SYSTEMIC LINKS BETWEEN SOCIETY, WETLANDS AND WOODLANDS - THE BUSHBUCKRIDGE CASE

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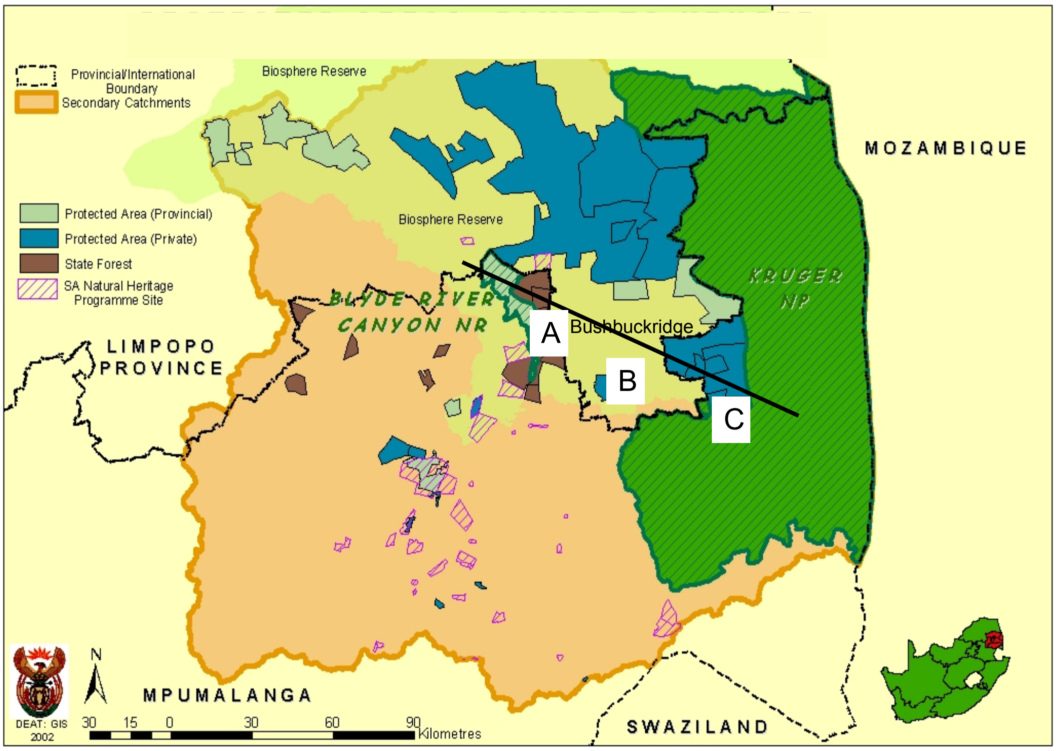
Abstract

This study undertaken in the Bushbuckridge area seeks to to establish systemic links between social, economic and biophysical subsystems. The Sand subcatchment of the Sabie has the advantage of receiving considerable study and project management action, because it is a highly stressed catchment with high levels of poverty and hence is a priority for rehabilitation. The focus in the study has been on linking ecosystem services derived from freshwater, with human livelihoods, and this includes important influences feeding through from the land-cover (woodland) subsystem. Wetlands play an important role in contributing to local livelihoods in the region. The techniques used in this study, which try to establish an overall picture of system function, include qualitative systems dynamics (interlinked cause-effect networks, particularly to pick up feedbacks) and vulnerability analysis determination using resilience theory. The idea was to test out these methods of generating a holistic picture of system behaviour and resilience, to test its usefulness as a general framework, especially since a common understanding by different stakeholder groups and sectors would help unify or at least facilitate future study, and future resource-related decision making (such as in a proposed bioregional programme). This particular paper will highlight the systemic woodland-wetland links, also as influencing and as mediated through human actions, in an overall socio-ecological system formulation.

1. Introduction

Fundamental disconnects usually exist between the way people understand and inplement issues in the different domains in society (Biggs, 2003), underlining the adage “the real world is integrated, it’s just our thinking that is disintegrated”. For instance, it can happen that the biophysical understanding of wetand processes in a certain area is good, but that the linkages to, say, the surrounding terrestrial landscape, are not taken into account in rehabilitation processes. Even more commonly, the linkages between biophysical and socio-economic processes are disjunct, and whole programmes might carry out, for instance, all the appropriate biohysical aspects of wetland rehabilitation, but not understand or evoke supporting social processes, causing the overall action to fail. Various attempts at systemically joining these various domains in some unifying framework have been attempted. In this study we test the use an approach by Allison and Hobbs (2004) who employs the generalised adaptive cycle as proposed by Holling (2001), combined with qualitative system dynamics (Forrester, 1961), the latter generating holistic cause-effect networks. The underlying belief is that we should attempt to view the system as a whole; along the lines of what is known as a socio-ecological system (SES) sensu Berkes and Folke (1998). A key corollary of this belief is “the rule of hand” which suggests that only a handful of drivers are responsible for most consequences in the system, with many other being entrained or “dragged along”.

