

EDITORIAL

**FROM STATE-TRANSITION MODELS TO ECOSYSTEM SERVICES—
A COMPENDIUM IN HONOR OF IMANUEL NOY-MEIR'S LEGACY**

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I had the great honor of being one of Imanuel Noy-Meir's Ph.D. students at The Hebrew University of Jerusalem during the early 90s of the last century. Therefore, it is a privilege for me to serve as Guest Editor of this special issue, which aims to honor his memory and legacy through the inclusion of manuscripts from a small group of researchers who collaborated with Imanuel. The compendium includes a wide range of topics, representing but a small proportion of the broad areas of interest to which Imanuel dedicated himself during his professional and academic life as an ecologist. Imanuel was a man of many interests and sharp thoughts. Noam Seligman, Eddy van der Maarel, and Sandra Diaz (Seligman et al., 2011, this issue) reflect in their obituary on Imanuel's wide range of active participation in ecological research that led to the development of a broad spectrum of ecological theory and thought, combining field work and applied issues in ecology. Within this spirit, Imanuel, jointly with his colleagues, Brian Walker and Mark Westoby (Walker and Westoby, 2011, this issue), developed the state-transition model idea. State-transition models are based on the assumption that alternative states exist in communities, and that communities are rarely in equilibrium. The development of the idea that ecosystem resilience embraces multiple system states is presented in the current compendium. The model considers that a given state persists until events or processes cause changes in the types or groups of species, and the system is forced to reorganize. Management based on ecological resilience emphasizes the need to view events or disturbances in a regional rather than a local context, and to maintain spatial heterogeneity. State-transition models can guide decision-making processes in rangelands by identifying possible outcomes of each current state and the conditions required for transition between states. Daniel Milchunas (Milchunas, 2011, this issue) in his study tackles important issues related to both state-transitions models and range management theory: How does grazing or protection from grazing affect the species composition of a range? It appears that the short grass steppe vegetation was basically insensitive to the grazing treatments applied in the study, possibly because of thousands of years of heavy bison grazing that have selected the most resilient species available. When grazing was excluded, or there was more rainfall, increased species richness was recorded following the invasion of exotics and native weeds. While relating to state-transition models and their application to the particular conditions of the ecosystem considered, the conclusions of this study could be transferred to Mediterranean ecosystems characterized by long-term

human effects on the landscape. Zalmen Henkin (Henkin, 2011, this issue) explores the multiplicity of transitions states in Mediterranean shrublands and woodlands under grazing based on the natural and human-made spatial heterogeneity that characterize the region. He discusses the range of management options that are critical for sustaining its diversity and potential productivity under the multiple-use of the landscape. Within this aim, Avi Perevolotsky and Efrat Sheffer (Perevolotsky and Sheffer, 2011, this issue) develop this topic further by considering the need for integrated management of the heterogeneous Israeli landscapes under Imanuel's conception of multiple-use for securing optimal ecosystem services. They propose a framework for integrated landscape management where all Israeli agencies responsible for the management of natural and planted ecosystems work together to sustain maximum heterogeneity while securing the ecosystem services.

Noy-Meir was also intrigued by plant traits that affect the responses of natural systems to environmental change and land-use. New studies on the mechanisms that relate vegetation composition to ecosystem functioning and ecosystem services have indicated the important role of functional diversity, represented by the range and distribution of trait values within communities, in this process. Sandra Lavorel and colleagues (Lavorel et al., 2011, this issue) have focused on the responses of plant functional diversity to land-use changes along an aridity gradient (also represented by a decreasing grassland grazing intensity). They selected key plant traits at the community level that allowed them to understand part of the mechanisms of community response to environmental change, particularly when grazing is excluded. This study has particular importance considering the scale of land-use and environmental changes currently occurring in Europe and Israel.

During the late 1970s Imanuel and his former student, Michael Luria, studied some key regeneration life-traits of annual populations in desert and Mediterranean ecosystems (Luria and Noy-Meir, 1979). This was an early work aiming to understand reproductive traits that allow population persistence in unpredictable environments such as desert and semiarid rangelands. Lebrija-Trejos and colleagues (Lebrija-Trejos et al., 2011, this issue) provide an interesting evaluation and quantification of reproductive traits of annual plant communities in a Mediterranean and a semiarid ecosystem. In their field study they quantified a number of important seed traits that enabled the analyses of different plant functional traits of communities along a rainfall gradient in Israel. The importance of seed loss (around 80%) in the semiarid community compared to that of the Mediterranean, despite opposite trends in primary productivity, provides new insights into the existence of diverse alternative strategies for coping with the wide range of environmental constraints in these systems.

One of these constraints relates to the synchronization between flowering period, pollinator activity, and environmental conditions. According to ecological theory, flowering time is critical for reproductive success, but phenology could be influenced by environmental conditions, particularly drought under expected climate change (Parmesan, 2006). Kigel and co-authors (Kigel et al., 2011, this volume) analyzed data from common-garden experiments in Israel to test whether water stress was an environmental sig-

nal strong enough to induce earlier flowering in plants. Interestingly, their experimental data did not support their original hypothesis that lower water availability induces earlier flowering in plants, despite clear phenological differences among populations along a rainfall gradient in Israel. This result highlights once again the wide range of strategies developed by the natural plant communities in the region to successfully cope with the diverse abiotic and biotic conditions in these heterogeneous environments.

Within Noy-Meir's thinking it was important to upscale from individual plant traits to ecosystem functioning at different spatial scales. Arnon and colleagues (Arnon et al., 2011, this issue) present a study of the spatial aspects of pastoral herding including flock route, flock speed, and frequency of flock presence, as influenced by distance from the corral, aspect, and slope angle. The authors used GIS and GPS tools for collecting and analyzing the data. The authors stressed and exemplified how these tools may allow improving management practices by understanding grazing patterns, which landscape features may affect the spatial and temporal characteristics of such patterns, and how actual grazing patterns differ from hypothetical ones. Most of these elements were considered (primarily under a theoretical approach) in Noy-Meir's classical paper of 1973 (Noy-Meir, 1973).

The present compendium ends with a manuscript co-authored by Noy-Meir (Koniak et al., 2011, this issue). It represents one of Imanuel's latest concerns in relation to use and management of open landscapes for environmental services such as public recreation. The outcome of this research may facilitate land managers and decision-makers in securing recreation in open landscapes, and in guiding management for obtaining the desired vegetation formations for this aim, according to the preferences of the "users" of these areas.

Imanuel Noy-Meir was the ecologist who had the greatest impact on ecological theory and its applied outcomes in his generation in Israel. His legacy will remain alive for many generations of ecologists to come.

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