CHANGES IN THE STRUCTURE OF A RIPARIAN COMMUNITY AS THE RESULT OF GRAZING

A. T. DOBSON*

University of Hull

SUMMARY: This describes changes due to grazing that occurred in the vegetation and topography of a previously ungrazed, riparian site. Grazing made the site more susceptible to erosion by eliminating the main pioneer species, *Phalaris arundinacea*, a rhizomatous reed grass.

INTRODUCTION

When investigating changes that have occurred in the environment, ecologists frequently find themselves at a disadvantage in that they have only been able to make their studies after the changes have taken place. In this instance, however, I was fortunate enough to have made an investigation of the site prior to its alteration. The site, which previously was ungrazed for an unknown period of time, became subject to relatively intense grazing pressure. The vegetational changes which are described in this paper thus have mainly been the result of a change in a solitary environmental factor.

DESCRIPTION OF SITE

The area with which this investigation was concerned is an island formed from alluvial material deposited by the River Wharfe. The island which lies on the boundary between the parishes of East Keswick and Sicklinghall, Yorkshire, is some 40 m above sea level. Although vegetated and normally above water level, it should be considered as part of the river course proper rather than as part of the flood plain of the River Wharfe — which is at a higher level. The island is regularly inundated during the winter months; but, when normal quantities of water are present in the river, it becomes more or less attached to the south bank of the river, through a series of muddy pools forming an "inner channel". The age of the present island is unknown but an island is shown as being present on the site in the Ordnance Survey map of 1890 (first edition, twenty-five inches to the mile scale, surveyed 1888). This edition shows an island separated from both banks whereas the 1962 edition shows it joined to the south bank. Intervening editions show an island on this site although occasional catastrophic destruction during floods followed by rebuilding is possible.

As part of the meanderings of the River Wharfe over its flood plain the river makes a broad southward sweep upstream of the island. This sweep is terminated where it meets the steep wooded slope of a higher fluvio-glacial terrace. Active erosion of the terrace has produced a cliff at this point but the river is also thrown back from the slope and it is in the slack water between the river and the wooded slope that the material of the island has been deposited (Fig. 1).

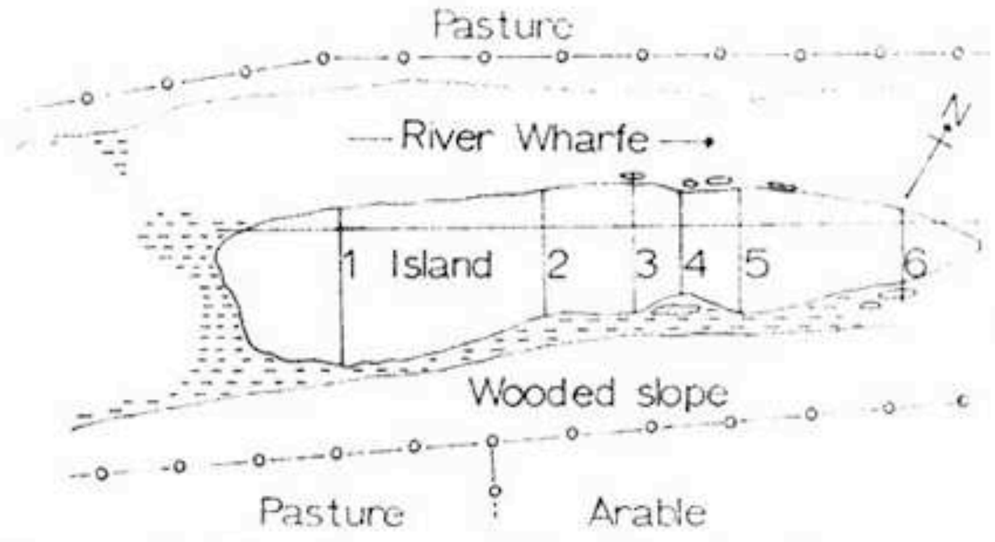

FIGURE 1. *Sketch map of the island as it appeared in 1966. (Solid lines are boundaries of vegetated areas and transects; lines broken by circles are fences; dashed areas are areas of stones, etc. normally exposed in summer).*

*Present address: Botany Department, University of Canterbury, Christchurch.

