Evolution and global change

In their article *Managing microevolution: restoration in the face of global change*, Rice and Emery (2003) provide an important reminder of the potential for evolutionary responses to global change, particularly that species populations could adapt in situ to climate change. They do an excellent job of discussing the various factors that will influence the potential for microevolution in response to global change, and of the importance of considering evolutionary issues in restoration efforts. As they point out, "an evolutionary perspective is rare in current discussions and research on the effect of global change". The word "adaptation" is commonly used in discussions of responses to global climate change, but rarely does it refer to evolutionary change.

While I agree that global change scientists who study the responses of ecosystems should be more aware of the evolutionary dimensions of the problem, one must be careful not to leave non-experts with a false sense of security that species will be able to adapt to global change. I have given numerous presentations where non-scientists and scientists alike revealed serious misconceptions about the possibilities of species adapting to anthropogenic climate change; some even think that new species could evolve in response to the changes. At the heart of the problem is the disparity in time scales (ie the projected rate of global climate change vs the potential rate of biological evolution).

In addition to mentioning this potential for misunderstanding, I want to suggest two interesting issues concerning microevolutionary aspects of global change that deserve further attention from researchers. First, what are the community and ecosystem implications of the fact that, all else being equal, species with short generation times (especially more invasive and weedy species) will be more likely to adapt than species with long generation times? The latter obviously include many trees, but perhaps surprisingly may also include some herbaceous species. How could this differential response potential affect the structure and functioning of ecosystems? Second, what are the implications of the fact that wide-ranging species may exhibit considerable population genetic differentiation and local adaptation? There is a tendency to think that wide-ranging species are less threatened by climate change than those with narrow geographic ranges, because even after climate change, populations will persist in some part of the original range. However, if populations are locally adapted, this may not be a valid assumption.

Clearly, it is important for scientists and decision-makers to be conscious of both the potential for, and the limitations on, evolutionary responses to global change.

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Rice RJ and Emery NC. 2003. *Front Ecol Environ* **1**: 469–78.

Alternative view on alternative stable states

Beisner *et al.* (2003) attempt to reconcile two perspectives of alternative stable states in ecosystems. However, their expanded definition is not consistent with the historical development of the concept, and the two perspectives are fundamentally different from an ecological point of view.

Lewontin (1969) considered the possibility of alternative stable states when he asked if there could be more than one stable state "in a given habitat". He also discussed two opposing explanations of the given state of an ecological community that were then being debated in the scientific community. One explanation states that history (eg disturbance events) plays a role in determining the structure of an ecological community, while the other perspective attempts to explain the community using fixed forces without historical events. The second explanation clearly represents the Clementsian view of succession that was the dominant paradigm at that time, and is still highly prevalent in ecological thinking. Clements (1936) believed that a given site would develop through a sequence of stages towards a single, unique vegetation type known as the "climax". The Clementsian perspective views disturbances as an external mechanism that "resets the clock to zero", whereas events that occurred before that zero are key in the other perspective.

A conceptual stability model describing the movements of a ball across a topographic surface with valleys corresponding to basins of attraction has been used to illustrate the alternative stable states concept since the idea was first introduced (Lewontin 1969; Holling 1973; Sutherland 1974; May 1977). However, in its original form, the cup and ball model was used to conceptualize the difference between the Clementsian model, where history does not matter (only one valley in the landscape), and the alternative stable states concept, where a given landscape could have more than one valley. While shifts in alternative stable states in the cup and ball model have traditionally been governed by disturbances, the analogy has now been extended to include shifts caused by changes in the landscape, which represent changes in environmental parameters (Beisner *et al.* 2003). While this can no doubt cause a state shift, it does not address the original question (Connell and Sousa 1983) of whether or not the same site can support different communities under the same environmental or climatic conditions. Connell and Sousa (1983) also stressed the need for the ecosystem to pass through one or several turnovers to prove that it can maintain its existence and thus be stable. These criteria must be observed in order to prove the existence of a system that is alternative to the "climatic climax". If not, then the ecosystem is merely responding to changing environmental or climatic parameters, and moving towards a new climax.

The expression "alternative stable states" has historically referred to cases where two or more different stable states can occur under similar environmental and climatic conditions (Lewontin 1969; May 1977; Connell and Sousa 1983), and not cases where disturbances are a catalyst to a new environmental climax. Our different perspective on alternative stable states in no way decreases the importance of the research conducted by those taking a broader view. If anything, a clearer definition highlights its importance; when an ecosystem cannot re-establish itself after a disturbance due to anthropogenic environmental changes (ie there is no "alternative"), the fragility of ecosystems and our impacts on them are observed. Sustainable ecosystem management and appropriate restoration ecology strategies call for a clear understanding of ecosystem dynamics and what might bring them from one state to another (Hobbs and Norton 1996). Concise conceptual criteria allow us to better investigate and understand these dynamics.

