

# Rethinking the natural capital metaphor: implications for education and learning

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One way in which the concept of sustainable development has been understood is through the metaphor of natural capital. This sees that the natural world has performing functions similar to those of economic capital. This metaphor is usually developed by applying to Nature standard economic techniques for capital valuation. However, where valuation of economic capital is complex, additional techniques are often used. One such technique is ‘real options’ analysis. Applying this technique to the concept of natural capital tends to lead to its revaluation, and has particular implications for the role of learning. Learning opportunities arising from the real options metaphor are explored through a number of examples.

## Introduction

Economic ideas can be influential to an extent well beyond what is apparent. The best economists know this. For example, an eminent economist of the present day begins one of his early works by quoting the thoughts of an eminent economist of the past, in the following terms:

The ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood. Indeed, the world is ruled by little else. Practical men, who believe themselves to be quite exempt from any intellectual influences, are usually the slaves of some defunct economist. Madmen in authority, who hear voices in the air, are distilling their frenzy from some academic scribbler of a few years back... . Soon or late, it is ideas, not vested interests, which are dangerous for good or evil. (J. M. Keynes, quoted in Krugman, 1994, p. vii)

This paper is concerned with one particular economic idea, that of natural capital. This concept is first explored in a preliminary way, and with particular respect to sustainable development. Secondly, natural capital is considered as a metaphor to inform wider thinking from the perspective of an orthodox, discounted cash flow

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approach to the valuation of capital. Thirdly, a alternative approach to the valuation of capital, real options, is introduced, and its metaphoric implications for learning and human behaviour explored. These prove, fourthly, to be radically different from those produced by the current orthodox mindset, and consistent with innovative contemporary thinking on both education and learning, and sustainable development. Fifthly, possible principles for the design of learning interventions using a real options metaphor for natural capital are discussed. Finally, a number of examples, both actual and prospective, are employed to provide preliminary indications of the potential of the approach.

### **Natural capital and sustainable development**

The following discussion draws particularly on contributions to the economics of natural capital by Maria Åkerman of the University of Tampere, Finland, and Paul Ekins of the Policy Studies Institute, London (Åkerman, 2003; Ekins, 2003). ‘Natural capital’ may be thought of as follows:

Natural capital refers to the various ways that the environment powers production—and indeed supports most aspects of human existence. Natural capital provides a major extension of the concept ‘land’, one of the classical factors of production in economic theory. It has both non-renewable and renewable dimensions, the latter including its generation of eco-system services and other life-supporting functions. (Ekins *et al.*, 2003a, p. 160)

The concept of natural capital was introduced by David Pearce (1988). Significantly for the present discussion, it was a contested concept almost from the outset. For Pearce, natural capital was a device to develop an approach to sustainable development from within the established dominant paradigm of economics. For others, such as Costanza *et al.* (1991) and Daly (1995), it was fundamental to the mounting of a challenge to that paradigm which emphasised ecosystem processes and ecological knowledge over the accounting of environmental assets. However, the term has continued to be found useful. One possible reason for this, suggested by Åkerman (2003), is that natural capital is a ‘boundary object’ (Star & Griesemer, 1989) which allows different social and intellectual constituencies to communicate with each other while maintaining both their own intellectual integrity and the internal coherence of their own arguments. (Of course, one might also suggest the same about the term ‘sustainable development’ itself.)

Such a view seems consistent with the subsequent work of Ekins *et al.* (2003b). This argues for a ‘strong sustainability’ assumption, for which, and in contrast to a weak sustainability assumption, the possibility of the existence of ‘critical natural capital’ is accepted: that is, ‘natural capital which is responsible for important environmental functions and which cannot be substituted in the provision of these functions by manufactured capital’ (Ekins *et al.*, 2003b, p. 169). However, the *primary* argument advanced for the adoption of the strong sustainability assumption here is not that such an assumption is somehow ‘correct’, but that it is methodologically more sound in a context in which the question of ‘correctness’ is not settled.

The important point is that, starting from a strong sustainability assumption of non-substitutability in general, it is possible to shift to a weak sustainability position where that is shown to be appropriate. But starting from a weak sustainability assumption permits no such insights to enable exceptions to be identified. In terms of scientific methodology, strong sustainability is therefore greatly to be preferred as the *a priori* position. (Ekins *et al.*, 2003b, p. 168)

Hence, dialogue is enabled to continue in a context of honest disagreement and mutual respect and, importantly for the developing argument of this paper, future learning is implied as a *characteristic* of the pursuit of sustainable development.

### Natural capital as metaphor

If we think of Nature as ‘being like’ a stock of financial or physical capital then an almost unavoidable consequence is that we are led into applying to Nature the rules of thinking which economists employ to understand financial/physical capital. Indeed, this is ultimately the point of the exercise. Natural capital is a powerful metaphor, in explanatory, exploratory and motivational terms. It is a way of organising directed learning as sense-making for negotiating the world, and so consistent with the view of learning as integral to sustainable development suggested above. It has:

- *explanatory power*: it is a metaphor from economics, so it presents problems (which are typically associated with economic development) and possible solutions as commensurable (both analysable in economic terms) within the favoured discourse of the policy world;
- *exploratory power*: it is semantically rich (it triggers an extensive and diverse set of ideas, implications and associations), and these can lend themselves to interestingly different emphases (benefit flow; production process); they also allow us to explore those areas of the conceptual space where meanings are more complex and contested (ownership of natural capital? ‘management’ of nature as a portfolio of capital assets?);
- *motivational power*: the intuitively basic idea in sustainable development is that a fundamental motive in human life is bettering our condition, but that this requires some assurance of continuity of our socio-economic and environmental arrangements into the future; the natural capital metaphor offers a way of operationalising that concern for continuity as an environmental sustainability constraint—we discharge our responsibility to the future by passing on an undiminished stock of at least critical natural capital.

However, as with any striking metaphor used as a learning tool in a central area of human experience, the explanatory power of the natural capital metaphor is in tension with its exploratory power. It is being used as a powerful conceptual device for focusing and simplifying what it also, at the same time, insists on as diverse and complex.