METHODS

A survey of the vegetation of the island was carried out in July 1966 as an undergraduate project while the author was studying at the University of Hull. However, about the time that the original investigation was made, the fence which separated the wooded slope from the field above began to disintegrate. This enabled the stock grazing in that field to gain access to the island. In the subsequent four years the fence was not repaired and cattle and sheep were able to graze the island's vegetation continuously except during occasional floods. I therefore decided to re-survey the vegetation and assess the effect of the grazing. This second survey was carried out in July, 1970.

The vegetation and topography of the island was studied along a series of six line transects. A base line parallel to both the river and the long axis of the island (Fig. 1) was taken. (The island was roughly elliptical with dimensions of the vegetated area in 1966 of 114 m x 22 m). The transects were made perpendicular to the base line, being 19, 49, 63, 70, 78 and 103 m respectively along the base line from the upstream (western) end.

The six transects were each levelled and at the same time the vegetation along the transect was noted. A complete species list was made for the island and the overall abundance of each species was assessed. Cryptogams were very rare on the island and were not recorded. In 1970 it was possible to relocate these transects from fixed points on the wooded slope and the procedure was repeated.

The topographic changes which occurred over the four year period are illustrated in Figure 2, and the floristic changes are given in Table 1. Nomenclatural authorities for the species are as given by Clapham, Tutin and Warburg (1962).

