DECISION SUPPORT TOOLS TO LINK ECOLOGY AND LAND MANAGEMENT: DEVELOPMENT OF HILL PLAN

CONTEXT

Farmers and land managers are currently under increasing pressure to review their strategic land-use plans in the light of changes in markets, in agricultural support mechanisms and in the wake of foot and mouth disease. For example, most hill and upland farms in the UK are dependent upon financial support from the UK government and the European Union. Public concern for the protection of the environment and its enhancement, and global pressures from food-producing competitors, are leading to changes in policy which will result in the need for change at the farm level.

The EU's Rural Development Regulation describes new forms of support for environmentally friendly and sustainable farm strategies based upon verifiable standards of good farming practice. In 2001, changes resulting from the Agenda 2000 agreement on Common Agriculture Policy reform confirm that support for farmers is a social and environmental measure. The changes have led in the UK to the replacement of the Hill Livestock Compensatory Allowances, which were paid on a headage basis for cattle and sheep, by the Hill Farming Allowance Scheme which is area-based. This Scheme has a more explicit environmental objective than the previous headage payment scheme and provides a clearer recognition of the farmer's role in maintaining upland habitats, safeguarding the environment and maintaining the countryside. Financial payments will be made at a basic rate, according to land classification, with additional top-up payments to farmers who meet certain environmental and other criteria.

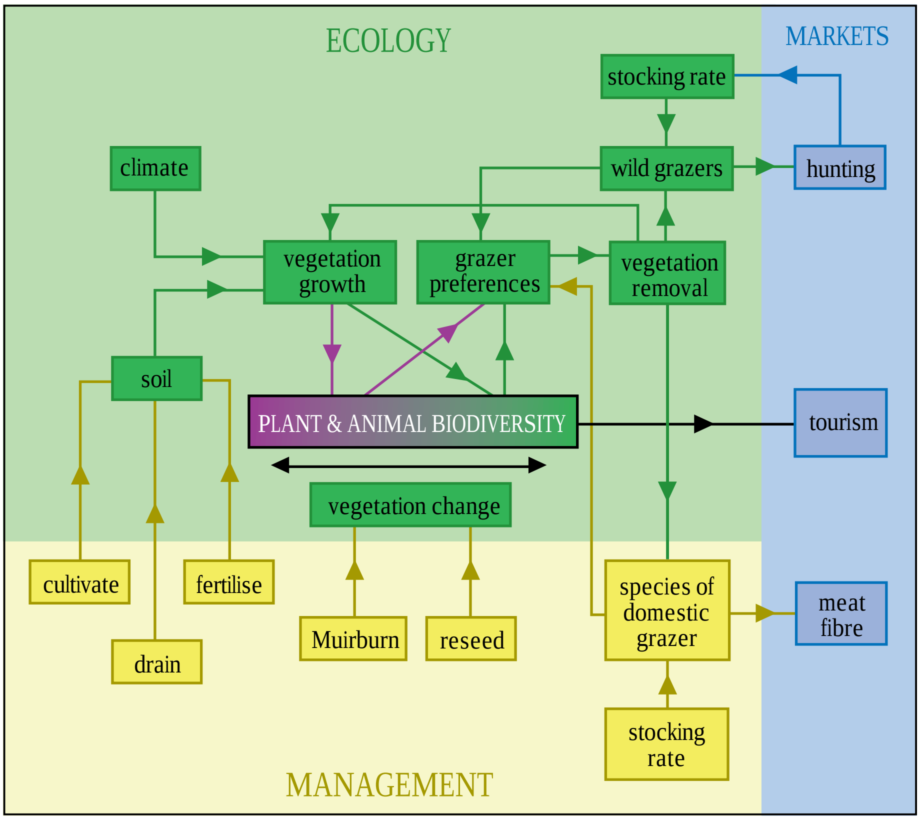
How are farmers and land managers to respond to these new environmentally-driven incentives? They will still generate income by selling conventional products from domestic livestock. They may be able to attract enhanced prices if they can market their goods as having been produced under verifiable standards of good farming practice. However, they will also have to meet the area payment criteria which will set minimum and maximum stocking rates designed to ensure that the vegetation resources are managed appropriately. They must strike the balance between meeting financial and environmental objectives. However, the systems they manage are complex with many interacting relationships between the ecological components and the management controls that they can apply. The components and the interactions must be manipulated through management in order to achieve multiple benefits over the long term because impacts on vegetation can take many years, even decades, to become evident.

How can those who implement policy be confident that stocking rates can be set which guarantee, for particular mixes of vegetation, that environmental requirements will be met in the long term? Is it possible to find methods by which grazing agreements between farmers and those who implement policy can be reached? Is it possible to provide information that will satisfy the other stakeholders that the proposed plans will meet their expectations with respect to, for example, landscape and wildlife impacts?

