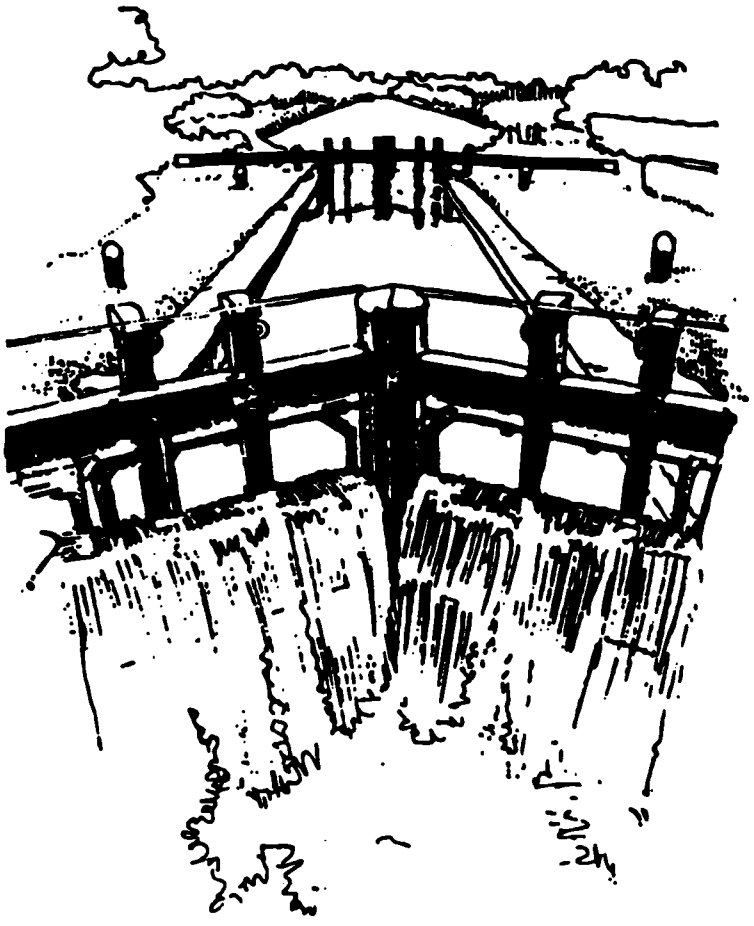
ECOLOGICAL SURVEY

OF THE

BARROW NAVIGATION



Part 1

Survey Report

OPW

Oifig na nOibreacha Poibli
The Office of Public Works

1994

ECOLOGICAL SURVEY OF THE BARROW NAVIGATION

PART 1: Survey Report 1992 and 1993

Prepared for:
The Waterways Division
and
The National Parks and Wildlife Service
of The Office of Public Works.

1994.

By
Marie Dromey
Brigid Johnston
Sinead Keane

SUMMARY

1. The results of the Ecological Survey of the Barrow Navigation are presented in two parts. Part 1 contains the field data and matters arising from this. The plants and habitats are discussed, the impacts of different management practices examined, and guidelines for conservation management outlined.

2. The plant species found along the Barrow Navigation are assigned to six zones - boundary, boundary verge, trackway, bank verge, channel and locks/bridges. Hedgerow is the dominant habitat in the boundary. There is often very little difference between the structure and flora of the boundary verge, the trackway and the bank verge. All three zones are dominated by coarse vegetation and tall herbaceous plants. The aquatic habitats vary from fast-flowing river to slow-moving canal cuts, and from shallow-water marginal vegetation to deep, open-water habitats. The stonework of the locks and bridges provides a range of habitats from very wet to very dry.

3. The results of a detailed survey of the vascular plants found are given in Chapter 3. Species diversity of the zones and % occurrence of the species were calculated. The sites or combination of sites showing the greatest species diversities are discussed. A list of the abundant and rare species found in each zone is given. The ecology of the Barrow Navigation is compared to that of the Grand Canal, and the nature conservation value of the Barrow Navigation is discussed.

The greatest diversity occurred in the boundary. Trees and shrubs were the most abundant plants. Species occurring infrequently were those of a woodland ground storey flora. The vegetation of the boundary verge, trackway and bank verge was often indistinguishable. Plants occurring most frequently on each were tall, coarse species of nutrient-rich soil. Diversity in the channel was quite low, with the most abundant species being those able to withstand harsh conditions.

4. Chapter 4 reviews the impacts of management and recreation on wildlife and nature conservation potential. Distinctions are drawn between maintenance practices which benefit wildlife and those that reduce the ecological value of the system.

5. Part 2 of the report contains general guidelines for conservation on the Barrow Navigation, and more detailed recommendations for each stretch of the system. The aim of these recommendations is to integrate nature conservation into the day-to-day management of the Barrow, maintaining the existing diversity and, in the long term, improving it. Part 2 contains the maps of the Barrow Navigation - 25 inch and 6 inch maps.

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ACKNOWLEDGEMENTS

This survey was supervised by Jim Ryan of the OPW National Parks and Wildlife Service who provided helpful comments. General help and support also provided by Gerry Wrynn, Joe Farrell, Ray Dunne, Jim Larkin and other staff of the OPW Waterways Section was much appreciated. Transport along the Barrow Navigation was provided by the maintenance staff along the waterway.

DEFINITIONS

Canal Corridor: The zones within the boundary structures;
i.e. channel
bank verges
towpath
canal cuts
embankments
boundary

Bank Verge (bkv): The strip of land between the channel and towpath

Boundary Verge (bdv): The strip of land between the towpath and boundary

ABBREVIATIONS

AFF : An Foras Forbartha
ASI : Area of Scientific Interest
BWB : British Waterways Board (now British Waterways)
BN : Denotes kilometre section on the Barrow Navigation
CFB : Central Fisheries Board
CIE : Coras Iompair Eireann
IWAI : Inland Waterways Association of Ireland
NCC : Nature Conservancy Council
NHA : Natural Heritage Area
OPW : The Office of Public Works

MANAGEMENT OBJECTIVES

1.1 To ensure that nature conservation requirements are fully integrated into the maintenance and development of the waterways network.

1.2 To maintain the habitat diversity of the waterways system, and to increase it where possible.

1.3 To highlight the contribution of different management practices in maintaining habitat diversity on the waterways system.

GENERAL GUIDELINES FOR CONSERVATION MANAGEMENT

2.1 MAINTENANCE

2.1.1 General

. Because of the conservation value of the waterways a full-time ecologist should be employed by the Waterways Section of The Office of Public Works.

2.1.2 Dredging

General

. The river channel should only be dredged in short sections (of not more than 5 km) to allow the vegetation to recolonise from adjacent lengths.

. Hydraulic machinery should be used where possible - i.e. where wide bank verges exist along the river and in the canal cuts - as it is more selective and flexible than drag-line dredgers.

. Spoil deposited between the bank and the towpath should be spread evenly over the bank verge vegetation as soon as it has dried out.

. Where possible - i.e. where wide bank verges exist along the river - the floating dredger should deposit the spoil on these banks.

. Dredging should be minimised during the months March to May to avoid the main growing season and to reduce disturbance to nesting birds of the banks and hedgerow.

. Natural revegetation of dredging spoil should be monitored annually to decide the best form of management.

Protection of reed fringe

. When dredging the boundary drain (which contains fish as well as many species of invertebrates) ensure that reed fringe remains along one bank.

. Dredging of the canal cuts should be carried out from one bank only leaving a wide band of marginal vegetation on the offside.

. In sections where the only surviving reedbeds are on the towpath side of the canal cuts the floating dredger should be used to avoid damaging the marginal vegetation.

Spoil deposition

. All spoil should be deposited on the bank verge and levelled.

. Spoil rich in nutrients should not be dumped on the small areas of unimproved grasslands along the canal banks and Barrow trackway as these sites are botanically the rarest and most diverse.

. Nutrient-rich spoil should be deposited on the wide bank verges which are found along much of the river. The floating dredger is suited to this type of work.

. Nutrient-poor gravelly spoil from the fast-flowing river may be spread thinly and evenly on the towpath.

. Spoil from the canal cuts should be deposited on the islands and island embankments especially where there is scrub present.

Control of plant growth on spoil

. The growth of coarse vegetation is quite vigorous on spoil deposition sites and often extends out on to the towpath. In these areas the early colonising plants should be mowed at least twice in the first year and the cuttings removed. In subsequent years, provided there is no further deposition of spoil, a single late summer mowing should be sufficient.

. In areas where scrub is desirable no management is necessary.

2.1.3 Control of plant growth along banks which are liable to flooding.

. The deposition of silt (nutrient-rich) as a result of flooding encourages vigorous growth of coarse vegetation.

Along the trackway this vegetation can be cut twice a year, and the cuttings removed. The bank and boundary verges should be mowed once a year and the cuttings removed. This will remove nutrients from the system.

. Giant Hogweed has been spreading along the banks of the Barrow Navigation in recent years, in particular along low banks liable to flooding. Vegetation is washed away at times of flood, especially where the water swirls about under saplings. When it dries out this bare ground is readily colonised by Giant Hogweed, the seeds of which are often carried in the water. Spray treatment using a solution of Roundup has been shown to be the most effective method of control, and the spraying programme should be continued. These plants are not to be cut as they will sprout new shoots.

2.1.4 Bankside trees

Trimming

. Tree cutting should be avoided during the months of March to July to reduce disturbance to nesting birds and damage during the main growing season.

. Removal of overhanging branches should be confined to those which obstruct navigation and walking.

. Pollarding is a suitable management method for Willows along the river bank. Young growth is trimmed each year at a height of 2m from the ground producing a solid stem and a crown of young growth.

. Coppicing is suitable for management of shrubs or young Hazel, Willow and Alder trees where access for machinery is necessary. Trunks are cut close to the ground using a slanting cut which sheds rainwater. Branches regenerate from the base or stool.

Selective removal of trees

. Removal of trees should be confined to the winter months to minimise disruption of plant communities and disturbance to nesting birds.

. Priority should be given to removal of exotic or introduced species such as conifers or Sycamore. Native species such as Alder, Willow, Ash etc. should be retained where possible.

. Cut stumps may need to be spot-treated with herbicide to prevent re-growth where tree or shrubs are to be removed from the system altogether.

2.1.5 Scrub

. Scrub clearance should not be carried out as a matter of course, but only where necessary for maintenance.

. Clearance of scrub should be avoided during the months of March to July to reduce disturbance to nesting birds.

. Scrub along the canal cuts should not be cleared from both banks at the same time. Instead the vegetation on the first bank should be allowed to stabilise before any work is carried out on the second bank.

2.1.6 Hedgerows

Management methods

. Hedgerows should be trimmed in short lengths on a two to three year rotation.

. Trimming should be carried out in the months of October to February to avoid damage to growing shrubs and disturbance of nesting birds.

. Hedgerow trees should be protected from damage during trimming and some young saplings should be allowed to grow to maturity.

. If using a flail cutter care should be taken to direct it at young growth. If used on thick old branches it will shred and tear them leaving branches that are susceptible to dieback and fungal attack.

Replanting

. Preference should be given in replanting programmes to the use of native tree and shrub species such as those which grow naturally in the surrounding countryside.

. Planting of shrubs and trees should be done in autumn or spring, but not during severe frosts.

2.1.7 Grassland

Mowing

. Mowing can be used to maintain grassland on the towpath and verges.

. A footpath 1.5m wide can be cut through grasslands in May/June if necessary to provide pedestrian access. A

wider band (2-3m) consisting of towpath, bank and boundary verges should be cut in August/September.

. All hay or other cut vegetation should be removed from the towpath to maintain the low nutrient status of the grassland. Methods/machinery for combined cutting and removal should be investigated and experimental trials carried out.

. Plant species colonising bare ground after disturbance of the towpath may need to be controlled by more frequent mowing during the first 2 to 3 years.

. Recommendations for the management of grasslands on nutrient-rich spoil are in Sections 2.1.2 and 2.1.3

Herbicides

. In general, herbicides should not be used as these may damage non-target grassland species. Spot treatment of woody plants and Giant Hogweed may be used as necessary.

2.1.8 Aquatic vegetation

Environmental control

. The level of boat traffic is likely to increase, and this will help to keep the navigation channel clear of plant growth.

. Reducing to the minimum the input of plant nutrients by controlling/monitoring all possible sources of pollution will help to control the spread of invasive plant species.

Mechanical cutting

. Cutting in the canal cuts should be carried out early in the year using a boat-mounted cutter.

. Cutting should be limited to the central navigation channel leaving marginal vegetation fringes as intact as possible.

. Decomposing aquatic plants can release a very unpleasant odour and should be disposed of away from the canal and used as compost.

Herbicides

. Herbicides should only be used where all other methods of controlling plant growth have been tried and have failed.

. Herbicides must not be used on stretches of the canal that support protected plant or animal species, or in those areas which have been identified as containing a high diversity of aquatic life.

. Herbicides must be used early in the growing season, as the decomposition of a large amount of vegetation in the channel could result in serious deoxygenation of the water.

Biological control

. The introduction of herbivorous fish such as Grass Carp (Ctenopharyngodon idella) is not allowed in this country.

. The use of Barley Straw on the Grand and Royal Canals has proved successful in the treatment of algae. This method could not be used on the river channel of the Barrow, where the fluctuating water levels and increased flows would limit its success. Trials could however be carried out on the canal cuts of the Barrow Navigation.

2.1.9 Masonry

. The vegetation growing on stone walls and similar structures adds to the diversity of the system. Plants which could damage the structures (eg Ivy, Ash, Sycamore or Bramble) should be removed. Smaller, less vigorous plants typical of stone walls should not be removed.

. Use only mechanical methods to clean and maintain stonework. Herbicides should not be used as they may enter the water and have damaging effects of aquatic plants.

2.1.10 Water quality

. All direct discharges to the system should be monitored to ensure early detection of pollution incidents.

. An effort should be made to ensure that all towns discharging domestic and industrial waste to the Barrow River should have secondary or tertiary treatment plants installed.

. Regulations should be drafted to ensure that boats use the pump-out facilities at Athy, Carlow and Graiguenamanagh.

2.2 RECREATIONAL MANAGEMENT

2.2.1 Boat traffic

. Speed limits should be strictly enforced for all boat traffic to prevent damage to the banks of canal cuts from wash.

. Regulations regarding permits and mooring must be strictly enforced to prevent ecological damage at sites where large numbers of boats are found in a small area.

. Regulations should be drafted to ensure that boats use the pump-out facilities at Athy, Carlow and Graiguenamanagh.

2.2.2 Angling

. The OPW do not own or manage the fishery on the Barrow Navigation. However the OPW does assist with the provision of easy access to the water for the fishermen by cutting swims. Limits should be placed on the interference with bank vegetation to facilitate anglers.

. Weirs should be kept clear of excess vegetation so as not to hinder salmon in their movements upstream.

. Herbicide spraying should not be used as a fisheries management method.

. Angling may need to restricted in certain ecologically sensitive areas or at certain times of year to avoid disturbance to birds.

PHOTOGRAPHS

OF THE

BARROW NAVIGATION

1992 and 1993

Plate 1. BN4. 25th July 1992. View south on a section of towpath along the canal cut on the approach to Fenton's Bridge. The boundary consists of an old wall supporting nutrient-poor plant species. The vegetation of the towpath - also nutrient-poor has been cut. There are young trees and tall herbaceous species growing along the bank.

Plate 2. BN2. 25th July 1992. View south along a section of towpath immediately south of Ardreigh Lock. This stretch was impassable. Spoil, rich in nutrients, was deposited on the bank in 1991. This encourages coarse vegetation such as Nettles, Hogweeds and Goosegrass to grow.

Plate 3. BN7. 11th June 1992. View across to the "terraces" of the west bank. In the foreground is the course vegetation of the bank verge including Nettles, Hogweeds, Docks and Goosegrass.

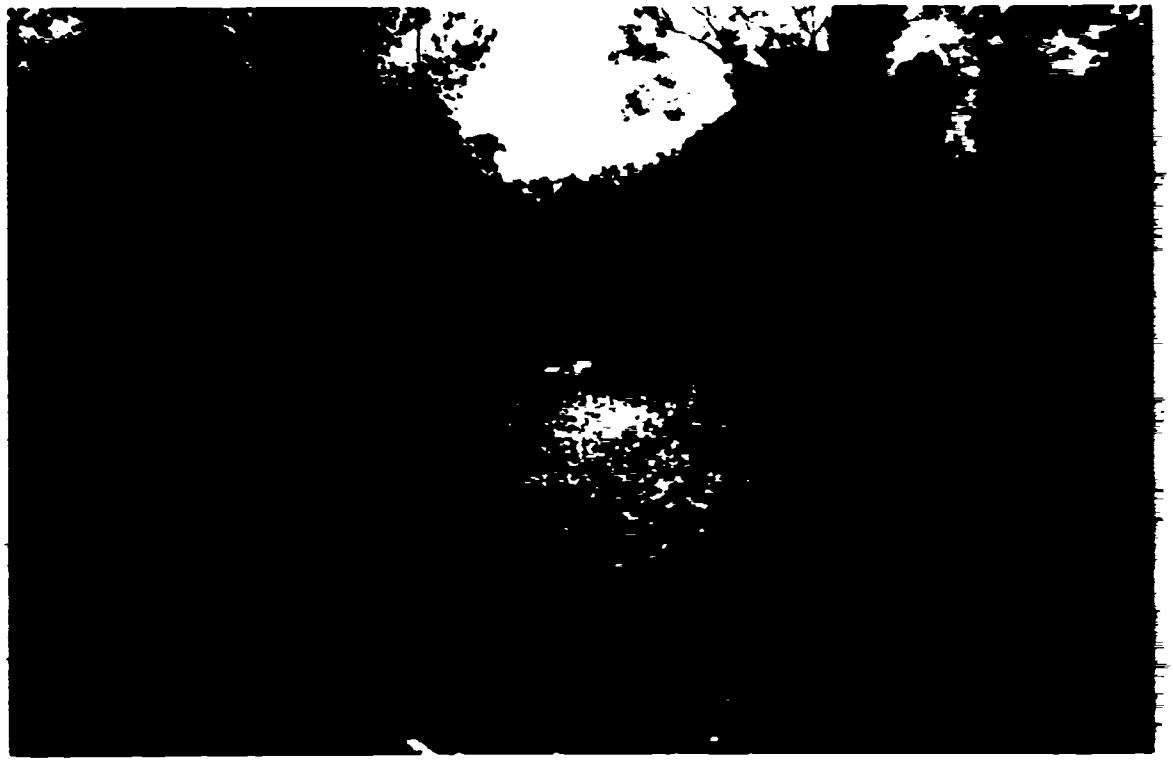


Plate 4. BN9. 11th June 1992. View south along the towpath north of Maganey Bridge. The trees and shrubs of the bank meet those of the boundary to form an arch giving an enclosed feeling to the walker. The vegetation of the towpath is dominated by Oxeye Daisy, a plant indicative of nutrient-poor ground.

Plate 5. 30th June 1992. Coarse vegetation similar to that remaining on the bank extended across the towpath. It has been cut but not removed. The cuttings are left to decay and add nutrients to the soil in turn encouraging coarse vegetation. It is also quite demanding walking on this "hay". Removal of the cuttings prevents nutrient recycling and in the medium term can result in a less competitive sward which does not grow as high and is less dense.

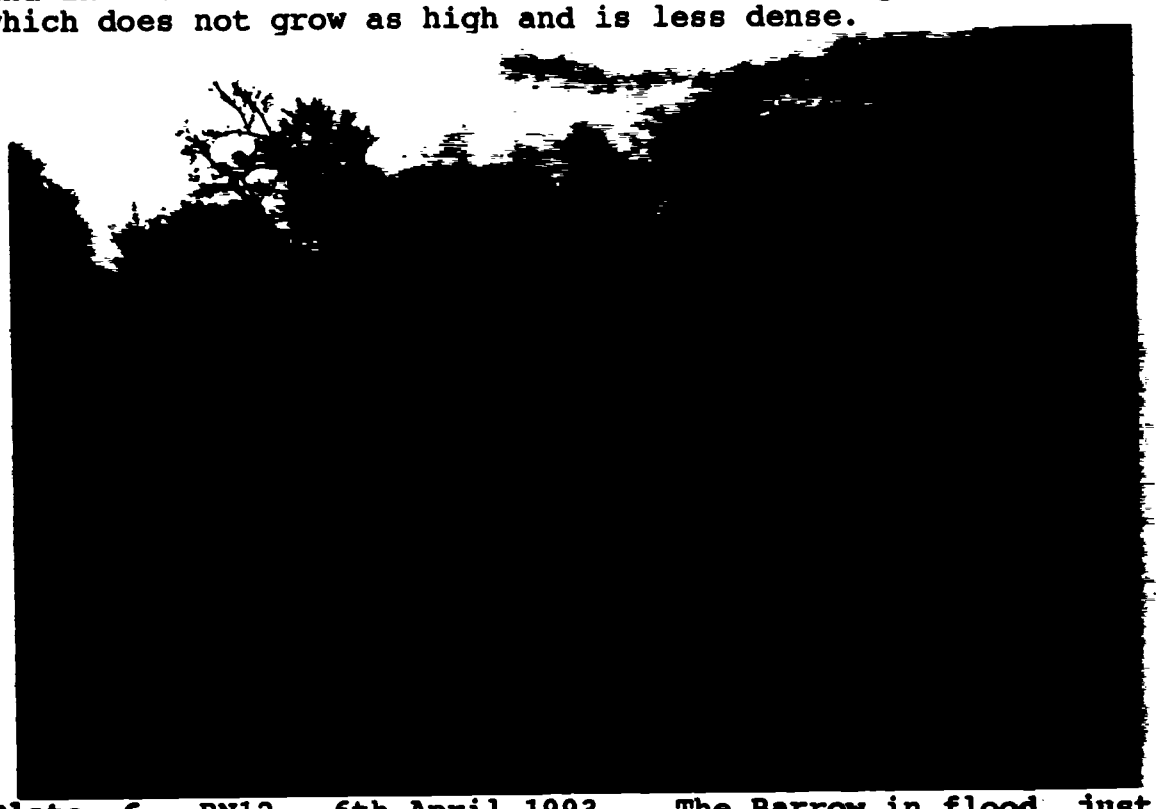


Plate 6. BN12. 6th April 1993. The Barrow in flood just north of Maganey Lock. Silt deposits, rich in nutrients, remain after the flood waters have abated. By June this wide expanse of bank verge will be covered in coarse vegetation of Nettles, Docks, Hogweeds, and Goosegrass - a vegetation similar to that which grows on rich spoil from the river bed.

Plate 7. BN12. 26th July 1992. A view north along the canal cut at Maganey Lock. Note the diverse reed fringe along the island side of the cut where the gradient between land and water is gentle.

Plate 8. BN12. 12th June 1992. Going south along the towpath south of Maganey Lock. The coarse vegetation reaches heights of 1.75m. A combination of factors such as late cutting, non-removal of cuttings from the previous year and spoil deposition result in this sward.

Plate 9. BN12. 30th June 1992. Spraying of Giant Hogweed using a solution of Roundup to 40 parts water. Giant Hogweed grew in the same location during 1993 and was again sprayed. It is a biennial plant - blooms every two years - so it is important to spray all plants whether flowering or not.

Plate 10. BN16. 12th June 1992. View south towards Carlow from Bestfield Lock. This was a pleasant walk along the narrow trackway. The vegetation, unlike those stretches where spoil was deposited, is diverse, lower and less dense. It consists of meadow species. It is important that when the vegetation of these sections is cut, it then be removed.

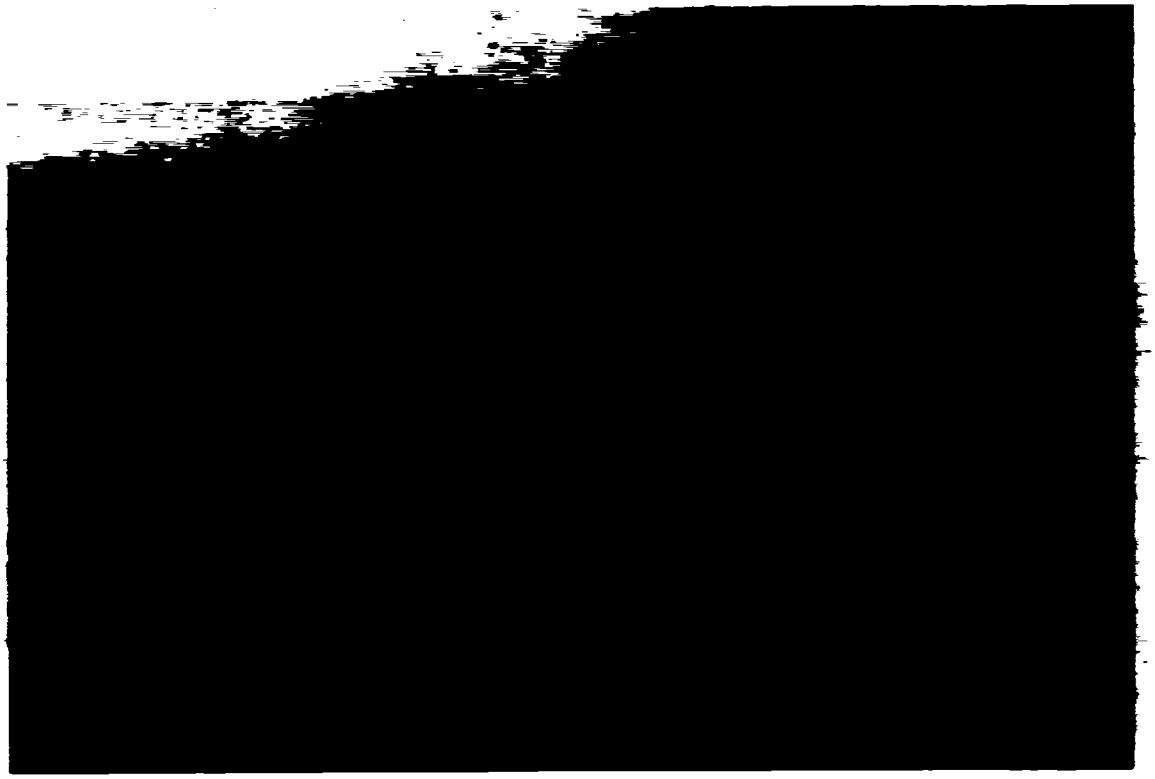


Plate 11. BN18. 1992. The river bank opposite the sugar factory has been cleared. During 1993, the entire stretch along this bank, extending almost all the way into Carlow, supported large amounts of Giant Hogweed - mostly non-blooming.

Plate 12. BN19. 13th June 1992. Immediately south of Graiguecullen Bridge in Carlow. There is a very nice aspect to the canal and river at this point - old bridge, weir and lock in close proximity. The old derelict properties on the river front present opportunities to improve the presentation of the town. Brady, Shipman and Martin, (1992), note that these buildings are likely to be redeveloped and recommended that these redevelopments address the water more directly and possibly incorporate water-related uses.

Plates 13-16. BN 20 and 21. 13th June 1992. The channel of canal cuts and below them are dredged each year after the heavy winter flows. The spoil, rich in nutrients, is deposited on the river/canal bank. The photographs show four deposition locations between Carlow and Clogrennan Locks. The vegetation which grows on the spoil is coarse and dominated by competitive species. The spoil should be mixed with topsoil and levelled. The vegetation should be cut as frequently as possible and the cuttings removed.