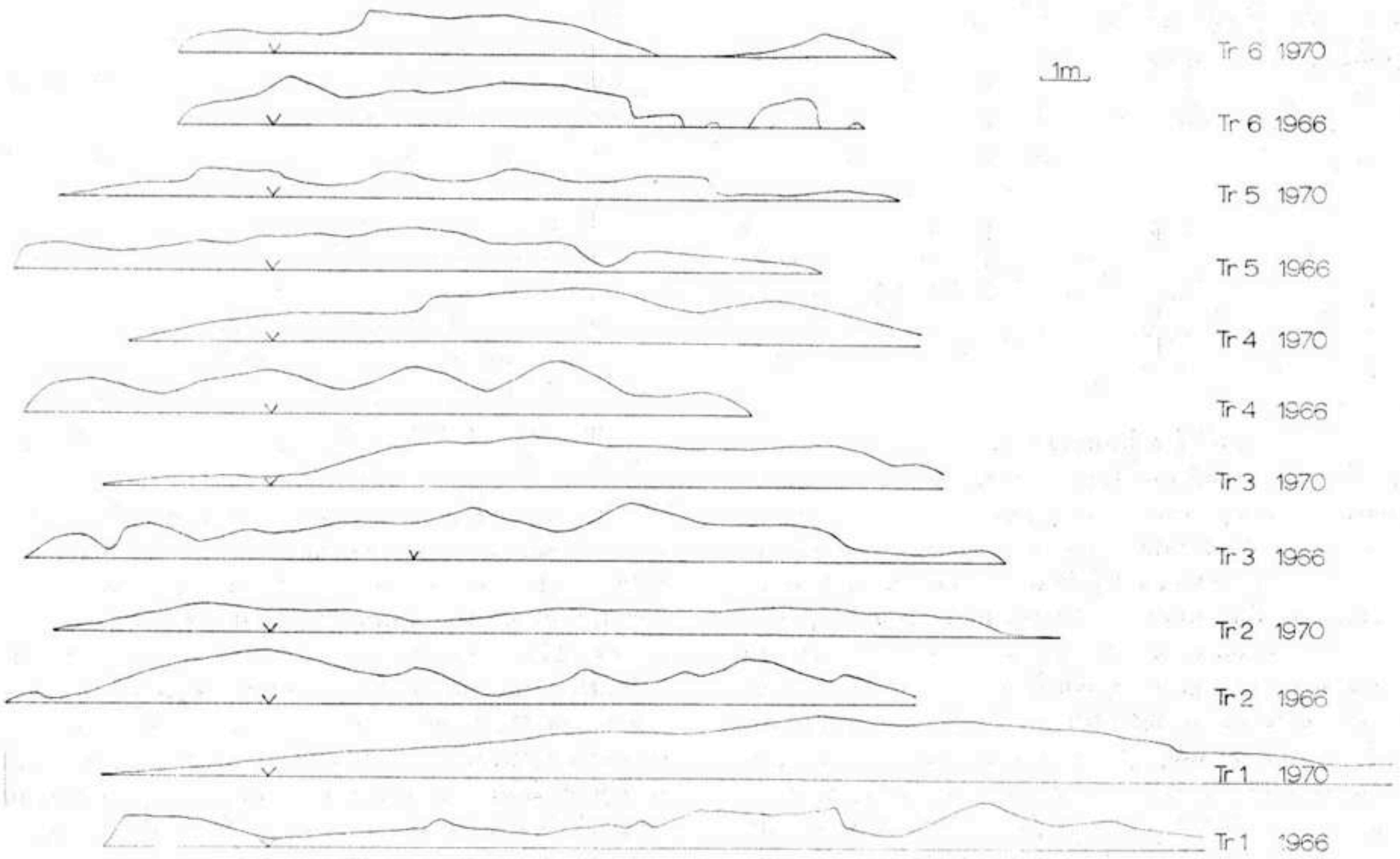

FIGURE 2. *Six transects of the island in 1966 and 1970. (Position of base line marked by "v").*

THE VEGETATION AND STRUCTURE OF THE ISLAND PRIOR TO GRAZING

In 1966 the topography of the island consisted of a complex system of hummocks and hollows although these were broadly orientated parallel to the river. The altitudinal range of the hummocks and hollows was slight, there being not more than 120 cm between the highest and lowest vegetated points on the island.

The vegetation of the hummocks and hollows, although complex, may be simplified into a number of broad types.

(a) *Phalaris arundinacea* hummocks.
Phalaris arundinacea, a reed grass, was dominant on the hummocks of much of the upstream (western) end of the island. It also occurred around the margins of the rest of the island. In the most extreme situations *P. arundinacea* formed almost pure stands. Elsewhere the most frequent associate was *Poa annua*.

(b) *Rorippa islandica* hollows.
The distribution of *Rorippa islandica* was similar to that of *Phalaris arundinacea* in that it was mostly restricted to the upstream end of the island. However, it occurred in the hollows which contained virtually no soil but only large stones (5-20 cm diameter). The vegetation was sparse and *Rorippa islandica* was either the only species present or it was accompanied by deep-rooted perennials such as *Cirsium arvense, Rumex crispus, Equisetum arvense* and *Taraxacum officinale*.

(c) *Urtica dioica* hummocks.
The hummocks of the eastern end of the island were mainly colonised by herbaceous perennials. Prominent among these was *Urtica dioica*, but *Cirsium arvense, Epilobium hirsutum* and *Mentha spicata* occurred frequently. Some species were dominant on a few hummocks but absent elsewhere—e.g. *Chrysanthemum vulgare*. The spring-germinating annual, *Impatiens glandulifera* was usually present on these hummocks, being able to survive because of its rapid early growth. *Ranunculus repens, Poa annua* and *Stellaria media* formed an understorey layer beneath the taller plants.

(d) *Weedy hollows.*
Plant cover was greater in these hollows than in the *Rorippa islandica* stands but it was not complete. Some soil was present and large stones were less abundant. These hollows were mostly colonised by ephemeral weed species, no one weed species being either common or dominant.

The island appears to have a two-fold physical structure. This, in turn, appears to be basis for the distribution of the different stands of vegetation. The base of the island consists of large water-worn stones, the beds of which were of an undetermined depth. These are exposed around the margins and in the hollows. Superimposed upon this basal layer are gravels, sands and silts and from time to time these are eroded and redeposited (by the river when in flood). The force of floodwater has also segregated the coarser fractions on the upstream end of the island; these grade into finer constituents towards the downstream end. The coarse fractions have been colonised by *Phalaris arundinacea*, the rhizomes of this plant being effective in binding the hummocks together. *Phalaris arundinacea* also occurred on hummocks bordering the inner channel (a protected site) where it was rooted in fine silt. However, these sites appeared to be the most recently deposited and that, on them, *P. arundinacea* was behaving as a pioneer species. It is also able to maintain itself on sites exposed to the force of flood water where other herbaceous perennials are unable to establish themselves. However, where the finer sediments are deposited and less rigorous conditions occur, other herbaceous perennials become established.

