Montane scrub: the missed opportunity of our ecologically impoverished uplands

Without a good understanding of their complexity, human activities tend to simplify ecosystems, with unexpected consequences as Diana Gilbert *explains.*

The Scottish government have proposed the development of a vision for the Scottish uplands [1]. If it follows an ecosystem approach, as the Land Use Strategy proposes, this vision would ideally start from an assessment of how the current land cover varies from the inherent natural productivity of fully functioning ecosystems. This 'ideal' vegetation cover would encompass a forest ecosystem in dynamic balance with open areas extending uphill to where montane scrub at its climatic extreme gives way to open montane heaths and grasslands. Tracking back to the present raises the question, how did we get here? As a scientist and ecologist, I am fascinated by how things work and in particular by the dynamics of natural processes. It is a conundrum that most natural systems are more complex than we seem to be able to comprehend. As a result, we tend to think about natural systems simplistically and from the perspective of the immediate, direct benefits they deliver, for example, raw materials including game, wood and fresh water. Until recently, in human terms, we have tended to ignore the workings of the systems that provide these benefits.

The purpose of this article is to raise ecological considerations related to the expanding human population and the impact of subsequent land use practices, and to question some interpretations of the current landscape of Scotland and its low productivity.

Ecological succession

The evidence of past vegetation in the UK that is available through pollen and macro-fossil records has been extensively studied [2, 3, 4] without particular agreement on the fine detail in relation to geography and time. As a result, historical information can tell us what species might make up the vegetation communities, but is of limited value in suggesting what is or might be a healthy, fully productive vegetation cover in the 21st century, suited to the current or any future climate. Taking an ecological approach allows a different type of reasoning. Long-term studies in other parts of the world are now beginning to provide the first insights into some of the rules that control ecosystem function [5] and which may provide a useful focus for studying Scottish vegetation and its dynamics. In particular, studies of the impact of loss or re-instatement of predators in ecosystems has been shown to have a dramatic effect on the balance of the remaining species, both plant and animal (for example, wolves [6]; sea otters [7]; rinderpest [8]). At a smaller scale, the regular use of fertiliser over more than 100 years in a UK grassland study at Rothamstead Research Institute has simplified the vegetation, reducing the range of species present significantly [9].

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All the indications suggest that a human induced loss or favouring of certain species changes the dynamics of the whole system because trophic cascades, as they have been termed, are complex and finely balanced (several articles by Ripple and Beschta are referenced in [10]).

How might this be relevant to the uplands of Scotland? There is reasonable agreement between authors about the sequence and rate of re-colonisation of woody species following the retreat of ice ten thousand years ago. Initial colonisation by shrub willows, hazel, juniper and dwarf birch [2, 3] was followed by trees, small-seeded then heavy-seeded high forest species. There is less agreement on the extent to which the forest trees expanded into the more climatically exposed locations (for example, exposed coasts and mountain tops) and how much of the original scrub persisted. However, remnants of this scrub do still exist and some shrub species (for example, eared-willow, dwarf birch and juniper) have retained a relatively widespread distribution. Animals, including humans, colonised in parallel and the whole suite of ecosystems developed into a dynamic balance, oscillating between open and closed habitats in response to changing climate, the development of soils and their biota, and the interplay of animal populations, primarily predator and prey, but including parasites in a predator role [5]. As human numbers increased, their impacts also increased as described in a number of documented histories of the Scottish landscape (including 11 and 12).

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Habitat loss

An area of major divergence of opinions relates to a particular period of peat-building between five and four thousand years ago [13]. Loss of tree/shrub cover increased, as did the degree to which climate is influenced by the sea (oceanicity), but which was the cause and which was the effect is unclear [14] and it is not at all certain that climate change was the driver [4]. Even if climate were the cause, there is no reason why this change in climate would have removed willows (mainly eared-willow), dwarf and downy birch, and alder which are able to cope with increased wet and windy climates.

