ECOLOGICAL SURVEY OF THE GRAND CANAL 1991

Part 1

Survey Report

Office Of Public Works 1992

ECOLOGICAL SURVEY

OF THE

GRAND CANAL

Part 1: Survey Report

Prepared for:
The Wildlife Service and Waterways Section,
Office of Public Works. 1992.

By
Marie Dromey
Brigid Johnston
Sinead Keane

SUMMARY

1. Part 1 contains the report of an ecological survey of the Grand Canal carried out over one full growing season in 1991. The main objectives were to assess the value of the canal corridor for nature conservation, and to make recommendations for the management of the canal taking these values into account. The Circular Line, the Mainline, the Barrow Line and the Edenderry Branch are all fully navigable. The Naas Braanch is navigable as far as Naas itself, but the section between there and the harbour at Corbally is blocked by a low bridge just outside Naas. This unnavigable stretch of canal is called the Corbally Branch in the report, to distinguish it from the navigable part of the same branch line. The Milltown Feeder links the canal with Pollardstown Fen, which is the main source of water for the Grand Canal system. The Kilbeggan Branch was closed to navigation in 1961, and is almmost dry. The possibility of re-opening this branch is being discussed at the present.

2. The habitats along the canal were assigned to the five zones into which the canal corridor was divided - boundary, boundary verge, towpath, bank verge and channel. Hedgerows are the dominant haabitat of the boundary, but in places where grazing did not occur scrub and small areas of woodland had developed. The boundary verge was dominated by grassland on the Mainline, and by scrub on the Barrow Line - suggesting a difference in past management practices. The towpaath was generally grassland dominated by trample-resistant species, or was unvegated (a bare track, or a tarred road). The ideal bank verge includes species that are transitional between dry and wet habitats, with grassland at the top of the bank and a reed fringe at the water's edge. This situation is not as common along the Grand Canal as it is on the Royal. The channel habitats ranged from shallow-water emergents at the margins to open-water in the centre of the canal. The stonework of locks, bridges and walls provides a range of habitats ranging from wet to dry.

3. The vascular flora was surveyed in detail. Diversities were highest in the boundary, boundary verge and bank zones. Species occurrence in each zone was calculated in order to determine rare and abundant species of each and therefore of the whole canal system. The occurrence of nationally rare species within the system was highlighted. Ecologically interesting areas are highlighted.

The Barrow Line was observed to be more wooded than other sections of the system. The Mainline itself was observed to be uniform along its length with much of the scrub/wooded areas removed and replaced by grassland which is frequently mowed. Bank repairs were carried out on the Milltown Feeder in 1990 and 1991 and the vegetation along its

banks was not fully established at the time of the survey. This accounts for the low terrestrial diversities there. Rare terrestrial species along the network were characteristic of habitats small in area which still survive. The Corbally Branch is not intensively managed and it is ecologically very interesting, supporting a variety of habitats each with a high species diversity. This area was prposed for designation as an Area of Scientific Interest in 1991.

In the channel, the greatest diversity occurs along the Corbally Branch, the eastern stretch of the Mainline and the southern end of the Milltown Feeder. These are stretches infrequently used by boats and untreated with herbicides. The Barrow Line and the Mainline west of Edenderry support extremely low aquatic diversities due to a combination of high boat numbers, herbicide spraying and bank repair. Aquatic species tolerant of eroding conditions make up this low diversity.

The findings concerning the impacts of boating, the effects of herbicide, rare plants and bank type along the Grand and Royal Canal networks are discussed.

4. The impacts of management on nature conservation throughout the canal system have been reviewed. These were considered under the general headings of maintenance and recreation. Dredging and dumping of spoil can have significant impacts of the flora and fauna, as can tree-cutting and scrub clearance. Changing the grazing regime may reduce species diversity on the towpath and boundary verge habitats. Miantenance of water quality is essential for nature conservation. Prolonged use of aquatic herbicides has reduced the botanical diverstiy of the channel.

5. Part 2 of the report contains gerneral guidelines for conservation management of the Grand Canal, and recommendations for each stretch of canal. This should allow nature conservation to be given equal priority with other values (in particular recreation and day-to -day maintenance) along the canal, which should allow for the existing diversty of the system to be improved and not merely maintained.

6. Part 3 ot the report contains the base-line maps produced in the field - each showing 1km of the canal, with the botanical features maked on it in some detail.

CONTENTS

LIST OF PHOTOGRAPHS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGEMENTS

This survey was supervised by Jim Ryan of the OPW Parks and Wildlife Service who provided helpful comments. General help and support provided by Gerry Wrynn, Joe Farrell and other staff of the OPW Waterways Section was also much appreciated. Transport along the canals was provided by the drivers of the canal maintenance staff.

Thanks are also due to the following:

Joe Caffrey of the Central Fisheries Board,
Declan Doogue of the Dublin Naturalists' Field Club
Staff of the Organisation Unit and Typing Sections of the OPW

DEFINITIONS

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

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

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

ABBREVIATIONS

AFF	:	An Foras Forbartha
ASI	:	Area of Scientific Interest
BWB	:	British Waterways Board (now British Waterways)
CFB	:	Central Fisheries Board
CIE	:	Coras Iompair Eireann
IWAI	:	Inland Waterways Association of Ireland
NCC	:	Nature Conservancy Council
OPW	:	Office of Public Works

MANAGEMENT OBJECTIVES

1.1 To give nature conservation equal priority with other criteria in the maintenance and development of the canal network.

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

1.3 To maximise diversity by varying management practices along the canal system.

1.4 To allow flexibility in management to take into account the variability of nature.

GENERAL GUIDELINES FOR CONSERVATION MANAGEMENT

2.1 MAINTENANCE

2.1.1 General

. Because of the conservation value of the canals a full-time ecologist should be employed by the Waterways Section.

2.1.2 Dredging

General

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

. Hydraulic machinery should be used where possible as it is more selective and flexible than drag-line dredgers.

. Where possible the spoil should be pulled into the side, and not removed from the channel.

. Dredging should be minimised during the months March to July to avoid the main growing season and to reduce disturbance to nesting birds.

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

Protection of reed fringe

. Dredging 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 the floating dredger should be used to avoid damaging the marginal vegetation.

. Where no reed fringe exists submerged berms should be

created along the bank to facilitate the growth of shallow-water marginal vegetation outside the navigation area.

. Create artificial islands in a number of the canal harbours as nest sites for mute swans and other breeding waterfowl. (The island in Maynooth Harbour on the Royal Canal provides a successful model).

Spoil deposition

. Spoil should not be dumped on wetlands such as fens and raised bogs or on unimproved grasslands along the canal bank as these are the richest sites botanically.

. Spoil may be dumped in a trench dug between the towpath and the boundary. This should then be recovered with topsoil and allowed to revegetate naturally.

. Alternatively spoil may be dumped between the towpath and the boundary and topsoil spread thinly over this.

. If there are no other suitable places close to the canal bank spoil could be spread thinly in scrub.

Control of plant growth on spoil heaps

. In areas destined to become grassland the early colonising plants should be mowed at least twice in the first year and the cuttings removed. In subsequent years a single late summer mowing should be sufficient.

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

2.1.3 Repair work

Bank protection

. Natural materials or vegetation should be used in bank protection wherever possible instead of sheet piling.

. Where clay is used to build up the banks it should be covered with topsoil or peat from the same site and allowed to revegate naturally.

2.1.4 Towpath revegetation

. Towpaths should not be reseeded after clearance and should be allowed to revegetate naturally.

2.1.5 Bankside trees

Trimming

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

- Removal of overhanging branches should be confined to those which overhang the canal and catch floating debris or obstruct navigation.

- Pollarding is a suitable management method for Willows. Young growth is trimmed off 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 or 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 trees or shrubs are to be removed from the system altogether.

2.1.6 Scrub

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

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

- Scrub 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.

2.1.7 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 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.

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 shrub and tree species should be done in autumn or spring, but not during severe frosts.

2.1.8 Grassland

Grazing

- Grazing of individual sites either by sheep or cattle should be consistent from year to year.

- Boundary fencing should be repaired where necessary to control stock.

- Stocking rates should be lower than the average on agricultural land to avoid damage to canal banks and poaching of towpath soils.

- Fencing should be erected along the water's edge where banks are gently sloping to prevent poaching of bank structure.

Mowing

- Mowing can also be used to maintain grassland on the towpath and verges. Species-rich grasslands should be mown once per year in late July or August when the main flowering season is over.

- A footpath 1m wide can be cut through the grassland twice a year (May/June and August/September) if necessary, to provide pedestrian access.

- All hay or other cut vegetation should be removed from the towpath to maintain the low nutrient status of the grassland.

- 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.

Herbicides

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

2.1.9 Wetlands

- Grazing in such areas should be limited to light stocking to allow full flowering of the wetland species and to avoid poaching.

- Where grazing is not feasible and scrub development is undesirable, these wetland areas will have to be cut once a year

(August), possibly by hand.

2.1.10 Aquatic vegetation

Environmental control

- Water depth should be managed to limit the growth of aquatic vegetation in the navigation channel.

- Boat traffic during the summer months can be used to keep the navigation channel clear of plant growth.

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

Mechanical cutting

- Cutting should be carried out twice per year (once in early summer and once in late summer) using a boat-mounted cutter.

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

- Cuttings should be disposed of away from the canal or should be composted and used elsewhere.

Herbicides

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

- 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.

- 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 plants.

Biological control

- The introduction of herbivorous fish such as grass carp (*Ctenopharyngodon idella*) should not be considered because of potential impacts on aquatic ecosystem.

- If the barley straw experiment at Abbeyshrule on the Royal Canal proves successful, the same method should be used to control algae at other sites on the canal system.

2.1.11 Masonry

- The vegetation growing on stone-walls and similar structures adds to the diversity of the system, and should not be removed as a matter of course but only when necessary for maintenance purposes.

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

2.1.12 Water quality

- All direct discharges other than feeder streams should be eliminated and the water quality of the streams themselves should be monitored to ensure early detection of pollution sources.

2.2 RECREATIONAL MANAGEMENT

2.2.1 Boat traffic

- Speed limitations should be strictly enforced for all boat traffic to prevent damage to canal banks from wash.

- Boat design also affects the force of the wash - high-powered boats designed for cruising on rivers and lakes should be discouraged from using still-water canals.

- 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.

- Disposal of effluent from boats into the canal should be prohibited to ensure continued high water quality.

2.2.2 Angling

- Re-stocking should be limited to the species of fish already found in the canal to avoid any imbalance in the predator-prey relationships which might affect invertebrate populations.

- Areas of the canal known to be important for breeding and overwintering wildfowl (especially swans) should not be developed for coarse angling due to the risk of contamination with discarded lead weights. Alternatively the use of lead weights along the canal should be banned.

- Herbicide spraying as a fisheries management method should be discontinued.

- Limits should be placed on the interference with bank vegetation to facilitate anglers.

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

Dromey

Plate 1:3rd September 1991. Ringsend Basin. The dominant aquatic plant is *Ceratophyllum demersum*, which thrives in nutrient-rich waters. Its presence is preferable to excess algae, which could become dominant if the *Ceratophyllum* is over-controlled. (ASI 20 in County Dublin).

