Handbook of Ecological Restoration

Volume 1
Principles of Restoration

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Contents

1 • Introduction and philosophy

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DEGRADATION AS A UNIVERSAL CONCOMITANT OF HUMAN SOCIETIES

The place of human beings in nature has always been ambivalent. At the present time it is easy to see that we need to cherish nature because, for so many reasons, it supports us. The physiognomy and well-being of our planet depends on its living skin, without which the land would become unstable and, more importantly, its atmosphere would lose its crucial oxygen content, and life as we know it would perish.

Yet at the same time human beings have never been able to live in any sort of stability and comfort without subduing nature to some extent. The early hunter–gatherer activity caused a small amount of damage to existing ecosystems but this was well within the recuperative powers of nature. But, as a result of increasing human populations, inevitably requiring more resources, and the development of techniques of exploitation, such a balanced situation was not to last. The domestication of animals allowed the stocking of selected areas, the domestication of plants allowed them to be grown to order, both permitting higher densities of human populations, with the formation of coherent societies, but with the concomitant destruction of original ecosystems as an incidental necessity.

It is from these considerations that the Judaeo-Christian justification of a domineering approach to nature stems – that man should 'subdue [the earth]; and have dominion over the fish of the sea, and over the fowl of the air, and over every living thing that moveth upon the earth.' (Genesis 1:28) – no sign of any kindness or respect. This attitude remains a fundamental part of the exploitive capitalist cultures which dominate the world, which Aldo Leopold eloquently deplored (Leopold, 1949). Despite Leopold's wish for an environmental ethic, human existence is not possible without damage – every individual needs space to move and to live with protection.

The situation has been exacerbated by demands for greater comfort, affecting the size and luxury of our living space. How many people now would accept a housing standard of 3.5 square metres of space per person not long ago applicable in China, or accept a building without an elaborate electricity network, of copper wires, running through it? For all this, quite apart from increasing amounts of simple building materials such as clay and cement, special raw materials such as iron, copper, chromium and nickel have had to be found. And the major source of energy for achieving this construction as well as for the comfort of warmth has been coal. All these resources lie in the ground, and can only be got at by major land disturbance.

This population has, of course, developed other demands, such as for increasing mobility and therefore for more roads, for increasing recreation and therefore for increased recreation space. Winding rural roads have turned into motorways, and narrow paths through sand dunes into eroded blowouts. Damage at first insignificant and unnoticed has had an uncomfortable way of becoming catastrophic.

To support this burgeoning population arable agriculture has spread to almost every part of the globe. The land surface has not been completely destroyed. But the original vegetation has been removed, the land surface cultivated and crops grown. At the same time there has been the widespread grazing of animals, and the felling of trees for timber. These may not initially have disturbed the soil, but have grossly altered the vegetation and allowed widespread erosion of the soil and the land

surface, and extended to the disturbance and degradation of adjacent water (Jacks & Whyte, 1939; Lowdermilk, 1953).

TOTAL LOSSES OF LANDSCAPES, ECOSYSTEMS AND SPECIES: OF USEFUL LAND AND COMMUNITIES

It was the most severe types of degradation from industrial operations which particularly caught our attention, because their effects were so radical, in areas often close to where people live – the people who had once gained their livelihood from what had been there. They have been a particular challenge, because the original ecosystems have been totally destroyed. However now, because these areas are treated and our ecological sensitivity is sharper, we are turning our attention to less degraded situations, where perhaps only a few species have been lost. They are a more subtle challenge.

Each country discovered the problem growing within it. So there is no one global account. But some indications of how the worst problems were realised and began to be faced up to, is to be found, for Britain, in Whyte & Sisam (1949) and Senior (1964) and for North America in Caudill (1976) and Gunn (1995).

If nothing is done, these different types of degradation accumulate, with obvious consequences. But the background is not one of a static world population, but one that continues to grow substantially. So the need for restoration as an integral part of the philosophy and activities of all human societies is crucial (Cairns, 1995; this volume).

AN ECOLOGICAL VIEW OF THE DAMAGE AND ITS RESTORATION: DEFINITIONS

On every area of the land surface of the world there is normally a cover of vegetation. It is made up of a characteristic spectrum of species. That vegetation roots into a mixture of weathered rock and organic matter derived from the plants, the soil. The soil and vegetation support a characteristic population of animals and micro-organisms. The whole is both supported and challenged by the local climate. Aquatic systems have an analogous structure.