THE USE OF DECISION SUPPORT TOOLS

One approach to providing these answers lies in the use of decision support tools which can represent not only the individual components of hill and upland grazing systems; the climate, the soils, the vegetation and the grazing animals, but also the impacts of management upon them and the interactions between them.

The management of hill vegetation by grazing animals lies at the heart of support through the Hill Farming Allowance Scheme which aims to protect or enhance the diversity and structure of plant species through control of grazing intensity, and in some cases seasonality of grazing, within pre-defined limits. Figure 1 is a simplified structural diagram of a typical UK hillside. It shows the main ecological and management components and the links between



them. Hill vegetation is of interest not only as a source of biodiversity and as a landscape resource but because it also supports domestic and wild grazers, both of which can be important to income, as well as a range of other animal species. The extent of change in both the species diversity and the structural diversity of the vegetation depends upon the balance between vegetation growth, senescence and its removal by grazing animals. How can we estimate what the impacts will be of a range of options for managing a hillside? For example, what will happen to the diversity of the hill vegetation if changes are made in stocking density, in species of grazer or seasonality of grazing or if heather is burned or an area of reseed removed?

In forecasting these impacts, the changes within the individual patches of hill vegetation, associated with the growth and death of constituent plant species, must be predicted. There must be knowledge of the grazing preferences of the different grazer species and the ability to predict what they will choose to eat and how much of it. There must be the ability to predict the consequences for the balance of plant species which will result from their different patterns of growth, senescence and selective removal by the grazers. The seasonality of plant growth and senescence, and of animal requirements for energy and protein must also be predicted.

The knowledge for constructing the models, which represent the components and their interactions, comes largely from research but also from the expert knowledge of people who manage and interact with hill resources. The mathematics of all of these components are coded, using structured object-oriented methods, into linked and interactive models which form the basis of computer-based decision support tools. They represent the behaviour of the whole system, provided, of course, that information is available which describes the specific hill grazing being considered.

Clearly, the descriptive information must reflect the species and structure of the hill vegetation. The complex nature of the inter-relationships between the plant species themselves and between the vegetation patches they create must be reflected in an appropriate description. To complement the computer package, we have devised methods of classifying and coding vegetation in a way that reflects its structure on a hillside. This classification takes less than a day to complete for any farm. This descriptive information includes details of animal species, breeds, flock/herd numbers and their locations and provides the basic information from which the decision support tools can be run.

HILLPLAN

Using this approach the Institute has developed a decision support tool called HillPlan which forecasts the changes in vegetation under a range of livestock management and heather-burning strategies. Livestock can graze the hill all-year round or livestock numbers can be varied over the seasons. Different species can be grazed: sheep, suckler cattle or red deer, alone or in mixed groups. Different classes of animals can be used, for example breeding ewes, hoggs or wethers, again alone or in different balances. Heather burning can be tested using different cycles of burning. HillPlan will forecast the balance of vegetation classes, the distribution of heather in different age classes and the mix of tussock and lawn areas for grassy vegetation types for any combination of livestock number and burning pattern. The next version of HillPlan will also forecast the productivity of the grazing animals.

The term "decision support tool" has been chosen carefully to reflect the fact that the packages are designed to assist in decision making; they do not make decisions. They should be used to compare options and to assess the impacts of different management strategies. The forecasts they generate should contribute to the decision-making process. Decision support tools may, in the future, be used at individual farm level as the basis for negotiating grazing agreements between farmers or other land managers and those who provide financial support. As such the basis of their forecasts must be transparent to all parties concerned. The structures of the decision support tools that the Institute has developed are based wherever possible on published information in order to guarantee their transparency and their credibility.