Dromey

Plate 2:25th August 1991. km 3, taken from Latouche Bridge and looking east. Good examples of reed fringe along both banks dominated by *Glyceria maxima*. This stretch of channel is not sprayed. (ASI 20 in County Dublin)

Dromey

Plate 3:30th June 1991. km 10 taken from Lock 8 on the Main Line, looking west towards the new M50. Guinness Filter Beds to the right. Aquatic diversity is good and the reed fringes are species-rich. This stretch of channel is not sprayed. (ASI 20 in County Dublin).

Dromey

Plate 4:26th September 1991. km 13 Taken from Lock 11 and looking east towards Lock 10. The southern boundary is not defined. This makes the canal very accessible as a dumping ground. Many items of furniture were found in the canal immediately west of Lock 11. (ASI 20 in County Dublin).

Dromey

Plate 5:30th June 1991 km 13. Taken from Lock 11 and looking east along the Main Line. There is a lot of rubbish and algae in the channel. There is also very good aquatic diversity and healthy reed fringes. This stretch of channel is not sprayed. (ASI 20 in County Dublin).

Dromey

Plate 6:26th September 1991. km 13/14. Looking east towards Lock 11 on the Main Line. The southern boundary along this stretch is not defined and often parts of the south bank are overgrown. The north bank, though grazed, is overgrown. Very good aquatic diversity and healthy reed fringes present. This stretch of channel is not sprayed. (ASI 20 in County Dublin)

Dromey

Plate 7:27th June 1991. km 20. Looking east from Hazelhatch on the Main Line. There is very good aquatic diversity along this stretch and very healthy reed fringes dominated by Glyceria maxima and Phragmites australis. This stretch of channel is not sprayed. The bank and towpath (N) are species-rich and nutrient-poor. There is a species-rich fen at the toe of the embankment (N). (ASI 18 in County Kildare).

Dromey

Plate 8:2nd July 1991. km 22. Taken from Aylmer Bridge and looking east towards Hazelhatch along the Main Line. Healthy reed fringes. This stretch of channel is not sprayed. Species-rich banks which were not cut during 1991 ensuring diversity for 1992. Species such as Oak, Ash, Hazel, Sycamore, Spindle and Beech present along the southern boundary. (ASI 18 in County Kildare).

Johnston

Plate 9:May 1991. km 30. Taken from the south bank and looking east to Lock 15 along the Main Line. Very healthy reed fringes dominated by Phragmites australis and Glyceria maxima. This stretch of channel is not sprayed. Many swans and moorhens present. (ASI 18 in County Kildare).

Dromey

Plate 10:2nd July 1991. km 31. West of Lock 15 and looking west along the Main Line. This stretch of channel is not sprayed and supports very healthy reed fringes. Calcareous meadow exists along the south bank with mature Beech along the southern boundary. (ASI 18 in County Kildare).

Dromey

Plate 11:3rd July 1991. km 38. Taken from Lock 17 and looking west along the Main Line. Good aquatic diversity and a diverse and healthy reed fringe. This stretch of channel is not sprayed. The towpath becomes impassable (N). (ASI 18 in County Kildare).

Dromey

Plate 12:13th August 1991. km 42. Looking east from Bonynge Bridge along the Main Line. Healthy reed fringes and a high aquatic diversity present. This stretch of channel is not sprayed. Large species-rich calcareous meadow on the south bank. The north bank becomes impassable both sides of Cock Bridge. (ASI 18 in County Kildare).

Dromey

Plate 13:18th July 1991. km 56. Looking west towards Ticknevin Bridge on the north bank of the Main Line. Little reed fringe and poor aquatic diversity. Both banks are cut too frequently. Flowers will not get an opportunity to seed and so diversity will be reduced the following year. High diversity evident in the uncut calcareous meadow of the boundary verge. (ASI in County Kildare).

Dromey

Plate 14:18th July 1991. km 58. South bank looking east towards Lock 20 along the Main Line. Healthy reed fringe, species-rich berm and calcareous bank including Common Spotted Orchid. This stretch of channel was not treated with herbicides in 1991. However, it is proposed to use Casoron and the mowing bucket in 1992.

Dromey

Plate 15: 18th July 1991. km 58. South bank looking north just west of Lock 20 on the Main Line. Two healthy reed fringes and species-rich berm and calcareous bank. This stretch of channel was not sprayed in 1991. However, it is proposed to use Casoron and the mowing bucket in 1992. The grass of the bank was not cut early in the season so diversity is maintained.

Dromey

Plate 16: 18th July 1991. km 59. South bank looking west (West of Lock 20) along the Main Line. All canal zones healthy and supporting a diversity of species. The management along this stretch of both aquatic and terrestrial habitats was minimal i.e. no sprays and no cutting. Ecological diversity is assured. The terrestrial canal zones can be cut at the end of the growing season after the grasses and herbs have set seed.

Dromey

Plate 17:South bank looking west along the Main Line towards Blundell Aqueduct km 60. A small stretch of bank was repaired using clay. Revegetation is very slow on clay because the clay is very hard and organically poor. Without the vegetation to stabilize the clay, it is eroded by wash from the boats.

Dromey

Plate 18:18th July 1991. km 60. On the south bank of Main Line and looking west towards Blundell Aqueduct. The banks have been repaired and partly covered in peat. Peat-covered area can support vegetation. The uncovered clay is too hard for revegetation and without the vegetation to stabilize it, the clay is washed back into the channel.

Johnston

Plate 19:16th May 1991. km 62. On the south bank of the Main Line and looking west immediately west of Blundell Aqueduct. The banks were repaired using clay, which was then covered in peat and reseeded. If it was not reseeded, natural revegetation would have occurred on the peat.

Dromey

Plate 20:18th July 1991 km 62. As for Plate 19 but two months later. The vegetation growing on the bank stabilizes it and prevents erosion.

Dromey

Plate 21:19th July 1991. km 65. Taken from Rathmore Bridge on the Main Line and looking west. The clayed banks were not covered in topsoil/peat so revegetation is proceeding very slowly. A wide band of species-rich grassland was cut along both banks mid-season so reducing ecological diversity over a wide area (a bank 1m wide can be cut for pedestrian access). Species-rich hedgerows and boundary verges (which were not cut).

Dromey

Plate 22:19th July 1991. km 69. Looking east to Trimblestown Bridge from the south bank of the Main Line. Picture showes repaired banks not covered in topsoil/peat. Wide band of grassland cut along both banks in mid-season so reducing the ecological diversity over a wide area; species-rich boundary verge. (ASI 30 in County Offaly).

Dromey

Plate 23:21st July 1991. km 75. Looking west immediately west of Toberdaly Bridge on the Main Line. A 2m wide band of species-rich grassland was cut and the cuttings were not removed. Cuttings enrich the soil which can then produce a species-poor sward. Species of the nutrient-poor grassland such as the yellow Bedstraw, and Quaking grass can be seen.

Dromey

Plate 24:9th June 1991. km 90. Looking west towards Tullamore on the Main Line. Nutrient-rich species-poor grassland of the bank which has been cut. The cuttings have not been removed and thus act as fertilizer which will encourage the more competitive grasses. A wide bank along the south bank has also been cut and many shrubs removed. This is not necessary along a rural stretch of canal.

Dromey

Plate 25: 9th June 1991. km 91. Taken from the north bank of the Main Line between locks 23 and 24 west of Daingean. No reed fringe along this entire stretch. Casoron was used here in 1991. It is proposed to leave this stretch free of herbicides in 1992. Wave action has undercut the banks. Trees/scrub being removed from the south bank.

Dromey

Plate 26: 9th June 1991. km 91. As for plate 25. The bank where it was undercut has fallen into the channel.

Dromey

Plate 27: 20th July 1991. North bank looking westwards between 24th and 25th locks on the Main Line. Clayed south bank has not been covered in topsoil. Bank verge (N) is cut too frequently and the cuttings not removed. No reed fringe. It is proposed to leave this stretch of channel free from herbicides in 1992.

Dromey

Plate 28: 24th July 1991. km 105. Looking east from Becan's Bridge back towards Rahan on the Main Line. This stretch of channel was free from herbicides in 1991. It is proposed to use some Roundup in 1992. Healthy reed fringe evident along parts of the stretch.

Dromey

Plate 29: 24th July 1991. km 105. Looking west from Becan's Bridge. Healthy reed fringe which was not treated with herbicide in 1991. However, it is proposed to use Roundup along some of the stretch in 1992.

Dromey

Plate 30: 8th September 1991. km 118. South bank of Main Line just west of Macartney aqueduct and looking eastwards. Bank which has been repaired but not covered in topsoil.

Dromey

Plate 31: 9th September 1991. km 122. A view east along the Main Line from Noggus Bridge. On 10th June 1991 both stretches of canal bank were impassable. By the 9th September a very wide band of scrub was completely removed from both banks with the loss of a very rich ecological habitat.

Dromey

Plate 32: 9th September 1991. km 122. View west from Noggus Bridge along the Main Line. Rough grassland along both banks. Very little reed fringe evident. Roundup and localised Casoron were used in 1991 and it is proposed to use some Roundup in 1992.

Dromey

Plate 33: 9th September 1991. km 125. Looking west towards Glyn Bridge along the Main Line. Species-rich boundary hedgerow including Hazel, Guelder Rose and Oak. Little reed fringe evident. This stretch of channel was sprayed with Casoron in 1991 and it is proposed to use Roundup in 1992.

Dromey

Plate 34: 13th August 1991. km 31. Photograph taken at the start of the Barrow Line. Species-rich calcareous meadow on the bank and towpath supporting such plants as Eyebright, Ox-eye daisy, Wild Carrot and Quaking Grass. This grassland was not cut so maintaining its ecological diversity.

Dromey

Plate 35: 13th August 1991. km B1. Diverse calcareous meadow along the bank. It is ungrazed and uncut. Photo taken at the start of the Barrow Line.

Dromey

Plate 36: 15th August 1991. km B11. Looking east towards Glenaree Bridge on the north bank of the Barrow Line. The photograph shows the large area of fen at the toe of the embanked canal. A similar fen area exists on the south bank. The orchid, *Epipactis palustris* was found here. In addition there is a high diversity of both habitat and species in the area.

Dromey

Plate 37: 10th September 1991. km B24. Taken from the bridge at the 25th Lock and looking west towards Clogheen Bridge. The south bank was cleared by 17th June 1991 but by September, revegetation was very slow. The soil has compacted making it very difficult for plants to grow.

Dromey

Plate 38: 11th September 1991. km B30. A view east from Fisherstown Bridge on the Barrow Line showing the species-rich hedgerow. It may be necessary to cut and spot-treat tree stumps of the east bank.

Dromey

Plate 39: 11th September 1991. km B30. A view west from Fisherstown Bridge on the Barrow Line showing overgrown banks. It may be necessary to cut and spot-treat tree stumps on one bank. Wholesale clearance of the banks should not be carried out.

Plate 40: 11th September 1991. A view west from Milltown Bridge on the Barrow Line. On the 8th June 1991, this stretch of bank was covered in scrub and impassable. A very wide area along one bank was cleared. At least half the cleared area should be left in scrub. The soil is compacted which will make it difficult for revegetation.

