THE MANAGEMENT OF SEA BUCKTHORN

HIPPOPHAË RHAMNOIDES L ON SELECTED SITES IN GREAT BRITAIN

Report of the Hippophaë Study Group

The Nature Conservancy

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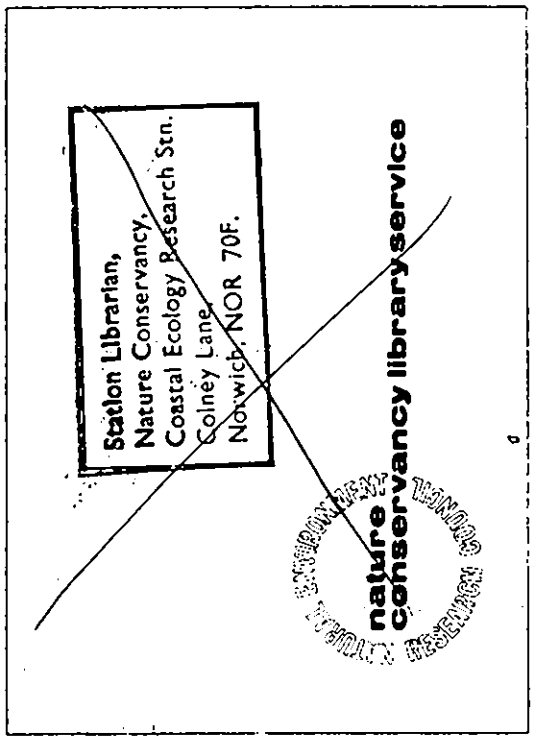

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PREFACE

The sand dune landscape is notable for its mobility and the variety of plant and animal species it can support. The British coastline contains a remarkable series of dune systems each with a background of species characteristic to most, and each with a distinctive species element dependent on the particular soil and climate type of the region in which it occurs. In addition there is a greater or smaller element of alien species largely dependent for their presence on the intensity of human activity in and adjoining any particular dune system.

A national series of sand dune nature reserves has been selected to preserve representative examples of the total sand dune resource and to maintain both the dynamic nature of the landscape and its species variety. Both these special features of dune systems are threatened by current human activities in many ways.

This report concerns a dune shrub, sea buckthorn (Hippophaë rhamnoides), which can check sand mobility and reduce species variety, but which, given time, could be instrumental in paving the way to new kinds of environmental variety in dune systems.

Hippophaë effectively controls the dune environment. It has wide ecological tolerance and wide distribution and is becoming increasingly abundant. It is big enough to suppress most other plant growth on dunes. For these reasons, it also has potentiality for control of the movements of people in heavily used dune areas as it can form impenetrable barriers.

The pollen record suggests that this plant was formerly widespread in Britain on nutrient-rich soils exposed at the end of the last glaciation. With the spread of forests it apparently retreated to the open habitats of the coast. Until recently rabbit grazing held it in check in sand dune habitats. It seems likely that the recent reduction in rabbit populations through myxomatosis, coupled with improved nutrient supply from air pollution, may be indirectly responsible for its present burst of active spread.

The success of controlling plant populations depends on clear and realistic aims related to the potentialities of the species concerned and on adequate knowledge of its behaviour. Armed with this we can make rational decisions on whether to allow the establishment of the species or not; plan effective "surgical" eradication at the right stage of invasion; modify the pattern so that grazing or human trampling can help to maintain the pattern we want; or have patience to allow an invasion to run its

course and create a new type of community.

This report brings together relevant facts about the biology of Hippophaë. It attempts to give a balanced assessment of the advantages and disadvantages the species confers in the dune environment, and recommends specific management policies which might be adopted for selected sand dune areas. It is hoped that the information given may also prove helpful to land managers concerned with other sites where Hippophaë occurs or could be introduced.

ACKNOWLEDGEMENTS

The Hippophaë Study Group is greatly indebted to all those who helped to complete survey cards and forms and also, in particular, to Dr. M.C. Pearson (University of Nottingham), Mr. A.E. Smith (Lincolnshire Trust for Nature Conservation), Mr. F.P. Tindall (East Lothian County Council), Mr. T. Dargie (University of Hull), Dr. M.J. Cotton (University of Dundee) and Mrs. J. Whatmough (National Trust, Northern Ireland), who kindly made available unpublished information on Hippophaë. We are also grateful to Miss Stella Ross-Craig and G. Bell & Sons, Ltd., for allowing reproduction of Fig. 1; to Mr. E.W. Groves (British Museum (Natural History)) for permission to reproduce Fig. 2; to the Botanical Society of the British Isles and Thomas Nelson & Sons, Ltd., for permission to use Fig. 3; to Mr G. de Boer (University of Hull) for supplying and allowing us to use the air photo stereograms in Plate 1; and to Mr. A.C. Aldridge, Mrs. A.C. Knowles (née Blanchard), Mr. J.V. Morley and Mr. R.E. Parker for supplying other photographs used to illustrate the text. Thanks are also due to Miss J.M. Winn and Miss E.J. Reeve for much help in the preparation of the manuscript and to many members of the staff of the Nature Conservancy who helped with advice.

INTRODUCTION

In the management of natural or semi-natural environments certain species demand particular attention. This may be because they are the natural "dominants" which determine the whole character of the environments, or because they are rarities which depend on a delicate environmental balance for their survival, or, because they are species which are themselves capable of causing great changes in the environmental balance. Invasive alien species are a special case within this last category and have often drawn attention to themselves, as in the case of the grey squirrel or the coypu, by the spectacular biological disturbance they are capable of causing.

In the plant kingdom similar disturbances have been and are being caused by the spread of invasive plant species, and are of special concern to persons involved in the conservation management of natural or semi-natural environments, in particular nature reserves, where the selection of the reserve has been related to the conservation of some specified ecological system. In some cases, such as in the explosive spread of the New Zealand willow-herb (Epilobium pedunculare) in montane Britain, there is little that can be done except observe the process, because the possibility of changing its course seems remote. In other cases, such as that of the rhododendron (Rhododendron ponticum) and sea buckthorn (Hippophaë rhamnoides), there is a need to develop a clear cut national management policy, at least as far as nature reserves are concerned.

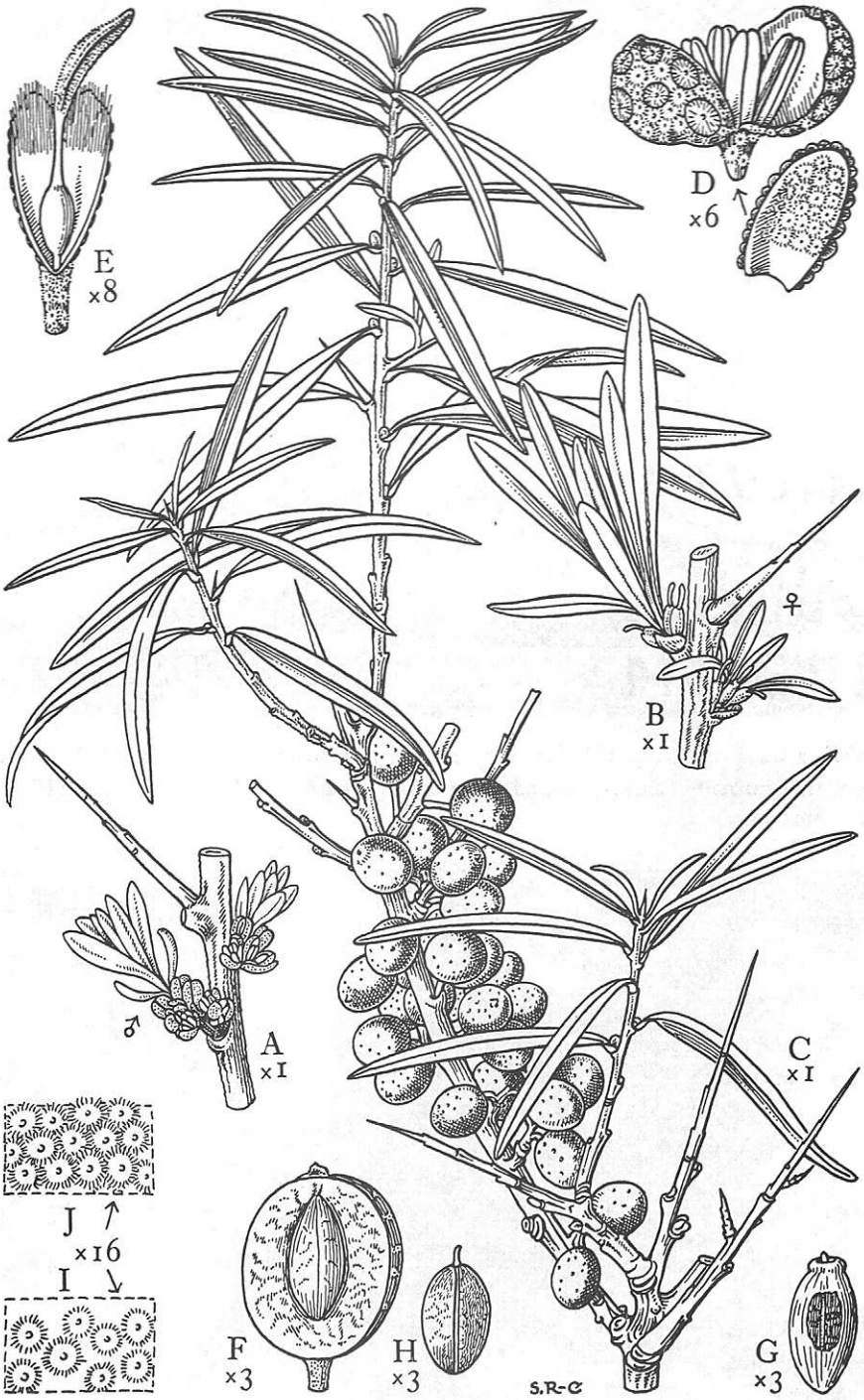
The highly invasive behaviour of sea buckthorn on certain sand dune systems has, in the past, brought it the reputation of being a pest species on some sand dune National Nature Reserves and stimulated the thought and action which led to the formation of the Hippophaë Study Group under the auspices of the Nature Conservancy's Coastal Habitat Team. However, although it is legitimate to regard Hippophaë as an invasive pest species in some circumstances, this is an over-simplified view of the situation on anything more than a local level.

The Hippophaë Study Group, at its first meeting in December 1969, set itself the following aims :-

1. To collect information relating to the natural history of Hippophaë and the plant communities of which it forms part.
2. To collect information on the fauna associated with Hippophaë.
3. To collect information on the current use of Hippophaë in environmental management.
4. To examine and make recommendations on methods of controlling Hippophaë.

5. To examine the alternative policies for the management of Hippophaë on selected sites.
6. To propose general, national policies for the management of Hippophaë and make recommendations on the management policies in relation to Hippophaë on the whole range of sand dune National Nature Reserves.

It must be emphasised that the Study Group did not consider that it should undertake an exhaustive investigation of the problems associated with Hippophaë management but rather that it should produce a satisfactory framework for the necessary immediate local action on Hippophaë management required by Regional Officers of the Nature Conservancy. At the same time an attempt was made to form the basis of a national yet flexible policy. During the preparation of the draft report many interesting issues arose that invited further investigation, but the pursuance of these was judged to be a follow-up function more appropriate for future research workers.

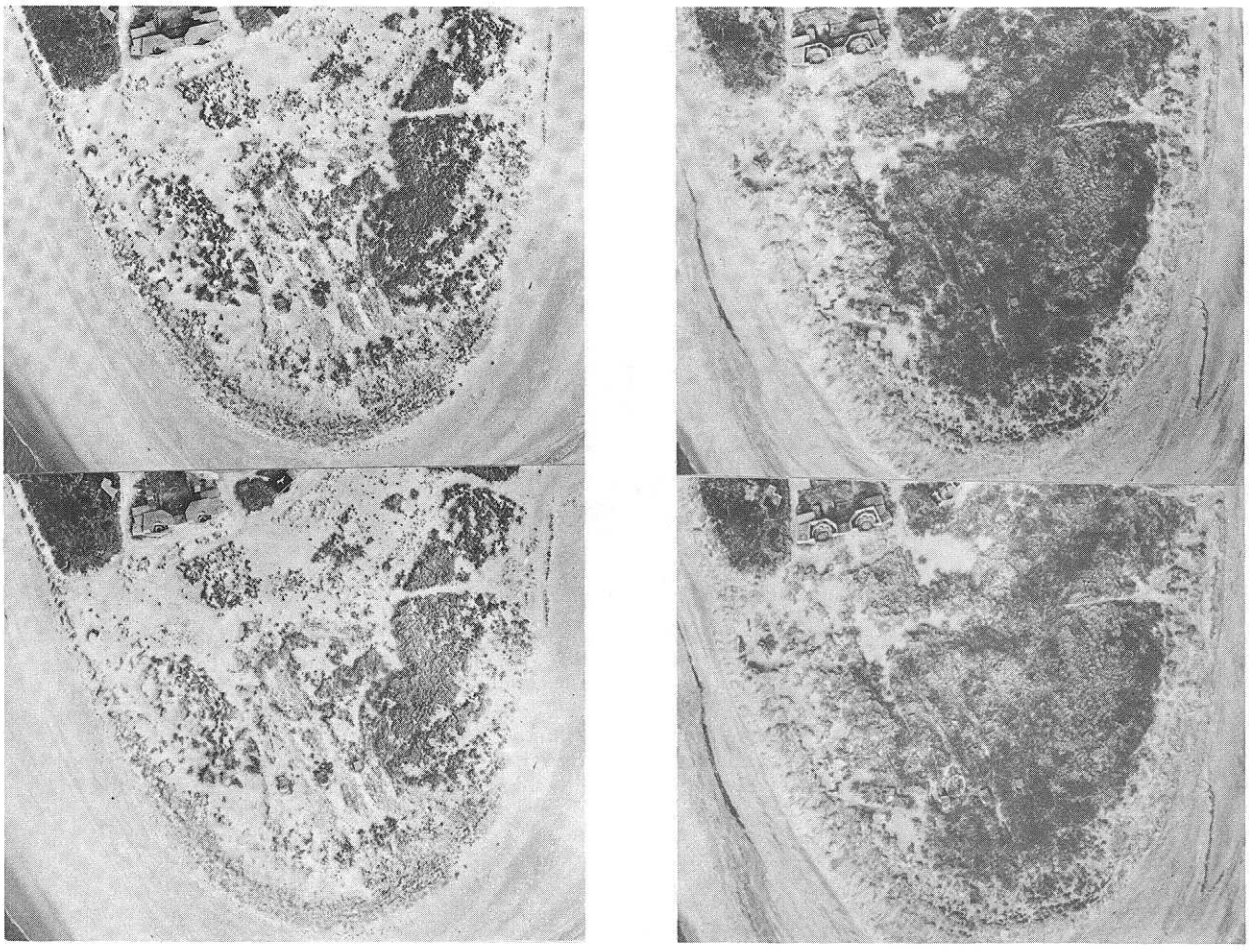


Hippophae rhamnoides L. Sea-Buckthorn

A, male flowering branches on part of main stem; B, female flowering branches on part of main stem; C, fruiting branch with young leafy shoots; D, male flower, and a bract, showing the inner surface; E, female flower, cut and opened out; F, drupe—partly cut away to show the stone; G, stone—part of the membraneous covering cut away to show the seed; H, seed; I, J, upper and lower surfaces of leaf.
Perianth green, anthers yellow; bracts densely clothed with reddish-brown scales. Leaves dark blue-green dotted with shining colourless scales, lower surface silvery-grey due to the scales. Fruit yellowish-orange.