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HillPlan

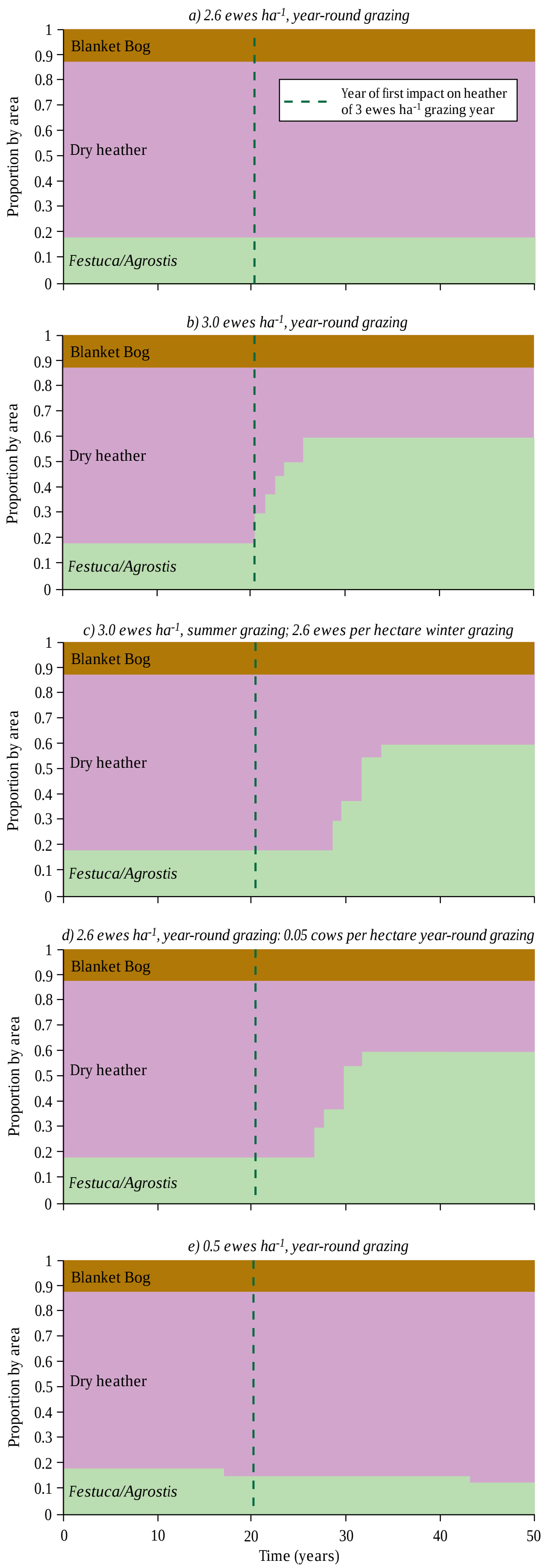
A HEATHER HILL

An example of the output from HillPlan is shown in Figure 2 for a hillside with 70% dry heather (predominantly *Calluna*) with 20% of Bent/Fescue pasture (*Festuca/Agrostis*) and an area of blanket bog on the hill top (10%). HillPlan predicts that year-round stocking with sheep is compatible with retention of heather cover if an appropriate stocking rate (2.6 ewes per hectare or approximately 1 ewe per acre) is used (Figure 2a).

Increasing the stocking rate to 3 ewes per hectare year-round, reduces heather cover dramatically after 20 years (Figure 2b). However, retaining 3 ewes per hectare in summer and reducing winter stocking rate to 2.6 ewes per hectare delays the onset of heather loss to around year 27 (Figure 2c). Stocking year-round with the equivalent total biomass of sheep at 3 ewes per hectare using cattle (0.05 cows per hectare, 10% of total biomass) and sheep (2.6 ewes per hectare, 90% of total biomass) delays the onset of heather loss until around year 25 (Figure 2d). Changing the year-round grazing balance to 20% cattle (0.1 cows per hectare) and 80% sheep (2.4 ewes per hectare) sustains heather cover at its starting level. Cattle are less selective grazers than sheep and therefore less damaging to vegetation on a dry heather hill. Heather cover can be extended in the long run by reducing year-round stocking rate to 0.5 ewes per hectare (Figure 2e). In all of these examples, the blanket bog remains unaffected.

Results from a range of options as shown in this example can be used to decide upon the most appropriate grazing scheme for the hillside to achieve the desired vegetation balance.

Vegetation types - areas of hillside



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HillPlan

A GRASSY HILL

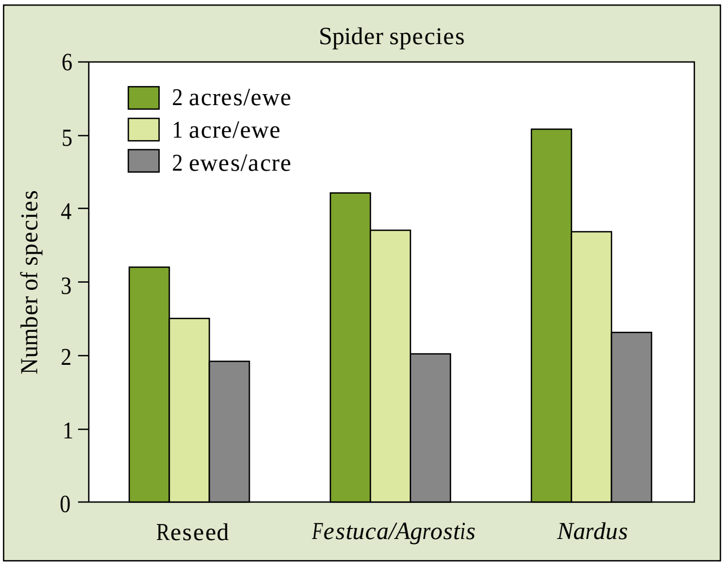
This example is based on a "typical" grassy Borders hill unit consisting of 60% Matt Grass rough pasture (predominantly *Nardus*), 35% Bent/Fescue pasture (*Festuca/Agrostis*) and 5% reseed. An "average", year-round stocking rate of 2.5 ewe per hectare (1 ewe per acre) was compared with a reduced stocking rate of 1.25 ewes per acre and an increased stocking rate of 5 ewes per acre.