Dromey

Plate 41: 19th July 1991. Edenderry Branch of the Grand Canal - on the north bank looking south to Downshire Bridge. Clayed bank is not covered in topsoil which will make it difficult for revegetation.

Dromey

Plate 42: 8th August 1991. km N5. Photo shows the Naas Branch of the Grand Canal with healthy reed fringes, good aquatic diversity and rich bank. Many swans and moorhens present.

Dromey

Plate 43: 2nd October 1991. km N 6/7. Naas branch along the east bank looking north. Part of the disused canal being dredged from one bank leaving the other intact. The spoil/dead reeds are pulled to the bank and not deposited on the towpath. (ASI)

Dromey

Plate 44: 2nd October 1991. km 6/7 East bank looking south. Dredging of one bank only and the deposition of some reeds along the bank. Both of these practices are environmentally friendly. However, depositing reeds along the boundary results in reeds growing there. They will choke out the natural vegetation. The dead reeds should be buried in a trench. (ASI)

Dromey

Plate 45: 2nd October 1991. Naas Branch on the east bank and looking south to highlight the differences between dredged/undredged stretch. (ASI).

Dromey

Plate 46: 9th August 1991. km N11. North bank of Naas Branch looking east towards Hoare's Bridge. Species-rich calcareous bank and boundary verge which is lightly grazed. Very high aquatic diversity also evident. (ASI)

Johnston

Plate 47: 13th August 1991. km N12. Calcareous grassland, grazed by sheep along the west bank of the Naas Branch. These heaps are nutrient-poor and were probably deposited at the time of the previous dredging approximately 60 years ago. (ASI)

Dromey

Plate 48: 12th August 1991. km M5. Taken from Pim Bridge on the Milltown Feeder and looking south towards the Hill of Allen. This stretch was dredged in 1990. Thistles are the dominant species one year later. Cut them down in June to prevent seeding and another crop the following year.

Dromey

Plate 49: 12th August 1991. km M11. Looking south from Milltown Cross Roads Bridge. Healthy reed fringes developing one year after bank repairs. The soil of the towpath is compacted making it difficult for revegetation.

Dromey

Plate 50: 28th October 1991 km K2. View south from Brook's Bridge on the disused Kilbeggan Branch. The channel is wet at this point and supports *Phragmites australis*. There are some birch trees present also. Both banks support scrub/trees.

Dromey

Plate 51: 28th October 1991. km K6. View north on the Kilbeggan Branch, of the Grand Canal on the approach to Whelan's Bridge. The canal passes through Bracklin Bog. The towpath is very interesting as both acid and lime-loving plants exist side by side. Many aquatic species present in the channel. It is necessary to define boundaries. Spoil to be deposited outside of the bog or in a deep trench which will then be covered.

Dromey

Plate 52: 28th October 1991. km K7. View north from Whelan's Bridge on the Kilbeggan Branch of the Grand Canal. This stretch of disused channel and towpath is presently grazed. Esker mounds dominated by Hazel along the west bank. It is necessary to define boundaries along both banks. Spoil should be deposited in a trench which will then be covered in topsoil.

Dromey

Plate 53: 28th October 1991. km K8. Rahugh Esker - an ASI of International Importance, No. 1 in Co. Westmeath - on the east bank of the disused Kilbeggan Branch. The site is important because of its nutrient-poor soils which support many nationally rare species. Spoil to be deposited away from the Esker.

Dromey

Plate 54: 28th October 1991. km K10. A view south from Grange Bridge on the disused Kilbeggan Branch. Trees/shrubs of the east bank were cut by a local Fás Scheme. The channel between here and Lowertown Bridge further south is dry and grazed for much of its length. Both boundaries need to be defined.

Dromey

Plate 55: 28th October 1991. km K11. Looking north from Grange Bridge on the disused Kilbeggan Branch. Sheep graze this stretch of towpath. Water present in the channel at this point. Spoil to be buried in a trench and covered. It is necessary to define boundaries. Esker in the distance through which the canal cuts.

Johnston

Plate 56: 9th January 1992 km B16. Taken from Wilson's Bridge on the Barrow Line and looking north. The east bank has been cleared of scrub which was present in September 1991. Clearance is approximately 10 metres wide.

Dromey

Plate 57: 9th January 1992. km B 34/35. Looking north along the west bank of the Barrow Line. Levelling of old bank mound which raised the height of towpath and results in a steeper bank. The path has been levelled for a width of 13-16 metres. The old towpath of approximately 3 metres is just beyond levelled section.

Dromey

Plate 58: 9th January 1992. As for plate 57.

Plate 59: 9th January 1992. km B37 View north from Ballymanus Bridge along the east bank of the Barrow Line. The canal is to the left of the picture. There is a road between it and the cleared stretch. In September 1991 this stretch supported a diversity of trees and shrubs including Hazel, Ash, and Guelder Rose.

Dromey

Plate 60: 9th January 1992. km B37 Looking north along the west bank of the Barrow Line at Ballymanus Bridge. This photo shows a view of the opposite bank to that shown in Plate 59. This bank has to be clayed in order to raise it. The clay should be covered with topsoil to facilitate revegetation which stabilizes the bank.

CHAPTER 1 INTRODUCTION

1.1 HISTORY OF THE GRAND CANAL

Work on the Grand Canal began in 1756 under the authority of the Commissioners for Inland Navigation, forty-one years after the first proposal to build a canal linking the River Liffey at Dublin to the Rivers Shannon and Barrow had been discussed. In 1772 the project was handed over to private enterprise to complete, as it was felt that it was too expensive for public funding. By 1783 the summit level at Lowtown was reached, and in 1791 the Barrow Line was completed.

In the early 1780s the question of linking the canal to the River Liffey arose. The original plan had been to descend directly into the river from the harbour at James's Street. This was rejected in favour of a more ambitious scheme - that of following the newly-built circular road and entering the Liffey at Ringsend. A pamphlet published in 1785 claimed that the circular route would not only add to the beauty of the city, it would also prove an amenity for the citizens (Delany and Delany, 1966) - an interesting point of view and one considerably ahead of its time. In 1796 the docks at Ringsend were opened, and the Main Line to the Shannon was completed in 1804. A number of branch lines were built (Fig. 1.1; Table 1.1), the final one being the Kilbeggan Branch, finished in 1835.

Passenger traffic on the canal was never as successful as had been anticipated, due to competition from first the railways and then the roads, and in 1852 the service was stopped. In 1950 the Grand Canal Company, despite vigorous protests from the Directors, was amalgamated with Coras Iompair Eireann (CIE) and the canal became part of the nationalised transport network. Decreasing returns and a decline in goods traffic led to the withdrawal of the trade boats in 1960, and in 1961 all the branch lines except Edenderry were closed.

In 1974 James's Street Harbour in Dublin was closed, and the short spur in from the Main Line was filled in and converted to a linear park. Since that time, however, there has been an increased interest in the recreational needs of Dublin (Mawhinney, 1975) and of the country as a whole, and a change in attitude about the potential value of inland waterways as a resource, both recreational and otherwise. This has ensured that no further irreversible losses were endured by the Grand Canal system. It was too late for the branches to Mountmellick, Ballinasloe and James's Street, but in 1987 - one year after responsibility for the canal passed from CIE to the Office of Public Works (OPW) - the Naas Branch was re-opened from the Main Line to the harbour in Naas. In 1990 work began on clearing Kilbeggan Harbour, the first step towards the restoration of the Kilbeggan Branch. The Corbally Branch, which is blocked to navigation by a low bridge just outside Naas, built in 1953, was designated as an Area of Scientific

ECOLOGICAL SURVEY

OF THE

GRAND CANAL

Part 1: Survey Report

Prepared for:
The Wildlife Service and Waterways Section,
Office of Public Works. 1992.

By
Marie Dromey
Brigid Johnston
Sinead Keane

SUMMARY

1. Part 1 contains the report of an ecological survey of the Grand Canal carried out over one full growing season in 1991. The main objectives were to assess the value of the canal corridor for nature conservation, and to make recommendations for the management of the canal taking these values into account. The Circular Line, the Mainline, the Barrow Line and the Edenderry Branch are all fully navigable. The Naas Braanch is navigable as far as Naas itself, but the section between there and the harbour at Corbally is blocked by a low bridge just outside Naas. This unnavigable stretch of canal is called the Corbally Branch in the report, to distinguish it from the navigable part of the same branch line. The Milltown Feeder links the canal with Pollardstown Fen, which is the main source of water for the Grand Canal system. The Kilbeggan Branch was closed to navigation in 1961, and is almmost dry. The possibility of re-opening this branch is being discussed at the present.

2. The habitats along the canal were assigned to the five zones into which the canal corridor was divided - boundary, boundary verge, towpath, bank verge and channel. Hedgerows are the dominant haabitat of the boundary, but in places where grazing did not occur scrub and small areas of woodland had developed. The boundary verge was dominated by grassland on the Mainline, and by scrub on the Barrow Line - suggesting a difference in past management practices. The towpaath was generally grassland dominated by trample-resistant species, or was unvegated (a bare track, or a tarred road). The ideal bank verge includes species that are transitional between dry and wet habitats, with grassland at the top of the bank and a reed fringe at the water's edge. This situation is not as common along the Grand Canal as it is on the Royal. The channel habitats ranged from shallow-water emergents at the margins to open-water in the centre of the canal. The stonework of locks, bridges and walls provides a range of habitats ranging from wet to dry.

3. The vascular flora was surveyed in detail. Diversities were highest in the boundary, boundary verge and bank zones. Species occurrence in each zone was calculated in order to determine rare and abundant species of each and therefore of the whole canal system. The occurrence of nationally rare species within the system was highlighted. Ecologically interesting areas are highlighted.

The Barrow Line was observed to be more wooded than other sections of the system. The Mainline itself was observed to be uniform along its length with much of the scrub/wooded areas removed and replaced by grassland which is frequently mowed. Bank repairs were carried out on the Milltown Feeder in 1990 and 1991 and the vegetation along its

banks was not fully established at the time of the survey. This accounts for the low terrestrial diversities there. Rare terrestrial species along the network were characteristic of habitats small in area which still survive. The Corbally Branch is not intensively managed and it is ecologically very interesting, supporting a variety of habitats each with a high species diversity. This area was prposed for designation as an Area of Scientific Interest in 1991.

In the channel, the greatest diversity occurs along the Corbally Branch, the eastern stretch of the Mainline and the southern end of the Milltown Feeder. These are stretches infrequently used by boats and untreated with herbicides. The Barrow Line and the Mainline west of Edenderry support extremely low aquatic diversities due to a combination of high boat numbers, herbicide spraying and bank repair. Aquatic species tolerant of eroding conditions make up this low diversity.

The findings concerning the impacts of boating, the effects of herbicide, rare plants and bank type along the Grand and Royal Canal networks are discussed.

4. The impacts of management on nature conservation throughout the canal system have been reviewed. These were considered under the general headings of maintenance and recreation. Dredging and dumping of spoil can have significant impacts of the flora and fauna, as can tree-cutting and scrub clearance. Changing the grazing regime may reduce species diversity on the towpath and boundary verge habitats. Miantenance of water quality is essential for nature conservation. Prolonged use of aquatic herbicides has reduced the botanical diverstiy of the channel.

