resources and wildlife from climate change impacts.
- Decreasing water diversions from streams, lakes, and rivers, where water will become critical to ecosystem health as the impacts of global climate change reduce water availability.
- Studying potential methods for maintaining sufficient supplies in water tables, which are important for ecosystem health and preventing catastrophic wildfires.
- Protecting cultural and historic resources, such as lighthouses, from climate change impacts such as rising sea levels and catastrophic wildfires.

CHRISTINE CORWIN, BLUEWATER NETWORK

Page 112, Chapter 10: Ecosystems First Overview Comment: It is important of strike an appropriate balance between observations from FACE and AmeriFlux with research to improve mechanistic understanding of processes. The observational systems can identify interesting responses, but these can not be entered into climate-carbon models or earth system models as interactive elements unless or until the observations can be reproduced by mechanistic models. This latter activity is heavily dependent on research work done by laboratory scientists. Continuation of this work and coordination with observational activities is essential. For example, there is no mechanistic understanding of control of stomatal conductance, arguably the most important physiological regulator of ecosystem-climate interactions. Second Overview Comment: Assuming we have a mechanistic understanding of an important component process, it may still be important to understand how this detailed information can be integrated to the appropriate scale for inclusion in climate-carbon models. Large experimental facilities will be essential for some of this work.

JOE BERRY, CARNEGIE INSTITUTION.

Page 112, Chapter 10: The authors briefly raise the question of how wildfires affect ecosystem albedo and exchange of greenhouse gases. Forest management in general should be a major research priority, because this is a national political issue of immediate importance to land managers. There is a current push to thin forests and use more prescribed fire. Will this result in a short term increase in carbon releases to the atmosphere and a longer term increase in carbon sequestration as forest productivity increases? How do the resultant impacts on climate compare with those caused by catastrophic fires which immediately recycle carbon in huge quantities? Land managers probably can have more influence on climate change through changes in forest management than through any other manageable activity.

Major attention has been focused on sea level changes, and that is appropriate. We also need to pay special attention to the other extreme, i.e., the mountaintops. In North America, with mountain chains that run north and south, the southern mountains are "islands in the sky" with Arctic and sub-Arctic environments. As the climate warms and cools, low elevation species can redistribute themselves north and south, respectively. Species confined to the mountaintops cannot do this, so they are especially vulnerable and they should be given special attention.

Among most categories of species, there will be winners and losers as the climate changes. Most will not require management attention; those at the extremes may require management attention. Among the rare species, those that turn out to be losers may be pushed to the brink of extinction. Among the pest species, those that are too numerous, the ones that turn out to be winners will become even worse pests. An example might be mosquitoes and their associated diseases. Monitoring, research and management should be focused at these extremes.

Maybe there is a principle here ? we need to focus on the extremes.
NATIONAL PARK SERVICE, TERRY CACEK

Page 112, Chapter 10: First overview comment: The issues of land cover change (Chapter 8), the carbon cycle (Chapter 9), and ecosystems (Chapter 10) overlap extensively. In order to closely link the research strategies for these three areas, the three chapters should explicitly reference each other at key overlapping points, as the IPCC authors did for the Third Assessment Report.

Second overview comment: In order to be more useful to land managers, such as National Forest Supervisors and National Park Superintendents, this chapter requires, in the terminology of the IPCC, more Working Group II (impacts and adaptation) and Working Group III (mitigation) and less Working Group I (climate science). Although it is important to understand the climate-vegetation feedback mechanisms given great weight under the chapter's question 1, forest managers more need to know, for example, the impacts of climate change on forest species ranges and the implications of climate change for planning reforestation, prescribed burns, and other mitigation measures.
PATRICK GONZALEZ, THE NATURE CONSERVANCY

Page 112, Chapter 10: Treating resilence to climate change on ecosystems separetly from human contributions creates an artificial distinction that is not helpful for policy making.
JENNIFER BIRINGER, WORLD WILDLIFE FUND

Page 112, Chapter 10: First Overview Comment: The term uncertainty is utilized without any clear definition of the term. As this is the main theme of much of the report, it portrays an incorrect image of climate science that everything is uncertain and that no one can or should act until the uncertainty levels are diminished. It then goes on to lay out a high risk strategy of waiting until an unknown day for uncertainties to be reduced before any action can be taken. The risks are high as the lifetime of greenhouse gases in the atmosphere is long and mitigation efforts will not take immediate effect, unlike some other pollutants. This also ignores decades of research by US institutions and others that have reduced uncertainty levels on a wide range of climate issues. A guide to the uncertainty levels is clearly included in the IPCC's Third Assessment Report.
We would therefore strongly recommend that the report and the research efforts around it not revolve around reducing uncertainties per se, but rather provide new and useful information for policymakers. Finally, to infer that policymakers must have 100% certainty before taking any decisions is not consistent with the current situation. As the

report notes, there are many uncertainties surrounding terrorism, but the government is not waiting for 100% certainty before taking preventative measures such as increasing security in airports.

JENNIFER MORGAN, WORLD WILDLIFE FUND

Page 112, Chapter 10:
First Overview Comment: “Global change”: This phrase is used, seemingly, in lieu of “climate change”, although the latter is used late in the chapter. However the title of this document is “Strategic Plan for the Climate Change Research Program.” Therefore the focus of this chapter should be “climate change.” If however you really desire to discuss “global change”, not just use it as a false synonym for “climate change” then you need to include all of those factors that are crucial to “global change,” such as enhanced UV radiation, pollutants, habitat destruction, invasive species, etc… If you don’t want to do that, stick to the topic of the larger document, identifying it properly by calling it “climate change.”

Second Overview Comment: “Goods and Services”: Ecosystems are about more than “goods and services,” there is a whole body of environmental law, such as the endangered species act, which has the aim of protecting species and biodiversity for their own sake. However there is no mention of the concepts of conservation or stewardship in this chapter. While it is important to make arguments that reach people by discussing direct impacts to them, it need not be done in the absence of any focus on conservation. Put simply, conservation is not just resource management. This chapter fails to examine any of the other aspects of ecosystems. This must be expanded.

Third Overview Comment: There seems to be a great fear of mentioning anthropogenic sources of greenhouse gas emissions in this chapter. It’s sort of like the elephant in the living room that everyone is trying to talk around. You can’t miss it. Failing to mention it in this chapter doesn’t make it not so, it just makes it look like you’re avoiding it.

Fourth Overview Comment: Where is the NAS report? Where is the national assessment? Where is the IPCC TAR? There is a wealth of information out there yet we seem bound and determined to ignore it. In some cases reinventing the wheel or rehashing debates that are already quite mature. Let’s take advantage of the wealth of knowledge that does exist and safe our effort and funds for the questions that get us to solutions, not those that help us put off solutions.

Fifth Overview Comment: Can we really resolve the uncertainties that the questions this chapter aims to resolve in 2-4 years? Many of these issues have been on-going for decades. To believe that we are now going to really focus and tie it all up is optimistic to put it kindly.

LARA HANSEN, WORLD WILDLIFE FUND

Page 112, Chapter 10: This chapter is extremely biased towards terrestrial ecosystems. A large percentage of the human population dependent on marine, and especially coastal, resources in the US and globally. Much greater attention needs to be placed on marine ecosystems in this plan. Additionally, the chapter seems to assume that we only have data from the past 100 years of modern research. Paleoecological data can provide tremendous information on the ability of organisms and ecosystems to respond to dramatic changes in climatic conditions. We need to use the past as a key to predicting future changes in ecosystems and their goods and services.

C. MARK EAKIN, NOAA/NCDC

Page 112, Chapter 10: Overview Comments on Chapter 10 Ecosystems, and Chapter 7 Water Cycle:

I applaud two important components of both these chapters:

a. The emphasis on interactions of climate with human activities, and the emphasis on linkages between all atmosphere and biosphere components (such as atmosphere, oceans, ecosystems and water. The plan appears much more integrated than previous programs.

b. The emphasis on sustained long-term measurements (and the explicit statement that current monitoring efforts are insufficient). Whether on the ground, or via remote sensing, there is inadequate coverage to track changes occurring currently in the water cycle and in ecosystem properties, and not enough information to use as input for models in order to make projections with much certainty.

JILL BARON, USGS

Page 112, Chapter 10: The comments that follow reflect the views of the National Wildlife Federation (NWF), whose mission is to educate, inspire and assist individuals and organizations of diverse cultures to conserve wildlife and other natural resources and to protect the Earth's environment in order to achieve a peaceful, equitable and sustainable future.

First Overview Comment:

If a major "societal goal" is to protect the Earth's ecosystems, then we must address the threat of climate change. This, in a nutshell, is the overarching message in Chapter 10 (Page 113, Lines 6-14). Accordingly, the research effort put forward under this section must be viewed as a process that will provide relevant decision-makers with the scientific basis that they need to develop and implement appropriate and effective conservation strategies – by identifying what is at stake if climate change continues unabated and ways in which we can help minimize its impact on natural systems.

With this overall context in mind, NWF recommends three priorities:

1. *Build on the current state of knowledge to improve our understanding of how climate variability and change affect wildlife and ecosystems in general*. In addition to having gained confidence that human activities are, indeed, altering the global climate system, scientists have already garnered considerable information on the known and potential impacts of this climate change, such as through the U.S. Global Change Research Program's (USGCRP) national and regional assessments and the Intergovernmental Panel on Climate Change (IPCC) *Third Assessment Report*. As

this draft plan acknowledges, scientists can already begin to detect a discernible influence that the current trend of global warming and associated climate change is having on species and habitat. There is, however, much more that we need to learn in order to better understand some of the *mechanisms* by which climate change is altering natural systems and the living things that depend on them.

2. *Rely on the latest climate change models and projections, where possible refined to more local and regional scales, to further identify how changes in climate could affect species and ecosystems in the future.* With an improved understanding of how plants and animals may respond to climate change and associated factors, researchers will be better able to project potential impacts in the future based on scenarios of change identified through climate models and other tools. This will require a well-coordinated effort with other research activities outlined in this plan, including building collaboration between ecologists, climatologists, and other relevant scientists to project potential changes at a more localized scale for vulnerable wildlife and ecosystems. Moreover, researchers should focus not only on the potential responses of wildlife under "business as usual" climate change, but also on the identification of how various scenarios of mitigating climate change, such as by curbing emissions of greenhouse gases, may result in alternative impacts (e.g., fewer species displaced).
3. *Synthesize the information garnered from this effort and develop effective ways to communicate the results to relevant decision-makers.* To help ensure that the CCSP will achieve its stated objectives, every effort should be made to ensure that the knowledge acquired through the research agenda put forward in this chapter (and through the program as a whole) will be made accessible and understandable to relevant stakeholders (e.g., policy makers, resource managers, conservationists, public health officials, business leaders, and so on).

Second Overview Comment:

Against these recommended priorities, NWF does not believe that issues related to ecosystem-climate feedbacks, addressed in Question 1, are particularly relevant for Chapter 10. While the potential for these feedbacks is certainly important, we believe that there will likely be few cases where scientists will find that the feedbacks alter climate change projections significantly enough to warrant major adjustments in their assessment of what the impacts of climate change may be on ecosystems. Probably the most noteworthy feedback would be the increased instance and severity of forest fires brought on by extreme drought conditions in some regions. We recommend that the issue of ecosystem-climate feedbacks be explicitly addressed in conjunction with similar questions elsewhere in the plan (e.g., Land Use/Land Cover Change, Carbon Cycle, Water Cycle).

