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Managing for Intergenerational Equity

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Our knowledge of the way things work, in society or in nature, comes trailing clouds of vagueness. Vast ills have followed a belief in certainty.

Kenneth Arrow

What we don't know won't hurt us; it's what we do know that ain't.

Will Rogers

Only the man who finds everything wrong and expects it to get worse is thought to have a clear brain.

John Kenneth Galbraith

1 Introduction

In an earlier paper (Wright 2006) it was argued that a concern by humanity for something like 'intergenerational equity' is plainly required and that democratically-elected governments serve this increasingly popular concern with appropriate rhetoric. (Here, as in the earlier paper, 'intergenerational equity' and 'sustainability' are treated as synonyms unless otherwise indicated.) At the same time there is a lacuna in humanity's repertoire of ways of doing sustainability. In meaningful analysis of the issues environmental economics is thwarted by relevant uncertainty and ecological economics offers nothing more compelling than a set of ultimate outcomes from which one should work backwards to define current optimal action. The latter is essentially simple method (goal programming) based on religious axiom (these outcomes are intrinsically good); uncertainty is dealt with religiously by appeals to behavioural norms.

Approaches to sustainability from other disciplines have failed significantly to touch mainstream discourse. Economic approaches are moving, and will inevitably move more, to inform analysis through time as the reality bites of the opportunity cost of various interventions in markets to pursue sustainability.

There are several core issues in play. The central one is that it is clearly the case that humanity has the capacity to damage its environmental niche sufficient to threaten the continued existence of the species. This demands a response. The focus of concern, however, is not well defined and may be conflated with other concerns. This fact, arguably, is enabling two unfortunate consequences: possible inadequacy in response; and widespread idiosyncratic interpretation of the focus by people with agendas and the capacity to constrain human activity but no justifiable mandate to do so.

In addition, the shallowness of rhetoric and much analysis is masking cost and ethical issues. Ironically, perhaps even tragically, the sustainability concern, while almost visceral in its appeal to many people, engages few. There is a vulnerable perceptual detachment of people in developed economies from the reality of the nature of human-environment interactions. Solutions are not widely perceived to be problematic. These effects flow from ignorance of any but trivial understandings of cost.

In this paper the core question to be addressed is how government should approach the management of intergenerational equity.

The coexistence of very clear and present issues, such as global warming and depletion of world fish stocks, and the failure of any discipline to yet identify an optimising algorithm has a single, clear implication: empowered managers of the earth's resources need to adopt an approach, or approaches, to managing the issue which is appropriate to the lack of knowledge which bedevils the disciplines. The major approaches that have been adopted to date are the rapid and widespread adoption, nominally at least, of the Precautionary Principle (PP) and commitments to sustainability.

2 Strategic Management

Management is the arrangement of resources in pursuit of objectives. Part of the process of managing is the specification of objectives, of plausible ways they might be achieved and of the resources required. 'Resources' is a broad church including clearly defined inputs as well as roles and relationships amongst people and organisations that are party to the process. At the level of individual organisations roles and relationships comprise 'organisation design'. Beyond this domain they comprise 'institutions' in the broad sense.

Strategic management connotes management processes at the highest levels within a planning entity. Sometimes it is redundant.

Strategy has meaning as an approach to planning when action based on immediate circumstances may be irrational or suboptimal because immediate circumstances are a poor indicator of circumstances over a longer period *and* instantaneous adaptation is not possible. That is, current action and its consequences persist beyond the immediate period. Strategy is redundant when optimal long-run performance is the sum of optimal short-run performance.

Immediate circumstances may comprise a poor indicator because change can occur in the operating environment of the entity in question, including change in its own purpose. Such change may be triggered by the actions of the entity.

Specific algorithms for optimising action can be employed only once objectives, options and resources have been specified. If relevant uncertainty exists, management includes accommodating it in decision making processes. This may be achieved within algorithms or may require alternative treatment.

3 Framing the intergenerational equity management task

To manage in pursuit of sustainability objectives it is useful to frame the management task. In the broadest of terms the desired outcome of analysing the task can be described as the identification of appropriate instances, styles and magnitudes of interventions to modify economic activity.

Two prominent features distinguish the task. First, because threats to sustainability usually arise incidentally to economic activity, the management task may commonly span manifold, diverse economic activity with implications for a single resource. The pursuit of sustainability activity-by-activity is likely to be inefficient. The policy objective is to achieve modifications in economic activity such that impacts on the ecosystem are better. In the absence of a crisis, policy is unlikely to involve direct pursuit of ecosystem outcomes as the single objective.

In sociological terms the objective is to modify the culture of resource use, redefining norms and salient beliefs.

Second, and related, while it is informed by the science of the impact of activity on resources, the management task involves modifying human behaviour. That is, the manipulation of the effects of economic activity on the ecosystem occurs in what we shall call a 'behavioural system'. That system is linked to other systems. One is the market(s) for its output(s). Another is the ecosystem.

The policy making process is undertaken to modify the behavioural system and, through this, impacts on other systems. The nature or status of linked systems inform this process but are not sought to be directly influenced by policy.

The complexity, scale and recency of discovery of 'the problem' have humankind scrambling to respond appropriately. This is exacerbated by the common presence of considerable relevant uncertainty. It is noteworthy, though, that we are in a transition between an implicit assumption of costless economic growth and managing the uncertain costs of which we have become generally aware. It would be surprising if such a radical change in our perceptions could be managed with prior approaches. Equally, humanity will get better at managing this in time.

In what follows the management task is structured as a strategic management problem.

4 Specifying the objective in the abstract

A feature of concerns for sustainability is that, like leadership, 'everyone knows what it means; it's just tricky to define'. One implication of such a proposition is that definition is difficult because there is not a shared understanding at all. A more generous interpretation is basically semantic: everyone knows what the *outcomes* of sustainability are and the awkwardness arises from the focus on process, which may not enjoy a shared understanding.

This more generous interpretation seems valid only at a very general level. It might be more accurate to suggest that everyone knows what the outcomes of the *absence* of sustainability are: the denial by current users of resources of access to them by future users. Most people for whom the notion of sustainability resonates seem to regard it as an ethical matter; a matter of equity involving failure to pass reasonable entitlements forward.

Sharing such a view in no way leads simply to a shared view of process, or even of 'resources'. The creation of sound policy in this domain requires valid conceptualisation of the issues and carriage of stakeholders through their analysis. We have yet to see this anywhere. Rather, governments have unquestioningly adopted the simplest and least sophisticated notion of 'resources': physical, natural assets.

The failure to lift popular understanding of the issues has fed a quasi religious chasm between 'ecologists' and 'economists' and, worse, an unholy mess surrounding conceptualisation of the issues. Unpacking this mess is fundamental to identifying guidance for the management of intergenerational equity.

'Sustainability' connotes the maintenance of the capacity for service flows from resources despite use. The service flows of concern may or may not be those being used. Thus, sustainable use of fertile land for crop production means maintenance of the capacity for future crop production, while sustainable use of a national park for mining means maintenance of the recreational service flow capacity of the park and sustainable use of species means preservation of species diversity with some quite imprecise service flow.

Plainly, sustainability is not entirely an intergenerational concern. The impacts on capacity of current economic activity may be imminent. In these circumstances the full panoply of analytical economic weaponry can be deployed to frame choices. This may be difficult but it is not intrinsically useless. While there may be intergenerational implications, engagement with a specific issue (of which global warming may be an example) is driven by plausible presumptions that utility functions of proximal generations will be similar to our own and that relevant technological innovation will spring from current research. Both assumptions may be wrong but they provide a basis for framing choice. Debates about whether such linear extrapolations are optimistic or pessimistic can, and will, be resolved through political processes.