The heavily populated Bushbuckridge area (zone B in Figure 1, a savanna) flanks the Kruger National Park along the central part of its western boundary. This area was formerly designated as bantustan homelands under the apartheid government, and has a history of forced resettlement, villagisation, and migrant labour to South African gold mines. It has a more recent history of considerable attention to poverty alleviation and ecosystem rehabilitation. It is also the site of an important current land use re-allocation on its western border, where five state farms (zone A in Figure 1) which were previously used for pine and gum forestry in the homelands, are being converted to the original grassland and incorporated into the recently-declared Blyde River Canyon National Park. From a sustainability point of view, this should lead to improved hydrological off-flow to wetlands in Bushbuckridge, and to the Sand River flowing through Bushbuckridge to the conservation areas (zone C in Figure 1) and Mocambique to the east. Also, the fact that the financially ailing commercial forests are now being felled to make way for grassland and national park, is hoped to offer a more sustainable financial future for the area through, inter alia, nature-based tourism. In the last decade and a half, Bushbuckridge has been the focus of many study and action projects. One such project, called “Save the Sand” (Pollard *et al*., 1998) attempted to address river and wetland sustainability issues from, concurrently, both resource usage and resource protection viewpoints. In the gently rolling topography of the western half of Bushbuckridge, several valleys have degraded or partly rehabilitated wetlands, important for those communities living immediately around them for a variety of reasons relating to their livelihoods (Pollard *et al.*, 1998), a notably profitable one being cultivation of 'madumbis'. "Save the Sand" has worked in these wetlands and in a wide range of other contexts relating to river and livelihood sustainability and governance, in the region.



Credit: Chris Clarke

Figure 1. Bushbuckridge and environs. Zone A represents the exotic forests currently being felled, the area being incorporated into Blyde River Canyon National Park. Zone B is Bushbuckridge proper, and Zone C includes the Sabie Sand Wildtuin and adjacent part of the Sand catchment in the Kruger National Park.

Save the Sand underlines three basic recurring questions, mirroring some of Holling's thinking on a multitude of cases worldwide (Holling *et al.*, 2002):

(1) Will the interevention have the intended affect at all?
(2) if so, will it be durable?
(3) What about unintended consequences?

We believed that if there was a reasonable chance of answering these three questions satisfactorily, that we may have found an effective way of thinking more sustainably. Our study pursued this quest. The Bushbuckridge region with its particular cogent history and status appeared to provide an excellent testing ground for the unifying SES concepts described above. We believed that the area had a rich data background to use empirically, and hence determine the value of these SES tools.

Resilience is defined by the Resilience Alliance as "the capacity of a system to absorb disturbance and re-organise so as to retain essentially the same function, structure and feedbacks – to have the same identity". We set out to view this study's finding through a resilience lens.

2. Methods

The generalised adaptive cycle shown in Figure 2 follows Holling (2001), and purports to act as a metaphor rather than a rigid model, applying to all social, economic and ecological systems, as well as their conjoined systems. It describes a front loop (with the two phases exploitation and conservation) reminiscent of conventional thinking e.g. of plant succession; but then postulates a backloop (consisting of the two phases release and reorganisation). Rather than seeing a process like plant succession as simply sliding up and down a continuum along various positions on the frontloop, the implication here is that the changes following disturbance (e.g, flood, avalanche, fire, pestilence) lead to a discrete new opportunity with its own defining characteristics, one in which differering forces can compete and potentially establish new system trajectories. As such, disturbances are not reasoned away as unfortunate accidents, but seen as integral and inevitable in system behaviour. The adaptive cycle is understood to be intrinsically scaled and nested, in that, for instance, patches fit into (say) ecosystems which fit into (say) biomes. This nesting, and the all important cross-scale linkages, are discussed in a book describing this so-called ‘panarchy’ or full nested array (Holling *at al*., 2002; Holling, 2001).

