VEMAP: model shootout at the sub-continental corral

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 (called VEMAPl) begins with three published scenarios (a surprising involvement 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 VEMAP 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 re-distribution of the major biomes.

VEMAP does not present a single answer or 'best' estimate for future biome boundaries and NPP. There is, however, a reassuring similarity and reasonableness 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.

Simulations with GCM climates for double CO₂ yield a diversity of results among models, and reveal the first contrasts in the direction of simulated responses. Especially for the most severe GCM climate [UKMO (Ref. 9)], two biogeochemistry models predict increased NPP, but one model predicts a decrease. Two biogeochemistry models predict an increase in the area of broadleaf forest, but one predicts a decrease. The range in estimated NPP and carbon storage expands still further in simulations with both doubled CO₂ and altered climate. Using the biome distributions simulated by the biogeography models as the vegetation maps for the biogeochemistry models does not further expand the range of results for NPP and carbon storage. For the simulations representing the greatest departures from current conditions (altered climate, doubled CO₂ and redistributed biomes), the range in estimated NPP is 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 VEMAP 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 re-distribution of the major biomes.

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Exploding species

Amidst 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 to 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 about 10,000 (Reas 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 Selborne separated the three British species – the familiar chiffchaff (P. collybita), willow warbler (P. trochilus) and wood warbler (P. sibilatrix) – based on their quite dissimilar songs. Two hundred years on, Alström, 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