Fig. 1: Morphology of Hippophaë rhamnoides (from Drawings of British Plants, Part 26, Plate 31, by Stella Ross-Craig; copyright: G. Bell & Sons, Ltd, London)

PLATE 1: Photo. a: Eroded roots, showing root nodules associated with nitrogen-fixing activities. Berrow, Somerset. (Photo. by J.V. Morley)



Photos b and c: Air photo. stereograms of Spurn Point, Yorkshire. Photo b: 3/9/59; Photo. c: 7/5/66, showing natural invasion of Hippophaë (darker patches) on open sand communities resulting from previous military activities. (Copyright: Dept. of Geography, University of Hull)

CHAPTER 1

THE STATUS OF *HIPPOPHAË* AS PART OF THE BRITISH FLORA

Hippophaë rhamnoides L., the sea buckthorn, is the only native member of the family Elaeagnaceae in the British Isles. It is a much branched, thorny, deciduous shrub, up to 9 m in height, and suckers freely. The narrow leaves are alternately placed, and the whole plant is densely covered in peltate silvery-brown scale-like hairs (Fig. 1). The male and female flowers are borne on separate bushes. The sub-globose fruits are green at first, but by September, when ripe, they become orange, and may persist on the shrub all through the winter. The fruits are rich in vitamin C, and are normally single-seeded. Germination is epigeal and the seeds exhibit a certain degree of dormancy which can be overcome by the cold treatment which is normally provided in nature during the winter. The plant bears root nodules (Plate 1, Photo. a) which are capable of fixing atmospheric nitrogen. (Bond et al. 1954 & 1956; Stewart and Pearson 1967).

Taxonomy

The taxonomy of the species probably requires further study, as there seems to be a variety of forms and races, some of which can be associated with particular ecological conditions. Servettaz (1909) recognized three sub-species, the European sub-species *rhamnoides*, a temperate Himalayan sub-species *salicifolia* (Don) Servettaz, and the dwarf montane Himalayan sub-species *thibetana* (Schlect.) Servettaz. Recently, van Soest (1952) divided the European sub-species into a coastal sub-species *maritima*, and an inland and alpine sub-species *fluviatilis*. The British specimens all fall into the *maritima* sub-species, and there is considerable variation in morphological form particularly in the leaf shape (Pearson and Rogers 1962).

European distribution

Hippophaë ranges throughout a considerable part of Europe from 68°N in Norway to North Spain, Central Italy and Bulgaria to the Black and Caspian Seas and Lake Baikal, and it is found on the mountains of the Pyrenees and Alps, and as far west as the Himalayas and south-West China (Pearson and Rogers 1962). Two main habitat types are occupied in Europe, the maritime habitats of the coasts of the Atlantic, Baltic, Black and Caspian seas, the shores of Lake Baikal, and the inland and montane habitat of open situations, on the upper limits of forests, as in Norway (Palmgren 1912), and on river gravels and alluvia, notably on those of the Rhone and Rhine

(Sendtner 1854). In Britain, Hippophaë occurs almost entirely in coastal habitats where it is most frequently found on sand dunes, but the native distribution is obscured by a history of introductions. However, in general it can be said that in Europe at least, native Hippophaë is local and absent from wide areas. (Tutin et al.1968).

The explanation for this type of distribution lies in the past history and ecological requirements of the plant, especially in its need for well drained open habitats. Thus, Godwin (1956) believes that the plant was widespread in North-West Europe in late glacial times, particularly before the spread of the woodlands. Scandinavia has particularly good pollen records of the plant spreading northward as the ice-front retreated, but retreating itself before the spread of the forests in many places, it remained only in open places with little competition from trees in mountain habitats and on coastal dunes (Sandergren 1943). In Britain, there are similarly a number of inland sites recorded in late glacial and pre-glacial times, but later the plant became virtually restricted to the coastal areas. Thus we must regard the present native occurrence of the plant in Europe as relict from a former much more widespread distribution.

British distribution

The status of Hippophaë on many British sites has to be questioned, because of its history of introduction by man to the sand dune system as a sand-stabilizer. The earliest date of the use of the shrub in this way is not known for certain, but in 1756 it was recommended for planting in Ireland by a Mr. Smith (Scully 1916), and this seems to be about the time that introductions began in earnest. The status of Hippophaë in Britain has been investigated by Groves (1958) who has traced the records of introduction for many sites (Fig.2). He concluded that the species was native on a number of sites in the south-eastern and eastern seaboard counties from east Sussex to north-east Yorkshire and including north Northumberland and Berwick. The whole problem is complicated by the natural spread of the plant, not only where it was originally planted, when it suckers freely giving the appearance of natural colonies, but also in places where it has been spread by seed. The latter is thought to occur at least in part by the agency of birds, and Groves indicates such sites on his map (Fig.2). Thus, although Stratton stated that Hippophaë was very rare in the Isle of Wight in 1909, in 1932 Drabble and Long stated that it was "certainly not rare now" and "fruits freely e.g. at Totland, and may be bird-sown in many of its stations."

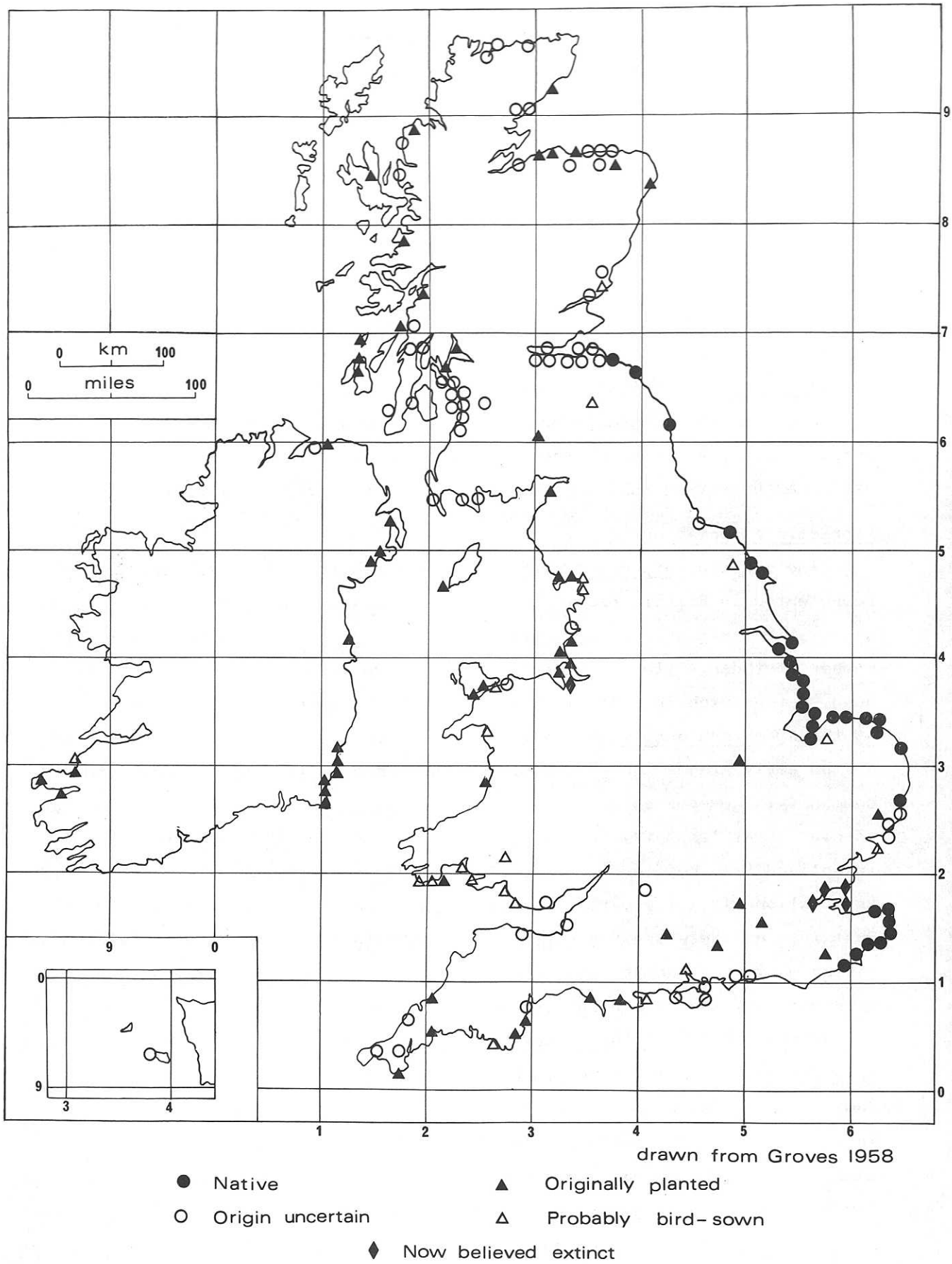


Fig 2: Distribution and status of Hippophaë rhamnoides in the British Isles up to 1958 (after Groves 1958)

Its present status is shown in Fig. 3. The cause of an apparently accelerated spread and increase of Hippophaë on many sites in Britain in recent years, is thought to be connected with the disappearance of rabbits after myxomatosis. Natural regeneration of this scrub species is not checked as it was in the past, and some of the more interesting communities of the open dune system are being lost (Plate 1, Photos. b and c).

It can be very difficult to decide whether a population is native or not. However, historical documents and old floras can be examined for earliest records and dates of introduction. In addition, it is thought that irregular spacing of bushes and the presence of other scrub species among the Hippophaë may indicate a native population although these features may also occur in the naturally sown stands near old introductions. The morphological variation of the plant could be studied to see if this gives evidence suggesting that more than one population type is present.

Floristic associations

The place of Hippophaë amongst the phytosociological associations represented in Britain has to be considered also. Only the maritime associations are present apparently, and Hippophaë can be a very important member of these, often forming the dominant woody species, especially on dune systems rich in calcium (Westhoff 1947). Hippophaë can enter the sere at the Agropyron junceiforme embryo dune stage, and as is usual with scrub in the early stages the predominating influence is that of the existing community; however as the sere progresses Hippophaë can become the dominant species. At least five maritime associations with Hippophaë are recognised in Holland (Westhoff and den Held 1969), and their comparison to the British associations is not clear. Two of the associations have been recorded for Britain, and these are the Hippophao-Ligustretum on dunes rich in calcium and having many woody shrub species present, and the Hippophao-Sambucetum, a nitrophilous association in dune slacks. The other associations described for Holland are the Althaeo-Calystegietum sepium associated with Calamagrostis epigejos on mesohaline dune slacks, the Salicetum pentandro-arenariae on damp areas of dunes poor in calcium, and the Salicetum arenario-purpureae in dune slacks with standing water in winter. In its final stages the seral progression of maritime scrub with Hippophaë is not properly understood for Britain. In Belgium, it may be included in the Quercetalia pubescentis sessiliflorae alliance (Lebrun et al.1949), while in Holland, amongst complex successional relationships, the sere progresses to Betula, Crataegus and

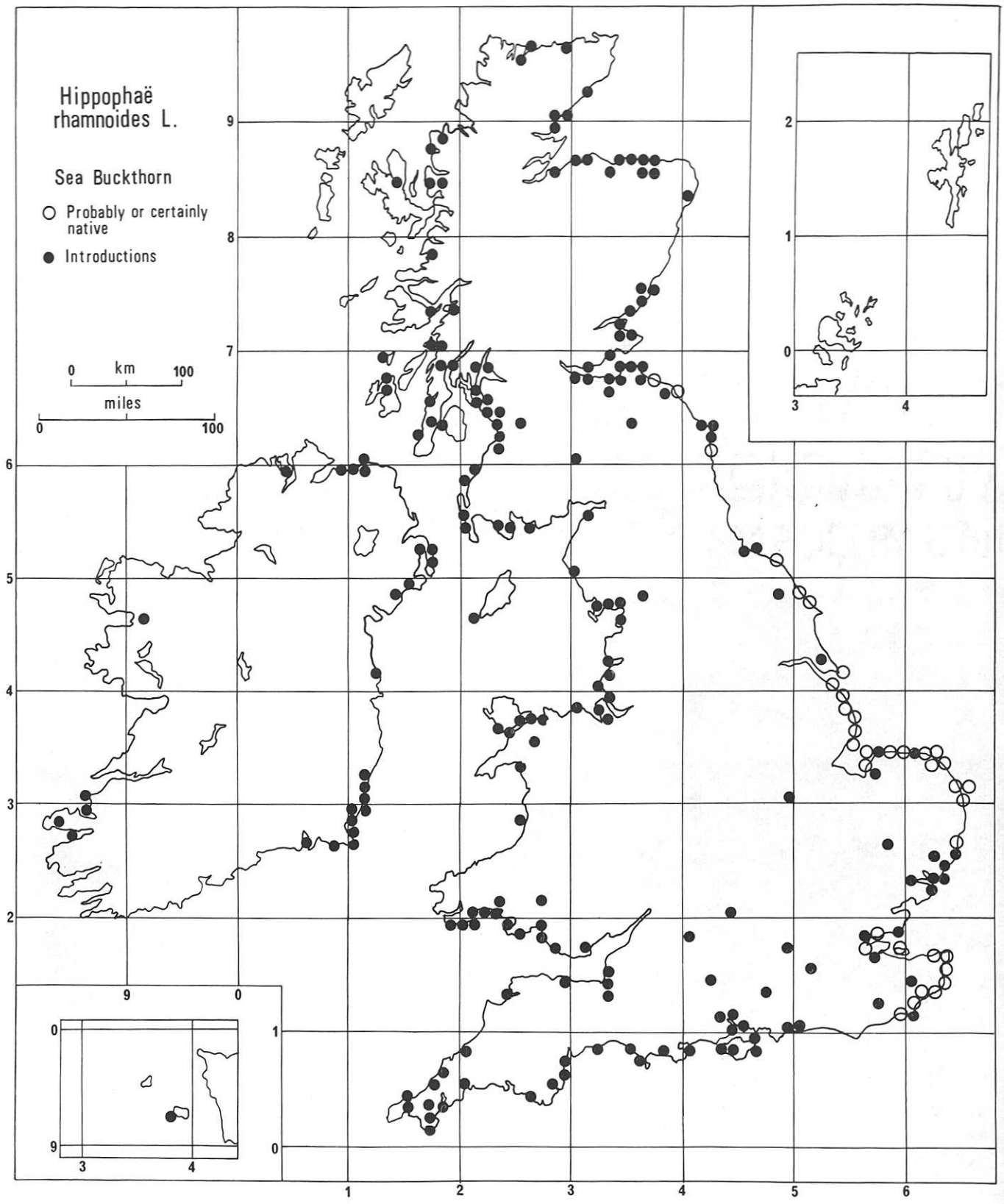


Fig. 3: Distribution of Hippophaë rhamnoides in the British Isles in 1970 (by permission of the Botanical Society of the British Isles and Thomas Nelson & Sons, Ltd.: data taken from Atlas of the British Flora, 1962, with recent additions compiled at the Biological Records Centre)

Populus and eventually to woodland of Quercus robur (van der Maarel and Westhoff 1964). Hippophaë is very light-sensitive, dies out in shade and is lost as soon as the sere reaches woodland proper.

Amongst scrub types the Hippophaë scrub is of interest in that it is typically maritime, and a primary invader of accreting sand dune systems which at least until recently have been little modified by man. This can be contrasted with the scrub types found invading many lowland grassland habitats, which are in themselves deflected successions induced by human activities. These scrub types usually pass fairly directly to woodland while Hippophaë may persist for longer periods owing to the effects of maritime conditions.

The rich dune scrub association is not well represented in Britain and the full seral range is apparently not present on any reserve. The reason for this is not understood but it is probably related to overgrazing by rabbits in the past, and by an early use of the fixed dune as arable land.

CHAPTER 2

THE ECOLOGY OF *HIPPOPHAE* WITHIN THE DUNE SYSTEM

Growth dimensions

Hippophaë rhamnoides can live for at least 40 years and grow to a maximum height of 12 m. The plant normally behaves as a nanophanerophyte (resting buds 0.25 to 2 m) in exposed mobile dune conditions in the British Isles and as microphanerophyte (resting buds 2 to 8 m) in stabilized dunes.

In stable soils most of the roots lie 10 to 20 cm below the surface, but they may be buried more deeply in mobile sand. Rhizome-like roots penetrate to at least 1.2 m (Pearson and Rogers 1962) and probably deeper on dunes.

Vegetative reproduction

Growth is in the form of standards, clusters of aerial shoots, or rhizome-like roots. If plants are propagated from root cuttings they produce standards, at least initially; plants propagated from suckers produce suckers. The maximum rate of horizontal vegetative spread recorded is 4 m in 2 years (Rogers 1961) and of vertical shoot elongation, 0.7 m per year (Pearson and Rogers 1962).

