CONF-9410306--1

Proceedings of the Second U.S.- Japan Workshop
on Global Change Modeling and Assessment:
Improving Methodologies and Strategies

October 24-27, 1994
Honolulu, Hawaii

INTEGRATED ASSESSMENT AND THE RELATION BETWEEN LAND-USE CHANGE AND CLIMATE CHANGE

Virginia H. Dale
Environmental Sciences Division
Oak Ridge National Laboratory[1]
Oak Ridge, Tennessee 37831-6038

October 7, 1994

Integrated assessment is an approach that is useful in evaluating the consequences of global climate change. Understanding the consequences requires knowledge of the relationship between land-use change and climate change. Methodologies for assessing the contribution of land-use change to atmospheric CO_2 concentrations are considered with reference to a particular case study area: south and southeast Asia. The use of models to evaluate the consequences of climate change on forests must also consider an assessment approach. Each of these points is discussed in the following four sections.

Using Integrated Assessment to Evaluate the Consequences of Global Climate Change

Integrated assessment is the process by which technical, social, environmental and economic consequences of alternative resource management options are evaluated. It requires bridging between science and policy considerations. The assessment process incorporates existing scientific knowledge, accommodates new knowledge, and directs acquisition of new information and understanding. Models used in the integrated assessment process range from complex and detailed "end-to-end" models to simple descriptions of relationships. Each approach has advantages and disadvantages. A framework for integrated assessment of effects of global climate change is proposed by Dale et al. (in prep). The framework provides a means of identifying major drivers, consequences, and

[1]Managed by Martin Marietta Energy Systems, Inc. for the U.S. Department of Energy, under contract DE-AC05-84OR21400.

DISCLAIMER

management alternatives for global climate change and for considering the ramifications of potential policy decisions. The framework clarifies that specific policy decisions may be directed at causes of changes in greenhouse gases; actual changes in greenhouse gas fluxes; resulting climate changes; or at the ecological, social, and economic effects of climate change.

The process of evaluating the consequences of greenhouse effects involves considering the urgency of making a decision, uncertainties about climate change and its effects, and the potential for extreme events. Evaluating policy requires considering seven aspects of potential decisions: timing of action, target of action, selection of implementation tools, spatial scale of action, coordination, choice of public versus private action, and choice of voluntary versus prescriptive action.

The Relationship between Land Use Change and Climate Change

Land-cover patterns are related to climate change as both a causal factor and a major way in which the effects of climate change are expressed. As a causal factor, land cover influences the flux of mass and energy, and as cover patterns change, these fluxes are altered. Projected climate alterations will produce changes in land-cover patterns at a variety of temporal and spatial scales, although human uses of the land are expected to override many effects. Dale's (submitted) review of the relationship between land-use change and climate change clearly shows that (1) land-use change has had much greater effects on ecological variables than has climate; (2) the vast majority of land-use changes have little to do with climate change or even climate; and (3) humans will change land use, and especially land management, to adjust to climate change and these adaptations will have some ecological effects. Therefore, an understanding of the nonclimatic causes of land-use change (e.g., socioeconomics and politics) are necessary to manage ecological functions effectively on regional and global scales.

Methodologies for Assessing the Contribution of Land-use Change on Atmospheric CO_2 Concentrations

Land use change is one of the major contributors to increases in atmospheric CO_2 concentrations. An interdisciplinary approach to addressing the carbon flux issue is presented in Dale (1994). The approach combines historical analysis, biomass estimates as provided by a geographic information systems model, book-keeping models that track factors affecting the carbon flux, and evaluation of how economic factors affect tropical deforestation. Land-use change has historically been the most important source of atmospheric carbon. The most important changes in the amount of carbon in terrestrial ecosystems are due to shifts in forest mass that result from agricultural expansion and forest harvesting.

South and southeast Asia are important for consideration of land-use change because (1) the massive deforestation and degradation of these forests during past centuries released large amounts of carbon from the soil and plants to the atmosphere (between 16% and 36% of the total biotic flux from 1850 to 1990), (2) extensive records of land-use changes were kept for tax collection purposes, and (3) the spatially explicit approach developed for estimating atmospheric release of carbon due to land-use change may be useful for other key regions or for the entire world and for other broad-scale environmental problems (e.g., regional air pollution or ozone depletion).

Evaluating Models of Climate Change Effects on Forests

Models that address the impacts of climate change on forests are reviewed by Dale and Rauscher (in press) at four levels of biological organization: global, regional or landscape, community, and tree. The models are compared for their ability to assess changes in fluxes of biogenic greenhouse gases, land use, patterns of forest type or species composition, forest resource productivity, forest health, biodiversity, and wildlife habitat. No one model can address all sources of impact, but landscape transition models and regional vegetation and land-use models have been used to consider more impacts than the other models. The development of landscape vegetation dynamics models of functional groups is suggested as a means to integrate the theory of both landscape ecology and individual tree responses to climate change. Risk assessment methodologies can be adapted to deal with the impacts of climate change at various spatial and temporal scales. Four areas of research needing additional effort are identified: (1) linking socioeconomic and ecologic models, (2) interfacing forest models at different scales, (3) obtaining data on susceptibility of trees and forest to changes in climate and disturbance regimes, and (4) relating information from different scales.

REFERENCES

Dale, V.H. 1994. Effects of Land-Use Change on Atmospheric CO_2 Concentrations: South and Southeast Asia as a Case Study. New York: Springer-Verlag. 384 pp.

Dale, V.H. The relationship between land-use change and climate change. Ecological Applications (submitted).

Dale, V.H. and H.M. Rauscher. 1994. Assessing impacts of climate change on forests: the state of biological modeling. Climatic Change (in press).

Dale, V.H., Leiby, P., Sanstad, A., Streets, D., Turner, R., and O'Neill, R. Characterizing the Key Policy Issues in Integrated Assessment for Global Climate Change. Environmental Management (in prep.).