

*Insight*, part of a Special Feature on [Exploring Resilience in Social-Ecological Systems](#)  
**Collapse and Reorganization in Social-Ecological Systems:  
Questions, Some Ideas, and Policy Implications**

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**ABSTRACT.** We tested the explanatory usefulness and policy relevance of Holling's (2001) "adaptive cycle" theory in exploring processes of "collapse," also called "release," and recovery in regional social-ecological systems (SESs) in Zimbabwe and Australia. We found that the adaptive cycle is useful in recognizing changes in system behavior during the various phases. However, our small sample of cases did not generally show either the sequential passage of stages or the prerelease decline in resilience that adaptive cycle theory implies. In all cases, however, the reasons for releases were apparent with hindsight. On the other hand, our examples mostly supported the proposition that resilience is controlled by slowly changing variables. Although we found the adaptive cycle, and complex system theory in general, to be useful integrating frameworks, disciplinary theories are required to explain causes and effects in specific cases. We used theories linking distribution of political power to institutional change; to investment in natural, human, social, and physical capitals; and to access to financial capital. We explored patterns of change of these capitals before, during, and after release and reorganization. Both the patterns of change and relative importance of the different capitals during reorganization varied widely, but the importation of resources from broader scales was often a key to recovery. We propose that the resilience of most regional or national SESs can be explained in these terms. The capacity to self-organize emerged from our studies as a critical source of resilience. Although rebuilding this capacity at times requires access to external resources, excessive subsidization can reduce the capacity to self-organize. The policy implication is that cross-scale subsidization should end when self-organization becomes apparent, because subsidization can increase the vulnerability of the system as a whole. When the aim is to recover without changing the system fundamentally, the focus should be upon conserving or investing in the elements of capital critical for this. If the current system is not viable, it is necessary to invest in forms of capital that will enable fundamental change. It will also be necessary to stop investing in the capitals that maintained the unviable regime. The political difficulty of doing this is why SESs so often remain maladapted to current conditions and opportunities and eventually reach the point of collapse.

**Key Words:** *Key words: resilience, collapse; recovery; social-ecological systems; adaptive cycle; natural capital; social capital; human capital; Zimbabwe; Australia*

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"See the end in the mirror of the beginning,  
and the beginning in the mirror of the end."  
Chinese Proverb

## INTRODUCTION

The aim of this paper is to assess the usefulness of the "adaptive cycle" (Holling 1987, 2001) in understanding the "collapse," reorganization, and recovery of social-ecological systems (SESs). The

adaptive cycle is a theory that can be used to examine the dynamics and resilience of ecological and social-ecological systems. It proposes that these complex adaptive systems (Cocks 2003) tend to follow a four-phase adaptive cycle that includes growth or "exploitation" (the  $r$  phase), "conservation" or consolidation (the  $K$  phase), "collapse" or "release" ( $\Omega$ ), and reorganization ( $\alpha$ ). The resilience of the system is thought to begin increasing during the  $r$  phase, grow more rapidly during  $K$ , peak and collapse in  $\Omega$ , and remain low

during  $\alpha$  before increasing again in the next  $r$  phase. The  $\Omega$  and  $\alpha$  phases are together known as the “backloop,” and they are the focus of this paper. During these phases, theory proposes that one of three types of change can occur. First, the system can reorganize and remain within the same regime. Alternatively, it can shift to a different regime, characterized by changes in feedback processes or changes in the scale at which the dominant processes operate, but with the state variables remaining the same. Finally, it can transform to a new regime characterized by changes in scale, state variables, and feedbacks (Walker et al. 2006).

According to theory, the adaptive-cycle dynamics of a system at a particular focal scale, e.g., a region, are influenced by the adaptive-cycle dynamics of linked systems at finer scales, e.g., a farm, and broader scales, e.g., a nation. This cross-scale aspect of resilience theory is termed “panarchy” (Gunderson and Holling 2002).

Our focus is on  $\Omega$  and  $\alpha$  processes and events. The applicability of the adaptive cycle as a conceptual framework for complex system dynamics and the problems of determining when a system has changed from one regime to another were examined by Cumming and Collier (2005). Scheffer and Carpenter (2003) analyzed catastrophic regime shifts in ecological systems. Scheffer et al. (2003) examined the reasons why it is so difficult for societies to respond quickly to new problems. There are case studies that use the adaptive cycle to analyze the growth and collapse of regional SESs (Allison and Hobbs 2004, Anderies 2005). Berkes et al. (1998), and the authors of the various chapters in the collection they edited, studied the role of what we later define as social and natural capitals in maintaining the resilience of local- and regional-scale SESs. Cocks (2003) discussed societal collapses using the adaptive cycle and synthesized theories about the drivers of social-ecological change that can lead to collapse. Brunk (2002) used complex adaptive systems theory to account for societal collapses. Working outside the complexity and resilience paradigms, Tainter (1988), Flannery (1994), and Diamond (2005) analyzed collapses of societies using other theories. By and large, however, little has been written about the recovery of SESs following collapse, with a few notable exceptions. These include Seixas and Berkes (2003), who studied crises and recovery in a Brazilian fishery; Alcorn et al. (2003), who researched the ways in which Dayak society

reorganized to cope with massive encroachment on their traditional lands by outsiders; Putnam (2000), who analyzed the adaptation of U.S. society to industrialization, urbanization, and immigration a century ago; and Cocks (2003), who briefly mentioned recovery in his examination of adaptive-cycle theory. This paper aims to expand our understanding of the important but relatively neglected area of  $\alpha$  processes and events, and relate it to preceding  $\Omega$  processes.

Walker et al. (2006) outline several propositions relevant to the  $\alpha$  and  $\Omega$  phases:

- multiple modes of reorganization are possible during phases of rapid change in an SES;
- transitions among the four phases of change may not be a fixed sequence or necessarily reflect a cycle;
- cross-scale interactions critically determine the form of the subsequent adaptive cycle at any particular focal scale;
- slowly changing variables control ecological resilience, whereas social resilience is controlled by either fast- or slow-changing variables;
- there are attractors in the ecological domain of SESs, although it is unclear whether there are similar attractors in the social domain;
- adaptability is primarily determined by (1) the absolute and relative amounts of all forms of capital, be it social, human, natural, manufactured, or financial, and (2) the system of institutions and governance. This proposition is so comprehensive that it is useful only in suggesting that researchers need to look at these elements, which we did;
- adaptability is enhanced through partially overlapping mental models of SES structure and function, i.e., there must be some commonality of understanding of the system among different stakeholders;
- efforts to deliberately enhance adaptability can unintentionally lead to a loss of resilience; and

- determinants of transformability include incentives, awareness, experimentation, reserves, and governance. Again, the main use of this very comprehensive proposition is to suggest that researchers need to look at these elements, which we also did.

With these propositions in mind, and with the aim of evaluating the usefulness of the concept of the adaptive cycle, we asked the following questions about case studies in Zimbabwe and Australia:

1. What caused the system to “collapse?”
2. What was released during the collapse?
3. What enabled reorganization and recovery?
4. What are the implications of our findings for policy and practice?
5. What has the concept of the adaptive cycle contributed to our understanding of collapse, reorganization, and recovery?

The rest of this paper is organized as follows: in the next section we discuss the identification and analysis of  $\alpha$  and  $\Omega$  events. Following that we analyze the case studies. We then draw out implications for resilience theory and relate these to broader systems theory. We conclude with policy implications.

## **IDENTIFICATION AND ANALYSIS OF $\alpha$ AND $\Omega$ EVENTS AND PROCESSES**

Clearly some social-ecological systems (SESs) change or transform regimes through collapses associated with major social-ecological disruptions (Tainter 1988, Flannery 1994, Diamond 2005). Others undergo a crisis and reorganize without regime change or transformation (Boserup 1981). Our research would be more useful if it included both categories, but to do so we need to be able to decide if a system has entered the  $\Omega$  phase. We used loss of capital as a means of deciding. By capital we mean a stock with the potential to yield a flow of benefits.

The dimensions of the adaptive cycle that Holling and Gunderson (2002) used were “potential” and “connectedness” rather than capital. However, connectedness, e.g., in social networks, can imply

the potential to, e.g., manage common property resources. Capital captures both potential and connectedness in social systems and ecological systems. Capital also captures the concept of “adaptive capacity,” which “... reflects learning, flexibility to experiment and adopt novel solutions, and development of generalized responses to broad classes of challenges” (Walker et al. 2002). In addition, the concept of capital links resilience theory to economics, sociology, ecology, broader discussions about sustainability (Cocklin and Alston 2003), and case studies reported in Berkes et al. (1998), including Holling et al. (1998). We therefore describe SES dynamics in terms of accumulation and releases of social, human, natural, and physical capitals, plus financial capital. We define the  $\Omega$  phase as one in which the loss of capital is large enough to require the rebuilding of capital through self-organization or an injection of capital from higher levels in the panarchy, so that the system can reorganize and recover within the current regime or transform to a different but desirable one.

In social capital (Cocklin and Alston 2003), we include social networks and the formal and informal norms and rules that mediate interactions among humans and between humans and their environment. Within social capital we also include cultural capital (Berkes and Folke 1994), institutional capital (Ostrom 1990), the “bonding” capital that links similar individuals, and the “bridging” capital that connects unlike groups (Putnam 2000). Human capital is “... the knowledge, skills, competencies and attributes embodied in individuals that facilitate the creation of personal, social and economic well-being” (OECD 2001:18). Natural capital is the ecosystems that support humans (Berkes and Folke 1998). Physical capital is technology and infrastructure, and financial capital is access to money.

Having identified changes in the various capitals as key processes within  $\Omega$  and  $\alpha$  events, we need to explain patterns of investment or disinvestment in them in each case. In our case studies, governments have been the main direct investors, or the institutions they inherit or establish have influenced investment. Governments are not, of course, free to invest or establish institutions at will, but must take account of the competing influences of industries and other interest groups, lobbyists, voters, and other sources of political influence (Magee et al. 1989, Godden 1997). We assert that it is generally

true, even in undemocratic societies, that governments and interest groups interact in establishing the institutions and investment patterns that, through changes in the capitals, drive, enable, or prevent change in SESs. “Policy makers” are, therefore, all those who influence policy formation, not just politicians, public servants, or dictators. The framework of this paper has drawn from Blaikie and Brookfield’s (1987) “regional political ecology,” with its conception of cross-scale hierarchical socioeconomic systems interacting with regional bio-physical systems. They emphasize the recurring political-economic tendency of particular groups to gain ascendancy, appropriate the means of control, and marginalize the less powerful, a theme that runs through our case studies.