Although *Phalaris arundinacea* associations have been described for central Europe by Kopecky (1967) it does not seem possible to equate the vegetation of the island with the stands he describes. The vegetation of the island was not sufficiently uniform and apparently was of a more open type than these associations. The open nature of the vegetation resulted in greater abundance of *Rorippa islandica* on the island compared with Kopecky's sites and the absence from the stand of a number of marsh species (probably due to dry summer conditions). However, Kopecky acknow

ledges that his associations are largely dependent on the hydrological and geomorphological properties of the running water bodies concerned and that these are the primary cause of variation.

Along that part of the island which bordered the main channel of the River Wharfe, a belt of *Phalaris arundinacea* occurred and it appeared that this was maintained by an erosion cycle (Fig. 3). It was possible to find, along the margin of the island, situations representing each of the four stages described in Figure 3. Furthermore, at one place where erosion was occurring, a subfossil rhizome layer was present below the present rhizome mat; a layer of gravel having been deposited over the subfossil mat.

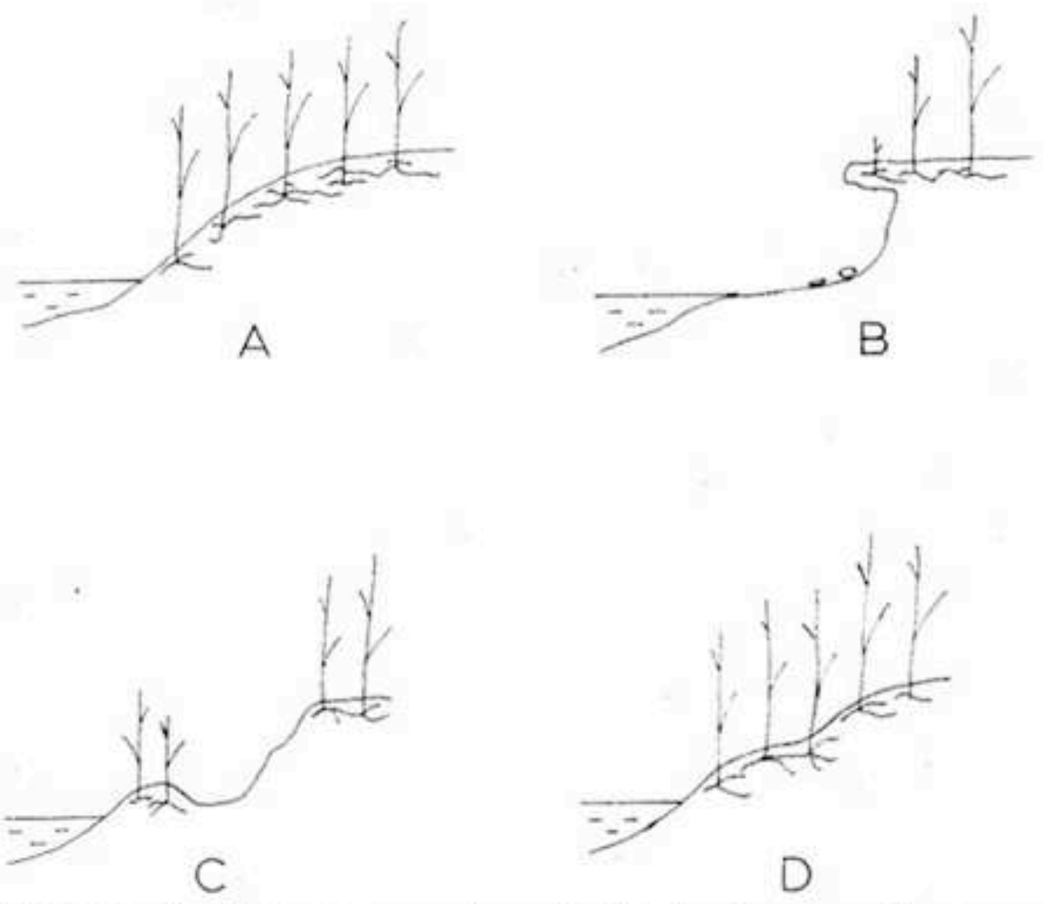

FIGURE 3. *Erosion cycle of* Phalaris arundinacea *hummocks bordering the river. The cycle begins with a bank of* Phalaris arundinacea *bordering the river (A). This bank becomes eroded and a small cliff is formed (B). The river continues to undermine this cliff until an overhang develops held together by* P. arundinacea *rhizomes. This eventually collapses and the* Phalaris arundinacea *takes root at the water's edge (C). Sediment accumulates (D), and the situation reverts to (A).*

