Exploring the significance of land-cover change in South Africa

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Changing land cover is a phenomenon that is growing in magnitude and significance, both globally[1] and in South Africa[2]. Changes in land cover include the conversion of natural vegetation to agricultural crops and forest plantations, changes to natural vegetation through bush encroachment and overgrazing, soil erosion, invasion by alien plant species, and accelerating urbanisation. Land-cover changes increasingly relate to climate and atmospheric changes in ways that are currently poorly understood but potentially significant, especially in terms of compromising or enhancing the delivery of vital ecosystem services from rangelands, agricultural croplands, water catchments and conservation areas.

Land-cover change is being studied in different ways, and at different scales, by ecologists, plant physiologists, applied biologists and social scientists. A core group of scientists has recently formed the Land Cover Change Consortium (LCCC), which aims to begin integrating the results of the varied approaches to studying land-cover change, and to guide future research directions, with a view to building a better science base for informing policy and management decision-making in conservation, agriculture and environmental management. The group has developed a simple conceptual outline that links field experiments, observation and monitoring, modelling and prediction of land-cover change (Figure 1), and is currently developing a funding base to support collaboration in addressing fundamental questions about how ecosystems might change in the coming decades, in training new graduates, and in communicating effectively with policymakers. The LCCC hopes to provide a theoretical and practical multidisciplinary platform for scientific collaboration on global change issues that also includes different stakeholder groups and contributes to policy and decision-making. Multidisciplinary collaboration is notoriously challenging, but holds great promise for novel insights.

The LCCC has begun organising itself over the past 2 years in a series of meetings, and in January 2012 held a session devoted to global change drivers and their effects on plant physiology,

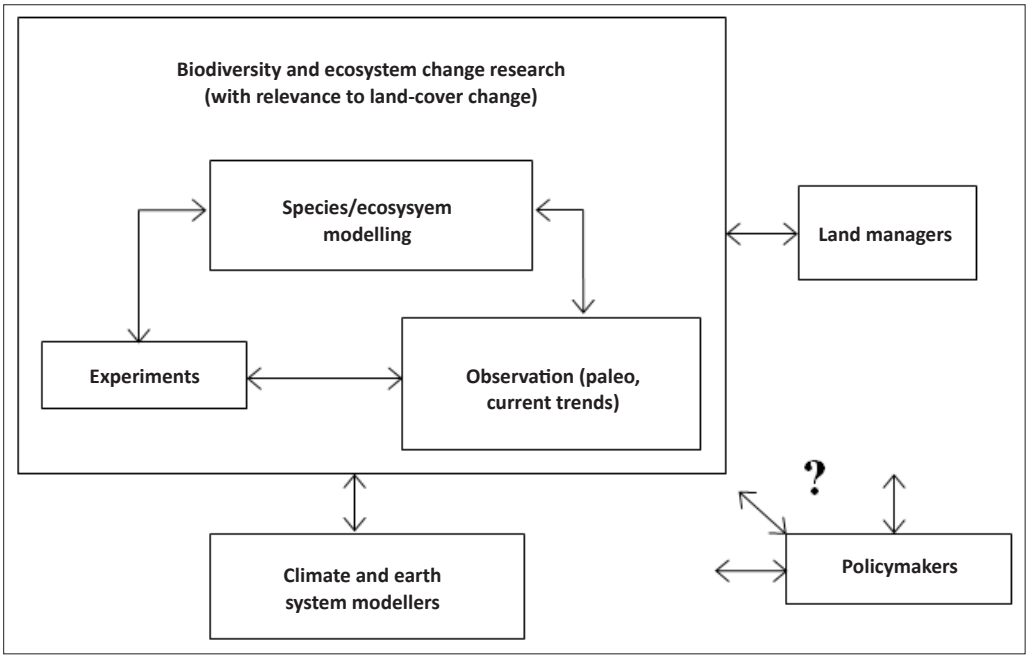

FIGURE 1: A framework for multidisciplinary communication (represented by arrows) engaged in fundamental research on biodiversity and ecosystem change that is relevant to land-cover change issues, which includes key users of the results as identified by the Land Cover Change Consortium. The consortium aims to enhance communication and collaboration between observation, experimentation and ecosystem modelling disciplines as essential for producing results credible to two important user groups, (1) large-scale earth system and climate modellers and (2) land managers. Mechanisms for effective interaction with these different user groups present distinct challenges, and communication with policymakers is poorly understood but nonetheless desirable.