The particular simplification in this case is to ‘rules of thinking’ about natural resources in terms of the classic definition of capital as a stock of assets used, but not

used up, in the process of producing a flow of benefits to human beings over time. The value of this stock at any time  $t$  is taken to be the net present value of the total flow of benefits as at  $t$ —that is, the value of the benefits actually flowing from the stock at  $t$ , plus the value (appropriately discounted) ascribed at  $t$  to the benefits which it is expected to provide in the future, less the corresponding values of any present or future costs associated with maintaining the stock in being.

There is however a serious problem with this approach when applied to issues of sustainable development. This is that future costs and benefits are calculated on the basis of what is known in the present, even though relevant present knowledge may be irreducibly incomplete at the point of decision. Indeed, in many environmental cases, given the inherent uncertainties and indeterminacies of environmental knowledge, it invariably will be thus incomplete. It is not just that under such uncertainty there is often nothing to stop us putting figures on probable futures which reflect the current state of our disposition to act, nor even that we may well be strongly inclined so to model the future that the net present value of our natural capital stock comes out as one we *can* maintain into that future with a minimum of disruptive adjustment. The underlying point is that *the capital model itself is unable to incorporate any restriction* on these crucially relevant inclinations and tendencies. The effect of this is that what is represented as a sustainability constraint cannot genuinely constrain us—that is, cannot impose on us any obligations which we are not already inclined to accept.

There is, however, no logical reason to suppose that transferring the currently most widely accepted rules of thinking which apply to a *metaphoric object* (in this case, financial/physical capital) to a *metaphoric subject* (in this case, Nature) is always best, or logically safe. To illustrate: if an individual is advised to live ‘as if every moment was their last’ then, in our present times, this is likely to be taken to mean that they should seek to live a life full of action and/or enjoyment and/or achievement. In other times and places it might be taken as grounds to focus on quiet submission to the ultimate will of God. The outcome depends on the theory the individual has about Death, for it is Death, ultimately, that is the analogical object here. A learning opportunity for how we live our lives in the future resides in the juxtaposition of these two (and there may well be others) completely different alternative theories.

In the same way, the sense we make as a result of employing a natural capital metaphor depends on the theory we have about valuing capital. We should therefore ask whether alternatives to the net-present-value approach may be more useful as ways of thinking about natural capital in the context of sustainable development.

### *Real options*

Real options theory (Amram & Kulatilaka, 1999) takes techniques used in the pricing of financial options and seeks to apply them to the valuation of capital assets. The theory starts from the idea that investment decisions have embedded within them a series of managerial options. Rather than seeking to arrive at a firm present valuation of expected returns, the approach instead seeks to value the *options* embodied in some forms of capital asset to take decisions at future points contingent on what may by

then be more securely known. Hence, for an environmental example, rather than trying to arrive at a valuation of an area of rainforest and then discounting that figure over whatever was judged to be an appropriate time-period, one would try instead to calculate the *option-value* of having the rainforest still intact at different decision-points, and given a range of contingencies, over the same time-period. This is *not* the same as a policy of ‘keeping options open’. In particular circumstances it might theoretically be the case that the greatest option-value was obtained by keeping available only one option which precluded all others.

The option-value would tend to *increase* the longer the time-period under consideration and the greater the inherent uncertainty. By contrast the discounted cash flow approach increases its discount rate in response to long time-horizons and high levels of uncertainty. The option-value would be compared with immediate net benefits and future option-values arising from possible alternative deployments of the asset, such as chopping down the trees for timber. The higher the option-value attached to the forest, the more likely would be its survival.

That real options thinking might inform learning and human behaviour in relation to sustainable development was first proposed by Gough (2002), and has since been developed through the project, particularly by John Foster (2003a, b). Aspects of the idea had to some extent been anticipated in the environmental economics literature by the concept of *quasi-options*, first mooted by Arrow and Fisher (1974). Quasi-option value is the difference between the value of preservation (say, once again, of an area of forest) obtained using expected values estimated under uncertainty, and the value that will be seen to have actually been realised by preservation once relevant uncertainties are resolved (see van Kooten & Bulte, 2000, p. 296). This is the value that would be lost through sacrifice of options by an irreversible present decision to harvest now rather than wait. The point of the concept is precautionary: recognising the existence of quasi-option value is intended to counteract our ingrained tendency (to which, as noted, a discounted cash flow model of sustainable development is especially subject) to underestimate medium-term to longer-term costs as against immediately accruing benefits. A real options approach, however, includes but also goes distinctively beyond this kind of recognition.

One important theoretical dimension which it adds is the idea of the ‘kinked payoff function’ (Amram & Kulatilaka, 1999, pp. 18–19). Under uncertainty, the option to make a contingent decision has high value because a contingent decision to develop represents a potential to increase the benefit-cost differential *significantly*. To foreground this feature is to focus on the positive and the potential. We are no longer just concerned with precaution against an irreversible sub-optimal outcome, but rather with maintaining, by not committing ourselves too early, our room for manoeuvre to achieve a significantly better outcome than any presently available. The effect, however, is still to preserve the environmental asset unliquidated into the next time-period, and to keep on doing so as long as it remains unclear, whether or not development actually is optimal and how best to make it pay. This is undoubtedly a difference in emphasis, and perhaps potentially quite an important one in the context of a mainstream environmental economic and policy discourse, which at present is

typically all about representing environmental protection as cost and constraint rather than as opportunity.

As a topical example of this potential practical purchase: it is pretty evident from the results of the various trials and studies now emerging that the right thing for the UK to do with GM crops is to put them firmly on hold, while continuing actively to explore both the scientific issues and the nature of public attitudes, and leaving questions of future licensing genuinely open. A real options model helps us see this as neither a failure (writing off much investment) nor a fudge (fear of taking a clear line), but in fact the *economically optimal course* for public policy.