## THE CASE STUDIES

Our case studies are from the South East Lowveld (SEL) of Zimbabwe and western New South Wales, Australia. We examine  $\Omega$  and  $\alpha$  dynamics in four examples. The African ones are cattle ranching switching to wildlife ranching, and wildlife ranching changing to an attempted resettlement scheme. The Australian examples are an Aboriginal hunter-gatherer system collapsing and partly recovering after colonization, and a pastoral system of wool-bearing sheep surviving drought and reorganizing.

One reason we chose our case studies was because we knew their histories well. Our judgment is that the cases were sufficiently similar to be comparable and different enough to yield insights. We found them particularly useful because the Zimbabwean and the Australian cases offered contrasting social systems facing challenges on the same regional landscapes. Most importantly, we chose them because they had undergone major changes that could potentially be construed as  $\alpha$  and  $\Omega$  events.

Before examining these case studies, we ask readers to note that, because this is a systems study based on historical analysis, conventional disproof of hypotheses is not feasible. Our interpretations of causality and patterns are based on varying amounts and qualities of data. We indicate where we are speculating. The explanations we chose were based on our judgments and intuitions, the coherence of each story, and some data. Obviously, alternative explanations could have been reached.

## South East Lowveld, Zimbabwe

The 45,000 km<sup>2</sup> of semi-arid South East Lowveld (SEL) contains communal farming areas under subsistence agro-pastoralism, commercial ranches, and large-scale agro-industries. Land tenure and resource access rights, introduced in 1911, enabled this parallel existence of subsistence and commercial land uses.

Commercial ranching was influenced by national policies on animal disease control, marketing zones related to foot and mouth disease (FMD), beef export quotas, controlled exchange rates that taxed producers, and worldwide declining terms of trade for beef (Jansen et al. 1992, Murphree and Cumming 1993). Changes in wildlife legislation such as the Parks and Wildlife Act of 1975 and generally supportive policies and legislation, combined with sufficient human and social capital at the ranch level, enabled the transition to wildlife during the decline and collapse of cattle ranching and through a severe drought in 1991–1992.

National-level policies and legislation regarding land and resource access rights for those living in the communal lands changed little over several decades (Murphree and Cumming 1993). As human populations in the communal farming sector increased, food security declined, and households became increasingly vulnerable to droughts and dependent on central government and international food aid (e.g., Cumming 2005). The devolution of wildlife resource access rights enjoyed by commercial farmers was not realized by communal farmers (Murphree and Cumming 1993). Households were increasingly supported by remittances earned by family members. HIV-AIDS reduced the availability of farm labor. A shortage of land and increasing levels of poverty aggravated by a declining national economy led to a radical agrarian reform program that started with farm invasions in 2000. The thresholds that triggered land reform were the decrease in support for the ruling political party and a growing rate of economic decline combined with local demands for land.

### *Change from large-scale commercial cattle ranching to wildlife ranches*

Large-scale commercial cattle ranching on freehold land started in about 1912. The industry was at first unable to break into world markets and survived

through government subsidies and periodic injections of financial capital (Phimister 1978). Publicly funded research subsequently boosted the industry and enabled entry into export markets. The national commercial herd peaked in the mid-1970s and declined following independence in 1980 (Central Statistical Office 1989) and the withdrawal of state subsidies and protection (Murphree and Cumming 1993:167). The Nominal Rate of Protection for beef in Zimbabwe declined from 20.7 in 1981 to -19.7 in 1990 at official exchange rates, whereas at realistic exchange rates it had declined to -25.7 by 1990. Cattle ranching gave way to wildlife-based tourism after the major droughts of 1983–1984 and 1991–1992, but the commercial beef herd in the SEL had been declining since the early 1970s (Fig. 1) through a combination of decreasing viability, civil war, and outbreaks of diseases such as FMD, plus an extended phase of low rainfall from 1980 through to 1996 (e.g., Owen-Smith and Ogutu 2003). Some ranches formed wildlife conservancies of up to 27 properties and 3500 km<sup>2</sup> to jointly manage wildlife (du Toit 1992).

#### *What caused the $\Omega$ event?*

Precursors of the decline and collapse of cattle ranching were in retrospect apparent before the 1991–1992 drought. They included increasingly unfavorable terms of trade in beef and repeated setbacks in markets and disease control. The decline was also encouraged by:

- an increasing appreciation of alternatives such as wildlife ranching and tourism, which had been developing since 1960 (Child 1988, Jansen et al. 1992);
- wildlife legislation, such as the Parks and Wildlife Act of 1975 and Act 14 of 1975, that devolved full responsibility for the management and consequent benefits of wildlife to landowners;
- subsidized fencing for managing black rhinoceros (du Toit 1992); and
- subsidized restocking with species such as black rhinoceros, elephant, and buffalo.

#### *What was the nature of the $\Omega$ ?*

Farmers were forced to destock during the drought, and the costs of restocking with cattle were prohibitive. Natural capital in the form of livestock was released or transferred to financial capital, albeit under adverse market conditions in a buyers' market. The ecological potential of the range was released from grazing pressure. Although wildlife populations declined in the drought, sufficient natural capital remained to enable recovery (Fig. 2). The mental models of the landowners who remained were “released” from cattle ranching. Those unable to make to the mental shift sold their ranches to others or to newcomers who invested in wildlife-based tourism.

#### *What was the nature of the $\alpha$ process?*

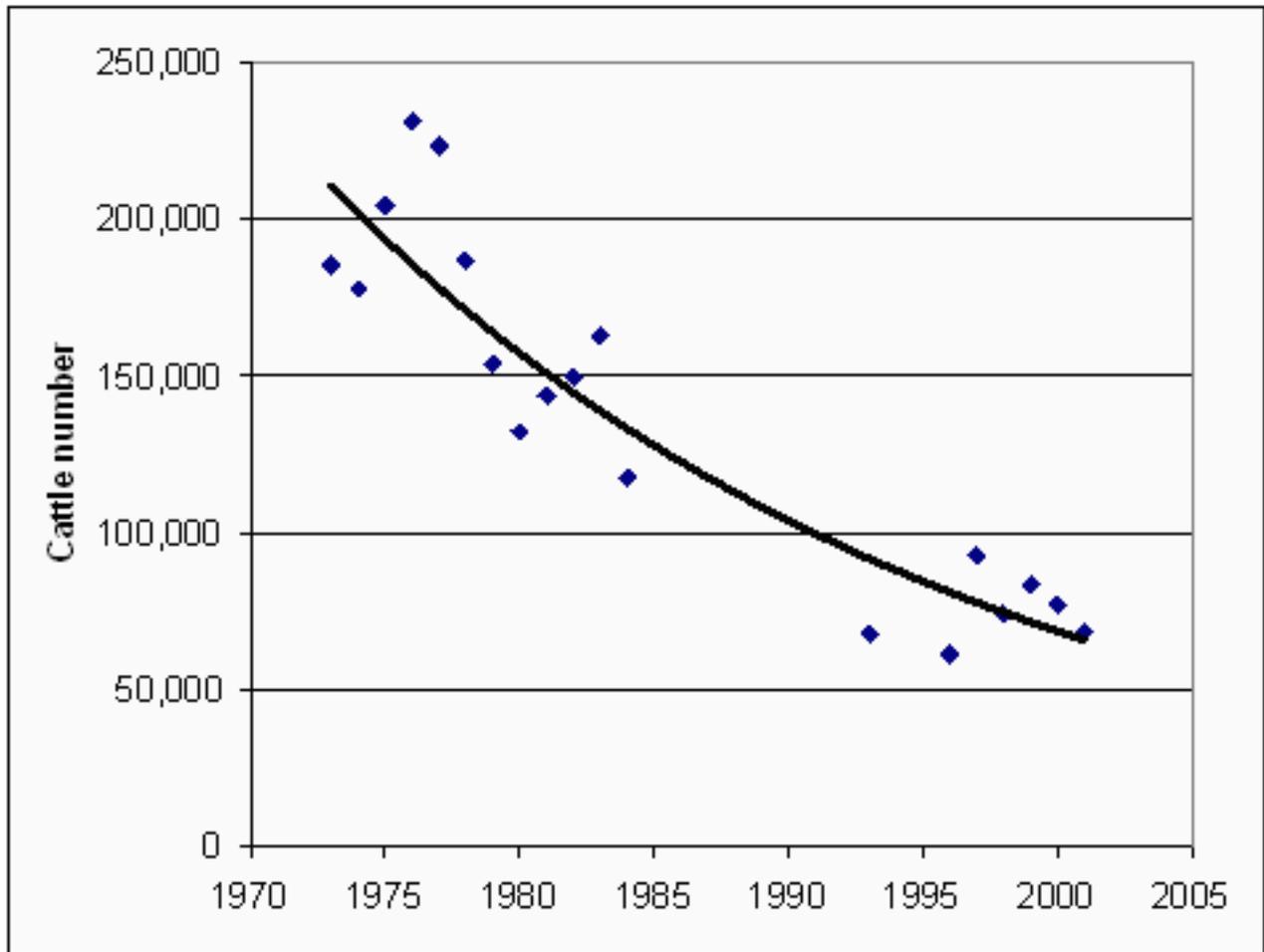
Reorganization was facilitated by (1) highly resilient ecosystems that were able to recover rapidly following destocking of cattle and a period of favorable rains, with the result that the natural capital was reasonably intact; (2) the exploration of alternative land uses, which had started during the prolonged *K* phase of cattle ranching; (3) leaders and agents of change who emerged in the community before the 1991–1992 drought; (4) the ranching community, which had survived droughts, disease outbreaks, sanctions, and war for 40 yr; (5) subsidies for restocking with valuable species such as rhinoceros and elephants and for fencing; and (6) new external investors.

Although the drought triggered the release phase, the preconditions for reconfiguration were in place when the shock came, and the system transformed into an early *K* phase, with wildlife replacing cattle and new institutions governing the collective management of wild, mobile resources replaced previously fenced and separately managed cattle ranches.

