Understanding plant dispersal and migration

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The Plant Dispersal and Migration workshop was held in Montpellier, France, from 19 to 23 June 2001.

In 1996, participants in a workshop on plant migration and climate change claimed that ‘a more realistic portrait of plant migration is essential to predicting biological responses to global warming in a world drastically altered by human activities’. Models used to predict the response of the biosphere to climate change then simply ignored migration by assuming that it was either not limiting or was absent. How much has our understanding of plant migration progressed since then?

Global vegetation models still lack any explicit representation of plant migration. This lack of progress contrasts with the recent proliferation of studies on long-distance dispersal, owing to the recognition of its crucial importance in fields as diverse as response of vegetation to past and future climate changes, management of invasive species and consequences of landscape fragmentation. Motivation for studying plant migration seems to have shifted from a purely functional question (how would ecosystem functioning be affected if some groups of plants cannot move fast enough to track climate change?) to including the broader biodiversity issue (which species are more at risk of extinction given both climate and landscape alterations?). Discussion at this recent workshop revolved around how to: (1) measure dispersal and other components of plant migration accurately; (2) build predictive models of plant migration; (3) relate migration abilities to species traits to identify species at risk; and (4) incorporate this information into large-scale vegetation models.

Progress and frustration in measuring dispersal

There have been considerable recent advances in the measurement of dispersal in various ecological situations because of an exemplary integration between modelling and data collection (James Clark, Duke University, NC, USA). Tutorials during the workshop helped participants to share methods of sampling, analysing and modelling dispersal distributions. In spite of enthusiasm for new methods, scepticism was expressed about their capacity to inform long-distance dispersal. Both ecological and genetic indirect methods suffer from their high sensitivity to local dispersal, which prevents the independent estimation of rare long-distance events. A mechanistic approach of dispersal, describing processes rather than patterns, could allow us to overcome these difficulties, as long as mechanisms underlying long-distance dispersal could be described properly (Ran Nathan, Ben Gurion University, Beer-Sheva, Israel).

A paradigm shift

Estimated migration rates from the paleorecord are generally much greater than are predictions of classic diffusion models (Reid’s paradox). This clash in predictions has been interpreted as evidence for rare, undetected, large dispersal movements. Long-distance components of dispersal distributions have thus been added to models of spread to generate estimated migration rates that are closer to those observed in the paleorecords. Although it was claimed that Reid’s paradox had been solved, recent findings concerning both estimates of past and present migration have shed a different light on this issue. Spatial distribution of cytoplasmic DNA in modern populations of trees suggest that recolonization during the Holocene might have relied on the existence of small refuges that are undetected by pollen records, rather than relying on rapid migration (Jason McLachlan, Duke University). In parallel, models incorporating more ecological complexity, such as stochastic variation in life history, or mosaic landscapes, predict smaller spread rates. Both findings have altered our perspective on migration: the role of seed dispersal has been eclipsed by that of habitat configuration (Mark Schwartz, University of California, Davis, CA, USA).

Which species are most at risk?

Migration ability cannot be measured for every species or every habitat on Earth. Can we use what we know about the few species and habitats where data have been collected to extract general patterns and extrapolate to other situations? The development of objective databases of plant dispersal potential might help to test hypotheses about relationships between species traits and long-distance dispersal, whose generality has rarely been assessed. They will also aid the identification of understudied biomes, life forms or dispersal modes, and potential methodological bias. Risk assessment also depends on the migration rates required to track climate change; for example, species inhabiting strong altitudinal gradients might have a shorter distance to migrate to reach the right climatic conditions compared with those in areas with a weaker gradient (Guy Midgley, NBI Cape Town, South Africa). A comparison of estimated and required migration rates across floras and life forms was initiated at the workshop.

Incorporating migration in global vegetation forecasts

Models used to simulate the dynamic interplay between climate and vegetation are based on several simplifications (Ron Neilson, US Department of Agriculture Forest Service, OR, USA). Species are lumped together in functional groups, large grid cells are considered homogenous and migration is ignored. Numerous issues arise when trying to transfer small-scale, species-specific knowledge about dispersal to larger scales. How does dispersal ability relate to traits involved in either the response to environmental factors or ecosystem functioning? On which basis should we split the considered functional groups to distinguish between poor and good dispersers? How would ecosystem functioning be affected if some but not all species within a functional group manage to keep up with climate change?
Conclusions
Understanding plant migration and its exact consequences for ecosystem functioning and biodiversity still seems far from reach. Paradoxically, our understanding of local dispersal processes has, during the five years that separated the two workshops, benefited from theoretical and empirical advances motivated by long-distance dispersal issues. Recent findings suggest that landscape structure, rather than dispersal potential, might be the key to understanding past and future migrations.

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References

Challenges of a changing Earth
Josep Canadell and Ian Noble

The Challenges of a Changing Earth: Global Change Open Science Conference was held in Amsterdam, The Netherlands, from 10 to 13 July 2001.

Earth has entered an era that has no precedent. Human-driven changes are modifying the global environment at a speed that rivals and often surpasses the geological forcing that drives changes of climate, biogeochemical cycles and biodiversity. These changes are cumulative and interactive, with multiple feedbacks and teleconnections that result in highly nonlinear system behaviour. Abrupt changes and thresholds within periods relevant to the span of a single human generation that are found in paleo-records provide insights into such planetary dynamics. The current rapid global environmental change could take the Earth into a different state, with implications for its habitability.

Earth system science faces the challenge of integrating the physical, chemical, biological and human systems to form a new understanding of the Earth’s dynamics in ways that we could not even imagine just a few years ago. In recognition of the need for an urgent scientific effort to take on this challenge, and to build towards a global sustainability agenda in light of increasing human perturbation, the three major global environmental change projects, the International Geosphere–Biosphere Program (IGBP), the International Human Dimensions Program (IHDP) and the World Climate Research Program (WCRP) jointly sponsored the Challenges of a Changing Earth, their first collaborative open science conference. With scientists from 100 countries, including more than 400 scientists from developing countries, this was the biggest and most internationally attended event in global change science that has taken place.

The conference encompassed a large range of topics dealing with the carbon cycle, water cycle, food production, biodiversity, land-use change and its feedbacks on climate change and variability. Areas considered worthy of special attention over the next decade of research include:

• Carbon sinks: can we rely on them? Many of the Earth’s ‘sinks’ for CO₂ are vulnerable to human actions and only buy time to make fundamental changes in our use of fossil resources. Where do we go from here?
• Greenhouse gases and the climate system: for the past 420 000 years, the Earth system has operated so that CO₂ levels remain within tight bounds. In the past century, we have pushed CO₂ levels well beyond these bounds. What does the future hold?
• Can technology save the planet? It is tempting to believe that our technological ingenuity will save us from environmental hazards, but how much can we rely on technology to save us?
• Air quality in the 21st century: the 21st century will see changes in the chemistry of the atmosphere as a result of human activities. What can be done to ensure that we have clean air to breathe?
• Mega-cities and global change: mega-cities (those with more than one million inhabitants) are growing in both extent and number. What impacts will they have and how vulnerable are they to global change?
• Our changing land: nearly 50% of the land surface has been significantly transformed by our actions and only ~5% remains pristine. What do such massive changes mean for the functioning of the planet?
• El Niño Southern Oscillation: some of the most important effects of climate change will come from its influence on El Niño. Will El Niño events become more frequent in the future?