Sexual reproduction

Sexes are on separate plants. One male plant will fertilize up to 5 or 6 female plants. Pollination is primarily by wind but insect pollination may also occur. Flowering and fruiting have been first observed on shoots in their second and third year. Fruits are single-seeded and may reach a density of 100 per decimetre of stem length. Holt (1958) notes that a bush 4 ft. (1.2 m) high on calcareous dunes at Berrow, Somerset, produced some 15,000 berries. Seeds remain viable after passage through the alimentary tract of birds (Pearson and Rogers 1962; de Vries 1947) and pigs (Kerner 1894). Potentially viable seeds have a 95 to 100 per cent germination rate. Where both sexes occur together 98 to 100 per cent of the fruits contain potentially viable seeds. In pure female stands as at Sandy Hirst, East Lothian, no fruits with viable seed were found (Pearson and Rogers 1962). Possibilities of limiting sexual reproduction by regulating the sex ratio in patterned plantings or in existing stands would be worth exploring.

Phenology

The chart (Fig. 4) is based on data for the year 1958 to 1960 at Gibraltar Point, Lincolnshire, after Rogers (1961). Variability within

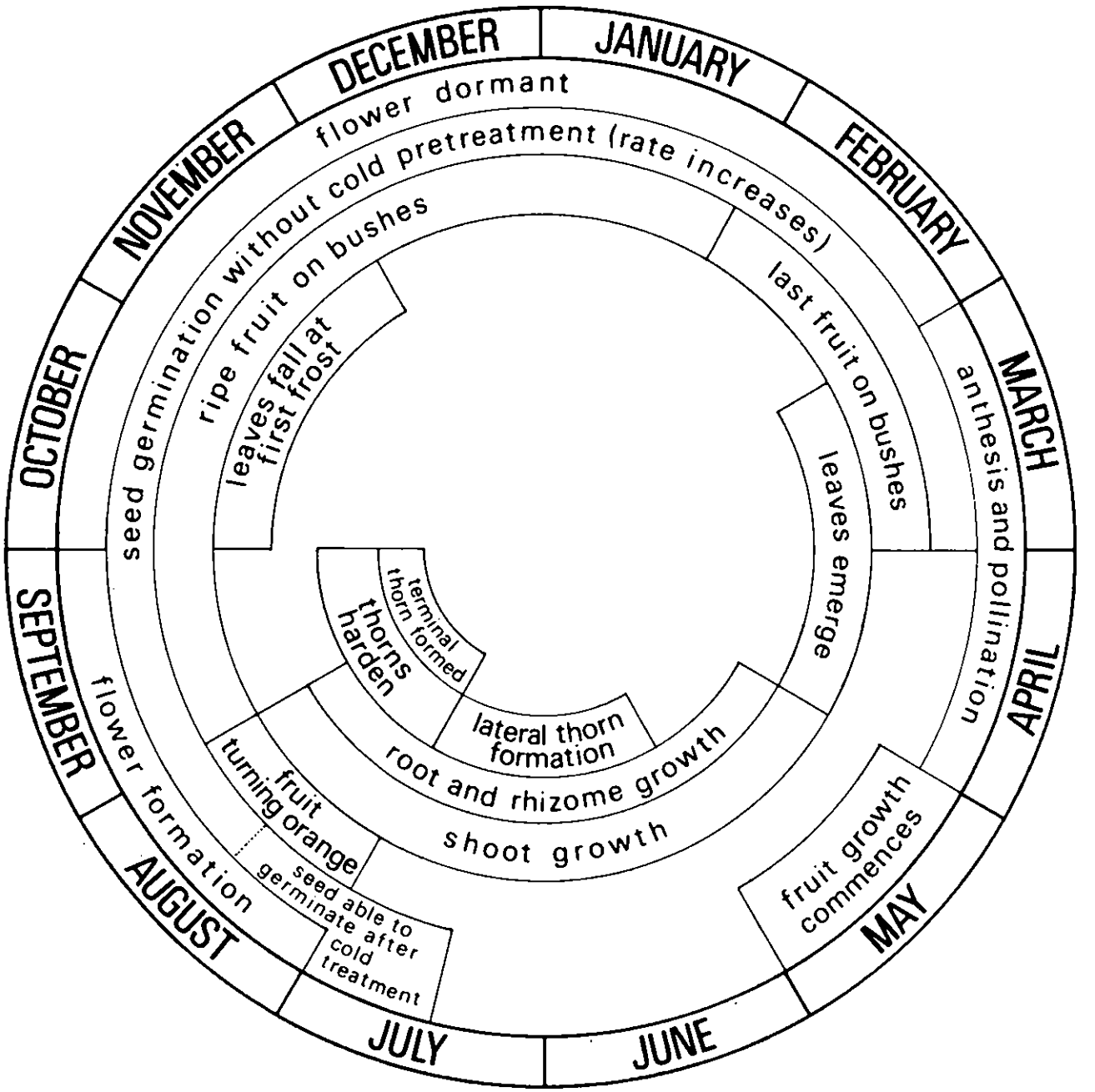


Fig. 4: Phenology of Hippophaë rhamnoides (after Rogers 1961)

one site, with up to 14 days' delay in leafing of dune slack plants compared with plants on open dune, probably exceeds the shift in phenological events from the south coast of England to the north coast of Scotland.

Environmental ~~constraints~~ restraints and reactions

The effect of environmental factors on Hippophaë (~~constraints~~ restraints) and the effect of Hippophaë on the environment (reactions) are as follows :-

Climatic restraints

There is no evidence that the distribution of Hippophaë rhamnoides in the British Isles is limited by climate in general, for the plant is in the centre of its latitudinal range.

Growth effectively ceases at light levels of 150 to 160 ft. candles (1615 to 1722 lx) - quite a high value compared with the light limit of birch at 40 ft. candles (430 lx). Germination of seed is slightly improved by light up to 200 foot-candles, but above 1000 ft. - candles (10764 lx) an increase is detrimental. Seedling growth is adversely affected by light intensities below 70 per cent of full daylight. Mature plants are unable to tolerate heavy shade from taller trees or tall scrub, but persist in rides and clearings (Pearson and Rogers 1962).

Seeds remain viable at temperatures down to -20°C for periods up to 12 weeks. Seeds require a period of cold pre-treatment at 2 to 5°C before they will germinate. Mature plants show no sign of frost damage in the field (Pearson and Rogers 1962).

Increased supply of nutrients in rainfall from polluted air may well favour the future spread of Hippophaë to dune systems at present too nutrient deficient for its healthy growth.

In years when precipitation exceeds evapo-transpiration the spread of Hippophaë in dune slacks may be limited by persistent flooding. However, it is recorded as surviving at Gibraltar Point, Lincolnshire, in a dune hollow flooded throughout the summer of 1958 (Pearson and Rogers 1962).

Seedlings may be susceptible to drought, but with age become increasingly resistant to it. No evidence of wilting or premature loss of leaves in drought has been reported.

The tight growth of Hippophaë is very resistant to mechanical damage from wind. Mature leaves are not damaged by sea-water in spray, but they are damaged by salt concentrations three times the strength of sea-water (Pearson and Rogers 1962) - concentrations they are most unlikely to

experience in natural conditions. Heavy snow drifts in winter may contribute to breakage of old stems. Provided that shoots are not completely buried they can grow through sand brought by the wind and withstand sand accretion of at least 0.5 m a year.

Climatic reactions

Hippophaë profoundly modifies the microclimate of the dune and slack communities it invades. In less dense thickets shade-tolerant species such as Conium maculatum, Glechoma hederacea, Stellaria media and Urtica dioica are among the last species to survive e.g. at Sandy Hirst, East Lothian. Beneath really dense growths, e.g. at Gibraltar Point, Lincolnshire, and Ainsdale, Lancashire, no flowering plants survive.

Fluctuation of soil temperature is markedly reduced in Hippophaë scrub compared with that in dune grassland and there is much less heat stored in the soil so that heavy dew often forms on Hippophaë surfaces at times when it is absent from adjoining dunes (Stoutjesdijk 1961). One would expect much higher humidity in the scrub and Stoutjesdijk (1961) has shown that wind velocity at 15 cm above ground level is between 2 to 8 times lower than that at a similar level above open bare sand. It is likely also that the leaching effect of rainfall on soil nutrients will be significantly less beneath Hippophaë compared with the leaching effect on open dunes.

Even an open scrub of Hippophaë will be likely to alter the microclimate and balance of species in dune grassland areas between bushes.

Soil restraints

Germination is completely prevented by salinity greater than 0.05 per cent (Pearson 1961) and mature plants do not penetrate into sand dune to saltmarsh transitions. Hippophaë is predominantly a plant of well-drained soils, but grows well on a variety of garden soils and where planted in wind breaks e.g. at St. Abb's Head, Berwickshire, and Folkestone, Kent, on clay soil. It can also grow on pulverized fuel ash. It is primarily a plant of dune soils in the British Isles.

Its growth and resistance to insect attack are markedly affected by the amount of lime in the soil. For example, growth is poor on lime-deficient dunes in the North Netherlands and plants are killed locally by defoliating insects; on lime-rich dunes, growth is much stronger and plants are more resistant to insect attack.

Recorded minimum and maximum values of some soil properties for Hippophaë are given in Table 1. It is not known at what minimum pH value

or exchangeable calcium level Hippophaë is unable to compete with native vegetation, but its presence at Tentsmuir Dunes, Fife, where Calluna develops locally, suggests these may be lower than the minimum values given in Table 1. The plant is absent or rare in dune systems with markedly acid soil, e.g. Studland, Dorset. Plants can certainly grow well on nitrogen deficient soils (e.g. on embryo dunes at Holkham, Norfolk, or on pulverized fuel ash). Bond et al. (1954 and 1956) have demonstrated that root nodules of Hippophaë can fix atmospheric nitrogen under laboratory conditions and are therefore likely to be independent of the soil nitrogen supply. Stewart and Pearson (1967) have shown that nitrogen fixation also occurs in the field, providing the levels of combined nitrogen in the soil are low, as is the case in the summer months.

Soil reactions

Apart from the generalized reduction in leaching and therefore conservation of nutrients likely to occur under Hippophaë stands, Stewart and Pearson (1967) have shown that large increases in total nitrogen (i.e. soil plus plant nitrogen) occurred with increase in age of the plants.

Nitrogen increased from 27 kg per hectare per annum in the presence of bushes 0 to 3 years old, to 179 kg per hectare per annum in the presence of bushes 13 to 16 years old. This six-fold increase in total nitrogen was not entirely due to nitrogen fixation alone.

When Hippophaë thickets are cleared the changed soil properties result in a flora rich in nitrogen-loving species such as Urtica dioica or opportunists like Chamaenerion angustifolium, quite different from the original dune grassland flora prior to Hippophaë invasion. Unless the new vegetation is regularly mown and the clippings removed to reduce nutrient levels, there is little likelihood of the original dune flora returning.

Biological restraints

In those dune systems where there are dense mature pine plantations e.g. at Holkham, Norfolk, it seems likely that Hippophaë growth is limited by shade beneath the pines. Increasing acidity of the pine litter may also be responsible for poorer growth. There is evidence of the death of quite young plants in small clearings amongst the pines at Holkham and it may be that these sheltered situations favour parasitic fungi or insect attack which bring about the final death of the plant.

As mentioned earlier, insect attack can be at least partly instrumental

in causing death of plants on acid dunes, but it also occurs on lime-rich dunes e.g. at Camber in Sussex to the extent that insecticide sprays have had to be used to control the attacks. There is a complex interaction between biological and environmental restraints such that increased rabbit-burrowing activity enhances drought effects in dry season when insect attack is at a maximum. It is the combination of these restraints rather than any one in particular which is likely to prove lethal to growth. The same might hold true for fungal attack in wet seasons for plants near the shade limit.

No figures are available for limitations on growth due to grazing activity by rabbits or stock or the destructive effects of human trampling, but these clearly affect the edge growth of Hippophaë thickets. Recent rapid increase in Hippophaë populations at Gibraltar Point, Lincolnshire, and elsewhere is believed to be largely due to reduction in the intensity of rabbit-grazing following myxomatosis in the mid-1950's.

Biological reactions

With the exception of permanently flooded hollows, dune heath communities, and those of our northern-most dunes with arctic-alpine elements in the flora (where exposure limits the establishment of scrub species), the evidence suggests that Hippophaë has the capacity to replace most of the remaining range of semi-natural dune communities in the British Isles. It has already reduced populations of many of the several hundred species (including rare species) which occur in these communities. As yet we have no evidence that Hippophaë has been responsible for the actual extinction of any species on any particular dune system. Dense Hippophaë increases evapo-transpiration, so allowing invasion of sites formerly too wet for its growth.

There is so little dune scrub on British dunes to compete with Hippophaë at the present time that almost pure stands of the species can form, as at Ainsdale, Lancashire (Plates 2-3). However, at Gibraltar Point, Lincolnshire, Sambucus nigra, Acer pseudoplatanus and Crataegus monogyna do persist locally in Hippophaë. At Berrow dunes, Somerset, Holt (1958) notes Alnus glutinosa, Salix sp., Crataegus monogyna, Prunus spinosa and Rosa sp., flourishing among the Hippophaë. Its thorny growths will help to protect more palatable shrubs from rabbit-grazing and we can expect gradual diversification of the shrub flora amongst developing Hippophaë thickets. This type of plant community is already well established in Dutch dunes, and Westhoff (1952) notes that it is "rich in ligneous plants, 22 woody species occurring more or less regularly in it; the effect of it is very decorative." With this diversity we may expect additional diversity in the insect flora, mammals and birds on dune systems, but at the expense of the existing fauna and flora of dune grasslands.

CHAPTER 3

THE FAUNA OF HIPPOPHAË

Succession and change in a floral association, such as occurs when Hippophaë colonises a sand dune, brings about corresponding changes in the animal species of an area. Perhaps the most important species to colonise a plant as it appears in a sere are the monophagous species, as these are solely dependent on the presence of a particular plant. However, other phytophagous species which are not exclusively attached to one plant, but can be found in other habitats and on other plants as well as on Hippophaë, are also important in increasing the richness of animal life. All these phytophagous species form the basis of food chains of parasites and predators.

If the plant is a dominant species causing major successional changes, as Hippophaë does in increasing shading, altering the microclimate, and nitrifying the soils, then numbers of new niches for animal species are produced, while at the same time, those associated with the former open habitat of the sand dune are lost. Again any phytophagous species colonising the sere can be the basis of food chains.

The fauna of Hippophaë has not been extensively studied, but for the purposes of description can be divided into three categories, the invertebrates, the birds, and the mammals.

1. Invertebrates

There are apparently only four monophagous species dependent on Hippophaë. This is a relatively low number for a woody plant, comparable to the numbers found on Buxus, but contrasting with over 100 species found on Betula. These monophagous species are: Psylla hippophaës Fors. (Homoptera; Psyllidae); Aceria hippophaëlla Nal. (Acarina; Eriophyiidae); Capitophorus hippophaës Walk. (Homoptera; Aphididae), which is found in most eastern sites and has Polygonum species as the alternative host for the summer generation; and Gelechia hippophaëlla Shr. (Lepidoptera; Gelechidae), which is found on eastern sites as far north as Spurn Head in Yorkshire, although at one time it was thought to occur in Kent only.