The associated danger, plainly enough, is that this general approach will make development (albeit aspiring to be environmentally benign), rather than precautionary preservation, into the default position. That possibility might well put off the environmental puritan. But this would be to overlook another new emphasis coming in with the real option picture: that on an active management process of acquiring information and using it to identify opportunities. Real options thinking specifically entails the development of a proactive learning stance to inform the contingent decision: indeed, it is only in virtue of this stance that the option to delay a decision acquires significant value. Such a learning stance in environmental cases in itself carries clear pro-environmental kinds of recommendation—it must at a minimum involve progressively fuller attention both to the interactions going on in ecosystems and to the whole range of social and cultural processes through which environmental goods are actually valued. Thus at the same time as shifting the emphasis towards development opportunity rather than constraint, the model adds a strong counterbalancing incentive towards the serious pursuit of better environmental-social intelligence.

There may be something further, and much more fundamental. The real options model implicitly recognises that uncertainty is ineliminable, and explicitly that it is productive, in human affairs. This model is not premised exclusively on our resolving a particular uncertainty at the end of some given time-period, but on our learning permanently to live with and welcome uncertainty as a condition of optimising value. It reflects our understanding that the learning posture adopted in face of a specific unknown will find us out things we weren't consciously looking for—whilst in resolving (provisionally) any one uncertainty, we will encounter others which in turn can prompt us to identify or create further configurations of contingent decision-making in our position. That is, this approach begins to make theoretical room for the undeniable human reality that uncertainty can in itself be a *good*.

Real options may thus offer a way of bringing within the scope of an economic model the positive valuation of endemic uncertainty. Elsewhere in economics (including that of quasi-option value), uncertainty is modelled as basically a negative—its presence and effects working to accentuate whatever downside may be in question: that is, all such economics participates fully in the radically scientific (and so, among other faults, deeply unscientific) assumption that the proper thing to do with uncertainty in human affairs is to make assumptions which reduce it to zero.

## Real options, learning and sustainable development

In the context of real options thinking, therefore, learning is crucially important. A three-fold typology of approaches to learning in the context of sustainable development has been developed by Scott and Gough (2003).

*Type 1* learning interventions are identified as those in which it is assumed that environmental problems have environmental causes. This leads to an attempt to identify solutions through natural scientific enquiry. In the process key and/or new information may be identified which must be communicated to the public. Once this communication has taken place, appropriate behaviour change is expected to follow. An example is offered by the development, across a number of Caribbean countries, of an educational response to the degradation of coral reefs which aims to teach children the basic science of such reefs (Hindson *et al.*, 2001). This happens to be a particularly well-thought-through instance of something very common, that is, responding to environmental threat by teaching environmental science. There are, it should be emphasised, many good reasons to teach environmental science, but no reason to think that predictable consequent behaviour change is one of them (Kollmuss & Aygeman, 2002). In this particular case, there is no doubt that many primary-age children have learned a great deal of good science in an interesting way. Whether this will make any significant difference to actual future events affecting the reefs they studied is, at best, a matter of speculation. An interesting alternative approach to this problem is discussed below under *Type 3*.

*Type 2* learning interventions assume that environmental problems have social causes. Solutions are therefore to be sought through social scientific enquiry (or, sometimes, appeals to ‘other ways of knowing’) and operationalised through social strategies, including education and training, which lead to changes in society. What people need, it is claimed, is not natural-scientific insights and technology, but rather social-scientific insights and technology through which they will come properly to understand the social obstacles to sustainability, and thus see the need for appropriate, collective social, political and environmental action. There are many examples of approaches of this kind using, in particular:

- techniques of participatory action research (e.g. Greenall *et al.*, 1993). These examples are often associated with a ‘socially critical’ perspective, which continues to be influential, for example in relation to teacher professional development in England (Huckle, 2003). The model essentially entails two rounds of learning. In the first, it is asserted, people’s eyes are opened to social and environmental truths. In the second, they learn (with others) how to live sustainably, through collective action.
- a focus on the development of an environmentally aware and responsible citizenry (e.g. Hungerford & Volk, 1990). This assumes, as a minimum, that countries (and indeed the world) are run by their citizens, and that people tend to be acting in the role of ‘citizen’ (rather than, say, ‘employee’ or ‘parent’) when they make environmentally important decisions.

Like *Type 1* approaches, *Type 2* learning interventions can claim some successes under what can be argued to be rather special circumstances (Scott & Gough, 2003). However, again there is abundant evidence (Kollmuss & Aygeman, 2002) that such success is limited. We should note that, like the net-present-value model itself, both *Type 1* and *Type 2* root our thinking about the future firmly in what we know (or think we know) in the present.

*Type 3* learning interventions assume: that uncertainty is in the nature of things; that society and its environment co-evolve, each reacting in incompletely predictable ways to changes in the other (Norgaard, 1984); and that deliberate actions which produce environmentally desirable outcomes at particular geographical and temporal scales may produce less desirable outcomes at other scales (Holling, 1995). They are therefore characterised by open-endedness, negotiation, and the juxtapositioning of competing perspectives (see Gough & Scott, 1999; Scott & Gough, 2003, for examples).

It is *Type 3* learning interventions which seem likely to support the fundamentally positive orientation to continuous learning in the presence of uncertainty identified through the real options approach to thinking about natural capital and sustainable development. This is because the value of real options *depends* on continuous learning. Such learning not only increases the number of possible courses of action available to people and changes perceptions so that possibilities previously little valued become more highly valued, or vice versa; it also increases levels of human skill in recognising and managing the contingent decisions through which our real options optimise value (Gough, 2002).

To return to the example of Caribbean coral reefs, the same research (Hindson *et al.*, 2001) found a contrasting instance in St Lucia, where literacy and numeracy courses were provided to adult fisherfolk to enable them to operate larger and more technologically complex vessels. They were then able to fish further out at sea, sustaining livelihoods while conserving reefs. A reported consequence was increased participation by children in school, as parents came to see increased economic value in schooling. The official intention at the time of the research was to continue by developing the ecotourism potential of the reefs, something which would seem very likely to create further educational priorities.