The common implicit assumption that such projections reasonably can be made of distal generations is, however, radically conservative since discontinuities are effectively assumed away.

As noted previously (Wright 2006), there are salient distinctions between proximal and distal generations. One is that proximal generations are more likely to be employing technology similar to that employed by the current generation. This implies similar interest in specific inputs. Another is that some costs with limited half-lives can be left to be borne by proximal generations. Examples include (old-) age-related welfare costs and national debt. Processes of equilibration make sustained transmission of such costs, across multiple generations, unlikely.

Uncertainty as to the technology, and valued inputs, characterising distal generations implies a need carefully to describe impacts to be imposed by current generations. Meaningful conceptualisation of this is central to rational management. This is, after all, the core of the concern.

One approach that is not credible is the routine characterisation of the impacts in terms of unfair consumption of rival goods. This conflates material and immaterial impacts in the way Ihde (1979) rejects. The proposition that a market exists for any resource, or insurance related to it (von Amsberg 1995), among generations assumes ongoing interest in the resource. This is to assume away some uncertainty that is central to the issue.

Such application of economic constructs to the intergenerational equity issue may have confounded analysis systematically. The framing of intergenerational questions in terms of notional markets for goods or services is logically flawed when ambiguity exists as to the existence of future demand for them. For policy-making purposes this ambiguity has to be either resolved or deliberately managed; modelling issues as though it does not exist leads to outcomes that may be totally irrelevant.

A related consideration is that the passage of time required, usually, for such ambiguity to resolve is not permissible for policy makers given the reality of current demand for the goods and services in question. Plainly, there is a need to commence analysis of the policy task with as much clarity as to its focus as can be achieved now.

Lack of clarity concerning the objective and its focus has arguably contributed to the loose use of the notion of sustainability and the awkwardness this has posed for policy makers seeking to respond to an idea that has intrinsic merit in the view of many people.

The use of market metaphors by economists has possibly compounded these features by implicitly bringing to analysis notions that are inappropriate. For example, what constitutes a properly functioning market, in terms of welfare distribution, may be too precious an interpretation of the fundamental concern.

5 Equity

Equity is to do with fairness. Intergenerational equity relates to the fairness of the impacts of the behaviour of current generations on future generations. What is 'fair' is a central question.

In abstract terms the concern can be expressed generally as relating to capacity: that it is inequitable for one generation to conduct its production of its lifestyle in a way that reduces the capacity of succeeding generations to do so. Anand and Sen (1994) argue that this is a matter of usufruct: the right to enjoy beneficial use of something belonging to another provided that its essence is not destroyed.

'This principle requires us to pass on to future generations [the accumulated capital and environmental resources] we have inherited from past generations – since we did not accumulate or produce it ourselves. It is not based on a claim of equal well being for the next generation' (Anand and Sen 1994 Section 2). This lies at the heart of the notion of stewardship and links directly to Boulding's (1958) use of the notion of capital stock.

An implication of this is that our inevitable ignorance concerning future uses of productive capacity, and valuation of its output, is irrelevant to the ethical debate. Likewise, the existence of market failure where the unborn are notional participants in markets for resources is, while undeniable, also irrelevant.

'Preserving productive capacity intact is not ... an obligation to leave the world as we found it in every detail. What needs to be conserved are the opportunities of future generations to lead worthwhile lives. The fact of substitutability (in both production and consumption) implies that what we are obligated to leave behind is a generalized capacity to create well being, not any particular thing or any particular resource' (Anand and Sen 1994 Section 2).

An implication of this is that it is necessary to identify those resources and capital that we know to be of critical importance to distal generations and that we might impair irredeemably. 'Capital', in this discourse, means goods that can be used in productive processes and which themselves have been produced. It includes, potentially, all manner of physical, intellectual and institutional components.

Current aspirations for economic growth imply continuing expansion of 'generalised capacity'. The focus of concern for intergenerational equity reduces, therefore, to incidental, irredeemable destruction now of elements of capacity that should be passed on.

It could be argued that capital is not susceptible to irredeemable impairment. This is because it is itself produced and, unless required natural resources disappear, can be reproduced. So production skills, the rule of law, intellectual progress and individual liberty may be subverted for periods but it is difficult to contemplate their permanent eradication should they be valued.

The threat, therefore, seems exclusively to relate to 'environmental resources'. To contemplate the rational management of sustainability for the long term it is necessary, first, to scope the task. Ihde (1979) has flagged the unhelpfulness of attributing similar importance to all environmental resources, suggesting that there are rankings of importance that can be contemplated. What he describes as 'minimal Nature' would seem to include, probably coextensively, the natural resource core of what Anand and Sen are describing as 'capacity'. What is this?

Fisher (2000) has provided the following.

> *A good starting point is the by now iconographic image of Earth from space taken by the Apollo astronauts. It fundamentally changed our view of Earth and of ourselves by demonstrating that the metaphor of the endless frontier no longer applies. In its place we see a small, isolated world, breathtaking in its beauty, an exquisite jewel set against the velvety black immensity of space. For the first time we saw Earth as a complex system of rock, soil, and water, veiled by a gossamer-thin layer of air, and inhabited by billions of fellow creatures, large and small. And we began to see that all species on Earth are related by an intricate web of biogeochemical cycles in which the chemicals needed for life--carbon, water, calcium, nitrogen, phosphorous, potassium--are recycled in a complex series of biological, chemical, and geological processes, mostly powered by solar energy. Though we had intellectually understood these points before, those Apollo photographs burned that new image into our consciousness in a way we could no longer ignore. We began to know in our hearts that we are all radically dependent upon that biogeochemical system and so are radically dependent upon one another.*
>
> *To understand that recycling system we can start with the familiar food chain, more accurately known as a food web. Food webs tend to vary a lot from one ecosystem to another, but there are a few features common to all. Surface ecosystems all begin with primary producers--plants--which use solar energy to convert CO_2 into organic matter. Consumers—first herbivores, then carnivores--ultimately derive the energy they need from those plants. But the food web doesn't end there. Animals produce waste products and plants produce dead organic matter. If that material were allowed to accumulate, we who live in Eastern forest systems would be up to our eyeballs in leaves and other organic debris; the carbon and nutrients they contain would be lost, and eventually nutrients they contain would be lost, and eventually the whole system would grind to a halt. So a third part of the system--the fungi and bacteria known as decomposers--play a key role by consuming all that dead organic material and converting the carbon and nutrients to a form in which they can be used again by the primary producers.*
>
> *On a planetary scale, all ecosystems are linked by a global carbon cycle, in which carbon is cycled in both the terrestrial and marine biospheres, and the two are linked by fluxes through the atmosphere and the river systems. The origins of this biogeochemical system are lost in the mists of time, but carbon isotopes from rocks in Greenland suggest that photosynthesis had already begun 3.85 billion years ago and that at least a primitive terrestrial carbon cycle had begun to operate.*

Today, this carbon cycle regulates the amount of atmospheric CO_2 which, along with water vapor and other greenhouse gasses, absorbs infra-red radiation emitted by Earth and leads to an average surface temperature of 17°C, roughly the most efficient temperature for carbon-based life. Without that greenhouse effect, Earth's temperature would be-18°C, and the oceans largely covered with sea ice, reflecting more incoming solar radiation, and cooling Earth so much that life as we know it would probably never have developed.