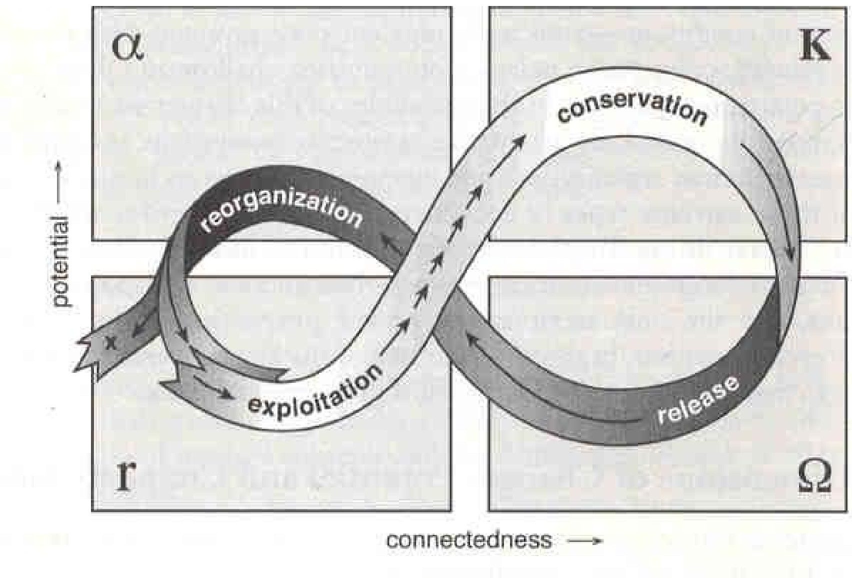


Figure 2. The generalised adaptive cycle of Holling (2001).

System dynamics diagrams are explicit cause-and-effect interactions which seek to portray the most influential basic drivers and their consequences. Formulation of these diagrams is done with a view to simplicity, but without trivialisation. Minor or entrained variables or consequences are thus intentionally ignored, but can be depicted on “unpacked” versions of parts of the diagram, which are often very useful, also for securing buy-in from persons who want to understand how an issue of concern to them fits into the overall picture. Most importantly, sequences of arrows in such a diagram can form a circle (or feedback). When they do, it is crucial to determine whether the net result is a “counterbalancing loop” (so-called ‘negative feedback, where an effect is ameliorated) or a “reinforcing loop” (so-called “positive feedback” where the effect of interest is exacerbated). Understanding reinforcing loops is the main way of determining the direction of trajectories, and invariably lead to thresholds being crossed and the system passing into another state, a key insight required in this approach.

Most data used were drawn from existing datasets and analyses, and these sources are recorded elsewhere (Pollard, pers. comm.). A limited number of fresh data extractions were undertaken to check particular issues, for instance whether sedimentation had increased in the middle catchment over the last two decades; and when river flow decreased most sharply.

Table 1. The workplan: original intended outline and sequence of activities in this study

Phase I: Description of past and current status of catchment
Description of **system focus and boundary**
Examination of **trends** over time and space, with a view to understanding their effect on resilience in later steps
Examination of **governance** and its effect on the intended resilience analysis
Identification of **main users groups**
Identification of sources of **leadership**, empowerment and action-learning.
Phase II: Analysis of the above
Describe prevailing **mental models** in use
Identification of different **states and thresholds** which lead to the system crossing into other states
Identification of key fast and slow **variables** in the system.
Identification of **ecological and social redundancy**.
Phase III: Workshops for stakeholder preparation (Preparation, integration and synthesis, scenarios generation with stakeholders
Panarchy analysis
Participatory **scenario** generation

3. Results

3.1 System dynamics

The system boundary was delineated in a primary meeting. Geographically, the focus area was seen as the Sand subcatchment of the Sabie basin, recognising that several wider systems fed out of or into this e.g. labour and remittance transfers. Thematically, the system focus was chosen to be riverine and wetland function (including the upland processes feeding into these) as related to ecosystem services and hence the livelihoods of people. Regarding timespans, we defined a hundred years, till present, as the operative timespan from which we planned to exploit data, and a generation ahead (25 years) as the desired timespan of our intended scenarios.

The history of events in the respective zones (A, B and C) was depicted as thoughtfully as possible in timelines, in which an attempt was made to identify major drivers and outcomes. These, together with other information such as the system dynamics diagrams, were intended to inform the rest of the steps below, as building blocks. The timeline in Zone B is shown in Figure 3, as illustrative of the outcome of the methodology. Using the timelines and the information in the systems dynamics diagrams, we concluded that the strongest drivers, taken over the last hundred years as a whole, were politico-legal, and drew a primary adaptive loop based on this (Table 2). Though not nested underneath this cycle, we concluded that the second strongest driver of our system, in quasi-twenty-year cycles, was droughts, but we have not shown our interpretations of this here in adaptive cycle form in this paper.