Third Overview Comment:

Issues highlighted in Question 2 of this chapter should be brought to the forefront. This section is quite comprehensive, and we believe that the plan effectively identifies the key issues that warrant further investments in research. We are particularly supportive of the plan's proposal to address the following:

1. *Multi-scale, multi-species analyses.* There is a significant need for more multi-scale, multi-species analyses that will help determine large-scale patterns and associations

among climate and ecological variables and some of the more specific causal mechanisms that underlie the longer term trends. For example, while we can identify certain trends in species ranges associated with changes in average temperatures, we must also be able to understand some of the specific factors (climate and otherwise) that help determine species' responses to those changes. [See, for example, Root, T.L. and Schneider, S.H. in *Wildlife Responses to Climate Change: North American Case Studies* (eds. Schneider, S.H. and Root, T.L.) 1-56 (Island Press, Washington, D.C., 2002).]

2. *Integrated/multidisciplinary analyses.* Scientists also need to consider how a host of factors may converge to affect wildlife and ecosystems. It is important to note that it is not climate change alone but the added impact of climate change and other environmental problems (e.g., habitat fragmentation, pollution, introduction of exotic species) that will have the greatest impact on the natural world [See Root, T.L., et al., "Fingerprints of global warming on wild animals and plants." *Nature* 421, 57-60 (2003)].
3. *Enhanced data availability and quality.* Each of these research questions will have significant data needs, and we support a certain amount of emphasis on how to expand the availability of data, including through voluntary monitoring efforts.

Fourth Overview Comment:

With respect to issues highlighted in Question 3 of Chapter 10, NWF agrees that, where possible, we need to identify ways in which we can help ecosystems (and the people and wildlife that depend on them) cope with climate change (i.e., adaptation/management strategies). There is no question that we must deal will changes that are already occurring and those that are likely no matter what we do in terms of reducing greenhouse gas emissions. There are clear examples of strategies we must take, as we begin to better understand the effects of climate change, that will help species become more resilient to changes and will protect key habitat. Examples include protection of coastal wetlands and expansion of protected areas beyond park boundaries. Indeed, many of the things we are already doing to maintain healthy wildlife populations and protect key habitat will help. One major oversight in this chapter, however, is that there is no emphasis on the identification of the potential costs and feasibility of adaptation strategies. For example, recent research by the U.S. Environmental Protection Agency estimates that the economic cost of protecting the Texas coast alone from sea level rise could run as high as 12.8 billion dollars (www.epa.gov/globalwarming/impacts/stateimp/index.html). Moreover, there are many species and ecosystems that will never be able to adapt to the changes we are facing. While farmers may be able to plant different crops, red-cockaded woodpeckers are not going to suddenly decide to start nesting on the ground if the trees in their habitat range die off. We will no doubt lose species and, perhaps, entire ecosystems if we do nothing to slow climate change.

Fifth Overview Comment:

Throughout this chapter and the plan as a whole, we need to emphasize precaution. No matter how much we learn about climate change and its impacts, by its very nature, there will always be some uncertainties. With the likelihood that climate change could well be catastrophic, there is no question that we must do what we can to minimize the threat by curbing greenhouse gas emissions.

PATRICIA GLICK, NATIONAL WILDLIFE FEDERATION

Page 112, Chapter 10: Overview Comments on Chapters 8, 9, and 10

Integrate chapters: These three chapters should be merged into a single chapter that addresses land use/cover, ecosystems, and the terrestrial component of the carbon cycle. The marine component of the carbon cycle and comprehensive carbon cycle modeling could be addressed in a separate chapter or in the chapter on atmospheric composition. Integrating the chapters focused on the terrestrial biosphere would reduce redundancy in the exposition, and more importantly, reduce the risk of analytical inconsistencies. For example, terrestrial carbon cycle models often project a terrestrial CO_2 sink without considering changes in land use that could eliminate the forests assumed to be sequestering carbon in response to higher CO_2 concentrations. Integration of the chapters will also help to focus attention on the key interactions and feedbacks between climate change and terrestrial ecosystems, including albedo as well as carbon cycle changes.

DANIEL LASHOF, NRDC

Page 112, Chapter 10: First Overview Comment: The scope of the program is breath taking – tantamount to moving ecology to predictive science – and of immense long-term importance. Yet the plan does not emphasize or even recognize the conceptual, informational and institutional pre-requisites of such a scope. The conceptual issues involve the appropriate means of characterizing ecosystems (which will always involve some degree of regional and historical idiosyncrasy) in ways that capture their full meaning to society: that is, beyond their function in biogeochemical cycling. The informational issues involve the kinds of data needed to flesh out the conceptual frameworks of ecosystems, in other words, the type of biological survey work needed to support prediction. A most promising step has been recent work on assessing the risk of invasion in particular ecosystems in which detailed information on niche characteristics and life history strategies of potential invasive species is used to predict success at different steps in invasion. These researchers should be consulted as they are blazing an impressive path for ecologists. Institutional issues involve the means by which a national program both collaborates and supports researchers working on regional or local ecological systems and either synthesizes or appends that regional work into a national perspective (see First Overview Comment on USGCRP above). So while the objectives are laudable the strategic plan needs to focus far more on the actions needed to accomplish this ambitious program.

CALIFORNIA RESOURCES AGENCY

Page 112, Chapter 10: **First Overview Comment:** There are a series of principles and issues that are touched upon in this chapter – and/or were emphasized by the expert panel at the stakeholder workshop – that can provide guidance in developing a framework for the difficult task of prioritization of systems, scales, and questions on which to concentrate. These issues include:

- The need to identify and understand linkages among ecosystem components, processes, biodiversity, and the provision of ecosystem services

- The key challenge of elucidating the interactions among climate change variables and other layered stressors, which may be operating at different spatial and temporal scales to generate complex ecosystem responses
- The critical role of long term studies to monitor, manipulate, and model key ecosystems in a comprehensive way, both to distinguish the effects of different variables and to "catch" and manage unexpected responses as they occur
- The need to not only monitor future changes, but to use paleoclimatic and paleoenvironmental observations to provide a baseline of natural variability
- The importance of distinguishing and evaluating abrupt threshold responses of ecosystems to climate change factors, compared to rates of change that are more gradual

Furthermore and related to the above, prioritization of research on key focal ecosystems should be based on: **(1)** their sensitivity and ongoing responsiveness to climate change; **(2)** their socio-economic importance to human society; **(3)** their potential to provide historical data on climate change and ecosystem responses; and **(4)** the extent to which research capacity is already in place to assure maximum results from any investment.

Coral reefs qualify in all of the above respects as a critical focal research system for comprehensive monitoring, modeling, assessment and management of the impacts of climate change on ecosystem components, processes, and services. **(1)** Coral reefs appear to be the first ecosystem showing global-scale degradation with a clearly demonstrated linkage to climate change (increasing sea surface temperatures and variability). Coral bleaching has been clearly demonstrated to result from climatic effects and may already be serving as one of the earliest and strongest indicators of the impact of climate change on marine organisms.

Quoting from the IGOS Coral Reef Sub-Theme (Draft), Arthur Dahl and Alan E. Strong (Eds.), Integrated Global Observing Strategy (IGOS) Committee, Submitted 2002: "Coral reefs are . . . now a significant coastal ecosystem under major threat. Widespread episodes of coral bleaching and mortality are being reported from around the world. The combination of local stresses from overfishing, physical destruction, coastal pollution and sedimentation, together with the growing threat from climate change, may result in permanent degradation of the coral reef ecosystem at a planetary scale. In fact, coral reefs may be the first major biological system to respond to human impacts at this scale.…Coral reefs appear to be the first major ecosystem type to show rapid degradation at a global scale due to human impacts."

(2) Coral reefs are a high priority focal ecosystem because of their great economic and cultural value both nationally and internationally. Coral reefs provide food from fisheries, serve as coastal protection structures, contribute major income and foreign exchange earnings from tourism, provide novel pharmaceutical compounds, and serve as repositories for some of the greatest biological diversity in the world.

(3) Corals themselves are recorders of both climate information and ecosystem responses. We already use coral skeletons to generate past (paleoclimatic) records of both natural and anthropogenic climate and we may soon be able to use them to reveal the impact of past climate on an important ecosystem. More work is needed to exploit multi-century coral records to understand natural variability such as El Niño and the Pacific Decadal Oscillation, and to use these records to separate natural from anthropogenic climate change.

(4) As a system that has been demonstrated to be highly sensitive to climate change, coral reefs are already the focus of concentrated study with respect to their responses to climate change variables. The U.S. Coral Reef Task Force is implementing an initiative to better coordinate monitoring, modeling, research, and assessment of coral reefs with respect to climate change – coordination will involve information-sharing and collaboration among not only Agencies but also among national and international non-governmental organizations that are active in this area of research. The initiative is being pursued by NOAA, which is active in remote sensing and modeling, the Department of Interior, which is active in targeted monitoring and research, and EPA, which is active in organizing stakeholder-driven, integrative environmental assessments.

JORDAN M. WEST, USEPA/ORD, ALAN E. STRONG, NOAA/NESDIS, WILLIAM SKIRVING, NOAA/NESDIS, C. MARK EAKIN, NOAA/NCDC, KAREN H. KOLTES, DOI

Page 112, Chapter 10: First Overview Comment: <u>The Federal Document Needs a Strategic Plan for Sea Level Rise (and Other Effects of Climate Change but this Report Does not Move us closer to such a Plan.</u>

The United States has neither a coherent policy nor a coherent research program to address the impacts of rising sea level. EPA, NOAA, the Corps of Engineers, USGS, FEMA, and US Fish and Wildlife Service are each responsible for managing consequences of sea level rise, researching the effects, or both. These agencies are each spending considerable resources conducting research to increase our understanding of the vulnerability of ecosystems to rising sea level, but little or no effort is being made to ensure that the research is coordinated so as to deliver the maximum usefulness. As a result, much of it is duplicative, or designed to only answer the question that one agency immediately needs answered without regard to the many opportunities to accomplish more for the same level of resources. For the most part, our knowledge regarding vulnerability to sea level rise depends on data created by programs that have little or nothing to do with climate change or sea level rise.

For example, FEMA has a $300 million/year program to improve floodplain maps. Accurate maps need good topographic information. Understanding the vulnerability of ecosystems to sea level rise (or precipitation changes due to climate change) also requires better topographic information than the 5- 10- and 20-foot contour intervals available for most regions. LIDAR offers the federal government an opportunity to get elevations to the nearest 20 cm—an order of magnitude improvement and sufficiently precise to understand the impacts of the 1 foot rise in sea level expected in the next several decades (including subsidence). Therefore, it would seem reasonable to assume that a coordinated strategic research plan would ensure that a great deal of the floodplain mapping resources went to LIDAR, which would make for both better flood maps and climate vulnerability analysis.

But this chapter does not get into such "details" (although this "detail" is 100 times larger than the "climate science" budget devoted to impacts of sea level rise). If an agency chooses to not call a program "climate science", then this chapter does not recognize it—even if such a program does more for climate science than the programs it does include. Nor does the chapter deal with all of the other questions of coordinating research designed for various purposes but which could allow us to advance our understanding. The chapter simply lists some questions—as if it's sole purpose was simply to provide a general guidance to scientists apply for grants, perhaps as a yardstick for the "relevancy reviews" for the grant programs.

