tions, and underline the value of their outputs in long-term field studies. These might restore them to their rightful place in the ecological pantheon, places where students can learn to appreciate the insights they offer, and hence maintain them.

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book review

Macro-ecology of the world's savannas

Ecosystem function in savannas: measurement and modelling at landscape to global scales, by Michael J. Hill and Niall P. Hanan (eds.)
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A quarter of a century has passed since the 'legacy work' of Tucker and collaborators (e.g. Tucker et al. 1985) characterizing the spatio-temporal dynamics of vegetation using temporal series of NDVI data from the NOAA AVHRR sensor, notably over the Sahel region. In the meantime, thanks to advances in Earth Observation (EO), an impressive array of technologies and methods has emerged, multiplying the number of biological and physical variables that can be measured, mapped and monitored over broader spatial and temporal scales than ever before. Progress comes from the development of new sensors, but also thanks to numerous initiatives aiming at facilitating data accessibility, the most recent of which is the launch of the Google Earth Engine© platform.

Therefore, although a number of books exist on savanna ecology, the time is definitely ripe for a general survey of where we are, after these crucial developments, in our understanding and monitoring capacity of savanna ecosystems. This is what Hill and Hanan, along with an impressive team of renowned contributors, have achieved in this volume, notably by bringing together different communities working respectively on field measurement, remote sensing assessment and modelling of savanna structure, dynamics and biogeochemical fluxes at landscape to global scales.

A central question, which continues to stimulate the scientific community, concerns the determinants of tree–grass coexistence in savannas. Mainstream hypotheses are reviewed (chapters 2 and 13), such as bottleneck models, in which perturbation by fire, herbivory or drought tend to reduce tree density, as opposed to the so-called Walter niche-separation hypothesis, according to which trees are maintained by access to deeper soil resources. Of course, real mechanisms are a great deal more complex, and a number of feedbacks and interactions between plants (facilitation and competition), and with grazers or browsers, are detailed. We could further argue that the question itself of 'tree–grass coexistence' might be stated in over-simplified terms, because not all tree and shrub species, for instance, show the same dynamics and strategies with regard to fires and herbivory (see e.g. Beckage et al. 2009).

Given the number of variables interacting in different soil and climate contexts (well presented in chapter one), and the spatial and temporal scales involved, it is clear that empirical/experimental approaches are difficult to implement. The combination of 'natural experiment' approaches with modelling studies is therefore a good way forward. In the former, one investigates multiple correlations and interactions between biological variables and potential physical drivers, through space and time, using EO data; in the latter, these correlations can be tested in 'controlled' conditions *in silico*.

This brings us back to the technological developments of remote sensors. In a synthetic table (table 27.2), the authors list a range of biophysical variables that can be estimated at different reso-

lutions and extents, from detailed 3D structure using new LiDAR, radar and hyper-spectral optical technologies at landscape scales, to fractional canopy cover and fire history at broader scales and extents. Chapter 8 illustrates quite well the exciting possibilities offered by active sensors, including ground- and air-based LiDAR, for instance to obtain reliable biomass estimates. I cannot resist citing another recently published application (Levick et al. 2010), in which airborne LiDAR was used to map the spatial distribution and sizes of termite nests, an important factor in savanna ecology.

Linking these remotely sensed data to field measurements may yield impressive results, despite the difficulty of matching scales —especially for low resolution data. This is illustrated by the link found in chapter 4 between MODIS-derived fPAR (absorbed fraction of the photosynthetically active radiation) and carbon fluxes measured at an eddy covariance site in the Kruger park; or in chapter 11 by the relationships found for fractional canopy cover between (field) densiometer measurements of the tree canopy cover, airborne LiDAR-derived estimates and a parameter inversion using Landsat and JERS-1 backscatter data.

The importance of using spatially explicit approaches, is emphasised throughout the book. Table 14.1 for instance, lists some of the major spatial processes in savannas, together with their scale and effects. I strongly agree with this vision, but I would have appreciated some more emphasis on the possible ways to quantify the spatial structure of vegetation (in terms of scales of patchiness for instance), or to model how heterogeneous structures may emerge endogenously, within a given catenal, edaphic, or climatic context. In that respect, the potential of very high resolution (metric) optical imagery should be highlighted. Indeed, the hindsight provided by aerial surveys starting in the middle of the 20th century and the recent release of confidential digitised spy satellite (Corona) imagery, along with the current development of space-borne digital sensors (Ikonos, Quickbird, GeoEye, SPOT) provide splendid sources of information for the dynamics of savanna structure (e.g. Laliberte et al. 2004, Barbier et al. 2006, Deblauwe et al. in press).

A large portion of the book covers the modelling of savanna dynamics and biogeochemical fluxes at various scales and using varying modelling frameworks. A crucial point is of course how to integrate field and remote sensing data within these models. However, despite the potential of EO data to establish cross-scale links, the authors deplore that most of the time EO data are still predominantly used to define basic land-cover categories, whereas their potential for obtaining quantitative estimates of biophysical variables remains largely underutilized. This certainly justifies the desire, expressed in this book, to build bridges across disciplines.

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