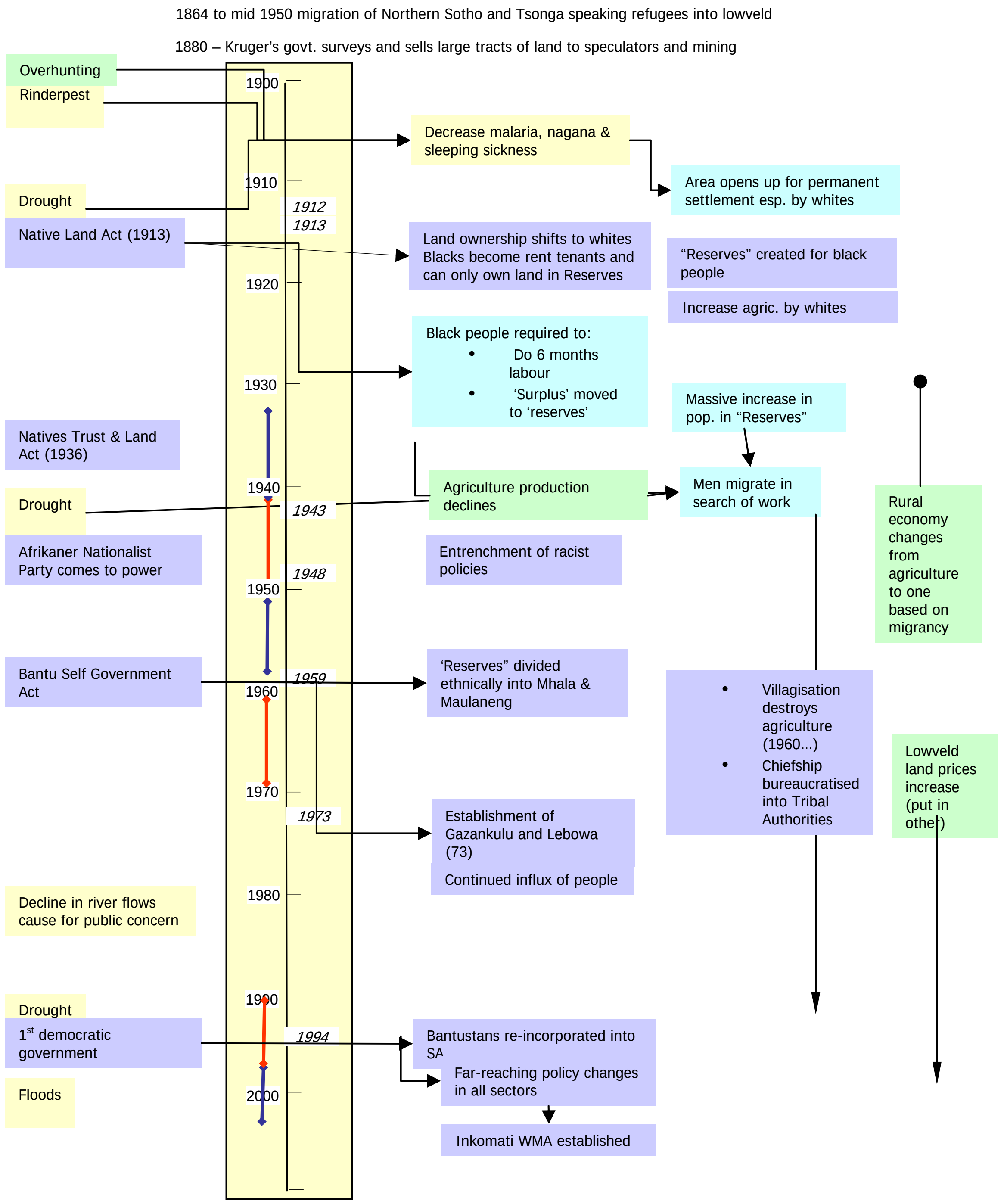


Figure 3. Timeline for Zone B, Bushbuckridge proper. Similar timelines were also drawn for Zones A and C. WMA = water management association.

