12. Banded Landscapes: Ecological Developments and Management Consequences

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Introduction

Most of the studies on banded landscapes have been carried out by groups totally isolated from each other, divided by language, culture, and differing objectives. This book has been structured into distinct themes ranging from the global distribution of these landscapes to their management strategies to synthesize this dispersed knowledge and facilitate the cross-linking of concepts and information. One of the aims of this volume was to integrate the scattered knowledge on banded landscape function to the level of ecological principles to be applied to more complex situations.

The literature on vegetation patterning is wealthier in hypotheses than in corroborating data. This concluding chapter discriminates and discusses the issues that have been clearly demonstrated and widely accepted from those that are still debatable or speculative. This leads us to identify the priorities for future research. We then examine the main lessons that can be learned from the banded vegetation pattern in the broader contexts of landscape ecology and land management. These conclusions are based on the various chapters of this book as well as from the recent special issues of *Acta Oecologica* (Tongway and Seghieri 1999) and *Catena* (Valentin and Poeson 1999) and from other recent publications.

Banded Landscapes: Established Principles of Structure and Function

The following discussion synthesizes the factors and processes now considered as intrinsic to all banded vegetation patterned landscapes.

Co-occurrence of Critical Factors in Banded Landscapes

With the exception of wave-regenerated forests and the ancient suppressed dunes (chapter 1, this volume), it is now well established that vegetation patterns occur only where particular critical combinations of soil properties, topographic shape, and rainfall characteristics are met. These factors must, in general, favor water runoff sufficient to produce sheet overland flow over a distance of few tens of metres but insufficient to trigger the concentration of runoff into rill-flow (chapter 4, this volume).

Soil Properties

There is now general consensus among researchers that differences observed in the soils of bands and conjugate interbands are a consequence of banding rather than a cause (Bromley et al. 1997). Banded vegetation develops on medium-textured soils with low infiltration capacity often due to surface crusting (chapter 4, this volume). Banded vegetation does not occur where sandy deposits locally cover impermeable soils (chapter 1, this volume). Existing banded vegetation collapsed in Mali when wind-borne sands were extensively deposited as a consequence of desertification (Chapter 6, this volume).

Topography

Banded vegetation occurs on planar surfaces with sufficient slope to enable sheet overland flow to initiate. In flat landscapes with a nondirectional runoff pattern, the vegetation is no longer banded but spotted (chapter 1, this volume). Banded vegetation occurs on slopes ranging from as low as 0.12% in Sudan (Worral 1960) to 40.4% in a Mediterranean regime (Cammeraat and Imeson 1999), even though the annual rainfall is similar (250 mm). Slope also controls the wavelength (band plus interband width) of the pattern even at local scale: the wavelength decreasing exponentially with increasing slope gradient (d'Herbès and Valentin 1997; Eddy et al. 1999).

Climatic Regime

Banded vegetation develops under arid and semi-arid conditions, with annual rainfall ranging from 75 mm yr^{-1} in Jordan (White 1969) to 640 mm yr^{-1} (Valentin and d'Herbès 1999). All banded landscapes are subject to a water shortage of some sort. Rainfall can vary from low and nonseasonal, as in Australia (Mabbutt and Fanning 1987), to moderate but highly seasonal, as in Niger (Galle, Ehrmann, and Peugeot 1999). In such a range of circumstances, banding can then be interpreted as a biotic evolutionary "strategy" for surviving lack of available soil water. The bands accumulate runoff water and the biological systems in them function as though they were in a higher rainfall climatic regime (Noy-Meir 1973).

Optimal rainfall for banded patterns has been derived from statistical and simulation studies for a range of different climatic regimes (Table 12.1). This optimal value increases with increasing percentage of high rainfall events and the mean monthly minimum air temperature and decreasing duration of the rainy season.

For a given slope gradient, the contrast between the band and interband becomes less distinct as mean annual rainfall increases (Valentin, d'Herbès, and Poesen 1999) and as the rainfall distribution becomes more even throughout the year (chapter 10, this volume). Further, in a given region, the mean annual rainfall controls the interband/band ratio (Valentin and d'Herbès 1999).

Although banded landscapes develop across a wide range of soil, topographic, and climatic conditions, the recent research has shown that they occur only where the co-occurrence of several critical conditions are met. This explains why such patterns do not occupy much larger proportions of arid and semiarid regions. The fact that most studies have been concentrated in Australia, Sahelian Africa, and Mexico (chapter 1, this volume) does not preclude the occurrence of banded patterns in other parts of the world (e.g., Asia).