Perhaps the most surprising feature of the island at this time was the absence of trees: only a solitary specimen of *Salix purpurea* was present. This was particularly difficult to explain because of the occurrence on other islands, a short distance upstream, of thickets of *Salix viminalis* and *S. purpurea* which completely dominate their vegetation. Comparison of the map of 1890 and the present situation shows that these upstream islands have completely altered their positions. These islands are therefore younger yet have developed a tree layer. The failure of willows to establish on the island under study cannot be readily explained, particularly as both their seeds and detached vegetative shoots would be readily available for colonisation.

THE VEGETATION AND STRUCTURE OF THE ISLAND IN 1970 COMPARED WITH FOUR YEARS EARLIER

In four years the vegetation and structure of the island altered dramatically (Fig. 2 and Table 1). The hummock-hollow system had broken down over much of the island, the breakdown being much more noticeable on the upstream end of the island. Erosion was pronounced on the side of the

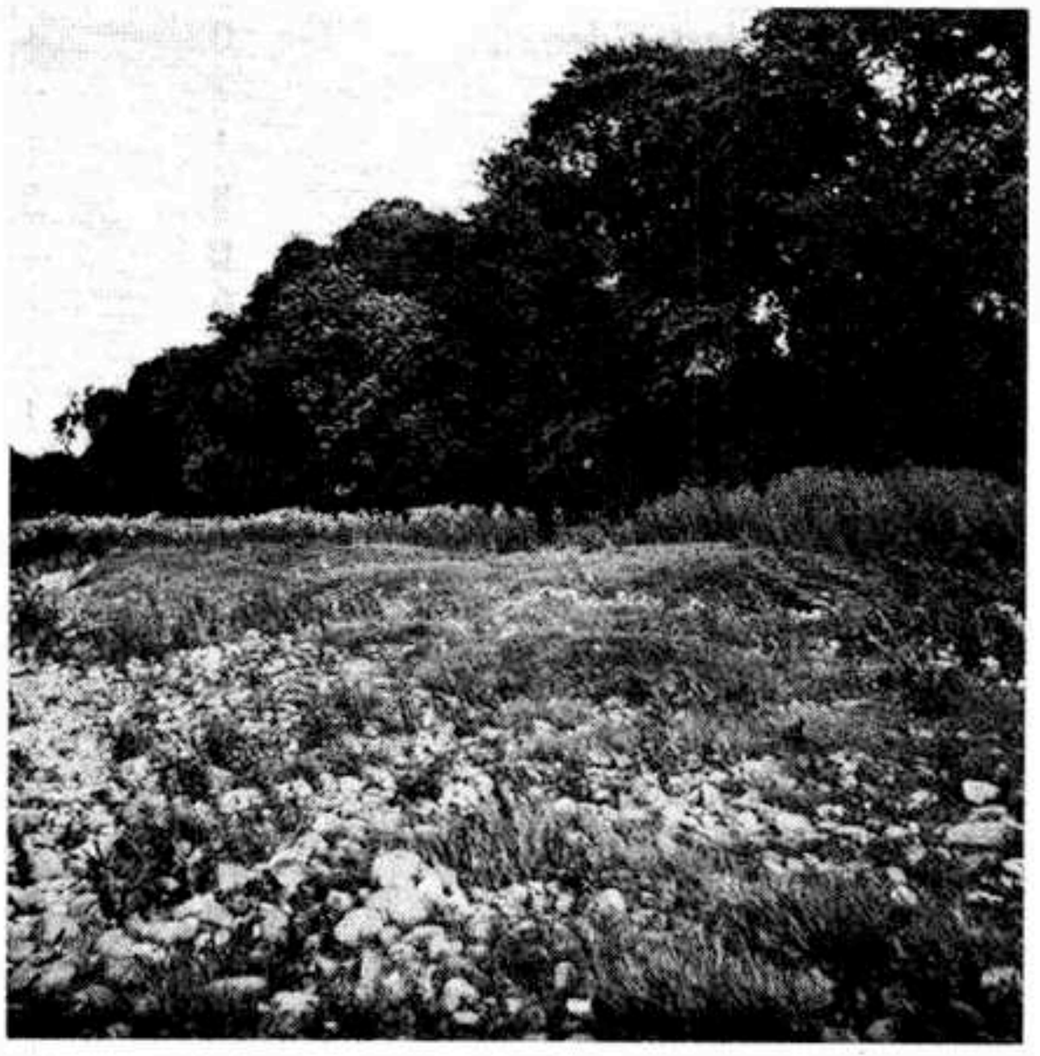

FIGURE 4. *Exposed boulder bed of island in 1970 colonised by deep-rooted herbaceous perennials and some annuals. Sward of* Agrostis stolonifera *in middle distance with* Cirsium arvense *beyond. In the background is the wooded slope, the "inner channel" being hidden by* Cirsium.

TABLE 1. *List of Species and Their Abundance on the Island in 1966 and 1970.* (5—*A major component of the vegetation;* 4—*abundant;* 3—*frequent;* 2—*widespread but nowhere conspicuous;* 1—*scattered;* +—*a few specimens present;* 0—*not recorded*).

Species	1966	1970	Species	1966	1970
Achillea millefolium	0	1	*Leontodon autumnalis*	0	1
Agropyron caninum	0	+	*Lolium perenne*	1	2
Agropyron repens	+	+	*Lycopus europaeus*	0	+
Agrostis stolonifera	0	5	*Matricaria matricarioides*	+	1
Angelica sylvetris	0	+	*Mentha spicata*	2	1
Anthryscus sylvetris	+	+	*Mentha aquatica*	+	+
Apium nodiflorum	0	+	*Mimulus guttatus*	+	+