vegetation cover and water balance at the annual meeting of the South African Association of Botanists (SAAB). This session was followed by a 1-day workshop at which about 50 participants from a wide range of disciplines further explored the significance of global-change drivers, land-cover change and interactions between these phenomena. Six keynote speakers presented overviews of important topics that broadened the specialist perspectives provided at the SAAB session. Participants then formed breakout groups to identify discipline-specific perspectives on drivers of land-cover change, key uncertainties and ways of integrating research findings, and delivering the findings to key policymakers. Disciplines then presented their ideas to the workshop in a final plenary discussion session to facilitate cross-disciplinary awareness and facilitate novel insights into approaches to studying land-cover change. Attendees were divided into 'ecophysiologists', 'modellers', 'field ecologists' and 'applied researchers' (those engaging directly with end-users).

Introducing the workshop, William Bond of the University of Cape Town (UCT) outlined how these groups could collaborate to expand our understanding of vegetation changes currently taking place. He contrasted NASA predictions of climate change in Africa with regional climate change predictions.[3] In particular, Bond highlighted how large areas of southern Africa were being transformed by an increase in tree and shrub cover, possibly as a result of the fertilisation of woody plants by rising atmospheric CO_2. Bob Scholes of the Council for Scientific and Industrial Research (CSIR) illustrated how recent developments in remote sensing could expand the potential to monitor land-cover change, and emphasised a key distinction between land cover and land use – that a piece of land has a single quantifiable cover type but can have multiple uses. He noted that most (80%) of the land cover in South Africa is natural or semi-natural, and monitoring and projecting changes in this cover would benefit from closer collaboration between ecologists and remote-sensing specialists in order to classify attributes and predict impact on ecosystem services. Land-cover change is also affected by invasive alien plants, which currently occupy over 10% of the country (at varying degrees of density), where they impact negatively on the delivery of ecosystem services. Brian van Wilgen of the CSIR presented an assessment of the costs of these invasions, which currently amount to an estimated R7 billion annually, with a range of invasive alien plant species increasing cover by between 6% and 14% per year. Current control efforts are not keeping pace with spread rates, despite significant investment in alien control (with the exception of selected species under biological control), and significant enhancement of existing approaches will be needed if this problem is to be prevented from reaching epidemic proportions.

Neil Mackellar of UCT discussed the implications of land-cover change for the water cycle, and discussed the application by climate scientists of land surface models which simulate fluxes of water, carbon and energy as well as plant physiology and dynamics, and additional elements such as fire and catchment hydrology. Two speakers then elaborated on human socio-economic drivers and vulnerabilities. Pippin Anderson of UCT elaborated on the complexities of urban–rural interactions and dependencies. Cities are significant sinks for nitrogen, phosphate and heavy metals, and as they grow, their 'footprint' into surrounding rural areas expands, driving further land-cover change. Urban populations are growing rapidly, and planning will largely determine their future sustainability. Finally, Jeff Manuel of the South African National Biodiversity Institute discussed how uncertainty in climate change projections and land-use change, and their effects, raises challenges for conservationists and land-use planners. The science and the policy environments are extremely complex, and land-use planners have the difficult obligation of balancing community and biodiversity needs.