It has been suggested that sites where Hippophaë is native might be distinguished from sites where it is introduced by the presence of particular insect species, and it certainly appears to be true that two of the monophagous species are found only in the east of England. However, it would be unwise to

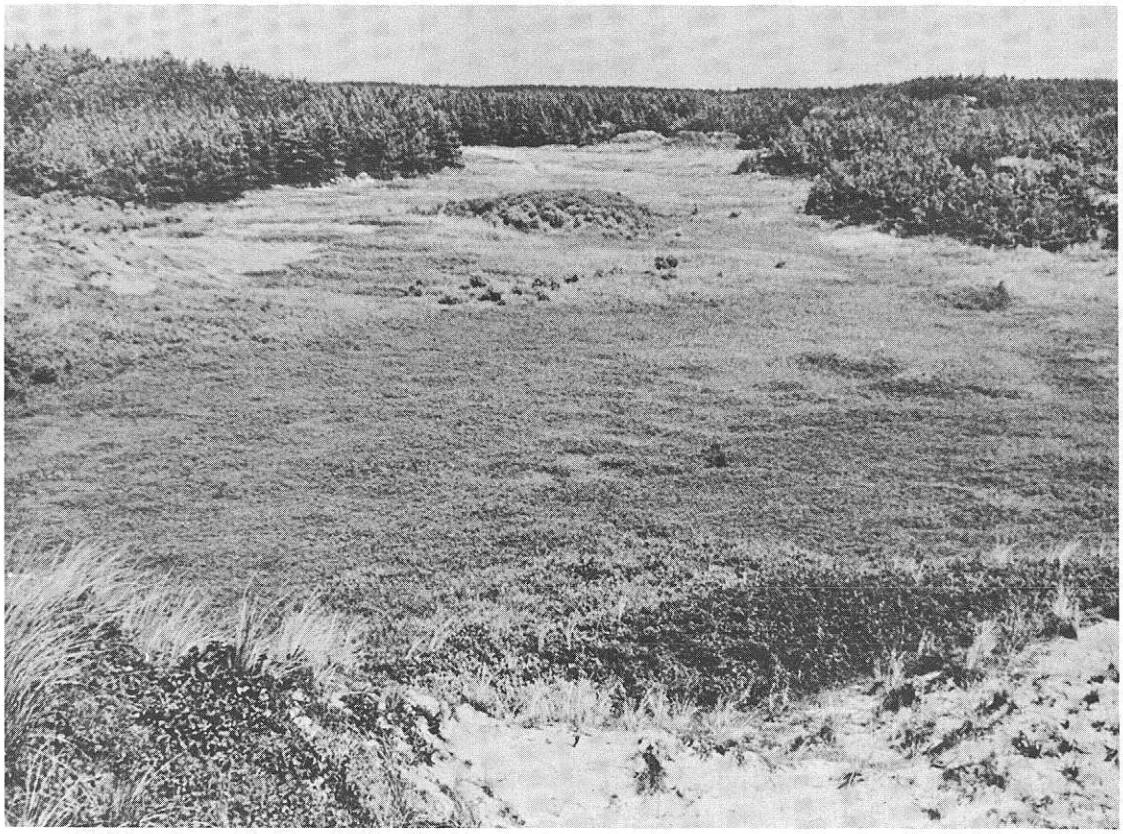


PLATE 2: Photo. a: View, taken in 1952, looking N.E. over damp Salix repens slack, with afforested dunes in background. Ainsdale, Lancs. (Photo. by B. Blanchard)

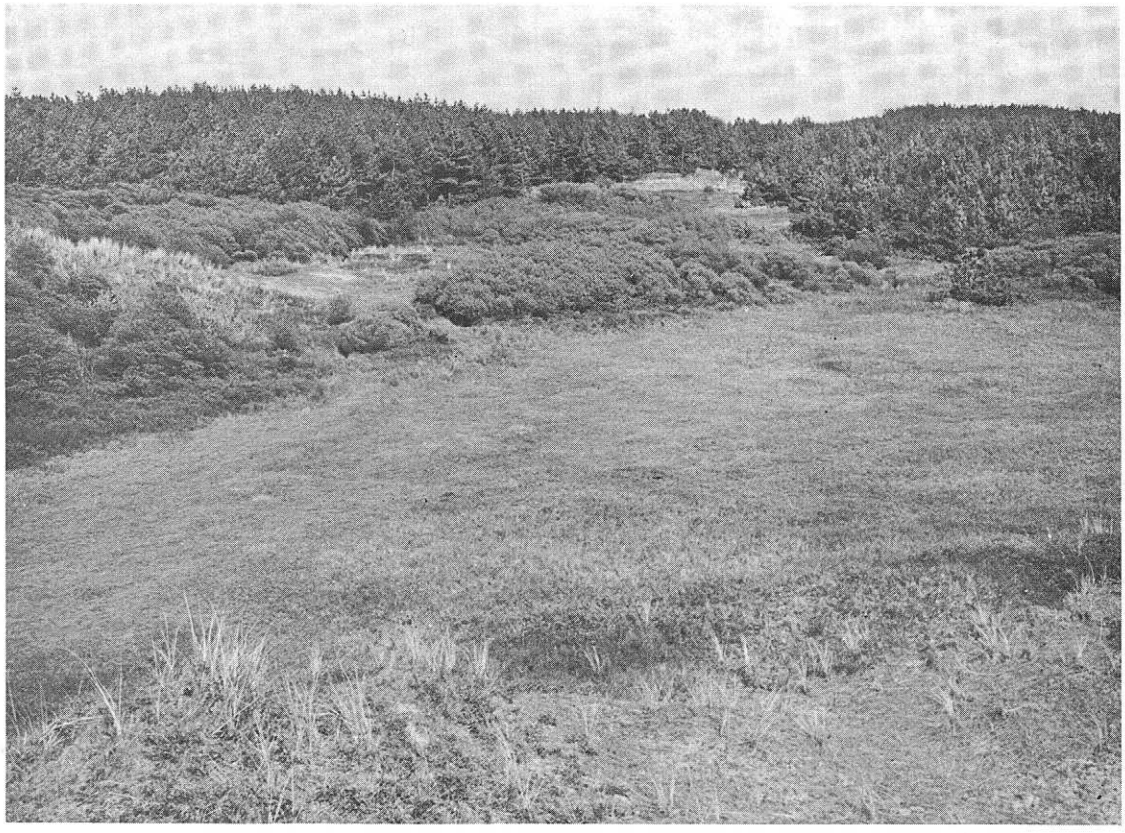


Photo. b: Same view, taken in 1971, 19 years later. Note extensive spread of Hippophaë between the slack and afforested dunes. (Photo. by A.C. Aldridge)

PLATE 3: Photo. a: View, taken in 1952, looking S.W. along landward side of coastal dunes. Note Hippophaë clumps in left foreground and centre. Ainsdale, Lancs. (Photo. by B. Blanchard)

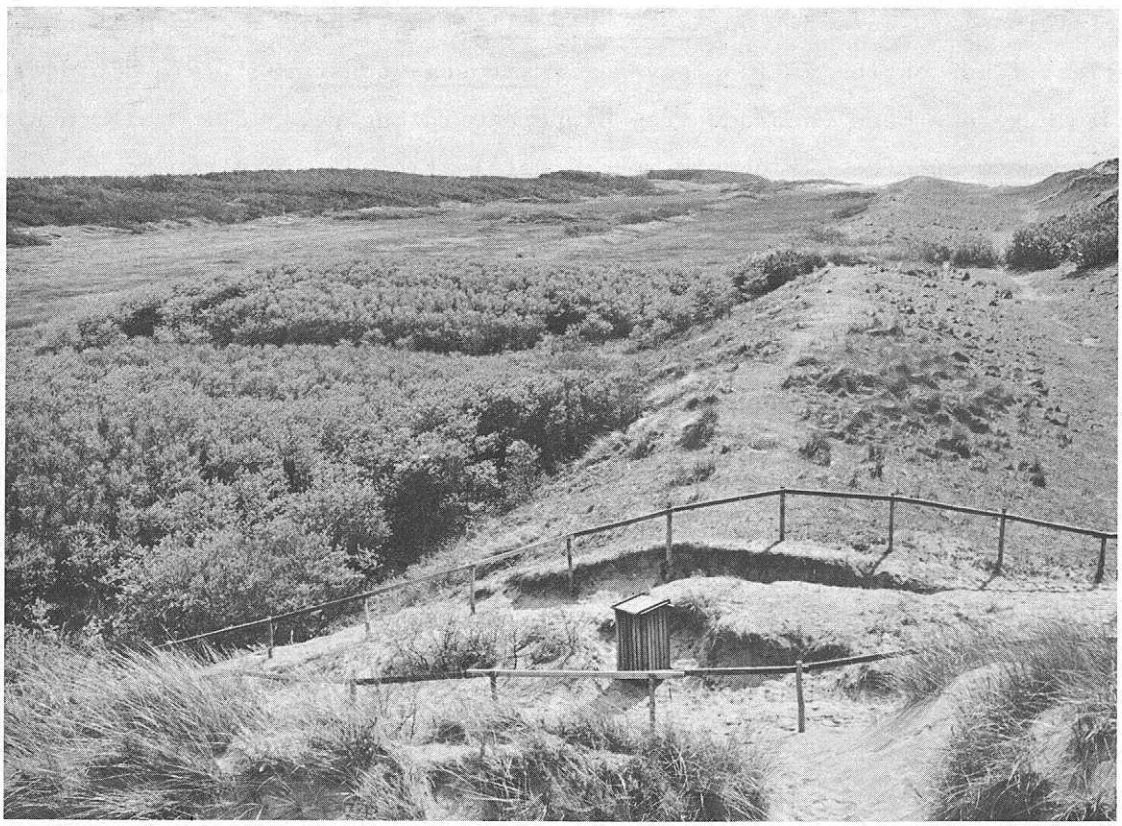


Photo. b: Same view, taken in 1971, 19 years later. Note closing up of the Hippophaë clumps. (Photo. by A.C. Aldridge)

generalise when so few monophagous species are involved. Climatic differences between east and west coasts could easily be the limiting factor, and then too, the dispersal of species from site to site has become easier with the increased spread of Hippophaë.

Amongst the most important of the polyphagous species on Hippophaë is Euproctis chrysorrhoea L. (Lepidoptera; Lymantridae), the browntail moth, which can become a pest on some shrubs and trees, notably on fruit trees. In the Netherlands, the problem is often quite serious, and Voute and van der Lind (1963) demonstrated that different host species were attacked in sequence and that the number of host species attacked increased with the higher populations of the larvae. Hippophaë was usually the preferred host, followed by various woody species, usually Crataegus, Quercus, Ulmus, fruit trees, and lastly shrubs such as Euonymus and Prunus. In this country the species is not a serious fruit pest but does become common occasionally in east Kent and Essex in coastal areas (Massee 1954), perhaps spreading from persistent populations on Hippophaë.

Five other species of Lepidoptera feed on Hippophaë occasionally, and these are Spileota ocellana Staph. (Eucosmidae), Orygia antiqua (Lymantridae), Operophtera brumata (Hydriomenidae; winter moth), Eupithecia innotata Hufn. (Hydriomenidae; angle-barred pug), and Olthreutes lacunana Schiff. (Tortricidae). In addition Adela croesella Scop. (Adelidae), a case-bearing species, feeds on the fallen leaves. Malcosoma neustria L. (Lasiocampidae; the lackey) has been recorded from Hippophaë in Europe, and in this country a Malocosoma species has caused severe defoliation at Gibraltar Point (Pearson and Rogers 1962). H.N. Michaelis (pers.comm. 1970) also recorded two species that appeared to be associated with Hippophaë and may have been feeding on the plant; these were Blastobasis lignea Wals (Blastobasidae), collected at Deganwy in Denbighshire, where it was probably feeding in decaying leaves below the bushes (although it could have been associated with Ulex); and Clepsis consimilana Hubn. (Tortricidae), which was seen flying around Hippophaë in numbers at Spurn Point, Yorkshire, and at Deganwy. Three leaf-mining species also occur occasionally on Hippophaë in Europe (Hering 1936), but in this country they have been recorded only on other plants; they are Bucculatrix crataegi Zell. (Lyonetidae), Nepticula ignobilella Staint. (Nepticulidae) and N. pygmaella Haw. Two species of Heteroptera which occur in Hippophaë stands on sand dunes, but do not necessarily feed on this plant, are Emblethis verbasci F. (Lygaeidae) (Southwood and Leston 1959) and Sciocoris cursitans F. (Pentatomidae). The latter is recorded from sand dunes

and chalk areas in this country, but the food-plant is unknown; however, van Heerdt and Bruyns (1960) in an interesting study of the fauna and flora of Terschelling showed that this species fed on the roots of various low plants in the Hippophaë phase of succession.

Another phytophagous species in Vasates tibialis Liro. (Acarina; Eriophyiidae) which has been recorded only in Finland (Liro 1943). A weevil occurs in France.

In addition to these species there are numerous predatory species, parasites, and those feeding on the bark flora, as well as the ground-dwelling species. Very little information is available on the synecology of the Hippophaë fauna. Dr. M. Cotton (University of Dundee) is working on the arthropods associated with Hippophaë at Tentsmuir Point National Nature Reserve, Fife.

2. Birds

The ornithological interest of Hippophaë scrub arises from its use by birds for nesting, feeding, roosting and taking cover. The species and numbers of birds are considerably influenced by the stage of succession of the scrub. The berries produced in autumn and winter may be an important food source, especially for migrant birds, while other species feed principally upon the insects living on the scrub. The difference between taking cover and roosting is not always clear, but generally birds that are sheltering from possible predators are taking cover, while sleeping birds are referred to as roosting. Roosting may be communal as in starlings, and a roost of this species in Hippophaë has been observed at Towyn Burrows, Carmarthenshire.

During a study of the birds breeding at Gibraltar Point, Williamson (1967) observed that, as the young Hippophaë scrub colonising the seaward ridge of the dune system reached a height sufficient to provide song posts, the reed bunting appeared, with occasional specimens of linnet and partridge. Later as clumps of buckthorn grew to form thickets, the whitethroat and dunnock appeared; the whitethroat was probably the first coloniser because it required a territory size of only about 0.25 ac (0.10 ha) compared to the 0.5 ac (0.20 ha) for dunnock. Later, sedge warblers and pheasants appeared, and in taller and more varied shrubby growth with elder, blackbirds, song thrushes and turtle doves occurred, with blue tits if there were nest holes in the older elder. These elder stands often provided cover for predators like magpies and foxes. In the more mature woodland type of scrub, chaffinch and wood pigeon appeared, and another species recorded was the bullfinch.

Taken overall, very high numbers of breeding birds were found in Hippophaë, many probably feeding on the associated insects. Thus in 86 acres of Hippophaë and Sambucus some 263 pairs of the four commonest species, whitethroat (the dominant species with 1.0 pairs per ac), dunnock (0.8 pairs per ac), linnet (0.7 pairs per ac) and reed bunting (0.5 pairs per ac), occurred together with 109 pairs of other species.

At Spurn, B.R. Spence (pers. comm. 1970) noted many dunnocks in Hippophaë as well as starlings and house sparrows. There were also a number of warblers such as the willow warbler feeding in the scrub during migration in August.

Other birds reported as breeding in mixed scrub with Hippophaë at Burnham-on-Sea, Somerset, by Holt (1958) were crow, robin, wren, greenfinch, nightingale, chiffchaff, grasshopper warbler and blackcap.

The fruits and seeds may be a very important supply of food to birds. Birds are concerned in seed dispersal, and Groves (1958) used a category of "bird sown" on his map of the distribution of Hippophaë (Fig. 2).

At Burnham-on-~~Crouch~~ Sea, Holt (1958) observed that birds ate the berries during dry spells from July until the following March, by which time the berries had become rather dried out. He observed crows, rooks, magpies, jackdaws, starlings, fieldfares, redwings, mistle thrushes, song thrushes and blackbirds swallowing the berries whole. At Gibraltar Point, Goddard (1949) found hooded crows eating Hippophaë berries and found as many as 68 seeds in one pellet. The seeds from the pellets germinated well.

Fieldfares are one of the commonest species feeding on the berries, and Hope Jones (1962) studied a flock of some 150 of this species at Newborough Warren. They were accompanied by a few redwings, song thrushes and mistle thrushes and were feeding on Hippophaë berries in January after several days of hard frost and snow. Many of the birds were starving and, during the frost and just after, some 10-20 per cent died or were caught by predators such as carrion crows. (A hen harrier and possibly a merlin were also observed.) When the weather improved, the fieldfares could feed on the berries and starvation was no longer a danger. Similarly at Spurn Point, Spence (pers.comm.1970) noted many fieldfares; in November the numbers rose from 100 to 2,000. They remained on the peninsula until all the berries were gone. In colder weather blackbirds and starlings with a few blackcaps and other species also tended to move into the Hippophaë area.