Plate 14. As above

Plate 15. As on previous page

Plate 16. As on previous page

Plate 17. BN22. 1992. The canal cut at Clogrennan. Nice contrast between colourful flowers on the chamber walls and heavy green foliage of the trees and shrubs of the island.

Plate 18. BN26. 27th July 1992. A view south along the towpath towards Milford Bridge. A diversity of habitats including the wet woodland on the offside, the dry woodland of the boundary with mature Oaks and the contrasting bank and towpath communities.

Plate 19. BN26. 27th July 1992. This view south along the Milford canal cut is a most picturesque section of the Barrow Navigation. In June of 1992 it was impassable and later the towpath vegetation was cut manually. In 1993 the towpath was cleared by a Fas scheme employed by Carlow Co. Council. Beyond the cut, Coughristic Wood, on the offside is an ASI.

Plate 20. BN29. 15th June 1992. The towpath here on the approach to Rathvindon Lock is similar in condition to that south of Maganey Lock. Coarse vegetation, typically found along river banks and on rich spoil, reaches heights of 1.5m. This vegetation requires several cuttings which then need to be removed.

Plates 21, 22 and 23. BN31. 15th June 1992. The towpath both sides of Leighlinbridge supports meadow grassland species. A strip in the middle of the path is mown regularly and the cuttings removed. Removal of the cuttings reduces the nutrient status of the soil resulting in a diverse, less dense low sward. The area to the left in Plate 22 is liable to flooding and is a wet meadow during the summer. There is a bank verge community at the edge of the towpath as is evident in Plate 23. Both these habitats add further to the ecological diversity.

Plate 22. as above

Plate 23. see previous page

Plate 24. BN33/34. 4th Feb. 1993. View north along the towpath at the Rathellin cut. This cut was dredged in a sensitive manner in early 1993. The Hazel wood of the boundary, the mature trees of the embankment between canal and island, the towpath and young saplings of the bank were not damaged during this operation.

Plate 25. BN38. 29th July 1992. Bagenalstown Esker (ASI) immediately south west of Royal Oak Bridge is outside OPW property. However, it is on the banks of the river and adds greatly to the ecological diversity of the area.

Plate 26. BN40. 30th July 1992. The weir at Fenniscourt is over vegetated. This can reduce the rate of flow and channel the extra water into the canal and it also makes it increasingly difficult for salmon to move upstream.

Plate 27. BN44. 19th Aug. 1992. South of Fenniscourt on the approach to Upper Ballyellen Lock. Prior to cutting, the vegetation of the towpath was coarse and overgrown. This type of vegetation results from the deposition of nutrient-rich spoil on to the river bank. The cuttings were not removed. All the nutrients used by the growing plants are therefore recycled back into the soil and the vigorous growth will recommence.

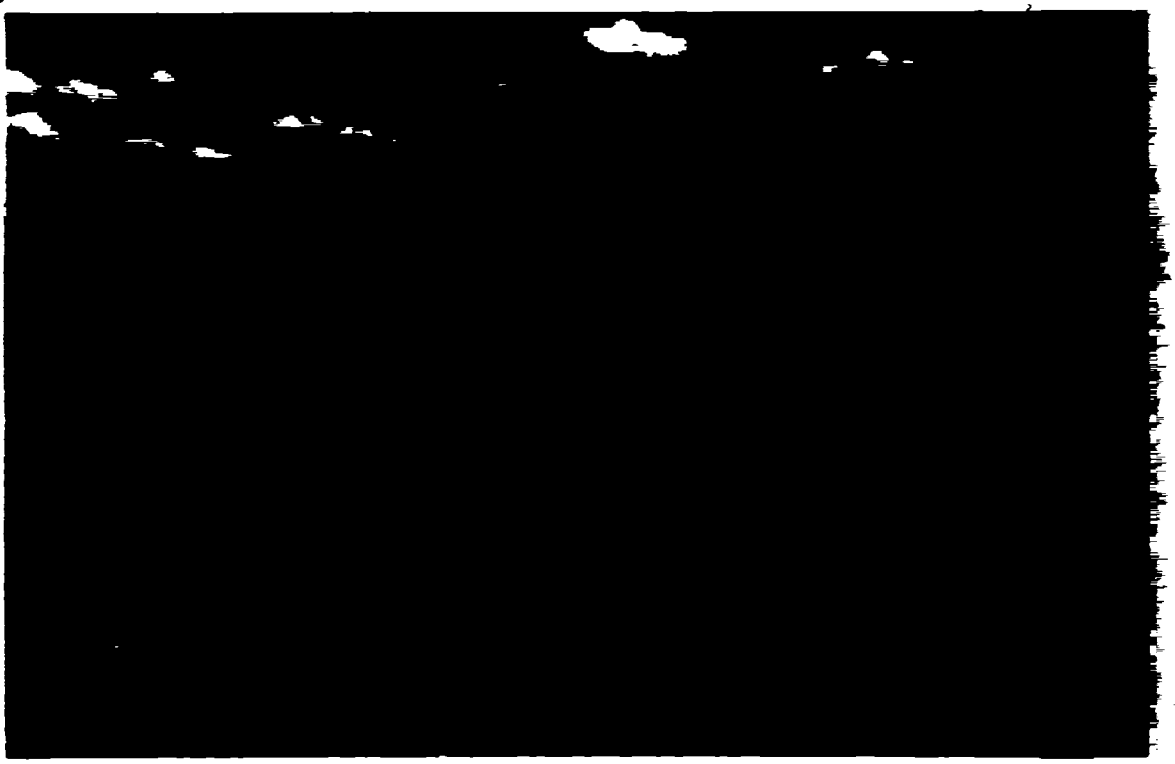


Plate 28. BN46. 17th June 1992. Immediately north of Goresbridge. Not all spoil is nutrient-rich. Where the spoil is removed from fast-flowing stretches it tends to be gravelly and nutrient-poor rather than silty. The fine silt is washed away from the river bed. In these circumstances a diverse, sparse and nutrient-poor vegetation results.

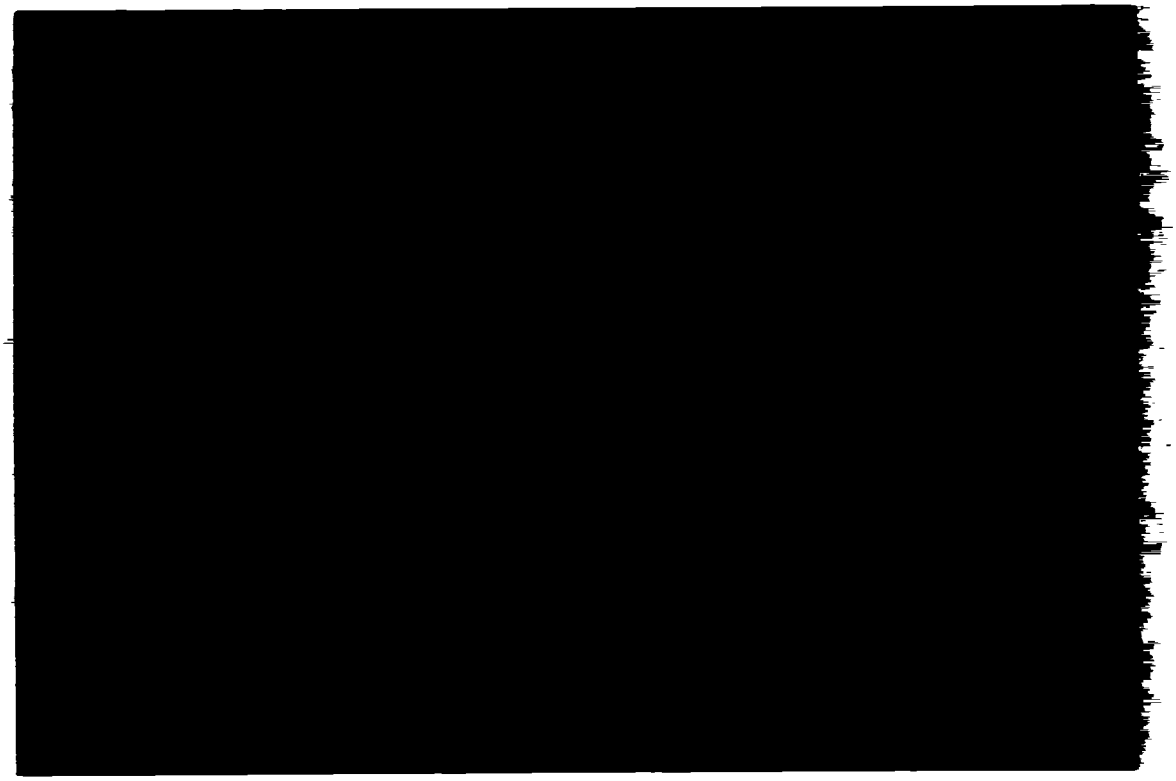
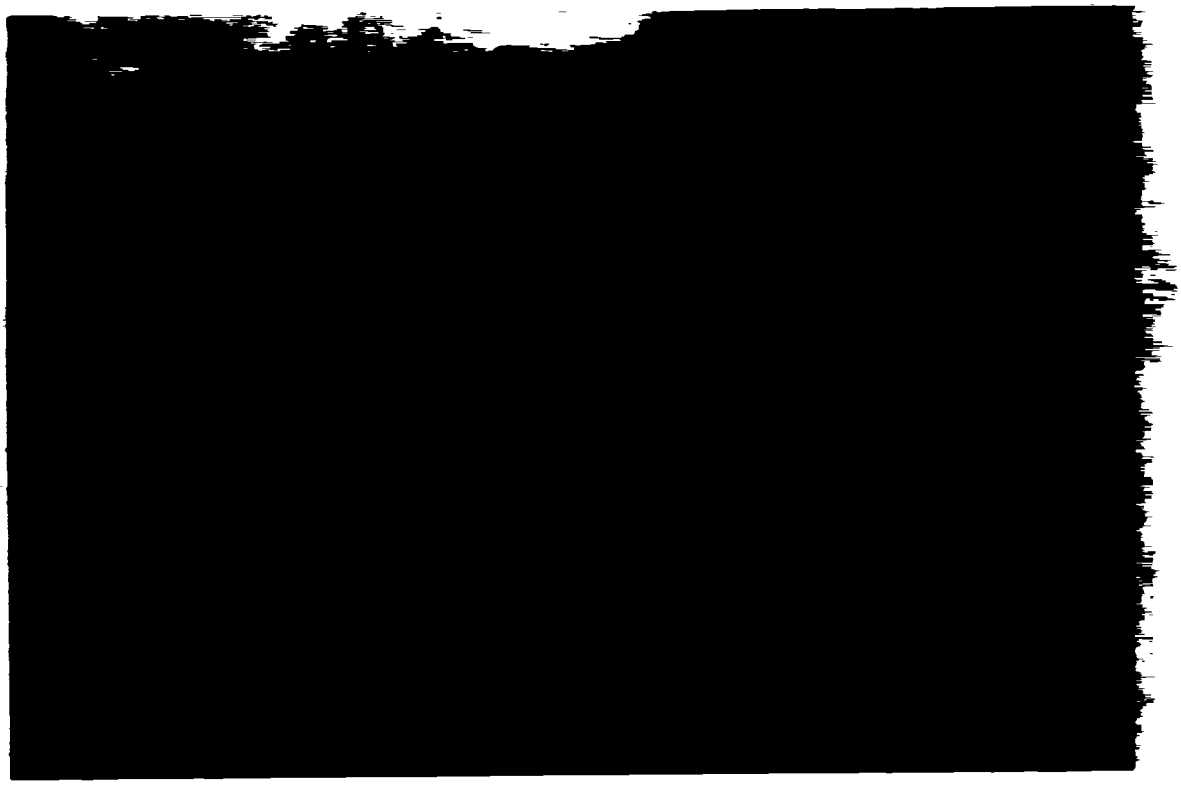


Plate 29. 23rd June 1992. BN51. View north from Ballytiglea Bridge. There are a diversity of habitats; fast-flowing river, bank edge, nutrient-poor towpath, pond with a diversity of aquatic and semi-aquatic species rarely found in a navigable system.

Plate 30. 23rd June 1992. BN54. Looking north towards the mixed deciduous woodlands of Borris Demesne (ASI) on the right bank. There is wet woodland on the offside. This section of the river affords a closed aspect. Horses use this stretch of towpath regularly.



Plates 31 and 32. 24th June 1992 and 4th Feb. 1993. **BN58.** Plates 31 and 32 show Ballykennan canal cut from both the north and south and in summer and winter. There is a diversity of aquatic plant species in the canal reed fringe. The island (to the left of plate 31) is grazed during the summer months. It supports meadow species and there is also scrub towards the southern end of it.

Plate 32. as above

Plate 33. 4th Feb. 1993. BN58. A view south towards Ballykennan Lock before work commenced on raising the footbridge and dredging the cut.

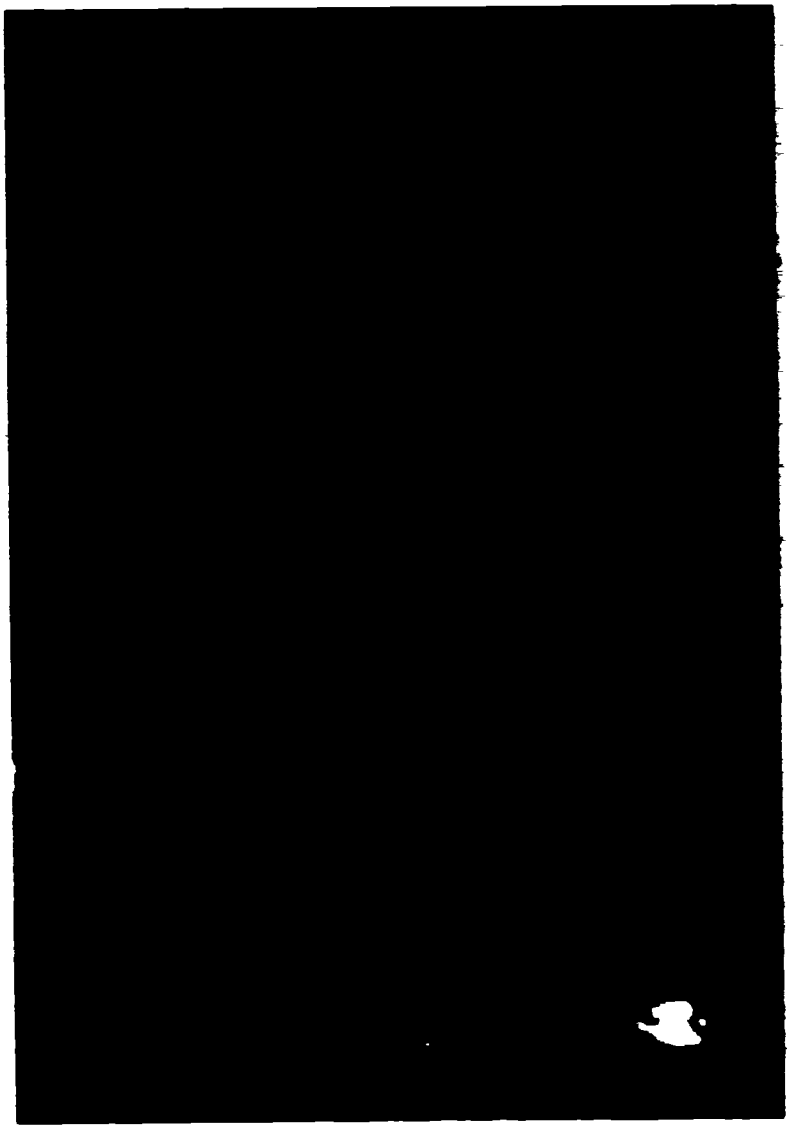


Plate 34. In addition to the habitats listed for plate 31, there is also the mixed deciduous woodland on the steep rock-strewn boundary. In the crevices between the rocks many ferns and mountainous grasses find a foothold. As shown, it is the ideal habitat for Foxglove.

Plate 35. 25th June 1992. BN63. Looking south from the lock at Tinnehinch Lower. The towpath along this stretch between Graiguenamanagh and St. Mullins is used quite considerably. There was no coarse competitive plant species present. Instead the vegetation is dominated by meadow grasses. The cuttings were not removed when cut. This practice allows the nutrients to be recycled back into the soil and this can result in coarse vegetation.

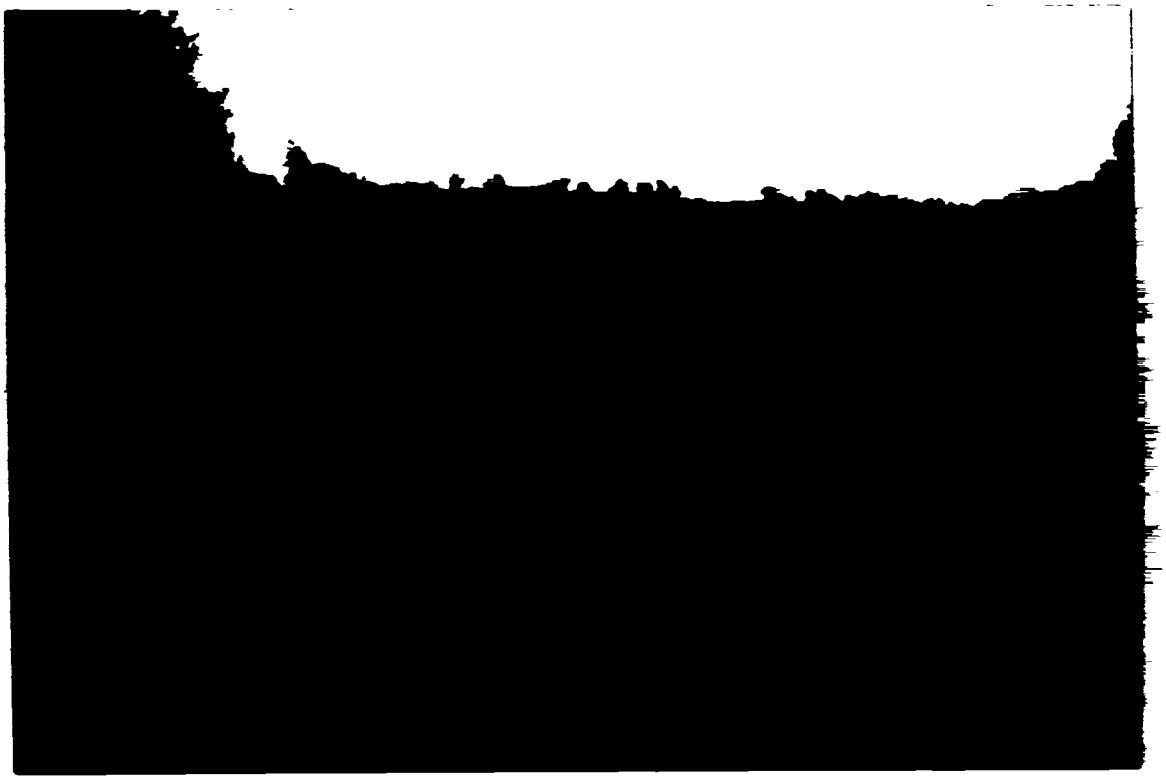


Plate 36. 4th May 1993. BN63/64 Looking south, south of Lr. Tinnehinch Lock. Well used towpath between Graiguenamanagh and St. Mullins.

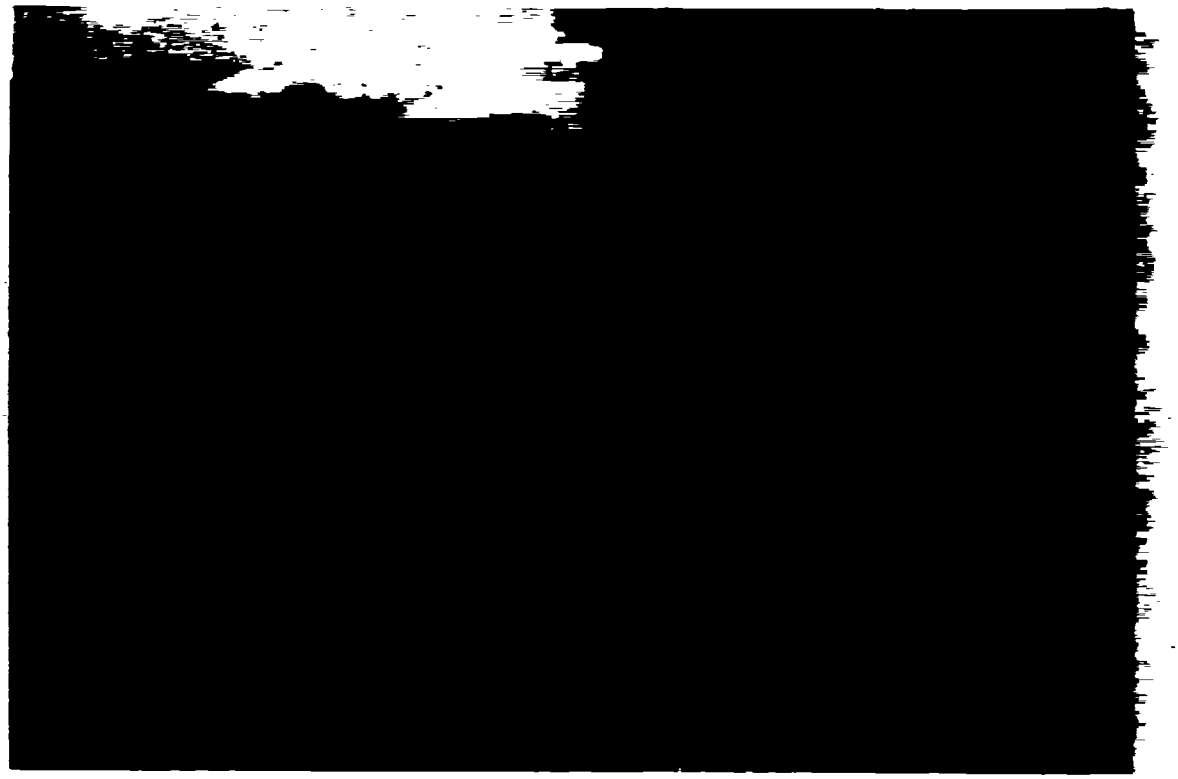


Plate 37. 25th June 1992. BN65. Looking south from Carriglead Lock towards the mature, mixed deciduous woodlands of Bahana Woods (ASI) (to the left of the picture). The vegetation of the towpath has been cut but the cuttings not removed. This allows nutrients be recycled back into the soil which in turn can encourage coarse vegetation.

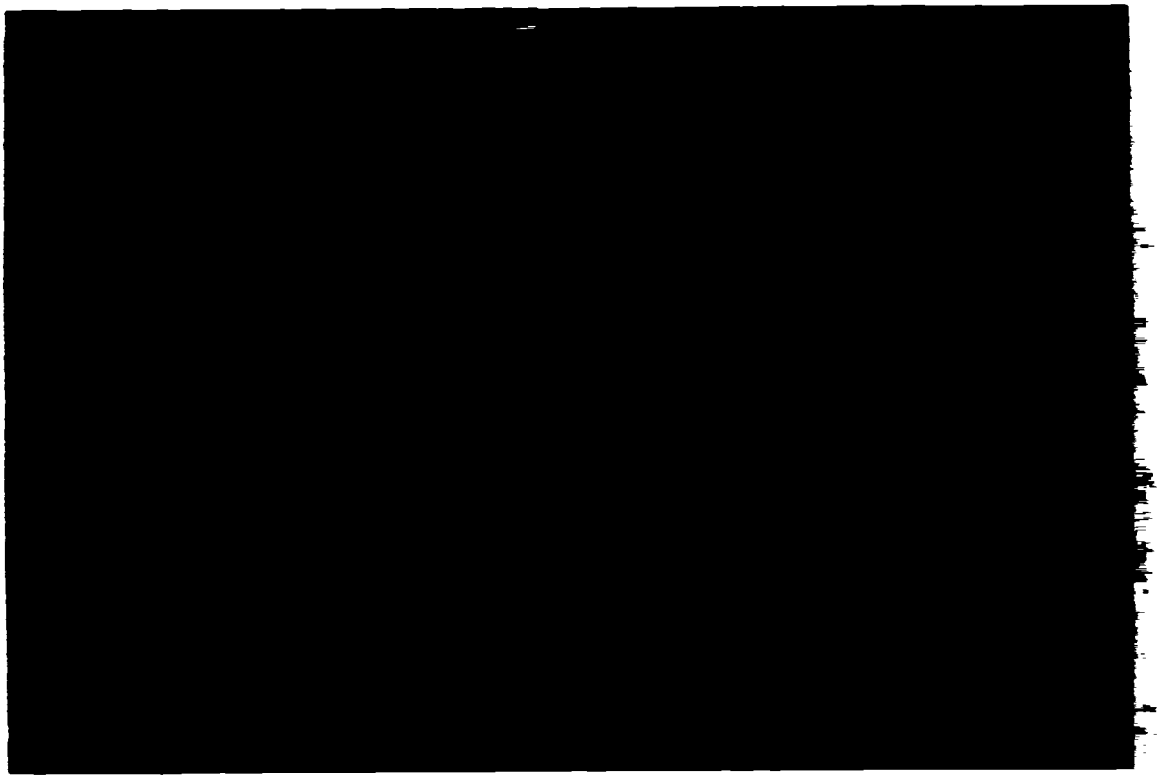


Plate 38. 25th June 1992. BN68. Looking north on the approach to St. Mullins. The vegetation of the bank is dominated by Impatiens glandulifera, a non-native which invades bare ground along river banks.

CHAPTER 1 INTRODUCTION

1.1 INTRODUCTION

This ecological report is the third which has been commissioned by Waterways Section of the Office of Public Works (OPW). It has been carried out to determine the floristic and habitat data of the Barrow trackway and channel. Management guidelines for maintaining and improving the conservation value of the system have been developed. When devising these management strategies, the recreation and amenity potential for both land and water-based activities along the navigation have also been taken into account.

The River Barrow rises in the Slieve Bloom Mountains, and runs for 192 kilometres (119.5 miles) to the point where it meets the River Suir at Cheekpoint. Above Athy, the navigation is linked to the Mainline of the Grand Canal by the Barrow Line. The river navigation extends from Athy to St. Mullins - a distance of 69 kilometres (43 miles) - where the river becomes tidal. The depth of water in the navigable stretch is controlled by weirs and locks. There are 22 locks on the 17.7 kilometres (11 miles) of lateral canals.

1.2 HISTORY OF THE BARROW NAVIGATION

Navigation works on the River Barrow were first authorised in 1715, but did not begin until 1761 (Delany and Delany, 1966). The early works were carried out by the Commissioners of Inland Navigation, established in 1751. In 1790 the Barrow Navigation Company was incorporated, and took over the earlier works. They completed the navigation and upgraded the earlier works (1812), but they did not achieve the five foot depth of water they had originally planned. In 1894 they were forced to sell out to the Grand Canal Company.

The navigation had always had problems with heavy currents in winter and with water shortages in summer. In 1935 a drainage scheme on the upper Barrow resulted in an increase in silting in the lateral canals and in even stronger currents in some sections of the river. The company accepted £18,000 in compensation and tried to alleviate the problems of the currents. Yet again nothing could be done to prevent the silting.