5. Part 2 of the report contains gerneral guidelines for conservation management of the Grand Canal, and recommendations for each stretch of canal. This should allow nature conservation to be given equal priority with other values (in particular recreation and day-to -day maintenance) along the canal, which should allow for the existing diversty of the system to be improved and not merely maintained.

6. Part 3 ot the report contains the base-line maps produced in the field - each showing 1km of the canal, with the botanical features maked on it in some detail.

CONTENTS

LIST OF PHOTOGRAPHS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGEMENTS

This survey was supervised by Jim Ryan of the OPW Parks and Wildlife Service who provided helpful comments. General help and support provided by Gerry Wrynn, Joe Farrell and other staff of the OPW Waterways Section was also much appreciated. Transport along the canals was provided by the drivers of the canal maintenance staff.

Thanks are also due to the following:

Joe Caffrey of the Central Fisheries Board,
Declan Doogue of the Dublin Naturalists' Field Club
Staff of the Organisation Unit and Typing Sections of the OPW

DEFINITIONS

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

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

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

ABBREVIATIONS

AFF	:	An Foras Forbartha
ASI	:	Area of Scientific Interest
BWB	:	British Waterways Board (now British Waterways)
CFB	:	Central Fisheries Board
CIE	:	Coras Iompair Eireann
IWAI	:	Inland Waterways Association of Ireland
NCC	:	Nature Conservancy Council
OPW	:	Office of Public Works

MANAGEMENT OBJECTIVES

1.1 To give nature conservation equal priority with other criteria in the maintenance and development of the canal network.

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

1.3 To maximise diversity by varying management practices along the canal system.

1.4 To allow flexibility in management to take into account the variability of nature.

GENERAL GUIDELINES FOR CONSERVATION MANAGEMENT

2.1 MAINTENANCE

2.1.1 General

. Because of the conservation value of the canals a full-time ecologist should be employed by the Waterways Section.

2.1.2 Dredging

General

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

. Hydraulic machinery should be used where possible as it is more selective and flexible than drag-line dredgers.

. Where possible the spoil should be pulled into the side, and not removed from the channel.

. Dredging should be minimised during the months March to July to avoid the main growing season and to reduce disturbance to nesting birds.

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

Protection of reed fringe

. Dredging 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 the floating dredger should be used to avoid damaging the marginal vegetation.

. Where no reed fringe exists submerged berms should be

created along the bank to facilitate the growth of shallow-water marginal vegetation outside the navigation area.

. Create artificial islands in a number of the canal harbours as nest sites for mute swans and other breeding waterfowl. (The island in Maynooth Harbour on the Royal Canal provides a successful model).

Spoil deposition

. Spoil should not be dumped on wetlands such as fens and raised bogs or on unimproved grasslands along the canal bank as these are the richest sites botanically.

. Spoil may be dumped in a trench dug between the towpath and the boundary. This should then be recovered with topsoil and allowed to revegetate naturally.

. Alternatively spoil may be dumped between the towpath and the boundary and topsoil spread thinly over this.

. If there are no other suitable places close to the canal bank spoil could be spread thinly in scrub.

Control of plant growth on spoil heaps

. In areas destined to become grassland the early colonising plants should be mowed at least twice in the first year and the cuttings removed. In subsequent years a single late summer mowing should be sufficient.

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

2.1.3 Repair work

Bank protection

. Natural materials or vegetation should be used in bank protection wherever possible instead of sheet piling.

. Where clay is used to build up the banks it should be covered with topsoil or peat from the same site and allowed to revegate naturally.

2.1.4 Towpath revegetation

. Towpaths should not be reseeded after clearance and should be allowed to revegetate naturally.

2.1.5 Bankside trees

Trimming

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

- Removal of overhanging branches should be confined to those which overhang the canal and catch floating debris or obstruct navigation.

- Pollarding is a suitable management method for Willows. Young growth is trimmed off 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 or 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 trees or shrubs are to be removed from the system altogether.

2.1.6 Scrub

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

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

- Scrub 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.

2.1.7 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 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.

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 shrub and tree species should be done in autumn or spring, but not during severe frosts.

2.1.8 Grassland

Grazing

- Grazing of individual sites either by sheep or cattle should be consistent from year to year.

- Boundary fencing should be repaired where necessary to control stock.

- Stocking rates should be lower than the average on agricultural land to avoid damage to canal banks and poaching of towpath soils.

- Fencing should be erected along the water's edge where banks are gently sloping to prevent poaching of bank structure.

Mowing

- Mowing can also be used to maintain grassland on the towpath and verges. Species-rich grasslands should be mown once per year in late July or August when the main flowering season is over.

- A footpath 1m wide can be cut through the grassland twice a year (May/June and August/September) if necessary, to provide pedestrian access.

- All hay or other cut vegetation should be removed from the towpath to maintain the low nutrient status of the grassland.

- 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.

Herbicides

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

2.1.9 Wetlands

- Grazing in such areas should be limited to light stocking to allow full flowering of the wetland species and to avoid poaching.

- Where grazing is not feasible and scrub development is undesirable, these wetland areas will have to be cut once a year

(August), possibly by hand.

2.1.10 Aquatic vegetation

Environmental control

- Water depth should be managed to limit the growth of aquatic vegetation in the navigation channel.

- Boat traffic during the summer months can be used to keep the navigation channel clear of plant growth.

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

Mechanical cutting

- Cutting should be carried out twice per year (once in early summer and once in late summer) using a boat-mounted cutter.

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

- Cuttings should be disposed of away from the canal or should be composted and used elsewhere.

Herbicides

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

- 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.

- 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 plants.

Biological control

- The introduction of herbivorous fish such as grass carp (*Ctenopharyngodon idella*) should not be considered because of potential impacts on aquatic ecosystem.

- If the barley straw experiment at Abbeyshrule on the Royal Canal proves successful, the same method should be used to control algae at other sites on the canal system.

2.1.11 Masonry

- The vegetation growing on stone-walls and similar structures adds to the diversity of the system, and should not be removed as a matter of course but only when necessary for maintenance purposes.

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

2.1.12 Water quality

- All direct discharges other than feeder streams should be eliminated and the water quality of the streams themselves should be monitored to ensure early detection of pollution sources.

2.2 RECREATIONAL MANAGEMENT

2.2.1 Boat traffic

- Speed limitations should be strictly enforced for all boat traffic to prevent damage to canal banks from wash.

- Boat design also affects the force of the wash - high-powered boats designed for cruising on rivers and lakes should be discouraged from using still-water canals.

- 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.

- Disposal of effluent from boats into the canal should be prohibited to ensure continued high water quality.

2.2.2 Angling

- Re-stocking should be limited to the species of fish already found in the canal to avoid any imbalance in the predator-prey relationships which might affect invertebrate populations.

- Areas of the canal known to be important for breeding and overwintering wildfowl (especially swans) should not be developed for coarse angling due to the risk of contamination with discarded lead weights. Alternatively the use of lead weights along the canal should be banned.

- Herbicide spraying as a fisheries management method should be discontinued.

- Limits should be placed on the interference with bank vegetation to facilitate anglers.

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

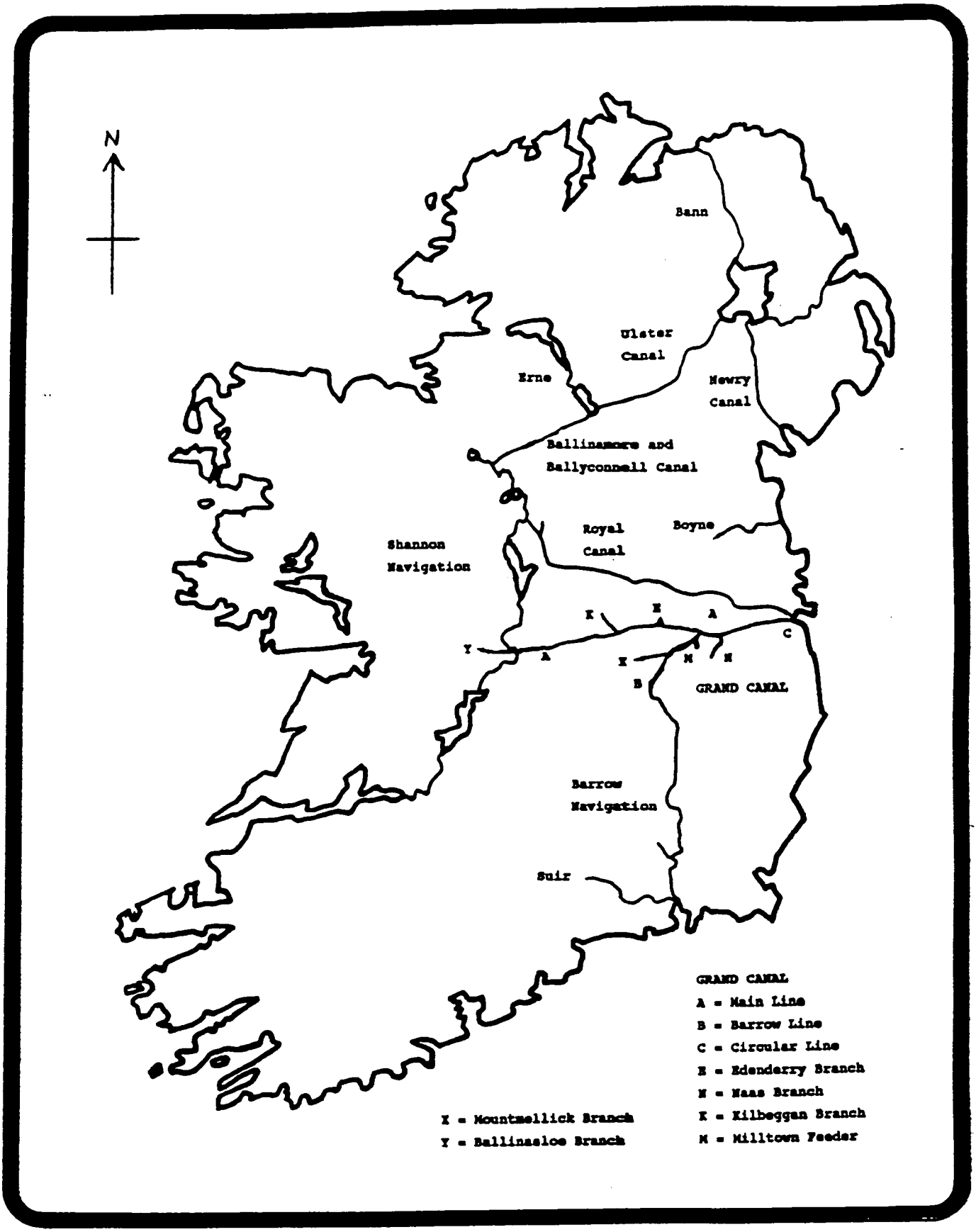


Figure 1.1 Inland Waterways of Ireland.

