1. INTRODUCTION

Four specific conclusions of our research are overviewed here. In-depth discussion of each is presented in the referenced papers. The conclusions are:

- Landscape directly and indirectly influences the earth’s energy budget through biophysical, biogeochemical, and biogeographic effects.
- Human-caused landuse change has an effect on local, regional, and global climate that is at least as large as could be caused by doubling of greenhouse gases.
- Since landscape (and other atmosphere-surface interactions) involve complex nonlinear feedbacks, skillful climate prediction beyond seasonal time scales may be unachievable.
- A broader assessment of risk to climate and other stresses is, therefore, a more appropriate guide to policy makers than trying to predict only a subset of possible future climate conditions.

2. LANDSCAPE DIRECTLY AND INDIRECTLY INFLUENCES THE EARTH’S ENERGY BUDGET THROUGH BIOPHYSICAL, BIOGEOCHEMICAL, AND BIOGEOGRAPHIC EFFECTS

Pielke et al. (1998), Pielke (1999), Avissar (1995) and Eugster et al. (1999) provide a review that summarize a wide range of papers that document the role of short, medium, and long-term effects of landscape processes on weather and climate. Biophysical effects include, for example, the influence of transpiration on the heat budget. Biogeochemical effects include the growth of plants, which alter the amount of transpiring leaf surface and the surface albedo. Biogeographic influences involve the alteration of vegetation species composition over time.

Figure 1 provides an example of the important role of land surface on deep cumulus convection. Figure 1 (top) is the model result for a specific date of cumulonimbus development over the central Great Plains of the United States using the current landscape. Figure 1 (bottom) uses the natural landscape. Pielke et al. (1997) provides a discussion of this experiment, while Shaw et al. (1997), Grasso (1996), and Ziegler et al. (1997) provide validation of the results for the current landscape situation. Clearly, the alteration of the landscape (with a reduction in transpiration in the natural landscape) has resulted in a reduction in cumulonimbus cloud activity in the model.

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Figure 1: Model output cloud and water vapor mixing ratio fields on the third nested grid (grid 4) at 21 GMT on 15 May 1991. The clouds are depicted by white surfaces with $q_e = 0.01$ g/kg, with the sun illuminating the clouds from the west. The vapor mixing ratio in the planetary boundary layer is depicted by the light grey surface with $q_e = 8$ g/kg. Areas formed by the intersection of clouds or the vapor field with lateral boundaries are flat surfaces, and visible ground implies $q_e < 8$ g/kg. The vertical axis is height, and the backplanes are the north and east sides of the grid domain (from Pielke et al. 1997).
3. HUMAN-CAUSED LANDUSE CHANGE HAS AN EFFECT ON LOCAL, REGIONAL AND GLOBAL CLIMATE THAT IS AT LEAST AS LARGE AS COULD BE CAUSED BY DOUBLING OF GREENHOUSE GASES

Pielke et al. (1999a) reported that the observed reduction in July-August rainfall in south Florida this century is of the same order as simulated by a model when the observed landuse change is inserted into the model. Chase et al. (1996, 1999) showed, using the CCM2 and CCM3 global models at NCAR, that landuse change, particularly in the tropical rainforests, can teleconnect to the middle and higher latitudes, resulting in major alterations to global climate. Figure 2, reproduced from Chase et al. (1999), illustrates the simulated 10-year averaged January near-surface temperature changes which resulted from a conversion of an estimate of the natural landscape to the current landscape. In this experiment, only about 8% of the earth’s land surface was actually changed, such that this is a conservative experiment. Actual landscape change has been estimated to be as high as 45% by Vitousek et al. (1997). Figure 1 in the IGBP Newsletter 37 is another example which illustrates the large change of landscape by human activity.