The navigation, with the rest of the Grand Canal system, was transferred to CIE in 1950. Some work was carried out by CIE as a result of increasing interest in pleasure boating and in the recreational potential of the river, but the problems remained. In 1986 CIE's inland waterways, including the Barrow Navigation, were transferred to the Office of Public Works to be developed as public amenities.

1.3 ECOLOGICAL SURVEYS

It is only relatively recently that the importance of the ecological aspects of the inland waterways has been recognised. Their wildlife is important in its own right, but also because it provides the background to all recreational activities, water-based and land-based, along the waterways. In order to maintain the diversity of habitats along canals and river navigations it is necessary to know what habitats are present, and also how to manage them in order to maintain and where possible to improve their ecological interest.

The Irish inland waterways never received the level of use common on the British and Continental waterways. As the level of recreational use and the degree of management increases, the ecological diversity of the inland waterways must be actively protected and maintained by integrating nature conservation into the management programme, together with navigation and recreational requirements.

Between 1989 and 1992 a series of ecological surveys were carried out along the Royal and Grand Canals (Dromey et al., 1991; Dromey et al., 1992), which identified areas of high conservation interest and suggesting how management practices could be modified to improve the nature conservation value of the waterways. The present report is a continuation of the Grand Canal survey onto the Barrow Navigation south of Athy.

1.4 BARROW NAVIGATION ECOLOGICAL SURVEY

The objectives of the present ecological survey were:

- to assess the present value of the Barrow Navigation for nature conservation;
- to determine what factors influence or have influenced the distribution of habitats along the river;
- to use this information to draw up recommendations on the management of the navigation with wildlife and nature conservation among the priorities;
- to promote an awareness of the wildlife potential of inland waterways, inside and outside the OPW.

The survey methods are described in Chapter 3 and in Part 2 of the report. The river corridor was divided into five zones, in the same way that the canal corridors were divided in earlier reports:

boundary
boundary verge - between the towpath and the boundary
towpath
bank verge - between the towpath and the channel
channel

1.5 STUDY AREA

1.5.1 Geology and Soil

The River Barrow rises in the old red sandstone of the Slieve Bloom Mountains in Co. Laois. It flows east and then south across limestone countryside to Goresbridge. The lower reaches pass through neutral or acidic soils derived from granite and sandstone (Geological Survey, 1962).

1.5.2 Water Quality

A survey of the water quality of the State's surface water resources was carried out during the period 1987 - 1990 (Environmental Research Unit, 1992). The water quality of the River Barrow was assessed as part of this work. The authors note that the river "continues to be in a generally satisfactory condition despite recent substantial increases in the extent of slight and moderate pollution."

The quality of the water below Carlow has improved significantly since the installation of improved sewage treatment works in the town. However in the winter months these waters are seriously polluted for up to 30 kilometres below the sugar factory. The sugar factory discharges waste from its settling ponds at times of high flow during the winter. There are also high levels of nutrients and high Biological Oxygen Demand (BOD) values recorded for the stretch between Royal Oak Bridge and Clashganna.

The installation of secondary sewage treatment works at Bagenalstown during 1993 and the promise to install similar plants at all inland towns by 1999 will help towards improving the water quality still further.

Boats also discharge sewage into the river. The installation of pump-out facilities at boat centres and a regulation requiring all boats to have storage tanks will further improve the quality of the water. The first pump-out station is already in place at Graiguenamanagh, and will be followed by others at Carlow and Athy.

1.5.3 Areas of Scientific Interest

A number of sites along the Barrow Navigation are designated as Areas of Scientific Interest (ASIs; Fig. 1.1) by the National Parks and Wildlife Service (An Foras Forbartha, 1981; Wildlife Service, 1989; National Parks & Wildlife Service, 1992). Three of the ASIs are woodland sites, three are gravel and sand eskers and one is grassland (Table 1.1). All sites are outside OPW property but are important in ecological terms, as they give structure and diversity to the

boundary, and they shelter the more open habitats in the river valley. The grassland site at Tankardstown Bridge is becoming overgrown and is in need of management.

The national survey of rare plants and the ongoing reassessment of ASIs, at present being carried out by The National Parks and Wildlife Service, will in all probability add other new sites to the present list. They will then be known as Natural Heritage Areas (NHAs).

TABLE 1.1 Areas of Scientific Interest along the Barrow Navigation.

COUNTY (ASI no.)	NAME GRID REF.	km SECTIONS	AREA or LENGTH	HABITAT	INTEREST	RATING
Carlow (5)	Bahana Wood S 72 40	BN 66 BN 65-68	11 ha 76 ha	Woodland - deciduous	Ecol	Regional Local
Carlow (6)	Borris Estate S 72 50	BN 52-54	92 ha	Woodland - deciduous	Ecol	Regional
Carlow (11)	Cloughristick Wood S 70 69	BN 26-28	10 ha	Woodland - deciduous	Ecol	Local
Carlow (813)	Powerstown	BN 29	NA	Sand/gravel Esker	Ecol	Local
Carlow (790)	Baganalstown Esker	BN 38/39	NA	Sand/gravel Esker	Ecol	Local
Carlow (794)	Ballyellin Quarries S 68 54	BN 45	NA	Sand/gravel Quarry	Ecol	Local
Laois (16)	Barrow Valley at Tankardstown Br. S 703 880	BN 6	5 ha	Grassland	Ecol	Local

Key : Ecol = Ecological

(after: An Foras Forbartha, 1981;
Wildlife Service, 1989;
National Parks & Wildlife Service, 1992)

1.6 NATURE CONSERVATION ON THE BARROW NAVIGATION

1.6.1 Nature conservation and engineering

Engineering works, because of their scale, usually have a very severe impact on both nature conservation and recreation along the waterways. The size of the machines used today and the speed at which they work mean that relatively large stretches of waterway can be affected in a short period of time, which doesn't allow the system time to recover naturally.

The main impacts of engineering works are dealt with in Chapter 4.1. The end result in most cases is a loss of habitat diversity as the system becomes more uniform. The ecological interest of the waterway can be reduced and its nature conservation value severely diminished if care is not taken carrying out engineering works.

1.6.2 Nature Conservation and Amenity Activities

Recreational use places certain demands on the landscape - the main one being constancy and stability. This need to maintain a stable environment often helps to maintain the ecological value of a site as well. For example maintaining open water in the centre of a canal for boats preserves a habitat that would be lost if no management were carried out. However the method of maintaining a particular habitat, in this case open water, will have a direct bearing on the nature conservation potential of the waterway. If the open channel is maintained using herbicides, the ecological diversity of the system will be reduced. If the channel vegetation is removed by cutting, then the ecological value can be maintained.

The method of maintaining a path for walkers also illustrates this point. Grass is the most suitable surface for long-distance walkers. If the grass path is over-maintained by constant cutting it will lose its ecological value. If the path itself is cut twice a year and the verges are treated as a hay meadow and cut once, the footpath remains walkable and the ecological interest is not lost.

It is very important to recognise that management for amenity and recreation will not always be suitable for nature conservation. In some cases the two may be dependent on the same feature of the waterway - a grassy towpath or open water in the channel. In others there may be conflict of interest - the opening of both banks to create a circular walking route (as suggested in Brady, Shipman, Martin, 1992) will result in the disturbance of the vegetation and wildlife on both sides of the waterway, thereby reducing the ecological value of the area.

All recreational activities have a series of impacts on the ecology of the system - some negative, some positive, but all interconnected. These are dealt with in Chapter 4.2.

1.6.3 Nature Conservation and Education

In order for the Barrow Navigation to fulfil an educational role its wildlife value must be conserved. Ecology is becoming an important part of the biology syllabus for secondary schools, while nature study has always been important in primary schools. Field work is now a feature of the curriculum for both primary and secondary schools. The educational value of the Barrow Navigation depends on its habitat diversity - the more habitats there are to show to the students the more they will appreciate the ecological complexity of natural and semi-natural systems.

Informal education is also important. People are interested to learn about nature and wildlife as they walk along a river bank. It is important to explain to the people who use the waterways why nature conservation cannot be left to happen on its own, but needs careful management. They need to understand why long grass is left on either side of the towpath - that this is a policy of maximising wildlife interest, not skimping on maintenance. Explanations and understanding will lead to a greater appreciation of the nature and wildlife they see around them.

1.6.4 Nature Conservation and Co-operation

The property owned and managed by the OPW along the Barrow Navigation consists of a relatively narrow strip of land and water. As a result the OPW is involved directly in the conservation of linear habitats such as the hedgerow, the grassy trackway, the reed fringe and the open water of the boat channel and the river. However the ecological value of these habitats, like that of the Barrow Valley as a whole, depends on the ecological value of the adjacent land as well.

It is therefore important to realise that in order to maintain the ecological value of the Barrow Navigation, the ecological value of both OPW and non-OPW land must be maintained and conserved. This will involve co-operation and liaison with the local landowners, with the Local Authorities and with local interest groups.

CHAPTER 2 HABITATS

2.1 INTRODUCTION

The wildlife resources along a waterway are represented by its habitats. A habitat is the physical structure that supports a particular community of plants and animals.

The Barrow Navigation is made up of river stretches and canal cuts. A number of different habitats are found along the navigation, some widespread and others rare. The ecological value of the navigation depends on its range of habitats and on the plant and animal communities they support. Loss of habitat would result in a decrease in diversity and a reduction in nature conservation value. Rare habitats, which tend to be small in area and to support species that are also rare, are particularly vulnerable, and may need a more active form of protection than habitats which are common along the full length of the navigation.

A trackway or towpath is maintained along one side of the navigation and this supports the same grasses and tall herbs along its length. The navigable portion of the river channel, usually at the towpath side, is deepened. The development of the trackway and the deepening of the boat channel reduces the habitat diversity at one edge of the river because the natural zonation of marginal vegetation from wet to dry of a typical river bank is lost. However, this loss of diversity of riverine habitat along the towpath side is compensated for by the back drain running parallel to the river and by the gentle slope at the river edge on the offside.

2.2 WOODLAND

On OPW property the woodland habitat exists only as woodland margins, as there is not usually sufficient width for true woodland to develop. However extensive woodland is found beyond the boundary of OPW property.

Woodland is the climax stage of vegetational succession for most of Western Europe, and is one of the more stable habitats found along the Barrow Navigation. Most woodlands consist of three layers: a tree layer, a shrub layer and a herb layer. The plants of the herb layer flower early in the year, before leaves develop on the trees and shrubs and block out the light to the ground.

The underlying soil conditions affect the woodland flora of all three layers. On the dry limestone soils of the upper Barrow Corylus avellana (Hazel) can dominate the tree and shrub layers, while the ground flora is diverse and species-rich, containing many species found in calcareous

grassland and scrub. Woodlands on the acidic soils of the lower reaches of the Barrow tend to have a much poorer ground flora, and a tree layer dominated by Betula (Birch), Quercus (Oak) or Pinus (Pine).

The woodlands of the Barrow Valley add greatly to the nature conservation potential of the Barrow Navigation. Three of them, generally mixed deciduous woods with some conifers, have been designated as ASIs (Fig. 1.1; Table 1.1). These habitats are important when considering the overall ecological value of the navigation.

On the offside, carr (wet woodland) has developed on the waterlogged soils. At the river edge the tree layer is dominated by Alnus glutinosa (Alder) and/or a range of Salix species (Willows). Behind these on slightly dryer ground are the very tall Salix alba (White Willow), Betula (Birch), Fagus sylvatica (Beech), Quercus species (Oak), Fraxinus excelsior (Ash), Corylus avellana (Hazel) and some Acer pseudoplatanus (Sycamore). The ground layer includes those marsh and dry-ground species that are tolerant of shade.

The diversity of woodland type and trees provides a home, shelter and food resource for birds, mammals and huge numbers of invertebrates as well as sheltering the river and its habitats.

2.3 HEDGEROW

The hedgerows are dominated by Crataegus monogyna (Hawthorn) with Prunus spinosa (Blackthorn) and Rosa canina (Dog Rose). Tree species including Acer pseudoplatanus (Sycamore), Fraxinus excelsior (Ash), Sambucus nigra (Elder) and Quercus (Oak) are also common. Viburnum opulus (Guelder-rose) and Euonymus europaeus (Spindle-tree) are often present on calcareous soils, where Corylus avellana (Hazel) may dominate.

The ground layer in a hedge resembles a woodland margin, and includes a variety of shade-loving plants such as Primula vulgaris (Primrose), Viola (Violets), Veronica chamaedrys (Germander Speedwell) and Glechoma hederacea (Ground Ivy) as well as those tolerant of higher light levels at the hedge edge - Anthriscus sylvestris (Cow Parsley) and Geranium robertianum (Herb-Robert).

Hedges, like the woodlands, provide valuable food crops for birds and animals - pollen and nectar in spring as well as berries and nuts in autumn. The hedgerow is an important habitat for song birds (Turdus merula - Blackbird, Erithacus rubecula - Robin) and small mammals (Apodemus sylvaticus - Field Mouse, Sorex minutus - Pygmy Shrew), as it provides them with food and shelter. Numerous species of

invertebrates also depend on the hedgerow, either directly (for food) or indirectly (for the shelter it gives to other habitats). The height of the hedgerow and the denseness of the vegetation at its base are important in determining its value for wildlife. In a low hedge (1 metre high or less) nest predation has a serious impact on breeding bird populations. Ground-dwelling mammals depend on dense vegetation at the base of the hedge for cover and protection.

Hedges or woodland are found along the boundary line of the entire Barrow Navigation, on the towpath side, except along small stretches of some urban centres. There is often a line of trees or scrub growing along the bank especially on those stretches where the bank verge is quite wide. The hedges along the boundary are quite dense but along the bank they usually consist of straggling Salix sp. (Willow) and Alnus glutinosa (Alder).

2.4 SCRUB

Scrub is an important habitat both in terms of the plant species it supports and because it provides food and cover for a wide range of birds and animals. In general scrub along the waterway is made up of the same species as the hedgerow - Crataegus monogyna (Hawthorn), Rubus fruticosa (Bramble), Prunus spinosa (Blackthorn), - although in wet areas Salix species (Willows) and Alnus glutinosa (Alder) are often the dominant species. Scrub therefore supports the same range of animal and bird species as a well-developed hedgerow. In addition, because it is more extensive than hedges, scrub can also provide shelter for larger animals, including otters - Lutra lutra (King and Potter, 1980).

Scrub can develop rapidly in areas that have been cleared of other vegetation, or when maintenance lapses and the hedgerow is allowed to become overgrown and to encroach onto the boundary verge and towpath. In some cases scrub is a successional stage, and will eventually develop into woodland if left unmanaged. In other cases the scrub itself is the climax stage, due to limitations of soil or climate. Both types are valuable habitats, adding to the diversity of the waterways network.

The scrub habitat found along the Barrow Navigation is generally confined to the offside - the non-towpath side. Because most of the ground on this bank is so wet and liable to flooding it is not managed. Scrub develops on these areas and if left alone will eventually grow into a woodland as already described.

2.5 DITCHES AND DRAINS

The boundary drains along the Barrow Navigation range from recently cleared and reprofiled channels to dry, overgrown ditches. A newly-cleared drain supports very little vegetation except opportunistic species of Chara and other Charaphytes. Over a growing season the diversity increases greatly. Fish have been seen in the boundary drain.

Older, more established drainage channels frequently support the same range of species as canals, with emergent vegetation on the banks and submerged and floating-leaved plants including Potamogeton (Pondweeds) and Lemna (Duckweeds) in the open water. Like the canals, an unmanaged drainage ditch will gradually silt up and become overgrown, eventually becoming part of the surrounding dryland habitats.

2.6 GRASSLAND

Grassland is a non-climax stage in vegetational succession and therefore needs management if it is to be retained. Because of the variation in environmental conditions and the varying degree of management in use this habitat is quite variable and can support a number of different plant communities.

2.6.1 Pasture

Pasture grassland is maintained by grazing. The height and species composition of the sward depends on the type of grazing animal, and on the grazing pressure. Sheep produce a very low, even grassland. Cattle produce a longer, uneven sward. Horses, being very selective grazers, produce a sward that is rapidly dominated by those unpalatable species that they will not eat.

The pasture grassland along the Barrow is outside OPW property and is found on the larger islands, on the offside and outside the boundary line. Most is liable to flooding. Cattle graze these lands during the summer months. The fields are not sprayed and support a diverse range of both semi-aquatic and terrestrial plants including Juncus species (Rushes), Iris pseudacorus (Iris), Lychnis flos-cuculi (Ragged Robin), Ranunculus species (Buttercups), Stellaria graminea (Stitchwort) and Dactylorhiza fuchsii (Marsh Orchid).

2.6.2 Meadow

Meadows were traditionally maintained by cutting for hay once a year, in July or August. This allowed the grasses and the

herbs to flower and set seed, maintaining the floral diversity of the grassland. Meadows differ from pastures in that the vegetation is allowed to flower before it is harvested as hay in midsummer. The non-selectivity of cutting as compared to grazing also has an effect on the species composition of the sward.

Meadows can be destroyed by early cutting (before seed has set), by too frequent cutting (more than once a year), and by the application of fertilisers which give the more invasive grass species a competitive advantage over the slower-growing grasses and herbs. The development of meadows along the banks would produce a colourful, herb-rich grassland with low maintenance requirements. This option should be considered for both ecological and recreational reasons.

2.6.3 Rough grassland / tall herbs

This habitat is found between the boundary hedgerow and bank along the Barrow Navigation. Its structure is similar to that of a traditional meadow but because of high nutrient levels in the soil the coarse grasses and vigorous plants have a competitive advantage over slower-growing species. As a result a small number of species dominates the habitat, and the diversity is fairly low.

The most common plants in this habitat are coarse species such as Heracleum sphondylium (Hogweed), Urtica dioica (Nettle) and Dactylis glomerata (Cock's-foot Grass). Along the boundary hedgerow species tolerant of lower light levels such as Geranium robertianum (Herb-Robert) and Torilis japonica (Upright Hedge-parsley) are common.

2.6.4 Trample-resistant grassland

This is usually the towpath habitat. However along the Barrow the trackway is dominated by rough grasses and tall herbs, and the level of trampling is not sufficient to affect the species composition.

Mild trampling has very little effect on the grassland vegetation, but heavier trampling either by pedestrians or by vehicles results in a change in the species composition of the sward as the more sensitive species are eliminated.

The centre of the path, where the impact of trampling is greatest, can be bare of vegetation, with trample-resistant species on either side. Where a trampled path is poorly drained people frequently move off it onto the undisturbed vegetation, creating a meandering network of paths.

2.7 WASTE/BARE GROUND

Opportunistic and pioneer plant species produce very light seeds that are unable to germinate in established vegetation. These species require patches of waste ground, where they form the first stage in the vegetational succession. This stage is generally very short-lived - perennial plants soon take over from the annuals.

There are two different types of bare ground found along the Barrow Navigation, both resulting from spoil deposition on the banks. The spoil from the canal cuts is rich in nutrients, while that taken from fast-flowing stretches of river is gravelly and nutrient-poor. The colonisation of gravelly spoil heaps is diverse and colourful (Plates 4 and 28) while the vegetation on nutrient-rich spoil is tall, coarse and very competitive (Plates 2, 8 and 20).

2.8 BANK/BANK VERGE

The bank is the transition zone between the terrestrial and the aquatic habitats. The range of species found along the bank depends on a number of factors, in particular the height and steepness of the bank. The bank along the trackway of the Barrow Navigation is both steep and high in places and this type of bank excludes the transitional zone of vegetation - ranging from tall herbs such as Iris pseudacorus (Yellow Iris) and Filipendula ulmaria (Meadowsweet) at the top of the bank to an emergent reed fringe at the water's edge. Instead the steep, high bank is generally colonised by hedgerow trees and shrubs (see Section 2.3 and 2.4) or by dry grassland species (Section 2.6.3).

In other locations along the Barrow Navigation, particularly at the northern end, the slope of the bank is more gradual and often a wide bank verge exists. Because these areas are usually flooded each year the resulting vegetation is semi-aquatic and also reflects the high nutrient status of the soil. The bank verge in these situations tends to be dominated by terrestrial plants such as Calystegia sepium (Hedge Bindweed), Epilobium hirsutum (Hairy Willowherb) and Urtica dioica (Nettle).

An interesting feature and one of major concern along the gradually sloping banks of the River Barrow is the increasing amount of Heracleum mantegazzianum (Giant Hogweed) which is becoming established.

2.9 AQUATIC HABITATS

2.9.1 Differences between canals and rivers

There are a number of differences between rivers and canals which create differences between the natural communities they can support.

2.9.1.1 Bank profile

Canals are man-made waterways, and their bank profile is determined by dredging and maintenance. Where the channel is saucer-shaped and there is shallow water along the edges of the canal, emergent vegetation including a reed fringe can become established at the canal margin. Where the canal banks are straight and steep it is more difficult for plants to become established due to the depth of water at the edge of the canal. Where a berm has developed along the edge of the canal emergent plants can flourish without encroaching into the deep central channel. Along some stretches of canal the nearside bank is steep, straight and sparsely vegetated, while the offside is shallower and supports more vegetation.

Rivers in their natural state have shallow water at the banks. Navigable rivers however are semi-natural systems, and tend to have an artificially deepened boat channel beside the trackway, with straight, steep sides. The offside usually retains its natural profile with shallow water supporting a reed fringe and emergent vegetation.

2.9.1.2 Flow regime and flooding

The water levels in a canal remain fairly constant over the year as the whole system is controlled and contained. Rivers on the other hand have annual variation in flow, as more water passes downstream in winter than in summer. Water levels are frequently very low in summer, while floods are common in winter.

Fluctuating water levels and changes in the strength of the flow also affect the plants and animals in the water channel itself, and very different communities are found in the navigable river stretches and the canal cuts. The weirs add another dimension the ecology of river navigations, and are colonised by a specialised group of plants and invertebrates.

2.9.2 Reed fringe

Reed fringe occurs along both sides of the canal cuts and, where conditions permit, along both sides of the river. A reed fringe will develop in shallow water which gradually deepens towards the central channel. This habitat has an important engineering function - protecting the banks by

absorbing wave energy on the canal stretches. It also has an ecological function as the reed fringe supports many species of aquatic and wetland invertebrates and their larvae (dragonflies, water snails) which are a food source for fish and it offers shelter and nest sites to Anas platyrhynchos (Mallard), Gallinula chloropus (Moorhen) and Cygnus olor (Mute Swan).

A wide variety of plant species may be present in the reed fringe, including grasses, sedges and herbaceous plants. Along the river bank the reed fringe vegetation is usually dominated by reed-grasses and wetland plants such as Sparganium erectum (Branched Bur-reed), Mentha aquatica (Water Mint), Nasturtium officinale (Water Cress) and Iris pseudacorus (Yellow Iris). A similar list of species is found along the reed fringe of the canal cuts. However, Glyceria maxima is dominant there.

2.9.3 Open water

The plants of the true aquatic ecosystem also provide the habitat (food, shelter and breeding sites) for many invertebrates and fish.

Within the open water habitats of river and canal are two main plant growth forms - floating-leaved and submerged. Some submerged plants are low-growing and only cover the bed of the channel. Other submerged species in similar situations grow up towards the surface, filling the water column eg. Myriophyllum spp. (Water-milfoil), Sparganium emersum, (Unbranched Bur-reed), Elodea canadensis (Canadian Pondweed), and Potamogeton (Pondweeds).

Floating-leaved plants may be rooted in the muds of the shallow, slow-moving channel (canals and river edges) - eg Nuphar lutea (Yellow Water-lily) and Sagittaria sagittifolia (Arrowhead) - or free-floating - eg Lemna spp. (Duckweeds).

There are particular pondweeds associated with both fast and slow-moving water. In the canals Potamogeton pectinatus (Fennel Pondweed) and P. lucens (Shining Pondweed) are found, while P. perfoliatus (Perfoliate Pondweed) is common in the river.

The aquatic fauna, which lives on the many forms of aquatic vegetation, includes many snail and mollusc species, insect larvae (eg caddis-fly, dragonfly and damselfly larvae) and water beetles. Fish species found along the Barrow Navigation include Salar salar (Salmon), Salmo trutta (Brown Trout), Rutilus rutilus (Roach), Scardinius erythrophthalmus (Rudd), Abramis brama (Bream), Tinca tinca (Tench), Esox lucius (Pike) and Anguilla anguilla (Eel).

2.10 STONEWORK

Locks, bridges and walls can all support a variety of plant species. Some, such as Cymbalaria muralis (Ivy-leaved Toadflax) and many species of lichen, are adapted to grow in the very arid conditions that develop on a south-facing wall or rock. Others, for example mosses, are restricted to the damper habitats of the north face and of crevices between the stones. Others, like Hedera helix (Ivy), are rooted in the ground and use the wall or bridge as a support to climb on.

It is on the stonework habitats of old bridges that bats can be found. They roost in crevices under the arches of the old, wide, dark bridges of the Barrow and its tributaries. The bat most commonly found near water is Daubenton's Bat which feeds on the flying insects associated with the water's edge. It is important that crevices be created/retained when building/restoring bridges and that the Co Council be made aware of this.

2.11 WEIRS

The weirs along the navigation are very specialised habitats, with very fast-flowing water. The number of plants which can survive such conditions is very limited. Where silt has accumulated, populations of Glyceria maxima (Reed Sweet-grass) and Scirpus lacustris (Common Club-rush) grow.

Salmon jump the weirs as they migrate upstream to their spawning grounds.

Otters are frequently seen playing and feeding near weirs.

CHAPTER 3 FLORA OF THE BARROW NAVIGATION

3.1 INTRODUCTION

The habitats and flora of the 69km of the Barrow Navigation were recorded throughout 1992 and early 1993.

The objectives of the study were many and include:

(a) a baseline survey of the vascular plants which grow along the waterway corridor.

(b) to map the locations of Giant Hogweed along the waterway. This plant poses a threat to humans.

(c) mapping plant associations typical of each habitat within this corridor.

(d) determining the factors which contribute to the development of the particular habitats along the system.

(e) to assess the importance of these habitats in the context of the river valley and in relation to their occurrence elsewhere in the country.

(f) to bring an awareness of the importance of these habitats to the attention of planners and engineers.

(g) to compare the effects on the flora of the various types of management at present in operation along the waterway.

3.2 METHODOLOGY

Each zone (boundary, boundary verge, towpath, bank verge and channel) of approximately 69 kilometres of OPW property along one side of the Barrow Navigation (Hanna and Delany, 1990) was surveyed during the period May 1992 to March 1993. The vegetation of each zone of all kilometres was recorded. The trackway was walked three times in order to record plants growing throughout the year. The habitat types, physical features and other relevant features of each zone along the entire system were mapped. This follows the method devised by the British Waterways Board (Tandy, 1989).

The maps of each individual kilometre section were at a scale of 1:2500. A summary of the information collected in the field was transferred on to 6inch maps (scale 1:10,560). Both sets of maps, together with guidelines for management, are contained in Part 2.

3.3 RESULTS

The species found along each zone are noted in Appendices 1 - 6, and the diversities for each zone are given in Appendix 7. Sites showing high and low diversities within each zone are given in Table 3.1 (at the end of this chapter). It was also possible to determine species showing the highest and lowest percentage occurrence within each zone. Species occurring infrequently along the system were many. Only those associated with habitats likely to be found in a particular zone are listed. This information is in Tables 3.2 - 3.7 (also at the end of this chapter).