To think of learning in this *Type 3* way, and in a context of the natural capital/real options metaphor, brings to the fore a relationship which is not often explicitly acknowledged, perhaps because of the institutional barriers that develop between academic disciplines: the relationship between economics and learning. Economists normally treat people's preferences as given. For educationalists it may be *influencing* people's preferences that lies at the heart of the enterprise. It is, of course, entirely proper that this should be so as long as one has a focus on issues which are discrete to one discipline or the other: but sustainable development is not such an issue. What the real options metaphor seems to offer is a route towards, on the one hand, a view of learning which is sensitive to the economic implications of what is learned and, on the other, a view of economics capable of accommodating *contingent* preferences. It may be that this goes some way to explaining the apparent compatibility of the



approach with innovative contemporary thinking in both education—for example, M. D. F. Young's (1998) case for a 'connective' approach to curriculum design—and economics, for example Amartya Sen's (1999, p. 298) case for economic development as 'a momentous engagement with freedom's possibilities'.

How then might learning interventions be designed which enable us to recognise and optimise the option value of natural capital?

### **The design of 'real options' learning: the significance of markets**

On the orthodox capital valuation approach, present knowledge is used to determine expected future returns which are then discounted to a present value. To emphasise the key issue, we arrive in each case at a single value which guides our choices for the future but is rooted in our present knowledge. By contrast, the metaphoric object of the real options approach is *not* a constructed present value but a *price*. In the world of financial options this price is arrived at not through calculation but through the market interaction of buyers and sellers of risk. It is recognised as being futile to try to arrive, in the present, at an objective calculation of inherently uncertain future outcomes. Instead it is accepted that different people have different circumstances and preferences, that uncertainty creates both threats and opportunities, and that some people are therefore anxious to acquire risk as others wish to be rid of it. In the present, the price of an option summarises all this information. When this thinking is transferred to the world of real rather than financial assets, options embodied in such assets are still priced through the use of 'tracking portfolios' of market-traded securities to represent the degree of volatility affecting the context of a potential contingent decision. If we think about natural capital using a real options metaphor, then an important part of the analogy is with this kind of market function.

Such a function can be understood as *essentially epistemological*. Work by Pennington (2003) offers a number of helpful insights on this point. His core argument rests on a Hayekian conception of the individual as an inherently social being—formed and continually re-forming, in many ways, through social processes—who is nevertheless capable of comprehending no more than a fragment of the total social (and environmental) context to which he or she belongs. This conceptualisation is therefore at odds with both:

- Approaches which call for 'collective' resolution of environmental issues (communitarianism, systems theory approaches, eco-socialism and so on). Note that these are typically associated with *Type 2* approaches to learning.
- Liberal, libertarian and individualist approaches, for which society is no more than an aggregate of individual preferences. These are characteristically associated with *Type 1* approaches.

Following Hayek, Pennington advances the concept of 'spontaneous order', which arises as a result of human action, but *not* from human planning. Language is an example of spontaneous order. In the policy arena the emergence of spontaneous order is best served by markets. This is because markets perform two functions. First,

they produce spontaneous coordination, enabling people to adjust their behaviour to changing circumstances through the price signals they send—*without* requiring those people to understand all the parameters of those changing circumstances (such understanding, notes Pennington, would be an ‘epistemological impossibility’). Second, they facilitate an intersubjective learning process in which different ideas—including the ideas of ‘multiple minorities’—are tested against each other. All this amounts to a case that there is in society a primary, *epistemological* need to which markets are typically the best response. Markets are not there to aggregate individual preferences but to facilitate social learning. This, according to Pennington, they can do better than deliberative or planning-based approaches because of the complexity and scale of the problems and the physical and intellectual impossibility of assembling, consulting, coordinating and synthesising the knowledge people have—in total—on the scale required.

Without necessarily endorsing all these claims, it might be suggested that a major advantage of real options as an approach is precisely that it represents a move away from ‘planning’ of all kinds based exclusively on presently available knowledge, and towards a more contingent, ‘spontaneous-order’ kind of valuation with its root (at least) in a notion of dynamic, *epistemologically productive* market interaction. The function of real options thinking in relation to natural capital and learning is therefore to produce better environmental decision-making through the *epistemological enhancement* of society. This does not necessarily (or, perhaps, at all) imply a larger role for *actual* markets. Rather it suggests that, where actual markets are unavailable or unsatisfactory, planning processes might ‘mimic’ their operation under ideal circumstances. Seen in this way, the real options approach might be seen as a special case of the use of ‘hypothetical markets’ (Dworkin, 2000) as a public policy tool.

This suggests the need for a learning technology, or a clearly articulated template for the design of such a technology, which would be used with policy-actors in the field of environment and human behaviour. To design such a technology it seems helpful to return to our natural capital metaphor, and to disaggregate it from the perspective of real options.

### **Elements of natural capital and their educative potential**

We begin by thinking of natural capital, at a point in time, as a stock (*KN*). One possibility is then to liquidate it. Examples would be the burning of living trees as cooking fuel, the destruction of fish stocks through over-fishing, or the burning of coal. Note that, of these actions, the first two liquidate natural capital which is in principle renewable. The last liquidates non-renewable natural capital.

It seems clear that some level of consumption of natural capital over time is not only unavoidable, but even integral to the evolution and continuing development of any recognisably ‘human’ species. The other side of the same coin, of course, is that such evolution and continuing development require the continued existence of at least minimal stocks of natural capital, precisely so that they can be consumed in turn.

A particular difficulty is that what exactly ‘minimal’ means here is irresolvably uncertain. *KNL* refers here to natural capital liquidated in this way.

