

## 15. DESERTIFICATION: IMPLICATIONS AND LIMITATIONS OF THE ECOSYSTEM HEALTH METAPHOR

Walter G. Whitford  
Senior Research Ecologist, US-EPA  
Environmental Monitoring Systems Laboratory  
P O Box 93478, Las Vegas, NV 89193  
USA

### INTRODUCTION

The semi-arid and arid regions of the world may provide some valuable insights into the applicability of the ecosystem "health" and ecosystem "medicine" metaphors. These regions provide an example of the applications and limitations of the metaphor because they have experienced and continue to experience degradation and change. Attempts at rehabilitation of degraded areas has proven to be expensive or impossible. Those parameters that are frequently examined to determine the "health" of ecosystems may be more robust in ecosystems that are generally considered to be degraded than in those perceived as healthy. Most such areas have suffered loss of productivity as measured by the capacity to support livestock and human inhabitants. Those losses in livestock productivity resulted from changes in the biological and physical characteristics of the ecosystems within these regions.

Such ecosystems are frequently perceived as "fragile" because low intensity single and/or multiple stressors produce large changes in ecosystem structure and properties. It can be hypothesized that fluctuation in the climates of arid and semi-arid regions frequently approach the thresholds for survival of component species and that the addition of other stressors even at low level push key species over those thresholds (Whitford and Steinberger 1989). Thus, in many regions of the world, the original mosaic of ecosystems that constituted the landscapes in recent historical time have been replaced by a mosaic of ecosystems that occupy different space in the landscape and that differ structurally and functionally from those that have been supplanted. The current mosaic of ecosystems that constitute the arid and semi-arid landscapes of the world thus provide a challenge in addressing questions of what constitutes ecological health: are the replacement or "new" ecosystems healthy? and if the desertified ecosystems are not healthy, can those ecosystems be restored to a healthy state?

Herein, I will attempt to address these questions by reviewing the history of desertification in North America, reviewing the available data on the characteristics of desertified ecosystems and by presenting some data from experimental studies on the resistance and resilience of one desertified ecosystem.

## DEFINITIONS

Desertification can be described as "the diminution or destruction of the biological potential of the land, and can lead ultimately to desert-like conditions. It is an aspect of the widespread deterioration of ecosystems under the combined pressure of adverse and fluctuating climate and excessive exploitation. Such pressure has diminished or destroyed the biological potential, i.e., plant and animal production, for multiple purposes at a time when increased productivity is needed to support growing populations in quest of development." (Verstraete 1986). This definition is the result of a series of United Nations conferences on desertification. The United Nations description of desertification emphasizes the economic implications of desertification and the reduction in management options resulting from degradation of the land resources. Note that the definition of desertification does not mention reduction in net primary productivity. Indeed, in many desertified ecosystems, the grams of carbon fixed per unit time may be higher than that in the undegraded ecosystems. The problem of identifying the changes in net primary productivity associated with desertification is that most of the measurements of primary production on arid rangelands have included only forage species (grasses and herbaceous plants) and the productivity of woody perennials has not been included in the measurements (Le Houerou et al. 1988).

The recognition that desertification has begun occurs when desirable forage species are replaced by species that are largely inedible by livestock (Milton et al. 1994). Desertification progresses along a continuum of erosion and changes in plant cover and species composition to the point where trees, shrubs, and most perennials are gone and the only vegetative production is that of annual plants during wet periods. At this end point of the desertification process, lack of vegetative cover often results in geomorphological changes where dunes, stony pavement slopes and gravel plains replace the original vegetated landforms.

The United Nations definition of desertification focuses on the "loss of options" for use by the human populations inhabiting desertified regions or wishing to use desertified regions in any number of ways. Desertification by this definition is a process in which the biological resources of the ecosystems are diminished thereby reducing current and future use options. Desertification can also be viewed as ill health of arid or rangeland ecosystems. The National Research Council (1994) defines rangeland health as the degree to which the integrity of the soil and ecological processes of rangeland ecosystems are sustained. This definition emphasizes integrity both biological and abiotic. Biological integrity has been defined by Cairns (1977) as "the maintenance of community structure and function characteristic of a particular locale or deemed satisfactory to society." Biological integrity is by this definition is therefore similar but not necessarily equivalent to the concept of ecosystem health (Rapport 1992). Rapport (1992) states that a variety of alternative states might be considered healthy as long as certain basic features, both structural and functional are embodied in those alternative state ecosystems that manifest ecosystem integrity. When ecosystem change results in the loss of options with respect to the use of the system by society, that is generally deemed