And so, the federal government is on it's way to missing the best opportunity in decades to actually reach a meaningful coordination on optimizing America's understanding of how to deal with sea level rise. FEMA employees have told me that in many cases, they will not collect LIDAR but will instead produce better maps using the same inadequate data that the existing maps use. Why? Because their management objectives tell them to produce a specific number of maps; 'tis better to produce 20 improved maps that still use inaccurate data, than to produce 10 maps that use dramatically improved data. From the perspective of the Flood Insurance Program, more maps with poor data may make sense. But from the perspective of the United States of America, a smaller number of maps with good elevation data would be better, because the federal climate program and other non-FEMA programs (e.g. Corps of Engineers, state emergency management, EPA hazardous waste spill response) would also be able to make use of that better elevation data.

We have an opportunity to at least develop a strategic plan that identifies a more rational use of federal research funds. The authors of this chapter, however, have indicated that they do not believe that they are supposed to develop a strategic plan that looks at this larger picture of federal resources. One has to draw the line somewhere, and for most of the scientific issues it may make sense to only consider resources labeled as "climate science" by the sponsoring agencies. But in the case of sea level rise—and probably some of the other effects as well—this approach excludes most of the important research. At the very least, the chapter needs a disclaimer explaining that the strategic plan is not really a plan for how the federal government can answer the key questions regarding impacts of sea level rise, because CCSPO decided not to consider most of the federal research related to those effects or analyze strategic choices. A better approach, however, would be to revise the chapter—and perhaps re-organize all of the chapters related to effects of climate change—to include a discussion of the objectives, the research taking place and needed to achieve those objectives, and a plan for meeting the objectives.

<u>Second Overview Comment:</u> The chapter summarizes the types of issues upon which research is likely to focus. The two summary questions deal with impacts and adaptation, which is entirely appropriate—and the discussion reads fairly well, albeit at a very general level. The chapter, however, is not in any sense a strategic plan, because it does not present specific objectives, measures of success, options for achieving success, criteria for choosing between options, or recommendations for setting priorities among

competing areas of research. Therefore, it would be useful for the chapter to state that it is not a strategic plan but rather a discussion of the broad research questions and current plans for research.

JIM TITUS, EPA (NOTE DISCLAIMER)

Page 112, Chapter 10: Biodiversity
Biodiveristy is mentioned in several sections of the plan, including the ecosystems chapter, however it may be under-emphasized as a contributing research element with regard to the assessment of climate impacts on ecosystems. That impact is measured in terms of ecological "goods and services" to human society.

Current assessments, such as GEO-3 and PAGE, strongly emphasize the critical importance of biodiversity to ecosystem function. While the exact relationship between biodiversity, resilience, and productivity may vary at different scales and in different systems, it is universally recognized that biodiversity is Nature's "insurance policy," and, as PAGE states it: "Biodiversity underlies all ecological goods and services."

Human and climate-induced impact on biodiversity has grown rapidly and dramatically in the industrial era. The rate of extinction now rivals that of the largest extinction events in geological history. Because of the potential direct consequences to society, the indirect effect on climate through ecosystem change, and the cumulative effect of increasing ecosystem vulnerability to climate change, biodiversity must be considered a major interest of the CCSP.

NOAA-NESDIS, KINEMAN

Page 112, Chapter 10: 1. Managed ecosystems, primarily for food production, are a particularly important part of food security for the US. This chapter, in general, does not give sufficient weight to this importance. Whereas natural systhistems are very important, the managed systems may be even more so in terms of homeland security. This aspect of the research plan needs to be enhanced substantially.

2. Below ground ecosystems are completely left out of the research plan; these should be added and they are especially important as a link to soil-borne pathogens and other microbes and they also feed into the water and carbon cycle in a major way.

3. Nothing is said about how the rate of climate change may impact ecosystems goods and services; it is easy to move annual crops (relatively) but very difficult to move perennial forests. Consideration of managed ecosystem susceptibility to extreme events and climate variability would be helpful.

4. Research is needs on how important rate of change is in regards to impact on agricultural productivity. Are there rates of climate change that are likely to cause catastrophic disturbances?

5. Managed ecosystems may be most susceptible to change; a matrix for rate of change needs to be developed so that those systems most susceptible will receive top priority for research.

6. More research is needed on plant disease and drought resistance as impacted by global change

STELLA M. COAKLEY, OREGON STATE UNIVERSITY

Page 112, Chapter 10: I recommend that you refer to the report, *The State of the Nation's Ecosystems –Measuring the Lands, Waters and Living Resources of the United States* by the H. John Heinz III Center for Science, Economics and the Environment, to establish a framework to identify sensitive ecosystems and establishing trends.

GEORGE WOLFF, GENERAL MOTORS

Page 112, Chapter 10: Climate warming changes are underway, especially in Alaska, not only prospective or potential.

GUNTER WELLER, ET AL, UNIVERSITY OF ALASKA FAIRBANKS

Page 112, Chapter 10: In this chapter, and elsewhere in this document less frequently, the phrase "ecosystem goods and services" appears almost platitudinously numerous times, and there are no indications that the authors place any (market) value on "ecosystem goods and services". Apparently, the authors only value ecosystems if they can absorb carbon. This is quite strange considering that on page 5, the text reads as follows (lines 26–31):

"*Emissions of greenhouse gases and pollutants and extensive changes in the land surface (both tied to widespread development of modern living standards) have potential consequences for global and regional climate. They also influence air quality, the Earth's protective shield of stratospheric ozone, the distribution and abundance of water resources and many plant and animal species,* ***and the ability of ecosystems to provide life-supporting goods and services***" (emphasis added).

Clearly, the value of ecosystems' "life-supporting goods and services" is greater than $0. Not placing a value on them is not only incorrect, it also distorts cost-benefit analyses by underestimating the benefits (costs) of preserving (destroying) ecosystems and their life-supporting functions.

Research into adequately and properly valuing ecosystems is essential for being able to conduct meaningful cost-benefit analyses. Such research is missing from this document (notwithstanding an apparent allusion on page 119, lines 34–35), and it should be added.

DAVID L. WAGGER, SELF

Page 112: The tone of this chapter may also deflect some its thrust, by overlooking the rather widespread sense that we are not currently managing resources sustainably, let alone can start with current practices and allocations for ensuring and improving sustainable services and goods from ecosystems (also P. 117, 118). Similarly, identification of adaptive measures is not the same as identification of obstacles to implementation.

JOHN WIENER, INDIVIDUAL COMMENTATOR

Page 112, Chapter 10: In questions 2 and 3, the strategic plan stresses the consequences of global change on goods and services. It would also be worthwhile here to include consideration of the fact that ecosystems also provide non-economical values (e.g. in the form of aesthetics and recreational opportunities) to humans. We acknowledge that these values are mentioned elsewhere, but believe that these values warrant more attention. Perhaps these values might be given their own question, "What are the potential consequences of global change for ecosystems and the sustenance of aesthetic, spiritual, and recreational resources?"

CALIFORNIA ENERGY COMMISSION

Page 112, Chapter 10: The terrestrial biosphere plays a central role in the global change science. While we must be cognizant of ecological systems over a wide range of scales, ecosystems are an appropriate scale on which to focus. Ecosystem analysis, as presented in Chapter 10, must be a major part of how we as a science community and we as a nation address the challenges of atmospheric and climatic change. As this chapter rightly points out, ecosystems have a dual role - they are important regulators of atmospheric composition through the global carbon cycle as well as providing other feedbacks to local and regional climate, and secondly, the likely responses of ecosystems to climatic and atmospheric change over the next few decades will be a primary way by which global change impacts people. The two roles are complementary - the responses of ecosystems to global change can exacerbate or moderate their feedbacks to the atmosphere, and understanding the current relationships between ecosystems and climate helps us to predict responses to changing conditions. Aspects of ecosystem research is seen throughout this science plan because of the importance of ecosystems in the carbon cycle, water cycle, land use issues, monitoring needs, and so on. Hence, a coordinated and tightly integrated research program is essential. A compelling vision is strongly needed to ensure that ecosystem research is not relegated to a side issue (e.g., to appease the "tree-huggers") but is central to the CCSP.

Second Overview Comment: Chapter 10 includes the important elements of a strong research program that encompass the dual role of ecosystems in global change analyses and the important organizing principle of ecosystem goods and services. However, those elements are not presented in a compelling manner that would lead to a comprehensive and well-integrated program. I recommend that the framework of the *Pathways* report be revisited to provide this chapter with better focus, clarity, and scientific rigor. A new ecosystem monitoring program that links observation, manipulation, remote sensing, and modeling could provide a focus for efficiently and comprehensively addressing the critical questions that have been posed. This chapter gives me reason to be concerned, however, that there is not a genuine commitment in the CCSP to address these needs.

RICHARD NORBY, ORNL

Comments on Chapter 10

Page 112, Chapter 10: A significant challenge in conducting integrated assessments of the implications of climate change across natural and societal systems is that associated with valuing non-market aspects of natural ecosystems, including the broad range of goods and services provided by ecosystems. Significant consideration needs to be given to improving methods for valuing ecosystems so that they can be sufficiently represented in integrated assessment models, and the implications of climate change for ecosystems can be effectively communicated to policy-makers. This is necessary to ensure that analyses of mitigation and adaptation policy alternatives reflect the full range of consequences associated with climate change, including values not readily monetized.

Comment 2
The study of impacts, to natural systems as well as societal systems and human health (Chapter 11), are temporally constrained, limiting understanding of the long-term implications of climate change. For example, impact assessments have traditionally been performed in response to the climate change associated with a doubling of the pre-industrial concentration of atmospheric CO_2. Although differences in climate models result in a range of climate change for a CO_2 doubling, current projections indicate that atmospheric CO_2 will reach a doubling of pre-industrial concentrations toward the middle of the 21st century, suggesting many studies only estimate the implications of climate change for the next several decades. As a consequence, decisions regarding policies to address climate change may be based upon short-sighted assumptions regarding the consequences of climate change. Granted, impact assessments are increasingly attempting to estimate the consequences of climate change over the next century, but even this is an arbitrary time period. Although it is helpful to have information on the consequences of climate change over the near-term, information is also needed on time-scales relevant to the affected system. Furthermore, there is a need for information on the transient impacts of climate change (i.e., how impacts change over time) as opposed to projections of impacts for a given time period. There are multiple examples, particularly agriculture and forestry, where the anticipated impacts of climate change may be positive over short-time scales, but negative over long-time scales. These temporal dynamics may be important for policy development.

VICKI ARROYO AND BENJAMIN PRESTON, PEW CENTER ON GLOBAL CLIMATE CHANGE

Page 112, Chapter 10: In the Products and Payoffs section regarding each major research question, the longest study period mentioned is 4 years or > 4 years. Solid quantitative study on the relationship between global climate change and ecosystem response requires multi decadal research to determine the biological response to cyclic climate cycles and the long term effects of global change. For example, in temperate Pacific marine systems, we are only beginning to discover the strong biological consequences of long term climatic cycles (~25 years) like oceanic regime shifts, and their potential interaction with climate variability of shorter periodicity, such as El Nino events. It must be made clear that truly long term research on the scale of decades is needed to properly examine these questions. The simplest way to accomplish this is to continue to support and utilize the few long term monitoring programs which already exist at the appropriate temporal scales.