Participants in break-out groups were given a broad guideline to list key drivers of change from the perspective of their discipline in relation to two axes: the impact of the driver and its uncertainty. Broad categories were identified as:

- Environmental drivers, including increases in CO_2 and other greenhouse gases, climate change, nitrogen deposition, invasive alien species, fire, extreme weather events, floods and natural disasters
- Political legacies and responses, including colonial and apartheid land policies, historical land use, land policy and reform, changes in land tenure and current policies on food security
- Economic considerations, including different economic paradigms, the carbon market, foreign investment, commodity prices and foreign aid
- Human population density increases, both through growth and through immigration, that drive changes in economic status, livelihood options, wealth and per capita consumption and disease patterns
- Social and developmental responses to human population growth, including urbanisation, infrastructure and service provision, industrialisation, energy demand and shifts in energy sources, demand for small-holder cultivation, grazing land, housing and infrastructure, employment opportunities, leisure and eco-developments
- Changing patterns of agriculture and plantation forestry
- Mining (especially open-pit and surface mining) that requires site rehabilitation and the safe disposal and/or treatment of waste and spoils.

The initial discussion of drivers and uncertainties was superseded by discussions that identified critical interactions between natural, human (local) and policy (national and global) drivers at different scales, but with the realisation that their study presents an extremely complex challenge. Participants agreed that land-cover change provides a useful cross-cutting theme for engagement between broad research and stakeholder communities. Mixed-use landscapes, occupied by people at varying levels of density, provide a natural experimental framework to explore linkages between biophysical and human systems. New tools are emerging

in many disciplines, making their study more tractable. Increasingly, many disciplines are engaging with complexity, transitions and transformations, and the recognition of change as the norm. Land cover will change in response to the above drivers, but land-use activities or management practices may even be more important than the changes in land cover themselves. There is much uncertainty on the net impact on human livelihoods, as the effects of land-cover change can have both positive and negative outcomes, and there are multiple possibilities for intervention. The outcomes themselves are perceived in different ways by different stakeholder groups, with the tourism, conservation, agriculture, impoverished rural community, and government policymaking sectors all having particular values and perspectives. These differences have clearly resulted in conflict in some situations, and emphasise the need for ways to quantify better the necessary trade-offs in such a way as to minimise negative consequences and maximise benefits and sustainability.

Workshop participants recognised that certain key areas and interactions between land-cover change drivers are poorly understood, and that the capacity of a multidisciplinary approach to address these will depend in part on how well important gaps may be filled. These gaps include the need for a more coherent and representative network of environmental and climate monitoring stations; for better integration, analysis and synthesis of data; and for focused experimental work on ecological responses to human pressures, climate and CO_2 change. The LCCC plans to interact with the South African Environmental Observation Network, which is addressing several of these gaps. Socio-economic research could usefully explore the perceived versus real value of natural resources, the perspectives of different stakeholder groups, and their role in human choices of particular forms of land use. An accurate agricultural census would also be useful and studies of the effects of environmental change on crop plants in Africa are urgent.

Several issues were identified as priority foci. Among natural processes, these included changing fire regimes and their effects; changing patterns of herbivory by livestock and wildlife, and the responses of vegetation to these; invasions by alien species and by endemic woody species and their consequences; and the effects of habitat fragmentation on the sustainability of natural ecosystems. Important socio-economic issues included human population growth and associated changing patterns of resource use; the growth in the cultivation and use of biofuels, and related consequences for food security, conservation and alien invasions; and the impacts of accelerating urbanisation. Many of these topics offer significant opportunities for collaboration between the natural and social sciences, including resource economists. Finally, participants called for a better understanding of the economics of land-use change and the value of ecosystem services, many of which are currently not explicitly valued (carbon storage being the exception). The consortium aims to offer a vehicle for cross-sectoral discussions on the scientific understanding of land-cover change, for building collaborative partnerships to tackle challenging questions, and for enhancing efforts to raise the funding necessary to research them.

Scientists interested in being included in the LCCC mailing list should contact:
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