#### *Change from large-scale commercial ranching to resettlement of small-scale ranchers*

The events that took place in an area adjacent to the confluence of the Shashe and Limpopo rivers, which was originally intended to form part of the international Shashe-Limpopo Transfrontier Conservation Area, provide an example of a backloop failure. Prior to the resettlement scheme, local land uses included a safari area, commercial ranching, and communal lands. The human populations in the

**Fig. 1.** The decline in beef cattle held on commercial ranches in the eastern sector of the South East Lowveld, Zimbabwe, from 1973 to 2001, based on data extracted from the annual livestock census reports of the Central Statistical Office and the Department of Veterinary Services.

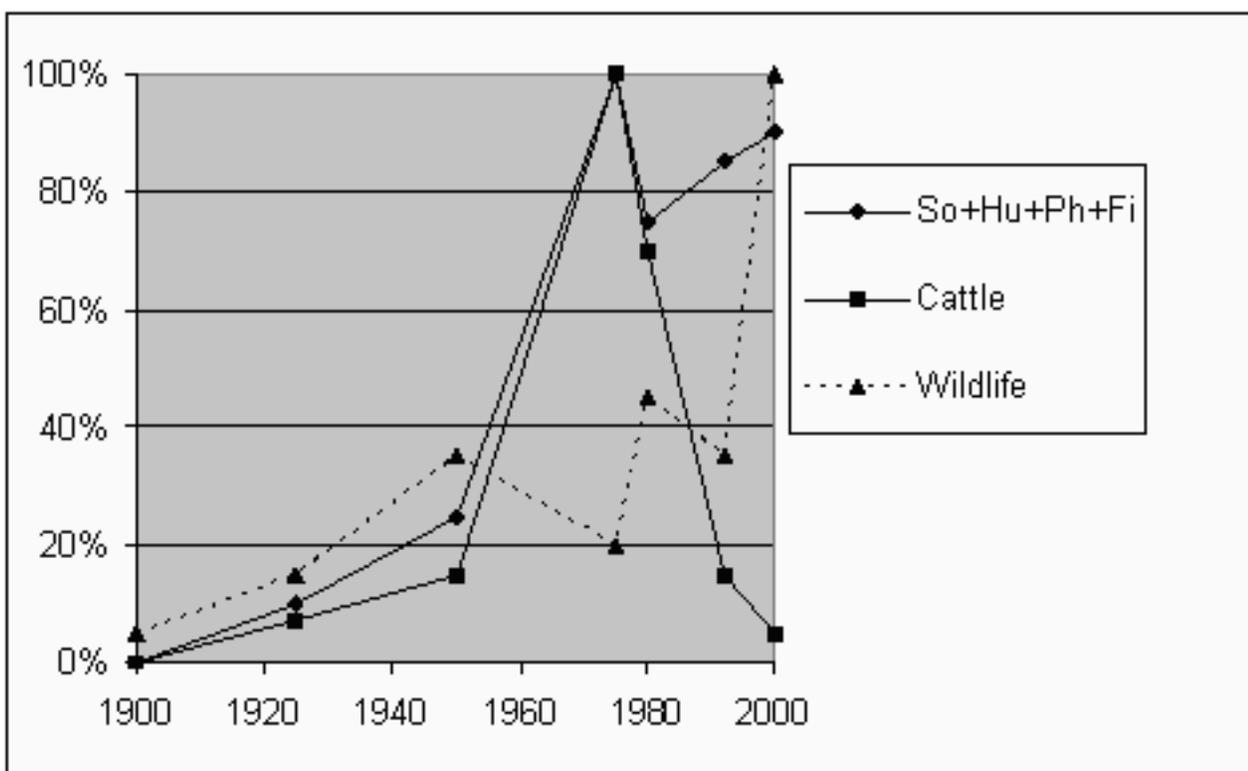


communal lands grew steadily, crop yields and livestock numbers declined, and livelihoods were supplemented by food aid, remittances, and trading (e.g., Campbell et al. 2002, Cumming 2005). Neighboring commercial ranches, which included irrigated farming, switched from cattle ranching to wildlife and safari hunting in the 1980s.

After 2001, two commercial ranches covering 470 km<sup>2</sup> were resettled by 300 families from neighboring communal lands with their livestock; each family received an allotment of 157 ha. Game fences were dismantled, hunting safaris disrupted,

and major tourism investments shelved. Drought in 2002–2003 and the presence of reserve grazing on the ranches attracted cattle from the communal lands. Grazing was depleted, and livestock died from starvation as well as from diseases contracted from wildlife. The new settlers lost their livestock, safari operations ceased, and poaching depleted the remaining wildlife. The government failed to deliver on plans to provide fencing, water, and cattle dips. The new farmers were, in their own words, worse off than they had been on the communal lands.

**Fig. 2.** Postulated changes in levels of capital during the transition from cattle ranching to wildlife ranching and tourism in the South East Lowveld of Zimbabwe. The years before and after release ( $\Omega$ ) and reorganization ( $\#0945$ ) are shown. Social capital (So), human capital (Hu), physical capital (Ph), and financial capital (Fi) followed very similar trends and have been lumped together. The initial decline in cattle ranching occurred during the war of independence as a result of cattle rustling followed by a decline in the terms of trade and a major drought in 1991–1992. Levels of capital are represented relative to the maximum level reached during the period of history we analyze. Levels of capital can be compared within but not between categories of capital. The lines joining the time axes represent the trend between years correctly, but they do not track fluctuations. The level of natural capital refers only to that natural capital accessible to ranchers. These levels are based on our opinions and interpretations of history.



The loss of the settlers' livestock, the collapse of commercial wildlife enterprises, and the absence of new financial capital investment and subsidies resulted in what has so far been a failed release and reorganization.

*What caused the  $\Omega$  event?*

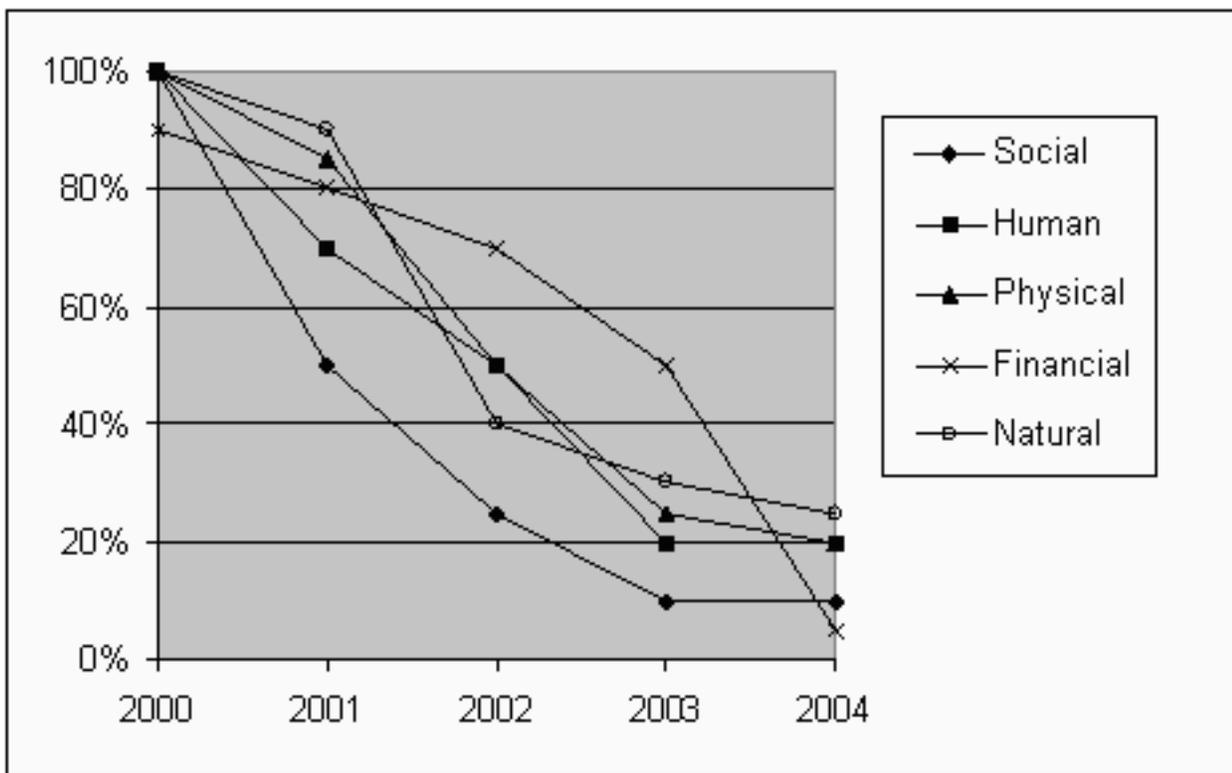
The major predisposing factors or triggers were:

- increasing human populations under conditions

that made it impossible for families to exist without external inputs and subsidies on less than about 500 ha per household (Cumming 2004),

- a "land hunger" generated by long-standing inequities in land and resource access rights that was readily exploited by politicians and newly emerged warlords, and
- a populist "fast-track" land-reform program introduced by the central government after it

**Fig. 3.** Postulated changes in levels of social, human, physical, financial, and natural capital during the transition from commercial wildlife ranching to resettlement under small-scale cattle ranching in the Shashe-Limpopo area of the South East Lowveld of Zimbabwe. The years before (2000) and during (2001–2004) the release ( $\Omega$ ) shown apply to both the commercial farmers and the new settlers, except for 2000, when the new settlers did not have access to the natural capital of the ranches. Levels of capital are represented relative to the maximum level reached during the period of history we analyze. Levels of capital can be compared within but not between categories of capital. The lines joining the time axes represent the trend between years correctly, but they do not track fluctuations. These levels are based on our opinions and interpretations of history.



had lost a referendum on constitutional reform.

#### *What was the nature of the $\Omega$ ?*

Freehold land was released for settlement by government fiat to selected families. Resource access rights, one of the institutions that comprise social capital, to wildlife and grazing were relaxed. The release of natural capital in the form of grazing and wildlife without appropriate institutions to govern their use resulted in an “open access” system followed by rapid depletion (Fig. 3). The removal

of physical capital in the form of costly game fencing further weakened any potential to enforce access rights to grazing or wildlife. Human capital in the form of managerial experience was effectively sidelined, and planned foreign capital investment in tourism development on the game ranches was suspended or withdrawn.

#### *What prevented reorganization?*

The impediments included (1) a lack of training and expertise, (2) reduced financial and physical capital for the new occupants, (3) the conversion of

resource access rights to open access, and (4) very low land productivity.