Second Overview Comment: This language in this chapter repeatedly refers to ecosystem "goods and services" in relation to research questions. I believe this is a dangerous concept to insert into a research framework. Ecosystems are complex and integrated, and often crucial components to the stability of those ecosystems are not "goods and services" in our eyes. Though a certain component of an ecosystem may not constitute a direct economic "value" to humans, that component may be important to the structural integrity of the ecosystem.
RUSSELL BRADLEY, PRBO CONSERVATION SCIENCE

Page 112, Chapter 10: There are significant couplings between Atmospheric Composition, Carbon Cycle and Ecosystems. Clearly the mechanisms coupling the Carbon-atmosphere-Ecosystems are at the core of this CCSP plant.

Again I will stress the need to develop process level studies on ecosystem response and function. They could be examined by choosing sites over a wide enough dynamic range geographically, having sites where factors change significantly on an interannual basis. Again as stresses in Chapter 9 Comments Biosphere-2 type facilities could provide data to develop robust models. In particular feed-backs such as terpene (e.g.. isoprene) production by plants and its response to climatic stresses can effect the carbon cycle. For example, terpenes have been hypothesized to help Plants manage stress (Sharkey et al.), and it is know to produce ozone in air when NOx is available which will damage plants. High CO2 may favor fast growing woody plants, hence diversity could disappear. Such carbon cycle feedbacks need to be tested and evaluated.

We know very little about soil microbial communities and their responses to climate variables and stresses. The control CO2, N2O, CH4, H2…fluxes in a major way. This area needs to be investigated and process level models developed to assess these soil-plant-air couplings.

Satellite measures for ecosystem activity on land and ocean should be regularly interpreted and analyzed by appropriate models.
MANVENDRA DUBEY, LANL

Page 112, Chapter 10: Provide a greater focus on wildlife and biodiversity concerns. The section overemphasizes the functional and use-value of ecosystem services to humans without adequately reflecting the intrinsic value of ecosystems and their components.

At the ecosystem level:

- Address ecosystem rates of change, buffering capacity and thresholds for recovery.
- Address the potential impacts of multiple environmental stresses (e.g., climate change, pollution and resource extraction).
- Assess the impacts of different adaptation/mitigation options on ecosystems and biodiversity (e.g., management of changing fire regimes, siting of wind farms in marine environments, geological sequestration, construction of sea walls, increased biomass developments).

- Provide greater detail on potential ecosystem impacts at the regional level with a focus on identifying scientific and management tools for localized adaptation and mitigation options.
- Use impacts on national parks and wildlife refuges as case examples. Such work should incorporate climate monitoring already being conducted in these areas (e.g., National Park Service's "Vital Signs" program).

At the species level:

- Focus on the role of invasive species in ecosystems impacted by climate change.
- Focus on the inter-relationship between migratory species and their ecosystems.
- Identify species unable to cope, particularly if already endangered.
- Identify potential response options to protect and conserve genetic diversity *in situ* and *ex situ*.

More generally:

- Consider rapid response teams to address the science and adaptation/mitigation strategies in cases of rapid climatic changes at the ground level.
- Utilize a wide range of qualitative and quantitative inputs, including from indigenous groups and local communities.

STAS BURGIEL, DEFENDERS OF WILDLIFE

Page 112, Chapter 10:
First Specific Comment: "What options does society have to ensure that desirable ecosystem goods and services will be sustained or enhanced in the face of potential regional and global environmental changes?" We could begin to address the problem of climate change by reducing our emissions of greenhouse gases. Has anyone thought of that yet?

Second Specific Comment: "Global environmental changes are altering the structure and functioning of ecosystems, affecting in turn the flow of ecosystem goods and services. Research during the last decade focused on the vulnerability of ecosystems to global change and contributed to assessments of the potential impacts of global change on ecosystems at multiple scales. We now know that impacts of environmental changes and variability may be manifested in complex, indirect, and conflicting ways." All the more reason the act NOW, and not wait for more evidence that we are heading down the slippery slope.

Third Specific Comment: "A positive feedback intensifies the environmental change whereas a negative feedback slows the change. Both positive and negative feedbacks could be brought about in many ways. A positive feedback could occur, for example, if warming and drying (caused by rising atmospheric CO2) of high latitude ecosystems containing large amounts of carbon in plants and soils (e.g., tundra and peatland) resulted in greater ecosystem respiration. That increase in respiration would accelerate the atmospheric CO2 increase, which could accelerate the warming and drying." Why are we gambling with these complexities? The only rational response to these possible outcomes is to reduce emissions starting now.

Fourth Specific Comment: “How might various global and regional environmental changes (e.g., temperature and precipitation) affect ne ecosystem exchanges (or timing or geographic distribution of those exchanges) of greenhouse gases?” No need to appropriate funding for this research question. Just wait and see if Bush and Dick get their way.

Fifth Specific Comment: “Ecosystems research needs include ecological experimental facilities, improved ecosystem models, and enhanced ecosystem monitoring capabilities and programs (at different scales) to link point observations with remote sensing data to scale up. New research and monitoring programs may be too expensive, so the major efforts might be directed at enhancing existing capabilities.” Someone needs to ... tell dick and bush to stop *[messing]* around with our planet.

Sixth Specific Comment: “Management practices may result in positive or negative feedbacks to the climate system by altering emissions, carbon and nutrient storage, or reflectivity of the Earth’s surface. However, while specific management strategies have been investigated, society’s knowledge and ability to manage the broad array of ecosystem services in the context of increasing and potentially conflicting demands is extremely limited.” How can we “manage” ecosystems when we can’t even manage a budget or industry? And you think ten years of under-funded research will change this? Please attempt to talk some sense into your boss, Bush. Everyone is counting on you!

TODD MARSE, UNO

Page 112, Chapter 10: In many respects this chapter hits the main points with regards to Ecosystems and Climate. I often found myself identifying a weakness or missing point, but then found the subject mentioned a paragraph or too latter. It is a tough job to write reports like this and make everyone happy. Either they are too broad, too parochial or don’t have enough specifics. This report does fall into the too broad category, but overall, this report does the job it intends.

Q1 is broad but an important question. Being a plant ecologist I tend to think in terms of plants, but one may need to be more specific and refer to terrestrial (plants, vertebrates and invertebrates) and aquatic ecosystems. There may also be a need to pose special questions for each grouping as the linkages, responses and vulnerability to climate change will be different.. Fire regimes and their links to climate may alter the health, sustainability and dynamics of forests, while overfishing, eutrophication, deteriorating water quality and El Nino may alter the status of aquatic ecosystems; as I read on I must confess I am seeing text addressing these issues, but in a very broad sense.

Q2 is on target, as we need to know if ecosystems can or will continue to take up carbon or will be so perturbed that their ability will change. Of course this question also involves knowing about ecosystem dynamics, invasion of species etc. Water yield and quality continues to be a major aspect of this question. Maintaining air quality is another benefit of ecosystems. Beauty and recreation are important, but hard to identify..

We need to increase our focus on landuse change. It is my feeling and that of growing evidence in the literature that landuse change is more important than the effects of elevated CO2 or N fertilization with regards to studying the carbon balance. Question relating to fire are particularly important. As the climate changes will fire be more important? Should manage fire as we have? Will different species invade if we change fire region and will it alter carbon cycling? As I peruse more of the report I see separate chapters addressing these questions, so I think the pieces are in place.

Any program on ecosystems must address multiple time and space scales. I see verbiage in this report specifying this fact. The report may need to be more specific on how to address ecosystems across many time and space scales. I'd rather see material devoted to this issue that a tutuorial on feedbacks. One consequence of non-linear processes and multiple scales is unanticipated responses! This message needs to come through strongly in this chapter. We have many examples of ecosystem mismanagement because we did not consider complex interactions. In California, selenium build up and water fowl die off in the San Luis reservoir is a classic example and consequence of irrigating desert, without a proper avenue for runoff.

The response and vulnerability of ecosystems to drought, pests and disease will follow along similar lines of study and should be of concern and consideration.

In my review of ch 9 I mentioned studying the role of switches, such as length of growing season, water table, drought, frost etc. This recommendation is critical here too. Late frost could affect reproduction, water tables reduction could cause more

Many Research needs are identified, but they either tend to be too broad or involve work already being addressed. Is it the purpose of this report simply to provide a laundry list to Congress and the agencies of work that is considered to be important and to be sustained? Or should it identify new avenues of research or areas that are underfunded? The answer to this question would cause one to produce much different chapters.

Having centralized data repositories will be important for evaluating the research. More efforts along the lines of NCEAS would help too; think tanks that support short term efforts to bring scientists together to address science questions and that support postdocs who aid in the distillation of data.

As with the Carbon Chapter, I also recommend coupled models that link climate, biosphysics, biogeochemistry and stand dynamics, eg models of Foley, Pacala and Prentice. Testing, parameterizing and further development of these state of art coupled models will be critical for making good decisions.

DENNIS BALDOCCHI, UNIVERSITY OF CALIFORNIA, BERKELEY

Page 112, Chapter 10: This chapter is not nearly as strong as the others.

ANTONIO J. BUSALACCHI, EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER (ESSIC), U. MARYLAND

Page 112, Chapter 10: I have just finished my reading of the "Ecosystems…" chapter of the CCSP strategic plan. My general reaction is that the text is comprehensive and the content high in quality. I am pleased and privileged to observe the shift toward viewing global change as a challenge and opportunity, as opposed to a problem. The transition is not just politically expedient. I believe that the entire scientific knowledge base, from thermodynamics through biology to behavioral psychology, dictates that this is the attitude which humankind must inevitably adopt. The writings of Van Bertalanffy on General Systems theory, the Odums on ecological energetics and recent emergence of rigorous studies of human cultural evolution are consistent on this point.

I think that I may have only one major comment to offer which has a probability of escaping other readers. Consistent with the above, the community might find it useful to conceive of societies and cultures as ecological entities. If we could move beyond anthropocentrism at least partially by applying the basic principles of physics and biology to our own behavior in the context of global change, new and useful concepts might arise. The result would of course not be pretty. Scientists and policy makers alike would have to take a deep breath and grapple with likelihood that the planetary environment will soon be recognized as a resource worthy of geopolitical gaming and conflict. But the result would certainly be fascinating. Imagine representing human cultural competition within an earth system model as first world globalization raises issues of planetary ecological governance. Great stuff. The sooner the community gets started on it the better. And incidentally since much of the research will be proprietary and covert, the DOE is one of the right forums. In my conception, energy channeling attenuated by population dynamics, biogeochemistry and technological innovation leads to clashes of gross cultural product, winners and losers, and a potential for stabilization of the biota a la Gaia.

I will conclude by making a few minor points. Multiple use of the term "vulnerability" presages a convergence with the new technologies of homeland defense. As we secure our own cities and territories and expand our military economic dominance, it will be necessary to ask whether global scale resources are also safe. If we cannot be attacked directly, other cultures will conceive of harming our coastlines, forests and ozone layers. In the "feedbacks" box I would recommend the inclusion of a marine geochemistry example for purposes of balance. The ocean covers three fourths of the planet but scientific managers tend to forget that it is there. The remote sensing challenge should be thought of in a spectrally resolved manner and always extended from land surfaces to include ocean physics and ecosystems. Iron geochemistry is as important as the carbon and nitrogen cycling which draws most discussion in the text. In several locations the white paper states that there is the need to "improve" ecosystem goods and services. This cries out for definitions which could be quite illuminating. "Improve" in the view of whom, or what?