Arenaria serpyllifolia	+	+	*Myosotis caespitosa*	2	2
Arrhenatherum elatius	1	1	*Myosotis secunda*	+	0
Artemisia vulgaris	1	+	*Myrrhis odorata*	+	0
Atriplex patula	+	+	*Phalaris arundinacea*	5	1
Barbarea vulgaris	1	1	*Phleum bertolonii*	0	1
Bellis perennis	0	1	*Plantago lanceolata*	0	1
Bromus sterilis	0	+	*Plantago major*	0	2
Capsella bursa-pastoris	+	+	*Poa annua*	3	1
Cardamine flexuosa	+	1	*Poa trivialis*	0	3
Carduus tenuiflorus	0	+	*Polygonum aviculare* agg.	+	+
Carex hirta	0	+	*Polygonum lapathifolium*	0	+
Centaurea nigra	0	+	*Polygonum persicaria*	+	1
Cerastium holosteoides	0	+	*Ranunculus acris*	0	+
Chenopodium album	0	+	*Ranunculus repens*	4	4
Chrysanthemum vulgare	1	+	*Rorippa islandica*	4	5
Cirsium arvense	3	5	*Rorippa nasturtium-aquaticum*	+	0
Cirsium vulgare	0	+	*Rumex acetosella*	0	+
Cochlearia officinalis	0	+	*Rumex crispus*	2	+
Crepis capillaris	0	+	*Rumex obtusifolius*	0	3
Cynosurus cristatus	0	1	*Sagina procumbens*	0	+
Dactylis glomerata	0	1	*Salix purpurea*	+	+
Deschampsia caespitosa	1	0	*Scrophularia aquatica*	+	+
Epilobium hirsutum	3	2	*Senecio aquaticus*	+	1
Epilobium montanum	0	+	*Senecio vulgaris*	0	+
Equisetum arvense	2	2	*Silene "dioica"*	0	+
Euphorbia peplus	0	+	*Sinapis arvensis*	+	0
Euphrasia nemorosa	0	+	*Sonchus oleraceus*	+	0
Festuca gigantea	0	+	*Stachys sylvatica*	0	+
Festuca pratensis	1	2	*Stellaria alsine*	0	+
Festuca rubra	0	+	*Stellaria media*	2	2
Galium aparine	0	+	*Stellaria neglecta*	1	0
Heracleum sphondylium	+	+	*Sysimbrium officinale*	+	+
Impatiens glandulifera	3	1	*Taraxacum officinale*	2	2
Juncus acutiflorus	0	+	*Trifolium pratense*	0	+
Juncus bufonius	0	+	*Trifolium repens*	0	2
Juncus spp.	0	+	*Tripleurospermum maritimum*	+	+
Lamium album	1	0	*Urtica dioica*	5	3
Lapsana communis	+	+	*Veronica beccabunga*	1	1

island bordering the main channel and much material had been removed, exposing the basal stone layer. This area had become colonised by annuals such as *Rorippa islandica* and *Stellaria media*, and by a sparse and stunted cover of deep-rooted perennials such as *Rumex obtusifolius, Cirsium arvense* and *Urtica dioica* (Fig. 4).