TABLE 1.1 Summary of the Grand Canal System

LINE	TERMINAL POINTS	YEARS OF CONSTRUCTION	LENGTH	NUMBER OF LOCKS	FEEDERS*	COMMENTS
Main	Suir Road Bridge - Lowtown	1756-83	25 miles	14 single 4 double	4	Open to navigation. James's St. Branch : closed 1974, filled in.
Barrow	Lowtown - Athy	1783-91	28.5 miles	7 single 2 double	6	Open to navigation
Shannon	Lowtown - Shannon Harbour	1789-1804	53 miles	17 single 1 double	7	Open to navigation
Circular	Ringsend - Suir Road Bridge	1790-6	3.75 miles	7 single	0	Open to navigation
Naas & Corbally	Soldier's Island - Naas	1786-9	2.5 miles	5 single	1	Closed : 1961 Re-opened : 1987
	Naas - Corbally	1808-19	5.25 miles	none	2	Closed : 1952
Edenderry	Shannon Line - Edenderry	1797-1802	1 miles	none	0	Open to navigation
Pollardstown (Milltown Feeder)	Lowtown - Pollardstown Fen	1780s	8 miles	none	-	Closed to navigation c. 1945
Blackwood Feeder	Main Line - Foranfan Reservoir	1780s	4 miles	none	-	Closed : 1952 Derelict, partly filled in.
Ballinasloe	Shannon Harbour - Ballinasloe	1824-8	14.5 miles	2 single	2	Closed : 1961 Derelict, partly filled in.
Mountmellick	Monassterevan - Mountmellick	1827-31	11.5 miles	3 single	2	Closed : 1960 Derelict, partly filled in.
Kilbeggan	Ballycommon - Kilbeggan	1830-5	8 miles	none	0	Closed : 1961

* Some of the feeders listed have been discontinued.

after : Delany, R. (1973)

interest (ASI) of ecological importance at a regional level in 1991. While this is not the only canal ASI on the Grand Canal System (Table 1.2) it does indicate that criteria other than navigation and engineering constraints are now being recognised in the development of the canal network as a whole.

1.2 ECOLOGICAL SURVEYS

From the time when canals ceased to operate as trade routes and were developed instead as recreational resources the importance of multiple-use has been stressed (Johnston, 1985; Brady, Shipman and Martin, 1987). However, it is only relatively recently that the importance of the ecological value of canals has been fully recognised. The wildlife along a canal is important in its own right, and also because it forms the backdrop for all other activities, both water-based and land-based. The Irish canals never received the level of use common on many British and Continental waterways. This fact, together with the relatively low-intensity management practised over the years, has meant that a series of interesting ecological habitats has developed along the canals. As the level of recreational use and the degree of management increase, the ecological diversity of the canal system must be actively protected and maintained by giving nature conservation equal priority with navigation and recreational requirements. The first step towards achieving this is the preparation of an ecological base-line survey, to determine the current status of the canal habitats.

In 1989 the OPW commissioned an ecological survey of part of the Royal Canal as part of their restoration plans for that canal. In 1990, the full length of the Royal Canal was surveyed. In addition a preliminary assessment was made of the recovery of the vegetation after dredging of certain sites. These sites were re-assessed in 1991. This present report is the base-line survey of the Grand Canal.

1.3 GRAND CANAL ECOLOGICAL SURVEY

Objectives

The objectives of the present survey were:

- To assess the current value of the canal corridor for nature conservation by documenting its biological resources.
- To determine what factors influence the present distribution of plant communities along the Grand Canal.

- To use these findings to draw up detailed recommendations for the management of each section of the canal taking nature conservation as one of the main priorities.

- To promote an awareness of the nature conservation value of the canal both inside and outside the OPW.

Terminology

The methods of the survey are given in detail in Part 2. However, some general terms used throughout the report are defined here. Five basic structural zones were recognised on either side across the canal corridor:

channel
bankverge - the zone between the water's edge and the towpath
towpath
boundary verge - the zone between the towpath and the boundary
boundary

1.4 STUDY AREA

Topography

The Main Line of the Grand Canal runs from east to west across the central plain of Ireland linking Dublin and the River Shannon at Shannon Harbour. The Circular Line links Lock 1 of the Main Line at Inchicore with the River Liffey at Ringsend. The Barrow Line links the River Barrow at Athy with the Main Line at the summit level at Lowtown. The altitude varies from 0 to 85m (0-279ft) above sea level at the summit level. The land surrounding the canal is predominantly flat.

Geology and Soil

The canal passes through the central plain which is formed of Lower Carboniferous limestone overlain by fluvio-glacial deposits and limestone tills (Herries-Davies and Stephens, 1978). The soils therefore tend to be base-rich, except in those areas where acidic peat has developed over the mineral soils. The soils of the canal banks are principally brown earths, grey-brown podzols and gleys, the latter being susceptible to impeded drainage (Gardiner and Radford, 1980). Complex alluvial soils occur in the river valleys. The canal passes through extensive areas of peatland, particularly in County Offaly.

Water Supply

The water quality of any freshwater system has important implications for the plant and animal communities which it supports. The main source of water for the Grand Canal is Pollardstown Fen via the Milltown Feeder. The Morrell Feeder enters the Main Line of the canal between Locks 14

and 15. The Naas Branch, which descends into the Main Line just west of Sallins, is fed by the Corbally Branch which intercepts two or three supply streams.

On the whole the water quality in the canal is good. The Molybdate Reactive Phosphorus (MRP) level exceeded 0.05 mg/l at one point - at the inflow from the Mount Prospect Feeder just south of Rathangan on the Barrow Line (CFB, 1990). West of Daingean on the Main Line, a stretch of canal with a number of small feeder streams, the MRP level was above 0.045 mg/l. Above 0.05mg/l MRP there is a serious risk of eutrophication. Nitrate/nitrite levels fluctuate over the entire length of the canal, and cannot be related to any specific parameter (CFB, 1990).

Herbicide Application

Herbicides, mainly dichlobenil (Casoron), are applied annually to most of the canal system except Lock 8 - Lowtown on the Main Line, where the aquatic vegetation is controlled mechanically. Prolonged dependence on chemical control methods leads to the development of an impoverished aquatic flora composed of herbicide-resistant species (Harbott and Rey, 1981). A survey of the Grand and Royal Canals in 1990 suggested that much of the current herbicide treatment was unnecessary, as many of the stretches treated with herbicides were in no need of weed control measures (Murphy and Eaton, 1990). A further problem associated with the spring-spraying of herbicides is the disturbance of nesting birds during the sensitive period of incubation.

Areas of Scientific Interest

A number of areas along the Grand Canal system are designated as Areas of Scientific Interest by the Wildlife Service (AFF, 1981; Wildlife Service 1989). Brief details of these ASIs are given in Table 1.2, and their locations are shown in Figures 1.2 and 1.3.

Table 1.2
Areas of Scientific Interest along the Grand Canal

COUNTY (ASI no.)	NAME GRID REF.	km SECTIONS	AREA or LENGTH	HABITAT	INTEREST	RATING
Dublin (20)	Grand Canal N 19 34 - N 97 29	5-19	14 km	Canal	Ecol (B)	Regional
Kildare (1)	Pollardstown Fen N 775 165	M12-M13	150 ha	Fen	Ecol (B/Z)	I'national
Kildare (18)	Grand Canal N 97 29 - N 65 31	20-60	40 km	Canal	Ecol (B)	Local
Kildare -	Corbally Branch N 87 19 - N 84 14	N5-N12	7.5 km	Canal	Ecol (B/Z)	Regional
Offaly (3)	Rahugh Ridge N 38 23	K8	20 ha	Esker Wood	Ecol (B)	National
Offaly (6)	Shannon River N 98 23	131		Callows	Ecol (O)	National
Offaly (30)	Grand Canal N 525 312-N 579-326	69-74	5 km	Canal	Ecol	Local
Offaly (39)	Barnaboy Bog N 43 29	85		(Raised Bog- destroyed)	(Ecol)	(National)
Westmeath (1)	Rahugh Ridge N 39 32	K8	32 ha	Esker Wood	Ecol (B) Geom	I'national

Key : Ecol = Ecological
B = Botanical
Z = Zoological
O = Ornithological
Geom = Geomorphological

CHAPTER 2 HABITATS

2.1 INTRODUCTION

Every plant species has a certain range of tolerance of soil conditions, climate, etc. For some this range is wide - these are the more common plants found growing in many different communities and habitats. Those species with a narrow tolerance range are relatively rare, growing only where all the conditions they depend on are right. A habitat is usually defined by the structure of the vegetation it supports, often qualified by a brief description of the dominant plant community involved - eg. Hazel woodland, Blackthorn scrub, acidic grassland.

Along the length of the Grand Canal a number of habitats are found, some of them widespread and others rare. The ecological value of the canal system depends on these habitats and the plant and animal communities they support. Loss of habitat would result in a decrease in the diversity of the system with a corresponding decrease in its wildlife and 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 canal.

2.2 WOODLAND

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

The underlying soil conditions will affect the woodland flora of all three layers. On limestone soils Corylus avellana (Hazel) can dominate the tree and/or shrub layer, while the ground flora will be diverse and species-rich, containing many species also found in calcareous grassland and scrub. Woodlands on acidic soils tend to have a much poorer ground flora, and a tree layer dominated by Betula (Birch), Quercus (Oak) or Pinus (Pine).

Carr (wet woodland) will develop on water-logged soils. The tree layer is dominated by Alnus glutinosa (Alder) and/or Salix spp. (Willows), while the ground flora tends to be species-rich including those marsh species that are tolerant of shade.

Along the Grand Canal the area of woodland is limited by the width of the canal corridor. In many cases the area of woodland could more accurately be described as "woodland margin", since it is not wide enough to develop a true woodland habitat. The margin between any two habitats is

more species-rich than either of the habitats involved, since it supports species belonging to both - and woodland margins are no exception.

2.3 SCRUB

Scrub is a very valuable 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. Scrub can vary greatly in both structure and species-richness, depending on the soil type and the dominant plant species. On acidic soils Ulex (Gorse) predominates, producing patches of dense and impenetrable scrub interspersed with patches of open grassland. More common along the Grand Canal is mixed scrub with Crataegus monogyna (Hawthorn), Prunus spinosa (Blackthorn), Rosa canina (Dog Rose) and Rubus fruticosus (Bramble). Scrub of this sort 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 greatly to the diversity of the canal system, and should be retained.

2.4 HEDGEROW

Some of the hedgerows along the Grand Canal date back to the building of the canal itself, and are therefore over two hundred years old. The older a hedgerow is the more species it supports, and the more valuable it is in ecological terms.

The hedgerows along the canal are dominated by Crataegus monogyna (Hawthorn) with Ligustrum vulgare (Privet), Prunus spinosa (Blackthorn) and Rosa canina (Dog Rose). Tree species including Acer pseudoplatanus (Sycamore), Fraxinus excelsior (Ash), Sambucus nigra (Elder) and Quercus sp. (Oak) are also frequent. A number of species generally restricted to the midlands due to their strong requirement for calcareous soils are relatively common in the hedgerows along the canal - Viburnum opulus (Guelder-rose) and Euonymus europaeus (Spindle).

The herb layer at the base of a hedgerow resembles that of a woodland margin, and includes a variety of shade-loving plants such as Primula vulgaris (Primrose), Ranunculus ficaria (Lesser Celandine) and Viola spp. (Violets) as well as those tolerant of higher light levels - eg. Anthriscus sylvestris (Cow Parsley) and Geranium robertianum (Herb Robert).