Another possibility is to convert natural capital into manufactured capital (*KM*). There seem three important points to note:

- This conversion cannot be achieved perfectly and must necessarily also involve some liquidation of natural capital (i.e. the laws of thermodynamics apply).
- Manufactured capital *may* functionally replace natural capital for human purposes. For example, people may prefer to seek recreation in simulated rather than natural settings. As we have seen, the existence and extent of critical, non-substitutable natural capital remain matters of debate.
- Manufactured capital may cause new natural capital (*KNN*) to come into being. This is because ‘being natural capital’ is a state attributed to aspects of nature by humans. It is not intrinsic to such aspects of nature. Whether something is natural capital or not depends on the state of technology and the wants people have. Hence, oil deposits are natural capital now, but were not natural capital 500 years ago. In this case new natural capital exists because new manufactured capital exists, principally in the form of the internal combustion engine. In a similar way, manufactured capital *may*, actually or potentially, add value to existing natural capital by making possible new, or more efficient, ways of exploiting it.

These sets of possible courses of action are interrelated. Both involve the liquidation of natural capital stocks. It also seems likely that both are strongly and predominantly correlated with gross national product.

Next, natural capital of some kinds may be maintained at levels which enable a continuing flow of benefits to be drawn down into the future. Such natural capital we term here *KNL*. It is the focus of debates about, and research into, questions of ‘sustainable use’.

A further possibility is to retain stocks of natural capital as a precautionary measure against possible future threats, unforeseen catastrophes, and other adverse consequences of all those things which, in relation to the environment, we *don’t know* we don’t know. Natural capital designated for this purpose is here termed *KNP*. Advocates of the ‘precautionary principle’ argue for high levels of *KNP*. For example, much of the case for maintaining the present balance of atmospheric gases is precautionary. We should note that for renewable natural capital, precaution indicates the maintenance of a minimum stock through sustainable use, whereas for non-renewable natural capital the implication is ultimately one of abstinence. As noted earlier, the emphasis here is on environment-as-constraint and environmental policy as defence.

Finally—and this is the aspect to which the real options approach is so vital in directing our attention—one might wish to retain stocks of natural capital as an adaptive, creative or speculative resource with which to respond to as yet unforeseen events. Natural capital designated for this purpose is here termed *KNA*. A specific, limited example might be the conservation of plant biodiversity as the basis for future, but as yet unspecifiable, pharmaceutical developments.

We might therefore summarise the possible outcomes between which an initial stock of natural capital  $KN$  may be distributed:

- it may be liquidated as  $KNL$ ;
- it may be converted into manufactured capital  $KM$  in ways which, to various degrees:
  - liquidate natural capital;
  - functionally replace natural capital;
  - create new natural capital ( $KNN$ ), or add potential or actual value to existing natural capital;
- it may be retained in order to maintain a flow of benefits at a particular level ( $KNI$ );
- it may be retained for defensive, precautionary purposes ( $KNP$ );
- it may be retained for adaptive, opportunistic and speculative purposes ( $KNA$ ).

Further work may enable these interrelationships to be expressed in a formal, mathematical statement.

At this level of analysis, we include the maintenance of  $KNA$  as one possible reason among others for the preservation of  $KN$  unliquidated. More broadly, however, it seems highly likely that *all* unliquidated natural capital will continue to facilitate human responses to changing circumstances in ways which are, for now, entirely unknowable. Flow-maintaining, precautionary and adaptive strategies in natural capital use, though radically different in outlook, are interrelated. All involve the conservation of the natural capital stock. They are likely to be fungible to some degree, that is, natural capital conserved for initially precautionary purposes may prove to have adaptive value later, and vice versa. They are also all likely to be positively correlated with the degree of perceived uncertainty about the future.

The companion Working Paper (*Rethinking the natural capital metaphor: implications for sustainability planning and decision-making*) explores in more detail this suggestion that natural capital *in general* may exhibit a structure of value broadly corresponding to the classic real-option format (as a ratio between a limited cost and potentially very significant gains); it also considers some of the implications for a sustainability criterion framed in terms of the maintenance of critical natural capital value over time. The present paper, however, focuses on the implications of this new inflection of the natural capital metaphor for individual and institutional learning. These concern the development in learners of a broadly *options-sensitive mindset* in relation to the understanding and management of environmental sustainability issues. The underlying thought here is that the more open to the general option-richness of environmental issues we can become, the better placed we shall be to identify and optimise over the real options for contingent decision-making which our natural capital assets, at whatever level, embody.

### **Towards a learning technology**

Table 1 outlines, at a general level, a possible programme for operationalising the real options inflection of the natural capital metaphor through learning, using traditional categories. It is followed by a detailed actual example, and a small number of indicative, possible other examples.

Table 1. Outline of a generic 'real options' learning technology

ASPECT	
Aims	<p>At the most general level, the aims of all relevant learning interventions will be to:</p> <ul style="list-style-type: none"> <li>● increase the broad option-sensitivity of learners by enhancing their awareness of, and capabilities in the use of, natural capital assets; AND/OR</li> <li>● enhance learners' skills in the recognition and management of options in the use of natural capital assets already technically open to them; AND/OR</li> <li>● enable learners' to explore, individually and with others, the value attached by themselves and others to particular possibilities in the use of natural capital assets; AND/OR</li> <li>● create engagement between learners who hold different, but in all cases incomplete knowledge about issues relating to sustainable development</li> </ul>
Learning outcomes	<p>Following any relevant learning intervention, learners will be better able, in ways appropriate to their age, status and context, to perform one or more of the following:</p> <ul style="list-style-type: none"> <li>● discern and describe some of the functions of natural capital in their own lives, and for the future</li> <li>● comment critically on alternative deployments of natural capital in hypothetical and/or actual examples</li> <li>● draw conclusions about the possible significance of alternative deployments of natural capital for their own lives</li> <li>● make reasoned recommendations for the deployment of natural capital in hypothetical and/or actual examples, in the presence of incomplete knowledge and divergent values</li> </ul>
Content	<p>Using hypothetical and/or actual examples, and in a manner appropriate to the age, status and context of learners, all relevant learning interventions will include some of the following:</p> <ul style="list-style-type: none"> <li>● the role of natural capital in economic activity</li> <li>● the liquidation of natural capital, the creation of manufactured capital, and the possible creation of new natural capital</li> <li>● the issue of substitutability of manufactured for natural capital over time</li> <li>● the precautionary retention of natural capital</li> <li>● the adaptive retention of natural capital</li> <li>● the nature of decision-making in relation to natural capital</li> </ul>
Pedagogy	<p>The focus will be on the use of actual and/or hypothetical case studies and simulations. There will be space for a range of pedagogies. For example, some straightforward transmission of information will be appropriate where there is no controversy about the facts or values of a particular case.</p> <p>The key pedagogy, however, will focus on confronting learners with alternative perspectives to their own in the context of natural capital decision-making.</p>

