Decision Support Tools for Adaptive Forest Management

William T. Sommers

EastFIRE Laboratory, Center for Erath Observing and Space Research, School of Computational Sciences

George Mason University

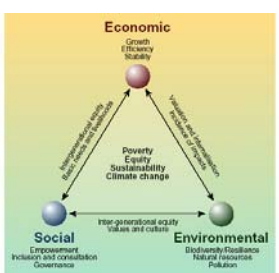
4400 University Drive, Fairfax, Virginia 22030

Abstract – Climate Change and Sustainable Development are likely to be more convergent in future IPCC Assessment activities. Ecosystem managers need to begin planning for adaptation to climate change. Those managers must balance multiple ecosystem values and multiple climate stressors, which may well act in a non-linear manner, as with forest fires for example. The use of Sustainable Forest Management Criteria and Indicators (SFM C&I) as endpoints in an ecological risk assessment approach is suggested as Decision Support Tools to aid these managers.

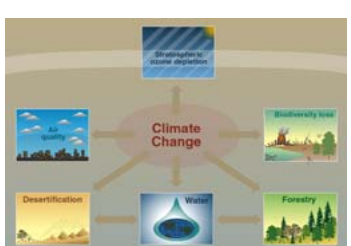
INTRODUCTION

Forest ecosystem productivity, health and diversity are known to be impacted by multiple factors including changes in temperature, soil moisture, and atmospheric carbon dioxide concentration. The Intergovernmental Panel on Climate Change (IPCC) Third Assessment Report (TAR) (IPCC 2001) offers projections of how those environmental variables are likely to change in the future. Houghton (Houghton 2005) in his recent update to TAR identifies trees as being particularly vulnerable to climate change. Forest ecosystem responses to climate change and variability are highly likely to be non-linear in nature (Breshears et al. 2005), and may involve phase shifts (Scheffer and Carpenter 2003), because of the major role that ecological disturbances play in shaping those ecosystems. Species and their functions may be lost if climate change is accompanied by widespread disturbance (Neilson et al. 2005). Fire is a major disturbance mechanism in most forest ecosystems and is an illustrative example of abrupt ecosystem change triggered by long developing ecosystem conditions and atmospheric factors such as drought. It is reasonable to expect that forests will respond to decadal and longer term climate change and variability via disturbances that produce non-linear ecosystem changes that directly affect ecosystem services and natural resource management.

Systems for understanding, predicting and assessing ecosystem effects in a systematic manner over time should be anchored by assessment endpoints that reflect established values for ecosystem goods and services. Those values should be based on more than economics. Fortunately, such a set of measurable values has been established for forests. A set of internationally agreed to Criteria and Indicators (C&I) for Sustainable Forest Management (SFM) have been developed since UNCED (UNCED 1992). The SFM C&I (SFM C&I) provide a comprehensive set of quantifiable endpoints reflecting an inclusive array of forest ecosystem values. They were used as the basis for a 2003 National Report on Sustainable Forests (USDA Forest Service 2004a).



Climate change and sustainability were linked under Article 2 of the United Nations Framework Convention on Climate Change (UNFCC) (UNFCCC 1992). IPCC plans to increasingly highlight linkages between climate change and sustainable development in its fourth assessment report (AR4) and future assessment activities. Climate Change Mitigation (CCM) and Sustainable Development have been strongly linked in presentations (Robinson 2001) by TAR Working Group III (WGIII).



SFM Criteria & Indicators

Sustainable Forest Management (SFM) Criteria

Criterion 1: Conservation of biological diversity
Criterion 2: Maintenance of productive capacity of forest ecosystems
Criterion 3: Maintenance of forest ecosystem health and vitality
Criterion 4: Conservation and maintenance of soil and water resources
Criterion 5: Maintenance of forest contribution to global carbon cycles
Criterion 6: Maintenance and enhancement of long-term multiple socio-economic benefits to meet the needs of societies
Criterion 7: Legal, institutional and economic framework for forest conservation and sustainable management

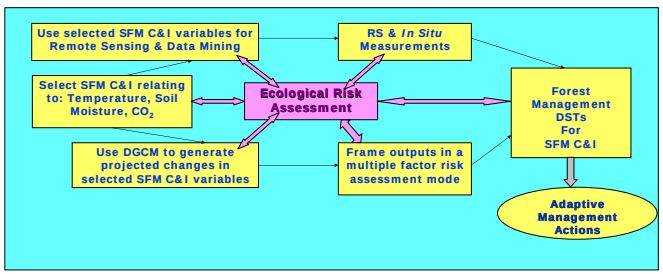
Examples of Indicators are:

Indicator 5: Fragmentation of forest types;
Indicator 10: Area of forest land and net area of forest land available for timber production;
Indicator 15: Area and percent of forest affected by processes or agents beyond the range of historic variation (e.g. by insects, disease, competition from exotic species, fire storm, land, clearance, permanent flooding, salinization, and domestic animals.);
Indicator 21: Area and percent of forest land with significantly diminished soil organic matter and/or changes in other soil chemical properties;
Indicator 27: Contribution of forest ecosystems to be the total carbon budget, including absorption and release of carbon (standing biomass, coarse wood debris, peat and soil carbon.)