Hedgerows produce valuable food crops for birds and animals - nector and pollen in spring in addition to the more

obvious berries and seeds in autumn. The height of the hedgerow and the denseness of the vegetation at its base are also 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, while ground-dwelling mammals depend on the vegetation at the base of the hedgerow for cover and protection.

2.5 FEN

Fens occur where the soil is permanently waterlogged with mineral-rich, alkaline water. Most fens are created by groundwater seepage, but along the canal the fen habitats that exist at the toe of embankments could be caused by the seepage of water from the canal. Fens are usually species-rich, supporting plants with a very restricted distribution such as Epipactis palustris (Marsh Helleborine) and Parnassia palustris (Grass-of-parnassis) as well as more common wetland plants (eg. carex spp. - sedges).

2.6 BOG

There are many stretches of the Grand Canal bordered by bogs. Raised bogs occur in large depressions, usually over a fen. The fen peat, consisting mainly of wood, reeds, rushes and sedges, formed when the vegetation was under the influence of mineral-rich groundwater, usually high in calcium. As the fen peat gradually increased in thickness the living vegetation on the surface became further and further removed from the base-rich groundwater, and eventually became dependent on atmospheric precipitation for moisture. This resulted in a complete change in the flora, to plants such as Calluna vulgaris and Erica spp. (Heathers), Eriophorum spp. (Bog Cottons) and Sphagnum masses, all of which are adapted to grow in acidic conditions. The raised bog is built up of the partially-decomposed remains of these and other species. Draining a bog changes the vegetation again, and a drier flora develops, with no Sphagnum.

A bog that is currently being worked for peat by Bord na Mona will support little or no vegetation, except at the edges - in this case the boundary verge of the canal. Here remnants of the bog flora can survive undisturbed, in spite of the large scale destruction of the bog itself.

2.7 DITCHES AND DRAINS

The boundary drains along the Grand Canal 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. Older, more established drainage channels frequently support the same range of species as the canal itself, with emergent vegetation on the banks and submerged and floating plants including Potamogeton spp. (Pondweeds)

and Lemna spp. (Duckweeds) in the open water. Like the canal, an unmanaged drainage ditch will gradually silt up and become overgrown, eventually becoming part of the surrounding dryland habitat.

2.8 GRASSLAND

Grassland is a non-climax stage in vegetational succession and therefore needs management if it is to be retained.

2.8.1 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; while 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.

Grazing by any animal reduces the dominance of the grass species, allowing low-growing herbs including many different orchids - eg. Gymnadenia conopsea (Fragrant Orchid), Listera ovata (Common Twayblade) and Anacamptis pyramidalis (Pyramidal Orchid) - to grow in the sward. The base-status of the soil will also influence the flora, determining which grass and herb species are common. The soils along the Grand Canal are nutrient-poor, a fact which helps to maintain a very diverse and species-rich pasture with Primula veris (Cowslips), Sanquisorba minor (Salad Burnet) and Pimpinella saxifraga (Burnet-saxifrage) growing with the limestone grasses.

2.8.2 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 two basic ways:
a - a single, annual cut rather than continuous cropping allows taller herbs and grasses to become established;
b - the non-selectivity of cutting as compared to grazing has an effect on the species composition of the sward.

Meadows can be destroyed by early cutting (before seeding), by too frequent cutting (more than once a year), and by the application of fertilizers which give the more invasive grass species a competitive advantage over the slower-growing grasses and herbs. For recreational purposes the development of meadows along the banks, with minimum maintenance producing a colourful, herb-rich grassland, should be considered.

2.8.3 TRAMPLED GRASSLAND

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, is often bare of vegetation, with trample-resistant species such as Poa annua (Annual Meadow-grass), P. pratensis (Smooth Meadow-grass), Lolium perenne (Perennial Rye-grass) and Plantago major (Greater Plantain) dominating the vegetation on either side of the path. Where a trampled path is poorly-drained people frequently move off it onto the unchanged vegetation, creating a meandering network of paths, and possibly altering the species composition of the full area of grassland.

2.9 BARE GROUND

Opportunistic and pioneer plant species produce very light seeds that are unable to germinate in established vegetation. These species require patches of bare ground, where they form the first stage in the vegetational succession. This stage is generally very short lived - perennial plants take over from the annuals, who then require a newly-cleared patch of bare ground for their seeds to germinate on.

2.10 BANK

The bank is a transition zone between terrestrial and aquatic habitats. The range of species found along a bank depends on a number of factors, in particular the height and steepness of the bank. The banks along the Grand Canal tend to be very steep, which prevents the development of a mixed bank verge vegetation ranging from tall herbs (eg. Iris pseudacorus - Yellow Flag and Filipendula ulmaria - Meadowsweet) at the top of the bank to an emergent reed fringe at the water's edge.

Where the banks are high as well as steep they are dominated by terrestrial vegetation, in particular by creeping plants such as Calystegia sepium (Hedge Bindweed) and Rubus fruticosus (Bramble). If the bank is low the reed fringe, where there is one, can extend up the bank. In many places along the Grand Canal however, there is no transitional bank habitat - the grassland of the towpath extends to the water's edge where the aquatic habitats begin.

2.11 AQUATIC HABITATS

The long-term use of herbicides in the channel eliminates the susceptible species, producing less diverse communities dominated by a few resistant species.

2.11.1 REED FRINGE

The shallow margins of most waterways support a rich community of reeds and reed-grasses together with marsh herbs such as Mentha aquatica (Water Mint), Menyanthes trifoliata (Bog-bean) and Caltha palustris (Marsh-marigold). This in turn supports a wide diversity of invertebrate species, as well as providing shelter for birds and fish. Along the Grand Canal however the steep banks result in deep water even at the edge of the channel. This eliminates the shallow-water species, producing reed fringes that tend to be mono-specific, dominated either by Phragmites australis (Common Reed) or Glyceria maxima (Reed Sweet-grass).

2.11.2 OPEN WATER

The vegetation of the open channel of the Grand Canal is controlled not only by herbicides but also by the movement of boats. As a result it is dominated by a small number of very vigorous species which are becoming increasingly difficult to manage - eg. Potamogeton pectinatus (Fennel Pondweed) and the submerged form of Sparganium emersum (Unbranched Bur-reed).

2.12 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 moister habitats of the north face and of crevices between the stones. Others, such as Hedera helix (Ivy) are rooted in the ground and use the wall or bridge as a support to climb on.

CHAPTER 3 FLORA OF THE GRAND CANAL

3.3 INTRODUCTION

The flora of the Grand Canal (131 km) and some of its branches including the Barrow Line (46 km), Naas Branch (12 km) and Milltown Feeder (13 km) was recorded throughout 1991. Figures 1.2 and 1.3. The disused Kilbeggan Branch (13 km) was surveyed, but no detailed species lists were recorded. The canal from Ringsend to the Shannon at Shannon Harbour is referred to as the Mainline throughout this Chapter. The objectives of the study were many, and include:

(a) a base-line survey of the vascular plants which exist in the canal corridor.

(b) mapping plant associations typical of all habitats within the canal corridor, and to determine the factors which contribute to the development and maintenance of the present vegetation.

(c) to assess the importance of these habitats in the context of the canal corridor itself, and in relation to their occurrence elsewhere in the country.

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

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

(f) to devise suitable management strategies to maintain floristic and habitat diversity.

3.2 METHODOLOGY

Approximately 200 kilometres of the canal had to be surveyed during one growing season. It was decided to survey each 5th kilometre as a separate unit and in detail, and to classify the findings from the four intervening kilometres as those of one sample unit. In this way the number of sites to be recorded was reduced to 87. The Grand Canal system, as noted above, but excluding the Kilbeggan Branch, was surveyed three times. The vegetation, habitat type and features from the various zones which exist on the canal corridor - boundary, boundary verge, towpath, bank, channel and locks/bridges - were noted and recorded separately on vegetation cards and maps. 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. These field maps are contained in Part 3 of the report. Information collected in the field on the individual kilometre maps was then transferred to 6 inch maps (scale 1:10,560). These maps, together with the guidelines for management strategies, are contained in Part 2.

3.3 RESULTS

The species found along each zone are noted in Appendices 1-12, and the diversities for each zone (excluding locks and bridges) are given in Appendix 13. Sites showing high and low diversities within each zone of the mainline and branches are given in Tables 3.1-3.5 at the end of this chapter. It was also possible to determine species showing the highest and lowest percentage occurrence along each particular zone. This information is supplied in Tables 3.6-3.11 at the end of the chapter.

3.3.1 Flora of the boundary and boundary verge

3.3.1.1 Mainline

There were 51 and 49 stretches respectively out of a possible total of 55 along the Mainline Canal where a boundary and boundary verge existed. They supported 201 and 278 species respectively - many common to both (Appendices 1 and 2). The boundary verge is more species-rich because in addition to the species common to both zones it also contains many grassland species not present in the boundary.

Diversity

A study of Tables 3.1 and 3.2 shows that km sites 26-29, 41-44 and 75 support high diversities in both zones. All these stretches support woodland and grassland habitats. A bog habitat is also found in km 75. Sites showing a low diversity in the boundary are found where boundaries are not defined, as is the case where the canal passes through a bog, where much of the hedgerow has been removed (kms 30, 50 and 70) and in urban areas. The boundary verge diversities are also lowest in urban areas and where clearance has been carried out.

3.3.1.2 Branch Lines

The vegetation of 17 sites was recorded along the boundary of the Barrow Line - supporting 155 species and also along the Naas Branch, Milltown Feeder and Edenderry Branch (Appendix 7).

Diversity - Branch Lines

The highest diversity along the boundary of the Barrow Line (Table 3.1) occurs between kilometres B6 and B30. There are large tracts of diverse scrub/woodland along most of this stretch and a high calcareous mound immediately South West of Monasterevin. This mound supports a very high diversity of species many of which do not occur elsewhere along the Barrow Line. High diversity along the boundary of the Naas Branch

occurs where the bank is impassable (N6-9) and the presence of many small habitats results in a high species diversity. Similarly with km M3 and M9-12 along the Milltown Feeder.

The low diversity sites along the boundary of the Barrow Line are the 1 km sites where there is a hedgerow dominated by one tree species. Low diversity along the Naas Branch occurs again where the hedgerow is dominated by one species (N11 -12) and where the boundary is not very well defined (N5). The boundary is not defined in the Pollardstown Springs area (M13) and has a low diversity despite the interest of the area.

3.3.1.3 Flora of the boundary verge - Branch Lines

The flora of the boundary verge was recorded at 17 sites along the Barrow line (209 species) and at 5, 6 and 2 sites respectively along the Naas Branch, Milltown Feeder and Edenderry Branch (Appendix 8).

Diversity

High diversity in the boundary verge is generally confined to those sites where a variety of habitats can be found (Table 3.2). Km B6-12 along the Barrow Line supports an exceptionally rich fen, grazed grassland, embanked towpath and some scrub and in addition is very wide. Epipactis palustris, (Marsh Helleborine) a rare species was found in km B10. Westwards between B14-20 there is again a very wide boundary verge consisting of grazed limestone grassland with some scrub invasion. Antennaria dioica (Mountain Everlasting) and Platanthera bifolia (Butterfly Orchid) - both rare - were found in B16-20.