3.3.1 Flora of the Boundary and Boundary Verge

The boundary along most of the length of the Barrow Navigation consists of a hedgerow and back drain. Below Goresbridge (BN47) - the southern end of the Barrow Navigation - there is mature woodland and no drain along some of the boundary. 212 plant species were recorded in the boundary (Appendix 1). The plants found in the boundary verge (201 plant species, Appendix 2) include those which are influenced by the presence of the hedgerow or woodland as well as tall herb species.

The highest plant diversities in both zones (Table 3.1) were recorded at kilometre sections with woodland as the boundary. At some of these sites, large rocks are found on both the steep slopes upon which the woodlands grow and on the boundary verge. The crevices between the rocks provide an ecological niche for many plants not found elsewhere on the system (BN59-BN60 and BN65-BN68).

Lowest diversities were recorded along sections with a wall/fence as the boundary such as at Milford (BN27) and at the sugar factory just north of Carlow (BN17); where the hedges were straggling (BN2 in Athy, BN11 on the approach to Maganey Lock, BN25 and BN27 both sides of Milford and BN29).

Low diversities in the boundary verge were recorded at those sites where the habitat was well defined and consisted of grassland (BN2, BN31 and BN32 at Leighlinbridge, BN21 and BN22 on the approach to Clogrennan); and in rural areas where the hedgerow/scrub of the boundary has encroached on to the boundary verge to the exclusion of grassland species (BN5, BN7 and BN27).

3.3.2 Flora of the Towpath

A vegetated towpath is found at 62 sites and it supports

154 plant species (Appendix 3). Tarred track and surfaced road are found in the urban areas. The towpath vegetation consists chiefly of competitive, tall-herb species which grow on nutrient-rich soil. The nutrient-rich soil of the lower Barrow in further enriched by silt left after flooding, spoil disposal and because vegetation cuttings are not removed.

The highest diversity (Table 3.1) is found where small, nutrient-poor sites make up part of the kilometre section. Gravel, from spoil taken from fast-flowing river sections, influences the vegetation at BN4, BN6, BN8, BN29 and BN46; the lime works at Upper Ballyellin Lock exert an influence on the soil status at BN45 and nutrients are removed from the system on a regular basis at Leighlinbridge (BN30) when cuttings are removed (Plates 21 - 23).

Lowest diversities were recorded from kilometre sections of urban areas; from paths which were well used (Bestfield Lock towards Carlow BN16 and 17) and on those sections supporting nutrient-rich vegetation which had recently been cut (between Carlow and Clogrennan BN20 - 22).

3.3.3 Flora of the Bank Verge

The structure of the bank verge, between the towpath and channel, varies along the navigation. It can be steep with deep, fast or slow-flowing water at the edge; it may be less steep with a reed fringe at the water's edge or there may be an accumulation of silt on low areas above the water level as a result of flooding - especially at wide-sweeping curves. A reed fringe exists along most of the banks of the canal cuts. Added to the variety of bank types is the fact that spoil is often deposited on them and this too exerts an influence on the vegetation. A total of 195 plant species were recorded on the banks (Appendix 4).

The highest diversities were recorded from the southern end of the navigation where the banks were steep. They were also dry and tended to support a wide range of terrestrial grassland species rather than semi-aquatics (BN46, BN60, BN61 and BN65). Banks of canal cuts which are more gradual support terrestrial, transitional and semi-aquatic species and are present in some of the sections with high diversities (BN59, BN68, and BN67).

Low plant diversities were recorded from sections where spoil had been deposited and resulted in competitive species dominating (BN21, BN22, BN28 and BN26); where hedgerow species were growing on the bank (BN24 and BN25) and where the river bank is subject to silt deposition as a result of flooding (BN11 and BN12 Appendix 7).

3.3.4 Flora of the Channel

The channel of the Barrow Navigation consists of separate river and canal stretches. A total of 41 plants were recorded from both (Appendix 5). Some kilometre sections cover stretches with both river and canal.

The highest diversity (Table 3.1) occurred at those stretches with both river and canal (BN57, BN62, BN37, BN53, BN35, BN40). Plants adapted to both the fast-flowing conditions of river and those of the slower moving canals are present as well as emergents at the edges of both, especially the canal. The river stretches at BN36 and BN38, both with high diversities, are either side of Bagenalstown Lock, with islands in the middle and are slow-flowing.

Low diversities (Table 3.1) were recorded from sections with only river and these were generally fast-flowing and in the more polluted upper reaches (ERU, 1992). The low diversity at BN22 - canal only - is as a result of recent dredging and shading.

3.3.5 Flora of Locks and Bridges

Locks and bridges or both were found in 37 kilometre sections and they supported 126 plants (Appendix 6).

As would be expected, the highest diversity (Table 3.1) was recorded at BN19 where both bridge and lock were present. Other sections with high diversities were those with locks. At a lock there will be the semi-aquatic habitat of the wet chamber as well as the dry habitat between the limestone coping stones at the top of the chamber.

Lowest diversities (Table 3.1) are not representative. It was not always possible to record all the vegetation at bridges because of height and lack of access. However, it can be said that overall the diversity at bridges was lower than at locks. The locks at BN62 and BN64 (Table 3.1) were low in diversity because most vegetation had been removed from them.

3.4 DISCUSSION

3.4.1 Boundary

The species occurring most frequently in the boundary are trees, shrubs, vigorous hedge edge plants and emergents in the back drain (Table 3.2). They occur at more than 85% of the sections reflecting the fact that the hedgerow and

back drain are the dominant features along the boundary. Alnus glutinosa (Alder), a tree of wet conditions grows, at 77% of the sites.

Plants which hardly feature at all include those of the smaller habitats found along the boundary - Asplenium ruta muraria (Wall Rue), A. trichomanes (Maidenhair Spleenwort), Ceterach officinarum (Rustyback Fern), Cymbalaria muralis (Ivy-leaved Toadflax) and Desmazeria rigida (Fern Grass) of walls; ground storey woodland plants such as Ajuga reptans (Bugle), Carex sylvatica (Wood Sedge), Circaea lutetiana (Enchanter's-nightshade), Epilobium montanum (Broad-leaved Willowherb), Equisetum sylvaticum (Wood Horsetail), E. telmateia (Great Horsetail), Fragraria vesca (Wild Strawberry), Hypericum androsaemum (Tutsan), Potentilla sterilis (Barren Strawberry), Primula vulgaris (Primrose) and Oxalis acetosella (Wood Sorrel).

Other interesting observations:- Reynoutria japonica (Japanese Knotweed), an invasive plant along river banks, has not taken hold. It was only found at one site in the vicinity of Carlow town. Oenanthe fistulosa (Tubular Water-dropwort), a plant which is nationally rare, was found growing in a pond near Ballytiglea Bridge. Sorbus hibernica (Irish Whitebeam), also nationally rare and which grows on nutrient-poor soils, was found near Athy. Melica uniflora (Wood Melick) and Blechnum spicant (Hard Fern), both found in shady woodlands, grow at one location each near St. Mullins and Clashganna.

3.4.2 Boundary Verge

The most dominant plants of the boundary verge are competitive grasses and vigorously growing tall herbs (Table 3.3). Agrostis stolonifera (Bent Grass), Dactylis glomerata (Cock's-foot Grass), Anthriscus sylvestris (Cow Parsley), Heracleum sphondylium (Hogweed), Rubus fruticosus agg. (Bramble) and Urtica dioica (Nettle) grow at more than 90% of the sections.

Interesting to note is that the invasive Impatiens glandulifera (Indian Balsam), usually found on river banks, is present at 43% of sites at the southern end of the system. Pteridium aquilinum (Bracken) is seen at practically all sites south of Ballytiglea Bridge (BN50). This plant favours open woods, mountain slopes, neglected pastures and sandhills (Webb, 1977), all of which occur along this stretch of the navigation.

Rarer plants of this zone again include those of smaller habitats. Most occur only once. Agrimonia eupatoria (Hemp Agrimony), Geranium molle (Dove's-foot

Crane's-bill), Knautia arvensis (Field Scabious), Primula veris (Cowslip), Rhinanthus minor (Yellow Rattle), Erigeron acer (Blue Fleabane), Trisetum flavescens (Yellow Oat-grass) are characteristic of nutrient-poor grassland.

No two of these rare plants occur at the same site but may occur in combination with other plants of a similar habitat which may not be rare to the system. This indicates that there are many small patches of nutrient-poor grassland along the navigation. These occur beside footpaths or on gravelly spoil. Blue fleabane (BN45) is a Red Data species though not listed for protection (Curtis and McGough, 1987).

There is another group of rare plants found in this zone - those typical of woodland ground flora (see sections 3.3.1 and 3.4.1 on boundary).

3.4.3 Towpath

Towpath plants are generally those which have adaptations allowing them to withstand pressure from trampling. Along the Barrow Navigation this is not the case. Instead competitive grasses occur most frequently (85-93% of sites) (Table 3.4). Trifolium spp. (Clovers) and Taraxacum spp. (Dandelions), both trample resistant, also occur but at fewer sites. Hogweeds, Nettles and Docks, more coarse, competitive species, occur at 47%, 39% and 42% of sites respectively. The dominance of coarse, competitive species can be attributed to the input of nutrients through non-collection of cuttings, flooding and spoil deposition.

Plants rare to the towpath (Table 3.4) are those of nutrient-poor grassland and, as noted in the section above on the boundary verge, soil conditions resulting in this habitat occur where gravelly spoil is deposited and where gravel/lime workings and footpaths exert an influence. Blue fleabane is found in BN45 beside Ballyellin Limeworks.

Overall, there are very few nutrient-poor plants found. Species common throughout the midlands such as Briza media (Quaking Grass) and Leontodon spp. (Hawkbits) are not found at all. Though these nutrient-poor habitats are small in area they contribute to the sections with the highest diversities.

3.4.4 Bank Verge

As noted in Section 3.3.3, the structure of the bank varies along the navigation. The highest diversities are

found on kilometre sections supporting dry steep banks and on gradually sloping banks of canal cuts. The plants occurring most frequently along the system (Table 3.5) however, are found on banks subject to nutrient input as a result of dredging and silt deposition from flooding. The plants are coarse and competitive and occur at 87-99% of sites indicating that most sites are subjected to these activities at some stage.

Other plants present along much of the system are grasses, reeds and tall herbs such as Filipendula ulmaria (Meadowsweet) and Epilobium hirsutum (Hairy Willowherb) which are associated with wetlands.

Plants occurring infrequently on the banks are those of a transitional zone between terrestrial and aquatic (Table 3.5). This zone only exists along the canal cuts of the Barrow Navigation and even there the input of nutrients reduces the diversity.

It is interesting to note that the invasive Reynoutria japonica (Japanese Knotweed) was only found at one site near Athy, though it was also found in the boundary at Carlow. However, 41% of sites support the invasive Indian Balsam as similarly noted for the boundary verge.

Heracleum mantegazzianum (Giant Hogweed), an invasive plant typically associated with river banks is spreading along the upper banks of the Barrow Navigation. It has been recorded, mapped and sprayed in 1992 and 1993 (OPW: File No. F96/1/115). It has not been found south of Leighlinbridge (BN32). It is found on both banks and grows on grassland and on the bank verges subjected to flooding, particularly on the bare ground underneath bankside trees, but also on such areas without trees/shrubs. The greatest number and largest sites with Giant Hogweed were on bare ground underneath thickets at the water's edge.

3.4.5 Channel

In the case of the Barrow Navigation, as already mentioned, there are two forms of open water, the slow moving canals and the faster flowing river stretches. Of the 41 plants recorded from both, Nuphar lutea (Yellow Water-lily), Glyceria maxima (Reed Sweet-grass), Sagittaria sagittifolia (Arrowhead), Sparganium erectum (Branched Bur-reed) and S. emersum (Unbranched Bur-reed) occur at more than 87% of sites (Table 3.6).

Taking these and the other species with high abundance into account it can be seen that all can withstand eroding conditions which may result from boat movements, varying

water flows and fluctuating water levels (Table 4.5; Liddle and Scorgie, 1980). They have successfully adapted to these harsh conditions.

All with the exception of Potamogeton perfoliatus (Perfoliate Pondweed) and Sparganium emersum (Unbranched Bur-reed) are emergents and provide food and shelter for any invertebrates which in turn become food for birds and fish.

Herbicides were not used along the Barrow Navigation to control aquatic weeds in 1993, except at one or two places (Central Fisheries Board, 1994). Instead weed-cutting boats were used on the canal stretches as it is these areas that aquatic plants cause problems for boaters. It is proposed to carry out this procedure again in 1994 (Central Fisheries Board, 1994). Treatment with herbicides was not successful for a number of reasons: the dominant plants are resistant to herbicides; the flow rate on the canals was too great and the herbicide was carried downstream and in some instances the operation of generators on the canal cuts also caused too much movement in the water.

Plants found infrequently include Rumex hydrolapathum (Water Dock) and Typha latifolia (Bulrush) which survive in wet, muddy, marshy conditions; Ranunculus circinatus (Fan-leaved Water Crowfoot) and Potamogeton natans (Broad-leaved Pondweed) of slow moving water.

3.4.6 Locks and Bridges

Plants occurring most frequently (Table 3.7) were typical wall species as well as grasses which grow in similar conditions. Plants tolerant of wet conditions such as Filipendula ulmaria (Meadowsweet) and Urtica dioica (Nettle) were present in the lock chambers or on the gates at 54% and 62% of sites respectively.

Plants rarely occurring on the locks and bridges are also wall plants and those requiring nutrient-poor conditions. The latter have found a niche in the crevices between the coping stones of the chamber and include the following list of species: Anacamptis pyramidalis (Pyramidal Orchid), Anthyllis vulneraria (Kidney Vetch), Bromus erectus (Upright Brome), B. sterilis (Barren Brome), Geranium dissectum (Cut-leaved Crane's-bill), Hieracium pilosella (Mouse-ear Hawkweed), Leontodon autumnalis (Autumn Hawkbit), Origanum vulgare (Marjoram) and Pimpinella saxifraga (Burnet-saxifrage).

3.5 ECOLOGICAL COMPARISON BETWEEN THE BARROW NAVIGATION AND CANALS

The ecological surveys of the three inland waterway systems under the management of the Waterways Division of the OPW are now complete. A comparison of the two systems - navigable waterway and summit-level canal - shows the differences in ecology of each, and highlights the fact that management practices for one may not suit the other.

3.5.1 Boundary

96% of the boundary along the river consists of well developed hedgerow/woodland and back drain which supports fish. It is more or less uniform and a valuable, well defined series of ecological habitats. It supports a much higher plant diversity than the boundary along the canal. It is important therefore that this habitat be conserved and that trees, shrubs, species-rich drain etc. be maintained in a sensitive manner and allowed remain. The boundary of the canal varies between wall, fence, hedgerow, and in some instances is not defined at all as a public road along by the canal marks the edge of OPW property. Where the boundary is defined, the ecological value can be increased by encouraging the development of hedgerows using native species.

3.5.2 Boundary verge

The reverse to above is found on this zone. Unlike the boundary verge along the Barrow Navigation, which is a uniform width of approximately 1m and not clearly defined from the towpath, the boundary verge along the Grand Canal varies in width up to 30m; supports a diverse range of habitats such as bog, nutrient-poor grassland, quarry, scrub and many more and is clearly separate from the towpath. There are management strategies suited to each of these habitats and are outlined in Chapter 4 of the Ecological Survey of the Grand Canal (Dromey et al., 1992).

The most common habitat of the Grand Canal boundary verge is nutrient-poor grassland. This habitat only occurs in isolated spots along the boundary verge of the Barrow Navigation, where the dominant habitat is tall, coarse, competitive vegetation of reduced ecological diversity. This coarse sward is due to differences in soil conditions and to nutrient input from spoil deposition, flooding and non-removal of cuttings. Management strategies in Section 4.1.2.2 outline guidelines on increasing ecological diversity of the zone.

3.5.3 Towpath

The towpath along the Grand Canal is well used by vehicles, bicycles, fishermen and walkers. Long stretches are road or surfaced track, and it is only vegetated for 70km of the 131km (53%). This vegetated section has a well worn track in the centre. Plant diversity is low as a result of amenity activities and use for access.

Plant diversity or ecological value is also low on the towpath of the Barrow Navigation but for entirely different reasons. The soil status, like that of the boundary verge of the Barrow Navigation, is rich in nutrients resulting in a sward of competitive plants (Plates 8 & 20). The implications of this is that the conservation value is reduced and because the plants are so tall, walkers are discouraged from using this vegetated footpath almost 62km long (90% of the Barrow Trackway).

Even when cut, it is difficult to walk the towpath because the cuttings of these tall coarse plants remain underfoot (Plate 5). The nutrients from this decaying material are then recycled back into the soil and further coarse vegetation growth is encouraged. The ideal solution towards eliminating the input of nutrients and making walking easier is to remove the cuttings.

3.5.4 Bank Verge

Like that of the boundary verge and towpath, the greater part of the river bank vegetation is determined by river dynamics. Flooding results in the deposition of nutrient-rich silt on the soil. Added to this is the fact that high winter flow rates result in channel silt being deposited in navigable sections. This is removed and some deposited on the bank - again further nutrient input. The vegetation reflects this (See Section 3.3.3. and 3.4.4).

Canal bank vegetation consists of terrestrial vegetation at the top, with plants characteristic of a transitional zone in the middle and semi-aquatic species near the water. The Grand Canal bank supports a much higher diversity of both small habitats and plants (260 as against 195 on the Barrow Navigation or 25% more) than that of the river navigation. Plants occurring most frequently are found on berms and on dry nutrient-poor grassland.

Angelica sylvestris (Wild Angelica) and Juncus inflexus (Hard Rush), plants of marshy conditions, occur at 87% and 85% of sites along the Grand Canal and only at 35% and 4% of Barrow Navigation sites. Galium verum (Lady's Bedstraw) is associated with nutrient-poor grassland and

is found at 87% of sites along the Grand Canal and only 7% of sites along the Barrow Navigation.

Another difference between canal and river bank vegetation is that invasive species are beginning to get a foothold along the river - Giant Hogweed on the upper stretches and Indian Balsam at the southern end.

3.5.5 Channel

The diversity of plants found in the canal is greater than that of the Barrow Navigation (53 species as against 41 in the Barrow Navigation - almost 25% more) even though there are two distinct types of open-water and weirs on the navigation. The water of the Grand Canal is clean, some large stretches remain untreated with herbicides and it is generally not subject to fluctuations in levels and flow rates. River navigation plants are subject to these stresses as well as growing in moderately polluted waters.

There are more Pondweeds in the river as they are adapted to the quicker flows. As against that there are no erosion and pollution-sensitive plants found in either the canal cuts or river. Stress-tolerant species survive and these have then to be removed by machine.

Because the navigation is subject to dynamics of the river, the navigable channel has to be cleared of silt after each winter, causing a continuous problem of spoil deposition. Silt on the Grand Canal on the other hand accumulates on the bed over a number of years.

Fish species on the canal and river vary. Trout and salmon can survive in the oxygenated water of the Barrow, while only coarse fish can live in the slow-moving canal water. Otters play and feed at the weirs on the river.

3.6 AREAS OF HIGH ECOLOGICAL INTEREST

The Barrow Navigation and Valley support a range of habitats which can be well-defined, stable, at the climax stage of development or undergoing successional change. Examples include mature mixed woodland, scrub, islands, wet meadows, gravel pits, pasture, boundary drain, river, canal and a variety of bank types on both sides of each. They are of high ecological merit and some are classified as ASIs.

Many of these habitats are outside OPW property and not managed by them. Notwithstanding this fact, and as outlined in Chapter 1 Sections 1.6.3 and 1.6.4, the maintenance of the ecological value of the Barrow

Navigation depends on the preservation and conservation of the ecology of adjacent non-OPW lands. To this extent co-operation between the OPW and the relevant bodies who own/manage these lands should be encouraged. In this way the Barrow Navigation and Valley will increase in ecological interest and become a valuable educational asset.

3.7 CONCLUSION

The most outstanding difference between the Barrow Navigation and the canals is the varying flow regimes of the river and the fact that this plays a major role in influencing management practices. Closely associated with this is the dominance across the boundary verge, trackway and bank verge of coarse vegetation.

The fluctuating water levels and flow rates exert a direct influence on channel vegetation. Only species able to adapt to these stressful conditions survive. These also tend to be the species resistant to herbicides. The implications of this is that they have to be manually removed and disposed of in an ecologically sensitive way.

Another effect of the flow regime is that strong winter currents result in the movement of silt on the bed of the channel. The silt comes to rest where the effects of the current are least felt such as below locks, at the beginning of canal cuts and at the river's edge. Where this natural deposition of silt interferes with the navigational channel a clearance operation takes place the following spring. Some of the silt/spoil is replaced back into the non-navigable channel and more is deposited on the bank. The method of spoil deposition on dry land and the management of the growth on it can be carried out in a sensitive manner.

A further effect of river dynamics is that flooding takes place. This impacts on the nutrient status of the soil so that the vegetation of the boundary verge, towpath and bank verge becomes indistinguishable from each other and is coarse and competitive. The management of these terrestrial habitats is of the utmost importance in maintaining and increasing, where possible, ecological diversity.

Habitats of high ecological merit along the system are the boundary hedgerow and drain, dry banks above flood level which have no spoil deposited on them, canal reed fringe and the range of habitats along the Barrow Valley.

TABLE 3.1

Sites with high and low plant diversities in each zone along the Barrow Navigation

HIGH DIVERSITY

BD		BDV		T'PATH		BKV		CH		L+B	
BN59	68	BN54	62	BN45	50	BN59	59	BN57	21	BN19	37
BN67	66	BN59	61	BN30	47	BN68	56	BN36	20	BN45	33
BN60	64	BN65	60	BN 6	41	BN46	54	BN62	20	BN27	31
BN66	60	BN68	60	BN 8	41	BN60	54	BN37	19	BN48	30
BN53	58	BN53	57	BN 4	40	BN61	53	BN53	19	BN65	30
BN 1	54	BN55	56	BN29	38	BN 9	52	BN35	18	BN22	29
BN58	53	BN60	55	BN46	38	BN65	51	BN38	18	BN 7	28
BN51	52	BN67	55			BN67	51	BN40	18		
								BN52	18		

LOW DIVERSITY

BD		BDV		T'PATH		BKV		CH		L+B	
BN 2	18	BN 5	12	BN47	2	BN22	24	BN18	6	BN38	NF
BN69	19	BN32	13	BN17	10	BN28	25	BN 6	7	BN67	NF
BN17	25	BN27	25	BN32	11	BN21	28	BN22	7	BN34	1
BN25	26	BN 2	26	BN16	13	BN26	28	BN13	8	BN33	2
BN29	27	BN22	26	BN20	13	BN24	29	BN24	8	BN62	3
BN35	27	BN24	26	BN21	14	BN25	29	BN15	9	BN64	3
BN11	28	BN 7	27	BN22	14	BN10	30	BN29	9		
BN11	28	BN21	27								
BN27	28	BN31	27								
		BN69	27								

NF = nothing found

TABLE 3.2
Species showing the highest and lowest occurrence (%) in the boundary along the Barrow Navigation

LOW OCCURRENCE	#	HIGH OCCURRENCE	#	%
Agrostis gigantea	1	Acer pseudoplatanus	48	73
Ajuga reptans	2	Agrostis stolonifera	53	80
Alliaria petiolata	1	Alnus glutinosa	51	77
Arabis hirsuta	1	Betula erecta	50	76
Asplenium ruta-muraria	1	Calystegia sepium	57	86
A. trichomanes	1	Crataegus monogyna	57	86
Blechnum spicant	1	Dactylis glomerata	61	92
Carex pendula	3	Epilobium hirsutum	56	85
C. sylvatica	1	Festuca rubra	58	88
Ceterach officinarum	1	Filipendula ulmaria	58	88
Circaea lutetiana	1	Fraxinus exelsior	60	91
Cymbalaria muralis	2	Galium aparine	57	86
Dactylorhiza fuchsii	1	Hedera helix	58	88
Desmazeria rigida	1	Phalaris arundinacea	57	86
Epilobium montanum	4	Poa pratensis	55	83
Equisetum sylvaticum	4	P. trivialis	59	89
E. telmateia	1	Rosa sp.	58	88
Fragraria vesca	2	Rubus fruticosus	61	92
Hypericum androsaemum	2	Salix sp.	55	83
Melica uniflora	1	Solanum dulcamara	53	80
Oenanthe fistulosa	2	Urtica dioica	59	89
Oxalis acetosella	2			
Potentilla sterilis	1			
Primula vulgaris	1			
Reynoutria japonica	1			
Sorbus hibernica	1			

No. of sites = 66

TABLE 3.3
Species showing the highest and lowest occurrence (%) in the boundary verge along the Barrow Navigation

LOW OCCURRENCE	#	HIGH OCCURRENCE	#	%
Agrimonia eupatoria	1	Agrostis stolonifera	64	98
Ajuga reptans	1	Anthriscus sylvestris	59	91
Allium vineale	1	Arrhenatherum elatius	61	94
Anagallis arvensis	1	Calystegia sepium	61	94
Blackstonia perfoliata	1	Dactylis glomerata	63	97
Bromus erectus	1	Festuca rubra	60	92
Carex remota	1	Galium aparine	56	86
C. sylvatica	1	Heracleum sphondylium	60	92
Deschampsia caespitosa	4	Holcus lanatus	60	92
Digitalis purpurea	1	Poa pratensis	62	95
Erigeron acer	1	P. trivialis	60	92
Festuca arundinacea	1	Ranunculus repens	53	81
Fragraria vesca	2	Rubus fruticosus	61	94
Geranium dissectum	1	Urtica dioica	60	92
G. molle	2	Viccia sepium	50	77
Knautia arvensis	1			
Lotus uliginosus	1			
Lycopus europaeus	1			
Melica uniflora	1			
Primula veris	2			
Rhinanthus minor	1			
Trisetum flavescens	3			
Tussilago farfara	1			
Verbascum thapsus	1			
Veronica persica	1			

No. of sites = 65

TABLE 3.4
Species showing the highest and lowest occurrence (%) in the towpath along the Barrow Navigation

LOW OCCURRENCE	#	HIGH OCCURRENCE	#	%
Agrimonia eupatoria	1	Agrostis stolonifera	50	81
Anacamptis pyramidalis	1	Arrhenatherum elatius	53	85
Anagallis arvensis	1	Dactylis glomerata	58	93
Arenaria serpyllifolia	3	Festuca rubra	56	90
Blackstonia perfoliata	1	Holcus lanatus	57	92
Bromus erectus	1	Poa pratensis	58	93
B. ramosus	1	P. trivialis	54	87
B. sterilis	2	Ranunculus repens	52	84
Dactylorhiza fuchsii	1	Taraxacum agg.	43	69
Erigeron acer	1	Trifolium pratense	53	85
Festuca arundinacea	1	T. repens	46	74
F. pratensis	1			
Linum catharticum	1			
Luzula campestris	2			
Myosotis discolor	1			
Origanum vulgare	1			
Pimpinella saxifraga	3			
Polygala vulgaris	2			
Primula veris	3			
Sagina apetala	1			
S. nodosa	1			
S. procumbens	1			
Sonchus asper	1			
Trisetum flavescens	3			
Verbascum thapsus	1			
Verbena officinalis	2			
Veronica persicaria	2			
V. serpyllifolia	1			

No. of Sites = 62

TABLE 3.5
Species showing the highest and lowest occurrence (%) in the bank verge along the Barrow Navigation

LOW OCCURRENCE	#	HIGH OCCURRENCE	#	%
Agrimonia eupatoria	1	Agrostis stolonifera	66	96
Barbarea vulgaris	2	Anthriscus sylvestris	57	83
Berula erecta	2	Arrhenatherum elatius	64	93
Carex pendula	2	Calystegia sepium	64	93
Equisetum fluviatile	1	Dactylis glomerata	68	99
Hypericum tetrapterum	2	Epilobium hirsutum	62	90
Juncus inflexus	3	Festuca rubra	64	93
Lycopus europaeus	1	Filipendula ulmaria	68	99
Mimulus guttatus	1	Galium aparine	60	87
Nasturtium officinale	1	Glyceria maxima	55	80
Reynoutria japonica	1	Heracleum sphondylium	64	93
Rorippa sp.	1	Holcus lanatus	61	88
Succisa pratensis	1	Phalaris arundinacea	62	90
Typha latifolia	1	Poa pratensis	65	94
Veronica anagallis-aquat.	1	P. trivialis	66	96
		Polygonium amphibium	57	83
		Ranunculus repens	61	88
		Urtica dioica	68	99

No. of sites = 69

TABLE 3.6
Species showing the highest and lowest occurrence (%) in the channel along the Barrow Navigation

LOW OCCURRENCE	#	HIGH OCCURRENCE	#	%
Lemna trisulca	1	Glyceria maxima	64	93
Oenanthe sp.	2	Lemna minor	59	85
Potamogeton natans	2	Nuphar lutea	67	97
Potamogeton x salicifolius	2	Phalaris arundinacea	54	78
Ranunculus circinatus	1	Potamogeton perfoliatus	55	80
Rumex hydrolapathum	2	Sagittaria sagittifolia	61	88
Typha latifolia	3	Scirpus lacustris	61	88
		Sparganium emersum	60	87
		Sparganium erectum	61	88

No. of Sites = 69

TABLE 3.7
Species showing the highest and lowest occurrence (%) on the locks and bridges along the Barrow Navigation

LOW OCCURRENCE	#	HIGH OCCURRENCE	#	%
Agrostis stolonifera	1	Achillea millefolium	23	62
Anacamptis pyramidalis	1	Cymbalaria muralis	20	54
Anthyllis vulneraria	1	Dactylis glomerata	23	62
Aphanes arvensis	1	Festuca rubra	30	81
Arabis hirsuta	1	Filipendula ulmaria	20	54
Arenaria serpyifolia	3	Hedera helix	28	76
Barbarea vulgaris	1	Parietaria judaica	24	65
Bromus erectus	1	Plantago lanceolata	20	54
B. hordeaceus	2	Poa pratensis	29	78
B. ramosus	1	Taraxacum agg.	25	67
B. sterilis	2	Urtica dioica	23	62
Eriophila verna	1			
Geranium dissectum	1			
Hieracium pilosella	3			
Leontodon autumnalis	1			
Origanum vulgare	1			
Pimpinella saxifraga	1			
Ranunculus sceleratus	1			
Sagina apetala	1			
Valerianella locusta	1			

No. of Sites = 37

CHAPTER 4 IMPACTS OF MANAGEMENT

4.1 MAINTENANCE

Some level of maintenance is essential if the waterway is to fulfil all its various functions - as a navigation, as a footpath, as a local amenity and as a national resource. In order to maximise its potential for nature conservation it is important that the management practices used are sympathetic. Inappropriate management leading to a uniform, over-maintained and sterile system would be even less desirable in wildlife terms than a policy of abandonment.