Processes That Maintain Banded Patterns

Although the role of wind cannot be overlooked in certain circumstances (Leprun 1999; chapter 1, this volume), surface hydrological processes are critical to the ongoing functioning of banded landscapes. These lands are excellent natural laboratories, demonstrating the principles of water and nutrient conservation in space and time. Three main processes are involved: obstruction to overland flow, differential infiltration, and efficient nutrient cycling. Feedback loops stabilize the operation of this "resource control" system (chapter 2, this volume).

Overland Flow

The banded patterns act as a natural water harvesting system, the overland flow produced from the bare and impermeable interbands running onto the bands (Valentin and d'Herbès 1999; chapter 4, this volume). The runoff coefficients (volume of total runoff/volume of total rainfall, %) ranges in the interbands from 23% in southeastern Spain (Bergkamp, Cerdà, and Imeson 1999) to 75% in northern Mexico (Janeau, Mauchamp, and Tarin 1999). Vegetation bands tend to obstruct or regulate sheet-flow so that sediments and organic matter are continually being deposited and conserved within the bands, forming a natural bench structure that favors resource retention (Dunkerley and Brown 1999; Valentin, d'Herbès and Poesen 1999; chapter 2, this volume).

Table 12.1. Optimal Annual Rainfall as Influenced by Climatic Regime[a]

Optimal annual rainfall (mm)	Seasonal rainfall distribution	Rainfall events distribution	Mean monthly minimum air temperature (°C)	Site and authors
250	75% in 6 summer months	20% (>12.5 mm)	3.9°C—July	Central Australia Slatyer (1961)
280	70% in 4 summer months	20% (>10 mm)	3.9°C—January	Northern Mexico Delhoume (1996)
390	Autumn and spring	35% (>15 mm)	9.3°C—January	Southeast Spain Cammeraat and Imeson (1999) Bergkamp et al. (1999)
550	90% in 3 summer months	40% (>10 mm)	15.9°C—January	Southwest Niger Galle et al. (1999) Valentin and d'Herbès (1999)

[a] See also chapters 4 and 5 (this volume).

Differential Infiltration

Rainwater redistribution is caused by higher infiltration rates in the bands compared with the interbands (chapters 4 and 5, this volume). These differences are mainly controlled by the surface soil properties of the respective zones. Physical and biological crusts dominate the interpatch zones, resulting in low infiltration rates (Eldridge 1999; Janeau, Mauchamp, and Tarin 1999; Macdonald, Melville, and White 1999; Malam Issa et al. 1999; Valentin and d'Herbès 1999), whereas vegetation, litter, and bioturbation effects facilitate high infiltration rates in the patches (Greene 1992; Seghieri and Galle 1999; chapter 6, this volume).

Due to this rainwater redistribution, the bands receive from two (in southeastern Australia) (Tongway and Ludwig 1990) to four times (locally eight, in southwestern Niger), (Galle, Ehrmann, and Peugeot 1999) the rainfall at the site. The center of the bands has abundant biopores enabling effective water capture from the interband (Seghieri and Galle 1999). The upslope grassy band edge is intermediate (Greene 1992; Bromley et al. 1997).

Nutrient Cycling

In addition to substantial runon and high infiltration rates, the soils in the bands also concentrate more soil nutrients and organic matter than the adjacent interband soils (Guillaume et al. 1999; Tongway and Ludwig 1990; Ludwig, Wiens, and Tongway 2000; chapter 10, this volume). As a consequence, the vegetation bands are alternatively known as "resource islands" or "fertile patches" (Tongway 1990; chapter 6, this volume). However, the dynamics of nutrient cycling seem to have been little studied in either intact or degraded landscapes.

Maximizing Plant Productivity

Recent field data and simulations on banded landscapes have substantiated the theory of Noy-Meir (1973), which postulates that in environments with limited resources, plant productivity is higher if the resources are concentrated into patches instead of being uniformly dispersed over the landscape (chapter 2, this volume). In the Sahel, this resource concentration enables the formation of a forest system (Hiernaux and Gérard 1999; Seghieri and Galle 1999). The productivity of this discontinuous forest at least equals (Hiernaux and Gérard 1999) and can even double (Ichaou and d'Herbès 1997; Valentin and d'Herbès 1999) that of adjacent nonbanded landscapes. Similarly, a simulation model has showed that under southeastern Australian conditions, the productivity of a banded pattern landscape is more than twofold that of a landscape with no patchiness (Ludwig, Tongway, and Marsden 1999).