The greenhouse effect has kept Earth's surface temperature within the 40°C temperature range required for life for nearly 4 billion years, despite the fact that the intensity of solar radiation has increased by approximately 20 percent; despite the fact that the atmosphere has changed from an early, reducing composition to its present oxygen-rich composition; and despite the fact that the species mix on Earth has been radically altered in five major extinctions in the last 500 million years. The most intense of which happened 250 million years ago and eliminated about 80 percent of the species then alive. The other extinctions weren't quite that strong, but utterly changed the makeup of the terrestrial system.

....

And because we are among the youngest of the mammals--modern humans appeared only 150,000 years ago--we obviously are not essential to the existence of life on Earth. Aside from a few bacteria, viruses, and parasites that have learned to live at our expense and some domestic species that we have bred into dependence, few of our fellow creatures would miss us if we were to disappear.

....

Assessing the system's vulnerability is difficult. On one level the system itself is extraordinarily stable. It has continued to sustain life on Earth for nearly 4 billion years, despite the transition to an oxidizing atmosphere, five massive extinctions, a 20 percent increase in the intensity of solar radiation, and so on. It will obviously be very difficult for us to destroy the system.

But of course the question for us is whether we might perturb the system so that it can no longer sustain us. Although the system itself has lasted a long time, individual species have not. Of the 500 million to 1 billion species that existed at one time or another, 97 percent have become extinct, due mostly to their inability to respond to changes in the system, especially changes in climate.

....

Unfortunately, we can't say exactly what confers survivability on a species, but we do have some important clues.

We might start by thinking about the relationship between individual species and an ecosystem as a whole. The welfare of individual species is critical to the system--the system exists only in that it is instantiated by a particular set of species. Yet no species can exist apart from a healthy ecosystem. The welfare of the system depends both on the welfare of individual species and on the effectiveness of the biochemical processes linking species together.

At the same time, the classical idea of a "balance of nature" like that of a uniform system in stable equilibrium is wrong. Natural ecosystems tend to be distinctly patchy, the nature of the key processes tends to change with the spatial and temporal scales at which we view them, and they seem to have multiple equilibrium configurations. Perhaps the best criterion of system health is adaptability, the ability to respond creatively to stress, to move easily from one stable configuration to another as needed.

At the species level, generalist species seem to be more adaptable--and more robust--than those that have adjusted to very specific niches. On that criterion, humans would seem to score pretty well, but as we begin to approach Earth's carrying capacity we severely limit our room for manoeuvring in response to change. The risk is that we may do our job too well. If we succeed in identifying precisely what our needs are and precisely where in parameter space Earth's capacity to meet those needs is maximized, we could become more vulnerable to change and to variation in the parameters of the global system.

And the importance of adaptability makes an ecosystem's health very difficult to measure. It means that we can't just measure some parameter of the system today and compare it with some supposedly "pristine" state of the system in the past. Healthy systems are constantly changing in response to the seasons, to climatic cycles, and to human forcing factors like deforestation in the Amazon or re-forestation in New England. So change by itself is not necessarily an indication that something is wrong with the system.

Perhaps the best we can do is to compile a variety of indices designed to compare our impact on different sectors of the global ecosystem with the capacity of that sector. A 1997 paper in Science by Peter Vitousek and others comes pretty close. They show that we have transformed nearly half the land on Earth's surface (put differently, we're using nearly half the land's biological production), that we have produced about 20 percent of atmospheric CO_2*, that we use over half of the available fresh water, and fix over half of the amount of nitrogen fixed globally, and so on.*

The finding regarding marine fisheries is one of the most dramatic. When I was growing up in the '50s,the sea was thought of as the ultimate source of food--if we ever outstripped the limits of terrestrial agriculture, the endless oceans stood ready to sustain us. Over half the fisheries were undeveloped. Today, yields in more than half of commercial fisheries have either plateaued or are declining. Our first real experiment in managing global sustainability seems to be going seriously awry. We could tick off other indices--urban air quality, infant mortality--and we could get involved in a prolonged debate of the importance of each. But that debate would miss the point.

The point is that geology has a message for us: That although we are utterly dependent upon the functioning of the global system, we are stressing the system in several critical ways, and there's evidence that we are approaching some of the limits of what the system can provide. Few of these limits are rigid. Most involve tradeoffs, and ask us to set priorities. But as global population expands by another 3 or 4 billion over the next century, stresses on the system are going to

> *increase. And those stresses will get even worse if people who now consume less than we do try to match our lifestyle.*

What seems plain from the above is that the key elements of the complex system that defines habitability of Earth by humankind are quite well understood. Much less clear are the manifold impacts of economic activity on the system. However, the focus of concern for distal generations is apparently tight and well defined; it is meaningful to express it in auditing terms using indices. This implies a context within which, a prism through which, the contribution of specific human activity to the cumulative impact on indices can be framed.

Fisher's perspective, above, seems to move us towards specification of the set within which Ihde's minimal Nature resides: the aspects of natural resource endowments whose irreversible destruction would breach usufruct. This creates the possibility of defining categories of threats to sustainability that require attention.

The World Bank's Adjusted Net Savings approach to green accounting (Bolt et al. 2002) is a move in this direction. The intention with the approach is 'to provide national-level decision makers with a clear, relatively simple indicator of how sustainable their country's investment policies are' (Bolt et al. 2002, p. 4).

It includes Gross National Saving, depreciation of produced capital, current (non-fixed-capital) expenditure on education, rent from depletion of natural capital, damages from carbon dioxide (CO2) emissions and Gross National Income at Market Prices. Randall (2006) argues that it should also include net depletion of water resources (in quantity and quality terms), depletion of biodiversity, net pollution damage (except CO2) and net degradation/enhancement of soil.

For the present purpose the main point to be inferred from this operational global example of green accounting is that the dimensionality of the capital stocks of interest is well-defined. The range of types of human impact on the ecosystem has been scoped. The fungibility (substitutability) assumed that allows the incorporation of diverse elements in the single index is debatable but not germane.

Also clear from Fisher, above, is that homeostasis characterises the natural system, with or without human impacts, and that preservation of the status quo with respect to individual components of the system is potentially dysfunctional to the system. This implies a need to specify systems, and subsystems, at adequately broad scale. Consequently, the specific natural resource components of Randall's more extensive list (or the World Bank's) can be viewed as items to be audited but this does not imply what should be done in response to variations in any or in the index as a whole.

The policy task is to make rational decisions about influencing economic activity taking these impacts into account. The sustainability aspect involves the incorporation of our understanding, or lack of it, of the impacts of activity on the resource base.

6 Relevant uncertainty

Strategy making involves making use of uncertain information. In economic discourse the distinction is made between Knightian risk and uncertainty (Knight 1921). The former is a context of known possibilities with known consequences and likelihoods of occurrence confidently perceived. What could happen is known. Rational action, given decision maker preferences and risk attitude, can be defined.

Knightian uncertainty is characterised by ambiguity. The set of possibilities is not (believed to be) known fully and/or the consequences cannot be valued (because purpose cannot be predicted). Rational action cannot be inferred from what can be known.

Under Knightian uncertainty it becomes rational to insure against the unpredicted. In the absence of knowledge, however, there is no algorithm with which to optimise insurance and therefore little likelihood of the existence of insurance markets external to the entity. Insurance has to be a component of the strategy of the entity and be provided by the entity.