4.1.1 Hedgerow

The ecological value of a hedgerow depends on a number of factors. Its botanical importance will be determined by its species-richness and diversity, including the ground flora. This in turn determines the number and diversity of invertebrates that the hedge can support (Table 4.1). Many hedgerow plants, including Hawthorn, provide abundant nectar in spring for insects, while the fruits, seeds and berries of autumn are a valuable food source for many animals and birds. The height of the hedge is important in determining its suitability as a nesting site - nesting birds in low (less than 1m) hedges are subject to predation from the ground (Brooks and Agate, 1988). Dense growth at the base of the hedge provides cover for Field Mice (Apodemus sylvaticus) and other animals.

Table 4.1 Invertebrate numbers & native trees

Hedgerow shrubs and trees	Soil pH Acid	Neutral	Alkaline	No. of invertebrate species
< 5m				
Birch	*		*	334
Blackthorn		*	*	151
Crab Apple		*	*	116
Hawthorn	*	*	*	205
Hazel		*	*	106
Holly	*	*	*	96
Rowan	*	*		58
> 5m				
Ash		*	*	68
Oak	*	*	*	423

(after Newbold, Honner & Buckley, 1989)

An unmaintained hedge will develop into scrub and expand its area at the expense of the adjacent habitats.

Trimming is the most common means of hedgerow maintenance used today. Trimming on an annual basis produces a visually dull hedge, and prevents the growth of berries which are a vitally important source of food for birds and animals (British Waterways Board, 1981). A 3-4 year cycle of cutting carried out in rotation produces a range of growth stages, with sections of one, two and three year regrowth as well as a newly-trimmed section.

A flail is the most efficient means of trimming a hedge that is in good condition. However if it is used to cut thick or old branches it will shred and tear them, leaving a mangled and ragged hedge that is very susceptible to dieback and fungal attack (British Waterways Board, 1981). Trimming, like pruning, encourages regrowth and maintains the dense, bushy cover that is important for wildlife. An A-shaped hedge, approximately 1.8-2.0 m high, provides secure nesting sites for birds and dense cover at its broad base for animals, making it a valuable habitat (Mabey, 1980).

Trimming should not be carried out in spring and early summer as this would reduce the nesting and breeding success of the hedgerow birds. Trimming in late summer or autumn would remove the berries that are an important part of the hedgerow food-chain. Trimming should be carried out between late autumn and early spring, but not during periods of heavy frost.

Coppicing (cutting to 75 mm above the ground) encourages regrowth from the base of the hedge. However cover, nest sites and food supplies are all lost during the period of regrowth. The impact is particularly severe if a long, continuous stretch of hedgerow is coppiced in one year.

Laying also encourages regrowth from the base of the hedge, but it is a labour-intensive and highly skilled operation.

A derelict hedge with extensive gaps may need replanting to restore its wildlife value. Only native species should be used in any planting scheme, and the plants chosen should be those present in the locality (Table 4.2).

Hedgerow trees add to the diversity of the habitat, and to the waterways system as a whole. They can be damaged by the flail, unless special care is taken to protect them during regular maintenance operations.

4.1.2 Grassland

Flooding in winter adds extra nutrients onto the banks and trackway of the Barrow Navigation. As a result the

Table 4.2 Native trees suitable for planting

SPECIES	SOIL pH			DAMP SITES
	Acid	Neutral	Alkaline	
< 5m				
Alder		*	*	*
Birch	*		*	*
Blackthorn	*	*	*	
Crab Apple		*	*	
Spindle		*	*	
Guelder-rose		*	*	*
Hawthorn	*	*	*	*
Hazel		*	*	*
Holly	*	*	*	*
Rowan	*	*		*
> 5m				
Ash		*	*	*
Oak	*	*	*	
Willows	*	*	*	*

Species to be avoided:

Sycamore: non-native species which seeds prolifically and can invade areas with dense stands of saplings.

Poplar: tends to produce suckers which can cause problems for access.

Suitable Species:

Alder: a small tree capable of growing in wet or waterlogged soils.

Ash: tall, light-demanding tree with an open canopy, often found on river banks.

Birch: Downy Birch is tolerant of damp sites. Downy & Silver Birch are light-demanding, and should therefore not form part of a mixture of trees.

Blackthorn: low dense shrub, valuable as cover for birds.

Spindle: striking scarlet & orange fruits.

Guelder-rose: nectar in spring, berries in autumn. Good autumn colour.

Hawthorn: the most common hedging plant. Nectar in spring and berries in autumn.

Hazel: pollen in spring, nuts in autumn. Coppices well.

Holly: evergreen shrub, coppices well. Fruit is popular with birds. Casts heavy shade which can kill the vegetation beneath it, so should not be planted where this might be critical.

Oak: large, open-crowned tree, but very slow-growing. A valuable tree for insects.

Rowan: medium to tall, light-demanding tree. A source of nectar in spring and fruit in autumn.

Willows: fast-growing, tolerant of wet conditions. Common along river banks.

(after Brooks & Agate, 1988;
Newbold et al., 1989;
British Waterways, 1993)

grasses on the trackway and verges tend to be coarse and vigorous species. Tall herbs such as Urtica dioica (Nettle), Cirsium (Thistles) and Heracleum sphondylium (Common Hogweed) are common. Grassland on nutrient-richsoils develop rapidly into tall herb communities and then into scrub if regular maintenance is not carried out.

4.1.2.1 Grazing

Grazing is one of the oldest and simplest methods of conserving grassland. In the past, when the lock-keepers grazed a few cattle on the banks and tow-horses were a feature of the Navigation, grazing was important in maintaining the grasslands of along the Barrow. Today, with increased amenity use of the relatively narrow trackway, grazing is not a feasible option, except perhaps in special areas.

4.1.2.2 Mowing

Mowing can also maintain a grassland habitat, with the time and the frequency of cutting determining the structure and composition of the sward. Frequent cutting within a single growing season produces a species-poor sward with little or no wildlife interest. Plants are prevented from flowering and setting seed, there is very little food for insects, and no cover for birds and small mammals (Newbold et al., 1989).

Mowing once a year, if carried out after the grasses and wild flowers have set seed (July/August), will lead to the development of a hay meadow, a species-rich grassland once common in the agricultural landscape but now rare. Taller plants, removed by grazing in pastures, have a competitive advantage in hay meadows.

If necessary a path for walking (1.5m wide) can be cut twice a year, in May/June and July/August. The verges should only be cut once, in late summer, to promote the development of a hay meadow. The vegetation at the base of the hedge and along the bank may need to be cut every few years to prevent scrub encroachment.

On nutrient-rich soils cutting every 2-3 years will allow a coarser vegetation to develop, with tall herbaceous plants such as Heracleum sphondylium (Common Hogweed), Urtica dioica (Nettle) and Epilobium spp. (Willowherbs) in the sward. This management technique will lead to reduction in species diversity of the flora, but will result in a habitat that supports a different range of invertebrate species. In addition the increase in cover will benefit ground-nesting birds and small mammals (Newbold et al., 1989).

The input of sediments with the flood waters in winter adds to nutrient status of the Barrow soils. It is therefore important that the soil is not further enriched by leaving the cut plant material to decompose on the banks. All cuttings should be gathered and removed from the system.

4.1.2.3 Herbicides

Herbicides are generally broad-spectrum chemicals, affecting a range of plants of similar growth forms. They are therefore relatively unselective and result in a decreased species diversity. Like fertilisers, herbicides eliminate the more sensitive, slow-growing plants and allow a few vigorous species to dominate the sward. As a result they should not be used along the banks of the Barrow Navigation.

The exception to this rule is in the control of Heracleum mantegazzianum (Giant Hogweed). This large, spectacular plant is a native of the Caucasus, and was introduced to Ireland towards the end of the last century. It is a highly invasive plant, particularly along river banks, where the large seeds are dispersed by the flowing water. It is quick to germinate on the bare ground left after floods have removed the vegetation cover. In addition to out-competing the native flora and reducing the area of native waterside vegetation, the Giant Hogweed is also a health hazard. The sap induces a form of photo-dermitis which damages the skin's ability to filter out ultraviolet light. This condition re-occurs for a number of years, every time the sufferer exposes his skin to sunlight.

The Giant Hogweed is spreading along the Barrow Navigation. The only successful way to get rid of Giant Hogweed plants is to spray them with a Glyphosphate solution (Round Up) early in the year, before they set seed (Plate 9). The Giant Hogweed is a biennial plant, which sets seed in its second year. As a result it is possible to control the plants at a very early stage, if the plants are located and identified in their first year. Care must be taken to avoid spraying any of the surrounding vegetation. It is also important to ensure that only Giant Hogweed plants are sprayed, and not the native Common Hogweed, or any other similar umbelliferous plants.

In the long term the only way to control the spread of Giant Hogweed will be to institute a national programme of eradication. Until then the seeds will continue to float downriver from the upper Barrow and from its tributaries, and will germinate along the banks and trackway where the OPW will have to deal with each plant as it is located.

4.1.3 Control of Aquatic Vegetation

Control of aquatic plants has a number of impacts on the system. Destruction of the emergent vegetation leads to an increase in the amount of light penetrating the water, with a corresponding increase in the growth of submerged species (Dawson, 1981); while the removal of submerged plants can lead to algal blooms. Removal of the marginal fringe of emergent plants also has a physical effect, leading to the destabilisation of the bank sediments and increased erosion.

The reduction in plant biomass leads to a decrease in primary production and the disruption of the nutrient recycling processes. These factors, together with the physical loss of habitat and shelter, will affect other aquatic organisms such as invertebrates and fish directly, and will lead indirectly to changes further up the food chain. Control of submerged vegetation results in the loss of the less frequent invertebrate taxa and a reduction in the abundance of the dominant taxa, with the species most closely associated with macrophytes being the most seriously affected (Murphy & Eaton, 1981). Loss of emergent vegetation results in the loss of insect species, in particular the dragonflies and damselflies which use the reeds as perches and deposit their eggs in the safety of the reed beds.

There are a number of different methods of controlling aquatic vegetation, each with different advantages and disadvantages. Active measures are carried out during the growing season to restrict and reduce plant growth where necessary. Preventative measures are carried out before much growth has occurred, usually in early spring, and aim to prevent excessive growth during the following summer. Environmental factors can also be manipulated to help control the growth of aquatic plants.

4.1.3.1 Environmental Control

Deepening the navigational channel so that it no longer forms a suitable habitat for emergent reeds restricts the spread of vegetation from the margins into the channel itself (Newbold et al., 1989; Brooks & Agate, 1990).

Plants differ in their tolerance to shading, but a reduction in the amount of incident light will affect all plants to some extent. Species that cannot tolerate shade at all will be eliminated while others will produce fewer and/or shorter shoots as a result of the reduced light (Lewis & Williams, 1984). Submerged plants tend to be more tolerant of shade than emergent species, making shading more appropriate as a management technique for the control of marginal vegetation than as a means of total

control.

Shading is a feature of the lower reaches of the Barrow Navigation. The input of extra organic matter and nutrients to the water of the canal cuts in the form of leaf litter could lead to an increase in the Biological Oxygen Demand (BOD) and a lowering of the dissolved oxygen concentration of the water. The faster flow rate and continuous aeration of the water at the weirs and shallows of the river sections prevent deoxygenation of the river water.

Increased boat traffic along the system would also help to control the growth of aquatic plants (Murphy & Eaton, 1983; 4.2.2).

4.1.3.2 Chemical Control

Herbicides are the most common means of controlling aquatic vegetation today. They are relatively quick and easy to use, and cost less than traditional labour-intensive methods. The main disadvantage of herbicides is that they are broad-spectrum, targeting not a single species but a range of species with similar growth forms (Table 4.3). Some species are more susceptible to herbicides than others and will therefore be the first to be lost. However, plant species react differently to herbicides under different geographical and water chemistry conditions (Central Fisheries Board, 1991; Table 4.4).

Downstream drift of herbicides results in the reduction of plant growth at sites not treated with the chemical (Eaton et al., 1981), making herbicides unsuitable for use on the fast-flowing stretches of the river.

On the canal cuts herbicides would have a number of impacts on the wildlife. The replacement of the target plants by non-susceptible plants or by susceptible but rapidly-growing opportunistic species is a feature of herbicide treatment (Murphy & Eaton, 1981).

If chemicals are used during the growing season they will leave a large mass of dead and dying plant material in the water. The decomposition of this material would result in the deoxygenation of the water which would have very serious adverse impacts on the ecological system.

One of the main disadvantages of herbicides in ecological terms is the speed at which they can be applied. Large areas can be treated with such speed that potential recolonisation sources are sprayed and destroyed before the phytotoxic period within the first area to be sprayed has elapsed. The rapid spread of resistant species, in

Table 4.3 Target spectra of selected herbicides

'Weed groups'	Terbutryn	Dichlobenil	Dichlobenil GSR	Dichlobenil, delapon	Diquat/diquat alginate	Delapon	Glyphosate	Maleic hydrazide	2,4-D amine	2,4-D amine Chlorpropham Maleic hydrazide	Asulam	Fosamine ammonium
(1) Algae	K				MR							
(2) Submerged plants	K	K	K	K	K							
(3) Free-floating plants (small leaf area)	K				K							
(3) Floating-leaved plants (large leaf area)		K	K	K			K		MR	MR		
(4) Reeds				K		K	MR					
(4) Sedges				MR		MR	K					
(5) Grasses and rushes							K	K		K		
(5) Broad-leaved weeds							K	K	K	K		
(5) Docks							K				K	
(5) Trees and shrubs												K

Figures in parentheses refer to 'weed group'
K = Kill; MR = Moderately resistant

Where a choice of chemical exists select the one affecting the least number of non-target groups.

NB. Paraquat is not approved for use in water even though it kills a similar spectrum of plants.

(Newbold et al., 1989)

Table 4.4 The susceptibility of aquatic plants to dichlobenil (Casoran) and terbutryne (Clarosan) based on trials conducted in Ireland and the UK

CASORAN

	Ireland	UK
Callitriche stagnalis	S	S
Ceratophyllum demersum	MS	S
Chara spp.	S	S
Elodea canadensis	S	S
Fontinalis antipyretica	R	S
Glyceria fluitans	R	S
Lemna trisulca	R	S
Lemna minor	R	R
Myriophyllum spp.	S	S
Nuphar lutea	MR	MR
Oenanthe spp.	MS	MS
Phragmites australis	R	R
Potamogeton crispus	S	S
Potamogeton lucens	S	MR
Potamogeton natans	MS	MS
Potamogeton pectinatus	R	S
Ranunculus circinatus	S	S
Sagittaria sagittifolia	R	S
Sparganium erectum	R	MR

CLAROSAN

Cladophora spp.	S	S
Enteromorpha intestinalis	S	S
Elodea canadensis	S	S
Myriophyllum spp.	MR	S
Spirogyra spp.	S	S
Vaucheria spp.	R	MR

S = susceptible
MS = moderately susceptible
R = resistant
MR = moderately resistant

(Central Fisheries Board, 1991)

particular algae, through the treated area limits the growth of other, more desirable plant species.

Continued use of herbicides results in the development of an impoverished and species-poor aquatic flora, composed of resistant species that cannot readily be controlled.

Herbicides, if used according to the manufacturer's instructions, should have no direct effects on fish or aquatic invertebrates (Spencer-Jones, 1974). However animal life is dependent on an annual cycle of increased plant production for its own cycle of growth and reproduction. If the food supplies are suddenly reduced the animal must either switch to another source of food or migrate. Species which are plant-specific are more vulnerable than those which feed on a wide range of plants (Murphy & Eaton, 1981; Newbold et al., 1989). In the long term, therefore, the poverty of the invertebrate fauna of herbicide-treated channels is due to the impoverishment of the flora and not directly to the chemical input (Harbott & Rey, 1981).

Herbicides are not widely used on the Barrow Navigation. The flora of the canal cuts is dominated by resistant species such as Sparganium emersum (Unbranched Bur-reed) and Potamogeton pectinatus (Fennel Pondweed). The flow in the river stretches is so great that herbicides, which need a period of little or no flow to be effective, cannot be used. Under these circumstances the policy of not using herbicides should be continued - they cannot control the vegetation, and would only result in the degradation of the ecological system.

4.1.3.3 Physical Control

Active measures must be used to control vegetation during the summer when large standing crops and higher temperatures make deoxygenation a serious potential problem. Cutting is a labour-intensive but effective method of reducing plant biomass. If the cut material is not removed from the system it will decompose in the water, increasing the BOD and resulting in stressed plant and animal communities and algal blooms.

Cutting, like herbicide application, is followed by a rapid increase in algal growth. However in this case it is a short-term effect (Eaton et al., 1981) and the regrowth of the vascular plants soon restores the ecological diversity of the aquatic system.

Cutting without the removal of the root-mats and rhizomes tends to stimulate plant growth (Brooks & Agate, 1990) and may therefor have to be repeated during a single growing season. However if a reduction in the final standing crop

is achieved there will be a decrease in the overwintering success of the target plants, and as a result less severe control measures will be required the following year.

Cutting does not result in plant death and a long-term loss of habitat, and therefore has a less severe impact on other aquatic organisms than herbicides. The decrease in diversity of the invertebrate fauna following mechanical cutting is less than that following herbicide application, and the rate of recovery of the macrophyte-associated community is more rapid (Murphy & Eaton, 1981).

Long-term management of the aquatic vegetation in canals by repeated cutting has been shown to give acceptable control of the vegetation without altering the macrophyte community structure to an extent that is unacceptable in terms of nature conservation (Murphy et al., 1987). Cutting is an appropriate method of controlling the aquatic plants in the canal cuts of the Barrow Navigation.

4.1.3.4 Biological Control

Biological control, i.e. the introduction of grass-eating fish, is not an option in a river system.

4.1.4 Dredging

Dredging has a number of impacts on both the channel and the banks of the canal. It is a straightfoward engineering process that affects the complex ecological system in a number of ways - some directly, some indirectly and all interconnected.

4.1.4.1 Impacts of Dredging

Channel
The removal of sediments deepens the navigation channel, affecting the range of aquatic wildlife that can live in it. The most obvious changes will occur in the plant community, with a reduction in shallow-water, emergent plants such as Phragmites australis (Common Reed) and a corresponding increase in species with a deeper, open water requirement - eg Nuphar lutea (Yellow Water-lily) and Potamogeton spp. (Pondweeds). Changes in the plant population will lead to changes in the aquatic invertebrate communities that depend on them, while bird and fish communities will also be affected by the loss of shelter and by changes in available food supply.

Plant populations are also affected by the removal of vegetation with the silt during the operations. The impact on populations of floating-leaved and submerged macrophytes is often a positive one, as new plants can

grow from sections of stem or rhizome which are broken off and float downstream. The effect on emergent plants, in particular those of the reed fringe, is usually less beneficial.

When land-based dragline dredgers are used the bucket is dragged up the bank, removing all the vegetation from the side of the channel on which the machine is working. Boat-mounted machines on the other hand can dredge the channel without destroying the reed fringes. Where land-based plant must be used, hydraulic machines are more selective than dragline dredgers and therefore cause less ecological damage.

Dredging the canal cuts from the bed of the dry channel and dumping the spoil onto the offside should, if carried out carefully, ensure that the reed fringes along both banks are retained.

Dredging the navigation channel of the river creates a deep, straight-sided channel beside the trackway. Emergent vegetation cannot grow in these conditions, and so there is often no reed fringe to protect the bank. It might be possible to create a narrow berm between the boat channel and the bank when dredging, which would overcome this problem and improve the wildlife potential of the Navigation. However where the steep bank is not a result of channel maintenance but due to increased water flow at a bend, this would not be possible.

Disturbance of the sediments on the bed of the channel releases some of the nutrients they hold, and the nitrogen and phosphorus levels can rise. In the river stretches, where the water flow, dilution and oxygen levels are higher, and the nutrients are carried downstream, this is not usually a problem. On the canal cuts it can be very significant. Increased nutrient levels, together with the removal of the plants that normally compete for these nutrients, can lead to algal blooms, which will in turn affect the rate of recolonisation of the canal cut by higher plants.

<u>Invertebrates</u>

The plants are not the only element of the aquatic ecosystem to be affected by dredging. Aquatic invertebrates are affected directly by the removal of individuals in the spoil, and indirectly by changes in plant populations and water chemistry. Again the problems are more severe in the canal cuts, which are narrow, slow-moving and easily disturbed.

Removal of vegetation can lead to the elimination of specialist plant-feeding species, while the reduction in food supply and loss of shelter can result in a decrease

in the number of individuals as well as the species richness of the system (Lewis & Williams, 1984).

Birds
Water birds are affected by the loss of nesting sites, the destruction of the reed fringe and by a decrease in food supply. Even more significant however, is the disturbance factor, particularly where an intensive dredging programme affects long stretches of the Navigation over a relatively short period of time.

Fish
Loss of submerged and marginal vegetation and changes in invertebrate populations can all have a negative impact on the fish community. Disturbance is also a problem. On river stretches the fish can migrate away from disturbances such as dredging. On the canal cuts their movements are restricted. It is important therefore that they are moved before operations begin, and are returned to the cut when the work is completed.

4.1.4.2 Recovery after Dredging

The vegetation of the channel recovers relatively rapidly. The rate of recovery of the marginal vegetation is a slower process, depending on a number of factors. The most significant of these are the amount of plant material removed during the dredging operation and the profile of the newly-dredged bank. Recovery is quickest where the new bank slope is gentle, and where some marginal vegetation is left on the bank.

4.1.4.3 Disposal of Spoil

Dredging also has a number of impacts on the terrestrial habitats. Disturbance is a factor even if water-based plant is used. Land-based operations have a more serious impact on the system, as the size and weight of the machines can cause physical damage to the vegetation cover on the bank and trackway. However the major impact of dredging on the terrestrial habitats is caused by spoil deposition.

There are two very different types of spoil encountered along the Barrow Navigation. On and immediately below the canal cuts the spoil is made up of very fine particles and is very rich in nutrients. The spoil from the faster-flowing river tends to be gravelly, with a much lower nutrient status.

Deposition of nutrient-rich spoil from the canal cuts can have a very serious impact on the system as it can dramatically change the nutrient-status of the terrestrial habitats. Along most of the Barrow Navigation there is no

room to bury the spoil in a trench between the trackway and the boundary, as was recommended for the Grand and Royal Canals. Instead the nutrient-rich spoil should be spread thinly over the bank verge, in scrub, or on the offside of the canal cut.

Nutrient-poor river spoil can be deposited on the bank and spread thinly over the trackway as it does not affect the nutrient status of the system.

4.1.4.4 Revegetation of Spoil

The low nutrient status of the substrate prevents many of the more common opportunistic plants from colonising the gravelly river spoil. Vegetation cover is slow to establish on this spoil, but the slow-growing plants typical of gravel soils are present from an early stage. As a result they are not a nature conservation problem, unless they cover extensive areas of the bank.
The vegetation of canal spoil, on the other hand, needs to be carefully managed. The first species to colonise the spoil are invasive species such as Cirsium (Thistles) and Urtica dioica (Nettle). Aquatic plants such as Glyceria maxima (Reed Sweet-grass) are also among the early colonisers. In time natural succession will restore a more balanced vegetation cover but it is a slow process. Cutting this vegetation before it sets seed reduces the dominance of these species, and so encourages the growth of less vigorous grasses and herbs.

The vegetation that is left undisturbed acts a focus for recolonisation of the disturbed areas. It is therefore important that a significant proportion of each habitat at the dredging site remains intact to improve the rate of recovery of the disturbed vegetation.

The recovery of the invertebrate populations will depend largely on the recovery of the vegetation, and on the amount of shelter left when dredging operations cease.

4.1.5 Removal of Trees and Scrub

Scrub is a valuable habitat, providing food, shelter and cover for a variety of birds and animals. Regular maintenance of the trackway will ensure that scrub does not encroach from the boundary. The habitat diversity, and therefore the ecological value of the system, can be improved by leaving scrub in the boundary verge and on the offside or by allowing it to develop in places where there is space for it.