There is a gradient of productivity across global ecosystems which decreases in general from the equator to the poles and from sea level to the high tops. In Scotland there is also a gradient from the windy oceanic areas, particularly along the Atlantic seaboard, towards more continental conditions in the east. Therefore, along the west coast and uphill towards the high tops there is a decline in the rate of plant growth, so recovery from damaging events is slow across the whole ecosystem. My contention is that, as humans used more of the landscape, along with the loss of tree cover there was a loss of mammalian predators followed by an increase in native herbivores, and then the introduction of domestic animals, including goats. As the shrub species mentioned above never grow above browse height and are not very tolerant of fire, it is clear that they are unlikely to have survived long in grazed and burned open areas in situations where their growth rates were sub-optimum due to altitudinal exposure.

Another consideration is the impact of the loss of trees and shrubs on soils. Without trees and shrubs there is no leaf litter, no aerating and percolating effect of tree and shrub roots leading, along with the effects of burning, to a reduction in aerobic conditions with the consequent loss of decomposing invertebrates, micro-organisms and fungi. A consequence is leaching and loss of nutrients from soils because the main agents responsible for the recycling of nutrients are lost and there is a constant removal of nutrients from the system in the form of meat. Some of these effects tend to be reversed by the re-colonisation of birch and shrubs in particular [15].

Unintended consequences

At the present time virtually all forms of land management tend to simplify ecosystems, even re-forestation projects initially, to the detriment of the overall diversity of an ecosystem and its function. However, more historical managements, particularly those aimed at specific objectives such as game [16] or extensive hill-stock grazing, have tended to initiate serious changes, perhaps beyond those intended. This has been illustrated by a recent study of the scavengers visiting deer carcasses that have been left in various upland areas which are managed for contrasting objectives. The observed scavenger diversity at carcasses on keepered ground was lower, limited to three species, short-eared owl, and control targets, fox and crow, while on unkeepered ground ten scavengers were observed [17]. This was an initial study of a small sample and the results are not categorical but it suggests that the removal of selected species in an ecosystem can create a domino effect.

Another aspect of the ecology is to look at the hill ground from the

perspective of the animals living on it. Herbivores can be divided roughly into two groups: grazers and browsers [18]. Red deer are both. They are grazers but also eat woody plants. Roe deer are predominantly browsers while sheep and cattle are predominantly grazers, although even they will eat bark from trees on occasion. Most plant-eating animals tend to feed on a range of different forage, focusing on a few plants but including a much wider range for occasional consumption, and this range provides their nutritional requirements. The point here is that given the opportunity, in a well-wooded landscape, red and roe deer both choose to eat woody plant material, particularly over winter. It has even been suggested there is a health benefit to them in occasionally eating plants normally considered unpalatable [19] due to the presence of secondary compounds (such as juniper [20]). Grouse in Scandinavia (the same species as that in Scotland) have a wider choice and eat a greater range of plant species in winter, including willows and dwarf birch [21], than their Scottish relatives. In the UK, grouse moor management aims to create a monoculture of heather restricting grouse food choice. Population-wide problems (such as ticks and other parasites) are reported from Scottish grouse despite the efforts to control their food and environment in the manner of poultry, isolating them from their pre-game habitat with its natural checks and balances.

Breaking the cultural prism

To summarise, ecologically there does not appear to be any evidence that the uplands of Scotland have become devoid of trees and a natural upper scrubby treeline by natural processes. There are a number of factors, primarily human induced, from clearance of woodland, burning, removal of keystone species such as top predators, and the introduction of domestic stock, that have combined to create the current deforested landscape. The long-term lack of trees has affected changes to soil nutrition and biota, potentially to the climate and, perhaps most importantly to the perception of land users such that there is now an emotional resistance to reforesting the hills.

Through this cultural prism we are perpetuating an impoverished ecosystem and so we continue to miss out on the benefits that we should expect from the landscape (see Halley, page **) as well as forcing those other animals we share the environment with to live in poverty, at best dependent on our provision of vital nutrients and trace elements, at worst to struggle to survive in over-crowded, under-nourished conditions.

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