Insurance usually implies an ability to cope with events that challenge achievement of purpose and, in a fundamental sense, insurance within strategy involves the same. The difference is that it is in the form of adaptive capacity, possibly of less specific character than, but exemplified by, simple cash reserves. It involves the weakening of commitment to current action which manifests as resources being directed deliberately towards enhancing the capacity to sense and respond to relevant change in the environment. This implies a reduction in all of technical efficiency, specialisation within the system and centralisation of command. Short-term productivity is reduced in favour of long-term adaptive capability.

This approach gives direction to managers but not magnitude, still. How much capability is enough? And how should we frame 'capacity to respond'?

An approach to knowledge management that deals with this is the Cynefin (pronounced kun-ev'in) framework (Kurtz and Snowden 2003). This framework poses five domains. These are specified in terms of the way each is sensed and responded to in decision making. In terms of the above an interesting feature is that each of three of the domains offer Knightian uncertainty. There is thus some elaboration and the prospect of this framework providing insight into the notion of 'response'.

Four of the domains are defined in terms of the nature of the causal systems determining features of the environment in which an entity is operating. These are Known, Knowable, Complex and Chaos. Distinguishing features are summarised in Table 1 together with appropriate management approaches to garnering knowledge about each.

Table 1: The Cynefin Framework

Complex Cause and effect are only coherent in retrospect and do not repeat Probe-Sense-Respond	***Knowable*** Cause and effect separated over time and space Sense-Analyse-Respond
Chaos No cause and effect relationships perceivable Act-Sense-Respond	***Known*** Cause and effect relations repeatable, perceivable and predictable Sense-Categorise-Respond

Known causes and effects enable an emphasis on technical efficiency and standardised responses. Knowable causes and effects can all, at a cost, be moved to the Known domain. Commonly the cost is excessive and it is more efficient to rely on adaptation and learning through time. Complexity arises from the interactions of many agents. The volume of each denies categorisation and formal analysis; 'emergent patterns can be perceived but not predicted' (Kurtz and Snowden 2003, p. 469). Probing is required to identify patterns or possible patterns followed by action to stabilise those desired or destabilise those which aren't desired. Chaos is characterised by no perceivable patterns, by turbulence. Insufficient time is available to investigate. Crisis management is required.

These four domains are not on a continuum of increasing ignorance. At any given point in time Knowable, Complex and Chaos domains present the same informational face to observers. There is a qualitative distinction between the pair of Known and Knowable and the remaining two, Complex and Chaos. Kurtz and Snowden (2003) distinguish between the former as relating to domains of order and the latter as domains of un-order: emergent order, organically-arising order, heavily influenced by the context of the time.

The fifth domain sits between the other four and is labelled Disorder. It exists when there is disagreement among decision makers as to how a situation should be characterised and, therefore, responded to.

> *'... individuals compete to interpret the central space on the basis of their preference for action. Those most comfortable with stable order seek to create or enforce rules; experts seek to conduct research and accumulate data; politicians seek to increase the number and range of their contacts; and, finally, the dictators, eager to take advantage of a chaotic situation, seek absolute control. The stronger the importance of the issue, the more people seem to pull it towards the domain where they feel most empowered by their individual capabilities and perspectives. We have found that the reduction in the size of the domain of disorder as a consensual act of collaboration among decision makers is a significant step toward the achievement of consensus as to the nature of the situation and the most appropriate response.'*
>
> Kurtz and Snowden 2003, p. 470

To these hypothesised determinants of inclinations to perceive issues in particular ways one might add personality traits such as locus of control, generalised self-confidence and similar.

There are parallels here with the analysis of competitive environments in terms of 'causal texture' by Emery and Trist (1965). These authors also sought to identify the bounds to the viability of various responses given qualitative differences they defined in the sources of environmental variance. Their emphasis on competition caused their framework to be somewhat more narrow.

The Cynefin framework proposes types of response that are rational according to the domain in which a problem sits. This informs the notion of 'capability' to respond. Domains of 'order' cause theorising and modelling to be useful since processes repeat. 'Un-order', however, denies projection on the basis of prior experience.

In the case of Complexity 'the decision model is to create *probes* to make the patterns or potential patterns more visible before we take any action. We can then sense those patterns and respond by stabilizing those patterns that we find desirable, by destabilizing those we do not want, and by seeding the space so that patterns we want are more likely to emerge' (Kurtz and Snowden 2003, p. 469). The inability to rely on high-information, deductive approaches leads to a more approximate, directional approach to responses.

Under Chaos the decision model is 'to act, quickly and decisively, to reduce the turbulence; and then to sense immediately the reaction to that intervention so that we can respond accordingly' (Kurtz and Snowden 2003, p. 469).

Plainly, in domains of un-order sensing the consequences of action is critical to management. Science is important here in terms of providing salient indicators of ecosystem status and change. Science also must identify the significance of change. Responses, though, rely on the behavioural system.

7 Uncertainty and sustainability

Applying the Cynefin framework to sustainability, a few interesting insights emerge. First, the domains have no direct link to time. All can co-exist and there is little influence of time, per se, on membership of a domain. That is, any notion that ignorance abates naturally over time, in the sense of permitting shifts in the Chaos-to-Known direction, can only be true at the margin.

This also serves to remind us that some of the missing information challenging management of sustainability, such as future technologies and preferences, is indeed missing. It is not in any of the domains. It cannot emerge in advance of its context. It is not knowable.

Second, when a feature of the concern for sustainability is that pertinent damage occurs collaterally to purposeful economic activity, the requirement in each of the four main domains, apart from Known, for resources to be deployed to guide response implies that defining problems is a pivotal task. This is especially so when the definition of a problem is intrinsically bound up with the domain in which it is located. That is, problem perception is likely to reflect predispositions to locate an issue in a domain.

This intersects with the simultaneous co-existence of dimensions of an issue in multiple domains. For example, CO_2 emissions can be identified as a problem, as can CO_2 levels in the atmosphere (ie, non-sequestered), as can global warming, as can some broader specification of a problem couched in terms of the consequences for various species of global warming. The more local, or partial, the specification of the problem, the greater must be the confidence of the direction and magnitude of linkages between the partial specification and the broadest specification of the problem.

An implication of the rationale for strategic management is that, as with a temporally local focus in planning, a focus on components of complex systems can lead to irrational behaviour. Where complexity is known to characterise the system of interest it is risk-preferring to focus only on component parts of it: local optimisation may well be globally dysfunctional.

Importantly, then, the science of the impacts of economic activity on natural systems is only one component of a sustainability policy problem. It is linked to the behavioural system(s) that define(s) the policy and market context, and the response of actors to it, whence relevant economic activity comes. Since this is the medium through which policy will have its effect, this is the system that needs to be framed.

The importance of this is reinforced when there are multiple economic sectors or policy jurisdictions involved. The response to various forms of intervention is defined in these behavioural systems.

For policy-making purposes, application of the Cynefin framework is therefore to the behavioural system to which the ecosystem system(s) link(s). The domain within which a linked ecosystem system lodges has implications for establishing alternative ecosystem targets, research effort and feedback systems but not for strategic policy making. Whether an ecosystem is Known (salinisation), Knowable (global warming), Complex (influenza evolution) or Chaotic (severe drought), it is the character of the behavioural system which determines the implications of uncertainty for policy making.