*Example: management education in Borneo*

The work described here took place during 1996–98. It was, for the most part, carried out in the small Sultanate of Brunei. However, the designation 'North Borneo' is also used here as a wider descriptor to include the East Malaysian state of Sarawak, which surrounds Brunei and, in fact, divides it into two disconnected parts. This is done because:

- some official policies which had a bearing on the work were conceived, at least in part, at this scale (e.g. tourism development);
- some environmental impacts relevant to the work crossed international boundaries (e.g. forest fires and the smoke they produced);
- this wider setting of North Borneo was used in conceptualising the work (Gough, 1995).

In terms of natural capital North Borneo has a number of interesting characteristics. It is located approximately 5°N of the Equator, has a hot, humid climate year-round, and was until as recently as the end of the Second World War entirely covered in tropical rainforest (Harrison, 1959). Three main cultural forms are present: Muslim Malay, overseas Chinese and indigenous Dayak. Citizenship is not fully extended to all these groups. Malays have political power.

These social arrangements are framed by a unique and rich tropical environment. North Borneo provides a fascinating example of tensions between ‘sustaining’ the natural environment on the one hand and ‘development’ on the other. Economic growth is rapid, environmental degradation widespread but uneven.

The work began by considering a form of education which was:

- in high demand;
- likely to influence learner behaviour in relation to natural capital;
- a focus of frequent official exhortations to young people to contribute to ‘nation-building’.

This was management education, which at the time was being introduced at post-16 level across the country. Courses were over-subscribed, no doubt in part because of the perceived need and opportunity for managers in a developing economy in which the number of public sector jobs had been effectively frozen, and official messages stressed strongly and repeatedly the need for entrepreneurship and management skills, particularly on the part of citizens (many Chinese entrepreneurs were non-citizens). The crucial point here, therefore, is that there was no question of imposing a new curriculum on unwilling learners. The most crucial test for this work was simply whether it was perceived by learners to be good *management* education. If it were not, they would be likely to conclude that they had been misled at some cost to themselves.

The work took place with two cohorts of approximately 150 young people (‘the students’) aged between 17 and 24 years. The ethnic distribution of this group approximated to that of wider Brunei society, with Dayaks under-represented. All the students had applied, and been accepted, to study management through an accredited programme. The work also focused on the lecturers (at different times between five and eight in number) teaching the programme, as well as educational administrators, local business people, and officials in more than one government department. Note that *none* of these individuals indicated *any* initial interest in natural capital or sustainable development. They were people who saw themselves as students or teachers of business management, or administrators of programmes which favoured dissemination of business management skills, or potential employers of graduates.

In the first phase of work, all students were provided with a nine-page resource booklet by their regular lecturers who had approved and, at their own discretion, adapted and/or expanded, the contents. The booklets directed students to four group-based activities, making clear that the work was time-limited and would be integrated in normal assessment procedures. It was also announced that some students would have the opportunity to present their work at a seminar organised by the Ministry of Development.

The activities related to a fictional proposal by a local/foreign joint venture company called Progressive Plastics to establish an industrial plant for the manufacture of plastic bags. This facility was to be located at an industrial estate (which really existed) near the mouth of the Brunei River. Though fictional, such a proposal was entirely credible for that location given that plastic bags are manufactured from ethane gas, which is produced as a waste product by oil and gas refineries and was therefore potentially available as a raw material. Further, industrial chemical industries were officially favoured with 'pioneer industry' status and so subject to tax advantages. Each activity required students to engage with the proposed development from a different perspective which they themselves might actually hold or reasonably aspire to. These perspectives were those of:

- A local manager hired by Progressive Plastics to report on the local policy situation with regard to quality and environment.
- A Ministry of Development official charged with regulation and monitoring of the proposed plant.
- A citizen responding to debate in the local paper, the *Borneo Bulletin*, about plastics and quality of life. This mirrored an actual debate in the *Bulletin* which weighed the visual pollution caused by plastic waste in the Brunei River and elsewhere against the convenience value of plastic containers.
- A scenario-writer for the multinational joint-venture partner of Progressive Plastics. This role was loosely modelled on that of a real individual, employed by Shell. Shell have an absolute monopoly of oil production in the region.

In the second phase of work students were required to prepare a detailed projection of the most appropriate use of the North Borneo coastline over the next five years, and in the light of this to write a conventional ('product, price, promotion, place') marketing mix for the nascent Brunei tourism industry. The first phase had implications for the second, since the plastics development would be likely to be unhelpful to the tourism industry. It was announced that, in this second phase, the Ministry of Industry and Primary Resources wished students to present work at an official function. Once again, work took place over an intensive week-long period, and at other points in time over a year. Also as in the first phase, students were confronted with the issues from a range of perspectives: those of government; villagers; tourists; hotel managers; and citizens.

In both phases a range of issues relating to the management choices and opportunities implicit in natural capital were raised, though the work was formative for the analysis of this paper, rather than its consequence. These issues were explored with

students through the technique of ‘dilemma analysis’ (Gough & Scott, 2000), which juxtaposes contradictory or incongruent statements participants have made in the course of the work. They included the tensions between:

- traditional and economically developmental uses of natural capital resources;
- the desire to conserve the traditional, and its finance through oil revenues;
- traditional and modern products, and the natural capital implications of their manufacture and use, now and in the future;
- different possible development opportunities, now and in the future: for example, between the development of a plastics manufacturing plant and an ecotourism industry;
- perceptions of natural capital from private business, corporate government, citizen and consumer perspectives; and from shorter and longer term perspectives within these;
- economic and cultural valuations of natural capital: for example, the Brunei river estuary, which has great value both commercially and culturally;
- being like others (the developed west), and being different.