SCOTT ELLIOTT, EARTH AND ENVIRONMENTAL SCIENCES, LANL

Page 112, Chapter 10: The scope of research needs and potential questions within this chapter is quite inclusive. The report needs to address the need for multiagency and multilocation projects to address these issues. The scope of the research program required to answer the questions posed in this chapter will require the development of an infrastructure that views the ecosystem(s) from a number of perspectives.

Second Overview Comment: The research questions within the ecosystem context will provide some answers to critical questions. I am concerned about the scope of these questions may not include measures of efficiency, e.g., light capture efficiency, water sue efficiency, etc, so that direct comparisons of ecosystems can be made.
JERRY L. HATFIELD AND STEVEN R. SHAFER, USDA-ARS

Page 112, line 3 add question:
What are the potential consequences of global change for ecosystems and the delivery of their goods and services?
GUNTER WELLER, ET AL, UNIVERSITY OF ALASKA FAIRBANKS

Page 112, Line 4: **This Chapter NEEDS A BASIC TENET STATEMENT, BEFORE PROCEEDING: E.G.:**
Given: There is no question that the main force behind today's Ecosystem Changes is human population growth and expansion of human population onto ecologically fragile terrain. Both fewer people and minimal downstream contaminants are the obvious solutions. This section will focus on Ecosystem Function and particularly Climate-related Issues, rather than the solution to the over-riding problem of too many people, their footprints, and their numerous stressful downstream consequences.
GARY D. SHARP, CENTER FOR CLIMATE/OCEAN RESOURCES STUDY

Page 112, Lines 5-17: The "goods and services" focus is distracting from the heart of the issues.
LARA HANSEN, WORLD WILDLIFE FUND

Page 112, Lines 5-7: The inclusion here of ecosystem services is appreciated. It is becoming increasingly evident that ecosystems provide services to humans in the form of clean air and water, through the recycling of elements, and through flood and storm control. Historically, these services have received little consideration because it is difficult to quantify their economic value. Inclusion of these ecosystem services, in addition to goods that have traditionally been considered (e.g. food, timber, and pharmaceuticals), will foster an increased understanding of the effects of climate change on ecosystems.
CALIFORNIA ENERGY COMMISSION

Page 112, Line 8: NWF recommends broadening the definition of ecosystems to reflect their importance to wildlife and biological diversity, not just to "goods and services" valued by humans.
PATRICIA GLICK, NATIONAL WILDLIFE FEDERATION

Page 112, Line 10-13: Add that this is called "resilience".
JENNIFER BIRINGER, WORLD WILDLIFE FUND

Page 112, Line 14-16: Add that this is called "resistance".
JENNIFER BIRINGER, WORLD WILDLIFE FUND

Comments on Chapter 10

Page 112, line 14-16. An overarching organizing principle throughout this chapter is that ecosystems provide critical goods and services to humans. Much of the research on ecosystems and global change in the past decade has focused on carbon cycling, an important ecosystem service, but only one part of the equation. The CCSP takes an important step forward by putting ecosystem goods and services as a central focus, and I strongly endorse this. Because the term is sometimes misinterpreted (as at the workshop) to refer only to extractive resources, it would be wise to provide a definition and explanation of the term (perhaps a box such as that for feedbacks?). Here is some text that might be useful somewhere in this chapter:

Ecosystem services represent the benefits human populations derive, directly or indirectly, from ecosystem functions (Costanza et al. 1997). Ecosystem services consist of flows of materials, energy, and information from natural capital stocks which combine with manufactured and human capital services to produce human welfare (Costanza et al. 1997). Examples of ecosystem services include atmospheric and climate regulation (including carbon sequestration), flood control, provision of fresh water, nitrogen fixation, recycling of waste products, habitats for migratory species, goods such as food and fiber, recreational activities, and aesthetic and spiritual values. Ecosystem services provide an important portion of the total contribution to human welfare on the planet, and as ecosystems and their services become more stressed and more scarce in the future, their value will increase. A report of the Ecological Society of America indicates that human activities are already impairing the flow of ecosystem services on a large scale (Daily et al. 1997). The primary threats are land use changes that cause losses in biodiversity and disruption of biogeochemical cycles, invasions of exotic species, releases of toxic substances, possible rapid climate change, and depletion of stratospheric ozone. Historically, society has largely ignored the nature and value of ecosystem services until their disruption or loss highlighted their importance. The recent steps to quantify the value of ecosystem services bring the issues into clearer focus and emphasizes the importance of including ecosystem response to global change as part of the overall analysis of societal responses to global change.

RICHARD NORBY, ORNL

Page 112, Line 18: first sentence is great!

LARA HANSEN, WORLD WILDLIFE FUND

Page 112, line 19ff. This sentence suggests that in the last decade we have addressed the vulnerability of ecosystems to global change and the potential impacts of global change on ecosystems at multiple scales. Clearly these have been important objectives under the GCRP, and we can say much more about the potential impacts now than we could have 10 years ago. However, it is important to recognize that this has been an incremental process, building up from an understanding of the responses of component processes and component organisms. Only recently have experiments been able to measure responses to manipulations of atmospheric factors at an ecosystem scale, and those experiments need to run for additional years. The scale of many of those experimental systems still is too small to encompass some important ecological processes. Most experimental efforts have focused on single-factor manipulations despite the recognition of the multiple-stress imperative. Most of the research has -- for good reason -- been directed toward carbon

cycling, and insights into broader issues of ecosystem goods and services have primarily been ancillary or fortuitous. Ecosystem models have been advancing our ability to project ecosystem responses and feedbacks into the future, but the models continue to be updated as new experimental insights challenge basic assumptions. This is how the process should work, and it must continue to advance and evolve. We cannot yet fully describe the vulnerability of ecosystems to global change, but our understanding continues to improve and the questions we ask are becoming better defined.
RICHARD NORBY, ORNL

Page 112, Lines 25: after ...”such as fire.” Add: “Ecosystems under stress are more susceptible to insects, plant pathogens, and invasion by exotic species.”
STELLA M. COAKLEY, OREGON STATE UNIVERSITY

Page 113: … to millennia). The spatial pattern of ecosystems will also affect the feedback of energy, water, and elemental cycles between the biosphere and the atmosphere. Global change has…
DENNIS OJIMA, COLORADO STATE UNIVERSITY

Page 113. One of the most important factors is the availability of water. Changes in the delivery of water or frequency and duration of drought will have major impacts on ecosystem performance. There is major concern in California that warming will raise the snow level in the Sierra, causing winter rains at lower levels to run of during the winter rather than spring. This will have major impacts of water availability for ecosystems during the spring and summer.
DENNIS BALDOCCHI, UNIVERSITY OF CALIFORNIA, BERKELEY

Page 113: Is there a need to have a whole grey box discussing feedbacks? Space is precious and I see this presentation as unnecessary in this case.
DENNIS BALDOCCHI, UNIVERSITY OF CALIFORNIA, BERKELEY

Page 113, Lines 1-4: Is this referring to global warming changes or changes in general. If the prior, the IPCC assessment of the pivotal role of humans in climate change should not be disregarded. Cite the IPCC if you don’t want to directly be credited with the statement.
LARA HANSEN, WORLD WILDLIFE FUND

Page 113, Line 4: This section should also include a statement about the importance of protecting ecosystems for the benefit of wildlife.
PATRICIA GLICK, NATIONAL WILDLIFE FEDERATION

Page 113, Line 8: In addition to developing approaches to “reduce the vulnerabilities or take advantage of opportunities that arise within ecosystems as a result of global change,” researchers should also focus on how to minimize the threat of global change (e.g., by reducing greenhouse gas emissions).
PATRICIA GLICK, NATIONAL WILDLIFE FEDERATION

Comments on Chapter 10

Page 113, line 9: **It should also be pointed out that:** All 'Stress' is additive, and debility is often initially hidden under what appear to be positive 'hormetic' responses. Then, once some threshold of stressors is exceeded, debilities, death, and destruction follow – often without any obvious major cause. Scientific research can contribute to this societal goal by addressing **four** questions…. Etc.
GARY D. SHARP, CENTER FOR CLIMATE/OCEAN RESOURCES STUDY

Page 113, lines 9-14. The first two questions really must be studied together, and their separation in the research plan seems artificial and confusing. Note the number of concerns expressed at the workshop about whether the plan should emphasize climate and carbon cycle feedbacks OR consequences of global change to ecosystem processes. BOTH are critically important topics and both can and should be studied together - even in the same experiment or model. The organization of this chapter could be counterproductive if it leads to a false dichotomy between these two aspects of ecosystem response.

The *Pathways* report proposed organizing ecosystems research around four imperatives: understanding the relationships between land surface biophysical processes and climate, understanding the changing biogeochemical cycles of carbon and nitrogen, understanding the responses of ecosystems to multiple stresses, and understanding the relationship between biodiversity and ecosystem function. These imperatives follow logically from research over the past few decades and provide a strong, scientifically-based framework for future research that addresses all three of Chapter 10's questions in an integrative, comprehensive manner. I advocate adopting a similar organization and imbedding the current three questions within that structure.
RICHARD NORBY, ORNL

Page 113, Box between Lines 15 and 16. In the discussion of this Question, the focus is on "feedbacks". Little is said about linkages between physical variability and ecosystem response. How will climate change affect ecosystem structure? How will productivity be affected? What about population dynamics, predator-prey interactions, and parasite-host interactions? There are a host of food chain interactions that WILL be affected by changes in climate due to warming itself, and to changes in the weather, seasonal cycles of production, shifts in distributions of dominant species, and latitudinal and altitudinal shifts in faunal boundaries. As a result it is going to be challenging to come up with better models for rates at which resources (wheat, soybeans, fir and pine trees, living marine resources) are exploited, and in the ways that ecosystems are managed. None of these issues are addressed adequately in this chapter.
BILL PETERSON, NOAA/FISHERIES

Page 113, Lines 17-30. Suggest that you break up the sentence that begins on Line 25 into two sentences. Purpose is to make clear that there are two issues here: (i) Global change has the potential to alter ecosystem structure and patterns of biodiversity ... and (ii) potential ecosystem changes might ...contribute to global change through feedbacks. As stated above, ALL of the Ecosystem chapter needs to be written to reflect these two very different concepts.
BILL PETERSON, NOAA/FISHERIES

Comments on Chapter 10

Page 113, Line 25: "..to alter ecosystem structure…" would be better worded as "…to result in altered ecosystems…"
LARA HANSEN, WORLD WILDLIFE FUND

Page 113, lines 32ff: somewhere in this list, make an explicit link to land use/land cover change (perhaps the reference to surface albedo)
PHILIP MOTE ON BEHALF OF THE CLIMATE IMPACTS GROUP, UNIVERSITY OF WASHINGTON

Page 113, Line 32: In the list of the most important feedbacks between ecosystems and climate change, no mechanisms from marine systems are mentioned. One crucial link is the effect of rising ocean temperature on the recruitment of marine organisms (i.e. fish).
RUSSELL BRADLEY, PRBO CONSERVATION SCIENCE