Finches, such as chaffinch, brambling and greenfinch, are found eating the seeds only, and this they do by working their bills scissorwise, ejecting the fleshy part of the berry at the side of the bill (Holt 1958). They have also been seen feeding on the seeds expelled in the droppings of other birds (Spence pers.comm. 1970).

A picture of the use of Hippophaë by birds on one particular site was compiled from observations at Ainsdale NNR, Lancashire, by R.N. Boston (Table 2). Quite a few of the species taking cover also nested or fed in the scrub, but some, such as the pheasant, water-rail, chaffinch, goldfinch, and starling, were only using the plant for sheltering.

3. Mammals

There is very little known specifically about the mammals of the Hippophaë phase of the dune system, although one species, the rabbit, is apparently very important in controlling the spread of the plant. Local increases in Hippophaë on dunes can often be dated back to the disappearance of rabbits after myxomatosis. There is surprisingly little information on this important aspect of the biology of Hippophaë and apparently no estimate of the numbers of rabbits required to control the spread of the plant has been made. There is some evidence that rabbits are recovering in sufficient numbers to have some impact on Hippophaë again; thus Ranwell (pers. comm. 1970) has noted that the sharply defined seaward edge of Hippophaë at Gibraltar Point is associated with locally intense rabbit-grazing. Hippophaë becomes a last refuge for rabbits, and in East Lothian thick stands have to be cut to keep clumps narrow enough for dogs and men to get at the rabbits (F.P. Tindall, in litt.). Horses and sheep are also known to graze on Hippophaë and to shelter among the thickets of dune scrub.

Fox earths have been seen in Hippophaë and Sambucus stands. Williamson (1967) noticed them at Gibraltar Point and saw the remains of rabbits and of birds including shelduck and pheasant. Foxes ranged over the salt marsh and shore, preying on eggs and young in little tern colonies at night.

Deshmukh and Cotton (1970) have done some work on the small mammals of the dune system including Hippophaë stands at Tentsmuir Point, Fife. They consider that Hippophaë is important in the establishment and survival of small mammals on dune systems, and in fact they recorded their biggest catches in Hippophaë stands. The commonest species was Clethrionomys glareolus

Schr. Apodemus sylvaticus was common, and it was also found in the marram tussocks of the dune ridge, where it was the only species recorded; however, it did not occur in the woodland habitats. Sorex araneus was also collected, but only one specimen of Microtus agrestis was caught. Goddard (1949) noted that seeds of Hippophaë were removed by Apodemus sylvaticus and Microtus agrestis at Gibraltar Point.

CHAPTER 4

HIPPOPHAË AS A MANAGEMENT TOOL

Sources of information

Hippophaë has been used extensively by the Forestry Commission for sand stabilization, as a possible soil improver, and as a deterrent to public access in coastal plantations in Wales, but enquiries to the Conservator, North Wales, and the Research Liaison Officer and Librarian, Forest Research Station, Alice Holt Lodge, did not reveal any written information on the results of these uses. Further information may be obtainable from Foresters directly concerned with the practical use of Hippophaë at Newborough Warren, Anglesey, Pembrey, Carmarthenshire, and Tentsmuir, Fife.

Hippophaë has also been used extensively by East Lothian County Council in its long term programme of coastal dune conservation and restoration. Other bodies concerned with management of Hippophaë are golf clubs, River Authorities, Local Councils and private landowners, particularly in relation to dune stabilization or amenity plantings.

Dune stabilization

On the East Lothian dunes Hippophaë has been planted in extremely exposed situations to protect steep eroding windward sand faces which have been exposed by the wind and appear to be too steep and too mobile for planting with grass. It has also been used on lee slopes to check and slow down accretion which threatens to overwhelm low-lying land or golf courses lying to landward. It has proved extremely robust in growth on lee slopes, and at Gullane plants have continued to grow although successively buried to depths of up to 15 ft. (4.5 m) with only about 2 ft. (0.6 m) of uppermost shoots showing above the sand surface. In addition it has been planted to divert people from over-used areas.

In exposed situations plants have also done very well, although in extreme conditions of exposure they tend to be undermined and the roots dessicated (Plate 4, Photo. a). Cut plants have been used for "Dutch fences" on the foreshore to trap blowing sand and to heal coastal dune blow-outs, at Yellowcraig for example. Experience has shown that the cut plants do not burn freely and, unlike conifer brushwood (or creosoted timber fences as used at Ainsdale, Lancashire), are not taken for driftwood fires for beach barbecues.

PLATE 4: Photo. a: Hippophaë on eroding coastal dune. Wave undercutting causes stems to topple, bringing dense upper branching into a position to help protect the erosion face from direct wave-attack and to act as a trap for wind-blown sand in quieter periods. Berrow, Somerset. (Photo. by J.V. Morley)

Photo. b: Picnic hollows bulldozed out of dense Hippophaë scrub, with relict bushes providing shelter. Gullane, East Lothian. (Photo. by D.S. Ranwell)

Soil improver

Evidence given earlier demonstrates that Hippophaë acts as a soil improver on dunes both in the build up of nitrogen and the conservation of other essential nutrients. This was one of the reasons for its introduction at Newborough, Anglesey, by the Forestry Commission.

Shelter

Hippophaë is being opened up for sycamore and pine plantation on East Lothian dunes in the belief that in the end when these trees grow up and overshadow the Hippophaë they will provide effective coastal protection. Experience with plantations which have been infested with Hippophaë (e.g. at Yellowcraig) shows that the trees do in fact overtake and suppress it in about six to eight years.

Very effective use of Hippophaë has been made at Gullane, East Lothian, (Plate 4, Photo. b) to shelter picnic sites provided with attractive wooden tables and benches in the more landward parts of the dune system. Planting has been carried out around the edges of natural hollows and established scrub has been opened up with bulldozed pathways and recontoured to provide sheltered hollows among it. These additional recreational facilities help to relieve human population pressure on more wind-sensitive parts of the dune system.

Management of access

Elsewhere in East Lothian both dead and planted Hippophaë has been used to block up unauthorised walkways along the crowns of dunes and play cavities within the dunes. Dead plants have been found to be extremely useful for this purpose where immediate control is required and where it is not desired to develop live stands.

Aerial photographs reveal that a natural stand of Hippophaë at Camber, Sussex, has effectively diverted people from walking straight towards the shore. This has resulted in much improved survival of coastal dune vegetation immediately seaward of the scrub area.

Hippophaë has also been used as a deterrent to public access in dune forest plantations at Pembrey, Carmarthenshire.

Amenity planting

Hedge plantings are widely used in coastal public and private gardens both for shelter and amenity purposes. At Yellowcraig, East Lothian, an extremely well designed caravan park uses Hippophaë among other shrubs

for screening purposes.

Plants have been used successfully in inland sites, around service stations on motorways (M.C. Pearson, in litt.) for example. Possibilities also exist for use of Hippophaë as a crash cushion and anti-dazzle barrier on the central reservation of motorways. It has also been used on a rubbish and colliery waste tip at Dysart, Fife, (F.P. Tindall, in litt.) and on pulverized fuel ash.

Habitat diversification

One of the main options open to managers of dune systems is whether or not to allow the development of scrub or woodland at all. In the case of nature reserves the decision on this issue will depend on the management aims for the reserve or the different parts of the reserve. Encroachment of scrub is a feature of many dune systems at present, due largely to the ecological changes resulting from myxomatosis in the rabbit populations. The process can therefore be regarded for most purposes as a natural one and there is little doubt that in many such cases the habitat diversification produced by scrub patches can add to the scientific interest of the area. However, there are frequently parts of dune systems which contain localised plant communities. As these could be damaged or destroyed by scrub encroachment, it is unlikely to be allowed to proceed in a completely uncontrolled way on National Nature Reserves.

It is necessary to consider the part that Hippophaë might play in promoting habitat diversity. The main factors having a bearing on this are :-

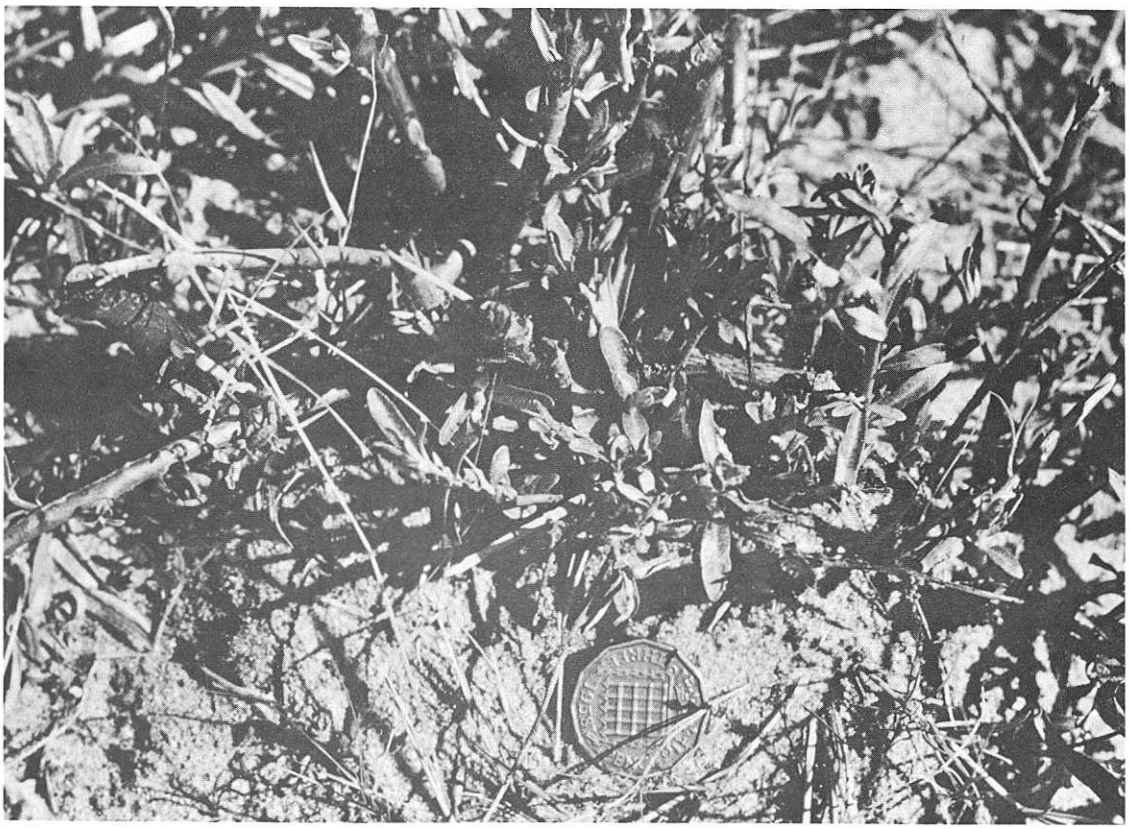
1. The degree of "naturalness" of the community produced.
2. The presence in the area of other communities which might be unexpectedly damaged by the production of Hippophaë.
3. The extent to which the introduction of Hippophaë might alter the balance of national and regional distribution.

The available evidence suggests that it is only on some of its east coast sites that Hippophaë is a native species and that elsewhere it has been introduced. It would, therefore, seem reasonable to assume that it is on the east coast sites that the most natural and interesting Hippophaë communities may develop if allowed to proceed to maturity. These east coast sites are nearest to the continental dune sites where interesting natural Hippophaë communities are known to occur. On the basis of

obtaining a spectrum of management policies towards Hippophaë on the national series of dune systems, it would seem advisable to allow the development of a habitat diversity through the maturation and spread of Hippophaë stands on some of the east coast systems. This would avoid the alteration to the national balance of distribution that might be caused if this policy were applied to some of the west coast systems where Hippophaë is more clearly a recent introduction. In these altered areas, the management of scrub encroachment for habitat diversification should involve some other woody species, probably Crataegus.

PLATE 5: Photo. a: Radial Section cut through Hippophaë colony, with oldest trees (maximum age 45 years) in foreground. Dundrum, Co. Down, Northern Ireland. (Photo. by R.E. Parker)

Photo. b: Regrowth from cut Hippophaë sucker growth, 6 weeks after cutting. Note that little regrowth occurs from cut standards; see Photo. a. Whiteford Burrows, Glamorgan. (Photo. by D.S. Ranwell)



CHAPTER 5

THE CONTROL OF HIPPOPHAË

Distribution of seeds by birds feeding on the berries has been observed to cause rapid spread of Hippophaë in calcareous dune systems when plants of both sexes are present. Vigorous growth and vegetative spread enables it to dominate most other vegetation except for over-shadowing trees or scrub. In Britain it is not generally controlled by competition from other native flora or fauna. In consequence it can only be kept under control by management, unless uncontrolled expansion is to be accepted. In some situations eradication may be preferable to control. When introducing Hippophaë to a dune system for a specific management purpose, a long-term control policy will be necessary to contain it within the bounds of fulfilling that purpose.

A number of issues will have bearing on the selection of a control method for a particular situation :-

1. Whether eradication or long-term control is to be the aim.
2. What form of maintenance will be needed to hold the degree of control desired.
3. What impact the control methods have on the associated flora and fauna and on the physiography of the dunes.

The relative merits of the various control methods in connection with these points are summarised in Table 3.

If complete removal is to be carried out, this valuable opportunity to obtain information on the structure and composition of the community and intrinsic characters of Hippophaë, e.g. age, sex ratio, depth of roots, degree of root nodulation, shoot density, standing crop, etc., should be made available to interested research workers.

Control methods

Machine mowing

East Lothian County Council mow regularly along the edges of Hippophaë hedges and stands to control rhizome spread. Rotary cutting machines are used on caravan sites and flail type mowers on rougher ground. This has proved effective in preventing the development of suckers and retaining the Hippophaë within its prescribed stabilising and sheltering functions.

At Gibraltar Point rides have been cut through sparse Hippophaë by an oscillating cutter bar machine, and are re-cut periodically. Sporadic regrowth of suckers has occurred. The ground flora was found to be grassing up and mosses were abundant. Cutting is also in progress at Dundrum, Co. Down, Northern Ireland (Plate 5, Photo. a).

Mechanical uprooting

At Gibraltar Point a bulldozer has been used to clear rides through dense Hippophaë scrub. This uprooted the bushes which were pushed into heaps and left to rot down, which they did fairly quickly. The result in terms of re-establishment of grass and herb communities was quite impressive but the method was not considered very satisfactory. The bulldozer caused considerable damage to the surface and much manual work had to be done in clearing the stumps and levelling the ground. Investigations are to be carried out into the use of machinery of the rotary saw head type.

Ploughing

In East Lothian, where Hippophaë has been used for agricultural hedging purposes for over 25 years, regular ploughing along the margins of windbreak hedges etc. has kept it under control.

Hand cutting

At Whiteford Burrows a power saw was used to fell mature stands and secateurs and pruning shears were used to cut smaller bushes. No regrowth occurred from mature stands (3 m high) and little from medium sized (1-2 m high) bushes, but the majority of smaller plants continued to produce suckers after cutting (Plate 5, Photo. b).

At Gibraltar Point about 0.6 ha of dense standard growth was cleared by hand in 1969 by Army personnel. A year later there was no sign of significant regrowth from the cut standards or of seedling regeneration. However, an area of sparser Hippophaë which had also been cleared was showing some sucker, as opposed to standard regrowth. Most of this had been topped but not killed by rabbit grazing.

In East Lothian it was found that axing was not effective, and the solution adopted was to pull out the roots. This proved largely successful although some regrowth occurred which was dealt with by chemical means.

Hand pulling

At Whiteford Burrows it was found that the regrowth which occurred after small plants had been cut could be pulled by hand, as it was still soft and

had not developed thorns. However, when all the suckers which had developed in this way had been removed by hand it was found that regrowth was still occurring.

Hand pulling of sucker shoots is more lastingly effective if horizontal roots are first chopped into sections with a spade at margins of invading stands.

Chemical application

a) Foliar sprays

East Lothian County Council have hand-sprayed a brushwood herbicide mixed with diesel on sucker regrowth and found it entirely successful.

The Forestry Commission used 2, 4, 5-T in water as a foliar spray at Newborough Warren and obtained good results, but have now suspended its use pending investigation of its possible teratogenic effects.