Trees are an important feature of the system, providing song-posts and nesting sites for birds, and food and

shelter for invertebrates, as well as being important in their own right. Selective removal of trees from the bank and verges can reduce the negative impact of shading and allow dredging and maintenance work to be carried out while still retaining the wildlife advantage. Non-native trees should be removed instead of native species, as they have a much lower wildlife value.

4.1.6 Masonry

A bridge that is covered with ivy (Hedera helix) can support very little else in the way of vegetation. When the ivy is cleared away other plants such as Asplenium (Spleenworts) and Cymabalaria muralis (Ivy-leaved Toadflax) can take advantage of the newly-available niche. Unlike Hedera these plants will not damage the structure of the bridges.

Herbicides should not be used to clear the vegetation on and around locks and bridges as they could cause serious ecological damage if they enter the water.

4.1.7 Weirs

Salmon cannot pass upstream if the weirs are allowed to become overgrown. However the plants and invertebrates associated with the fast-flowing waters of the weirs are also important, and the management of the waterway should take both these facts into consideration.

4.2 RECREATION

Recreation, like maintenance, has an impact on the wildlife of the navigable river (Fig. 4.1).

4.2.1 Navigation

The impacts of management practices designed to facilitate boats have been dealt with in Section 4.1 and will not be covered here. However the boats themselves can affect the wildlife of the system in a variety of ways (Fig. 4.2).

4.2.1.1 Physical impacts

The physical impacts of boating are more significant in the canal cuts, which are narrow and confined, than on the

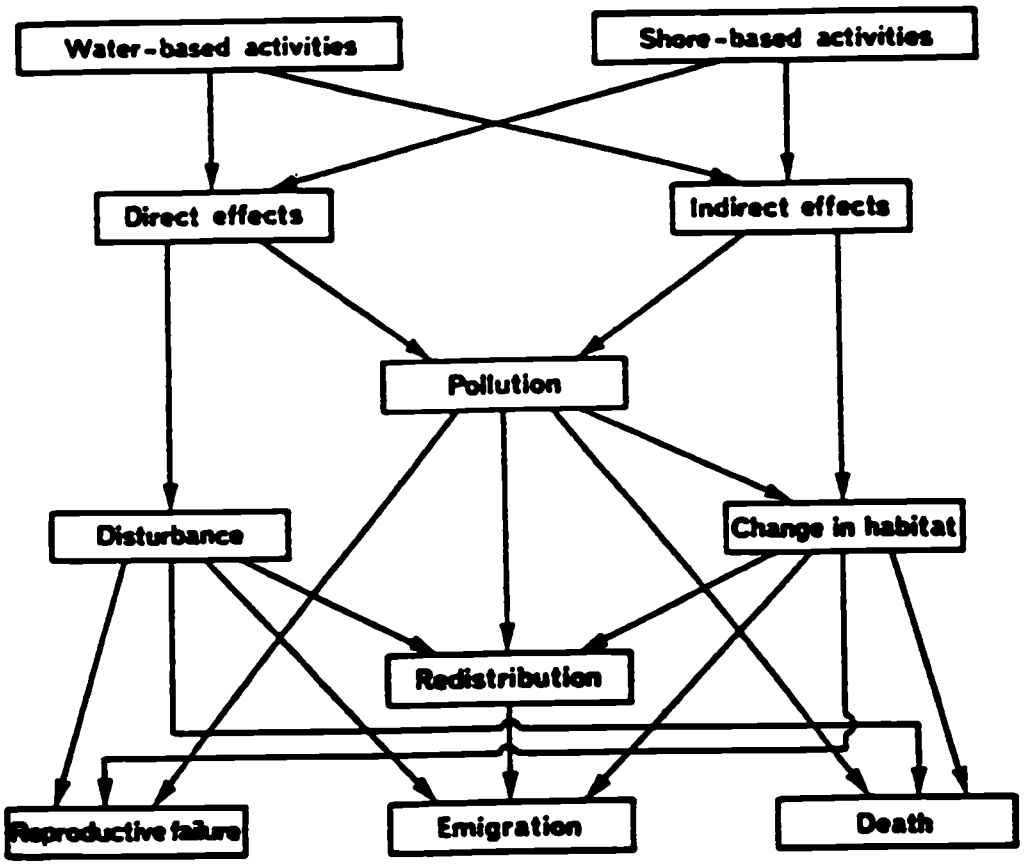


Figure 4.1

The impacts of recreation (excluding management) on animals

(Liddle & Scorgie, 1980)

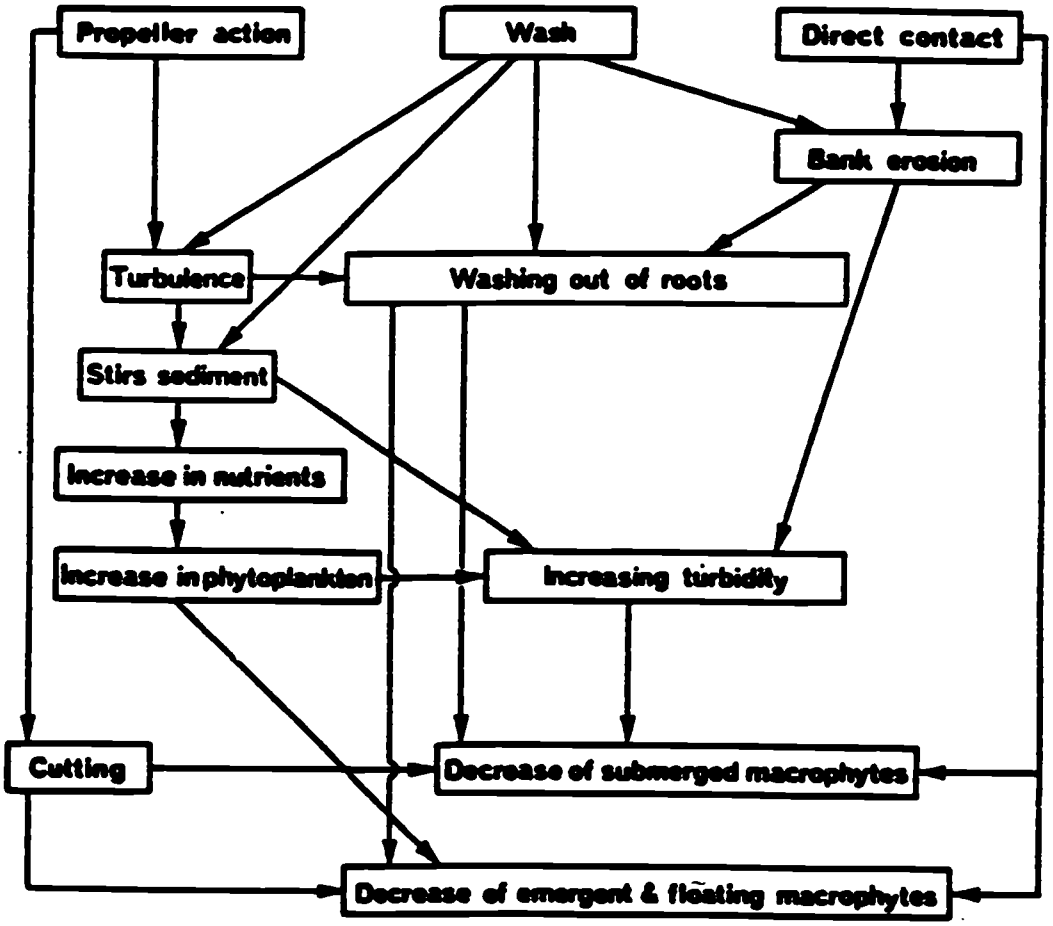


Figure 4.2

The impacts of boats on plants

(Liddle & Scorgie, 1980)

open river.

Wash
The wash from boats can cause problems in the canal cuts. The first problem is the erosion of the plants along the bank. Plants differ in their susceptibility to erosion (Table 4.5), and so the species composition of the marginal vegetation will change as the more sensitive species are eliminated as boat traffic increases.

Where marginal vegetation is sparse or absent, the energy generated by the wash impacts on the unprotected banks, causing undercutting and erosion.

Turbulence / turbidity
The main impacts of turbulence are the washing out of plant roots from the banks and bed of the channel, and an increase in turbidity. Turbidity depends on the depth of water, the amount of fine clay in the sediments, and the power of the boats. In the canal cuts turbidity can be a serious problem, resulting in decreased light penetration and a subsequent reduction in the biomass of submerged vegetation. This leads to a reduction in the diversity and biomass of aquatic invertebrates, which can have an impact further up the food chain.

Propellor action
The leaves and stems of submerged and floating-leaved plants can be cut by propellors, again resulting in a decrease in the biomass of the channel vegetation and subsequent reduction in invertebrate fauna.

Some submerged plants can regenerate from sections cut from the parent plant. Propellor action and boat traffic may therefore help these to spread throughout the navigable network. Other plants are more susceptible to propellor damage, and are not found on waterways with relatively high levels of boat traffic.

Direct contact
The reed fringe may be damaged by the collision of boats with banks. The subsequent effects are the same as when the reduction or loss of vegetation cover is caused by wash.

Disturbance
Disturbance generally results in the redistribution of animal populations away from the affected area (Fig. 4.1).

4.2.1.2 Chemical impacts

The main chemical inputs from boat traffic are sewage and fuel/oil. Fuel and oil pollution is most significant at

Table 4.5 The susceptibility of plants to erosion

Very easily eroded

Agrostis stolonifera	(submerged)
Epilobium hirsutum	(rooting fragments)
Ceratophyllum demersum	
Elodea canadensis	
Rorippa amphibia	
Nasturtium officinale	

Easily eroded

Callitriche species
Epilobium hirsutum
Myosoitis scorpioides
Myriophyllum spicatum
Sparganium erectum
Zannichellia palustris

Rather difficult to erode

Apium nodiflorum
Berula erecta
Potomageton crispus
Potamogeton perfoliatus
Scirpus lacustris
Sparganium emersum

Difficult to erode

Glyceria maxima
Nuphar lutea
Oenanthe fluviatile
Phalaris arundinacea
Phragmites australis
Potamogeton pectinatus
Ranunculus trichophyllus

(Liddle & Scorgie, 1980).

areas where a number of boats are using a relatively small area - eg at marinas and mooring sites (Liddle & Scorgie, 1980). On the Barrow, where there are no major boat centres or marinas as yet, and a relatively low level of boat traffic, this is not a problem. However it is important that the potential for pollution is considered when developing the Navigation in the future.

The input of sewage from boats is relatively small compared to the amount entering the river from the urban centres along its banks. However this does not mean that the provision of holding tanks and pump-out facilities is not important in the long term.

4.2.2 Walking

Access along the trackway of the Barrow Navigation is restricted to pedestrians, and the maintenance vehicles are the only motorised traffic allowed on the banks. The level of damage caused by trampling on the trackway depends on the structure and wetness of the underlying soil. The vegetation on a well-drained path is better able to withstand trampling than that in a poorly-drained area. The first effect of trampling is a change in species composition as the more sensitive species are lost. If the level of trampling is sufficiently high even the harder-wearing plants suffer, and the path becomes bare and unvegetated. At this point, particularly if the path is poorly-drained, people often move off it and walk through the adjacent vegetation, creating a meandering network of paths.

Trampling can also have an effect on the fauna of the trackway and verges, although this has not been quantified. Surface-dwelling invertebrates are affected directly, while populations of flying invertebrates can be reduced by a loss of food plants and shelter. The breeding success of nesting birds and hedgerow mammals can also be reduced by disturbance. The nature conservation implications would be particularly significant if both sides of a canal cut were to be cleared for walking.

4.2.3 Angling

4.2.3.1 Fishery management

The OPW do not own the fishery on the Barrow Navigation, and therefore are not involved in fishery management or fish stocking. They are, however, concerned with access to the fishing sites, and maintenance of the channel and banks.

4.2.3.2 Bankside vegetation

The unsupervised activity of anglers cutting gaps in the bankside vegetation and clearing swims can add considerably to the problems of bank stability and erosion (Murphy & Pearce, 1987). In addition to cutting the vegetation they sometimes also cut out sloping banks to create flat spaces near the water's edge to keep nits and other equipment on. The effect of this is to change the tall bank verge vegetation to a short sward consisting of trample-resistant species such as Lolium perenne (Perennial Rye-grass), Poa pratensis (Smooth Meadow-grass), Plantago major (Greater Plantain) and Polygonum aviculare (Knotgrass).

CHAPTER 5 CONCLUSIONS

5.1 CONSERVATION OF THE BARROW NAVIGATION

The ecology of the Barrow Navigation is different to that of the canals - it is a river rather than a still-water canal, the underlying soil conditions are different, the habitats to be found along the banks and in the water are different, and the management regime in the past has been different. For all these reasons the Conservation Management Guidelines for the Barrow Navigation are not the same as those for the canals.

Boundary
The boundary consists of a species-rich hedgerow and boundary drain for most of the length of the navigation. It is ecologically the most interesting zone. The two principal habitats are well-established and contain many micro-habitats. These habitats must be protected.

Boundary Verge, Trackway and Bank Verge
Unlike the canals, there is very little difference between the vegetation of these three zones, which are dominated by coarse vigorous grasses and tall herbs. The soil is already rich, the river floods and this is the only area where spoil can be deposited. For these reasons careful menagement is needed to enhance ecological diversity of the zones. The trackway should be cut twice a year to allow pedestrian access. The verges should be cut once, after the plants have set seed, to encourage the development of hay meadow. All cut vegetation should be removed from the system immediately after cutting to reduce the nutrient input to the already enriched soil.

Channel
The river channel and the canal cuts have different water regimes and support different plants and animals. Plants found in the faster-flowing river stretches have to be tolerant of harsh conditions. A greater diversity of plants is found in the slow-moving canal cuts. Dredging spoil from the river, gravelly and nutrient-poor, may be deposited on to the trackway and levelled. The nutrient-rich spoil from the canal cuts and from just below the locks should not be deposited on the trackway but on the bank verge and levelled when dry.

5.2 CONSERVATION OF THE BARROW VALLEY

The ecological value of the Barrow Navigation is dependent on the preservation and conservation of the ecology of adjacent non-OPW lands. It is important therefore that co-operation between the OPW and the owners/managers of the adjacent lands is encouraged.

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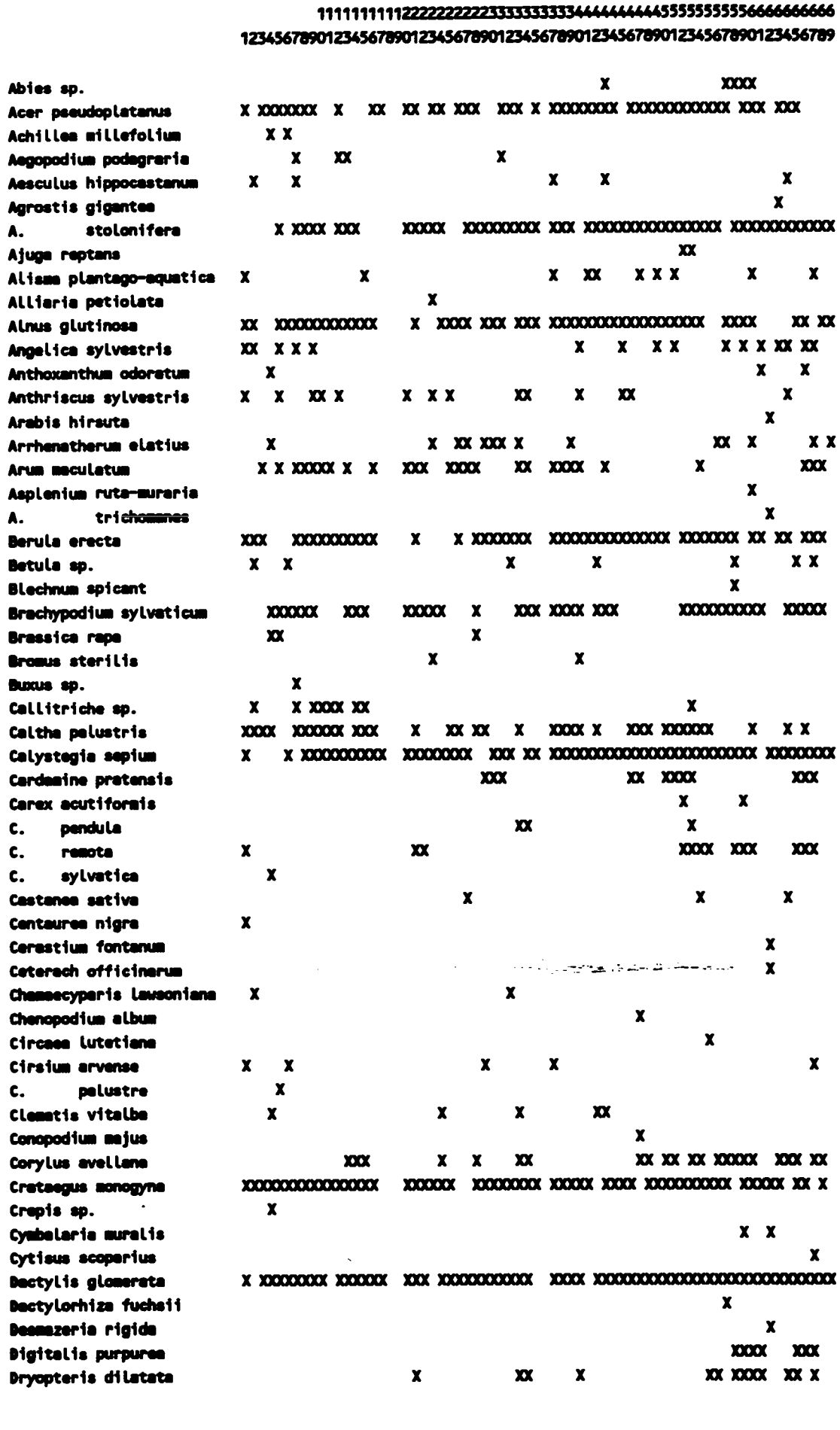
APPENDIX 1

The Flora of the Boundary

BOUNDARY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Abies sp.
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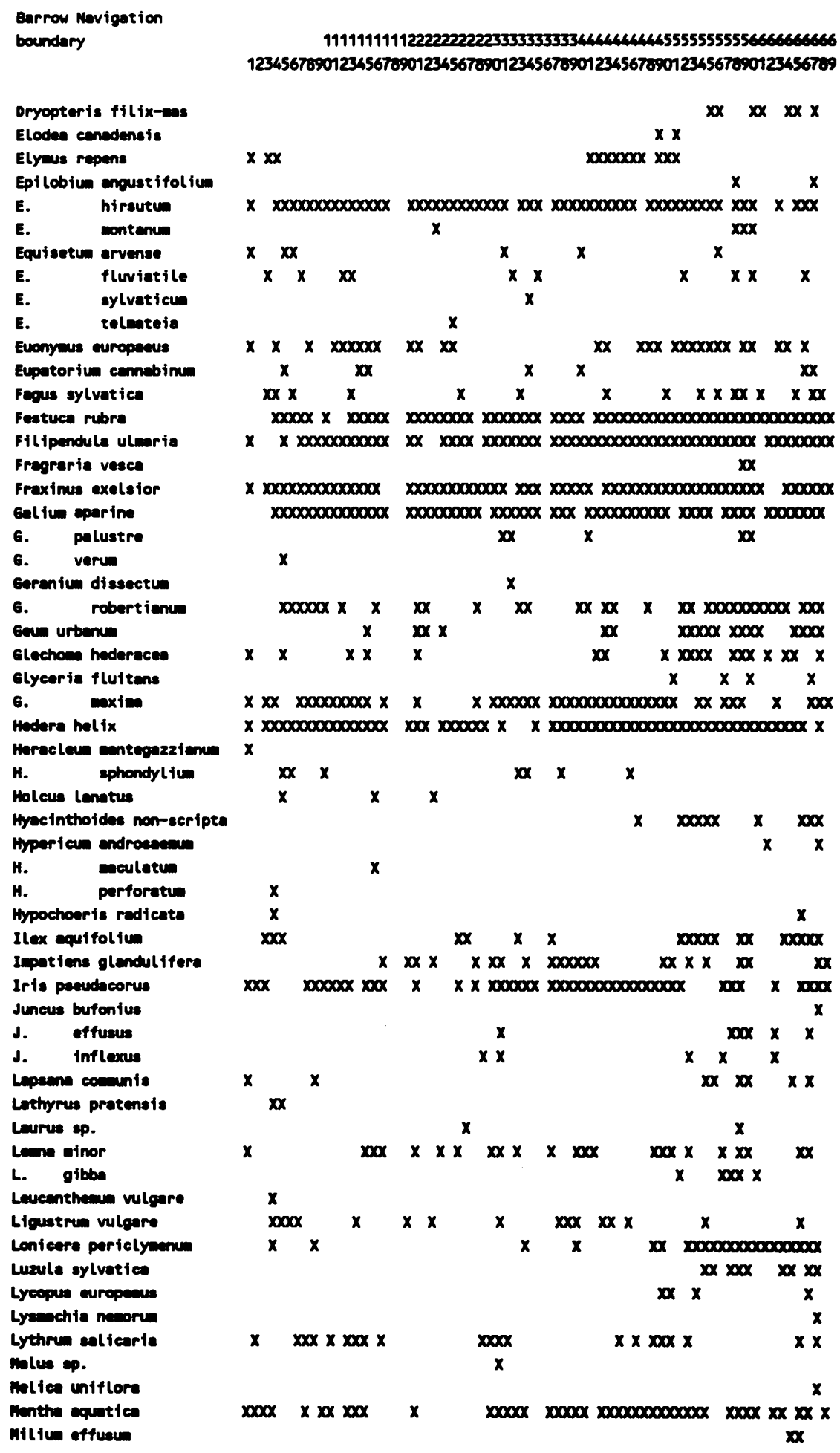
Achillea millefolium
Aegopodium podagraria
Aesculus hippocastanum
Agrostis gigantea
A. stolonifera
Ajuga reptans
Alisma plantago-aquatica
Alliaria petiolata
Alnus glutinosa
Angelica sylvestris
Anthoxanthum odoratum
Anthriscus sylvestris
Arabis hirsuta
Arrhenatherum elatius
Arum maculatum
Asplenium ruta-muraria
A. trichomanes
Betula erecta
Betula sp.
Blechnum spicant
Brachypodium sylvaticum
Brassica rapa
Bromus sterilis
Buxus sp.
Callitriche sp.
Caltha palustris
Calystegia sepium
Cardamine pratensis
Carex acutiformis
C. pendula
C. remota
C. sylvatica
Castanea sativa
Centaurea nigra
Cerastium fontanum
Ceterach officinarum
Chamaecyparis lawsoniana
Chenopodium album
Circaea lutetiana
Cirsium arvense
C. palustre
Clematis vitalba
Conopodium majus
Corylus avellana
Crataegus monogyna
Crepis sp.
Cymbalaria muralis
Cytisus scoparius
Dactylis glomerata
Dactylorhiza fuchsii
Deamazeria rigida
Digitalis purpurea
Dryopteris dilatata


Barrow Navigation boundary
1111111111222222222233333333334444444444555555555566666666661234567890123456789012345678901234567890123456789012345678901234567890123456789
Dryopteris filix-mas
Elodea canadensis
Elymus repens
Epilobium angustifolium
E. hirsutum
E. montanum
Equisetum arvense
E. fluviatile
E. sylvaticum
E. telmateia
Euonymus europaeus
Eupatorium cannabinum
Fagus sylvatica
Festuca rubra
Filipendula ulmaria
Fragraria vesca
Fraxinus excelsior
Galium aparine
G. palustre
G. verum
Geranium dissectum
G. robertianum
Geum urbanum
Glechoma hederacea
Glyceria fluitans
G. maxima
Hedera helix
Heracleum mantegazzianum
H. sphondylium
Holcus lanatus
Hyacinthoides non-scripta
Hypericum androsaemum
H. maculatum
H. perforatum
Hypochoeris radicata
Ilex aquifolium
Impatiens glandulifera
Iris pseudacorus
Juncus bufonius
J. effusus
J. inflexus
Lapsana communis
Lathyrus pratensis
Laurus sp.
Lemna minor
L. gibba
Leucanthemum vulgare
Ligustrum vulgare
Lonicera periclymenum
Luzula sylvatica
Lycopus europaeus
Lysmachia nemorum
Lythrum salicaria
Malus sp.
Melica uniflora
Mentha aquatica
Milium effusum

Barrow Navigation boundary	1111111111222222222233333333344444444445555555556666666666 1234567890123456789012345678901234567890123456789012345678901234567890123456789
Myosotis scorpioides	X X XXXX XXXX XX X X X X X X XX XX
Myriophyllum sp.	X
Nasturtium officinale	XXXX XX XXXXXX X X XXX X XXXX XXXXX XXXXXXX X X XX
Nuphar lutea	X X
Oenanthe crocata	XXXX X X
O. fistulosa	X X
Origanum vulgare	XX
Oxalis acetoselle	X X
Parietaria judaica	X
Petasites hybridus	X
Phalaris arundinacea	XXXXX XXXXXXXXX X XX XXXXXXXXX XXXXXXXXXXXXXXXXXX XX XXXXXX
Phleum pratense	X
Phragmites australis	XX XX X XX X XX
Phyllitis scolopendrium	X XX XX X XX XX XXXXXX XXX XX X
Picea sp.	X X
Pinus sylvestris	X X
Poa pratensis	X XX XXX X XX XXXX XXX XXXXXX XXXXXXXXXXXXXXXXXXXX XXX XXX
P. trivialis	X XXXXXX XXXXX XXXX XXXXXXXXX XXXXXXXXXXXXXXXXXXXX XXX XXX
Polygonum amphibium	X X X X X
Polypodium vulgare	XXXXX XXX
Polystichum setifurum	XXXX
P. sp.	XX
Populus sp.	X XX XX X X X X X X X
Potamogeton natans	XX
P. pectinatus	X XX
P. sp.	X
Potentilla reptans	X X X X
P. sterilis	X
Primula vulgaris	X X
Prunus spinosa	XX XXXXX XX XX XXX XX XX X X XXX X XXX XXXX XXXXXXX X
Pteridium aquilinum	X X XXXXXXXXXX
Quercus sp.	X XXX XX X X X X X X XX XXXXX XXXXXXXXXX
Ranunculus acris	X X X X
R. ficaria	X X X XX XXX
R. repens	X X X X XX XX XXXX
Reynoutria japonica	X
Rhamnus cathartica	X X X
Ribes rubrum	X
Rorippa palustris	X
Rosa sp.	X XXX XXXXXXXXXX XXXXXXX X XXXXX XXXXXXX XXXXXXXXXX XXXXXXXXX
Rubus fruticosus	X XXXXXXXX XXXXX XXXXXXXXX XXXXX XXXXXXXXXXXXXXXXXXXX XXXXXX
Rumex acetosa	X
R. conglomeratus	X
R. crispus	X
R. hydrolapathum	XX XX X X X
R. obtusifolius	XX
R. sanguineus	X X X
Sagittaria sagittifolia	X X
Salix alba	X X X XX X X X X XX X X
S. cinerea	X
S. fragilis	X X X X X X
S. repens	X
S. viminalis	X X XX XX X X X XXX X X X X
Salix sp.	XXXXXXXXXX XXXXX XXX X X XX XXX X XXXXXX X XXXXXXXXXX XXXXX X
Sambucus nigra	X X XXX X X XX X XXXXXXXXX XXX X XX X XXXXXXXXX XXXX XX XX X
Sanguisorba minor	X
Scrophularia auriculata	X XXXX X X X X X XX X X XX