Of interest is the interaction between the ecosystem and behavioural system. Un-ordered ecosystems, where causal paths are neither known nor knowable, imply a need for policy to pursue the identification of patterns and interventions to stabilise or destabilise them. If the behavioural system is ordered (Known or Knowable), policy can be defined and implemented without intrinsic difficulty. The management of perceived ozone layer damage and drought may be examples.

Arguably the ozone layer system is in the Complexity domain. The behavioural systems exporting chlorofluorocarbons (CFCs) are Knowable, if not Known. The negative valuation of the consequences of increasing ozone layer damage, which is one aspect of the behavioural system, was not contested. Intervention to avert continued contribution to a perceived decline in the environmental resource was swift and effective. Predictably, the functioning of the ozone layer system is not as we first understood it and our policies may have been less important to its future than we thought (Weatherhead and Anderson 2006) but that is irrelevant.

Humanity makes droughts. They appear as Chaos in ecosystem terms but are the products of Known behavioural systems; notably a behavioural system that is characterised by cost-shedding by 'victims' when drought appears. Appropriate policy is not intrinsically difficult to define or implement and Australian drought policy is moving steadily in a socially rational direction. Socially irrational policy was in place previously, a product of the known electoral power of victims and the ignorance of other taxpayers. That is, these provided the incentive and the capacity, respectively, for farmers and politicians to present droughts as Complex and thus an unmanageable burden that farmers should not be required to bear.

If the behavioural system, on the other hand, is un-ordered, policy construction and implementation will be difficult. An example is probably global warming. An emerging consensus that humankind is contributing to global warming has not yet had much impact on progress in policy. Un-ordered aspects of the behavioural system include unknowables such as long-term (intergenerational) valuation of costs and benefits, the willingness of various actors (eg, nations) to bear immediate costs to alleviate the acceleration in warming and the behavioural, cost and benefit options created by pertinent technological innovation over even the nearest timeframe for warming to be slowed detectably by interventions (eg, clean coal consumption).

The seeming intransigence of the world to respond to global warming does little to discourage suggestions that Chaos is imminent: warnings of proximity to a 'tipping point' (eg, Eilperin 2006). This is consistent with the Snowden and Kurtz perspective, and popular notions (such as the notion beneath 'crying wolf'), that categorisation of global warming as being in Chaos, by warranting an immediate corrective response, would be attractive to those who reject the seeming tardiness of negotiation of the Complex behavioural system.

When the ecosystem is ordered this may be accompanied by either an ordered or un-ordered behavioural system. An example of the former may be urban water supply in Australia's major cities. Policy making is not, or need not be, fraught with difficulty. Behavioural systems in the Known domain enable policies with highly predictable effectiveness.

If an un-ordered behavioural system rests over an ordered ecosystem, there is an interesting implication. The ordered state of the ecosystem will signal clear causal sequences for interventions. The un-ordered behavioural system will impose uncertainty on the value of ecosystem outcomes or the implementability of interventions. The clarity in the ecosystem will tend to privilege it; to give it greater status relative to the behavioural system than it should have. That is, interventions will be attempted which make scientific 'sense' but are irrational. Policy with respect to salinisation in Australian may be an example (see Pannell and Ridley 2006). Learning from policy probing is present (Pannell and Ridley 2006).

Two prominent issues flow from this strategic management analysis: what is the role of PP and sustainability policy commitments in effective responses to heterogeneous uncertainty; and are existing institutions sufficient to the management task?

8 Rule-based approaches

Given the superior role of the character of uncertainty of behavioural systems relative to that of salient ecosystems, it is arguably rather optimistic for protagonists to imagine that appropriate management of sustainability issues could possibly be achieved by the application of syllogistic, rule-based approaches. Unless the role of environmental damage in the behavioural system is defined, the identification of strategies that are appropriate and acceptable is unlikely if they are derived from principles invoked by the character of uncertainty of linked ecosystems.

This is most unfortunate for those who might rely on precautionary or sustainability approaches because it implies that such policies will be effective only when behavioural systems are ordered. The manifestations of ineffectiveness will be failure to comply and contesting of key issues such as the need for some targets rather than others, the distribution of costs of policy and even the quality of 'the science'; all consequences of complexity in the behavioural system. This complexity displays as confusion about policy outcome valuation, diverse incentives and disincentives and all the other unique specifics of any given complex behavioural system.

This perspective warrants some elaboration. The proposition that arises from applying the Cynefin framework is that we can identify (at least) two connected systems that bear on economic activity that may damage natural resources: the relevant ecosystem; and a behavioural system in which are embedded all responses to market incentives, available technologies, government policies, production economics and so on. Also embedded is the culture of resource use. Management of damage to natural resources requires knowledge of relevant ecosystems, to track the activity-damage linkage, and knowledge of behavioural systems, to identify feasible policy interventions.

Both systems will likely contain some uncertainty. Cynefin is one model that enables categorisation of uncertainty in terms of the intrinsic, current knowability of a system's state. Appropriate management responses, given an objective of modifying activity and related outcomes, are conditioned by the nature of the source of uncertainty. In the Cynefin framework these management responses seem to take intrinsic uncertainty as limiting, explicitly eschewing approaches that involve modelling the unknowable.

When applied to sustainability questions we may find that ecosystems are ordered or un-ordered. We may also find linked behavioural systems to be ordered or un-ordered. The domain to which policy is directed is the behavioural system. This creates an importance ranking between the ecosystem and behavioural system in defining appropriate policy.

Sustainability issues which embody intergenerational equity concerns (involving distal generations) inevitably are un-ordered. There are prominent aspects of the salient behavioural system (eg, future resource valuation, future technology, future substitution possibilities in production and consumption) which are utterly context-dependent and yet to emerge. It is not meaningful to seek to model these in any way. They are profoundly unknowable.

Linked to the un-ordered behavioural system may be an ordered or un-ordered ecosystem. The Cynefin domain in which it resides will imply suitable damage or restoration targets to be specified for the behavioural system. Even an ordered ecosystem, which most may be, cannot enable other than management responses appropriate to un-ordered domains when intergenerational equity is involved. The notions of caution, prudence and precaution are empty in this context. Attempts to force caution can be expected to fail because there is not a shared perception of its meaning.

This is a recipe for people facing low, or no, costs to be evangelical while those facing costs are exposed to the moral hazard of adopting sublime optimism about substitution possibilities. There is no possibility of resolution of such contests. The truth has yet to evolve.

When policy makers adopt commitments to sustainability and precaution, for intergenerational equity reasons, they create awkward futures for themselves. By adopting approaches to management which are appropriate to ordered domains, but will be implemented in un-ordered domains, they create intrinsic conflict. The unique features of each un-ordered domain case can be expected to lead to idiosyncratic contortions in the application of these approaches and mounting dissatisfaction amongst possibly all parties involved.

In short, policy designed to satisfy usufruct obligations for distal generations cannot be practical if it relies on absolutist nostrums.

9 The Precautionary Principle

The Precautionary Principle (PP) is, or is often thought to be, a decision strategy. As previously argued (Wright 2006), PP is an extremely conservative strategy. The intention is to respond to ill-defined hazard with prudence. Unfortunately, this seemingly sensible approach is radical in the presence of relevant uncertainty. PP 'seems to suggest that the choice is between risk and caution, but often the choice is between one risk and another' (Bodansky 1991, p.43).

PP is quite different to any other choice criterion developed formally in decision theory. This is a significant problem. There is no general agreement on its proper definition (Peterson 2006, Randall 2006, Quiggin 2004) nor its appropriate use to guide decisions (Peterson 2006, Quiggin 2004).