Page 113, Line 33: Should read, "Altered ecosystem/atmosphere exchange" Without the atmosphere part is makes no sense as you have to have two compartments in order to have an exchange.
LARA HANSEN, WORLD WILDLIFE FUND

Page 113, Line 32- Page 114, Line 2: This list of key factors seems oddly selected. You need to support why they are "the most important". Simply creating a list does not make it so.
LARA HANSEN, WORLD WILDLIFE FUND

Page 114, Lines 1-2: Isn't this just a more specific aspect of the first bullet point in this set?
LARA HANSEN, WORLD WILDLIFE FUND

Page 114, insert an additional bullet at bottom of page to convey the potential importance of snow cover in terrestrial regions:
How might changes in vegetation and land use interact with snow cover to affect freshwater discharge, surface albedo and associated feedbacks?
GUNTER WELLER, ET AL, UNIVERSITY OF ALASKA FAIRBANKS

Page 114, line 5: Change "predict" to "protect"
MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 114, Lines 5-7: NWF recommends that the feedback issues addressed under Question 1 be emphasized elsewhere in the plan (i.e., incorporated with Carbon Cycle, Water Cycle, Land Use/Land Use Change, and other relevant chapters). Focusing Chapter 10 on the issues raised in Questions 2 and 3 will be most appropriate for the relevant stakeholders (e.g., resource managers, etc.).
PATRICIA GLICK, NATIONAL WILDLIFE FEDERATION

Page 114, lines 6-7: And additional collaborations as well.
MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 114, Line 8: In the Feedbacks box, the phrase "rising atmospheric CO_2" is used twice in this section. I think that you mean to say "rising atmospheric CO_2

concentrations”. Failure to include this makes it look like you are hedging the issue, or you just think the CO_2 is physically going up in the atmosphere but not increasing in concentration. Presumably that is not the case. Let’s explain Dr. Keeling’s work clearly.
LARA HANSEN, WORLD WILDLIFE FUND

Page 114, Line 8: In the Feedbacks box, for the positive feedback scenario you provided an example. You should do the same for the negative feedback, otherwise it seems a less likely scenario.
LARA HANSEN, WORLD WILDLIFE FUND

Page 114, Line 8: In the Feedbacks box 23-25: It is very unlikely that this could be completed in 3 years with any degree of accuracy.
LARA HANSEN, WORLD WILDLIFE FUND

Page 114, line 8: The text needs to make clearer that a negative feedback moderates a change, but does not change its sign.
MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 114, Lines 17-18: Why are industrial sources omitted from this list? Power plants are a big deal for the atmospheric/ecosystem exchange and air quality.
LARA HANSEN, WORLD WILDLIFE FUND

Page 114, Lines 20-21: Great point, but not in initial “most important” list. How can it be reflected there?
LARA HANSEN, WORLD WILDLIFE FUND

Page 114, Line 20. Need to be more specific about what is meant by this bullet. What possible changes could there be in Arctic ecosystems which will alter ocean currents????
BILL PETERSON, NOAA/FISHERIES

Page 114 line 20-21 Makes little sense to me. Why and how would the Arctic ecosystem effect climate? One might argue the case in the tropics because the light absorption depends on changes of the biomass. Please remove …
MARTIN VISBECK, COLUMBIA UNIVERSITY

Page 114, line 21 I am not sure I see how changes in Arctic ecosystems will alter ocean circulation. This is far-fetched. It may be at best a third order effect.
MARK R. ABBOTT, OREGON STATE UNIVERSITY

Page 114, Line 22: add “burning of fossil fuels” to this list.
LARA HANSEN, WORLD WILDLIFE FUND

Page 115: Research Needs
A key research need not included is how to develop a common research framework with the social science community to address feedbacks. The recognition that human activities are modifying ecosystem in a significant manner needs to be dealt with more

formally by developing a research theme that works toward identification of how human activities and decision making affect global change feedbacks at the ecosystem level.
DENNIS OJIMA, COLORADO STATE UNIVERSITY

Page 115, Line 3: Question Two should include a link or a reference to Chapter 11 on human contribution.
JENNIFER BIRINGER, WORLD WILDLIFE FUND

Page 115 Line 3. What is the specific reference to the need for "experimental facilities" all about? Isn't this document about general concepts and overarching questions rather than infrastructure needs?
BILL PETERSON, NOAA/FISHERIES

Page 115, line 4-5. Enhanced ecosystem monitoring and links to satellite observation are invoked here but not pursued. Ecosystem monitoring also is mentioned in Chapter 3 of the CCRI - Chapter 10 is the place to provide some detail about a potentially exciting and invaluable new program. A new ecosystem monitoring program could be a key initiative that brings together a platform for studying ecosystem processes and ecosystem interactions with weather and climate, a focus for model development, and linkages to ongoing satellite-based remote sensing. Intensive monitoring of selected ecosystems could also provide the focal point for ecosystem-scale manipulative field experiments, creating a coordinated program of observation and prediction.
RICHARD NORBY, ORNL

Page 115 Lines 5-7: Cost is a poor measure of scientific importance or need. New scientific initiatives should not be arbitrarily pushed aside simply because they might cost more. The need for, and potential benefit of, a particular area of scientific investigation should be judged against the cost of inaction. For example, if warming is hypothesized to limit production of forest and agricultural systems, the cost of conducting research on warming of forests or crops should be balanced against potential future economic losses if the hypothesized losses were true. Research expenditures will be cost effective if they help uncover and/or avoid future problems.
PAUL HANSON, ORNL

Page 115, line 5-7. Given the multi-faceted importance of ecosystem research and the potential value of a large-scale monitoring program, it is disappointing and disturbing that this sentence specifically indicates that new research programs may be too expensive; this is tantamount to giving up on the research agenda before it is even started.
RICHARD NORBY, ORNL

Page 115, line 6 – Delete the word "too." These research and monitoring programs are expensive, but it is a value judgment to say they are *too* expensive.
VIRGINIA DALE, ORNL

Page 115, Line 8: This Large Scale, Long term should also specify "multiple locations" to get us to generalizable results. Otherwise researchers need to run new, discrete

experiments at every location to assess every system. We should create designs to look for commonalties and variance from the beginning.
LARA HANSEN, WORLD WILDLIFE FUND

Page 115, Lines 12-13: Why is the concept of "function" omitted from this?
LARA HANSEN, WORLD WILDLIFE FUND

Page 115, Line 12: Add a bullet, " Targeted experiments to test mechanistic hypotheses, approaches to scaling in complex systems and models."
JOE BERRY, CARNEGIE INSTITUTION

Page 115, line 15 – instead of "representing" say "capturing" for the modeling goal is to include the key elements and interactions not to mimic the details of the ecological system.
VIRGINIA DALE, ORNL

Page 115, Lines 15-16: Creation of these requires the above-mentioned modification of lines 8-9.
LARA HANSEN, WORLD WILDLIFE FUND

Page 115, line 18. Products for Question 1 include identification of the critical indicator processes to monitor, and definition of the initial requirements for a monitoring program. These are appropriate, but should be coupled to an initiative toward tool development. To accomplish the important objectives of a monitoring program, new measurement tools are needed that permit extensive, real-time, non-invasive, and highly networked data streams with advanced computing facilities to process them. There must be new tools for studying belowground processes - a key uncertainty that is never mentioned in this chapter. A new initiative for tool development would be an appropriate near-term product for Question 1.
RICHARD NORBY, ORNL

Page 115 line 19: such a report would duplicate IPCC efforts, although somewhat sooner than the planned Fourth Assessment report.
PHILIP MOTE ON BEHALF OF THE CLIMATE IMPACTS GROUP, UNIVERSITY OF WASHINGTON

Page 115, Lines 19-22: This objective could possibly be met in 2 years, given its review nature.
LARA HANSEN, WORLD WILDLIFE FUND

Page 115, lines 19-22 -- Many of the reports generated by the USCGRP synthesized the current knowledge. How is this task different from the previous effort (other than now being later in time)?
VIRGINIA DALE, ORNL

Page 115, Lines 23-25: What about indicators that are important for ecosystem function? They must be included.

LARA HANSEN, WORLD WILDLIFE FUND

Page 115 Lines 23-25: 'Indicators of ecosystem change' is a vague concept that needs focus. Specific measures of change should be targeted. For example:

1. Net ecosystem carbon exchange or net ecosystem production,
2. Growing season duration
3. Species mortality
4. Etc.

PAUL HANSON, ORNL

Page 115, lines 23-28: The time intervals here look ambitious and unrealistic without a substantial increase in the budget.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 115, Lines 26-28: This could be developed in 4 years at only a simplistic level.

LARA HANSEN, WORLD WILDLIFE FUND

Page 115, Lines 29-32: This objective is poorly worded. It is unclear what you would be trying to achieve.

LARA HANSEN, WORLD WILDLIFE FUND

Page 115, Lines 29-32: How much longer than 4 years is this envisioned to take? Very vague timeline. Or is that meant to mean "ongoing"

LARA HANSEN, WORLD WILDLIFE FUND

Page 115, insert a new product after line 32 – Data related to climate change and its impacts on ecological systems (e.g., data on climate-induced disturbances – fires, wind throws, hurricanes, ice storms, droughts, insect and pathogen outbreaks, invasive species).

VIRGINIA DALE, ORNL

Page 115, Line 37: this list includes a lot but is really too vague to do much with.

LARA HANSEN, WORLD WILDLIFE FUND

Page 115, line 36ff: My compliments on actually giving an indication of the type of issue being faced.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 115, line 38: **(43-ES)** Instead of "property", how about using "climate element" here?

HP HANSON, LANL

Page 115, line 38: Use of the word "property" is very odd here. The example should just be "temperature" not "rising or extreme temperatures". Perhaps the term you are looking for is "parameter" or "factor."

LARA HANSEN, WORLD WILDLIFE FUND

Page 115, Line 40 – Page 116, Line 1: These lines state that "climate change variables interact", but then give an example of how one variable (increased temperature) may cause multiple responses of corals. A more accurate example would be the interaction between increased sea surface temperatures and increased penetration of light, which together result in the coral bleaching response.

Also, because coral bleaching occurs on time scales of months while range expansion of corals poleward would occur on a scale of hundreds-to-thousands of years (if at all – we do not know whether seasonal light levels and substrate availability would allow such expansion), this example is not a very useful comparison of multiple coral responses to the same variable. Indeed, we object to the implication of "no net loss" inherent in this example. We assert that the scientific community would strongly argue that the short-term loss of coral reef biodiversity will not be compensated by long-term range expansion.

A better example might be the direct effect of increased atmospheric carbon dioxide in reducing skeletal growth of corals (through changes in sea water chemistry) along with the indirect effect of the same variable in generating increased sea surface temperatures that result in coral bleaching.

JORDAN M. WEST, USEPA/ORD, KAREN H. KOLTES, DOI

Page116-117. There needs to be specific reference to long term ecological research sites and networks. Continued support and expansion of this research effort is crucial. There may be need to set up more manipulative experiments at these sites, like John Harte' work in the Rockies that is warming ecosystems and finding many unexpected results.

DENNIS BALDOCCHI, UNIVERSITY OF CALIFORNIA, BERKELEY

Page 116, Lines 1-2: These two processes happen on completely different temporal scales (bleaching and range shifts), yet they are lumped here to give the impression that corals can simply move out of harms way.