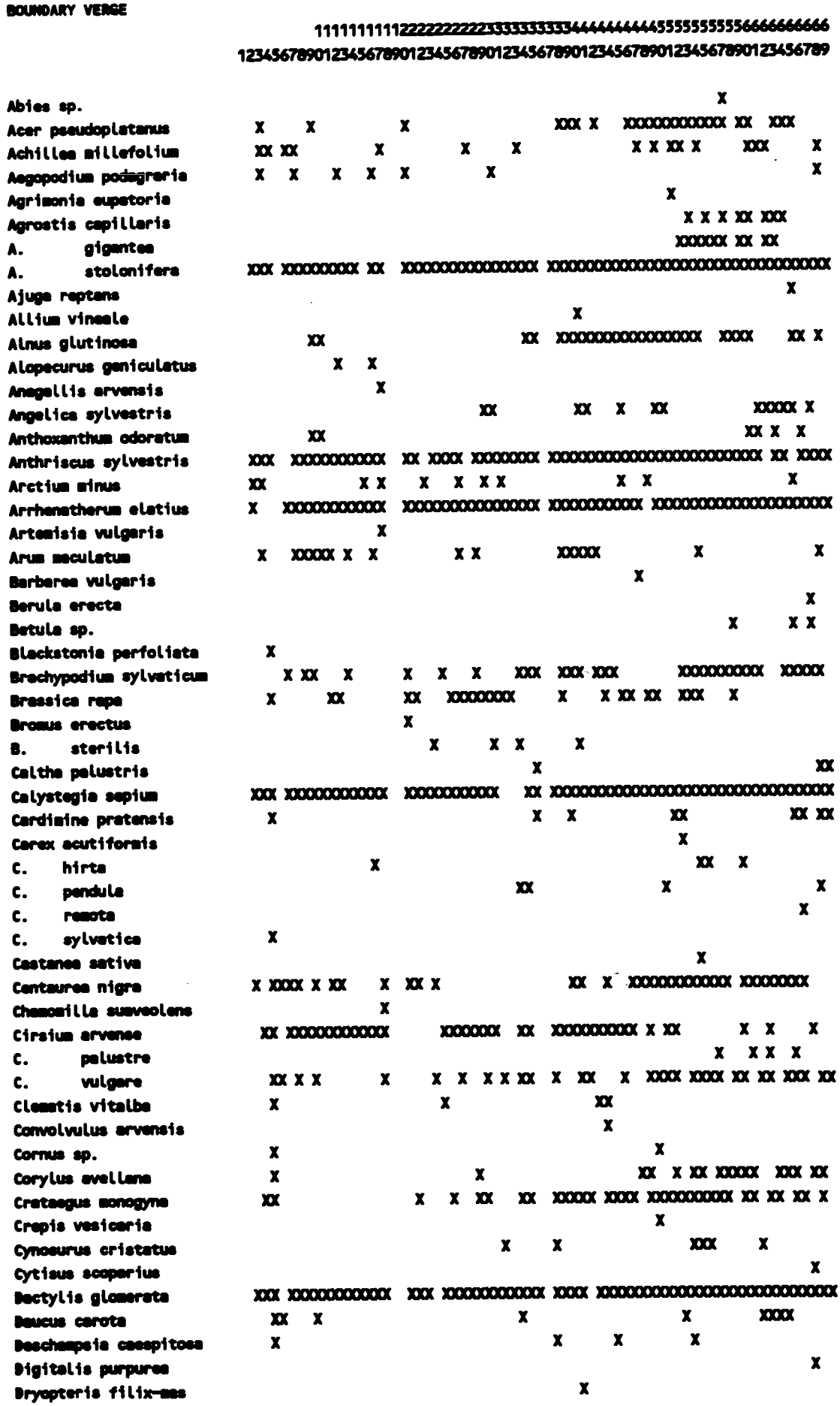
Barrow Navigation boundary

```
                                1111111111222222222233333333334444444444555555555566666666661
                                2345678901234567890123456789012345678901234567890123456789012
Scrophularia nodosa                                                                        X
Sedum acre                                                                                  X
S.    album                                                                                 X
Senecio aquaticus               X          X                    X        X XX    X       X
S.      jacobea                 X                                        X
Silene alba                       X
Solanum dulcamara               XXXX  XXXX XXXXX   XXXXXXXXXX XXXX  XXXXXXXXXXXXXXXXXXXXXX   X
Sorbus aucuparia                                                                        XX     XXX
S.      hibernica                 X
Sparganium emersum                      XX XXX                          XXX          XX
S.        erectum                     XXXXXXXXX              X      X XXXXXXXXXXX X    X
Stachys palustris                XX    X                  X X       X        XX
S.      sylvatica                 X               X         XX                X   X
Stellaria graminea                                                          XX   XX  XX X
S.        holostea                                                        X X          XX
Symphoricarpos albus            X     X             X       X                          X
Symphytum uplandicum                                                                     X
Syringa vulgaris                      X                                                  X
Taraxacum agg.                  X
Teucrium scordonia                                                                  XXXX  XXXX
Tilia sp.                         X           X                        X
Torilis japonica                X                           X
Trifolium repens                X
Typha latifolia                           X XX                  X           X
Ulex europaeus                    XX X              X       X                        X     X
Ulmus agg.                        XXX  X    XXX  X X   XX   X X X X  X   X        X X       X XX
Umbilicus rupestris                                                              X XXXXX XXXX
Urtica dioica                   X XXXXXXXXXXXXX   XX XXXXX XXXXXXX XXXXXXXXXXXXXXXXXXXXX X XXX XX
Valeriana officinalis            XX XXXX    X X       X X X XXXX XXXXXX X  XX   X X XXX X  XX XXXX
Veronica anagallis-aquaticaX       X                                        X     X
V.        arvensis                                                                        X
V.        beccabunga                                                    XX          X
V.        catenata                                                      X X     X
V.        chamaedrys            X   X     X        XX          X     X            XX XX  X X
V.        montana                                                               X   X
V.        serpyllifolia                                                                   X
Viburnum opulus                   XXXX  X  XXXX     X  XX                .  XX X XX          X
Vicia cracca                    X   XXX        X              X
V.    sepium                    X    X      XXXX    X XXXXX    X      X X  XX  X   X XX      X
Vinca sp.                                                                                   X
Viola sp.                                                                 XX              XXX
```

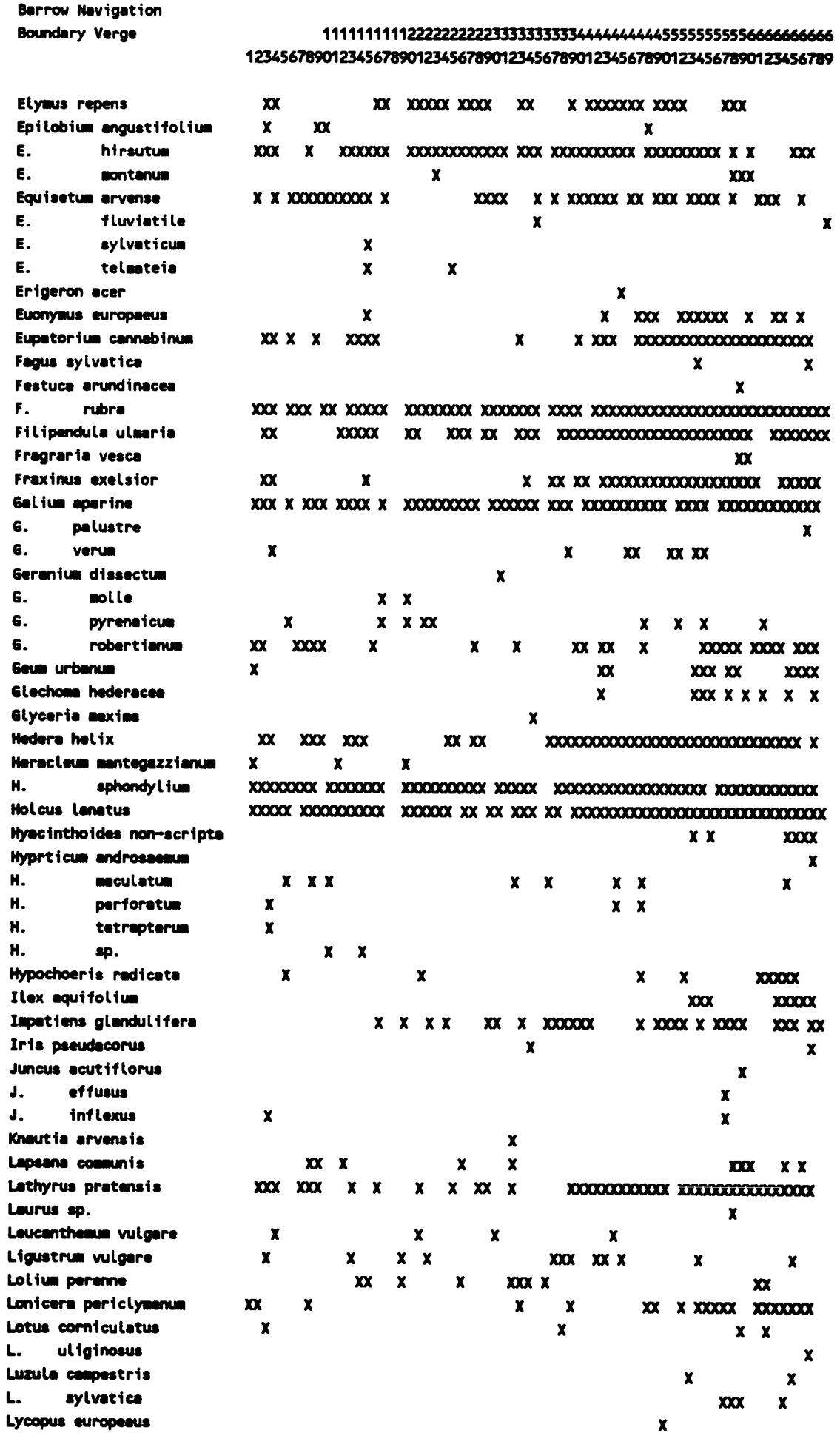
APPENDIX 2

The Flora of the Boundary Verge

BOUNDARY VERGE



Barrow Navigation
Boundary Verge



Barrow Navigation	1111111111222222222233333333344444444445555555556666666666
Boundary Verge	1234567890123456789012345678901234567890123456789012345678901234567890123456789
Lythrum salicaria	X X X XX X X X X XX X X XX
Medicago lupulina	X X X
Melica uniflora	X
Mentha aquatica	XXX
Myosotis scorpioides	X
Oenanthe crocata	X XX
Origanum vulgare	X X
Papaver rhoeas	X
P. sp.	X
Petasites hybridus	X X XX X XXX X X X
Phalaris arundinacea	X X X
Phleum pratense	X
Phragmites australis	X X X
Phyllitis scolopendrium	X X XXXX X XXX
Pimpinella saxifraga	X X X
Plantago lanceolata	X XX XX X X X X X X X
Poa annua	XXXXX XXXXXX
P. pratensis	XXXXXXXXXXXXXXX XXXX XXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXX XXX XXX
P. trivialis	XXXXXXXXXXXXXXX XXXX XXXXXX XXX XXXXXXXXXXXXXXXXXXXXXX XXX XXX
Polygonum amphibium	XX X XX X
Polypodium vulgare	X X
Populus sp.	X X
Potentilla anserina	XX X X X X
P. reptans	XXXXXX XXXXX X XXX XXXX XX X XXXX X
Primula vulgaris	X X
Prunus spinosa	X XX X X X XX X X XXX X XXX XXXX XX XXXXX X
Pteridium aquilinum	X XXXXX XXXXXXXXXX
Pulicaria dysenterica	X X X XX XX
Quercus sp.	XX XXXXXX XX XXXXXX
Ranunculus acris	X X X XX XXXXXXXXXXXXX
R. ficaria	XX XXXXXXXXXX XXXXXXX XX X X XXXXXXX XXX X XXXX XXXXXX
R. repens	XXX XX XXXXXXXXX XXXXXXX XXXX XXX XXXXXX X X X XX XXXXXX XXXXXXX
Reseda luteola	X X
Rhamnus cathertica	X X X
Rhinanthus minor	X
Rosa sp.	XXX X XX X XXX XXXX XXXXXXX XXXXXXXXXX XXXXXXXXX
Rubus fruticosus	XXX X XXX XXXXXX XXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXX
Rumex acetosa	X X X X XX XX
R. conglomeratus	XX XX XX XXX XX X XXX
R. crispus	X X XX X
R. obtusifolius	XX XXXXXX X X X XXX XXX X XX XX X XXX
R. sanguineus	X X X X X X
R. sp.	XX
Salix alba	X X X XX X X
S. cinerea	X
S. fragilis	X X X
S. viminalis	X X X XX XX X
S. sp.	XX XXX XXX X X X XX XX XX X XXXXXX XXXXX XXXXX
Sambucus nigra	X XX X XXX X XX X XXXXXXXXX XXXX X XX X
Scrophularia auriculata	X X X X XX X XX X X
Senecio aquaticus	XX X X X
S. jacobea	X X XX X XXX X X X XXXX X X X XXX X
S. vulgaris	X
Silene alba	X X X X X
Solanum dulcamara	X XXX XXXX XX XXXXXX X XXX XXXXXXXXXXXXXXXXXXXXXX X
Sonchus asper	X X X X X
S. oleraceus	X X X X

Barrow Navigation
Boundary Verge

```
                    1111111111222222222233333333334444444444555555555566666666661
                    2345678901234567890123456789012345678901234567890123456789012345678901234567890123456789
Sorbus aucuparia                                                                  X
Sparganium erectum                                                             X
Stachys palustris          X   X     X    XX    XX      X   X X    XXXX    X    XX
S.      sylvatica                      X        XX      X          X   X   X  X XX X X
Stellaria graminea                                                        X
S.      holostea                                                             XXXXX
Succisa pratensis                                                      X     X
Symphoricarpos albus        X             X
Symphytum officinale                            X                         X
S.      uplandicum                                                      X  X    X
Syringa vulgaris            X
Tanacetum parthenium                          X
Taraxacum agg.          X       X   XXX  XXXX            X     XX          X
Teucrium scordonia                                                    XXXX   XX
Tilia sp.                                                    X
Torilis japonica                              X   X   X   X                 X  X X
Trifolium pratense      X     XX   XXXX                   X    XXX X X XXX   XX XX
T.      repens                 X   X                      X
Trisetum flavescens                                          XX X
Tussilago farfara                                         X
Ulex europaeus           X    X  X        XX                   X    X   X     X X X
Ulmus agg.              X                    X     X X X     X       X X      X XX
Umbilicus rupestris                                                  X  X
Urtica dioica           XXX XXXXX XXXXX  XXXXXXXXXXXX XXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXX XX
Valeriana officinalis    X  X        XX      XX   X  XXX  XXXXX    X   X X X      X XXXX
Verbescum thapsus                      X
Veronica chamaedrys     XX  XXX  XXXXXX              X    X    X       XX XX  X X
V.      persica                                              X
Viburnum opulus         XX       X XX                      XXXX XX          X
Vicia cracca              XX  X X XXXXX          X  X     X  X X   X   X         X
V.    sepium            X  XXXXX XXXXXX   XXXXXXXXX  X X   X XXXXXXXXX XXXXXXXXXXXXXXXX
Viola sp.                        X                                          X XXX
```

APPENDIX 3

The Flora of the Trackway

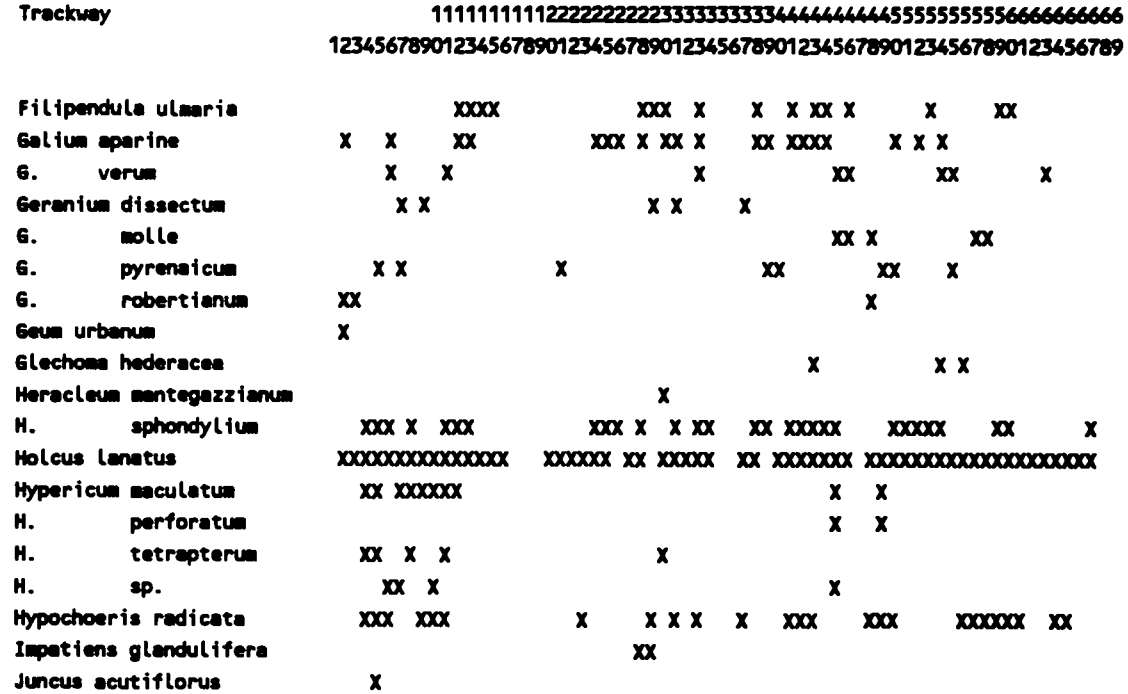
BARROW NAVIGATION 1992

TRACKWAY

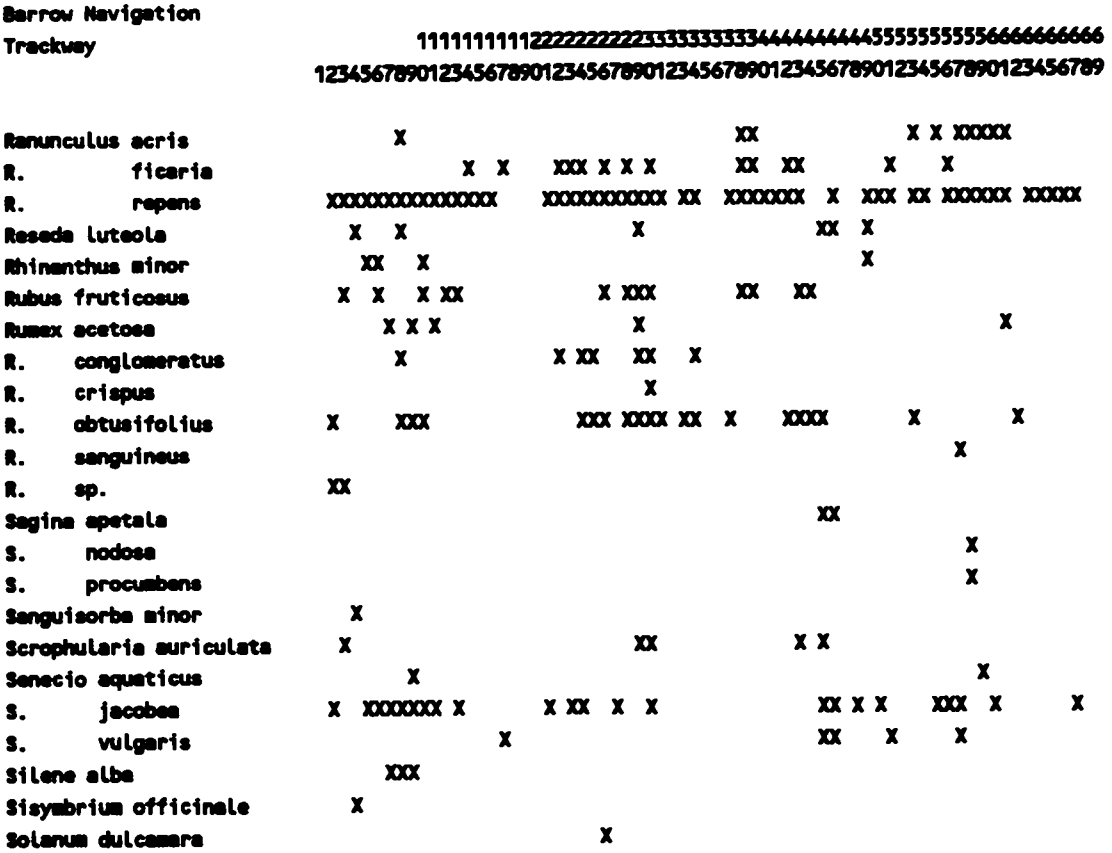
```
                                1111111111222222222233333333334444444444555555555566666666666
                                1234567890123456789012345678901234567890123456789012345678901234567890123456789
Achillea millefolium            XX XXX  XX      X  XX    XXX X   XXXX XX XX XXXXXXX X XXXXX XX
Aegopodium podagraria                 X
Agrimonia eupatoria                                             X
Agrostis canina                             X
A.      capillaris                                                      X X
A.      stolonifera             XXXXX X XX      XXXXXXXXXXX  XX  XXXXXXXXXX XXXXXXXXXXXXXXXXXX
Anacamptis pyramidalis                                          X
Anagallis arvensis                                              X
Angelica sylvestris     XX      X
Anthoxanthum odoratum     XXX  XX                                                       XXX X XX
Anthriscus sylvestris         XX  X         XXX XXX       XX X XXX   XXX X
Arctium minus           X                   XXXX
Arenaria serpyllifolia                                          XX X
Arrhenatherum elatius   X X XXX  XXXXX    XX XXXXXXXXXXX  XXXXXXXXXX  XXXXXXXXXXXXXXXXXX
Atriplex patula                                                 X
Barbarea vulgaris                                               XX  X
Bellis perennis         XX      XX      X   X      XX       X    XX X       X       X X
Blackstonia perfoliata    X
Brachypodium sylvaticum             X                                       X
Brassica rapa                       X           XXXXXX              X
Bromus erectus            X
B.      ramosus             X
B.      sterilis                                XX
Calystegia sepium       X X X   XXX           X  XXX       XX   XX
Capsella bursa-pastoris                                         XX  X
Cardamine hirsuta                   X
C.      pratensis                                           X
Carex flacca              XX
C.    hirta               XX  X X                               X    X X    X XX
Centaurea nigra           XXXXXX XX                           X   X   XX   XX XX
Cerastium fontanum      X                       X   X         X  XX       XX X
Chamomilla suaveolens                           X               X  X          X
Chenopodium album                                               XX
C.          bonus-henricus                                      XX
Cirsium arvense         XXXXX X X XX          XXXXXXX       XX XXXXXX            X
C.      vulgare           X  X X            X    X X             XX           XX       X
Convolvulus arvensis                                        X
Crepis vesicaria                                                    X
C.      sp.             X    XXX                                    X
Cynosurus cristatus       XX              XX       X     X  X     X      XXXXXXXXXX X XX
Dactylis glomerata      XXXXX XXXXXXXXXX  XXX XXXXXXXXXXX  XXXX XXXXX XXXXXXXXXXXXXXXXXX
Dactylorhiza fuchsii      X
Daucus carota             XXX XXX             X      X                    XXXX  XXX XX
Deschampsia caespitosa    X
Desmazeria rigida             X                                     XX       XX
Elymus repens                           XX   XX           X XXXXXX  XXX
Epilobium hirsutum                  X             X         XX   XX
E.      montanum                                X                 X
E.      parviflorum                             X                 X
Equisetum arvense           XXX XXXX          X     XX      X X XXXX    XX
Erigeron acer                                                   X
Eupatorium cannabinum                                           X
Festuca arundinacea     X
F.      pratensis                                                           X
F.      rubra           XXXXXX XX XXXX   X XXXXXXXXXXXX  XXXX XXXXX XXXXXXXXXXXXXXXXXX
```