4. SINCE LANDSCAPE (AND OTHER ATMOSPHERE-SURFACE INTERACTIONS INVOLVE COMPLEX NONLINEAR FEEDBACKS, CLIMATE PREDICTION BEYOND SOME TIME SCALE IS UNACHIEVABLE

Pielke (1998) discusses climate as an integration of atmospheric, ocean, cryosphere, and land-surface processes and concludes that climate is inherently unpredictable beyond some period if the linkages between parts of the earth system are sufficiently nonlinear. Eastman (1999) and Lu (1999) provide examples of such nonlinearities. Lu (1999), for example, demonstrates using a coupled atmosphere-land surface modeling system (RAMS-CENTURY), the nonlinear dynamic role of seasonal vegetation growth on the evolution of seasonal vegetation in the central Great Plains of the United States. Pielke et al. (1999b) demonstrates the critical role of the soil moisture at the beginning of the growing season on the evolution of the seasonal weather in this region.

Figure 3, reproduced from Eastman et al. (1999) shows the results over the central Great Plains where the relative importance of landuse change, doubled CO$_2$ in the radiation calculation, and doubled CO$_2$ in the biological calculation are examined in a 210-day model run during the growing season. A coupled atmosphere-land surface modeling system (RAMS-GEMTM) was used. The model results indicate that the biological effect of a doubling of CO$_2$ would have an immediate, and much more important effect on seasonal weather than the radiative effect on this time scale. A climate change model which does not investigate this effect on longer-term climate change (such as due to the radiative effect of a doubling of CO$_2$) necessarily is (probably erroneously) incomplete. In

![Figure 2: Simulated January reference height temperature difference (current-natural) (C) from Chase et al. 1999.](image)

Fig. 3, a conversion of the current landscape to the natural landscape in this region, and the effect of a doubling of CO$_2$ in the biological calculation are both shown to produce cooling. This result, if correct, indicates regional climate change involves more than just the radiative effect of a global change in CO$_2$ and other greenhouse gas concentrations. If enough land areas are similarly affected, a global feedback response should be expected, as based on the Chase et al. (1996, 1999) landuse change experiment.

5. A BROADER ASSESSMENT OF RISK TO CLIMATE AND OTHER STRESSES IS THEREFORE MORE APPROPRIATE AS A GUIDE TO POLICY MAKERS THAN TRYING TO PREDICT ONLY A SUBSET OF POSSIBLE FUTURE CLIMATE CONDITIONS

If skillful climate prediction is not possible beyond some time scale, a vulnerability assessment approach is the preferred scientific approach to provide policy makers useful information (Pielke Jr., 1998). Figure 4 as reproduced from Pielke et al. (1999c), illustrates an example of this approach. With this technique, needs of the policy maker are better met, in that the focus is on decisions and not predictions (Sarewitz et al. 2000). This vulnerability perspective is further discussed in Pielke and Guenni (1999).

Figure 5 presents a schematic where climate model calculations can be presented as one of four types:

- sensitivity studies
- scenarios
- projections
- perfect foresight

In a sensitivity analysis, one of the important forcings on climate are perturbed (e.g., a doubling of CO$_2$). This is the approach used to produce the IPCC reports. This method could, in principle, generate skillful predictions if other climate forcings, such as landuse change and the biological effect of doubled CO$_2$ were unimportant. As discussed earlier in this
Figure 3: RAMS/GEMTM coupled model results – the seasonal domain-averaged contributions to maximum daily temperature, minimum daily temperature, precipitation, and leaf area index (LAI) due to: f1 = natural vegetation, f2 = 2×CO₂ radiation, f3 = 2×CO₂ biology, f12 = interaction of natural vegetation and 2×CO₂ biology, f13 = interaction of natural vegetation and 2×CO₂ biology, f123 = interaction of all three factors (from Eastman et al. 1999).

6. CONCLUSION

Unless it can be shown that landuse change and biogeochemical effects on the regional and global climate system are insignificant relative to the radiative effect of a doubling of CO₂, the IPCC reports are summaries of sensitivity analyses only. It is, therefore, unlikely that the future climate is actually produced using these models.

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8. REFERENCES