With a 20-fold human population increase over the course of a century, communal farming areas such as these have been transformed from an agrarian subsistence farming community into an urban dormitory and poverty trap. Continuing inappropriate policy responses from central and local governments seem determined to maintain that situation, if not extend it to former commercial ranches.

### **Western New South Wales, Australia**

The Aboriginal and the pastoral examples are set within this sparsely populated region of 325,000 km<sup>2</sup>. It is subject to severe climactic variations that demand adaptive social organization. The Aboriginal and pastoral systems both showed the capacity to adapt, but in very different ways.

#### *The Aboriginal hunter-gatherer system*

Aboriginal cultures were characterized by high levels of social capital. Religion, ecological understanding, and social organization were linked through the “Dreamtime” myths that made the land sacred and humans, plants, animals, and the physical environment “of one essence.” Spiritual and economic connections linked a person to a specific part of the country, and groups of related individuals to particular stretches of country (Berndt and Berndt 1981).

Precolonial Aboriginal social structures were decentralized and nonhierarchical in this mobile system. Resource use rights were conferred through Dreamtime stories. Gathering was carried out by foraging units from more than one descent group, which allowed access to more than one territory (Berndt and Berndt 1981), thereby increasing resilience to high spatial and temporal variability in resource abundance. Extensive networks and reciprocity made the society more mobile and thus more resistant to drought. Tribes were recognized by differences in language and custom, but tribal spatial and social boundaries were probably fuzzy (Hardy 1976). However, this system, highly resilient as it was to spatio-temporal variation, was vulnerable to invaders. After colonization by the British, the scale above the Aboriginal social-ecological system (SES) became the colony of New

South Wales, later a state within a federal system. Although tribal and clan structures were broken up by colonization, displacement, and deaths, Aboriginal culture at a national scale, and tribal affinities at local scales in those areas in which tribes survived, remained to provide a platform of bonding capital (Putnam 2000) for the reorganization of the Aboriginal system. The Aboriginal SES appears to have gone through two backloops, one in the mid-1800s, the second following the Great Depression in the 1930s.

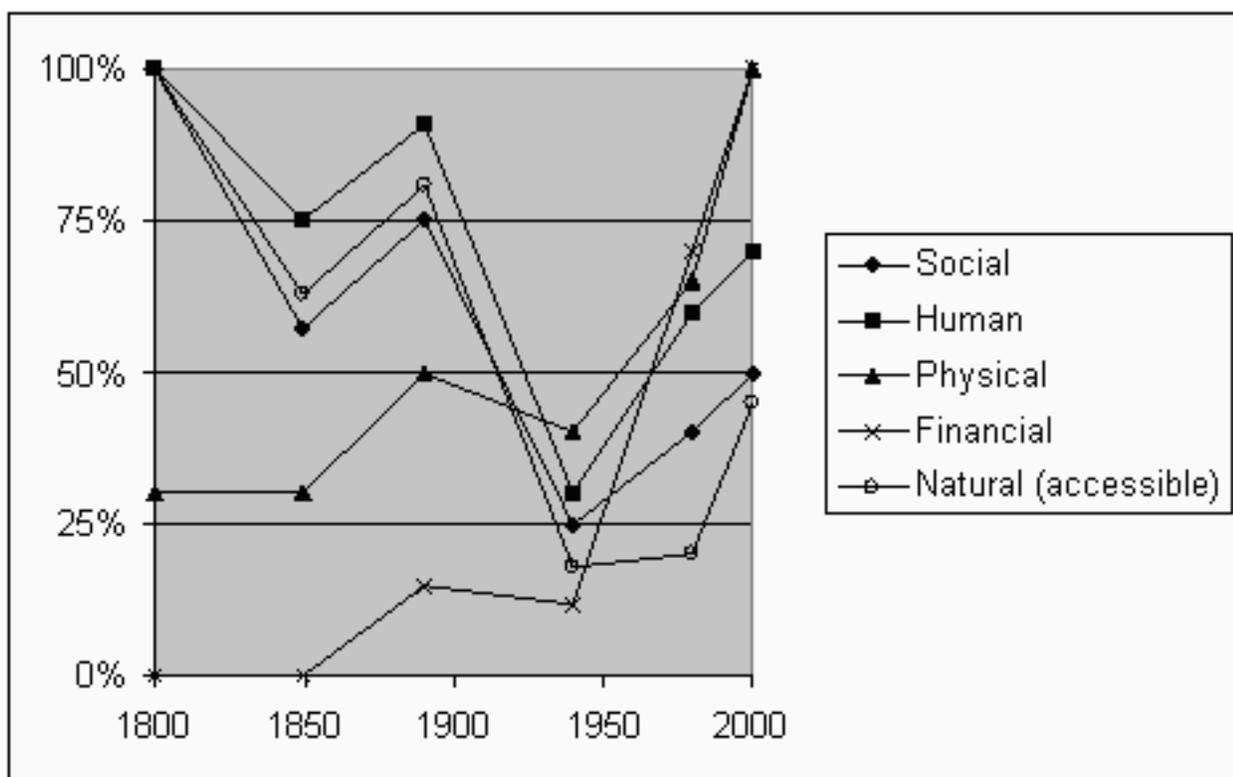
#### *What caused the first $\Omega$ event?*

In the pre-European era, levels of physical capital were low, and there was no monetary economy (Fig. 4), but human and natural capitals were high. Simple technologies were enhanced by complex ecological knowledge. The Aboriginal system was adapted to high spatio-temporal variation in rainfall, but it also modified the land to suit its needs. Frequent and patchy burns from “fire-stick farming” facilitated travel, assisted hunting, and changed the vegetation structure in favor of food plants for humans and prey (Jones 1969). We hypothesize that the sources of resilience that enabled the persistence of the regime were:

- social networks (social capital) and knowledge (human capital) adapted to exploit spatial and temporal heterogeneity across and from outside the region;
- knowledge (human capital) of how to organize for the collective management (social capital) of a fire-adapted system (natural capital) tolerant of and dependent on Aboriginal fire-stick farming; and
- a cultural memory that encompassed the knowledge, beliefs, and values passed on through religion (social and human capital). We believe that it was the persistence of this memory that enabled the Aboriginal SES to survive colonization as a recognizable system.

The system was unable to resist or adapt to British colonization. New diseases brought by the colonists, including smallpox, influenza, and measles (Goodall 1996), preceded the explorers and settlers and overwhelmed Aboriginal immune systems that had been isolated for millennia.

**Fig. 4.** Postulated changes in levels of social, human, physical, financial, and natural capital during the history of the Aboriginal social-ecological system. The years before and after release ( $\Omega$ ) and reorganization ( $\alpha$ ) are shown. The first  $\Omega$  occurred after the spread of diseases and the pastoral invasion starting in 1800. The first  $\alpha$  phase began after the gold rush in 1850. The second  $\Omega$  in 1940 was caused by the closer settlement policy and triggered by the drought and depression of the preceding decade. The level of natural capital refers only to that natural capital accessible to Aboriginal peoples at a particular time. Levels of capital are represented relative to the maximum level reached during the period of history we analyze. Levels of capital can be compared within but not between categories of capital. The lines joining the time axes represent the trend between years correctly, but they do not track fluctuations. These levels are based on our opinions and interpretations of history.



*What was the nature of the first  $\Omega$ ?*

Disease depleted the national Aboriginal population to a fraction of its precolonization level (Lourandos 1997), which in turn depleted the social networks (social capital) and knowledge (human capital), and reduced the labor (human capital) for hunting and gathering (Fig. 4).

The first  $\Omega$  event occurred when the Aboriginal peoples were displaced by the settlers who occupied

the region after the 1840s and cut them off from their natural capital. In addition, the natural capital on the pastoral stations was depleted because grazing reduced the diversity of the plants within grazing radius of water. The introduction of dams and groundwater bores gave livestock access to ecological communities whose biota had evolved under a regime of occasional grazing after rain. Extinction rates of native biota were very high (Dickman 1994, Sadlier 1994, Smith and Smith 1994). Grazing also reduced the frequency of fires by reducing fuel loads; as a result, the Aboriginal

fire mosaic was lost (Noble 1997), and with it the diversity of species and suitability of the vegetation structure for hunting and gathering.

*What enabled the first  $\alpha$  event?*

Aboriginal human, social, and natural capital declined until gold was discovered in 1851 (Fig. 4). Pastoralists lost so much labor to the ensuing gold rush that properties could not operate. They sought alliances with the Aboriginal tribes to secure their labor, and an 80-yr period of dual occupancy began. Aboriginal peoples returned to their tribal lands, where they resumed their ceremonies, hunted and gathered food, and provided an ecologically knowledgeable labor force to pastoralists who provided some food and cash in return (Goodall 1996).

*What was the nature of the second  $\Omega$ ?*

The discovery of gold triggered a large population increase in New South Wales and increased the demand for land. This was met in part by a policy of subdividing larger land holdings, but dual occupancy was not viable on smaller properties. The resilience of the Aboriginal SES was therefore already declining when the Great Depression of the 1930s put Aboriginal peoples in competition with unemployed white workers (Goodall 1996). Aboriginal peoples were discriminated against, and they and their dependents were dispersed from pastoral properties. Tribes were split, and social networks damaged in this second  $\Omega$  (Fig. 4). They were moved into reserves in which tribes were mixed and their ecological knowledge depleted because it was no longer used. Contact with the land and ceremonial sites was broken, and they became wards of the state following dispossession, without rights to land or to vote.

*What enabled the second  $\alpha$  event?*

The second phase of reorganization is still happening. It was enabled by:

- the formation of state and national organizations of Aboriginal peoples that pressed for Aboriginal rights and formed alliances (bridging capital as per Putnam 2000) with non-Aboriginal urban activists (Goodall 1996) to influence urban votes;

- the immigration after World War II of many nationalities, which made multicultural policies acceptable through necessity and increased the pressure to accept Aboriginal cultures (Goodall 1996);
- British atomic weapons tests on Aboriginal land in South Australia, which created national support for their cause;
- mixed-race children who had been removed from their Aboriginal families and educated as part of the assimilation policy becoming leaders, political activists, and lawyers;
- links to the civil rights movement in the United States in the 1960s and international support;
- the granting of citizenship to Aboriginals in 1967;
- legislation in the 1980s and 1990s that enabled Aboriginal peoples to acquire land, conserve ceremonial sites, and negotiate mining rights; and
- the emergence of leaders from within Aboriginal and Torres Strait Islander communities outside of New South Wales that had been less disrupted by colonization. These leaders led anti-mining protests and secured native title legislation.