The Weed Research Organisation of the Agricultural Research Council report that a summer foliage spray of 2, 4-D at 2 to 4 lbs/ac (2.25 to 4.5 Kg/ha) in water is still one of the cheapest and most generally effective treatments for the control of woody species, and they expect that this would be true for Hippophaë. The herbicide 2, 4, 5-T is also known to be particularly effective for control of woody growth and may be used as an emulsion containing 2 parts of 2, 4, 5-T to 1 part of 2, 4-D (low volatile ester). Oil can also be used as a dilutant and is a better carrier than water. Sprays should be applied after maximum leaf development until the end of the growth period (July and August). Treated growth should not be cut until dead, or regrowth from stumps may occur. Ammonium sulphamate, a contact and translocated arboricide, is also likely to be effective, but it is more expensive, corrosive, and persistent in the soil (3 to 4 months), than 2, 4-D or 2, 4, 5-T.

b) Basal bark treatment

This method is useful on trees and other small shrubs. The bark is sprayed thoroughly to a height of 1 to $1\frac{1}{2}$ ft. (0.3 to 0.45 m) with 2, 4, 5-T and oil as a carrier. This method must be used in dry weather on dry stems. The best results are obtained in January to early April, though successful results

can be obtained at any time of year.

c) Stump treatment

At Newborough Warren the Forestry Commission have used 2, 4,5-T in diesel on stumps to prevent regrowth.

At Whiteford Burrows some cut stems (2.5 to 7.5 cm in diameter), were treated with 2, 4, 5-T applied carefully using a small brush. In this particular case the effect could not be assessed as neither treated nor untreated stumps were found to produce regrowth. Presumably they were the stumps of mature standards, which give little or no regeneration anyway when cut.

Stump treatment is best carried out in February to March or May to September. Ammonium sulphamate can be used as an alternative to 2, 4, 5-T and either one can be sprayed or painted on. The stumps should be treated within 4 weeks of cutting.

Burning

Accidental fires have been observed to kill thicket Hippophaë at Ainsdale and at Gibraltar Point. At Ainsdale the dead, bleached standards are still present 10 years later. Thickets too large to be dealt with by other means could be eradicated by controlled burning during summer months (subject to permission being obtained from the County Agricultural Executive Committee), but this would raise questions about effects on other wild life, and clearance of the fire remains would be desirable.

Biological control

At Gibraltar Point and Ainsdale rabbit grazing has been observed to stunt the growth of suckers and young plants, but it does not kill them. Although rabbits probably restrained the expansion of Hippophaë before myxomatosis, their numbers are generally no longer adequate to have any significant effect.

A defoliating insect or disease-producing organism specific to Hippophaë might well prove effective, but there have been no organised developments in this field as yet. Moth larvae (Malocosoma sp.) have been known on occasions to cause severe defoliation at Gibraltar Point.

Prevention of fruiting

The main factor responsible for rapid expansions of Hippophaë is believed to be dispersal of seeds by birds feeding on the berries. The species is dioecious and wind-pollinated, and where both sexes are present

nearly all the fruits contain viable seeds. If fruiting could be prevented propagation would be confined to the slower process of vegetative expansion of existing thickets, and control would be easier.

It appears that where Hippophaë has been introduced female plants have often been preferred, possibly because of their attractive appearance when laden with orange berries, but enough male plants to effect pollination are usually also present. In East Lothian where there are very extensive female thickets fruiting seems to be confined to the vicinity of a few male plants. Presumably therefore where male plants are in the minority the spread of seedlings could be halted by a selective cull of the male plants. An all female, non-fruiting population would remain something of a potential hazard in that the self-seeding of male plants or the blowing in of pollen from plants outside the area of control might initiate fruiting. Both male and female plants become sexually reproductive while still quite small.

Where Hippophaë is being considered for introduction to a dune system for the first time its management would be greatly facilitated if male plants only were used and any adventitious females were removed. Management could then be confined to the control of vegetative growth. The prevention of fruiting would of course deprive birdlife of a source of food and remove the chief aesthetic appeal of the species - the orange haze of autumn berries. These considerations would have to be weighed against the desirability of control.

Summary: Tactics

1. Introducing Hippophaë

Seedling production (and therefore control commitments) could be reduced if fruiting were prevented by introduction of one sex only. A long-term control policy of some sort should accompany introduction, unless uncontrolled expansion is to be tolerated.

2. Controlling or eradicating established Hippophaë

There is a marked difference in the response of standards and suckers to cutting by hand or machine. Whereas little or no regeneration occurs from standards, suckers and young plants respond by vigorous regrowth and will require continual recutting unless killed by chemical means. Regular mowing around margins can be used to retain thickets within desired limits. Where it is desirable to reduce the area of existing thickets labour could be economised by concentrating

the attack initially on areas of standards which are not likely to regenerate. It may be preferable to allow the surviving peripheral suckers to develop to the non-regenerating standard stage before cutting them.

The continual establishment of seedlings may undermine attempts to contain or reduce Hippophaë populations. In this case the primary control method may need to be supported by selective cull of one sex to reduce fruiting, or by hand pulling of the seedlings.

CHAPTER 6

MANAGEMENT OPTIONS FOR *HIPPOPHAË*

Many considerations have to be taken into account in the formulation of management policies for *Hippophaë* on dune systems and the emphasis given to each of the different possibilities will vary greatly from one dune system to another. In this account attention will be focused on the development of management policies for National Nature Reserves and other areas of outstanding natural interest, where the *Hippophaë* management policy will be largely determined by the over-all policy of habitat conservation within the area, but it should be borne in mind that ultimately this can only be done satisfactorily within the framework of a comprehensive national policy which takes into account the whole range of *Hippophaë* habitats.

Types of situation

There are two fundamentally different situations within which *Hippophaë* management policies can be formulated. First, there is the situation in which *Hippophaë* is at present absent from the area but there is a need to have an anticipatory policy on whether a) to prevent the establishment of *Hippophaë*, b) to allow its establishment, or c) to promote its establishment. Secondly, there is the situation where *Hippophaë* is already present in the area and the policy for management has to decide a) to allow the natural development of the colonisation process, b) to control and manage the process, or c) to eradicate *Hippophaë* from the area. The range of management options is illustrated in Table 4.

Policies where *Hippophaë* is at present absent

There would seem to be no reason why *Hippophaë* could not become established on all or nearly all sand dune National Nature Reserves in Britain. There is therefore need to anticipate the arrival of *Hippophaë* on dune systems where it does not already occur with a definite policy as regards the steps to be taken if seedlings of the species appear. In the first place it is necessary to decide whether the establishment and subsequent spread of *Hippophaë* is acceptable in terms of the over-all management objectives for the Reserve. In other words will the spread of *Hippophaë* irreparably damage the particular ecological system that it is desirable to conserve on the Reserve?

An adequate policy on this issue can only be developed within a national frame-work. If the aim of the series of sand dune National Nature Reserves is to conserve representatives of the full range of communities presently characteristic of sand dune systems, then clearly the uncontrolled spread of Hippophaë to all or most of these systems could seriously reduce the range of communities represented.

The situation is rendered complex by the status of Hippophaë in the British Flora. Thus on parts of the east coast of England it is almost certainly a long established "native" species; elsewhere, as in parts of eastern Scotland or North Wales, it is clearly a recent introduction. However, there are many intermediate situations where the history of introduction is obscure, and there is reason to believe that the establishment and spread of the species has been a "natural" process, not directly aided by man.

There would, therefore, seem to be four alternative policies for areas to which Hippophaë may possibly spread :-

1. Prevention of establishment or, more practically, eradication in early stages of establishment, in those areas where the establishment and spread of Hippophaë would cause an unacceptable change in the extent and distribution of ecological systems which it is wished to perpetuate in a relatively unchanged state - e.g. "type" examples of particular plant communities forming part of a series within the dune Nature Reserve complex.

   Before this policy can be formulated in detail it is necessary to define these ecological systems within the context of the national series of dune communities.

2. The establishment of Hippophaë to be allowed, but the subsequent spread limited to those parts of the dune system where the ecological changes resulting would be acceptable - e.g. communities which are well represented elsewhere and are therefore expendable and/or where the conservation value is enhanced by the establishment of Hippophaë.

3. The establishment of Hippophaë and the subsequent spread to be allowed to take its course as an ecological experiment. This is a policy of rather limited application now that the situation already exists on so many dune systems.

4. The deliberate introduction, usually followed by control of

Hippophaë to change the area for management purposes - of rather limited application with National Nature Reserves, but an important possibility elsewhere.

Policies where Hippophaë is already present

Because of the general impracticability of eradicating Hippophaë from an area once it is well established, it would appear necessary to approach the problem of formulating management policies on the basis of an initial dichotomy into areas where the Hippophaë is in an early stage of colonisation and those where it is already well established.

A. Areas of initial colonisation

Three alternatives present themselves :-
1. Eradication.
2. Control.
3. No control.

. Eradication

As pointed out above, there will be places where the spread of Hippophaë into a dune system will be unacceptable because the changes to the ecology of the area would cause a loss in variability within the pre-chosen range of representative habitat types. Both in this case, and also where there is major uncertainty as to the course that colonisation will take, there is a good case for attempting complete eradication on the basis that this could always be modified to a Hippophaë control scheme later but that the chance of eradication will probably not present iself again. However, it must be noted that eradication is not a once-and-for-all process on a dune system open to Hippophaë invasion and there must be a continual process of seedling removal and destruction of young plants before they reach the seeding stage.

2. Control

This is likely to be the policy adopted where the main areas of interest are not subject to unacceptable change due to Hippophaë colonisation and also where it is recognised that the addition of Hippophaë results in a beneficial change, e.g. greater habitat diversity.

3. No control

This is a policy which is of limited application within National Nature Reserves, except in selected situations where it is desired to follow the "natural" course of the spread and development of Hippophaë communities. However, there are some Reserves where it is necessary to follow such a policy.

B. Areas where Hippophaë is well established

Here the options are :- 1. Control.
2. No control.

Control

The factors that are likely to play a part in determining policy here are :-

a) the intrinsic interest of those parts of the susceptible areas remaining uncolonised;

b) the intrinsic interest of the developing Hippophaë communities;

c) the feasibility of control and whether the disturbance due to the control measure is acceptable.

No control

This may be a desirable policy where the developing Hippophaë communities are of greater value than the communities they are replacing, but is unlikely to be followed except on a few carefully selected Reserves because of the risk of reduction in variety of habitat that it might entail.

Action

Each of the possible policies outlined above probably has a part to play in the range of situations found on dune systems in Britain. The application of a nationally based policy requires a detailed analysis of the individual site situations that would take some time to accomplish. The immediate essential is a satisfactory provisional policy which will allow flexibility in the future. The attempt has therefore been made, in the concluding chapter of this report and the accompanying appendix, to present recommended policies for the management of Hippophaë on National Nature Reserves and other selected dune areas within the framework of a provisional over-all national policy that is capable of revision as more detailed information comes to hand and as the situations themselves change.

CHAPTER 7

RESULTS OF A SURVEY

In order to obtain information on sites an enquiry was initiated by the Coastal Ecology Research Station. Nature Conservancy Regional Officers were asked to assist in obtaining information and completing the enquiry forms and the cards. The enquiry form (Fig.5) and card (Fig.6) illustrated are examples of the most informative ones received. Less easy to display here are the large-scale maps showing detailed distributions, e.g. on Spurn Point, which were sent in by the participants in the survey.

Seventeen replies were received: some referred to existing nature reserves, others to sites with Hippophaë.

The returns were about equally divided between no control and partial control, with two sites in Wales - Whiteford Burrows and Morfa Harlech - being considered suitable for eradication of the species.

Control measures have been tried at seven sites. Cutting and uprooting have been favoured methods with some positive effect. Burning, mainly accidental, of mature stands showed little regeneration but was not effective on young stands. Stump treatment with herbicide, 2, 4, 5-T, was tried at Whiteford without success, but has been used successfully by the Forestry Commission at Newborough.

Effects from trampling or grazing were noted at six sites. Human trampling slows the spread outwards from bushes and helps to keep paths open, but it is not totally effective. Grazing by rabbits and hares was recorded, but no diminution of growth was reported.

In some places Hippophaë has been planted to stabilize sand with considerable effect. It is also planted in game preserves and to deter trespass. However, in most places, it is now considered to exceed the purpose for which it was planted. This is due to lateral spread from the original plantings, resulting in too great an area being covered by the plant. At eleven sites it was considered to be actively spreading, and at five to be dying back or maintaining itself.

Nine reports indicated that it favoured wildlife. It had been noted at several sites as providing shelter for foxes and rabbits, and some studies are being made of small mammal populations found beneath it. At many places it provides shelter for migrant birds and the berries are eaten by many species. The invertebrate fauna of both the plant and its litter

Fig. 5: Specimen form accompanying survey card used in *Hippophae* Enquiry

HIPPOPHAE ENQUIRY FORM

Please return completed form to D.S. Ranwell, Coastal Ecology Research Station, Colney Lane, Colney, Norwich by May 31st 1970. Thank you.

Site Name/Grid Reference Tentsmuir Pt. and area

County Fife

Observer's name and address
Malcolm Smith (Senior Warden Tentsmuir Pt. NNR)

Control 1) Is control considered desirable?

Delete as appropriate ~~Eradication~~ Partial control ~~No control desired~~

2) Have any of the following control measures been tried, and with what degree of success? Herbicides, growth retardants, cutting, stump treatment, uprooting, mowing, burning, ditching, biological control (or any others).

Delete: Yes/~~No~~. Details if Yes: (and in subsequent questions)

A programme of cutting and uprooting started August 1970.

3) Is the *Hippophae* affected, and if so in what way, by stock grazing, rabbit grazing, or trampling (human or stock)?

Yes/~~No~~. Probable grazing by rabbits and hares, both of no significance.
A certain amount of trampling by Dundee Univ. staff in their experimental area.

Use 1) Has *Hippophae* been planted on the site to fulfil a purpose (e.g. coast protection, sand stabilisation, shelter belt, screening, controlling the public, etc.), and if so to what extent has it proved effective?

Yes/~~No~~. Originally planted by F.C. in section between Kinshaldy ~~Kinshacoy~~ Burn and Earlshall S.S.S.I. for coast protection. Not effective. This section of coast has suffered severe erosion recently - profiles showing root systems on vertical dune faces photographed.

2) Does its extent now exceed the purpose for which it was planted? Yes/~~No~~. Is it actively spreading? Yes/~~No~~.

Rapidly on Reserve within last 4 years.

Wildlife 1) Has *Hippophae* any special significance as a wildlife habitat on the site, and if so what?

Yes/No. Not yet known, but experimental work on small mammals and invertebrates in progress.

2) Is there evidence of plants or animals lost by spread of Hippophaë?

Please name species. Yes/~~No~~. Juncus balticus area in 1962 extension of Reserve being invaded.

3) Is there evidence of other species behaving invasively in association with Hippophaë?

Please name species. Yes/~~No~~ Salix spp., Betula sp.? spp.? and Alnus glutinosa are increasing rapidly in the slack areas, and have done so (subjective observation) coincidentally with the spread of the buckthorn in the last 4 years. (But the slack in the North part of the Reserve is losing its salinity owing to accretion of sand building over all former tidal breaks.)

HIPPOPHAE SURVEY	SITE	COUNTY
	HOLME-next-the-Sea	NORFOLK

DATE OF SURVEY	OBSERVER	GRID REFERENCE	ESTIMATE OF TOTAL AREA OCCUPIED BY HIPPOPHAE / MAX. HEIGHT
3.7.70	C.J.Beale	53/74	35000 sq.m / 3.75 m.

DATE OF EARLIEST KNOWN RECORD FOR SITE	DATES OF ANY KNOWN INTRODUCTIONS
-	-

SITE WITH FEW CLUMPS (E.G. LESS THAN 20)

CLUMP SIZES (E.G. TWO CLUMPS 5×5 metres OR 2(5×5) metres)

The centre of clump X was 2 m high 5 years ago it is now the maximum i.e. 3.75 m.

SITE WITH MANY CLUMPS

PLEASE PLOT ON 6 INCH TO 1 MILE GRID OVERLEAF (LABELLING GRID LINES AND USING MORE CARDS AS NECESSARY):-

1) OUTLINE OF CLUMPS OF PLOTTABLE SIZE (>10 metres DIAM.)