Quiggin (2004) suggests that it may not be possible to express PP as a formal decision rule but that, notwithstanding this, it is a good guide to decisions where uncertainty and incompleteness (ambiguity, in effect) expose conventional decision-theoretic analyses to systematic optimistic bias in favour of least-understood action alternatives. Peterson (2006) provides a detailed rationale for the development of guidelines for its application. Peterson (2003) makes explicit the role of PP in decision making: it is employed to frame decision problems. Specifically, it is used to reject alternatives from consideration (or to trigger interventions).

These observations make clear the fact that PP is not, in fact, a decision strategy but a strategy of decision making. Its operationalisation is fraught with difficulty, not least because many seeking to employ PP seem not to recognise its pre-analytical role.

Problems that Peterson (2006) identifies in its application include: 'the major social choice and definitional problems involved in implementing the principle may confer a high degree of discretion on decision makers' (p. 11) generating uncertainty and inconsistency and breaching good regulatory practices of transparency, accountability and effective consultation; the distortion of regulatory priorities with the possible effects of imposing significant costs on society and exacerbating environmental damage; the stifling of innovation and development; incurring perverse consequences due to failure to contemplate the costs and risk effects of regulation; and misuse as a rent-seeking tactic, including protectionism.

Various formulations of PP have been identified, such as 'weak', 'moderate' and 'strong' (Peterson 2006), 'Under the weak, or least restrictive, form, the precautionary principle comes into play when threats of harm are "serious", "irreversible" or "significant"' (p. 6). Likelihood and impact severity have to be indicated by evidence; scientific uncertainty and 'insignificant but real' possible damage will not trigger the PP. Many weak formulations require consideration of the costs of precautionary measures, in terms of cost-effectiveness meaning minimum inputs to achieve the objective. The burden of proof usually falls on those advocating precaution. This category includes the main international statements such as the Rio Declaration and the UN Framework Convention on Climate Change (Peterson 2006, p. 7).

Moderate formulations specify easier triggering of action to avert threat.

Strong formulations, emanating mainly from private organisations, have the lowest threat thresholds and shift the burden of proof of no prospect of harm to proponents of an activity. This is a totally risk averse position.

'[N]one of the three formulations of the principle specify the nature of any precautionary measure that must be taken' (Peterson 2006, p. 9). One is to wait and see; to delay decision.

It is apparent that PP is not a principle in the normal sense. More an 'approach' (Peterson 2006), it appears to codify the structuring of decisions under incomplete knowledge but is susceptible to such variety in application that it has no more practical usefulness than other broad admonitions such as 'act sustainably'. As Wills (1997) has pointed out, logically coherent application of PP requires the existence of knowledge with whose absence it is designed to cope.

The mess composed of attempts to formalise such vagueness is headed for unproductive reification as government commitments to PP are tested legally.

PP, like 'sustainability', is arguably little more than a call for prudence in the face of unknown risks of potentially serious consequence. What 'prudence' means may vary with the dimensions of relevant uncertainty. This is because the cost of precautionary responses, to engage in acts or forbid acts, has different characteristics according to the nature of uncertainty. For example, the more temporally distant the outcomes of damaging actions, the greater is the likely capacity of humankind to adapt, and to have adapted en route. That is, with time new solutions expand and the cost of damage, relative to now, reduces. At the same time, the cost of suppressing economic growth now compounds significantly with time.

This is not to argue sheer optimism. Rather, the point is that knowledge states, or 'ignorance states', are heterogeneous. For example, it has been suggested that global warming is a good example where precaution can be seen to be a valid response (Quiggin 2004). Compared to other challenges, such as genetic modification of crops (GMO), this is an issue characterised by quite high levels of scientific knowledge.

The precautionary options against global warming can be contemplated in a decision making framework that is much more specified by scientific knowledge and plausible forecasts than is true of GMOs. Global warming may be a 'soft' test of the prudence of precaution.

Allegedly principled pre-analytic approaches may need to differ according to heterogeneity in our ignorance. If so, one would expect a single invariant approach to vary in its relevance and acceptability.

Arguably the various formulations of PP reflect this fact as does the disappointment of some observers with its implementation. The pre-analytic nature of the 'principle' condemns its application to have to cope with heterogeneity in uncertainty, as well as in opportunity cost. Hence the chaotic definition situation. The radical conservatism of PP lies not in its intention but in its application to decision framing.

Moreover, the decision-framing role of PP is applied, it seems, with sensitivity to science but not the behavioural system. This is incomplete analysis and arouses concern, identified above, about excessive discretion being exercised in the application of PP. All formulations of PP involve regulation once a threshold is breached. This impedes any probing of behavioural systems that are Complex or learning of Knowable behavioural systems. As well, adaptive responses are ruled out. Stability is imposed. The question is begged as to whether the narrowing of the behavioural repertoire is a rational response to relevant uncertainty.

For example, if it is fair to describe global warming as involving an ecosystem that is Knowable, we have clear criteria for preferred futures of the ecosystem. We can define particular ecosystem targets such as stabilisation by some date of rates of average temperature gain. The behavioural system is Complex. That complexity means that effective policies cannot be derived from analysis. Modifying behaviour to pursue ecosystem change targets will require probing, experimenting with policies to explore patterns of response in the behavioural system. In this situation the imposition of a rule, such as the Kyoto Protocol, to limit additions to CO_2 emissions would be expected to fail. Compliance would be expected to be patchy.

Recently, Nordhaus (2006, p. 31) has asserted that 'the Kyoto Protocol is widely seen as somewhere between troubled and terminal. Early troubles came with the failure to include the major developing countries along with lack of an agreed-upon mechanism to include new countries and extend the agreement to new periods. The major blow came when the United States withdrew from the treaty in 2001. By 2002, the Protocol covered only 30 percent of global emissions, while the hard enforcement mechanism in the ETS [Emissions Trading Scheme of the European Union] accounts for about 8 percent of global emissions.'

In addition to implementation problems, the threat of syllogistic approaches creates incentives for the 'science' to be contested.

Alternatively, many ocean fisheries are under stress in a situation where the resource system is Knowable, if not Known, but the behavioural systems are possibly in the Complexity domain. In the Australian context it has been argued that '[t]here appear to be a small number of instances where the Australia Commonwealth Government, and some State Governments, have applied the precautionary principle to ocean management issues. However, these examples are overshadowed by a number of important examples where the principle has not been applied, even though its application was warranted' (Nevill 2005, p. 25). Thus, in a context of classic sustainability concern, with imminent implications of failure, progress is apparently poor.

Approaches to stewardship involve selection of constraints on choice. Incomplete knowledge of natural systems of interest requires those constraints to be set politically. (Incompleteness thwarts optimisation of decisions.) The attempt to routinise constraint setting by the use of the Precautionary Principle or generic sustainability policies simply shifts the political debate. Any perception that PP or sustainability policy could imply specific action is naive. The character of the ecosystem which we contemplate to identify choice constraints and desired policy targets may have nothing to do with the character of the behavioural system on which policy must play to pursue those targets. The clarity, or vagueness, of desirable ecosystem changes implies nothing about appropriate interventions apart from ecosystem objectives.

From a management perspective it is necessary to distinguish between ideal ecosystem targets and pursuable targets. The latter are a subset of the former, or interior to them, and are determined by the nature of the behavioural system. It is in the process of identifying pursuable targets that opportunity costs, changes to property rights and policy instruments are contemplated. It is in this process that ideal ecosystem targets are 'mugged by reality', which is to say 'made real'.