We propose that the main influence that made it possible for Aboriginal people to reorganize was Aboriginality itself. We argue that, because colonization was slower and far less complete in some parts of Australia than in New South Wales and Aboriginal cultures were far less disrupted, these relatively intact cultures remained to serve as cross-scale “memory” for Aboriginality in New South Wales, despite important tribal differences. Cultures, though impaired, have persisted or been renewed to provide frameworks around which contemporary Aboriginal societies are reconstructing themselves.

The Aboriginal peoples in this region now live in Third World conditions of health, wealth, and education within a First World nation. Relative to earlier times in its history, their society is characterized by a very low level of accessible natural capital and low levels of social and human

capital, although, compared with earlier times, they have relatively high levels of financial capital and physical capital in the form of housing and infrastructure (Fig. 4). In our opinion, the Aboriginal SES is still in the  $\alpha$  phase.

### *The pastoral system*

Our region is the 325,000-km<sup>2</sup> area of New South Wales occupied by pastoralists from the 1840s (Hardy 1969). Leasehold production of sheep for wool is the dominant land use by area (~ 94%). At our focal scale of the region, the pastoral system comprises networks of properties held by pastoral families or companies, supporting services, communication and transport networks, abattoirs, and markets for wool and meat. Below the focal scale is the pastoral lease-holding family or, increasingly, the pastoral company. Above the focal scale is a system comprising state and federal governments, lobby groups, voters, media, and the Australian and international economies. The resilience of Australian pastoral systems has been analyzed by, among others, Anderies et al. (2002) and Walker and Abel (2002).

### *What caused the $\Omega$ event?*

An  $\Omega$  phase was triggered by the drought of 1895–1902 (McKeon et al. 2004) and the economic recession and wool price crash with which it coincided (Fig. 5). Underlying causes included the spread of feral rabbits near water and an increase in shrub density, which was no longer controlled by Aboriginal burning (Noble 1997). Grazing near surface water further reduced fuel loads and thus the frequency of accidental fires. A run of high rainfall years preceded the drought, causing sheep numbers to reach a level never achieved since (Fig. 5) and exacerbating the scale of their population crash.

### *What was the nature of the $\Omega$ ?*

Dust storms carried news of the loss of natural capital (Fig. 6) to cities. Susceptible land systems lost landscape function (natural capital), which is the capacity to regulate water, nutrients, organic matter, and propagules (Tongway and Ludwig 1997). Some land systems never recovered their original functionality. The diversity of flora and fauna, a potential source of resilience (Walker et al. 1999), probably declined (Lunney et al. 1994).

When the recession hit, Australian banks collapsed, wool prices fell severely, and pastoralists were beset by debt. Fifty percent of leases came into the hands of banks or pastoral companies. The departure of bankrupt lessees caused losses of human and social capital. Damage to the infrastructure from shifting sand and catastrophic losses of sheep represented losses of physical and natural capital. We hypothesize that two key thresholds were crossed in entering this  $\Omega$  phase: the profit-to-debt ratio and the median rainfall over a sequence of several years, i.e., the average was too low for too long, so that stock were sold cheaply or slaughtered (McKeon et al. 2004).

### *What was the nature of the $\alpha$ process?*

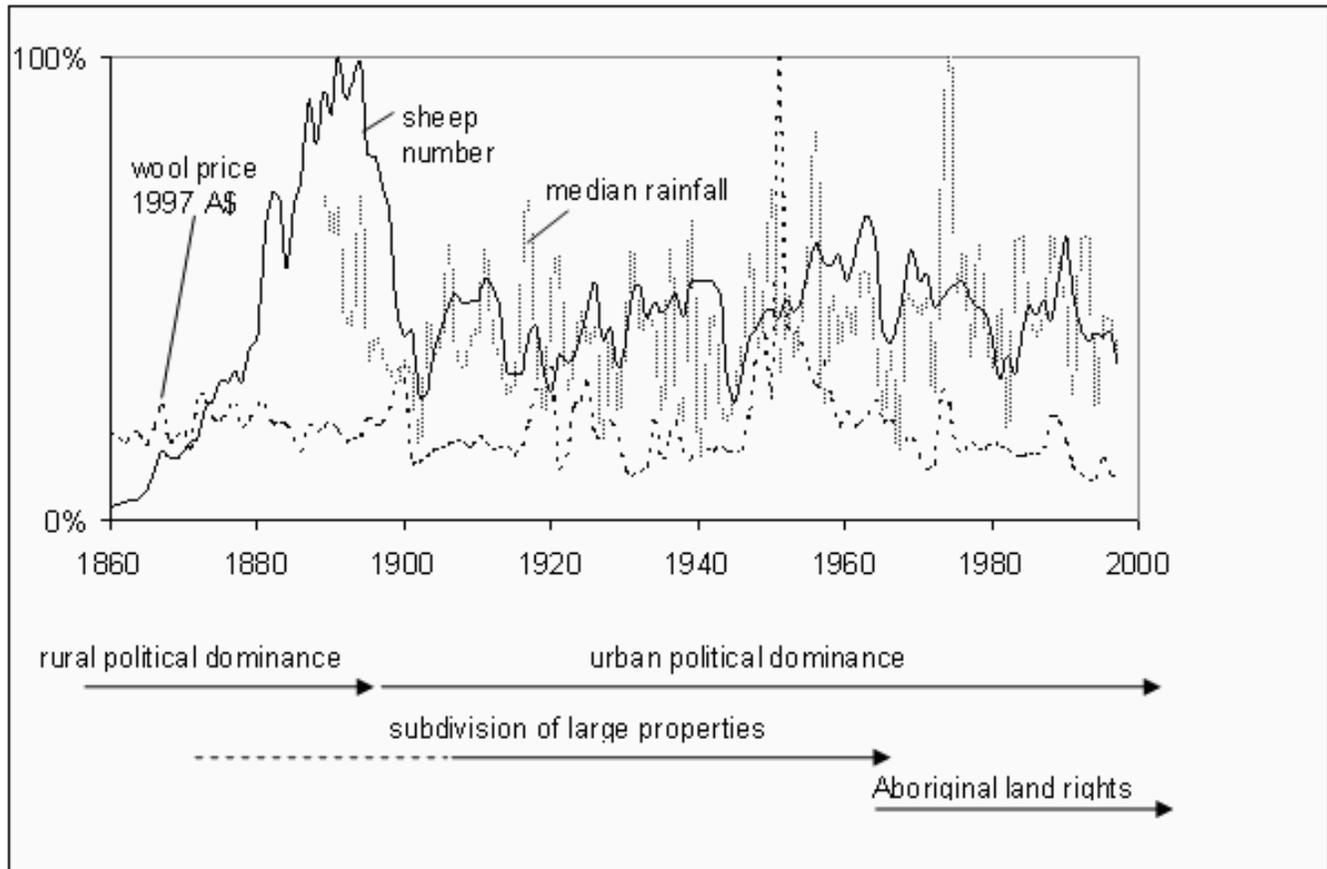
Factors that enabled reorganization included:

- the high price of wool between 1880 and 1891, which had given pastoralists economic power and political influence (Cain 1962);
- additional political influence that had accrued because the pastoralists occupied “empty” land. This was considered an imperative in the national ideology because of a perceived territorial threat from the more densely populated countries to the north, and was one of the multiple motives behind closer settlement (Williams 1975);
- access to external resources through this political influence;
- an increase in the duration of leases to enable longer-term resource use (Young et al. 1984, Quinn 1995);
- the forgiveness of pastoral debt by banks under government pressure; and
- post-drought rains and post-recession recovery of wool prices (Fig. 5).

Since 1902, there have been major crises when drought and wool price decreases have coincided (Fig. 5). There has been no regional  $\Omega$ . We suggest that this is because of:

- the continuing, but now waning, political influence of pastoralists, which enabled them to maintain external support. Public

**Fig. 5.** Rainfall, number of sheep, wool price, and policy changes in New South Wales, Australia. Sheep numbers for 1860–1902 are from Barnard (1962); for 1903–1979, from the Western Lands Commissioner (1979); for 1980–200, from the ASPIRE database produced by the Australian Bureau of Agricultural and Resource Economics.

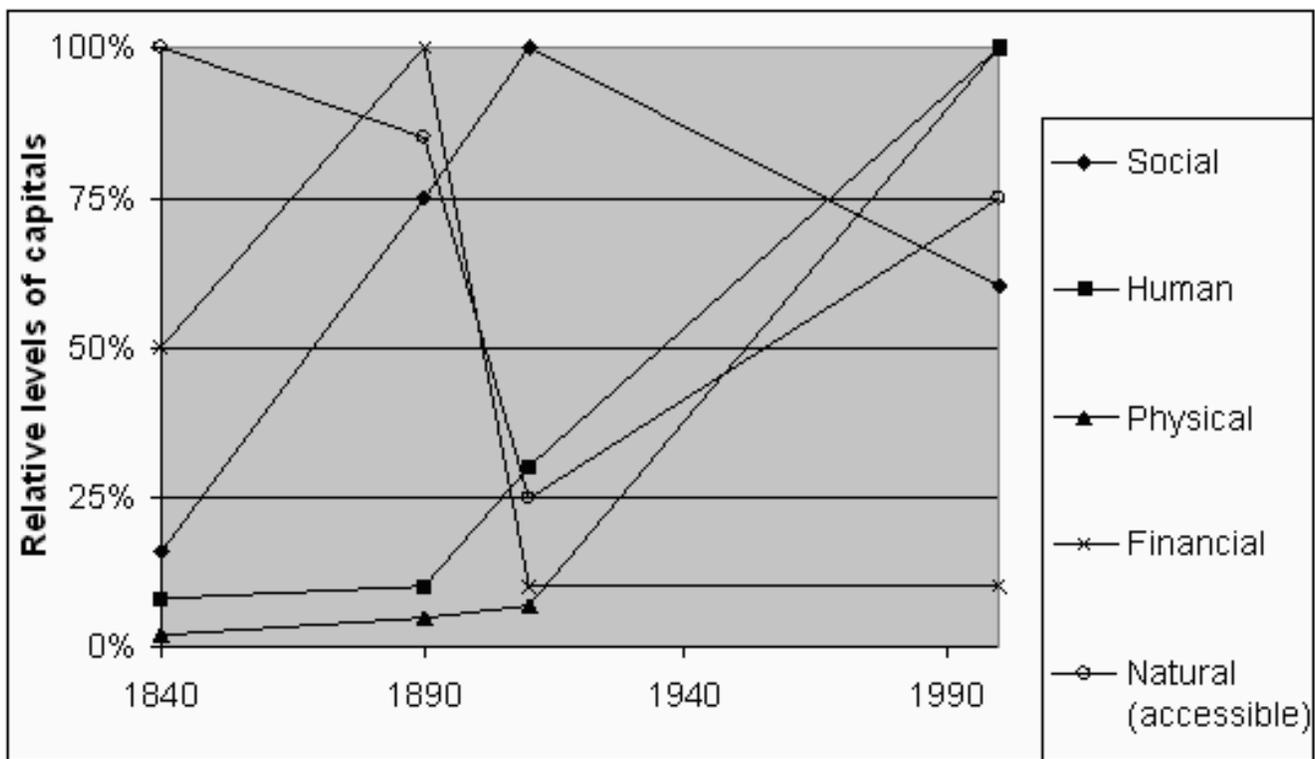


investments were made at various times in infrastructure and communications, agricultural research and extension, pest control, tariff protection, price support, drought, and tax relief; and