LARA HANSEN, WORLD WILDLIFE FUND

Page 116, Line 2: After "poleward." add: Both soil borne pathogens and plant parasitic nematodes have been documented as moving northward with warming temperatures in the Northern Hemisphere.

STELLA M. COAKLEY, OREGON STATE UNIVERSITY

Page 116, Lines 4-5: Why are atmospheric greenhouse gas concentrations omitted from this list? As mentioned above they are basic to the premise for the need for this chapter.

LARA HANSEN, WORLD WILDLIFE FUND

Page 116, Line 8: Should "changes" actually be "stresses"?

LARA HANSEN, WORLD WILDLIFE FUND

Comments on Chapter 10

Page 116, Line 8: …changes ~~at any given time~~ which can vary across time and space affecting system functioning. Recent …
DENNIS OJIMA, COLORADO STATE UNIVERSITY

Page 116, line 8: In referring to "recent reviews", references should be indicated.
MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 116, Line 10: Why single out nutrient pollution? What about metal pollution, acid pollution, salinity pollution, organic pollution, synthetic pollution? It would seem much more useful to just say, "pollution."
LARA HANSEN, WORLD WILDLIFE FUND

Page 116, Line 14: You should specify that this is focused on "terrestrial" ecosystems, not "ecosystems."
LARA HANSEN, WORLD WILDLIFE FUND

Page 116, line 20. The illustrative research questions here are very broad and all-encompassing, and therefore not very useful for defining a research agenda.
RICHARD NORBY, ORNL

Page 116, Line 20: All these questions require that one ask the following questions first: "what are the ecosystems of interest (using which classification system?) And within each, what are the key structures and functions (i.e. aspects important to society – from old growth trees to soil fertility to anadromous fish habitat) likely to be driven by climate change?"
CALIFORNIA RESOURCES AGENCY

Page 116, Line 21: Again, "change" should likely be "stress."
LARA HANSEN, WORLD WILDLIFE FUND

Page 116, Lines 21-24: This is a great question.
LARA HANSEN, WORLD WILDLIFE FUND

Page 116 Lines 21-24: The first illustrative research question on this page needs focus. To be successful, the CCSP will need to choose environmental variables of primary concern for important ecosystem. Such a list may not be the same for all ecosystems. We cannot afford to study interactions among all possible environmental drivers.
PAUL HANSON, ORNL

Page 116, line 22. Biodiversity is brought into the discussion without any foundation as to the kind of research questions that might be important.
RICHARD NORBY, ORNL

Page 116, line 21-24. A whole host of environmental changes is invoked without any attempt to prioritize or even a suggestion that there might be a need for prioritization. While it might not be appropriate to prioritize in this document (although I would maintain that warming coupled with increasing CO2 should be the highest priority and UV radiation low priority), it should be made clear that prioritization is needed and it

should be based on sound scientific knowledge about the potential vulnerabilities of different ecosystems, as well as our level of uncertainty about different drivers.
RICHARD NORBY, ORNL

Page 116, line 29: … groundwater recharge, water quality, flood …
DENNIS OJIMA, COLORADO STATE UNIVERSITY

Page 116, line 30. Suggest you insert "mariculture" in the list of goods and services.
BILL PETERSON, NOAA/FISHERIES

Page 116, Line 35: How are associated changes in disturbance regimes affecting the provision of goods and services?
DENNIS OJIMA, COLORADO STATE UNIVERSITY

Page 116, line 36. There is a high degree of overlap between questions 1 and 2 and the research approaches that are needed to address them - this should be made explicit so as to encourage a more cost-effective, coordinated research program.
RICHARD NORBY, ORNL

Page 116, line 37: Identifying and quantifying <<nature of the multiple interactions affecting>> the consequences of ….
DENNIS OJIMA, COLORADO STATE UNIVERSITY

Page 117-118: The omission of thresholds, limits, toxics, wetlands pollution and losses, and other widely felt needs or perceived issues undermines credibility. I hope the next draft will use these popular concerns as examples of the abstractions employed.

I would also urge inclusion here of soils issues, based on my personal conviction that this is a problem insufficiently addressed, but eventually very important.
JOHN WIENER, INDIVIDUAL COMMENTATOR

Page 117, Line 1: add a research need statement identifying the need for investigating, documenting, and monitoring major climate change events in ecosystems (forest insect outbreaks, hydrological events) as they are happening.
GUNTER WELLER, ET AL, UNIVERSITY OF ALASKA FAIRBANKS

Page 117 Lines 1-2: In my opinion, the link between biodiversity and ecosystem function is important, but not the primary research question in the climate change arena.
PAUL HANSON, ORNL

page 117, Line 3: What is an "intact natural system"? How do you define it? Where do you find it?
LARA HANSEN, WORLD WILDLIFE FUND

Comments on Chapter 10

Page 117 Lines 3-5: The proposed emphasis on studies of intact ecosystems is critical. Key feedbacks are likely to operate through changes in biogeochemical cycles, which can only be appropriately represented in intact systems.

PAUL HANSON, ORNL

Page 117, line 3-5. The research need concerning experiments is vague and fails to mention the multiple stress imperative or the need for long-term experiments. Also, it is unclear whether the focus is intended to be species or ecosystems.

RICHARD NORBY, ORNL

Page 117, line 6: Better integration of remote sensing data to ground observations in order to quantify key characteristics ….

DENNIS OJIMA, COLORADO STATE UNIVERSITY

Page 117 line 7. Insert "topography" in the list of key characteristics. (At least this might leave the door open to coordinating with FEMA's $300 million flood mapping effort, whose possible use of LIDAR would really benefit analysis of sea level rise vulnerability and hydrologic flows in terrestrial areas.)

JIM TITUS, EPA (SEE DISCLAIMER)

Page 117, line 12 – Insert "in situ" before networks.

VIRGINIA DALE, ORNL

Page 117, lines 16-19: Will it really take 2 years to do a literature review?

ANN FISHER, PENN STATE UNIVERSITY

Page 117, line 16: This is what the national assessment is all about. How does this "product" relate to and build on the work that has already been done?

DANIEL LASHOF, NRDC

Page 117, Lines 16-19: Feasible on this time line.

LARA HANSEN, WORLD WILDLIFE FUND

Page 117, Lines 16 – 27: Spatially explicit models must not be relegated to a later time, but in fact even very draft versions must be developed at the start of the program. Without them, conclusions regarding potential consequences will have little support and will amount to little more than hand waving. The development of ecosystem models must be considered from the start as the development of ever-improving platforms.

CALIFORNIA RESOURCES AGENCY

Page 117, Line 16 : add "actual" so the sentence would read "Reports describing the actual and potential…" The regional and sectoral reports of the U.S. National Climate Change Assessment contain much quite recent information on this subject, so the unique character of the goal here should be identified (More complete? More current? Special emphasis?)

GUNTER WELLER, ET AL, UNIVERSITY OF ALASKA FAIRBANKS

Page 117 line 16: that's precisely what the US National Assessment did, and it should be mentioned.
PHILIP MOTE ON BEHALF OF THE CLIMATE IMPACTS GROUP, UNIVERSITY OF WASHINGTON

Page 117, line 16-19. A report in 2 years about potential consequences of global change to ecosystems would provide incremental information over that of reports that have already been written, but these complex questions cannot be resolved in 2 years. There must be a commitment to long-term, sustained experiments and monitoring efforts.
RICHARD NORBY, ORNL

Page 117 Lines 16-19: To develop useful reports on the consequences of global climate change, defensible and accepted scenarios must be established. Models used to evaluate responses over time need to be tested against available data. Predictions from general models applied to multiple ecosystems should acknowledge uncertainty as a function of the system being modeled. That is, general models tend to do a better job predicting some ecosystem responses more than others.
PAUL HANSON, ORNL

Page 117, line 16-19. A report in 2 years about potential consequences of global change to ecosystems would provide incremental information over that of reports that have already been written, but these complex questions cannot be resolved in 2 years. There must be a commitment to long-term, sustained experiments and monitoring efforts.
RICHARD NORBY, ORNL

Page 117, Line 19: add after "..Ecosystems (2 years)." : Include expected consequences for managed agroecosystems to ensure adequate food."
STELLA M. COAKLEY, OREGON STATE UNIVERSITY

Page 117, Line 19: page 117, line 19 The phrase "range of ... ecosystems" is used followed by some specific examples. What criteria will be used to select specific ecosystems?
MARK R. ABBOTT, OREGON STATE UNIVERSITY

Page 117, Lines 20-23: Unlikely on a 4 year time scale.
LARA HANSEN, WORLD WILDLIFE FUND

Page 117, Lines 24-27: Unlikely unless it takes much more than 4 years.
LARA HANSEN, WORLD WILDLIFE FUND

Page 117, Line 28: In addition to addressing options for "sustaining and improving ecosystem goods and services valued by societies, given projected global changes," researchers should also address the sensitivity of wildlife responses under various scenarios of *mitigating* climate change. This would provide relevant decision-makers with an opportunity to more effectively evaluate the potential benefits of such scenarios.

Comments on Chapter 10

PATRICIA GLICK, NATIONAL WILDLIFE FEDERATION

Page 117, line 30ff (general comments). The integration of ecosystem research with evaluation of management regimes would be an important advancement for the next decade. The recognition of the importance to society of ecosystem goods and services, and their vulnerability to atmospheric and climatic change, define the need. This analysis must be closely linked to land use issues, because clearly the best way to preserve ecosystem goods and services is to preserve ecosystems. This section tends to discuss services as apart from the structure and functioning of the ecosystem as a whole.

RICHARD NORBY, ORNL

Page 117, lines 31ff. Need to highlight the need for "ecosystem management" as a better way of managing resources. I would be happier if examples from marine and freshwater systems were included with the many examples presented.

BILL PETERSON, NOAA/FISHERIES

Page 118, Lines 7-10: This sentence rightly expresses the difficulty – and, in some cases, impossibility – for some ecosystems to be effectively managed to limit the effects of global climate change. NWF recommends that this fact be made even more explicit, including encouraging researchers to help identify the potential economic costs of possible "adaptation" strategies as well as those species/ecosystems that simply will not be able to adapt.

PATRICIA GLCIK, NATIONAL WILDLIFE FEDERATION

Page 118, lines 12-31: Analogous to the question in Chapter 11, lines 24 to 29, the following additional research question is needed:
"What opportunities will exist for the establishement of new ecosystems."

OREST LEWINTER, CITIZEN

Page 118, lines 12-18. Sea level rise is the one area where several states have regulations requiring adaptation to climate change. Therefore, the landward migration of ecosystems and/or management of ecosystems in place as the sea rises ought to be addressed. The easiest way to deal with this would be to insert "coastal wetlands" on line 13, and insert "coastal development" somewhere in lines 12-18.

JIM TITUS, EPA (SEE DISCLAIMER)

Page 118, Lines 13-23: This is the first reference in the chapter for a need to protect biodiversity or species. I'm glad it is finally in here, but why isn't it earlier and more frequent?

LARA HANSEN, WORLD WILDLIFE FUND

Page 118, line 13: It seems a little bit strange to be suggesting that coral reefs can be managed in a way that would sustain them? We can perhaps slow the impacts, but not much.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 118, line 19-23: The research question is acceptable; however, the scope should be broadened to include an understanding of the increased variability associated with climate change.