Although temporal variations in herbage yields were higher in banded systems than in nonbanded adjacent ones (Hiernaux and Gérard 1999), perennial plants commonly dominate the bands. This implies that sufficient water and nutrients are available to cope with either chronic or seasonal drought (see above).

Response of the Banded Landscapes to Climate Change

Most predictions concerning the possible response of banded landscapes to climate change have been derived from studies over the past 50 years (Hiernaux and Gérard 1999; chapter10, this volume) and from models (chapter 8, this volume). The systems can persist in the face of severe drought by adjusting the proportion of runoff and runon areas. A time response of 15 years illustrating this adjustment was monitored along a climate gradient transect about 200 km long, covering an annual rainfall range of 300 to 750 mm, by using air photos from 1950 to 1992 (Valentin and d'Herbès 1999). These results suggest that the runon zone cannot be maintained when the mean annual rainfall falls below 155 mm. Similar results (200 mm) were obtained from evapotranspiration assessments in the same region (Culf et al. 1993).

The scenario of expected climate change in eastern Australia (chapter 8, this volume), which includes warmer temperatures (+2°C), greater summer rainfall (+10%), and lower winter rainfall (–10%) indicates that the potential impact of changed land management (e.g., tree clearing or cropping) is far greater than any expected from climate change.

Response of Banded Patterns to Land Use

Banded patterning is sufficiently resilient to resist the stress and disturbance caused by traditional moderate land use. For example, Cammeraat and Imeson (1999) observed the resprouting of shrub bands after a forest fire in northeastern Spain. Major stress arising from overgrazing or excessive woodcutting and inappropriate land use (cropping) can lead to several stages of landscape degradation (chapter 10, this volume).

The earliest indicator of deterioration is the decline in the contrast between the two mosaic phases (Mabbutt and Fanning 1987). Overgrazing by domestic (sheep and cattle), feral (goats and rabbits), and native (kangaroos) herbivores is considered to be the prime cause of deterioration of banded landscapes in Australia (chapter 11, this volume). Persistent grazing with set stocking levels, coupled with drought, results in the death of perennial grass species (Hodgkinson 1993; Noble, Greene, and Müller 1998).

The occurrence of rills and gullies indicates the second stage of degradation in which water is lost rapidly out of the local ecosystem by concentrated rapid flows (Greene, Kinnell, and Wood 1994).

The late stage in vegetation degradation is characterized by disruption of the band pattern (Tongway and Ludwig 1997; Wu, Thurow, and Whisenant 2000). The bands may become shorter in length along the contour, narrower, or bisected by animal tracks. This pattern fragmentation results in a loss of landscape function and hampers rehabilitation. High stocking rates (0.7 to 0.8 sheep ha^{-1}) lead to such breakdown in landscape function and patterning (Tongway and Ludwig 1990; Wilson 1991) and in increased runoff and sediment yield (Greene, Kinnell, and Wood 1994; Tongway and Ludwig 1997; Ludwig, Tongway, and Marsden 1999; chapter 4, this volume). In Africa, vegetation bands become fragmented near cattle tracks particularly near villages and around watering points (Boaler and Hodge 1964; Hiernaux and Gérard 1999; chapter 10, this volume). Firewood and timber harvesting near urban centers and cropping are, however, more serious threats for tiger bush in West Africa (Torrekens, Brouwer, and Hiernaux 1997; Hiernaux and Gérard 1999; chapter 10, this volume). The clearing of tiger bush thickets to crop sorghum or millet, a marginal agricultural practice in itself, constitutes a "resource-mining" process that leads to desertified landscapes subject to severe wind and water erosion.