Table 2. **Interpretation of political drivers over the last 100 years as these match the adaptive cycle phases. This table will be most easily read in conjunction with Figure 2.**

Time periods	Loop	Comment
Circa 1890 - 1913	Ω?	***omega phase of release*** ("things fall apart") with the prevailing livelihoods collapsing with the advent of immigration of hunters and entrepreneurs.
1914 – 1935	∀	**Alpha phase**, of new ideas being tested, namely labour recruitment plans, Native land Act, Black Reserves. Conditions favourable for permanent white settlement. The 1913 Land Act was fruition of the separate philosophy which came to be the dominant one (of one competing idea over another).
1936 - 1947	r	***r phase*** which is the beginning of the 'conservation' phase, ideas being consolidated.
1948 – c1988	K	***K phase consolidation*** of power of the whites under the apartheid regime.
1988 -present	Ω	***omega phase – crisis and re- organisation***

Most time was spent on system dynamics diagrams, our initial strategy being to draw one diagram for each subsystem (ecological, economic and social) and for each time era in the major adaptive loop and for each of zones A, B and C. Many of these proved to be overlapping, and we soon consolidated this into a few key diagrams, depicting also the full set of inter-relationships in the overall socio-ecological system. We illustrate a key example of this in Figure 4, the overall SES for Zone B during the apartheid years.

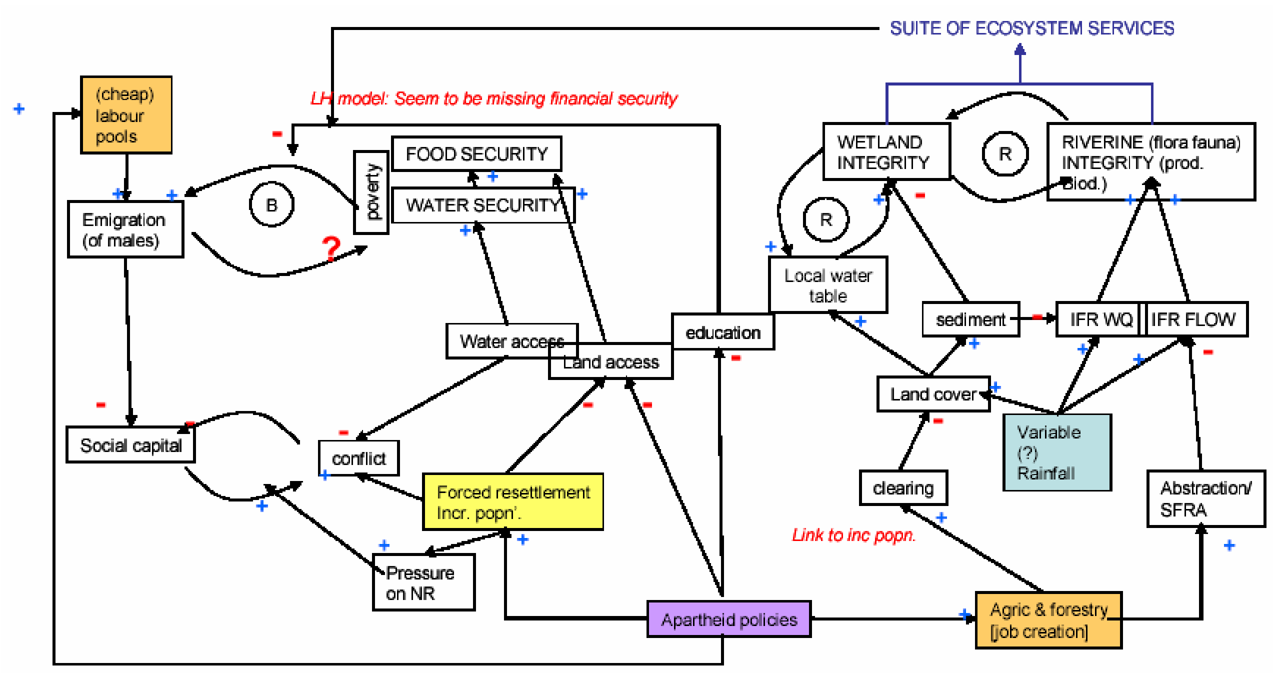


Figure 4. **Systems dynamics diagram for the 1960s to 1980s: Zone B: Bushbuckridge. IFR = instream flow requirement, applied retrospectively; WQ = water quality; NR = natural resources; SFRA = streamflow reduction activities; B are counterbalancing loops and R reinforcing loops.**

Key questions that inform system resilience, as guided by the workplan in Table 1, were then addressed using the above results as inputs. Examples of some key results, under the appropriate headings corresponding broadly to the workplan, are:

Cross-scale issues
Economic growth elsewhere in South Africa had already, and was likely to, offset several potentially weaker features of the local system, and hence confer at least local resilience. (Another important cross-scale interaction of interest to the woodlands audience, is that medicinal herbs are being stripped to unacceptable levels, due to loss of local control mechanisms in the post-apartheid era, in the face of rising subcontinental demand, and reducing resilience)

Governance
The current plethora of well-intended resource-related policy reforms were not yet operating in concert, and many, even in isolation, not yet proving implementable. Depending how this situation develops and is managed, it could lead to greater resilience (see next point on co-operative governance) or more vulnerability.