As in any enterprise, if the pursuable is judged to be inadequate, the behavioural system has to be changed. In individual organisations (which are effectively autocratic nation states) this is done using fiat to change the system. This is probably impossible politically in a democratic nation and meaningless at larger (multi-jurisdictional) scales.

The rhetoric of precaution trails implicit predictions that ideal targets are pursuable. This is a recipe for stakeholder disappointment and for low recognition of needed institutional change (see below).

Wills (1997) contrasts 'precautionary' and 'reactive' approaches, highlighting the real risk of perverse outcomes of the former under uncertainty about 'economic-environmental' systems, or behavioural systems as we have defined them.

Wildavsky (2006) argues for 'resilience' (ie, a capacity to react) rather than precaution except for situations of near-certain catastrophe and known preventative interventions (ie, a Known ecosystem confidently heading for Chaos).

> *In regard to the consequences of technological risk, there are two major strategies for improving safety: anticipation versus resilience. The risk-averse strategy seeks to anticipate and thereby prevent harm from occurring. In order to make a strategy of anticipation effective, it is necessary to know the quality of the adverse consequence expected, its probability, and the existence of effective remedies. The knowledge requirements and the organizational capacities required to make anticipation an effective strategy—to know what will happen, when, and how to prevent it without making things worse—are very large.*

> *A strategy of resilience, on the other hand, requires reliance on experience with adverse consequences once they occur in order to develop a capacity to learn from the harm and bounce back. Resilience, therefore, requires the accumulation of large amounts of generalizable resources, such as organizational capacity, knowledge, wealth, energy, and communication, that can be used to craft solutions to problems that the people involved did not know would occur. Thus, a strategy of resilience requires much less predictive capacity but much more* *strategy of resilience requires much less predictive capacity but much more* *growth, not only in wealth but also in knowledge. Hence it is not surprising that systems, like capitalism, based on incessant and decentralized trial and error accumulate the most resources. Strong evidence from around the world demonstrates that such societies are richer and produce healthier people and a more vibrant natural environment.*

This intersects with Fisher's thoughts on adaptation, above, and suggested rational responses to Complexity under the Cynefin framework.

So how is usufruct to be satisfied?

10 Managing for Intergenerational Equity

Managing sustainably, where proximal generations are the most distant that stakeholders may be, is not intrinsically difficult. Even Complex domains, for ecosystems or behavioural systems, can be explored usefully with research and policy probing. Arguably, ordered domains predominate making rational policy even more accessible.

Managing for intergenerational equity related to more distant generations, we have argued, involves Complex behavioural domains which, due to the absence of relevant contexts, cannot be probed productively with respect to, most importantly, natural resource valuation. This is the core of the challenge to usufruct.

In considering this question it is useful to note that the first task is not to identify how ecosystem targets can be pursued; it is to identify pursuable targets. Two types of management implication can flow from this. One is specification of the interventions required to modify behaviour in desired ways, given what is pursuable. The other is the identification of inadequacy in what can be pursued; that is, changes required to be achieved in and on the behavioural system itself to enable pursuit of more satisfactory ecosystem targets. As noted above, the scope for intervention here is probably very limited.

There are two substantive tasks here. One is the comprehending of the status of ecosystems and trends within them and the identification of desirable change. The other is the comprehending of behavioural systems via which this change must be sought. While 'desirable' is derived from the behavioural system, the analysis based on Cynefin implies that the former task is tractable with respect to proximal generations. That is, relevant preferences for ecosystem status are known or can be projected with considerable confidence.

With respect to distal generations, meaning beyond four or so, desirable ecosystem change must involve ad hoc selection.

The extent of discretion implied in this ad hocracy is muted. Practically, desirable changes for all generations are set simultaneously to inform current decision making. Usufruct related to distal generations can be observed separately only in situations where relatively near-term optimisation of resource use varies with incorporation of ad hoc, very long-term targets. How commonly is this likely to be the case?

To employ strategic management language, the situation can be described as rolling strategic planning with guesses being made, in each cycle, as to what capabilities must be preserved for the very long term. This is a smaller set than that of capabilities of near-term relevance. While current activity may spawn ecosystem damage that only becomes apparent over generations, at any point in time long-term capabilities that can currently be identified will be a subset of immediate capabilities. That is, adaptation will be required and will occur in future near-term decision making episodes.

It may be objected that this is a denial of the essence of strategy: the resistance of short-term optimisation where it is, or may be, irrational for the long term. However, the situation we are contemplating is not quite this. Rather, we are considering likely conflicts between the setting of ecosystem targets looking three or four generations ahead compared to targets looking farther ahead.

This line of reasoning is consistent with Ihde's notion of 'minimal Nature'. It indicates, as well, the process by which new substitution possibilities, in production and consumption, enter decision making.

Too, this reasoning reminds us that the ecosystem 'threat' has been scoped. We are past the stage of making alarming discoveries of incidental damage arising from human activity.

A useful example of the overlap of long- and short-term objectives is species diversity. While the maintenance of species diversity appears to have a strong intergenerational equity intent, arguably there is a widespread belief that the benefits of maintaining species diversity could be imminent, especially if 'imminent' is defined as within four generations or so. Longer-term considerations are redundant to the selection of this as an ecosystem target. Moreover, applying our analysis, longer-term considerations cannot help because technology may well evolve in the very long term to collapse the value of, and need for, naturally-occurring DNA. If and as this emerges, future near-term decision making and ecosystem targets will shift.

An implication here is that current sustainability issues inevitably outnumber intergenerational equity concerns. Further, constraining behaviour specifically for very long-term concerns will therefore result in considerable deadweight losses.

11 Institutions

The need for new institutions to cope with sustainability concerns is implicit in the earlier suggestion that an atomistic, activity-by-activity approach will fail to deliver sound policy. The mapping of ecosystems and behavioural systems does not appear to fall naturally into the charter of existing institutions.

Dovers (2001, p.12) argues the following.

> *'Existing institutions are inadequate because they are not adapted to sustainability problems. These attributes [of policy problems in sustainability] challenge research, policy making, law, and institutions. To achieve sustainability, we need to plan and act for the longer term, across traditional sectors, issues and political boundaries. We need to recognise and address complexity and uncertainty, both in terms of informing ourselves better and of acting without adequate information. We need to develop, apply and test new policy and management approaches, and to evolve new legal and economic definitions of rights and responsibilities. And we need to keep a range of interests engaged.'*

The attributes he identifies are: ' broadened and variable spatial scales; deepened and variable temporal scales; the possibility of ecological limits to human activity; irreversible impacts; complexity within and connectivity between problems; pervasive risk, uncertainty and ignorance; important environmental assets not traded or valued in markets; often cumulative rather than discrete impacts; new moral considerations (eg. other species or future generations); 'systemic' problem causes, embedded in patterns of production, consumption, settlement and governance; lack of accepted research methods, policy instruments and management approaches; lack of defined policy, management and property rights and responsibilities; demands for increased community participation; and sheer novelty as a set of policy problems' (Dovers 2001, p. 12).