- pastoral investment in artificial water points that enabled them to maintain high numbers of sheep. They graze mainly within 2 km of water. The spread of water points across previously unwatered country simultaneously gave sheep access to more grazing while reducing stocking density by orders of magnitude (Fig. 7).

The pastoral system appears to be in a late *K* phase, and a regional  $\Omega$  may be impending. Production costs for wool continue to rise, and competition from artificial fibers drives the price down, bringing pastoralists increasingly closer to financial thresholds (Fig. 8) and a consequent release of human and social capitals. Meanwhile there is no more land that is not already within grazing radius of water, so that the area grazed cannot be increased with additional water points to compensate for shrub encroachment. In contrast with Aboriginal land modification by fire, which was successful for millennia, this strategy may have run its course.

**Fig. 6.** Postulated changes in levels of social, human, physical, financial, and natural capital during the history of the pastoral social-ecological system in New South Wales, Australia. The axes indicate selected years before and after the  $\Omega$  and  $\alpha$  stages. We believe that the  $\Omega$  was caused by the depletion of natural capital near permanent water and triggered by the drought and recession of 1895–1902. The  $\alpha$  phase that followed was dependent on imported resources. We speculate that a second  $\Omega$  may now be in the offing. The level of natural capital refers only to that natural capital accessible to pastoralists at a particular time. Access to natural capital has been increased by the construction of artificial water points (physical capital), which has been the main means of maintaining the system in a  $K$  phase. The marginal benefit of additional water points is probably approaching zero. Levels of capital are represented relative to the maximum level reached during the period of history we analyze. Levels of capital can be compared within but not between categories of capital. The lines joining the time axes represent the trend between years correctly, but they do not track fluctuations. These levels are based on our opinions and interpretations of history.



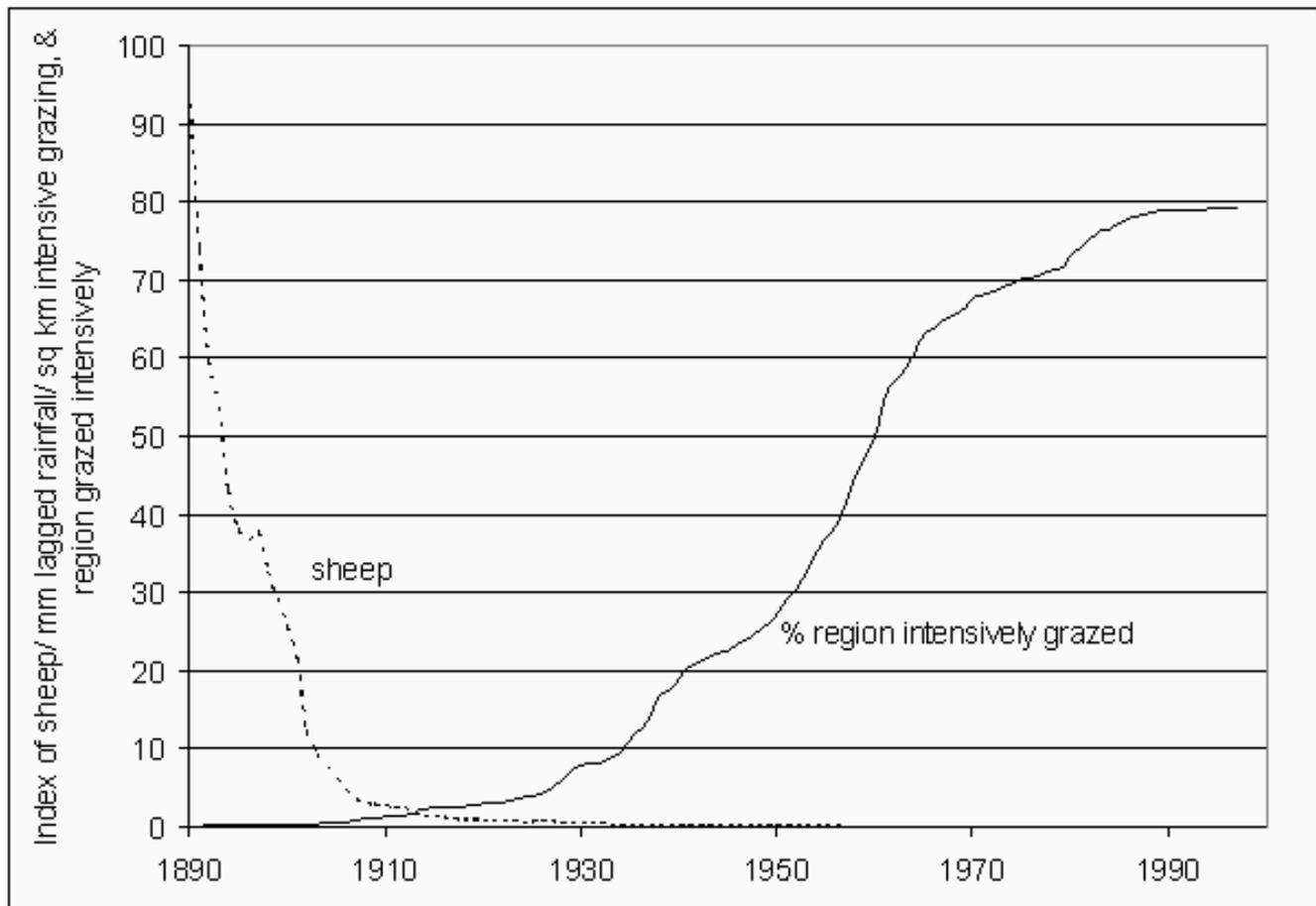
## IMPLICATIONS FOR RESILIENCE THEORY

### Preconditions and triggers for $\Omega$

Adaptive-cycle theory proposes that systems tend, with exceptions (Walker et al. 2006), to be in the late  $K$  phase prior to an  $\Omega$  event. In the commercial ranching social-ecological system (SES) of the

South East Lowveld (SEL), this was apparently so. It was not so with the other systems. The Shashe-Limpopo ranches had already switched adaptively to wildlife, but the  $\Omega$  event, i.e., the conversion to a settlement scheme, was imposed by the government. The New South Wales pastoral system showed by its subsequent development that it had been in the  $r$  phase when drought and recession drove it into an  $\Omega$  phase. The highly adaptive Aboriginal SES probably never was in a late  $K$  phase

**Fig. 7.** Effect of artificial water on intensity of grazing in New South Wales, Australia. The dotted line represents a 5-yr running mean of the index of sheep number/mm of rainfall lagged over the previous 2 yr/km<sup>2</sup> of land within 2 km of artificial water. The continuous line represents the percentage of the region within 2 km of artificial water.



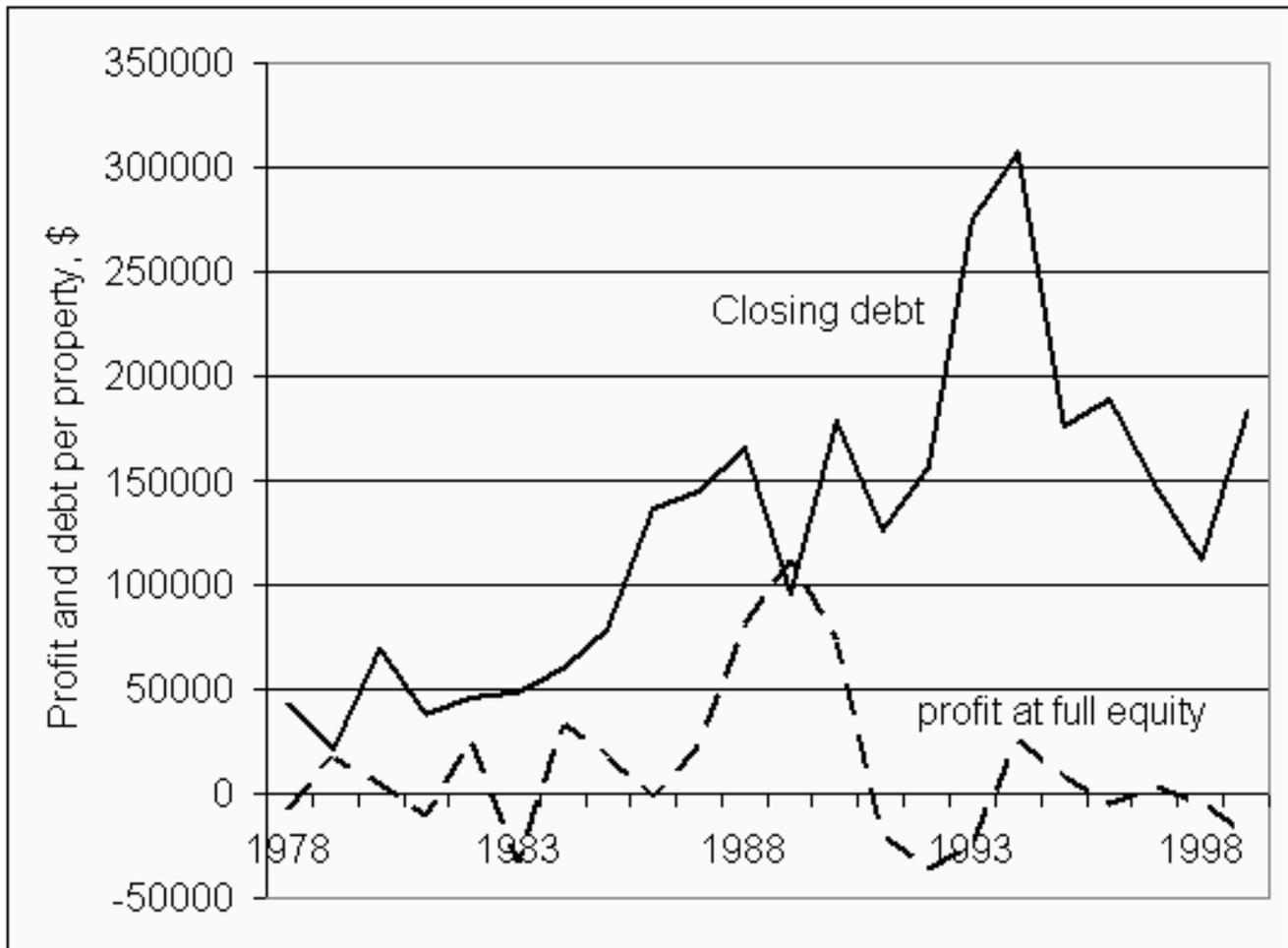
before colonization, because frequent droughts, acting on a system that relied on mobility rather than accumulation, prevented it. We see no evidence it was in a late  $K$  phase before the second  $\Omega$  event.