There was evidence of environmental learning by students against two separate (and competing) sets of criteria derived from the literature of environmental education. It was felt by lecturers, and confirmed by analysis of students’ work submitted for examination, that the interventions had enhanced students’ business management learning. Not only students, but also local business people, college administrators and management lecturers were exposed to an environmental perspective on particular issues, perhaps in many cases for the first time. This happened particularly through the ministry-organised functions at which students presented their work. In the case of the second phase of work in particular there was also evidence of frequent enthusiasm and involvement on the part of students’ family members.

However, although this example is focused on the fourth educational ‘aim’ listed in Table 1, that of bringing about ‘engagement between learners who hold different, but in all cases incomplete knowledge about issues relating to sustainable development’, no formal attempt to reach (provisional) resolutions of these issues through the processes of ‘mimicking’ the Hayekian market in the way described above was made. A suggestion of how this might possibly be done, at least with older learners, is made below. First, however, three further, outline examples of what might be possible, in terms of the other individual aims in Table 1, are offered.

*Aim: increasing the number of options available*

Schoolchildren of a range of ages might study, for example, how the proposed location of a new airport on an existing wetland habitat opens up some options while foreclosing others. A particular example has been featured in UK news stories in 2003. The choice of a contemporary issue seems likely to be important. Adult stakeholder groups would be likely to be willing to contribute their point of view,



and even quite young pupils may be encouraged to adopt, for the purposes of simulation, a particular interest-group perspective and, perhaps, *vote* or *participate in an auction* of particular outcomes from its perspectives. This would be consistent in principle with an attempt to ‘mimic the market’ in the manner outlined above. Older children might be engaged in an issue of this kind from the perspectives of a number of different school disciplines, which may perhaps tend to point to different conclusions. Finally, pupils might monitor and evaluate *actual* outcomes. The particular aspect of natural capital addressed here is that of the replacement of natural capital by manufactured capital. The creation of new natural capital might be addressed if the focal case chosen was, for example, a plan to build a factory locally to manufacture wind turbines, or the construction of a large hospital with its attendant construction, waste and energy impacts, leading to increased life expectancy for local people.

*Aim: enhance learners’ skills in the recognition and management of options*

Again, quite young children can be, and indeed are, brought to an understanding of the difference between: cutting down trees to make room for a hospital; cutting down trees to make a bonfire; cutting down trees to make room for a hospital while planting new trees somewhere else in order to maintain a precautionary stock; and living healthier lifestyles so that fewer new hospitals are needed and both trees, and the creatures that live in them, can be spared, perhaps to serve some other valuable function in the future. All the types of natural capital distinguished above are represented in this example. Older learners would consider specific examples as a means to explore the ways in which such decisions are taken, and capital assets of all kinds managed.

*Aim: explore the value attached to particular courses of environmental management action*

Again the focus would probably be on particular, probably local, case studies of natural capital assets. For example, learners might focus on the use of a local river, considering its possible:

- use (liquidation) to create drinking water, ornamental fountains, and car washes, or to support industrial processes of various kinds;
- conversion to manufactured capital of various kinds (hydroelectrics, irrigation, leisure uses);
- precautionary conservation, perhaps in the context of global warming;
- adaptive future potential. For example, the Rio Grande might become a major tourist attraction if it wasn’t already a sewer.

Teachers might object at this point that this is exactly the sort of work that already goes on in the best schools with the best teachers. This may well be so: but the case being made here is that such teaching is not to be seen as an occasional luxury, but as a means to economic optimality.

### **‘Mimicking the market’: an outline example for adult learners**

One group of professions who increasingly find themselves concerned with sustainable development, and therefore natural capital issues, are procurement managers. In, for example, a large public sector organisation, purchasing decisions impact on the environment in many ways and at a range of scales. Issues which loom large include: whether to buy locally, thus supporting local economies, or at the cheapest available price; and, whether it is best to compete or collaborate in procurement with other, similar organisations. Implications for natural capital, for example through land-use or energy production, may be very significant. In addition, procurement managers are continually in a position of at least tacitly evaluating real options—that is, the scope for future contingent decision-making entailed by different present purchasing choices (‘Do I lay in stocks of X which costs more but is capable of the necessary adaptation to a changed use if E happens, or do I go for Y which might save money on the outlay, but only if E doesn’t then happen?’).

It would be possible to develop a database of case studies relating to such issues. Learning, by managers with responsibility in this area, might take place online, face to face, or, perhaps ideally, through a mixture of these. This learning might occur through a two-stage process of simulation. In the first stage participants would engage with a range of problems identified in one or more case studies from a *retrospective* standpoint, that is, the actual outcomes of the case would be known in advance to the course facilitators though not to the participants. Participants would work towards goals which they set for themselves, either individually, or collaboratively with others of their own choosing. They would be faced with a number of key decision points.

The second stage of the process would develop the case(s) in a prospective, fictional way in which the outcome (computed by the facilitators according to pre-established rules) depended on the judgements made by the participants during the progress of the simulation itself. The purpose here would be to achieve learning through active engagement in ‘real’ situations. Participants would be required, collaboratively or not, to make decisions in evolving contexts. For example, at particular stages in the simulation any of the following might be triggered:

- shifts in market prices;
- inputs of new, unexpected information;
- imposition of new external regulations (for instance, new environmental standards);
- crises of one sort or another.

Participants would be given advice, but also the freedom to ignore it. Their decisions, again made at particular preset decision points, would amount to both bets on the eventual outcome of the simulation, *and* an influence on that outcome. Those achieving the final result judged most nearly optimum (perhaps also a value subject to change through the process of the simulation) might be refunded their course fee.

It is interesting to note that there exists at the time of writing interest among some in the procurement community in the development of innovative training technologies in relation to sustainable development.