Unresolved Issues

Initiation of Bands

The preconditions for band initiation is a common thread through all the available literature but the least satisfactorily resolved. Models have demonstrated that banded vegetation patterns may result either from landscape degradation or rehabilitation (Thiéry, d'Herbès, and Valentin 1995; Dunkerley 1997), but the natural initiation of banded vegetation has never been observed (chapter 2, this volume). Many authors (Clos-Arceduc 1956; López-Portillo and Montaña 1999) consider that vegetation bands form from the coalescence of smaller patches, resulting for an increasing obstruction of sheet-flow and deposition of sediments (Bryan and Brun 1999; chapter 2, this volume) rather than from the degradation of a continuous vegetation cover (White 1971). However, this issue is likely to remain speculative in the absence of more abundant field evidence and long-term monitoring studies.

Upslope Movement of Vegetation Bands

The hypothesis that vegetation bands slowly migrate upslope is also a much debated topic. It is clearly intimately linked to the runoff/runon theory that underpins the basic functioning of banded vegetation. The obstruction of overland flow by the bands would favor the upslope germination of pioneer plants in this upslope edge and the decline of vegetation due to resource shortage at the downslope edge. Although the runoff/runon and/or source and sink theory has been clearly demonstrated by field measurements, the upslope movement of bands is still a matter of contention (López-Portillo and Montaña 1999; Valentin, d'Herbès, and Poesen 1999; Couteron et al. 2000; chapter 2, this volume).

An array of arguments has been proposed to support the upslope migration of bands based on the distinct zonal distribution of physical and biological components of the bands as well as direct and indirect assessments of vegetation dynamics. A sequence of soil crust types strongly supports the notion of soil deposition on the upslope edge of the bands (Valentin and Bresson 1992; Valentin and d'Herbès 1999). Marked gradients of soil organic carbon content provide corroboration (Tongway and Ludwig 1990; Guillaume 1999). Similarly, the presence of abandoned termite nests in the bare interband suggests the former presence of a vegetation band here (Ouédraogo and Lepage 1997; chapter 6, this volume). The strong similarity of subsoils between bands and interbands as observed by Bromley and colleagues (1997) supports the notion that subsoil properties do not preclude migration. This is not uniformly so. Banded mulga in Western Australia is underlain by a siliceous hardpan that is much deeper within the tree band than the interband (Mabbutt and Fanning 1987).

Seedlings are frequently observed to be concentrated on the upslope edge of the band (Montaña, López-Portillo, and Mauchamp 1990; Tongway and Ludwig 1990; Seghieri, Floret, and Ponanier 1994; Seghieri et al. 1996) Thiéry and associates (1995) called this zone the "pioneer zone." In addition, dead trees or shrubs are commonly reported near the downslope edge, suggesting that these plants had died as a consequence of resource "starvation."

The migration "velocity" of bands has been assessed on a subset of sites, by using a variety of methods including field monitoring with benchmarks, digitized aerial photographs, age distribution of trees with dendrochronology, and residual ^{137}C distribution in the soil, under a wide range of climatic and topographic conditions (Table 12.2). The fastest observed migration was 1.5 m yr^{-1} for grass bands, 0.8 for shrubs, and 0.8 for trees. At the global scale, the mean annual rainfall does not seem to influence migration velocity, neither does wind action despite its importance in Mali. However, at the local scale, faster migrations have been monitored in Mexico and in Niger during wetter years, the upward shift being less and even possibly nil during drier years (Montaña 1992). Although mulga bands may migrate upslope (chapter 2, this volume), it has not been reported in Australia.

Where migration has been detected and measured, most authors considered that it is highly variable in space and time. During dry years, the thicket vegetation density thins (Valentin and d'Herbès 1999; Couteron et al. 2000) and the downslope edge contracts due to plant death (Ambouta 1984; Wu, Thurow, and Whisenant 2000). Conversely, during the wetter years, the bands extend on the upslope edge, implying a net upslope migration (Ambouta 1984). Clearly, these processes are asynchronous.

The process of band movement at fine scale has been associated with differences in local slope at the upslope edge of the band that might influence the differential availability of water and seeds (Seghieri, Floret, and Ponanier 1994). The upslope edge of the vegetation band is often scalloped or wavy, with "prominences" and "bays" causing the capture of water, alluvium, and seeds to be uneven. Due to a very slight counterslope, the upslope migration might be less rapid in the prominences than in the bays. Over time, these microtopographic units would be expected to alternate.

Stationarity of some systems studied was attributed to the difference in the soil depth between bands and interbands as in Western Australia (Mabbut and Fanning 1987) or because of the even distribution of the age structure of shrubs across the bands in northern Mexico (López-Portillo and Montaña 1999).