Work has been done that examines quantity, quality and sources of available ground based data for each of the 67 Indicators (USDA Forest Service 2004b). We will review and update this information, and examine remote sensing information, for use with our models. The selected subset of Indicators will have high ecological and/or economic importance and that will clearly be impacted by non-linear ecosystem responses to climate change and variability as identified in climate change assessments and the scientific literature. For example, Indicator 27 would likely be impacted by increases in fire frequency and intensity associated with predicted climate change. Forest carbon sequestration and future potential sudden carbon releases are known to be issues of interest to the scientific community. But they will also be issues of concern to forest managers and planners if they are shown to negatively impact forest sustainability. We know that the available land based data tends to be of varying geographic coverage depending on the indicator and data source in question. We anticipate that many of our end products will be regional in focus because of the underlying data coverage, unless remote sensing data can serve to expand the geographic coverage. Our approach will be to use already analyzed land based data for specific indicators and examine available remote sensing data for applicable proxies. The regional nature of the end products also mirrors the regionalism of predicted forest ecosystem responses to climate change, and sub-regional issues such as water supply and demand. Knowledge of the Indicators will help us determine the ecological (i.e. domain, division, province) and governance (region, state, county) scales that will ultimately be required.

Ecological Risk Assessment

Natural resource management involves a continual weighing and balancing of multiple factors. Competing resource demands, and the weighing of near term and long term consequences, make forest ecosystem planning and management a multi-variant balancing act. In forest planning (USDA Forest Service 1976), this balancing act presents itself as a menu of options, or scenarios, of likely outcomes if different resource management emphases are adopted. Climate change prediction and assessment are inherently probabilistic in nature and frequently rely on scenarios (IPCC 2000) to allow a degree of stability and continuity of input variables. Currently climate change and variability are not included in forest planning and resource options are not included in climate change assessments. Both, however, acknowledge the importance of non-linearity (disturbance) and multiple factors, and work is actively underway to include climate change and variability in watershed assessments of forest plans in the southeastern United States (McNulty personal communication).



Ecological risk assessment (ERA) is described as a process for evaluating the likelihood that adverse ecological effects may occur as a result of exposure to one or more stressors. EPA's Risk Assessment Forum has published (U.S. EPA 2003) a set of generic ecological assessment endpoints (GEAEs) that can be considered and adapted for specific ecological risk assessments. An assessment endpoint is defined (U.S. EPA 1998) as "an explicit expression to be protected, operationally, defined as an ecological entity and its attributes." The three selection criteria suggested are: ecological relevance, susceptibility (exposure plus sensitivity) and relevance to management goals. Our approach will be to adaptively employ ERA to select candidate SFM C&I based on their susceptibility (their ecological and management relevance are taken as already established) to non-linear ecosystem responses to climate change and variability, particularly relating to changes in temperature, soil moisture, atmospheric carbon dioxide concentration and/or atmospheric ozone concentration. ERA will essentially be used as a data selection and screening process and to frame model outputs in a multiple factor risk assessment mode. Defining the data attributes of the selected Indicator endpoints will also help us to determine which details and processes need to be included in our models and which can be ignored or simplified.

REFERENCES

Breshears, David D., Neil S. Cobb, Paul M. Rich, Kevin P. Price, Craig D. Allen, Randy G. Balice, William H. Romme, Jude H. Kastens, M. Lisa Floyd, Jayne Belnap, Jesse J. Anderson, Orrin B. Myers, and Clifton W. Myer 2005: Regional vegetation die-off in response to global-change-type drought. Proc. Natl. Acad. Sci. USA 102, 15144-15148. (www.pnas.org/doi/10.1073/pnas.0505734102

IPCC 2001. Climate Change 2001: IPCC Third Assessment Report. Cambridge University Press

Neilson, Ronald P., Louis F. Pitelka, Allem M. Solomon, Ran Nathan, Guy F. Midgely, Jose M.V. Fragaso, Heike Lischke, and Ken Thompson. 2005: Bioscience, **55**,9,749-759

Robinson, John. 2001: Climate Change Mitigation and Sustainable Development:
A Framework for Integration. Powerpoint Presentation available from IPCC

Scheffer, M. and SR Carpenter. 2003: Catastrophic regime shifts in ecosystems: Linking theory with observations. Trends in Ecology and Evolution 18:648-656.

UNCED 1992: United Nations Conference on Environment and Development (UNCED) 1992. *(http://www.un.org/geninfo/bp/enviro.html)*

UNFCCC 1992: United Nations Framework Convention on Climate Change. *http://unfccc.int/*

USDA Forest Service. 1976: The U.S. National Forest Management Act of 1976. *(http://www.fs.fed.us/forum/nepa/nfmalaw.html)*

USDA Forest Service. 2004a: National Report on Sustainable Forests--2003 (FS-766, February 2004)

USDA Forest Service. 2004b: Data Report: A Supplement to the National Report on Sustainable Forests--2003 (FS-766A, May 2004)