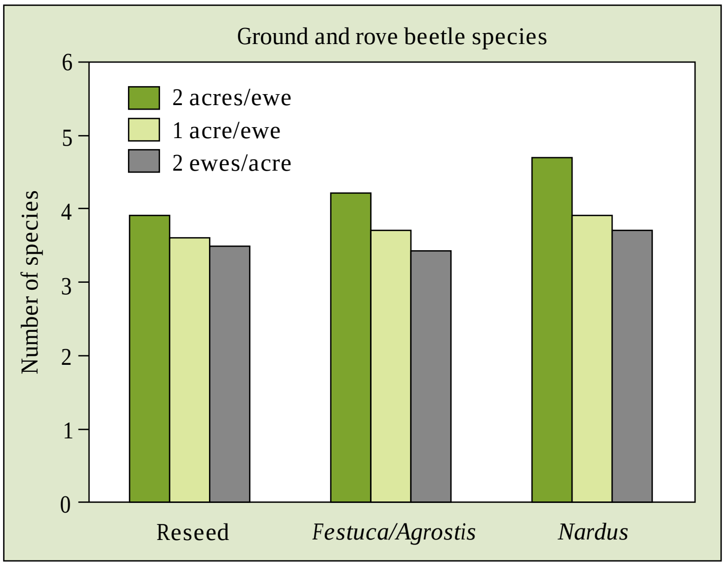
HillPlan forecast that, over a 10-year period, the botanical composition of the hill unit would not change under the "average" or the lowest stocking rate, However, the lowest stocking rate would result in a much greater proportion of tussock and less closely-grazed "lawn" in the Bent/Fescue pasture, in the Matt Grass rough pasture and in the reseed, resulting from the lower grazing pressure.

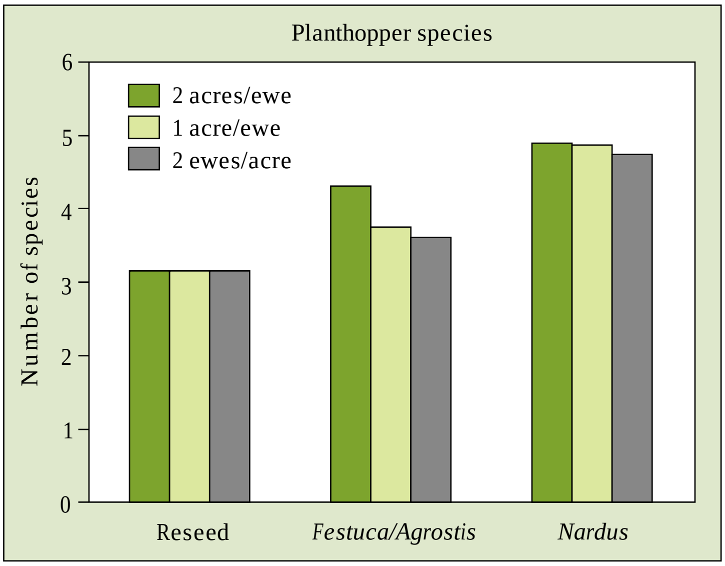
HillPlan forecast that, after 10 years under the greater grazing pressure of the highest stocking rate, the Bent/Fescue pasture would spread into the area of Matt Grass Rough pasture and there would be a much higher proportion of closely-grazed "lawn" areas with much less tussock in all three pasture types.

Using the output from HillPlan and knowledge from an environmental research programme in The Macaulay, the consequences for the numbers of species in three classes of arthropods under these different pasture structures were calculated and are shown in the figures below. Lower stocking rates generally result in greater structural diversity and greater numbers of all three classes of arthropods in each of the different pasture types.

The arthropods form part of a complex food web and will contribute to a generally higher level of biodiversity despite the fact that there will be little change in the botanical composition of these grassy hills.







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