A similar pattern of a mosaic of habitats can be found at the sites of high diversity along the Naas Branch and Milltown Feeder. Spoil from previous dredgings at least 50 years ago (CIE files) - at the southern end of the Naas Branch have undergone changes and are now nutrient-poor mounds. These are species-rich and grazed by sheep.

Relatively low overall species diversities are found at sites where only one habitat type exists. This is the case along the wooded stretches of the Barrow Line. It must be said however, that species diversity for the particular habitat present is in fact quite high and therefore these areas are considered to be of nature conservation value. M13 has a low diversity but it is a very short site.

3.3.2 Flora of the towpath

3.3.2.1 Mainline

A towpath exists at 25 out of a possible 55 sites along the Mainline. It supports 114 species (Appendix 3). A grassy towpath is a feature along approximately 70 km of the Mainline.

Diversity

High diversity (Table 3.3) is confined to those sites with a wide towpath which consists of many habitats. Site 40 is impassable but supports many habitats, is also wide and therefore has a high diversity. Low diversity is found at those sites where the towpath is well worn and also where canal repairs are on-going.

3.3.2.2 Branch Lines

The flora of the towpath was recorded at 11 sites along the Barrow Line (81 species), at 5 sites at both the Naas Branch and Milltown Feeder and at 2 sites along the Edenderry Branch (Appendix 9).

Diversity

Diversity along the towpath (Table 3.3) is never very high. The highest number of species found was 42. Species growing along a towpath have to be competitive and stress tolerant. Highest diversities were found along stretches which consisted, at lease in part, of grazed grassland. Towpaths which were used by farm machinery or frequently cut yielded low diversities.

3.3.3 Flora of the bank

3.3.3.1 Mainline

A total of 260 species was found at the 55 sites (Appendix 4). The majority of species found along this zone belong to either grassland or to a transitional habitat between water and grassland.

Diversity

The greatest diversity (Table 3.4) in 1991 occurred at those sites where the soil status was nutrient-poor, where the vegetation was not cut several times a year or where the banks were not recently repaired as was the case around Pollagh (km 110-114), west of Gallen Bridge (km 121-124) and west of Belmont (km 126-129). There is a calcareous mound along much of the stretch between km 126-129. The connection between high diveristy and lack of frequent cutting may be conditional on the high base-status and low nutrient-status of the soils. The banks at other sites with high diversities - km 25 at Ardclough, east of

Ticknevin and km 60 displayed similar characteristic but are shorter sites.

Low diversities were associated with frequent cuttings and recent bank repairs. These diversities were evident around Dublin, Tullamore, Edenderry and the rural stretch between Daingean and Tullamore. It is interesting to note that the banks east and west of Trimblestown Bridge km 66-69 and 70 were clayed two years ago and still only support a very low diversity.

3.3.3.2 Branch Lines

The flora of the bank was recorded at 20 sites along the Barrow Line supporting 214 species, at 6 sites each along the Naas Branch and Milltown Feeder and at 2 along the Edenderry Branch (Appendix 10).

Diversity

Diversity along the banks (Table 3.4) of the branches is high in most instances. Shorter sites have a lower diversity but they are four times shorter than the long sites. Diversity is lowest at sites which had recently been repaired. The high diversity along the Barrow Line can be accounted for by the presence of species-rich grasslands along part of the bank.

The banks of the Naas Branch are, in contrast to those of the Barrow Line and Mainline, sloped, and lead gently to the water's edge. There are many species favouring wet conditions present along these banks which add to the diversity.

3.3.4 Flora of the channel

3.3.4.1 Mainline

A total of 53 species were found at the 55 sites along the Mainline (Appendix 5).

Diversity

There is a stretch along the Mainline which is not sprayed any year. It extends from Lock 8 - Lock 19 (km 10-46). Coincidentally, most of this stretch of channel is infrequently travelled by boat when compared to the western end of the canal. The highest diversities (Table 3.5) occur at these unsprayed and infrequently used sites. The other two sites of high diversity - km 56-59 and 65 - were also unsprayed during 1991 (Caffrey, 1991). The following list of species were only found within the unsprayed stretch east of km 65:

Berula erecta
Callitriche spp.
Ceratophyllum demersum
Equisetum fluviatile
Groenlandia densa
Hippuris vulgaris
Lemna trisulca
Menyanthes trifoliata
Nasturtium officinalis
Myosotis scorpioides
Oenanthe aquatica
O. crocata
Ranunculus circinatus
Saggitaria sagittifolia
Sparganium erectum
Zannichellia palustris
Fontinalis antipyretica

In contrast the sites with the lowest diversities are all west of Rathmore Bridge (km 65). This channel stretch receives the most boat usage. In addition bank repair is being carried out which further increases the turbidity of the water making it impossible for submerged aquatic plants to grow as their light is blocked. To compound the problems for the plants, most of the western stretches are also sprayed (Caffrey, 1991).

3.3.4.2 Branch Lines

38 species were recorded at the 20 sites along the Barrow Line. Channel flora was also recorded at 6 sites of the Naas Branch and Milltown Feeder and 2 of the Edenderry Branch (Appendix 11).

Diversity

The aquatic diversity along the Barrow Line (Table 3.5) is low whether examining the long or short sites. The entire stretch of the Barrow Line is used frequently by boaters. There is no haven for plants as there is along the eastern stretch of the Mainline. In addition, much of the Barrow Line (76%; km B3-9 and B21-46) was sprayed during 1991 (Caffrey, 1991).

The diversity along the Naas Branch is highest along the unused stretch west of Naas Harbour which is not dominated by a competitive species such as Phragmites australis (Common Reed). The lowest diversity is found where the entire canal is covered by the dominant Phragmites australis.

The diversity along the Milltown Feeder is quite good given that bank repairs had been carried out during 1990 and 1991. Diversity was lowest where bank repair was in progress (M 13). The Milltown Feeder is not sprayed.

3.3.5 **Flora of locks and bridges**

3.3.5.1 Mainline

Locks or bridges or both were found at 40 sites along the Mainline and possessed a total of 133 species (Appendix 6). It was not possible to assess the sites of high and low diversity as some sites had 2

bridges and locks and more only a lock and individual records for such structures were not made.

3.3.5.2 Branch Lines

The flora of the locks and bridges along the Barrow Line (15 sites and 75 species), Naas Branch, Milltown Feeder and Edenderry Branch was recorded (Appendix 12). The diversity at the different sites along the Barrow Line was not calculated as some sections had many more stonework structures than others, and individual records for each were not made.

3.4 DISCUSSION

BOUNDARY

The species occurring most frequently in the boundary of the Mainline are trees and shrubs with their associated herbaceous plants. A similar range of species is found along the Barrow Line. The boundary of the Barrow Line was observed to be more wooded than that of the Mainline. It supported more sites with Hazel, Beech, Sycamore, Ash, Blackthorn, Elder, Spindle, Rose and False Brome (Brachypodium sylvaticum) than did the Mainline. However, many typical woodland and woodland edge species such as Allium ursinum, Orchis mascula, Sanicula europaea and Veronica montana rare to the Mainline were not found along the Barrow Line. This can be for two reasons - the predominance of scrub reduces the light necessary for the growth of woodland edge species and secondly the seeds of typical woodland ground species may never have reached the area.

Other rare species of both the Mainline and the Barrow Line are those associated with habitats that are relatively rare - e.g. bogs, fens, permanently wet drains and stone walls. Many of these habitats in addition to being uncommon along the canal, are also small in area and may need special protection.

BOUNDARY VERGE (Table 3.7)

The boundary verge along both the Mainline and the Barrow Line tends to be either grassland or scrub. Rare species are again associated with rare habitats, often small in area. Along the Mainline grassland is the most common boundary verge habitat. Rare grassland species include Anacamptis pyramidalis (Pyramidal Orchid), Antennaria dioica (Mountain Everlasting), Blackstonia perfoliata (Yellow Wort), Brome species, Carex caryophyllea (Spring Sedge), Carlina vulgaris (Carline Thistle), Orchis mascula (Early Marsh Orchid), Epipactis palustris (Marsh Helleborine), Geranium dissectum (Cut-leaved) and

G. pyrenaicum (Hedge Crane's-Bill), Linum catharticum (Pale Flax), Listera ovata (Common Twayblade), Origanum vulgare (Marjoram), Platanthera bifolia (Butterfly Orchid), Gentianella amarella (Autumn Gentian) and Silene alba (White Campion).

Many of the grassland species of the Mainline were not found along the Barrow Line - probably due to the predominance of scrub along the Barrow Line.

TOWPATH

The species occurring most frequently along the Barrow and Mainline (Table 3.8) are the competitive grasses and those plants such as Plantago major (Greater) and P. lanceolata (Ribwort Plantain), Bellis perennis (Daisy) and Trifolium spp. (Clovers) which are stress tolerant. These species occur much more frequently along the Barrow Line indicating that the grassed towpaths of the Barrow Line - which are at the northern end - are used more frequently by walkers than those of the Grand Canal which are much more rural.

BANK

The grassland species occurring most frequently along the bank of both systems are similar to those found along the boundary verge with the addition of Creeping Bent. Common species typical of the transitional zone between wet and dry are listed in Table 3.9.

Some grassland species rare to the bank zone and occurring at up to only 10% of sites along the Mainline are similar to the list of the boundary verge with the addition of Yellow Pimpernel, Centaurium erythraea (Common Centaury) and Primula veris (Cowslip). Other rare species of the bank of the Mainline are characteristic of the wetter section of bank and are listed in Table 3.9. Many of the rare species of the bank along the Mainline are not found along the Barrow Line at all and include Anacamptis pyramidalis (Pyramidal Orchid), Antennaria dioica (Mountain Everlasting), Blackstonia perfoliata (Yellow Wort), Bromus sterilis (Sterile Brome), Centaurium erythraea (Common Centaury), Carlina vulgaris (Carline Thistle) and Sherardia arvensis (Field Madder) which require a nutrient - poor grassland. The species Carex acuta (Slender Tufted Sedge), C. echinata (Star Sedge), C. otrubae (False Fox Sedge), Epilobium parviflorum (Hoary Willowherb), Equisetum fluviatile (Water Horsetail), Juncus bulbosus (Bulbous Rush), Lycopus europaeus (Gipsywort) and Myosotis scorpioides (Marsh Forget-me-not) require a marsh habitat and are missing from the Barrow Line. The absence of grassland and marsh habitat from the Barrow Line is probably due to scrub invasion. Missing from the Mainline are Baldellia ranunculoides (Lesser Water

Plantain), Carex elata (Tufted Sedge), C. pendula (Pendulous Sedge), Hydrocotyle vulgaris (Marsh Pennywort) and Senecio aquaticus (Marsh Ragwort) again which need a marsh habitat. The Marsh habitat is very much endangered along the banks of both systems. A species-rich berm along the edge of the canal can only be found in the unsprayed, little used stretch of the eastern Mainline.