JERRY L. HATFIELD AND STEVEN R. SHAFER, USDA-ARS

Page 118, lines 19ff: include carbon sequestration in this list.

PHILIP MOTE ON BEHALF OF THE CLIMATE IMPACTS GROUP, UNIVERSITY OF WASHINGTON

Page 118, Lines 24-26 and Lines 40-42: Implicit in this research question and in this research need is the suggestion that it is important to investigate population genetic changes and species decline due to climate change, so as to manage compositional biodiversity. However, this question does not address the importance of investigating behavioral systems in non-human animals as they might become modified by a changing climate. Though underrepresented in the literature, the ability (or inability) of non-human animals to modify their behavior in response to climate change may have important consequences for the preservation of ecosystem services. Whereas population-level genetic changes would occur over the course of many generations, behavioral modification would occur on an ontogenetic (developmental) timescale. And in cases where climate change is rapid, populations may be unable to respond to a modified climate with genetic change. In these cases, individual animals may only be able to respond to climate change through ontogenetic behavioral modification. Though highly mobile species may simply move to new habitat as old habitat becomes unsuitable, animals that are unable to migrate may be forced to cope in a modified environment. This could have consequences for feeding, reproductive, and hibernation/estivation behavior as animals are forced to respond to resources that may change in abundance, predictability, or density. Research that investigates animal behavior in a changing climate would be worthwhile since altering interspecies interactions in a community could have ecosystem-level impacts that would alter the services that ecosystems provide.

CALIFORNIA ENERGY COMMISSION

Page 118, line 24: It would be more correct to say, "What options, if any, exist …"

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 118, Line 26: There is mention here of "environmental change." It is the only place it is mentioned in this chapter. From a semantical point of view it would be good to have a clear delineation of "climate," "global," and "environmental" change.

LARA HANSEN, WORLD WILDLIFE FUND

Page 118, line 30: I found the use of the term "non-market services" confusing. By suggesting that ecosystem "goods and services" that are not directly used by human have questionable value, the integrated ecosystem concept is again being ignored – see overview comment 2. While certain ecosystem components may not directly affect humans, indirect effects of their potential removal might have far reaching consequences.

RUSSELL BRADLEY, PRBO CONSERVATION SCIENCE

Page 118, lines 33-39. Add "regulations and rolling easements to ensure that wetlands migrate inland as sea level rises"

JIM TITUS, EPA (SEE DISCLAIMER)

Page 118, Line 33: Research Needs

Comments on Chapter 10

Integrated approach which incorporates ecological, physical, and social sciences to evaluate ecosystem dynamics, land use, and natural resource use changes affecting sustainability of different regions of the world.
DENNIS OJIMA, COLORADO STATE UNIVERSITY

Page 118. Lines 40-42. Development of genetic tools was not very well justified. Clarify or delete.
BILL PETERSON, NOAA/FISHERIES

Page 118, Line 40: ìExamining the response of ecosystems to climate changes in past centuries and millennia to provide clues to potential responses over the next century.î
C. MARK EAKIN, NOAA/NCDC

Page 118, line 41. The use of genetic and molecular tools is first introduced here, and there has been no explanation or rationale provided.
RICHARD NORBY, ORNL

Page 118, Line 42: add: "it is especially critical that food production systems be included and given special consideration."
STELLA M. COAKLEY, OREGON STATE UNIVERSITY

Page 119, line 1: The focus should be on developing information that actively informs decisions rather than passively studying how decisions are made now.
DANIEL LASHOF, NRDC

Page 119, Line 4. What are "decision support tools"?
BILL PETERSON, NOAA/FISHERIES

Page 119, Lines 12-17: The 2-year time frame would provide only a very preliminary product not likely to assist in decreasing any uncertainty.
LARA HANSEN, WORLD WILDLIFE FUND

Page 119, Lines 15 and 20: Why has Nitrogen suddenly become a dominant focus? The justification is lacking. It just appears out of nowhere.
LARA HANSEN, WORLD WILDLIFE FUND

Page. 119, line 15 -- Replace "N_20" with "greenhouse gases."
VIRGINIA DALE, ORNL

Page 119, Line 17: For selected forestry and agricultural ecosystems, data on insect pests and pathogens should be collected and compared as an outcome of chosen management strategies."
STELLA M. COAKLEY, OREGON STATE UNIVERSITY

Page 119, Lines 18-22: With four years this question will provide even more preliminary results. The state of the knowledge is just too far out.

LARA HANSEN, WORLD WILDLIFE FUND

Page. 119, line 20 -- Replace "N_20" with "greenhouse gases."

VIRGINIA DALE, ORNL

Page 119, Line 20. Suggest you delete "...focusing on N_2O emissions, trace gas fluxes..." as these are overly specified in my view. Let the managers decide on how best to compare management practices.

BILL PETERSON, NOAA/FISHERIES

Page 119, Lines 23-25: This would take far longer than 4 years.

LARA HANSEN, WORLD WILDLIFE FUND

Page 119, line 26: Question 4: What are the various Stressors, and their relative contributions to the total stress loads and potential for ecological debilities, within local, regional and downstream ecosystems?

STATE OF KNOWLEDGE:

Basic Foreward statement needed here: E.G.:

More often the not, ecological research is done on a small selection of potential interactions, hoping to identify 'causality' for specific responses. Stress physiology is one of the keystone sciences necessary to address ecological response questions. This is despite near constant denial by physicists and agency management of the millennia of insights. Such cause-effect physiological studies have identified general biological responses that show that there are initially positive responses to minor stress loads. These form the underlying basis for enhanced egg production in hen houses, meat production in feedlots, or enhanced plant development in greenhouses. The crucial point being that there are thresholds, beyond which the positive advantages are quickly lost, usually resulting in lowered egg-laying, decreased growth rates, complete physiological collapse and death of the organisms involved.

The additive nature of stressors is termed 'hormesis', and is particularly visible in high-density culture systems. That ecosystems are more or less productive, thus, does not indicate that these same stress agents are not present at sub-lethal loads in many or most effluents from highly productive systems. The first signs of negative results of increased fertilization, hence production from agricultural systems is often not obvious within the plots where the studies are located, but various effluents and chemicals end up being transported downstream, via various aquatic and atmospheric intermediaries, to locations that are thus more heavily burdened, and severe consequences are eventually observed, well away from the source(s).

Coastal waterways, bays, and lakes are the subjects of intense studies, in recent history, as humanities' effluents have impacted their downstream ecological services. For example, salmon runs and marine mammal colonies disappeared in the Thames River and estuary system in the early 1800s, only to begin returning in the recent decade, due to enhanced health laws, and sewage treatment. The Great Lakes underwent drastic ecological disasters, through both industrial effluents, as well as species introductions, and are recovering after a generation-long effort by a cooperative, Canadian/USA efforts to clean up the problems. The Milford, Conn., NOAA/NMFS lab showed in the late 1980s that the New York Bight fish production is nearly nil due to debilitating genetic interference in the early egg-chromosome replication processes, due to an array of effluents from industry and households. There is a linear survival increase as the fish eggs are located farther offshore, into the open ocean. Yet, little, or nothing has been done to resolve the upstream human- effluent issues, and fishing activities are wrongly blamed for the collapses of such ecolical systems..

The invertebrates inhabiting most shorelines are amongst the best indicators of stressors, given their direct respiration and feeding-related filtration. This insight provided the impetus behind the IMER, Plymouth, UK, laboratory's Mussel-Watch project. Growth rates in stressed, by not overburdened areas, are greater than those in less contaminated waters. However, mortality rates are enhanced with any increased stress, such as minor temperature rises due to even brief anomalies such as those associated with ENSO Warm Events, or local seasonal warming due to enhanced cloud cover.

While Global Change is likely to repeat previous ocean temperature change patterns, any enhanced warming will have direct respiration rate consequences on aquatic life forms, and with the recent century's increased effluent loading due to human population growth, the more likely readily applied solutions will lie in cleaning these effluents up than in controlling earth's dynamic climate change patterns. For those species adapted to the sub-polar and Polar regions (such as cod, Atlantc salmon, and capelin), low ambient temperatures induce similar increased respiratory rate responses as do warming patterns, thus suggesting that their dynamics would be somewhat greater.

ILLUSTRATIVE RESEARCH QUESTIONS

What are the effluent stressor loads from upstream sources, and where do they enter the aquatic environment? How can they be minimized, or removed from the aquatic intermediaries?

This is a far more focused approach than those related to 'management' of aquatic ecosystems, which would only be addressable, given answers to this all-important question.

What are the additive consequences of the various stressors that are being merged at various foci within the waterways and aquifers?

This, like the MusselWatch assay techniques, is necessary in order to address 'solutions' to the effluent discharge management/cleanup, and downstream interactions. These include testing under an array of ambient temperatures, to help assess the relative vulnerability of various stress loads to increased or decreased temperatures.

What organisms are most sensitive to these stressors, and might be deployed and/or monitored as 'indicators' or measures of relative stress levels at key monitoring sites within these aquatic systems?

RESEARCH NEEDS

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PROACTIVE developments of assays and organism models for identifying stressors, at all levels, are needed, now. The usual pattern of crisis response, then study has led to the present chaos in the research funding, and problem identification/resolution sequence.

Much is already known, due to recent and historical breakdowns of specific ecological systems, e.g., the Great Lakes, New York Bight, Chesapeake Bay, Los Angeles Harbor, San Francisco Bay - Sacramento River estuarine systems, etc. It appears that there needs to be a generic refocus upon the downstream ecological consequences of all upland activities, and efforts made to initiate clean-up procedures.

Key Linkages

It is imperative that researchers be allowed to minimize the denial within agencies of the importance, and impacts of various economic activities on downstream ecology. Then, it will be more likely that the differences between natural Climate Change ecosystem responses and the initializing human-activity related stress loads that create cataclysmic vulnerabilities might be separated. While GHG may well be the source of some portion of Global Change, the downstream stress effects are much more important to identify, and fix, than are the relatively minimally controllable carbon cycle-related Climate consequences.

All the other issues in the Global Change Research Program are generally linked via waterways, and influenced by upstream human activities. To actually account for the true causes of ecosystem responses, these stressor sources must be accounted for, and minimized.

GARY D. SHARP, CENTER FOR CLIMATE/OCEAN RESOURCES STUDY

Page 119, Lines 30-31: "the scientific elements of this plan" What does this mean? What does that include? Isn't this a research plan? Isn't it all scientific?

LARA HANSEN, WORLD WILDLIFE FUND

Page 119, Line 31: Add after "of this plan." : The paleoclimate record needs to be reviewed in the context of ecosystem studies."

STELLA M. COAKLEY, OREGON STATE UNIVERSITY

Page 119, lines 34-36: This statement applies to all of the data generated or used in the CCSP!

ANN FISHER, PENN STATE UNIVERSITY

Page 120, lines 11-17: It should be mentioned that these programs do not really pay for the research—instead they help to coordinate international research activities.

MICHAEL MACCRACKEN, LLNL (RETIRED)

Page 120, Line 13 : add "ILTER (international LTER)"

WELLER, ET AL, UNIVERSITY OF ALASKA FAIRBANKS

Page 120. Line 16. Add to your list the IGBP program known as GLOBEC (Global

Ocean Ecosystem Dynamics). On the order of 20-30 countries worldwide have active GLOBEC programs that are funded through the year 2009.

BILL PETERSON, NOAA/FISHERIES