2) AREAS (CROSS-HATCHED) WHERE HIPPOPHAE OCCURS AS SCATTER OF CLUMPS TOO SMALL TO PLOT (<10 metres DIAM.)

FOR ORGANISERS USE ONLY

ADDITIONAL DATA ON CONTROL/BIOLOGY AT C.E.R.S. NORWICH.	CARD NO

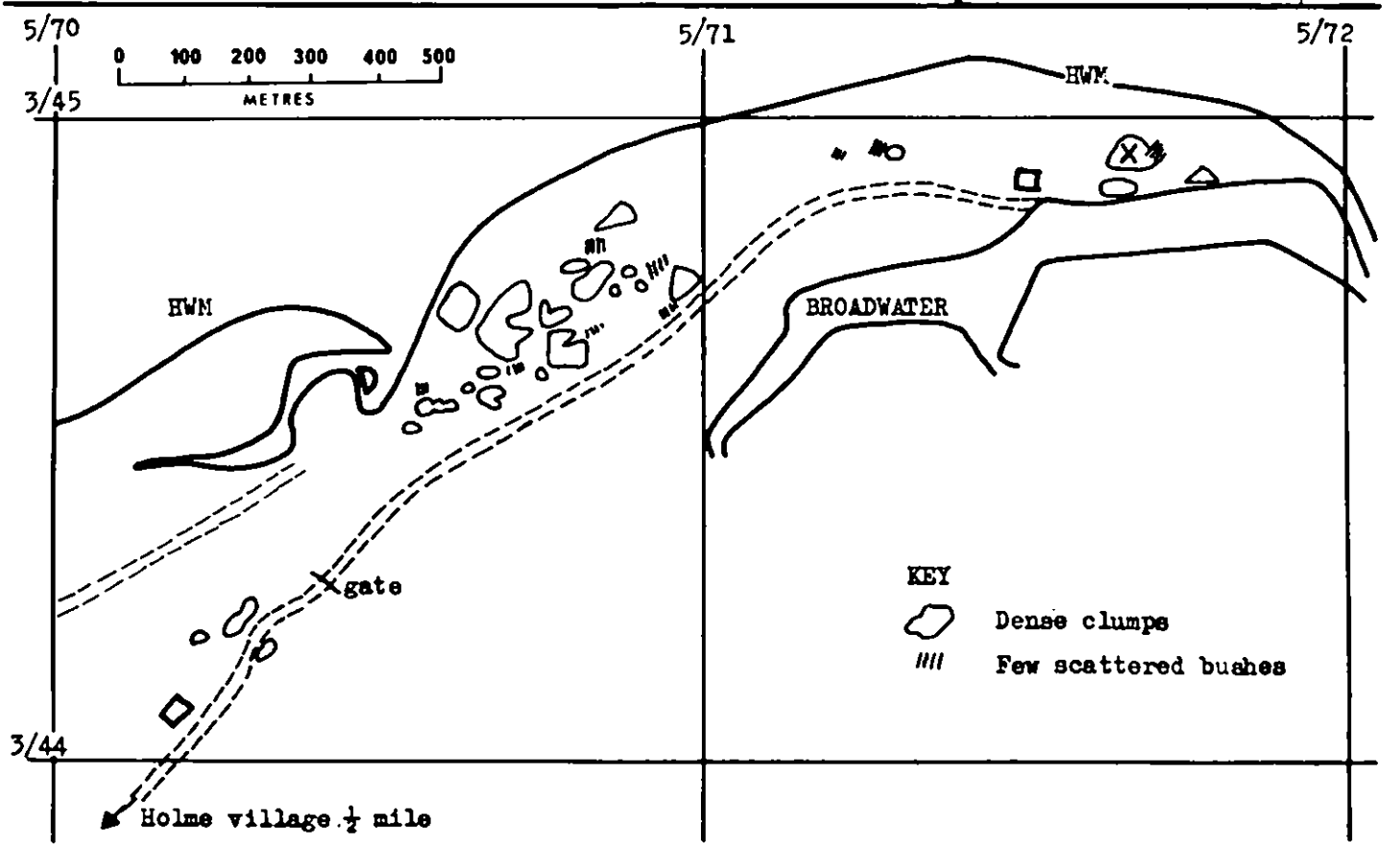


Fig. 6: Specimen survey card used for Hippophaë Enquiry

seems considerable, with insects and molluscs being especially noted. Lichens were found on the standing dead wood.

Only two reports considered that species had been lost through invasion of Hippophaë. This is possibly because the question was slightly ambiguous. If a species invades ground occupied by other species, then some of the residents will die out. However, if the invasion is local, the species crowded out will still be plentiful elsewhere on the system. Thus, generally speaking, participants in the enquiry interpreted the question as referring to extinction of species on the dune system rather than to species being shaded out locally. Hippophaë had eliminated species of open and semi-fixed Ammophila dunes at Holkham, where it covers a wide range of habitat. However, at Tentsmuir, an area containing Juncus balticus is being invaded and the extinction of a local species could result.

Six returns reported other species behaving invasively with Hippophaë. Tree species seem to be the most frequent invasive plants. Betula spp., Salix spp., Alnus glutinosa and Pinus spp. have been recorded. Rubus fruticosus is mentioned in some reports, and one writer suggests Rubus might invade where Hippophaë has been burnt. Chamaenerion angustifolium also occurs frequently. There were single reports of Clematis vitalba and Montia perfoliata being more common in association with Hippophaë.

The location of sites for which returns have been received have been plotted on a map (Fig.7) and are shown with a symbol indicating the management policy thought desirable by the participant. On most west coast sites some control is thought desirable, and on two Welsh sites eradication is thought both desirable and possible.

The sites mapped are numbered as follows :-

1. Nigg Ferry
2. Tentsmuir
3. Spurn Point
4. Holkham Dunes
5. Winterton Dunes
6. Dungeness
7. Chichester Harbour
8. Braunton Burrows
9. Oxwich Dunes
10. Whiteford Burrows
11. Bosherton

12. Morfa Harlech
13. Newborough Warren
14. Ainsdale Sand Dunes
15. Ardpatrick

The discrepancy with the total of 17 returns (see above) is due to the fact that one site is covered by two returns and one return covers a stretch of coastline.

List of sites showing distribution of Hippophaë rhamnoides

The data presented (Table 5) are partly derived from the Hippophaë Enquiry. Only sites with sand dunes are included. Some coastal sites with Hippophaë are therefore omitted.

Where the plant is marked "present" under "Status", it means that the return was received as a result of the enquiry. Where marked "absent", the plant was returned as absent from the site and no Biological Records Centre (B.R.C.) record was known from that area. This gives quite an accurate picture for England and Wales. However, Scotland is less well-known and, where there is a B.R.C. record for the 10-Km square, this is noted.

Where possible the acreage of Hippophaë present has been included and likewise the maximum height. However, where information was less precise, broad categories of less than 1 acre, 1 - 5 acres, and greater than 5 acres have been used. Generally, where reliable measurements of the area are available, these are accompanied by reliable measurements of height.

The dates of first records are mainly derived from B.R.C. data, which are mainly based on the work of Groves (1958). The earliest records date from the 1660's, when Hippophaë was recorded as plentiful on the east Kent and Lincolnshire coasts.

Judgements on susceptibility to invasion are based on available knowledge of the sites and the known fact that Hippophaë is much more vigorous on calcareous sites.

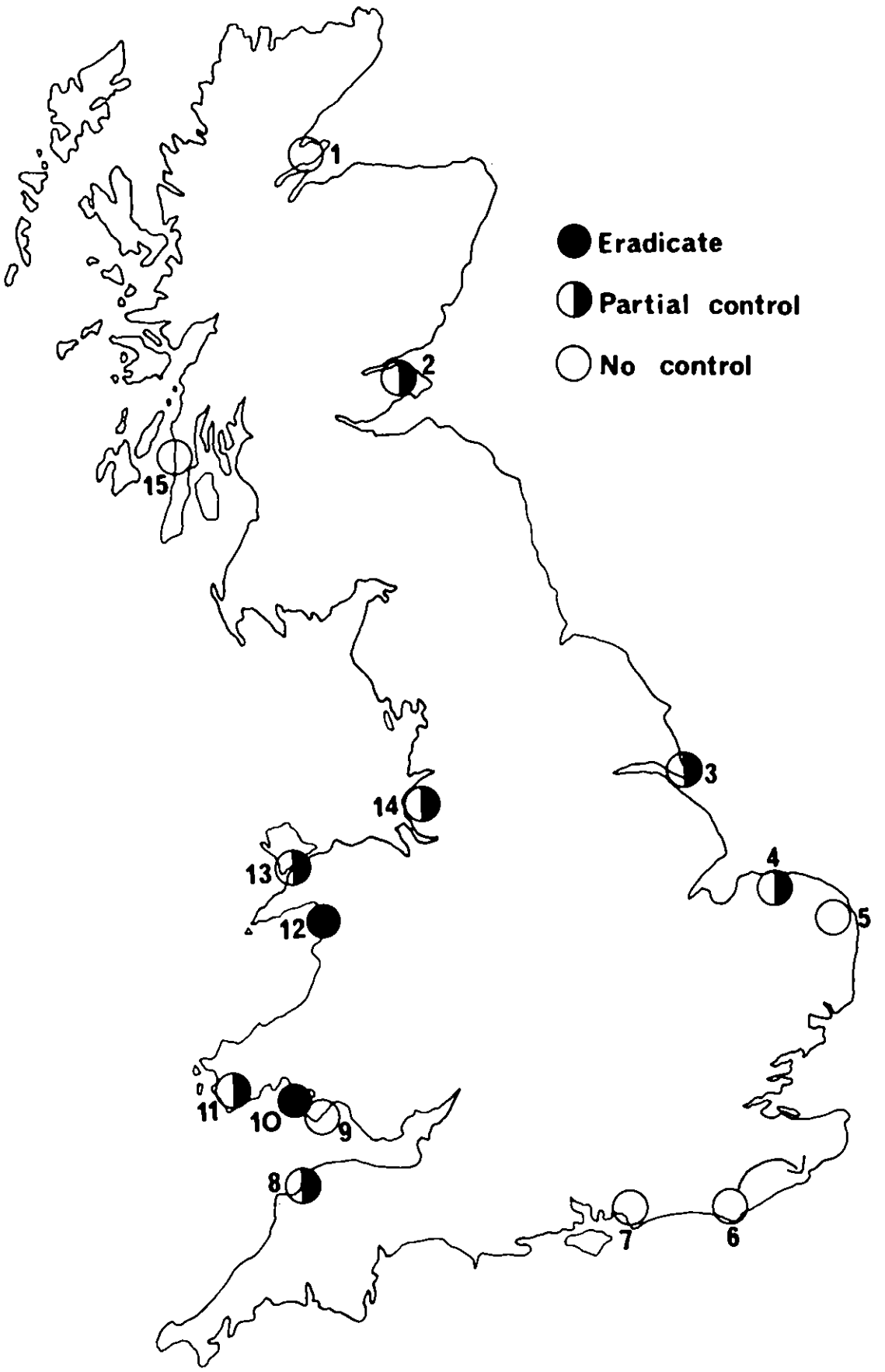


Fig. 7: Management proposals put forward by observers who completed Hippophaë Enquiry Forms

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

The Hippophaë Study Group has considered the status of Hippophaë as a species within the British Flora, its autecology and ecology in relation to the other components of sand dune vegetation and associated flora. From these studies the Group has concluded that Hippophaë cannot be regarded simply as a pest species of sand dune systems but has considerable interest in its own right and can, in certain circumstances, contribute positively to the scientific interest of an area.

The Hippophaë Study Group therefore recommends that :-

1. The management of Hippophaë on coastal sites of scientific interest, including National Nature Reserves, should be according to a national rather than a regional or local policy.

2. Because of the highly invasive nature of Hippophaë in many dune systems, it is necessary to have an anticipatory policy on those dune systems where it does not yet occur. In most circumstances of this type, relating to sites of high scientific interest, the aim of management should be to prevent the establishment of the species by uprooting the seedlings at an early stage. This policy is recommended as the one which allows for future options and because there are already a high proportion of Hippophaë-invaded dune systems.

3. In those dune systems where Hippophaë is already established a useful distinction can be made between cases where the establishment of the species is at an early stage and where its extermination or control is still a practical possibility and those cases where the species is well established and where its extermination is impracticable and/or undesirable because of the cost or disturbance involved.

4. In dune systems where the establishment of Hippophaë is at an early stage, unless there are very good reasons to the contrary, the management policy should aim to eliminate the species.

5. In dune systems where Hippophaë is well established, no attempt should be made to eliminate the species, but it should be controlled so as to maintain habitat diversity within the dune system. In these situations a proportion of the stands should be allowed to develop naturally to maturity.

6. The Management Plans of all coastal sand dune Reserves should contain a section setting out the management policy in relation to Hippophaë.

7. The policy contained in the Management Plans for Nature Reserves should conform to the policies outlined in the appendix of the final approved version of the Study Group's report.

8. Further study should be made into the ecology of Hippophaë on sand dune systems and in particular into the ecology of mature and old Hippophaë stands.

9. Plans for large-scale clearances of Hippophaë should be brought to the notice of appropriate research workers who could take advantage of such opportunities to obtain population data.

Table 1 Hippophaë rhamnoides - recorded ranges of some soil properties

	Soil Factor	Min.value	Site	Author	Max.value	Site	Author
	pH (water)	5.9	Winterton, Norfolk		8.2	Wassenaar dunes, Netherlands	
% dry wt. of soil	Organic matter	0.5	Wassenaar, Netherlands		10.4	Aberlady	
	Total Nitrogen	0.009	Camber, Sussex		0.142	Gibraltar Point	
	Total Phosphorous	0.02	Wassenaar, Netherlands		0.03	Wassenaar	
m.e. per 100 gm oven dry wt. of soil.	Sodium	0.023	Aberlady, East Lothian		0.169	Sandy Hirst	
	Calcium	0.102	Gibraltar Point, Lincolnshire		0.372	Sandy Hirst	
	Potassium	0.043	Camber, Sussex		0.071	Sandy Hirst	
	Iron	0.00017	Gibraltar Point, Lincolnshire		0.004	Sandy Hirst	
	Chlorine	0.091	Gibraltar Point, Lincolnshire		0.141	Gibraltar Point	

1. Boerboom (1963)
2. Pearson and Rogers (1962)
3. Ranwell (1970 - in litt.)

Table 2 Sea buckthorn as used (x) by various species of birds in Ainsdale Sand Dunes National Nature Reserve

SPECIES	NESTING	FEEDING		ROOSTING	COVER	PERIOD WHEN USED
		FRUIT	INSECT			
MALLARD						MARCH - JULY
PHEASANT					x	THROUGHOUT YEAR
WATER RAIL					x	NOVEMBER - APRIL
MOORHEN	x (FRINGE)					THROUGHOUT YEAR
TURTLE DOVE	x					MAY - JULY
WREN	x					THROUGHOUT YEAR
DUNNOCK	x					THROUGHOUT YEAR
SEDGE WARBLER						APRIL - AUGUST
BLACKCAP						JANUARY - FEBRUARY
WHITETHROAT	x (FRINGE)					APRIL - AUGUST
WILLOW WARBLER	x (FRINGE)					APRIL - AUGUST
GOLDCREST						THROUGHOUT YEAR
ROBIN	x (FRINGE)					THROUGHOUT YEAR
FIELDFARE						OCTOBER - FEBRUARY
BLACKBIRD				x		THROUGHOUT YEAR
REDWING				x		NOVEMBER - FEBRUARY
SONG THRUSH				x		THROUGHOUT YEAR
COAL TIT						THROUGHOUT YEAR
BLUE TIT						THROUGHOUT YEAR
GREAT TIT						THROUGHOUT YEAR
CHAFFINCH				x		OCTOBER - MARCH
GOLDFINCH				x		OCTOBER - MARCH
GREENFINCH				x		THROUGHOUT YEAR
BULLFINCH				x		THROUGHOUT YEAR
LINNET				x		THROUGHOUT YEAR
STARLING				x		OCTOBER - MARCH
MAGPIE						THROUGHOUT YEAR
TOTAL BIRD SPECIES USE	10(14)	10		11		

Table 3 Relative merits of control methods for Hippophaë

METHOD	APPLICATION	LIMITATIONS
Machine mowing	Can be used on the vegetative margins of thickets to keep stands within existing limits, if systematically applied. Also effective on re-growth in cleared areas.	Applicable only in sites where effects on associated species are approved. In dune communities tending to be dominated by woody species in general this treatment would favour herbaceous species, which could be advantageous.
Mechanical uprooting	A gross method for dealing with major thickets.	Only applicable where damage to the terrain is not considered important. Restoration work and further treatment to deal with re-growth from underground portions which have escaped excavation may be required.
Ploughing	A convenient method of preventing invasion where Hippophaë is used for windbreaks and hedges adjacent to fields.	Only applicable in agricultural situations.
Hand cutting	The most practical and least disturbing method for dealing with standards; little regrowth occurs, there is very little damage to the terrain, and the aerial parts are removed in the operation (cf. chemical methods and burning).	Effective on standards, but, if applied to plants in a state of active vegetative re-growth, the response will be vigorous re-generation, necessitating further action.
Hand pulling	The only truly selective method for dealing with seedlings and sucker regrowth, without damage to associated species or to the terrain.	Can only be applied to young growth: seedlings and sucker regrowth. Further regeneration from suckers will follow and treatments must be maintained until the underground system expires.
Foliar sprays	Can effect eradication of sucker regrowth in one application. Also effective on vegetative margins and small bushes.	Single treatment is not always effective and regrowth from roots or stems may occur. Dead woody vegetation remaining may be persistent and unsightly. Bare ground may be colonised by undesirable spp. Not applicable to major thickets owing to difficulty of reaching foliage.