The features he argues that institutions for sustainability should possess are

> *'Persistence, where efforts are maintained over time, enabling learning from experience, rather than the past pattern of ad hocery. This principle addresses the attributes of temporal scale, pervasive uncertainty, cumulative impacts, systemic causes, and lack of methods and policy and property rights.*
>
> *Purposefulness, where efforts are supported by stated principles and goals (ESD [Ecologically Sustainable Development] principles provide the basis for this). This principle addresses the attributes of temporal scale, uncertainty, new moral dimensions and novelty.*
>
> *Information-richness and sensitivity, where the best information is sought and made widely available. This principles addresses the attributes of uncertainty, lack of methods and policy approaches, the need for participation, and systemic causes.*

> *Inclusiveness, where the full range of stakeholders are involved in policy formulation and in management. This attends the attributes of demand for participation, spatial scale, uncertainty and lack of policy and property rights and responsibilities.*
>
> *Flexibility, where there is a preparedness to experiment, preventing persistence and purposefulness from becoming rigidity. This attribute addresses temporal and spatial scale, uncertainty, and novelty.'*
>
> Dovers 2001, pp. 13-14

While our prior discussion may conflict in detail with some of Dovers' bases here, the thrust of his call for a new institutional set is consistent with our analysis.

There have been moves in this direction. The Victorian Department of Sustainability and Environment, and the Arthur Rylah Institute within it, is an example. As Dovers (2001) notes, State of Environment reporting is widespread if not always a persistent policy pursuit.

Overall, though, there seems (still) to be much to be done to create the capability to derive meaningful policy responses to sustainability issues. Failing the evolution of appropriate institutions, humankind will struggle to move from the current phase of problem recognition to one of coherent management. (See Olmstead and Stavins (2006) for an approach to a post-Kyoto institutional model.).

It is beyond the scope of this report to propose ways forward in this regard. It seems apparent that that this task of institution building is significant. Equally, its difficulty signals the infeasibility of rule-driven approaches (which can not overcome the Complex nature of salient behavioural systems) and the strange distribution of costs of sustainability (particularly reduced resilience) that isolated applications of rules will create.

12 In the absence of institutions

It is apposite, however, to indicate the consequences of the absence of appropriate institutions. This is pertinent because the ad hoc management of sustainability can have consequences beyond mere clumsiness in pursuit of objectives. Ad hoc and partial interventions may waste time and stakeholder goodwill, and may even lead to perverse outcomes, but the greater issue is the imposition of unwarranted costs on affected stakeholders.

This is a risk when, in the absence of institutions which contemplate the (typically Complex) behavioural system, the tendency to privilege ecosystems due to their Knowable character can lead to policies that penalise stakeholders that are readily regulated. Pursuable goals become locally-pursuable goals. Coupled with ignorance of the complexity of a fully-specified behavioural system, the risk of rule-based approaches being imposed inappropriately is greater than might generally be realised.

One could express this as a failure to contemplate opportunity costs adequately but the point is rather different. In the context of inadequate framing of the management task, the set of intervention alternatives may be heavily influenced by power considerations. This can enable a 'planner' approach which, inevitably, will be as productive as the planner's perceptions are valid and will threaten property rights and the adaptive capability of economic actors. It behoves governments to constrain intrusions of this kind on economic actors in the absence of good cause. Rent seeking by those with strong knowledge of ecosystems is not good cause.

In effect, the power to intervene may attract more vigorous pursuit of inappropriate policy. An analogy is the seemingly relentless restructuring of public sector organisations (eg, universities) which face Complex environments and low (strategic) control over performance in them.

Nordhaus (2006, p. 31) argues that '[f]or global public goods, there are three potential approaches: command-and-control regulation, quantity-oriented market approaches, and tax- or price-based regimes. Of these, only the tradable-quantity and the price-like regimes have any hope of being reasonably efficient.' The rationale for this is the considerable risk of policy failure under command-and-control given the magnitude of uncertainty. 'Command and control' is a government-sourced rule-based approach.

13 Rational policy

There remains the question as to how governments might usefully proceed while appropriate institutions evolve. Two aspects of the foregoing analysis pertain. First, there is no benefit to contemplating far distant generations. Those aspects of ecosystems about which we are concerned for the sake of proximal generations are sufficient. Moreover, the automatically Complex nature of behavioural systems involving far distant generations denies a meaningful response; we are unable to probe them.

Second, while the exploration of ecosystems to bring Knowable to Known attracts interest and concern, behavioural systems are the context in which policy is or is not effective. Sufficient understanding of these is fundamental to the effective definition and pursuit of sustainability objectives. As pragmatic and unexciting as research into behavioural systems may seem it is that part of capital that defines the interface between our species and natural resources. Our ability to meet the threats arising from abuse of natural resources is bounded by it.

The common hope that environmental damage is a matter of clumsiness, and hence cheap to deal with, is an inadequate conceptualisation. Damage is a characteristic of production functions. Its role in them is the key to identifying relevant signals and incentives economic actors face. In turn, this is the context in which policy will, or won't, function. A plausible starting point for analysis is that, currently, if damage is occurring, it is rational.

While it is sensible for policy makers to signal a commitment to sustainability, it is arguably problematic to commit to rules, such as the Precautionary Principle, which are triggered by ecosystem characteristics but are operationalised in behavioural systems.

14 Summary

The concern in this paper has been to work towards a meaningful approach to policy to deal with sustainability. The framework has been, broadly, a strategic management orientation.

Much of published work dealing with the implications of the vulnerability of our resource base is tightly focused on the resource base. This has led to a somewhat chaotic set of analyses of appropriate human responses. Important dimensions of the discussions have been intergenerational equity and salient uncertainty. A characteristic of the discussions has been conflation.

The awful, quite recent discovery of our impact on the planet seems to have spawned generalised responses which have focused on specific natural resources, assumed merit in pristine states and opted for radically conservative responses which many seem to imagine are costless and prudent.

Thus, natural resources have not been ranked in importance beyond simple distinctions such as exhaustibility and susceptibility to irredeemable harm. Likewise, and as important, the role of natural resources in behavioural systems that use them has not received much attention. As a result what seem to be suitable ecosystem targets have been discussed with little regard to the broader system to which they are input.

Economists, whose science is to do with behavioural systems, have wrestled with the objective of identifying rational responses in the difficult context of Knightian uncertainty which bedevils the specification of opportunity costs of different responses and for which there is no metric which enables optimisation.

The tack taken in this paper is to distinguish between the ecosystem and the behavioural system that employs it. The rationale for this is that policy does not operate on the former; it is directed at the behavioural system.

This separation enables, inter alia, consideration of uncertainty arising in both systems. Going beyond Knight's notion of uncertainty, differences in causal systems underlying uncertainty are explored using the Cynefin framework. This indicates differences in appropriate responses according to differently-natured uncertainty. This enables the identification of appropriate approaches to defining ecosystem targets and, separately, to defining policy objectives.

While the science tends to capture attention, particularly when we know we have an incomplete understanding of it, policy making has to have its effect in the context of the causal system of activity. Desired usufruct outcomes have to be achieved via the modification of economic activity. If this is not understood, the prospect for effective policy is weak, and weakest where the need may be greatest: across multiple jurisdictions.

The separation also enables consideration of intergenerational equity as an input to policy formation.

In this context it seems to become clear that appeals to equity concerns of distal generations are effectively subsumed by a focus on usufruct concerns of proximal generations. Approaches to intergenerational equity for the distant future which rely on market-based analysis are dismissed as flawed.

As well, commitments to syllogistic or rule-based policy postures, such as the Precautionary Principle, are argued to be an invalid and unhelpful mapping of ecosystem targets into the behavioural system.

Relatedly, as humanity exits the transitory stage of becoming alive to the challenge to usufruct the major task is proposed to be the creation of institutions capable of informing and enabling relevant policy. In their absence there is not a coherent behavioural system for policy making itself.

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