At present, the evidence is that the upslope migration of vegetation bands is not an invariable property of the banded systems at the time scale of the observers. The question remaining unresolved is "What are the factors and processes controlling

Table 12.2. Velocity of Upslope Migration of Vegetation Bands

Country	Site	Mean annual rainfall (mm)	Mean slope gradient (%)	Mean annual velocity (m yr^{-1})	Method	Source
Mexico	Mapimi	184	0.37	0	Field monitoring of a peak of species richness (5 years)	Montaña 1992
Mali	Gossi	200	2.1	0.20	Field benchmarks (4 years)	Leprun 1992
Somalia	Northern region	213	0.22	0.15–0.30	?	Boaler and Hodge 1964
Sudan	Butana	250	0.36	0.3–1.5	Field benchmarks	Worral 1959
Mexico	Mapimi	311	0.37	0.80	Field monitoring of a peak of species richness (5 years)	Montaña 1992
Mali	N'Daki	300	1.9	0.25	Field benchmarks (21 years)	Leprun 1992
Mali	Hombori	450	0.9	0.75	Field benchmarks (21 years)	Leprun 1992
Niger	Sofiabangou	476	0.41	0.5	Dendrochronology (45 years)	D'Herbès et al. 1997
Niger	Hamdallaye	480	NA	0–0.65	Aerial photographs (1960–1992)	Wu et al. in press
Niger	Banizoumbou	495	0.27	0.19–27	^{137}Cs techniques (32 years)	Chappel et al. 1999
Niger	Banizoumbou	495	0.27	0.37–0.42	Extension of sediment crusts & dendrochonology (19 years)	Chappel et al. 1999

NA, not available

the upslope migration?" Permeable soils in the bare zone with low water runoff characteristics have been credited with the stability of the bands in northern Burkina Faso as compared with the migrating bands of Niger (Couteron et al. 2000). Different dynamics have been observed on sites located close by, leading to the interim conclusion that stationarity or movement of bands is a subtle dynamic involving climatic, geomorphic, biotic, and management interactions (López-Portillo and Montaña 1999).

The lack of a genuinely consistent theory here, linking different sites probably reflects complex issues that have not been adequately integrated at the conceptual level. Temporal scale is a major issue that may not be amenable to conventional studies over time scales typical of scientific experiments. Landscapes may well be operating at vast time scales or reacting to rare stochastic events such as drought, flood, and fire, or expanding and contracting according to seasonal variations. In this respect, grasses are likely to react more quickly to events than trees. It is an important process to fully understand, but comprehensive explanations are still in the future.

Priorities for Future Research

At the Global Scale

All the global occurrences of banded vegetation have not been yet identified. Observation of the macropattern in satellite images would enable this task to be effected with existing data. When located, the ecological principles presented in this volume should assist in dealing with the management issues of those lands. In particular, the well-understood outcomes of research to date at the ecological principal level should be deployed to avoid a new round of research ab initio.

At the Regional and Landscape Scales

Long-term monitoring needs to use extensive, remotely sensed data that should be calibrated against and integrated with ground-based measurements, so that the interpretation is based on processes and directed to management solutions (Wu, Thurow, and Whisenant 2000). Hyperspectral sensors will give more targeted information. These techniques will play a major role in extending the ecological principles understood at fine scale to the management and regional scale.

Manipulative experiments (Noble, Greene, and Müller 1998; Seghieri and Galle 1999; chapter 7, this volume) need to be directly related to rehabilitation or sustainable use rather than driven by just scientific curiosity. The human dimension should be thus more prominent, especially in long-term management experiments (chapter 9, this volume).

At the Local and Detailed Scales

We can distinguish three main themes: physical, biophysical, and purely biological processes. Although these have been separated for discussion, the integration of information from these areas needs to occur to provide insights into overall landscape functioning.

Physical

Processes under this heading comprise the interaction of climatic events with the soil/terrain system. Whereas the role of runon and runoff processes in regard to differential soil water storage have been clearly shown to be pivotal for banded vegetation, the effect of erosion and deposition processes have not yet been clearly elucidated. Water erosion and sedimentation are likely to greatly affect slope profile evolution (Bryan and Brun 1999; Valentin and d'Herbès 1999) and thus upslope migration. This migration should be studied further, by using such isotopic measurements as residual ^{137}Cs (Chappel et al. 1999). Further work is also needed on the origin and the role of wind-borne soil material, its accumulation in the vegetation bands, and its impact on texture, mineralogy, and fertility (Tongway and Ludwig 1996).