All this constitutes an ecosystem (Tansley, 1935). There are no bounds to an ecosystem, because the earth's living cover is effectively continuous. But we arbitrarily recognise different ecosystems based on location or on species. The crucial characteristic of an ecosystem is that its components, which could be a major element such as soil or an individual species, interact physically, so that a change in one component can lead to corresponding changes in others. At the same time the components share, and circulate between them, materials. Many important materials, such as phosphorus, cycle almost completely within an ecosystem and do not move out; others such as nitrogen are more labile.

An ecosystem therefore has two major attributes, structure and function, each made up of different elements. They can be used to define and illustrate the damage that ecosystems can suffer (Magnuson *et al.,* 1980; Bradshaw, 1987*a*) (Fig. 1.1). An original ecosystem will typically (although not always) have high values for both. Degradation drives one or both attributes downwards, often to nearly nothing. If the area is left to its own devices, the natural processes of primary succession will restore the ecosystem to its starting-point (Miles & Walton, 1993). It is these processes that, unaided, originally produced the variety of natural ecosystems we see today.

In aquatic systems if the disturbing factor is removed natural recovery can be quick, but on land natural succession is a rather slow process and may be very slow where the degradation has left an unnatural inhospitable substrate. It is this that prompts us to undertake restoration. We expect a short timescale. It is hardly acceptable that children living beside a colliery spoil heap should spend the whole of their childhood with this as their environment. Half would be more than enough. If a childhood is from two to 12 years, this means that the restoration should take no more than five years.

But what should constitute 'restoration'? In ecological restoration four words are in common use – *restoration, rehabilitation, remediation, reclamation* – although there are others (Bradshaw, 1997*a*). Perhaps the most complete guidance is from the *Oxford English Dictionary* (1971).

The relevant definition of *restoration* is: 'the act of restoring to a former state or position . . . or to an

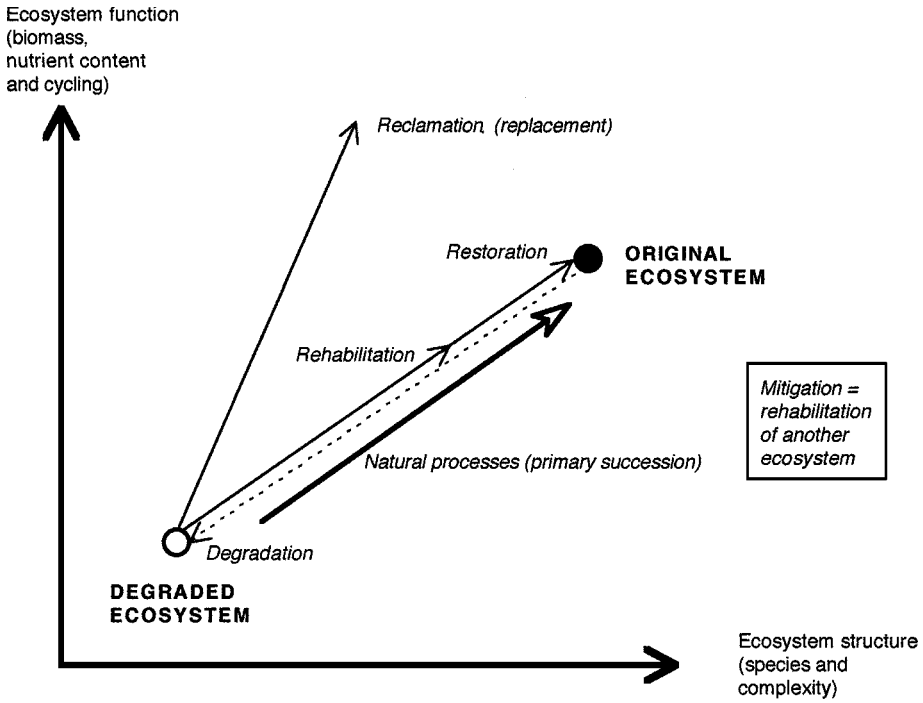

Fig. 1.1. The different options for the improvement of a degraded ecosystem can be expressed in terms of the two major characteristics of structure and function. When degradation occurs both characteristics are usually reduced, although not necessarily equally. Used in its narrow sense, *restoration* implies bringing back the ecosystem to its original or previous state in terms of both structure and function. There are then a number of other alternatives, including *rehabilitation* in which this is not totally achieved, and *replacement* of the original by something different. All of these alternatives are covered, by many people, by the general term *reclamation*. *Mitigation* is a different consideration. (See Bradshaw, 1987*a*.)