Barrow Navigation

Trackway



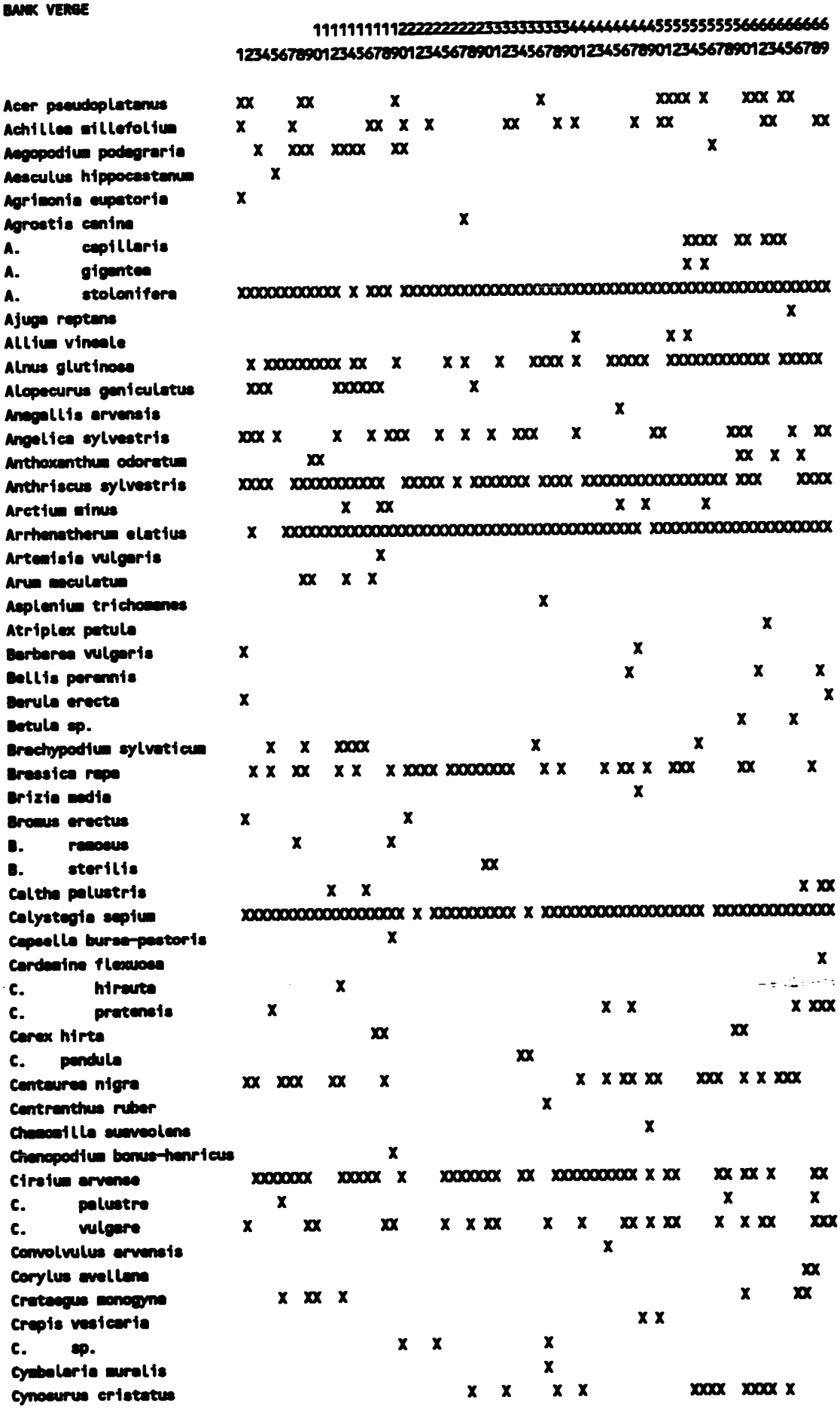
Barrow Navigation
Trackway



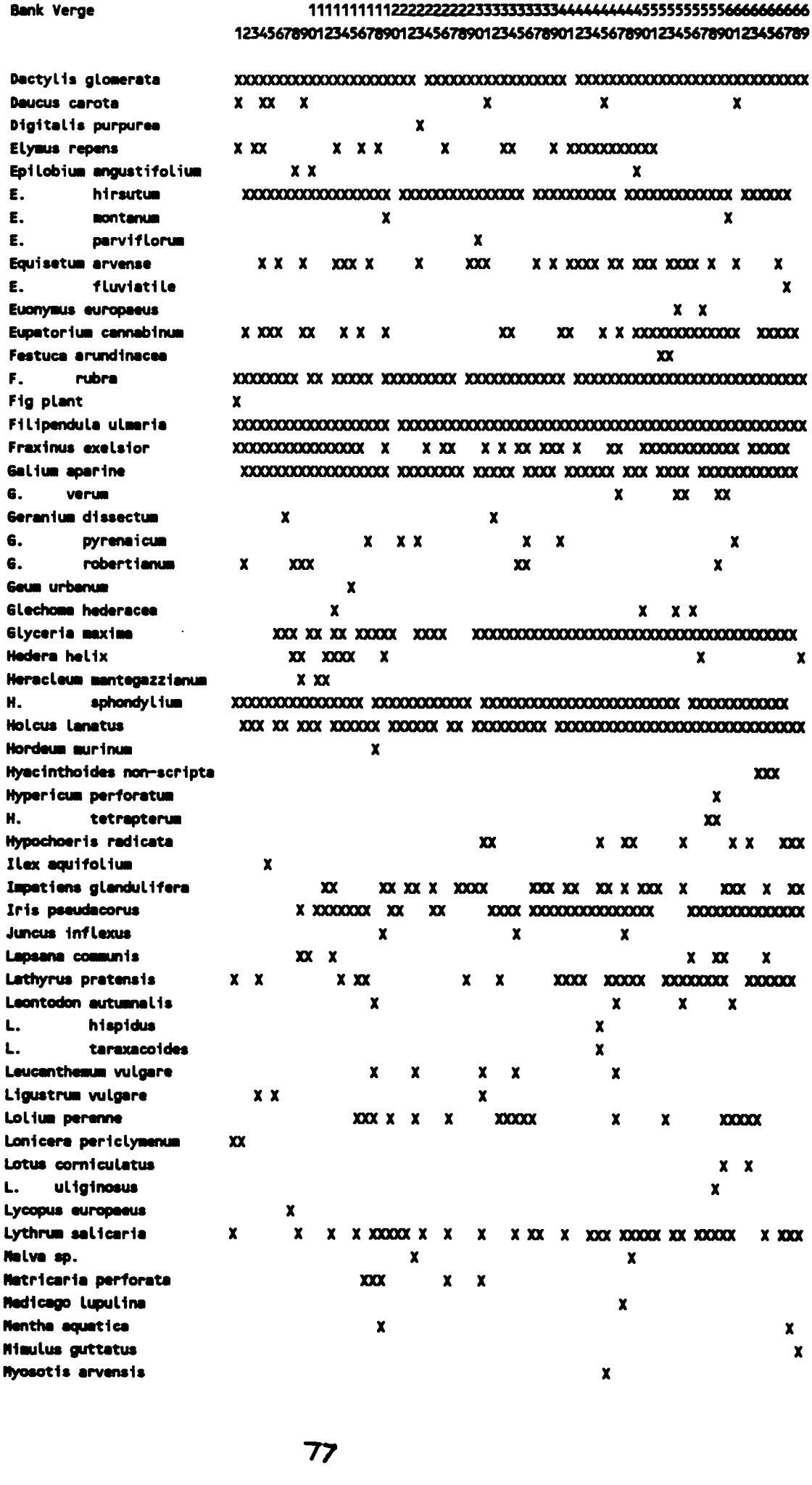
APPENDIX 4

The Flora of the Bank Verge

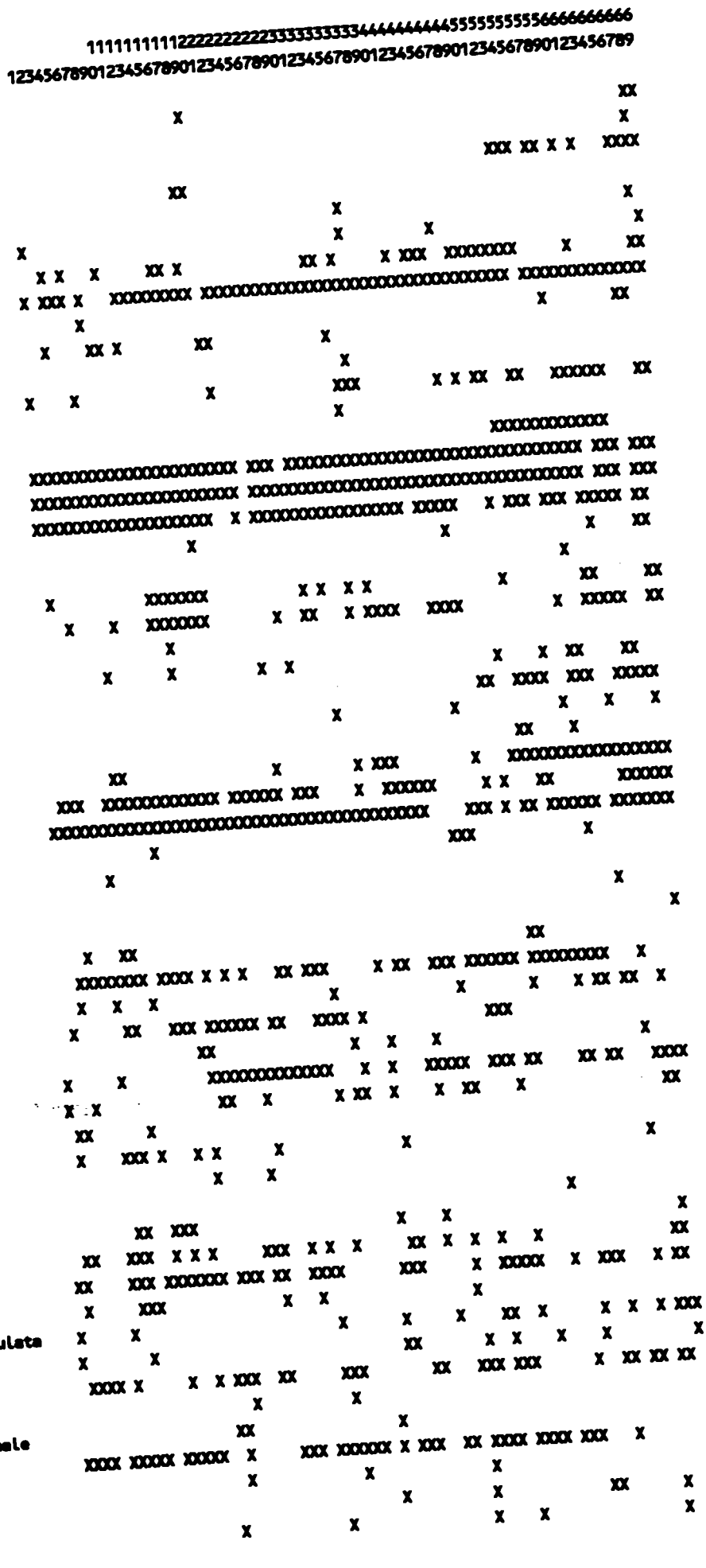
BANK VERGE


1111111111222222222233333333344444444445555555556666666666
1234567890123456789012345678901234567890123456789012345678901234567890123456789
Acer pseudoplatanus
Achillea millefolium
Aegopodium podagraria
Aesculus hippocastanum
Agrimonia eupatoria
Agrostis canina
A. capillaris
A. gigantea
A. stolonifera
Ajuga reptans
Allium vineale
Alnus glutinosa
Alopecurus geniculatus
Anagallis arvensis
Angelica sylvestris
Anthoxanthum odoratum
Anthriscus sylvestris
Arctium minus
Arrhenatherum elatius
Artemisia vulgaris
Arum maculatum
Asplenium trichomanes
Atriplex patula
Barbarea vulgaris
Bellis perennis
Berula erecta
Betula sp.
Brachypodium sylvaticum
Brassica rapa
Brizia media
Bromus erectus
B. ramosus
B. sterilis
Caltha palustris
Calystegia sepium
Capsella bursa-pastoris
Cardamine flexuosa
C. hirsuta
C. pratensis
Carex hirta
C. pendula
Centaurea nigra
Centranthus ruber
Chamomilla suaveolens
Chenopodium bonus-henricus
Cirsium arvense
C. palustre
C. vulgare
Convolvulus arvensis
Corylus avellana
Crataegus monogyna
Crepis vesicaria
C. sp.
Cymbalaria muralis
Cynosurus cristatus

Barrow Navigation
Bank Verge



Barrow Navigation
Bank Verge



Barrow Navigation

Bank Verge

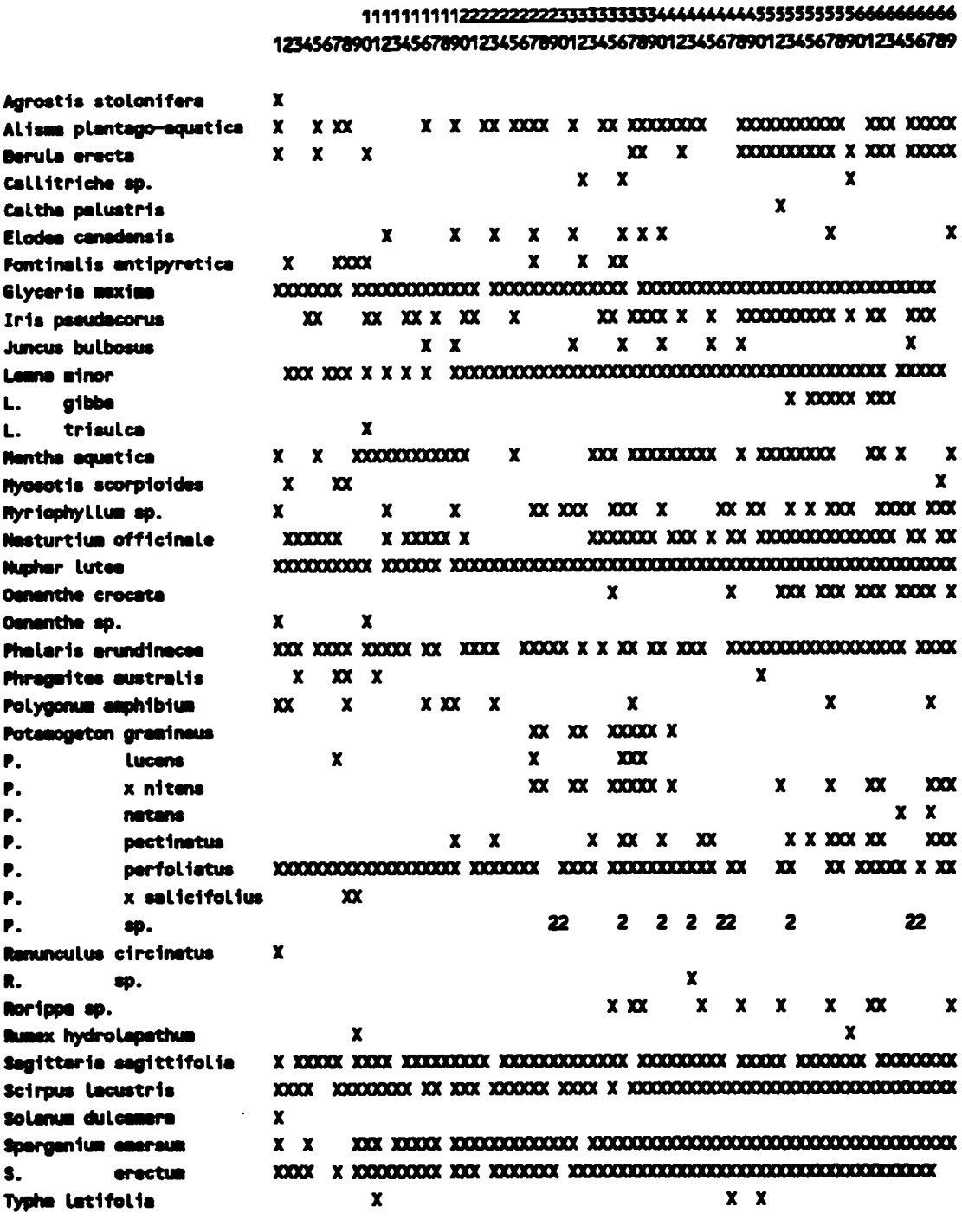
```
                                       1111111111222222222233333333334444444444555555555566666666666
                              123456789012345678901234567890123456789012345678901234567890123456789

Sparganium erectum             X                                      XXXX XXXXX XXX   X XXXXX X
Stachys palustris             X X XX X  X  XXX XXX        XXXXXX X    XXXX XXXXXXXX X XX XXXXXXXXX
Stellaria holostea                                                                          X
S.       palustris                X         X                                      X
Succisa pratensis                                                                      X
Symphoricarpos albus                                                                         X
Symphytum uplandicum                                 XXX                         X     X     X X     X
Tanacetum parthenium                                                        X
Taraxacum agg.                X    XX   X   XXX  XXXX                X     X                X      X
Torilis japonica                                                             XX                 X
Trifolium dubium                                                               XX
T.       pratense             X       X   X  XX     X       X X X X  X    XXXXXXXXXXXXXXXXXXXXXXX X
T.       repens               X              XXXXX                   X       X       X    X       X
Trisetum flavescens                                                                   X X      XX
Tussilago farfara                                              X       X    X
Typha latifolia                         X
Ulex europaeus                                             X                 XX
Ulmus agg.                      XX                     X          X                X         X XX
Urtica dioica                 XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XX
Valeriana officinalis           X XXXXXXX  X XX X              XXXXXXXXXXX  X    X XXXXXXXXX XX  XX
Verbascum thapsis                     X
Veronica anagallis-aquatica                   X
V.       chamaedrys                 XXX  XXXXX                                X
Viburnum opulus                       X
Vicia cracca                      XXX      X XX X              XX         X X       XX  XX X   XXXX
V.       sepium                  X XXXX  XXX    X     X   X  XX X    X   XXXX   X XXXXXXXXX XXXXXX
Viola sp.                                    X
```

APPENDIX 5

The Flora of the Channel

CHANNEL


Agrostis stolonifera
Alisma plantago-aquatica
Berula erecta
Callitriche sp.
Caltha palustris
Elodea canadensis
Fontinalis antipyretica
Glyceria maxima
Iris pseudacorus
Juncus bulbosus
Lemna minor
L. gibba
L. trisulca
Mentha aquatica
Myosotis scorpioides
Myriophyllum sp.
Nasturtium officinale
Nuphar lutea
Oenanthe crocata
Oenanthe sp.
Phalaris arundinacea
Phragmites australis
Polygonum amphibium
Potamogeton gramineus
P. lucens
P. x nitens
P. natans
P. pectinatus
P. perfoliatus
P. x salicifolius
P. sp.
Ranunculus circinatus
R. sp.
Rorippa sp.
Rumex hydrolapathum
Sagittaria sagittifolia
Scirpus lacustris
Solanum dulcamara
Sparganium emersum
S. erectum
Typha latifolia

APPENDIX 6

The Flora of the Locks and Bridges

LOCKS AND BRIDGES	* ****	* *	*	*	*	**	*****	**	*	* *	**	*	**	*	*	*	*****	**
	1111111111	2222222222	3333333333	4444444444	5555555555	6666666666												
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890												
Acer pseudoplatanus			X	X		X			X					X	X		X X	X
Achillea millefolium	X XXX	X X	X	X	X	X	XX	X X			XX	X	X	X	X		X	X
Aegopodium podagraria			X	X														
Agrostis stolonifera																		X
Alnus glutinosa	X X	X	X	X	X	XX	X	X		X	X	XX	X	X	X	X	X	X
Anacamptis pyramidalis							X											
Anemone nemorosa									X									
Angelica sylvestris	X	X		X		X				X								X
Anthoxanthum odoratum														X	X			
Anthriscus sylvestris			X							X	X							
Anthyllis vulneraria									X									
Aphanes arvensis											X							
Arabis hirsuta			X															
Arenaria serpylifolia	X X	X																
Arrhenatherum elatius							X							X				
Asplenium ruta-muraria	X XXX	X	X				X		X	X	X	X	X X	X	X			
A. trichomanes	X X	X X	X	X			X	X		X	X	X		X X	X	X		
Barbarea vulgaris			X															
Brachypodium sylvaticum	X																	
Brassica rapa								X		X	X							
Bromus erectus				X														
B. hordeaceus		X				X												
B. ramosus	X																	
B. sterilis	X									X								
Calystegia sepium		X						X		X			X			X		
Capsella bursa-pastoris		X		X														X
Cardamine hirsuta				X														
Carex caryophyllea												X						
C. hirta												X						
C. remota						X					X		X				X	
Centaurea nigra	X						X			X	X		X	X		X		X
Centranthus ruber	X X	X		X	X	X	X	XX			X							
Cerastium fontanum										X		X X	X			X	X	
Ceterach officinarum	X	X		X		X		X			X				X			
Cheiranthus cheiri										X	X							
Cirsium arvense	X						X											
Convolvulus arvensis									X									
Crataegus monogyna	X										X							
Crepis vesicaria															X			
C. sp.	X	X		X														
Cymbalaria muralis	X	X X		X	X	X	X	XX	X	X	X	X	X	XX		X	XXX	
Cynosurus cristatus						X												
Dactylis glomerata	XX	X X		X		X	XX	X		X		X	XX	X	X	X	X X X X X	X
Daucus carota							X				X		X					
Desmazeria rigida	X X	X		X								X		X		X		
Epilobium hirsutum					X			X		X								
E. montanum				X		X			X								XXX	
Erophila verna										X								
Eupatorium cannabinum	X			X	X					X	X	X	X	X			X X	X
Fagus sylvatica															X			
Festuca rubra	X XXX	X X	X	X	X	X	XX	X X	X	X	X	XX	X	XX	X	X X X X X	X	
Filipendula ulmaria	X	X	X	X		X	X	XX	X X		X X	X	X	X	X	X X X	X	X
Fragaria vesca														X				
Fraxinus excelsior	X	X	X				X	X X		X X		X	XX	X				X
Galium aparine	X			X					X		X		X			X		X

Barrow Navigation		*		*	*	*	*			*		*				*			*			*				*	*				*	*	*	*	*		*	*		*			*		*		*	*		*		*	*		*		*		*		*	*	*	*	*		*	*	
locks and bridges	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69
Galium verum		X		X						X		X																							X								X		X			X		X							X						X		X				
Geranium dissectum																																X																																					
G. molle		X		X												X											X																					X																					
G. robertianum				X																		X				X	X								X																	X					X												
Hedera helix		X		X	X	X	X			X		X				X			X			X				X	X				X	X			X		X			X			X		X		X	X				X	X		X		X						X		X			X	
Hieracium pilosella				X	X					X																																																											
Holcus lanatus							X												X																																								X										
Hypericum maculatum							X																																																										X				
Hypocharis radicata																																					X						X																X										
Impatiens glandulifera																																																							X														
Lapsana communis																																															X																						
Leontodon autumnalis																																																X									X												
Leucanthemum vulgare						X																X					X				X														X			X															X						
Lolium perenne					X	X	X									X											X																		X		X												X				X		X				
Lotus corniculatus																																																											X										
Lycopus europaeus							X																								X						X			X			X					X		X													X		X			X	
Lythrum salicaria							X												X			X					X								X					X					X			X									X												
Medicago lupulina					X		X									X															X	X			X										X							X													X				
Mentha aquatica																X															X																																		X			X	
Oenanthe crocata																																																																				X	
Origanum vulgare				X																																																																	
Parietaria judaica		X		X								X				X			X			X					X				X	X			X		X			X			X		X		X	X				X			X		X				X	X	X		X			X	
Phalaris arundinacea							X												X			X					X				X				X		X								X			X		X					X		X												
Phyllitis scolopendrium												X							X																					X								X					X		X				X				X		X				
Pimpinella saxifraga																																																																	X				
Plantago lanceolata					X	X	X			X		X				X						X					X					X					X								X		X	X		X					X		X		X				X		X			X	
Poa pratensis		X		X	X	X	X			X		X				X			X			X				X	X				X	X			X		X			X			X		X		X	X		X		X	X		X		X		X		X				X			X	
Polypodium vulgare																			X			X															X										X														X								
Potentilla anserina		X																																																																			
P. reptans					X							X				X						X					X					X											X		X					X					X		X		X						X			X	
Pteridium aquilinum																																																									X												
Ranunculus repens																																																																	X			X	
R. sceleratus																																								X																													
Rosa sp.																						X									X												X																										
Rubus fruticosus		X				X	X												X							X					X				X		X								X							X									X		X		X			X	
Rumex conglomeratus							X					X				X			X																																																		
R. crispus																			X																																																		
R. hydrolapathum																																																X																					
R. sanguineus		X																	X								X				X				X		X						X							X			X		X				X					X				X	
Sagina apetala																			X																																																		
Salix sp.																						X															X																				X												
Sambucus nigra																																					X																																
Saxifraga tridactylites										X						X			X																					X					X																								
Scrophularia auriculata																																																		X							X												
Sedum acre										X																							X	X																																			
S. album						X																X																							X			X																					
S. sp.										X																																																											
Senecio aquaticus																																																																				X	
S. jacobaea							X												X																										X												X				X								
S. vulgaris																			X																																																		
Silene alba																X																																																					
Sinapis arvensis					X														X																																																		
Solanum dulcamara												X																			X																																						
Sonchus arvensis																X																																																					
S. oleraceus																			X			X																																											X				
Stachys palustris																																															X			X							X						X						
Symphoricarpos albus																						X					X																																										

Barrow Navigation locks and bridges	* ****	* *	*	*	*	**	*****	** *	* *	**	*	**	*	*	*	*****	**
	1111111111222222222233333333344444444445555555556666666666																
	1234567890123456789012345678901234567890123456789012345678901234567890123456789																
Symphytum uplandicum											X		X				
Syringa vulgaris				X					X								
Tanacetum parthenium						X											
Taraxacum agg.	X X XX	X X	X	X	X	X	X X	X X	X	X X	X X	XX	X X	X X	X X	X	
Trifolium dubium	X XX				X		X X	X	X X	XX	X	X					X
T. repens	X X																
Trisetum flavescens	X				X								X		X		
Ulex europaeus						X											
Ulmus agg.	X															X	
Urtica dioica	X X X		X	X	X	XX	X	X X	X	X X	XX	X	XX	X X	X	X X	
Valeriana officinalis	X X					X	X			X							X
Valerianella locusta			X														
Veronica chamaedrys	X									X							
V. hederifolia					X												
Vicia sativa			X														

* denotes the presence of a bridge and/or a lock in a section.

APPENDIX 7

Species Diversity of the Habitat Zones
along the Barrow Navigation

Species Diversity at all sites along the Barrow Navigation, 1992

SITE	BD	BDV	TP	BKV	CH	L & B
BN 1	54	—	—	41	17	—
BN 2	18	26	30	38	11	23 L
BN 3	33	45	30	34	10	—
BN 4	49	49	40	38	10	16 B
BN 5	43	12	35	32	10	14 B
BN 6	32	30	41	31	7	21 B
BN 7	44	27	29	43	14	28 L
BN 8	39	29	41	47	11	—
BN 9	43	46	36	52	11	—
BN 10	44	32	33	30	15	21 B
BN 11	28	28	28	33	11	—
BN 12	36	29	32	39	12	18 L
BN 13	41	36	22	44	8	—
BN 14	42	33	16	44	12	—
BN 15	43	40	16	43	9	—
BN 16	43	38	13	47	14	27 L
BN 17	25	45	10	46	11	—
BN 18	—	—	—	44	6	—
BN 19	—	—	—	49	15	37 L+B
BN 20	30	39	13	31	11	—
BN 21	45	27	14	28	10	—
BN 22	30	26	14	24	7	29 L
BN 23	29	33	22	37	12	—
BN 24	30	26	24	29	8	—
BN 25	26	31	18	29	11	—
BN 26	33	35	24	28	10	18 B
BN 27	28	25	23	32	16	31 L
BN 28	29	34	24	25	12	—
BN 29	27	33	38	31	9	—
BN 30	29	33	47	38	11	—
BN 31	49	27	21	39	14	27 L
BN 32	31	13	11	33	13	15 B
BN 33	50	44	22	36	11	2 B
BN 34	43	38	18	33	11	1 B
BN 35	27	36	—	35	18	21 L
BN 36	—	—	—	39	20	—
BN 37	46	40	24	40	19	26 L
BN 38	34	34	26	36	18	0 B
BN 39	37	38	30	31	15	—
BN 40	45	51	21	40	18	14 L
BN 41	33	38	18	31	13	—
BN 42	36	36	24	34	14	—
BN 43	41	43	37	35	15	25 L
BN 44	36	37	31	33	13	—
BN 45	35	46	50	47	13	33 L
BN 46	33	38	38	54	10	—
BN 47	41	45	2	42	14	24 B
BN 48	39	54	32	45	16	30 L
BN 49	39	51	33	45	12	—
BN 50	44	48	29	41	16	23 L
BN 51	52	47	29	44	13	—
BN 52	49	52	17	38	18	13 B
BN 53	58	57	32	47	19	14 L
BN 54	48	62	31	50	14	—

SITE	BD	BDV	TP	BKV	CH	L & B
BN 55	51	56	24	44	16	25 L
BN 56	48	48	23	43	15	—
BN 57	41	47	32	47	21	31 L
BN 58	53	54	33	44	15	—
BN 59	68	61	27	59	16	20 L
BN 60	64	55	25	54	11	—
BN 61	39	47	16	53	18	14 B
BN 62	39	50	18	44	20	3 L
BN 63	35	52	23	39	13	23 L
BN 64	50	52	20	42	13	3 L
BN 65	49	60	21	51	16	30 L
BN 66	60	50	16	39	16	—
BN 67	66	55	20	51	17	0 B
BN 68	48	60	—	56	14	28 L
BN 69	19	27	—	42	16	—

Figure 1.1
Areas of Scientific Interest
along The Barrow Navigation