Conflict and power
The co-operative governance imperative in the South African constitution held great promise to improve resilience in Bushbuckridge, if it holds up to current promise.

Mental models
Linear thinking (not cognisant of thresholds) still predominates, enhancing vulnerability. One form of this is the so-called “hydraulic mission” (a old-style engineering approach to water resources).

Alternative states
Recognising these is crucial to the approach sought after in this paper. Experts we consulted in plenary consider the loss of “plugs” at the bottom of wetlands on the granitic substrate in Bushbuckridge, to lead to a system “flip” i.e. into a true alternate state. This however is relatively local in effect on livelihoods, influencing the respective micro-catchments. Other alleged biophysical system flips (such as degraded vegetation) appear to not yet be near threshold, testifying to a resilient system. Regarding social organization, it appeared from expert consultation that a threshold was passed more than a decade ago in which the extended patriarchal family, and even the nuclear family, unit had been replaced by a flexible and dispersed social support network, the implications of which for resilience require further thought. The postulated “economic high-road” cross-scale effect mentioned above, if it realizes, will constitute an important system threshold with definite though not always clear implications for resilience.

Slow variables
These are the slow creeping changes which can often go undetected, but which are eventually the signals or drivers of deep change. Sedimentation in river systems in the lowveld has been posited as a slow variable, and it indeed appears from some confirmatory work (Rountree, pers. comm.) that the Sand River is becoming sandier in the long run. Implications of this and of diminishing flow regimes in the Sand River signify degradation but not necessarily catastrophic thresholds. Social capacity, especially the educational component, is considered a slow variable, with a large question mark currently still over quality issues. Only a sustained and marked improvement in quality will confer additional resilience. Economically, the “well-being” index associated with the “high road” mentioned above, is known to be a slow variable with threshold behaviour.

Sources of leadership and learning
We perceive an increasing number of inter-sectoral initiatives which we believe marks a definite increase in the kind of societal learning required for resilient resource management. We watch with interest and try to positively influence various of these e.g. catchment management agencies and their institutional apparatus at all levels. This heading also cross-links strongly with education and awareness programs.

Redundancy
The range of agencies carrying out similar functions is regarded (within reason, and if in concert) as a positive contributor to resilience. Catchment issues have since the early 1990s been driven by a number of government, conservation, and water user agencies, and a number of NGOs.

3.2 Scenarios

The panel of experts with local knowledge of various themes in the Bushbuckridge region, helped the authors construct three 25-year scenarios as possible (but markedly different) future trajectories, across a feasible range of such options. This is done in an attempt to raise preparedness and assess resilience of various elements of the system to various challenges. Summarised very briefly, the three scenarios (named respectively: affluent society; resilient adaptor; and desperate measures) had different outcomes for water-related issues but very different outcomes for socio-political issues, including consequences of HIV/AIDS.

4. Discussion

This study was set up as a learning exercise, to test the value, in our hands, of these techniques. We will first discuss our experiences implementing the system, and then some key results of insights into system behaviour as we determined it, and its meaning for the system as a whole.

The workplan proved difficult to follow in linear steps, in that the process in which we were engaged, seemed to us, once we were underway with it, to be intrinsically iterative. We often found we needed to have some idea of the outcome of the next step to gauge what the inputs from a current step should be. We therefore adapted our modus operandi to facilitate this.

We adopted a subsystem-by-subsystem approach, in which the biophysical and socio-economic systems were first separately worked out (with some important suggested in- and outflows from the other, e.g. ecosystem services as a suggested outflow from biophysical subsystem, “waiting” to be connected to the socio-economic one later) and then joined later by “tying ends together”. This requires some modification of diagrams and connectors, but is believed to be more understandable to participants who work mainly in one of the subsystems. The alternative is to, from the outset, create one SES, as was done in another emergent exercise which includes Bushbuckridge but covers a far wider transfrontier conservation area and environs, for the AHEAD (Animal Health for Environment and Development) programme (Cumming, D H M, pers. comm.). Our current opinion is that both methods have advantages and disadvantages, and may ultimately result in similar products.