unimpaired or perfect condition'. To *restore* is: 'to bring back to the original state . . . or to a healthy or vigorous state'. There is the implication of returning to an original state, and to a state that is perfect and healthy. This seems to be the way in which we continue to use the word on both sides of the Atlantic (Box, 1978), even although it does have perfectionist implications (Francis *et al.*, 1979). In fact the term has been taken to have substantial implications:

> Restoration is defined as the return of an ecosystem to a close approximation of its condition prior to disturbance. In restoration, ecological damage to the resource is repaired. Both the structure and the functions of the ecosystem are recreated. Merely recreating the form without the functions, or the functions in an artificial configuration bearing little resemblance to a natural resource, does not constitute restoration. The goal is to emulate a natural, functioning, self-regulating system that is integrated with the ecological landscape in which it occurs. (National Research Council, 1992.)

This has been broadened, perhaps excessively, by the recently formed Society for Ecological Restoration to 'ecological restoration is the process of assisting the recovery and management of ecological integrity. Ecological integrity includes a critical range of variability in biodiversity, ecological processes and structures, regional and historical context, and sustainable cultural practices.' (Society for Ecological Restoration, 1996.)

Rehabilitation is defined in the *Oxford English Dictionary* as: 'the action of restoring a thing to a

previous condition or status'. This appears rather similar to restoration, but there is little or no implication of perfection. In common usage, something that is rehabilitated is not expected to be in as original or as healthy a state as if it had been restored (Francis *et al.,* 1979). For this reason the word can be used to indicate any act of improvement from a degraded state (Box, 1978; Wali, 1992).

Remediation is: 'the act of remedying'. To *remedy* is: 'to rectify, to make good'. Here the emphasis is on the process rather than on the end point reached.

Reclamation is a term used by many practitioners, especially in Britain but also in North America. It is defined as: 'the making of land fit for cultivation'. But to *reclaim* is given as: 'to bring back to a proper state'. There is no implication of returning to an original state but rather to a useful one. *Replacement* may therefore be involved. To *replace* is: 'to provide or procure a substitute or equivalent in place of' (although an alternative meaning is to 'to restore').

Enhancement is sometimes used in the USA to indicate the establishment of an alternative ecosystem (Pratt & Stevens, 1992). This seems an unsatisfactory use of the word which is defined in the *Oxford English Dictionary* as: 'to raise in degree, heighten, intensify; or to increase in value, importance, attractiveness'. This is in fact the use suggested by Francis *et al.* (1979). There is no implication of making something bad better, but of making something already good better.

Mitigation is often used when restoration is considered. But it is nothing directly to do with restoration. To *mitigate* is to 'appease . . . or to moderate the heinousness of something'. So although mitigation can be an outcome of restoration (or rehabilitation or reclamation) it is a separate consideration. It may well involve the improvement of quite another ecosystem. All of these options are represented in Fig. 1.1.

HUMAN PERCEPTIONS OF WHAT IS NEEDED: PHILOSOPHICAL PROBLEMS

It is easy to believe that restoration should only have one aim, that of restoration in a narrow sense – to put back faithfully what was there before. But this has led to endless problems, particularly in North America. Should it be what was there just before the area was damaged – which may be a cultural landscape heavily influenced by human beings, or should it be what was there before human beings started to modify it? In the light of Fig. 1.1 it would seem that, whether the term restoration or the more general term reclamation is used, all types of restoration should be acceptable, and what is actually carried out should be based on pragmatic considerations.

There may be important reasons, such as maintenance of biodiversity, for putting back precisely the original native ecosystem, as in the Australian mineral sand industry. But there may equally be good reasons for putting back the man-made ecosystem which existed previously, as arable agriculture after surface mining of coal in Illinois. But it may be imperative to establish a vegetation cover that will rapidly provide stability and prevent surface erosion, as in the establishment of grassland after the Aberfan mining disaster in South Wales. Equally it may be entirely justifiable to allow natural successional processes to go where they will, which may not be to replace what was there before, as in many gravel pits and hard rock quarries, thereby contributing to biodiversity (Bradshaw & Chadwick, 1980).

Context should influence our understanding of what restoration is. As Parker & Pickett (1997) argue, restoration is more to be considered as a process, with the degree of active intervention being determined by contextual circumstances. This is the attitude adopted in the recent overview (Fox *et al*., 1998), significantly entitled 'Land reclamation: achieving sustainable benefits'.