Phalaris arundinacea had been eliminated as an important species and only a few grazed, non-flowering patches remained. Where the *Phalaris arundinacea* hummocks had not been removed by erosion the vegetation had changed to a mixed sward typified by species such as *Agrostis stolonifera* and *Ranunculus repens*. Most of the tall perennials had persisted but only formed open and stunted stands. The only tall perennial that had greatly increased in density was *Cirsium arvense* (Fig. 4) and this was now the most conspicuous feature of the vegetation of the island.

On the parts of the island less exposed to the force of floodwaters the removal of the tall vegetation had not greatly increased the area of open ground as low-growing turf species had increased in abundance. Where *Phalaris arundinacea* had been removed, however, much of the sand and gravel had also disappeared leaving open stony areas. Although material had been removed from the main channel side of the island there had been increased deposition in the inner channel and, indeed, the upstream end of the inner channel was now completely blocked. This removal of material can readily be seen from a comparison of the transects for 1966 with those of 1970 in Figure 2.

In 1970 the boundaries between the different stands had become less easy to define and the stands had increased in complexity. The number of species present on the island had increased. Thirty-nine species were present on the island in both 1966 and 1970. Eight that had been present in 1966 could not be found in 1970 (although in the case of *Myosotis secunda* it could merely have been non-flowering and therefore overlooked as *M. caespitosa)*. However, 43 new species were recorded and, of these, the majority were ephemeral weeds although no one species predominated. While the weed population of the island probably fluctuated in content before the commencement of grazing, the effect of grazing had been to open up the vegetation, creating more niches in which the weeds could establish themselves. Most of the remaining new arrivals were common pasture species and some of these had become well-established, e.g. *Agrostis stolonifera, Trifolium repens, Plantago* spp. and *Leontodon autumnalis*. These species could all be found in the pasture in which the stock grazed.

The most interesting new arrival was *Cochlearia officinalis,* normally a plant of coastal habitats and short montane grassland and which, because of its high light requirements and poor competitive powers, is not found at intermediate altitudes. Only a solitary specimen was present but this was both flowering and fruiting in July 1970. Presumably the seed had been washed down from upper Wharfedale where the plant occurs.

The solitary willow was still present although it was much damaged and had not grown appreciably.

DISCUSSION

Over the four year period in which this island was grazed a profound change occurred in its structure and vegetation. Apparently most of the damage was initiated by the trampling and grazing by the cattle and sheep. Trampling had damaged the surface of the turf enabling erosion processes to begin. It may have been responsible for the smoothing of the hummocks and hollows by spreading sand and gravel but flooding probably also played its part. Also, grazing had effected changes in the species composition. *Phalaris arundinacea* showed itself to be very susceptible to grazing pressure in this type of community. In 1970 *P. arundinacea* was still abundant on adjacent ungrazed areas of river bank; but grazing had encouraged some species—notably *Cirsium arvense* which is avoided by stock, and *Agrostis stolonifera* whose pattern of tillering enables it to endure grazing. Although *Urtica dioica* is not normally grazed it had been reduced in abundance, possibly by trampling.

The main effect of the removal of *Phalaris arundinacea* was to expose the island to erosion processes. The rhizomatous habit of *P. arundinacea* helps to bind together riverbanks and the results described here illustrate the effects of removing such a species from a susceptible habitat.

The effect of grazing on the vegetation was to increase its complexity and diversity, but, at the same time, the community had become more sensitive to the other external forces acting upon it.

REFERENCES

CLAPHAM, A. R.; TUTIN, T. G.; WARBURG, E. F. 1962. *Flora of the British Isles.* 2nd edition Cambridge.

KOPECKY, K. 1967. Mitteleuropaische FluBrohricht-gesellschaften des Phalaridion arundinaceae-Verbandes. *Limnologica* 5 (1): 39-79.