A significant experience for us was realizing that we did not have sufficient information to empirically validate all but a few key parts of the adaptive loop/s or the system dynamics diagrams, in any way that would measure up to hard hypothetico-deductive science. At best we were able to “circumstantially” inform the adaptive loop construct, and “prove” just a few key cause-effect steps in the system dynamics diagrams. It turned out that what we had perceived as our rich data history for the area, could really only be considered fairly complete for 15-30 years (depending on the particular theme) in the biophysical arena, and just more than a decade for social results. A few very basic rainfall, human demographic and economic parameters are available for more than half a century. Our conclusion is that the holistic view we aimed to study over the last hundred years is poorly served by available data, and we suspect that if this is the case in the Sand basin, that this will be fairly general in Southern Africa. We had originally seen the stakeholder workshop as a scenario-building step which would follow on our (we had thought, by then, completed) earlier results, but in fact landed up using the expert evidence as the best available substantiation of the base results - the adaptive loops and the system dynamics diagrams. We were however complimented at the workshop for having assembled all the available data into this organized form, making it possible for the experts to understand immediately what we needed to know and to deliver their opinions on the content of these constructs.

That the main adaptive loop reflected political drivers, is in our opinion the consequence of a century indeed dominated by political decisions and their consequences for resources and human livelihoods. While some may argue that this is universal, we disagree. We are satisfied that in other situations where the political environment is set up to enable other drivers, rather than overcome or largely entrain them, that such an analysis will in fact reflect those drivers. For instance, we find it credible that drought in fact played the second most important independent role, as a factor not politically As should be clear from the data availability profile backwards in time, we were increasingly unsure of context of conclusions about patterns in the early 20^{th} century. We were, however, confident that the last 50 years could be realistically portrayed as a classic forward loop and ensuing release and early reorganization phase. The fact that South African society is changing its rules of operation radically post-1994, raises questions as to our understanding of resilience vocabulary – is this adaptation, in the sense that society is resilient, and returned to essentially the same state; or is this transformation, in which a new system with new rules came to be? We feel both are true, and that the adaptive metaphor applies convincingly to aspects of life in where there was no fundamental change, and “business-as-usual” could in fact continue after the reorganization, whereas other aspects (several at a national scale) were genuinely transformed. Some of these larger-scale changes may only work their way down into the “business-as-usual” environment after time, and under enabling circumstances.

The system dynamics diagrams generally created, amongst ourselves as authors, and amongst the range of persons exposed to them, a feeling of completeness, in that the main system elements and their interlinkages seem credibly covered. Even where this was not true, the reaction of those persons was to immediately draw a revised version which they felt more credible. Sometimes this was more about providing “unpacked” detail, and in a few cases, introduced new or different drivers. Since we felt that none of these variants had broken down the dynamics in Figure 4 substantially, we will use that as a basis for discussion in this paper.

The biophysical subsystem representation depicted on the right of Figure 4 appeared, at the scale it featured, to be stable over the full time period, not only during the period 1960s to 1980s that the diagram represents. This caused us to think (and this perception was reinforced at the stakeholder workshop) that in fact the system was largely intact and had not undergone a “flip”. However, smaller-scale diagrams (not shown here) verify that a flip had taken place as the result of loss of “plugs” at the front end of wetlands, an issue only touched on via the box “wetland integrity” in Figure 4. The larger system around the wetlands, although degraded in terms of excessive sediment accumulation, reduced river flow, and large tree removal, had not altered its own basic operating rules or state. It can thus be considered resilient, and although its productivity is demonstrably lower now, the degradation is evidently still reversible without major intervention – at least compared to what might be required once the system rules change. While this is a valuable insight in its own right, and warns us about how and when such a flip might occur (indeed, in the “desperate measures” scenario, it can flip) it does not add particular further value to current rehabilitation initiatives except to realize they are taking place in the “pre-threshold” space.

The linkages we posit between land use and river/wetland health are abstraction (in Bushbuckridge today, mainly from citrus plantations) and clearing (driven by both subsistence-style cropping and by commercial agriculture/forestry). The underlying drivers of these are indicated, the political links being clear. Provided instream and riparian biota were in a sufficiently healthy overall condition, this and healthy wetland function would positively reinforce each other. However, the expert workshop considered wetland “flip” effects relatively local, possibly altering this interpretation somewhat.

The way in which the biophysical system supports lifestyles is via production of ecosystem services (in our system boundary, as defined) from rivers and wetlands – also a part of the diagram which is rich in unpacked detail (not included here). This arrow or flow remains important post-apartheid, but if national and global urbanization/affluence drivers become dominant in subsequent diagrams (currently still one possible future scenario), it could become less important overall. However, local ecosystem services will remain important in all scenarios for at least the poor.