This pragmatic approach is, however, only a small step away from serious philosophical problems. Is it possible, anyway, to achieve restoration in the narrow sense without an inordinate passage of time? If it is not, are restoration and restoration ecology misleading terms? This is the view taken by some philosophers, notably Katz (1996) and Elliot (1997) – restoration is faking nature. This attitude seems to miss the essential qualities of restoration, that whatever is carried out involves nature and natural processes, in the achievement of a functioning ecosystem. Restoration would only be faking nature if the ground was being covered with synthetic plastic turf.

The trouble is that common usage has accepted restoration as the term to describe a variety of different operations/objectives. At one stage the normal word to cover these was 'reclamation', seen from the titles of seminal books such as Oxenham (1966) *Reclaiming Derelict Land*; Hutnik & Davies (1973) *Ecology and Reclamation of Devastated Land;* Schaller & Sutton (1978) *Reclamation of Drastically Disturbed Lands.* For the UK Government 'reclamation' has always been the standard term. If, now, we have to live with 'restoration' it will be a reasonable usage if it is applied not just to putting back what was there before but 'as a blanket term to describe all those activities which seek to upgrade damaged land or to recreate land that has been destroyed and to bring it back into beneficial use, in a form in which the biological potential is restored.' (Bradshaw & Chadwick, 1980, p. 2). This will involve attending to all the component ecosystem characteristics, well discussed by Ehrenfeld & Toth (1997). With the overlay of 'ecological', restoration can (and should) therefore be applied to the individual components of an ecosystem, as illustrated in Fig. 1.1, rather than to the ecosystem in its entirety (Ehrenfeld, 2000). The value of using the word restoration in this way is that it encourages us to think of all the fundamental processes by which an ecosystem works (Cairns, 1988), and the importance of natural processes in restoration, especially those involved in succession (Bradshaw, 1997*b*; Parker, 1997).

It also means that people from many different disciplines are likely to be involved in restoration, from the ecologist to the engineer, from the landscape architect to the community worker, and indeed from the politician to the ordinary person. Successful restoration can only be achieved if many different disciplines are involved in the process (Higgs, 1997).

RESTORATION AS AN ACID TEST FOR ECOLOGY

When can restoration be deemed to have been achieved, assuming that the word restoration is being used in the narrow sense? The only answer is that this will be a matter of arbitrary definition, because the end point ecosystem is not a fixed entity. But it will require careful experimental design (Michener, 1997). If restoration is being used in a wide sense, then there is more flexibility, because achievement can be in relation to a single character or process. In either case the purist may decide that perfect restoration is an unattainable end point and that what we should expect and settle for is rehabilitation.

Nevertheless the level of achievement in restoration is something about which we should be concerned, not only to fight back accumulating damage, but because it is a fundamental test of our ecological understanding. Restoration is not only a problem-solving matter; it is a tool for ecological research (Jordan *et al.,* 1987). It is not difficult to take a piece of machinery to pieces without understanding it properly. But putting it together again and making it work is a test of our real understanding. There are innumerable papers in which mechanisms and qualities purporting to be important in ecosystems have been described. To show whether they are or not is another matter, and there is always the uncertainty as to whether some other undescribed character is not much more important. Restoration is a crucial test – if we put an ecosystem together and it does not work, or does not work properly, our knowledge is faulty (Bradshaw, 1987*b*), a concept now widely accepted (e.g. Niering, 1997). There is only one problem, arising from the self-restoring properties of ecosystems. We might put it together wrongly and yet it could still begin to work. Under such circumstances it is necessary to include a rate of achievement as a criterion. In the absence of any treatment, self-restoration of almost any ecosystem, at least on land, is relatively slow. So our test should look for success within a relatively short period of time.

Because of its significance, restoration ecology should be an expanding subject within ecology. In many ways it is, with two dedicated journals, *Restoration Ecology* and *Ecological Restoration*, each with increasing circulation, and a continuous flow of papers into other journals and edited volumes, and a focused professional society. Thirty years ago the flow was minuscule, although a few overviews, on reclamation, were beginning to appear, already mentioned. Yet despite its clear heuristic value,

because of its origins it remains a discipline rooted in practice. But readers can judge whether a 'quite new ecological science is emerging to give us the necessary knowledge to take control of our flora and fauna' . . . to become . . . 'not just tinkerers but craftsmen and engineers' (Harper, 1987).

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