Global change presents grand challenges for ecology. For a science with a rich tradition of description that developed and matured with an emphasis on explaining current patterns in nature, the transition to prediction is exciting but daunting. The VEMAP (Vegetation/Ecosystem Modeling and Analysis Project) members—26 ecosystem scientists, modelers and biogeographers—have accepted aspects of the challenge of prediction at the sub-continental scale. They are exercising two kinds of ecological models in order to explore the possible consequences of doubled atmospheric CO₂ and altered climate. The first VEMAP product (called VEMAP1, hereafter) strides boldly but guardedly into the landscape of prediction, armed with general circulation model (GCM) scenarios, previously published ecological models, and a philosophy that emphasizes exploring issues, uncovering weaknesses with existing tools, and establishing priorities for future research.

VEMAP is, at its core, about the development of a predictive global ecology. The approach is not comprehensive. It is not yet validated. It is doubtful that the specifics of the predictions are of any use to policy makers. Yet, the first VEMAP product is an important advance. It makes solid progress in demonstrating that different classes of models can fit together and that small differences in model structures and mechanisms do not necessarily explode into uninterpretable results. In addition, it makes interesting and heuristically useful predictions about the future carbon balance and distribution of biomes in the conterminous United States.

VEMAP1 begins with three published scenarios for global equilibrium climate (i.e. temperature and precipitation) in a world with double the present amount of atmospheric CO₂. The three GCM scenarios suggest quite different climate regimes for the conterminous United States—the target area of VEMAP1. Simulated mean temperatures increase from 3.0 to 6.7°C, and precipitation increases by 4 to 21%. This variation introduces another of the objectives of VEMAP1. Previously published model results about future ecosystem structure and function vary greatly. This variability has contributed to the challenge in drawing general conclusions. Until VEMAP1, however, it has not been possible to partition this variation between effects of climate scenario and ecological model. VEMAP1, which concludes that the variation among GCM and ecological scenarios is comparable, should help modulate any feelings of 'low variance' superiority harbored by students of the physical climate system.

VEMAP1 develops these scenarios (a surprisingly involved and important aspect of the study) and uses them as the climate for experiments with three biogeography models and three biogeochemistry models. The biogeography models [BIOME2 (Ref. 3), DOLY (Ref. 4) and MAPSS (Ref. 5)] simulate the equilibrium distribution of potential natural vegetation. The biogeochemistry models [BIOME-BGC (Ref. 6), CENTURY (Ref. 7) and TEM (Ref. 8)] simulate net primary production (NPP) and ecosystem carbon stocks. The basic VEMAP1 experiment ran each of the six ecological models under (1) current climate, (2) current climate with high CO₂, (3) future climate with current CO₂ for each GCM scenario, and (4) future climate with doubled CO₂ for each GCM scenario. A fifth experiment used the biome distributions output by the biogeography models under increased CO₂ and under future climate, as input for the biogeochemistry models. The multi-stage design provides a basis for assessing the separate and combined effects of climate, CO₂ biome distributions, and ecosystem physiology. It also provides a first estimate of the changes in NPP and carbon storage that might result from redistribution of the major biomes.

VEMAP1 does not present a single answer or 'best' estimate for future biome boundaries and NPP. There is, however, a reassuring similarity and robustness among the simulations with different models, especially for current conditions. Yet, even perfect agreement among models is no guarantee of accuracy. Comparisons against experimental data are much stronger tests of accuracy, and these will be essential if the emphasis on prediction increases in the future. For current conditions, all three biogeography models produce similar estimates for the potential area of forests, grasslands, shrublands and savannas, and all three biogeochemistry models simulate similar NPP and total carbon stores. Changing the amount of atmospheric CO₂ has almost no effect on the spread among models. All three biogeochemistry models predict a small increase (5–11%) in NPP. One of the biogeography models predicts an increase in the ratio of C₃ to C₄ grassland as the only CO₂-dependent change. The other two predict modest increases in forest area.
Exploding species

A midst all the discussion and disagreement about just how many species exist there used to be two accepted principles. The first is that we are unsure within an order of magnitude exactly how many species there are in total, and the second is that we know pretty well how many species of birds there are; with a typical figure being around 10,000 (Refs 3,4). Participants at a recent conference have thrown the second principle into question. Results from molecular studies are showing various populations to be quite different genetically from each other, and they should therefore perhaps be reclassified as species. Such reclassifications are debated, because they do not appeal directly to the classic biological species concept, which stakes reproductive isolation as the main criterion for erecting a subspecies to species status. Field researchers directly address this question, and their results are also pointing to a revised estimate of the number of bird species, which is considerably more than was previously thought.

These studies are typified by research on the Old World leaf warblers (genus *Phylloscopus*), a group of small greenish birds living throughout the temperate regions of Eurasia. Many species look extremely similar to each other, and it was only in 1768 that Gilbert White in his book *Natural History of Selbourne* separated the three British species—the familiar chiff-chaff (*P. collybita*), willow warbler (*P. trochilus*) and wood warbler (*P. sibilatrix*)—based on their quite dissimilar songs. Two hundred years on, Alstrom, Olsson and Colston, working in China, have added three new species using the White approach, which is essentially skilled field observation. The main additional tool they use is song playback. Heterospecifics usually show no interest in other species' songs. At least one of the newly described species had representatives sitting in the drawers of the British Museum but had been lumped with other species similar in plumage and size, raising questions about

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**References**


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**NEWS & COMMENT**

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**Christopher B. Field**

Anne Ruimy

Carnegie Institution of Washington, Dept of Plant Biology, 290 Panama Street, Stanford, CA 94305, USA

Yiqi Luo

Bioresources Center, Desert Research Institute, 7010 Dandini Boulevard, Reno, NV 89506, USA

Carolyn M. Malmström

James T. Randerson

Matthew V. Thompson

Dept of Biological Sciences, Stanford University, Stanford, CA 94305, USA, and Carnegie Institution of Washington, Dept of Plant Biology, 290 Panama Street, Stanford, CA 94305, USA