An Indicator Framework for Assessing Agroecosystem Resilience

Joshua F. Cabell and Myles Oelofse

ABSTRACT. Taking departure in the theory of resilience in social-ecological systems, we present an analysis and discussion of how resilience theory can be applied to agroecosystems. Building on the premise that agroecosystems are too complex for resilience to be measured in any precise manner, we delineate behavior-based indicators of resilience within agroecosystems. Based on a review of relevant literature, we present and discuss an index of 13 such indicators, which, when identified in an agroecosystem, suggest that it is resilient and endowed with the capacity for adaptation and transformation. Absence of these indicators identifies points of intervention for managers and stakeholders to build resilience where there is vulnerability. The indicators encompass various phases in the adaptive cycle and seek to link core aspects of social-ecological systems. We stress the strong societal need for building resilience in agroecosystems and advocate for a broader way of evaluating resilience in agroecosystems.

Key Words: adaptive cycle; agroecosystems; behavior-based indicators; resilience; social-ecological systems

INTRODUCTION

The global food system is experiencing rapid and dramatic changes concurrent with global social-political and ecological changes. However, this is nothing new, as societies have experienced rises, falls, and shifts in food production and availability ever since humans sowed the first crops (Diamond 2005, Carpenter et al. 2006). As philosophers and scientists from Heraclitus to Gunderson and Holling have observed, change is one of the few inevitabilities of life. What sets apart the changes occurring today are the rate, magnitude, and genesis of the changes, and the fact that we have the capacity to anticipate and possibly influence the trajectories of these changes (Holling 2001). In terms of the global food system, changes in climate, increased economic disparity, political instability, and shifting consumption patterns have repercussions that are causing nearly one billion people to go hungry while one billion more suffer from obesity worldwide. The loss of freshwater resources, erosion of topsoil, and general degradation of ecosystem services are further undermining the ability of humans to meet their nutritional needs (Millennium Ecosystem Assessment 2005, Carpenter et al. 2006, McIntyre et al. 2009). As the human population approaches nine billion by the mid-21st, as diets shift to demand more meat products and as the discovery of new oil reserves, upon which modern agriculture relies, reaches a plateau, there is a pressing need to find new paths to both food security and resource conservation (Gliessman 2007, Ericksen 2008).

The theory of resilience in social-ecological systems, as first described by Holling (1973) and developed further by others representing a wide range of fields, offers a useful framework for understanding the dynamic relationship between humans and the environment (their so-called social-ecological systems, or SESs), and provides models for increasing society’s capacity to manage change. Essentially, resilience is measured in three ways: (1) the amount of change the system can undergo and still retain the same controls on function and structure; (2) the degree to which the system is capable of self-organization; and (3) the ability to build and increase the capacity for learning and adaptation (see Holling 2001, Gunderson and Holling 2002, Folke 2006, and Folke et al. 2010 for an overview of resilience theory, including the adaptive cycle and panarchy).

Although resilience theory is valuable as a metaphor, one area in which it is critically underdeveloped is in metrics (Carpenter et al. 2001, Cumming et al. 2005). The reason that resilience is difficult to operationalize, admit Cumming et al. (2005), is because of its abstract and multi-dimensional nature. Nevertheless, they, and others, attempt to operationalize it. Resilience is an emergent property of systems and can be very context dependent, particularly in spatio-temporal scales and perspectives (Carpenter et al. 2001). A system that is considered resilient today may not be considered so in 50 years, let alone next month, because the internal conditions or the larger system in which it is embedded can and will change. And change can happen suddenly and unexpectedly (Holling 2001). Compounding the difficulty is the fact that resilience in the short term may paradoxically reduce a system’s resilience in the long term. In contrast, apparent instability today might build greater resilience for the future (Carpenter et al. 2001, van Apeldoorn et al. 2011). Finally, resilience is not always positive. Systems can become stuck in a cycle of poverty or ecological degradation that is resistant to transformation into a more positive configuration. By its nature and because of our own limitations of comprehension, resilience defies measurement.

In addition to Cumming et al. (2005), other authors have acknowledged the inherent challenges in measuring resilience and propose alternative approaches (Bennett et al. 2005,