Two of the  $\Omega$  events we studied were not preceded by losses of resilience. The Shashe-Limpopo commercial wildlife ranches underwent an  $\Omega$  event as the government attempted to reorganize them as a settlement scheme. The causes were increasing human populations on communal lands, coupled with a local hunger for land and a populist land-reform policy. Although there was no suggestion that the wildlife ranches were losing resilience

before the  $\Omega$ , the preconditions for collapse were there, namely a mismatch between the interests of the ranchers and government and a match between the interests of government and communal-land farmers. Nor was there evidence of any downward trend in resilience in the precolonial Aboriginal SES, but the preconditions for an  $\Omega$  event were there: the lack of antibodies to European diseases and a social organization and weapons unsuited to defense against the invaders.

Three  $\Omega$  events were preceded by declines in resilience. Although the commercial ranches in the SEL faced increasingly unfavorable terms of trade

**Fig. 8.** Pastoral profit and debt in New South Wales, Australia, according to the ASPIRE database of the Australian Bureau of Agricultural and Resource Economics.



and endemic diseases that affected exports, changes in the wildlife legislation created new opportunities for them. The ranchers had retained, despite difficulties in the cattle market, the necessary mix and levels of capitals, and the system was transformed. Drought was the trigger. The New South Wales pastoral SES was made vulnerable before its  $\Omega$  by an increase in shrubs with the cessation of Aboriginal burning, an increase in feral rabbits, a period of years with unusually high rainfall that encouraged high stocking rates, and a falling profit-to-debt ratio. Drought and economic recession triggered the  $\Omega$ . The second Aboriginal  $\Omega$  was preceded by the subdivision of pastoral

properties that made dual occupancy increasingly unviable financially, and the Great Depression was the trigger.

Walker et al. (2006), predict that slowly changing external variables control ecological resilience, whereas social resilience is controlled by either slow or fast variables. The preconditions for  $\Omega$  in all five examples, except perhaps the disease outbreaks, involved slow external control variables. Walker et al. also propose that, although there are endogenous attractors in ecological systems, it is unclear whether there are similar attractors in the social domain. We have argued that Aboriginal cultural

memory in New South Wales has been a powerful social attractor.

### Characteristics of $\Omega$

The use of the capitals proved to be a useful way of linking the resilience case studies to the adaptive cycle and the literature on regional sustainability (Cocklin and Alston 2003). Patterns of depletion of social, human, natural, physical, and financial capitals were different in the various studies. In part, this is because of initial differences in their relative endowments. In the SEL commercial ranching system, the main releases (Fig. 1) were natural capital lost through emergency livestock sales and the associated loss of financial capital because prices were low during the drought. In the Shashe-Limpopo scheme (Fig. 2), social capital was lost because wildlife and grazing access rights were removed to create open access regimes, resulting in the depletion of those resources. Managerial expertise (human capital) was sidelined, financial capital was lost and impending investments diverted, and wildlife fencing was removed (physical capital). This SES did not reorganize successfully. Although the New South Wales pastoral  $\Omega$  (Fig. 5) was similar to the SEL commercial ranching event in the loss of financial capital, there was considerable retention of social capital, especially external political and institutional support, but some loss of human capital as individuals left their properties. Unlike the SEL ranches, but like the Shashe-Limpopo event, significant natural capital was lost in the form of stock, flora, fauna, and landscape function, but enough remained to enable recovery.

Compared with the other three SESs, the Aboriginal system (Fig. 3) entered its first and second  $\Omega$  events with high levels of social, human, and natural capitals, very little physical capital, and little or no financial capital. Both  $\Omega$  events involved major losses of social, human, and natural capitals through the breakdown of social networks, deaths of individuals, loss of knowledge, depletion of flora and fauna for food and medicine, and loss of access to ceremonial sites and lands.

### Characteristics of $\alpha$

Two of the five  $\alpha$  events involved little or no external support. The government removed exclusion rights (social capital) from wildlife and grazing in the Shashe-Limpopo resettlement scheme and provided little material support. There was insufficient human capital (knowledge of commercial farming or wildlife management), and the land was unproductive (natural capital). This system has not recovered or reorganized. The first recovery of the Aboriginal SES was made without external support. It was enabled by the need of pastoralists for labor, the only source at the time being Aboriginal peoples. Their ecological knowledge (human capital) made them skilled shepherds. Their social organization was functioning well enough, and their natural capital was sufficiently intact for viable communities of hunter-gatherer-shepherds-housemaids to become established on pastoral properties.

External support was critical in the other three  $\alpha$  events. Wildlife ranches in the SEL were able to emerge from the  $\Omega$  of the cattle-ranching system because of the local persistence of human capital (knowledge, management, coping skills, and leadership) and natural capital (vegetation and wildlife resources); in addition, external subsidies and legislation on wildlife property rights provided alternatives to cattle. The New South Wales pastoral recovery similarly required national political, institutional, and financial support. The national ideological concern with maintaining settlers in otherwise "empty" land ensured continuity of support, or "system memory" (Walker et al. 2006). Its recovery was also enabled by the recovery of the wool market, rain, and the resilience of its landscapes. The second Aboriginal  $\alpha$  phase is still happening. In New South Wales, it is happening with minimal access to natural capital, relying mainly on social capital. The beginnings of recovery were made possible by the persistence of Aboriginal identity and culture and enabled by Aboriginal political activism and leadership, urban and international political support, changes in national ideology and legislation, and some federal and state funding for education, health, and welfare.

Walker et al. (2006) propose that adaptability is enhanced through partially overlapping mental models of social-ecological system structure and function. The transformation from cattle to wildlife in the Zimbabwe SEL, the dual occupancy of land

by pastoralists and Aboriginal peoples, the convergence of pastoral and governmental interests in New South Wales, and the formal national acceptance of Aboriginality could all be interpreted as confirmation of this proposition. The closure of the Shashe-Limpopo wildlife ranches in Zimbabwe to make way for a settlement scheme and the collapse of the presettlement Aboriginal SES can likewise be seen as a lack of overlap in mental models.

### **Cross-scale interactions: panarchy effects**

Examples of cross-scale interactions (Walker et al. 2006) are summarized in the two previous sections. They include the transfer of resources, disturbances arising externally, and externally created opportunities. In some cases, external influences were benign, but for Aboriginal peoples they were initially catastrophic. In the Shashe-Limpopo resettlement case, the government caused the collapse of apparently resilient wildlife ranches, and its influence in weakening resource exclusion rights was a major reason for failure. The government's failure to provide the planned infrastructure for small-scale cattle ranching further compounded the problem. The strategy of proponents of an SES attempting to avoid an  $\Omega$  event or to reorganize would be entirely different depending on whether its aims were aligned with or in opposition to the government's aims. SEL ranchers and New South Wales pastoralists sought support from cooperative governments, but in the early days of their reorganization Aboriginal peoples did not have that support, so they worked outside of formal institutions and created links (bridging capital) to urban supporters in Australia and overseas (Goodall 1996).

Although it is clear that cross-scale transfers of resources can enable recovery, there are dangers. During the 1930s, the Great Depression made it difficult for the government to support pastoralism in New South Wales because of a national scarcity of resources. Collapses in the transition from large- to small-scale farming have occurred across Zimbabwe, and the national capacity for cross-scale subsidy no longer exists, threatening collapse at a national level (Clemens and Moss 2005). Tainter (1988) concluded that a widespread human reluctance to allow any regional system to collapse risks increasing the vulnerability of the planetary SES.

An additional problem is that the ability to self-organize can be inhibited or destroyed by excessive external subsidies. Some Aboriginal leaders regard the current dependency of their peoples on government welfare as a key constraint on the recovery of the SES. Drought subsidies could make it unnecessary to move livestock to other regions (McAllister et al. 2005), as is the current practice in New South Wales. Continuing subsidies to maladaptive cattle ranching in the SEL could have made the transition to wildlife unattractive.