## Concluding thoughts

In this paper we have seen how the idea of natural capital is implicated in sustainable development. We have asked whether the way in which capital is conventionally valued is necessarily the only or best way of thinking about natural capital, and proposed an alternative, though one also drawn from economic theory. We have seen that this alternative conceptualisation has the effect of creating an intrinsic role for learning. We have begun to explore both the underlying principles of, and practical possibilities for, policy which aims to influence human behaviour through education and learning.

A key element of what is being proposed here is that we need to find ways to live with uncertainty, rather than pretending to each other that it is something we can, and should, eliminate. If this is a hard message for some economists, it is harder still, perhaps, for policy-makers—or at least those for whom the ‘U-turn’ is the ultimate indicator of failure. However, to pretend to ourselves that decisions about natural capital can be made with certainty on the basis of what is known in the present, constitutes a special case of what Paul Krugman (1994) has identified as a commonly occurring feature of the application of economic theory in policy-making: that bad ideas drive out good.

## Note on contributor

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## References

- Åkerman, M. (2003) What does ‘natural capital’ do?—the role of metaphor in economic understanding of the environment, paper to the seminar *Natural Capital: Metaphor, Learning and Human Behaviour*, Lancaster University, 15 April.
- Amram, M. & Kulatilaka, N. (1999) *Real options: managing strategic investment in an uncertain world* (Cambridge, MA, Harvard Business School Press).
- Arrow, K. & Fisher, A. (1974) Environmental preservation, uncertainty and irreversibility, *Quarterly Journal of Economics*, 89, 312–319.
- Costanza, R., Daly, H. & Bartholomew, J. (1991) Goals, agenda and policy recommendations for ecological economics, in: R. Costanza (Ed.) *Ecological economics: the science and management of sustainability* (New York, Columbia University Press).
- Daly, H. E. (1995) On Wilfred Beckerman’s critique of sustainable development, *Environmental Values*, 4(1), 49–56.
- Dworkin R. (2000) *Sovereign virtue: the theory and practice of equality* (Cambridge, MA, Harvard University Press).
- Ekins, P. (2003) Critical natural capital: operationalising sustainable development, paper to the seminar *Natural Capital: Metaphor, Learning and Human Behaviour*, Lancaster University, 15 April.
- Ekins, P., Folke, C. & de Groot, R. (2003a) Identifying critical natural capital, *Ecological Economics*, 44, 159–163.

- Ekins, P., Simon, S., Deutsch, L., Folke, C. & de Groot, R. (2003b) A framework for the practical application of the concepts of critical natural capital and strong sustainability, *Ecological Economics*, 44, 165–185.
- Foster, J. (2003a) *Learning, behaviour and sustainability: the 'real options' option*. Available online at: [www.lancs.ac.uk/fss/projects/ieppp/naturalcapital/](http://www.lancs.ac.uk/fss/projects/ieppp/naturalcapital/) (accessed 1 February 2005).
- Foster, J. (2003b) *Living options: ecological capital as 'real options'*. Available online at: [www.lancs.ac.uk/fss/projects/ieppp/naturalcapital/](http://www.lancs.ac.uk/fss/projects/ieppp/naturalcapital/) (accessed 1 February 2005).
- Gough, S. (1995) Environmental education in a region of rapid development: the case of Sarawak, *Environmental Education Research*, 1(3), 327–336.
- Gough, S. (2002) Increasing the value of the environment: a 'real options' metaphor for learning, *Environmental Education Research*, 8(1), 61–71.
- Gough, S. & Scott, W. A. H. (1999) Education and training for sustainable tourism: problems, possibilities and cautious first steps, *Canadian Journal of Environmental Education*, 4, 193–212.
- Gough, S. & Scott, W. A. H. (2000) Exploring the purposes of qualitative data coding in educational enquiry: insights from recent research, *Educational Studies*, 26(3), 339–354.
- Greenall Gough, A. & Robottom, I. (1993) Towards a socially critical environmental education: water quality studies in a coastal school, *Journal of Curriculum Studies*, 25(4), 310–316.
- Harrison, T. (1959) *World within: a Borneo story* (Singapore, Oxford University Press).
- Hindson, J., Dillon, J., Gough, S., Scott, W. & Teamey, K. (2001) *Mainstreaming environmental education: A report with recommendations for DFID* (Shrewsbury, Field Studies Council).
- Holling, C. S. (1995) Sustainability: the cross-scale dimension, in: M. Munasinghe & W. Shearer (Eds) *Defining and measuring sustainability: the biogeophysical foundations* (Washington, DC, United Nations University/World Bank), 65–75.
- Huckle, J. (2003) *Education for Sustainable Development: a briefing paper for the Teacher Training Agency (July draft)* (London, Teacher Training Agency).
- Hungerford, H. & Volk, T. (1990) Changing learner behaviour through environmental education, *Journal of Environmental Education*, 21(3), 8–21.
- Kollmuss, A. & Agyeman, J. (2002) Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behaviour? *Environmental Education Research*, 8(3), 239–260.
- van Kooten, G. & Bulte, E. (2000) *The economics of nature: managing biological assets* (Malden, MA, Blackwell).
- Krugman, P. (1994) *Peddling prosperity: economic sense and nonsense in the age of diminished expectations* (New York, W. W. Norton and Co.).
- Norgaard, R. B. (1984) Coevolutionary agricultural development, *Economic Development and Cultural Change*, 32(2), 525–546.
- Pearce, D. (1988) Economics, equity and sustainable development, *Futures*, 20(6), 598–605.
- Pennington, M. (2003) Hayekian political economy and the limits of deliberative democracy, *Political Studies*, 51(4), 722–739.
- Scott, W. A. H. & Gough, S. (2003) *Sustainable development and learning: framing the issues* (London, RoutledgeFalmer).
- Sen, A. (1999) *Development as freedom* (Oxford, Oxford University Press).
- Star, S. L. & Griesemer, J. (1989) Institutional ecology, 'translations' and boundary objects: amateurs and professionals in Berkeley's Museum of Vertebrate Zoology, 1907–39, *Social Studies of Science*, 19, 387–420.
- Young, M. F. D. (1998) *The curriculum of the future: from the 'new sociology of education' to a critical theory of learning* (London, Falmer).

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