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The authors reply

Jasinski and Asselin suggest that our treatment of two different perspectives of alternative stable states is inconsistent with the historical development of the concept descended from Lewontin (1969), May (1977), and Connell and Sousa (1983), and that these two perspectives differ fundamentally from an ecological point of view. Our intention, however, was not to produce a historically consistent perspective, nor indeed to comment on the importance of the ecological differences between the two points of view. Our intention was to show how and when the earlier notion – Lewontin's "community perspective" – and the more recent "ecosystem perspective" (eg Scheffer *et al.* 2001) may be thought of within the same conceptual framework. We argued that the two viewpoints can be reconciled by recognizing that a "parameter" from the community perspective might be considered a "variable" from the ecosystem perspective.

Whether these perspectives are different ecologically does not relate to whether we can view them under the same mathematical umbrella. We fully agree that whether a given habitat can maintain potential alternative stable states under fixed environmental parameters is an interesting and important question. However, an overly narrow definition of when alternative stable states exist will lead to a prolonged and ultimately unproductive debate regarding appropriate evidence and tests for their existence. For example, there may be feedback between species and environmental conditions that prevents a return of the community and the environment to its original state, even when an environmental perturbation is removed. This type of alternative stable state is not included in the community perspective, since the realized environmental conditions differ between the two states, but is clearly the same phenomenon.

For example, consider a quantity that influences the state of a community, but which is itself not influenced by the community composition. Such quantities are usually treated as parameters. When a parameter is changed, the topological surface defining domains of attraction for the stable states that the community will adopt is also changed. Now consider a quantity that both affects and is affected by the state of a community. Such a quantity is usually treated as a constituent variable of the community, and adds to the dimensionality of the topological surface which defines the available domains of attraction. Ecologists make a distinction between when alternative stable states exist under fixed parameter conditions and when they only arise as parameters are changed. This distinction is only meaningful as long as the definition of parameters and variables is unambiguous. In practice, whether or not we regard a relevant changeable quantity to be subject to feedback from the community depends on the questions we are asking, and, most importantly, the time scales we are considering. Thus, whether or not a community is said to have simultaneously existing alternative stable states may be simply a matter of perspective.

While we think both community and ecosystem views outlined in our paper are useful in thinking about ecology and conservation, our intention was to show how these seemingly disparate views share a common theoretical framework and thereby focus the debate on the real distinctions.

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Hot air in the hot seat

Douglass Rohrman's 2003 analysis of international cooperation to limit the increase of atmospheric greenhouse gases in the Laws of Nature article "Hot air", needs clarification.

Following announcements by the US and Australia that they will not ratify the Kyoto Protocol under the Framework Convention on Climate Change, the only industrialized nation whose ratification would allow the Protocol to come into force is Russia. Mr Rohrman is correct on this point. However, Russian ratification now seems unlikely. President Putin, during his October 29 opening speech at the World Climate Change Conference in Moscow, said that climate change "might even be a good thing – we would spend less money on fur coats and other warm items". Yuri A Israel, one of three vice-chairs of the Intergovernmental Panel on Climate Change, added that Russia "should not be in a hurry" to ratify the pact, as it could do unknown damage to the country's economy.

Mr Rohrman's statement that there is doubt that Russia "will ever be able to lower its CO_2 emissions enough" to meet its Kyoto obligations is incorrect. The collapse of Russia's economy has resulted in a 32% decrease in emissions since the 1990 Kyoto base year. Russia's interest in the Kyoto Protocol was largely based on selling emissions credits to countries that could not otherwise meet their targets. When the US – the largest potential customer – announced it would not ratify the Protocol, Russia's incentive to do so was greatly weakened.

The Framework Convention on Climate Change and the Kyoto Protocol aim to achieve stabilization of greenhouse gas concentrations "within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner". The prospects for the Kyoto Protocol to come into force, and for effective global cooperation to meet this objective, are now greatly diminished.

Mr Rohrman counsels us to "be patient" in the face of tornadoes, and adds, "Meanwhile, I'll crank up my air conditioning". I'd suggest exploring other alternatives.

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Rohrman D. 2003. *Front Ecol Environ* **1**: 393.

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