### **Regime shifts and transformations**

Backloop dynamics had different consequences for the four SESs. The question is whether each returned to its original regime, i.e., same feedbacks, state variables and scale; shifted to a new regime, i.e., same state variables, different feedbacks or scale; or transformed to different feedbacks, state variables, and scale (Walker et al. 2006). Judging by these criteria, the New South Wales pastoral system recovered within its original regime. The SEL system changed its scale of operation by moving from single-ranch cattle operations to large-scale collective wildlife enterprises. The main subsidy maintaining the cattle-based system had been government support for cattle. The removal of subsidies encouraged wildlife enterprises to emerge and replace cattle as a state variable, and the categories of feedback and state variables therefore changed. In addition, the scale of operations broadened as ranches amalgamated. A similar transformation occurred in the Shashe-Limpopo ranches after 1980, but this changed abruptly in 2001 when land and resource access rights were withdrawn from the ranch owners. The new settlers occupied the ranches, but without the land and resource exclusion rights needed to protect wildlife and grazing for their cattle. The main feedback enabling the Shashe-Limpopo ranches to remain in wildlife tourism was government respect for freehold land-tenure rights. It shifted to government appropriation of freehold land and neglect of the settlement scheme's needs. State variables changed from wildlife to cattle and freehold to an ill-defined leasehold tenure under resettlement operating at a finer scale. Based on the above criteria, this is a transformation. When the Aboriginal SES collapsed and began its first recovery, the scale changed to that of a pastoral property. A critical feedback had previously been food scarcity; now it became security of their dual occupancy as determined by

the financial viability of the property. State variables changed to include number of sheep and employment on the property. When Aboriginal peoples were, for the second time, evicted from their lands during the Great Depression, the new critical feedback became the level of “welfare” available on reserves and missions. The scale shifted from large pastoral properties to small reserves or missions, and state variables now included public servants administering “Aboriginal affairs” and various churches running the missions. In terms of the definitions, the Aboriginal SES transformed twice.

### **What has the concept of the adaptive cycle contributed to our understanding of $\alpha$ and $\Omega$ processes?**

In the absence of the concept of the adaptive cycle, our choices of theory for analyzing these case studies would have been general systems theory (von Bertalanffy 1956), complex systems theory (Brunk 2002), theories of collapse (Tainter 1988, Diamond 2005), theories of the drivers of social change (Cocks 2003), and Putnam’s work on the role of social capital in recovery (2000). Here we discuss what adaptive-cycle theory may add to the understanding of  $\alpha$  and  $\Omega$  processes gained from these other theories. We also discuss conflicts among the theories, including the adaptive-cycle theory.

General systems theory holds that all phenomena share structural similarities and obey similar natural laws (von Bertalanffy 1956:8), and that disciplines can communicate better if they learn this common language, a view developed by Wilson (1998) but criticized by Midgley (2000). Although general systems theory is too abstract for analytical purposes, the transdisciplinary idea of the adaptive cycle is in the tradition of general systems theory. It is focused upon change in complex adaptive systems, a particular category of system.

Complex adaptive systems are self-organizing, “evolving” systems that often exhibit threshold behavior. Their dynamics are frequently guided by connectivity across and within scales (Cocks 2003). Brunk (2002) argues that societal collapses are a form of cascade, an intrinsic feature of any self-organizing system in which the components are connected. Wars, stock market variations, shifts in voting patterns, and riots are examples of cascades.

When system components are so strongly interconnected that any internal disturbance is propagated throughout the system, an internally initiated cascade occurs. After the cascade, the connectivity among components is decreased, and another cascade cannot occur without an external disturbance, or until connectivity again reaches a critical level. If self-organization leads to the rebuilding of connectivity following a cascade, then internally driven cyclicity occurs.

Intrinsic cyclicity is the basis of Holling and Gunderson’s (2002) adaptive cycle. However, despite the evidence for intrinsic cyclicity, the adaptive cycle is not predictive, and Walker et al. (2006) are right to recognize in their propositions that the phases of the adaptive cycle are not necessarily sequential. One reason is the obvious one that the frequencies of cascades are stochastic and general, and not deterministic and specific to particular events (Brunk 2002). A second reason is that societies have become more adept at dampening such cyclicities and extending the periods of stability (Brunk 2002). Democratic capitalism, for example, is largely about inserting internal feedback loops into economic and political systems to avoid cascades. A third reason is that cascades can be initiated by a sufficiently large external disturbance at any phase. It is likely that, the finer the social or spatial scale of the system, the more susceptible it is to external disturbances, and the less likely it is to show intrinsic cyclicity. It is thus no surprise that our small sample of cases, all regional in scale, did not support the proposition that the four phases tend to be sequential. Neither did they support the proposition that  $\Omega$  events generally occur in the late  $K$  phase and are preceded by declining resilience. Tainter’s theory of societal collapse (1988) does, however, concur with the last proposition.

Tainter’s theory proposes that societies tend to add organizational complexity to solve each new problem as it arises, and maintain their integrity so long as the benefits of complexity exceed the costs. Collapse occurs when the costs of complexity exceed the benefits, and citizens withdraw their support from the state, leaving it unable to cope with external shocks. The adaptive cycle adds concepts about reorganization and recovery that are missing from Tainter’s work.

Diamond (2005) rejects Tainter’s (1988) general explanation and accounts for SES collapses mainly in terms of:

- failure to anticipate or perceive problems, for example, the unpreparedness of the pastoral SES in New South Wales for major drought;
- individually rational behavior in which those benefiting from the current configuration of the SES block change at the expense of society. The theory of political economy we used to explain resource allocation to regional SESs supports this perspective, which is compatible with a view of SESs as self-organizing and essentially leaderless systems;
- collective adherence to values that are detrimental to SESs. Our examples are ideologically driven land-settlement policies in Zimbabwe and New South Wales;
- failure to solve problems for climatic, technological, or ecological reasons. Often a solution is not feasible, e.g., the Aboriginal peoples were unable to prepare for or prevent the British invasion of Australia.

Our examples demonstrate the compatibility of our work with Diamond's, but this is not because of concepts drawn from adaptive-cycle theory. The highly abstract adaptive cycle cannot be expected to explain causes and effects in particular cases. We used it to integrate disciplinary theories about political economy and the relationships between social, human, and natural capitals and resilience. In discussing resilience and the  $\alpha$  phase, the adaptive cycle and our use of it go beyond Diamond's work. As with Tainter's work (1988), the adaptive cycle is also useful in proposing that the trajectory of an SES is difficult to influence from within during the  $K$  phase, and that an  $\Omega$  may be a precondition for a change of direction.

Cocks (2003) has reviewed explanations of historical social change and identified drivers that he proposes will continue to be important in the future. They are population growth, trade, war, technological change, resource degradation, catastrophes, and competition and cooperation within and between societies. Changes in these drivers could cause societies to collapse. Cocks incorporates them into a complex systems framework, they can be readily applied within an adaptive-cycle framework as causal explanations, and we have in fact referred to all of them in one or more of our case studies.

Our introduction pointed out that, although a number of researchers have used adaptive-cycle and other theories to analyze  $\Omega$  processes, few have studied  $\alpha$ . One is Cocks (2003), who like us uses adaptive-cycle theory when discussing reorganization and recovery. He focuses upon  $\alpha$  as a window of opportunity for evolving complex adaptive systems, but without discussing mechanisms of recovery as we do. Putnam (2000) also discusses  $\Omega$  and  $\alpha$  processes, but uses sociological theory. His analysis of declining social capital during rural decline in the United States a century ago and the subsequent adaptation of U.S. society to industrialization, urbanization, and immigration through the rebuilding of social capital concurs with our understanding of similar processes in our regional case studies. Our work has in addition analyzed the roles of human, physical, and financial capitals.

Regarding the usefulness of the adaptive cycle in the context of other systems theories, we conclude that:

- general systems theory continues to be a useful legitimation of transdisciplinarity;
- complex adaptive systems theory is a strong foundation for understanding change in SESs, in particular in its recognition of self-organization and nonlinear change;
- the adaptive cycle, as an elaboration of complex adaptive systems theory, is useful in recognizing the change in system behaviors during the various phases;
- although there is likely to be intrinsic stochastic cyclicity in any self-organizing system, external disturbances can disrupt this cyclicity at any time. The finer the scale of the system, the more susceptible to external influences it is likely to be, so we should not be surprised when, in a particular regional SES, the four phases are not sequential, and resilience does not decline before an  $\Omega$  event; and

- the adaptive cycle and complex systems theory in general are useful integrating frameworks. However, to explain causes and effects in specific cases, disciplinary theories must be used.

Consideration of our cases studies leads us to advocate replacing the current “sustainable development” paradigm that underpins much environmental policy with the concept of resilience. Sustainability is about maintaining the stability of current life-styles and production systems, whereas resilience is about change and adaptation. We suggest that generalizable content can be added to the resilience concept to increase its usefulness as a paradigm for a nation-state or region. Following Blaikie and Brookfield (1987) for regional scales, and Gale (2000) for the global scale, we propose that this content should be broad theory about how the distribution of political power influences institutional change, which consequently affects patterns of private and social investment in natural, human, social, and physical capitals. We propose that the resilience of most regional or national SESs can be explained in these terms.

## IMPLICATIONS FOR POLICY

1. Papers on environmental crises tend to end with stern recommendations to governments about their responsibilities and the policies they should implement for the long-term collective good. However, because SESs are self-organizing, their evolution rarely follows the path intended by governments (Hobsbawm 1994). As we pointed out in the section on the identification and analysis of  $\alpha$  and  $\Omega$  events and processes, governments are not free to invest or establish institutions at will, but must take account of the influence of industries and other interest groups, lobbyists, voters, and other sources of political influence.
2. The capacity to self-organize is the foundation of resilience. Rebuilding this capacity at times requires access to external resources. Excessive subsidization can, however, reduce capacity.
3. Cross-scale subsidization should end when self-organization becomes apparent, because cross-scale subsidization can increase the

vulnerability of the broader system. A long-term perspective is essential. Cross-scale relationships should in the long term be mutually sustaining, neither exploitative from above nor parasitic from below.

4. Investment in the capitals is the way to enable reorganization. This is already well understood by many international aid agencies, but humanitarian and political pressures may overpromote immediate relief rather than capital investment.
5. When a system is in the backloop and the aim is to recover without a regime change, the focus should obviously be on conserving or investing in the elements of capital critical for this recovery. If the aim is to shift regimes or to transform, then there will be a need to invest in the elements of capital that support those changes. It will also be necessary to disinvest in the capitals that maintained the previous regime. The political difficulty of doing this is why SESs so often remain maladapted to current conditions and opportunities, to the point of collapse.

Responses to this article can be read online at:  
<http://www.ecologyandsociety.org/vol11/iss1/art17/responses/>

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In contrast, when individuals interested in social-ecological systems think about resilience, they consider the interplay between disturbance and reorganisation, contextualised by system dynamics and cross-scale interactions, and focusing on adaptive capacity, learning, and innovation (Folke 2006). The ways in which social-ecological systems, such as agricultural communities, watersheds, or cities, sustain function in the face of change, and use change to precipitate reflection, learning, and moving to a more desirable state, are of particular interest to the authors in this collection.