Table 3 contd.

METHOD	APPLICATION	LIMITATIONS
Stump treatment	Stops regrowth from stumps. Careful treatment should not affect other species.	May be unnecessary as little regrowth is reported from stumps large enough to paint.
Burning	Kills standards, and little or no regeneration occurs.	Might be employed as a drastic method for dealing with major thickets, but the dangers to wildlife and the possibility of a fire escaping control are obvious. February, March and August have been suggested as the months when the danger to fauna would be least, but to burn in August a licence is required from the County Agricultural Executive Committee. The dead trunks left by burning are persistent and unsightly.
Rabbit grazing	Has been observed to retard sucker regrowth and seedling establishment. The only existing method of "biological control". Probably acted as a severe brake on Hippophaë expansion when rabbit populations were large.	Rabbit populations are no longer adequate to be significantly effective in this respect. The rapid expansion of Hippophaë in dune systems since the 1950's may be equated with the reduction of rabbits by myxomatosis.
Prevention of fruiting	Can be used to prevent invasion of new sites by seedlings - a major step in keeping Hippophaë under control for management purposes	Only applicable where one sex is present in a small enough proportion to be eliminated or where Hippophaë is being introduced into an area for the first time and one sex (preferably male) can be used.

Table 4 Management options for Hippophaë

HIPPOPHAE ABSENT	Prevent establishment		Eradicate at seedling stage	Of general application in areas where spread will lead to undesirable changes in the ecosystem.
	Allow establishment		Control spread	May apply where it is impracticable to prevent establishment at an early stage.
			Allow spread	Of limited application. May be acceptable in certain experimental situations.
	Introduce		Control spread	When used as a management tool. Of limited application to N.N.R.s. See Chapter 6.
			Allow spread	Application confined to selected experimental situations.
HIPPOPHAE PRESENT	Early stage of colonisation		Eradicate	Of general application in areas where spread will lead to undesirable changes in the ecosystem.
			Control	Applicable where some Hippophaë is required for management purposes. See Chapter 6.
			No control	Of limited application except in selected experimental situations.
	Well established		Eradicate	Generally impracticable.
			Control	The usual approach. See Chapter 7.
			No control	Of limited application on N.N.R.s except in selected experimental situations.

Table 5 Distribution of Hippophaë rhamnoides at nationally important sites with dunes

No.	Site	Status	Area covered (ac)	Maximum height (m)	Date of first record	Susceptibility to invasion
	East Anglia					
	Saltfleetby - Theddlethorpe	present	>5		1805 (Skegness)	high
	Gibraltar Point - Wrangle Flats	present	>5		1895	high
	North Norfolk Coast					
3	(a) Scolt Head Island	present	0.02	1.5	1957	high
4	(b) Wells - Stiffkey Marshes (Holkham Dunes)	present	9.7	4.2	1906	high
5	(c) Blakeney Point	absent				low
6	(d) Cley - Salthouse Marshes	absent				low
7	Winterton Dunes	present	0.7		1801 (Hemsby) 1908	low
	South-East England					
	Sandwich - Pegwell Bay, Kent	present			1666	high
	South-West England					
9	Poole Harbour	absent				low
10	Exe Estuary	absent				high at Dawlish Warren
11	Isles of Scilly	absent				low
12	Braunton Burrows	present		c.4	1950's	high

Table 5 contd.

No.	Site	Status	Area covered (ac)	Maximum height (m)	Date of first record	Susceptibility to invasion
	South Wales					
13	Gower Coast	present	One very small clump		1963	high at Oxwich
14	Burry - Whiteford	present	1-5 (originally) 1 (now)	1+		high
14A	Broad Haven Dunes	present	c.0.05			high
15	Dovey Estuary (Aberdovey and Ynyslas)	absent				high
	North Wales					
16	Morfa Harlech -	present	0.4	2	1953	high
17	Morfa Dyffryn	~~present~~ absent	~~0.4~~	~~2~~	~~1953~~	high
18	Newborough Warren (N.N.R. only)	present	1	2	1956	high
19	Aberffraw Dunes	absent				high
20	Dee Estuary	absent				high at Point of Air
	North England					
21	Ainsdale Sand Dunes	present	c.20		1890	high
22	Walney - Sandscale	absent				high
23	Drigg Point	absent				high
24	Longnewton and Skinburness	BRC record 35/15			1896	low at Grune Point
44	Holy Island - Ross Links - Budle Bay	absent				high
45	Humber Estuary	present	38		1884	high at Spurn Point

Table 5 contd.

No.	Site	Status	Area covered (ac)	Maximum height (m)	Date of first record	Susceptibility to invasion
	South Scotland					
25	Torrs Warren	absent				low
	West Scotland					
26	Loch Gruinart - Loch Indaal, Islay	BRC*records 16/36 and 16/37			1955 Since 1950	high
27	Barrapoll and Balephetrish, Tiree	absent				high
28	Isle of Rhum	absent				low
29	Grogarry and Loch Hallan, S. Uist	absent				low
30	Baleshare - Kirkibost, N. Uist	absent				high
31	Monach Isles	absent				low
32	Balranald, N. Uist	absent				low
33	Northton, Harris	absent				high
34	Southern Parphe	absent				low
35	Cape Wrath - Aodann Mhor	absent				high
36	Invernaver	absent				high
37	Loch Fleet	BRC*record 28/29			1957	high
38	Morrich More, Tain	absent				high

Table 5 contd.

No.	Site	Status	Area covered (ac)	Maximum height (m)	Date of first record	Susceptibility to invasion
	East Scotland					
39	Culbin Sands	absent				high
40	Strathbeg	absent				high
41	Sands of Forvie and Ythan Estuary	absent				high
42	St. Cyrus	absent				high
43	Tentsmuir Point, including Earlshall S.S.S.I.	present	34		1835 (Inverkeithing)	high

*Biological Records Centre, The Nature Conservancy, Monks Wood Experimental Station, Abbots Ripton, Huntingdon.

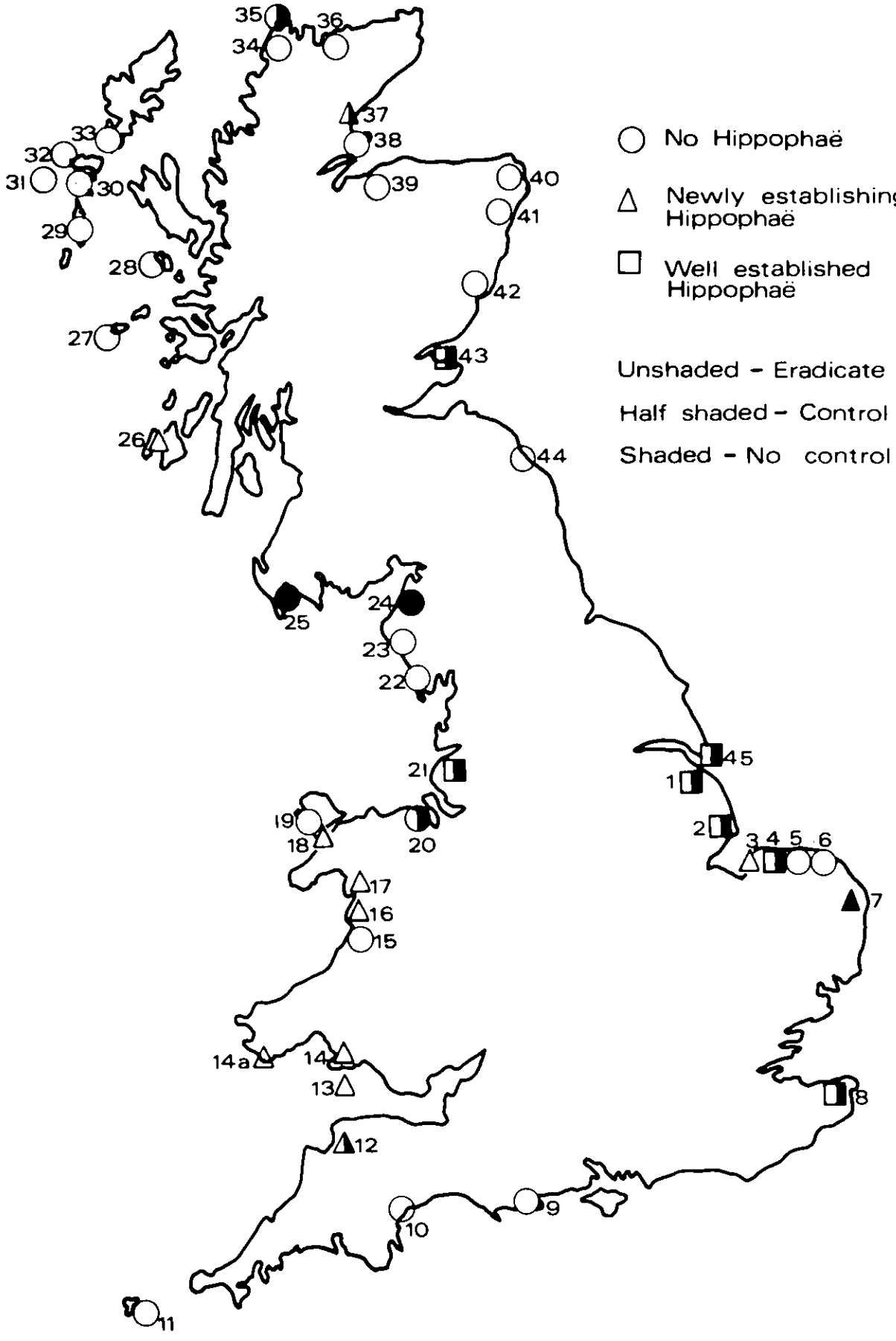


Fig. 8: Management recommendations of the Hippophaë Study Group

APPENDIX

Management recommendations for individual sites

No.	Site	Recommended management
	East Anglia	
	Saltfleetby - Theddlethorpe	Uproot seedlings and cut growths in selected areas. Allow selected growths to mature.
	Gibraltar Point	Uproot seedlings on seawardmost dunes. Utilize different density growths for experiments on control and management. Allow selected older growths to mature and diversify.
	North Norfolk Coast	
3	(a) Scolt Head Island	Eradicate existing colony. Uproot any seedlings that appear west of present west boundary of Holkham Forest. Control main populations at High Cape by cutting any further spread east or west of present limits. Discourage any further attempts to plant Hippophaë.
4	(b) Wells - Stiffkey	
5	(c) Blakeney Point	Prevent establishment.
6	(d) Cley - Salthouse	Prevent establishment.
	Winterton Dunes	No control. Spread unlikely on acid dunes.
	South-East England	
	Sandwich - Pegwell Bay	Uproot seedlings and cut growths in selected areas. Allow selected growths to mature.
	South-West England	
	Poole Harbour Studland Dunes	Prevent establishment.
	Exe Estuary	
10	Dawlish Warren	Prevent establishment.
11	Isles of Scilly	Prevent establishment.

Appendix contd.

No.	Site	Recommended management
12	Braunton Burrows	Allow strongly established growths in northern dunes to develop. Eradicate from central dunes by uprooting seedlings and cutting standards. Leave growths round lighthouse to help control public, but do not allow them to spread northwards.
	South Wales	
	Gower Coast	
13	Oxwich Dunes	Prevent establishment.
	Burry-Whiteford	
14	Whiteford Burrows	Complete eradication by uprooting seedlings, cutting standards and spraying sucker growths.
14A	Broad Haven Dunes	Eradicate by uprooting seedlings and cutting growths.
	Dovey Estuary	
15	Ynyslas Dunes	Prevent establishment to protect both Ynyslas and Merionethshire and Cardiganshire coast at present almost free of Hippophaë.
	North Wales	
	Morfa Harlech - Morfa Dyffryn	
16	a) Morfa Dyffryn	~~Eradicate by uprooting seedlings and cutting growths.~~ Prevent establishment.
17	b) Morfa Harlech	Eradicate by uprooting seedlings and cutting growths.
18	Newborough Warren	Uproot plants and seedlings east of Clwt Gwlyb. Assess distribution west of this and discuss with Forestry Commission 1) possibilities of eradication, or 2) possibilities of containing present growths and plantings planned to control access of public to forestry areas in limited compartments.
19	Aberffraw Dunes	Prevent establishment but review policy in light of recreational use.

Appendix contd.

No.	Site	Recommended management
	Dee Estuary	
20	Talacre Warren	Introduce for management purposes, but uproot seedlings at Point of Air.
	North England	
21	Ainsdale Sand Dunes	Allow growth to continue in selected compartments. Uproot seedlings and cut back growths in selected compartments. Experiment with cutting and selective unisex culling control methods.
22	Walney - Sandscale	Prevent establishment.
23	Drigg Point	Prevent establishment.
	Longnewton - Skinburness	
24	Grune Point	Allow colonization to occur as shelter for migrants. No control likely to be needed on this small exposed site.
44	Holy Island and Ross Links	Prevent establishment.
	Humber Estuary	
45	Spurn Peninsula	Uproot seedlings and cut sparse growths locally.
	South Scotland	
25	Torrs Warren	No control. Spread unlikely on acid dunes.
	West Scotland	
	Loch Gruinart (Islay)	
26	Killinan Dunes	Uproot seedlings and cut out any existing growths.
27	Barrapoll and Balephetrish, Tiree	Prevent establishment.
28	Isle of Rhum	Prevent establishment.
29	Grogarry and Loch Hallan (South Uist)	Prevent establishment.
30	Baleshare - Kirkibost (N. Uist)	Prevent establishment.
31	Monach Isles	Prevent establishment.

Appendix contd.

No.	Site	Recommended management
32	Balranald (N. Uist)	Prevent establishment.
33	Northton (Harris)	Prevent establishment.
34	Southern Parphe	Prevent establishment.
35	Cape Wrath - Aodann Mhor	Allow any natural colonization for diversity and shelter for birds on limited area. Cut or uproot other growths.
36	Invernaver	Prevent establishment.
37	Loch Fleet	Prevent expansion of existing colonies beyond defined limits by uprooting seedlings and cutting.
38	Morrich More	Prevent establishment.
	East Scotland	
39	Culbin Sands	Prevent establishment.
40	Strathbeg	Prevent establishment.
41	Sands of Forvie	Prevent establishment.
42	St. Cyrus	Prevent establishment.
43	Tentsmuir Point	Cut and uproot seedlings in north part of system. Allow selected stands to reach maturity in south part of system.

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