Biophysical

Soil biota and soil physical properties are intimately linked through bioturbation and soil organic matter decomposition dynamics. The impact of soil fauna on infiltration, as well as the structural stabilization of soil aggregates by soil organic matter, has been well established, but the reciprocal role of soil physics on the fate of soil organic constituent has still to be explored. For example, the natural abundance of ^{13}C in the organic matter associated with mineral soil particle fractions in Niger shows that although carbon from C_3 plants is the dominant contribution, carbon from C_4 plants was disproportionately high (Guillaume 1999). This raises questions about the differential carbon mineralization rates as between C_3 and C_4 plants and the role this might play in providing evidence about band movement. Such work needs to be substantiated under other circumstances, and the general principles will be relevant also to nonbanded landscapes in these climatic zones.

Biological

The use of vital attributes sensu Noble and Slatyer (1980) would be useful to identify the common and divergent properties of plants composing banded vegetation. Vital attributes are those of a species that are essential to its function in the vegetation intergenerational replacement and thus band maintenance. They include mainly, but not only, the arrival pathway and persistence at the site and the ability to establish and grow to maturity in the community. The assessment of plant functional attributes sensu Gillison and Carpenter (1997) and Walker, Kinzig, and Langridge (1999) would favor rapid and uniform assessment of plant properties as a response to variation in the physical environment at differing spatial scales, independent of species per se. Properties such as life cycle, physiological, and phenological features have been identified in Niger (Seghieri and Galle 1999). Structural-functional plant classification (also called "functional grouping") groups species with similar functional and morphological attributes such as root distribution and leaf area index, properties that are crucial to understand both resource utilization and the processes by which plants maintain themselves in the landscape (Box 1996). A comparison of the occurrence and distribution of functional groups between the different zones in a banded landscape would help to identify a framework of the common biological processes such as facilitation, tolerance, and competition/inhibition, as has been done for the physical processes.

Consequences for Landscape Ecology

The use of the neat geometrical arrangement of tiger bush has been used as a springboard to deal with ecosystems with more subtle spatial arrangements. Tiger bush lends itself well to modeling exercises (chapters 5 and 6, this volume) that are readily verifiable because the output is a distinctive pattern. The underlying process were generalized to apply to less overtly patterned landscapes to understand both their spatial arrangement and functioning (Ludwig and Tongway 1995). In the absence of a regular pattern as a starting point, this might have not eventuated. In turn, this has lead to a generalized framework by which to understand overall landscape function (Ludwig and Tongway 1997; chapter 2, this volume) and a monitoring system now implemented in Australia based on these principles (Tongway 1994; Tongway and Hindley 1995, 2000).

Consequences for the Management of Arid and Semiarid Environment

The lessons drawn from these banded patterns have lead to the recognition of heterogeneous landscape systems as being ecologically "sensible" and sustainable compared with homogeneous systems. In this respect, many traditional cultures in Africa have used resource-regulating structures in their cropping activities for centuries. Sometimes, modern methods based on European farming models have ridden roughshod over satisfactory traditional methods. For instance, water harvesting and runoff farming are simple to implement and more easily adopted by populations than irrigation in the Sahelian zone (Rockström and de Rouw 1997).

Rehabilitation of desertified banded landscapes will never be successful if complete vegetation of the previous band and interband zones is attempted (Thiéry et al. 1997). It is more sensible to create structures that favor trapping of runoff and sediments along the contour to rebuild vegetation patches. For instance, in a rehabilitation experiment, after 11 years the infiltration rate is about 320 mm hr^{-1}, compared with about 12 mm hr^{-1} for controls, which remain crusted interband zones (Tongway and Ludwig 1996; Tongway, Ludwig, and Hindley, pers. comm.).

Summary

The study of banded landscapes over the past 40 years has established a sound scientific basis for the understanding and management of banded landscapes. Some issues such as the initiation of the banding vegetation patterns remain unclear. What remains ahead is the development of the scientific principles that will underlie the sustainable use of banded landscapes in a range of socioeconomic settings around the world. Banded landscapes are likely to produce further sound lessons not only for the arid and semiarid environments but more broadly to landscape ecology and land management. Management guidelines will be improved over time as new information comes forward.

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