The part of the diagram which is very characteristic of apartheid is the social subsystem on the left, characterized by mining labour demand (ultimately, if enough labour was sourced, it may be that a counterbalancing effect developed, as indicated by the ? at that point), and by severe restrictions on land and water access, all politically underlain. It is proving very interesting, following the demise of these drivers, to envision the system which replaces their roles. It turned out that this was best done as scenarios, each of which will clearly result in a “way-the-world-works” which is very different from the 1960s to 1980s diagram in Figure 4. For this, and for other reasons relating to the collapse in that region of traditional family networks, the social system and its economic components, must be considered as under fundamental transformation at present.

Interestingly, we constructed a socio-economic system (details not shown here) for zone C (the private and state reserves), which since the 1980s follows a classic neo-liberal economic pattern, with reinforcing loops of capital growth, efficiency boosting and demand growth (Allison & Hobbs, 2004). It is also in this region where human capacity inflows in the form of work done by persons originating from, and cash remittances back to, zone B provide a small but significant interface with zone C. Increasingly, ways are being sought to broaden this interdependence by, in particular, training and enterprise opportunities for skills in zone B, and the improved river flows increasingly demanded by conservation areas in zone C.

There are additional back-and-forth loops which could be added to Figure 4, linking food/water security directly to the (apartheid policy) drivers of agriculture and forestry: the recognition that this security was inadequate led to further forestry and citrus plantations. These had the potential to counterbalance the problem, but judging from information on living standards at that time, were unable to keep up. This means that further pressure for clearing was likely to be tipping the system in favour of degradation, even if it is true that this degradation did not reach the steep collapse “flip” state, except for the wetland plugs. The fact that there are now new social systems evolving means that the overall SES is changing, and possibilities exist to avoid an entrenched degradation route. Obviously the converse is also true, that the possibility exists that even less sustainable systems than those operative in Figure 4 might evolve – we have already mentioned the possibility that the “desparate measures” scenario might actually cause the woodland system to "flip" into a generally undesirable non-recoverable state – this would lead to serious knock-on effects akin to universal "clearing" of the Bushbuckridge area, in our diagram.

In terms of the resilience analysis done via our attempts to answer the key questions, the following major opportunities and threats present themselves:

- Dealing with an affluent society (should this scenario emerge) requires understanding when the local dependence on resources significantly shifts to a lower level, and confirmation that there is not a concomitant growth in offtake of natural products from demands elsewhere in the affluent system (as seems to currently be happening with medicinal herbs). Also, it is crucial to detect whether there is a compensatory shift in societal attitudes to a renewed ecosystem care ethic, and how this can best be stimulated or harnessed.
- The success or otherwise of co-operative governance initiatives in South Africa will be a cusp from which very different "ways-the-world-works" will develop; a related issue will be whether communities will "drown" in well-intended legislation, and just how successful harmonization efforts between legislation turn out to be.
- Tracking (and trying to stimulate) a shift in mindsets from "linear thinking/hydraulic mission" type paradigms to acceptance of complexity; and the general societal understanding that complexity can indeed be tractable.
- Ongoing refinement of our understanding of when state changes are occurring, usually based on subtle ongoing changes in slow variables.
- Above all, the leading indicator will be understanding whether we as a society are learning sufficiently fast to decide how to handle the changing world. This involves education, awareness, thoughtful experimentation, and often some redundancy, to ensure not only a "back-up" if part of the system fails, but also alternate lines of thinking.

All the above discussion points play out in influencing the makeup of the three scenarios which were constructed to illustrate three sharply different likelihoods by 2030. Although these scenarios are only mentioned here, it is important to appreciate that the above information informs our state of readiness for handling any of the three, or, more likely, some combination of different challenging elements of all three.

5. Conclusion

The methods followed and results obtained so far, have proved to be of value in helping unify (to an extent greater than before) our view of the region and its issues. For instance, we had not previously been able to clearly articulate anything near an overall system narrative. Therefore we believe that although there are still many shortcomings in our understanding, and many more new questions, that this initiative has helped at two levels:

- improving several important aspects of understanding interlinkages in the system. Many of the findings were incipient i.e. we had mentioned or known about them in some way before, but these became far more explicit and we became more certain of their meaning and context because of this approach. There are also some arguably new findings, uncovered by the methods.
- As a method of enhancing common understanding and buy-in. This applies particularly to the system dynamics diagrams, which are well-suited to simplification to support an extension message. Alternately, the diagrams can be generated afresh. Our experience is that these versions may differ a little from ours, but are likely to be compatible. This also then serves as a verification method for alternate lines of thinking.

It will be interesting to see whether this way of thinking influences planning, research and actual management action in resource-based initiatives such as the forthcoming north-eastern escarpment bioregion. It is clear to us that addressing resource issues holistically, while requiring the use of conventional scientific methods, also requires thoughtfully stepping beyond these.

Acknowledgements

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