CHANNEL

The species occurring most frequently (in descending order) along the Mainline are Nuphar lutea (Yellow Water Lily), Phragmites australis (Common Reed), Glyceria maxima (Reed Sweet-Grass), Scirpus lacustris (Common Club Rush), Sparganium emersum (Unbranched Bur-Reed), Polygonum amphibium (Amphibious Bistort) and Myriophyllum sp. (Milfoil) species. According to Liddle and Scorgie (1980) (Table 4.6) five of these seven species can exist in eroding environments. It is not surprising therefore that such plants will be dominant in a well used canal. All with the exception of Myriophyllum are emergents. The stronghold of Myriophyllum sp. along the Grand Canal is in the less impacted stretch (approximately one-third of the canal), where boat propellor action does not hinder its growth.

There are very few plant species which occur frequently along the channel of the Main Line. This is because suitable conditions for the survival of most channel species exist along one third of the eastern Mainline which is unsprayed and infrequently used. This is further borne out when it is realised that the species number only exceeds 10 at 6 out of 27 sites west of Cartland Bridge (km 67) where usage and spraying regime are more concentrated.

The aquatic species occurring frequently along the Barrow Line are similar to those of the Mainline. However, their % occurrence is not as high. Two factors contribute to this: usage of the Barrow Line is not as heavy as along the Main Line allowing less erosion tolerant species to survive and therefore reduce the dominance of the tolerant species; the greater dominance of Potamogeton lucens and P. pectinatus (Shining and Fennel Pondweeds) due probably to their tolerance of lower water quality and their resistance to Casoron (CFB, 1991). Carex rostrata (Bottle Sedge) - an emergent species is present at 55% of sites along the Barrow Line but only 42% of the Mainline. Bank repair and greater amounts of traffic along the Mainline (G. Wrynn, pers. comm) account for this.

The rare plants in the channel of the Barrow Line are similar to those which are only found, for the most part in the unsprayed and rarely used stretches of the

allowing plants characteristic of a transitional zone between wet and dry to colonise. This adds to overall species and structural diversity and in turn provides a habitat for a greater range of animal species. Plant species characteristic of this transitional zone are very rare along the Grand Canal but not so rare to the Royal Canal. These species include Carex otrubae (False Fox-sedge) Equisetum variegatum (Variegated Horsetail) and E. fluviatile (Water Horsetail) Hydrocotyle vulgaris (Marsh Pennywort), Lycopus europaeus (Gypsywort), Ranunculus flammula and R. lingua (Lesser and Greater Spearwort), Sparganium erectum (Branched Bur-reed) and Typha latifolia (Bulrush). Ranunculus lingua was not found along the bank or channel of the Mainline.

Banks of the navigated Grand Canal are for the most part being eroded underneath at the water's edge. Many banks are being repaired using clay and sloping banks created. However, if the clay is not covered in topsoil which encourages vegetation to take root and so stabilize the banks and act as a buffer, the clay erodes in one summer season and undercutting takes place thus rendering the whole operation futile. Plates 17 and 27 illustrate this.

(2) The channel of the much used Grand Canal System i.e. Barrow Line and West of Robertstown along the Mainline is dominated by erosion-tolerant species as Nuphar lutea (Yellow Water-lily) Phragmites australis (Common Reed) Sparganium emersum (Unbranched Bur-reed), Scirpus lacustris (Common Club-rush) and Glyceria maxima (Reed Sweet-grass). Myriophyllum spp. (Milfoils), which occurs the most frequently along the Royal Canal - 86% (Dromey et. al., 1991) only occurs at 60% and 40% respectively along the Mainline and Barrow Line. It is not tolerant of boating (Liddle and Scorgie, 1980) whereas both Scirpus lacustris and Sparganium emersum are. Of further interest is the fact that Sparganium emersum occurred at only 50% of the sites along the watered stretch of the Royal Canal. Its spread is contingent on reduced amounts of Milfoil. This will occur when boating levels increase. Potamogeton pectinatus (Fennel Pondweed) and P. lucens (Shining Pondweed) were not found along the Royal Canal probably due to better water quality.

(3) The plant Sagittaria sagittifolia (Arrowhead) was not found to occur along the Royal Canal during 1989-90 (Dromey et al., 1991) yet it occurs along approximately 50-60 kms of the Mainline or 18 sites, much of the Naas Branch and at one site along the Milltown Feeder and Barrow

Line (Appendices 5 and 11). Only one of these sites - that along the Barrow - was sprayed during 1991 (Caffrey, 1991) indicating that S. sagittifolia does not occur in sprayed stretches and is therefore most sensitive to herbicide. In England (CFB 1991) a similar situation exists but Caffrey (CFB 1991) finds this plant to be only moderately susceptible to herbicide in Ireland. This plant was found in 1974 along the Royal Canal east of Maynooth (J. Ryan, Wildlife Service, pers. comm.) but was not found once spraying of the Royal Canal by CIE in 1976 had commenced. The effects of herbicide on this plant needs further study.

(4) There are some species once found along the channel of canals (Doogue, pers comm.) which were not found along either canal by the authors. Such species include Bidens cernua (Nodding Bur-marigold) and Butomus umbellatus (Flowering Rush). The wet muddy conditions required by the former no longer exist along the canals while the decline of the latter is probably due to disturbance and herbicides.

(5) There are many rare species along both canals - see Tables 3.5 and 3.9 and 3.12 in Dromey et al. (1991) and Tables 3.6-3.11 in this volume. Many of these have been considered for protected status (B.S.B.I. Conference 1991) and include Epipactis palustris (Marsh Helleborine) B10 and km 85, Sagittaria sagittifolia (Arrowhead), along the Grand Canal Hydrocharis morsus-ranae (Frogbit) along the Royal Canal west of Longford Bridge, Equisetum variegatum (Variegated Horsetail) and the grasses such as Bromus sterilis (Barren Brome) and B. erectus (Upright Brome) of nutrient-poor soils along both canals. Species such as Groenlandia densa found along both canals, and Orchis morio on the banks of the Royal Canal have already attained protected status.

3.6 AREAS OF HIGH ECOLOGICAL INTEREST

Areas along the canals which have not been over-managed and which support a particularly high diversity of plant species, habitat, invertebrate and bird species are as follows.

(1) The stretch along both banks from Lucan Bridge to Hazelhatch.

A wide boundary verge of nutrient-poor poor intermittantly grazed pasture supporting many orchids and rare limestone flora now exists on what was once a quarry. There are many large ponds present on both banks with a high aquatic

plant diversity. Westwards, the boundary verge narrows and a diverse hedgerow shelters the towpath but as yet does not encroach upon it. A path has been trodden through the long grass by pedestrians. There is a very diverse woodland along part of the south bank with many bird species present. There is a species-rich fen at the toe of the embankment just east of Hazelhatch.

(2) Lock 18 - Bonynge Bridge km 39-42

Here the canal cuts through a part of the Galtrim moraine (the Hills of Downings) (Van Dam and Eysten, 1987) which is very similar to an esker ridge along both banks. There is a disused quarry just west of Cock Bridge. The towpath is impassable and extremely species-rich. Canal bank repairs may not be necessary along this stretch. Instead the trees and scrub can be manually removed and the stumps spot-treated. Light grazing by sheep on the slopes will ensure that scrub will not re-invade.

(3) Lock 20 - Blundell Aqueduct along both banks. (Plates 14-16).

The breach occurred along this stretch where the banks are embanked. There are diverse bog and nutrient-poor limestone grassland habitats existing side by side in the boundary verge. The bank supports a diverse flora and there is also a healthy reed fringe present. There is a Birch woodland along part of this stretch on the southern bank. Although much work was carried out in the vicinity of the aqueduct the habitats nearer Lock 20 do not appear damaged.

(4) Toberdaly to Killeen Bridge (Plate 23)

The towpath on the north bank consists of a diverse nutrient-poor grassland bordered by Alder woodland and a diverse bank. Further west the woodland thins out and is replaced by bog - another species-rich habitat. Along this stretch species of acidic and alkaline conditions exist side by side. There is a Bord na Mona lifting bridge crossing over the canal but otherwise little interference along this stretch. The grass does not grow too high along the towpath as there is not sufficient nutrients.

(5) km 83 and 85 West of Daingean.

There are two very small stretches which support a very high diversity of rare species characteristic of nutrient-poor conditions in the boundary verge by the road. Neither area is any

larger than 7 square metres. The areas are highlighted in the field maps (Part 3) of this report.

In km 83 there is a small depression at the side of the road supporting such species as Epipactis palustris, Carex pulicaris, Molinea caerulea, Gymnadenia conopsea and many more. Epipactis palustris is protected in the North of Ireland and occurs locally in the centre. (Webb, 1977).

In km 85 there is an esker-like ridge of gravel in which has been damaged. On the fallen gravel, species such as Antennaria dioica (Mountain Everlasting), Carex pulicaris (Flea sedge), Carlina vulgaris (Carline Thistle), Gymnadenia conopsea (Fragrant Orchid) and Epipactis palustris (Marsh Helleborine) are growing. It is a tiny habitat which needs protection.

(6) km 101-103 west of Ballycowan.

Here there is a species rich hedgerow including Oak, Hazel, Beech, Spindle, Holly indicating it is quite an old hedge. There is also the locally frequent Origanum vulgare (Marjoram) present along this stretch with a diverse bank also.

(7) West of Pollagh km 111-113

Here the bank, towpath and boundary verge are very diverse. The canal passes through raised bog along this stretch. Lime and acid-loving plants exist side by side. Antennaria dioica (Mountain Everlasting), nationally rare, is found on the bank in km 113/114. The occurrence of the river Brosna parallel to the canal and just one small field away from it adds to the habitat diversity of the area.

(8) Judge's Bridge to Belmont km 124 and 125.

There is an old quarry and esker ridge on the south bank which now supports an esker woodland. The boundary verge and bank verge is a species rich grassland with many Orchids and lime-loving species present. Part of the towpath is grazed. Growth of tall grasses is not a problem on this nutrient-poor terrain.

(9) Beginning of Barrow Line and Milltown Feeder.

Here there is an exceptionally rich meadow grassland (Plates 34 and 35) across the towpath boundary and bank verge. The vegetation was not cut early during the growing season of 1991 thus

ensuring a viable seed bank for next years hay meadow. There is a well worn path through the long grass. The adjoining fields between the Barrow Line and Milltown Feeder also support rich hay meadow.

(10) Fen at Rathangan (Plate 36) B10/11.

The canal at this stage is embanked with a wide expanse of fen along both banks. There is a very high diversity of rare wetland species along both banks including many rushes, sedges and orchids. Epipactis palustris (Marsh Helleborine), locally frequent in the centre of Ireland but rare elsewhere (Webb, 1977), was found in the southern fen.

(11) Wilsons to Macartney Bridge B16-B21.

There are large stretches of lightly grazed nutrient-poor grassland along this stretch. These areas are highlighted in Parts 2 and 3 of this report. Such nationally rare species as Antennaria dioica (Mountain Everlasting) and Platanthera bifolia (Butterfly Orchid) were found growing on the low hillocks as well as many other lime-loving species.

(12) B25-B41 - The highly diverse scrub hedgerow along banks and boundaries west of Clogheen Bridge on the Barrow Line.

This habitat is not found in such good condition elsewhere along the Grand Canal System. The combination of trees/saplings present along a small stretch is rarely found elsewhere. Such tree species as Yew, Buckthorn, Spindle and Guelder Rose have lost many of their strongholds in the countryside but seem to be flourishing along the linear wilderness they have helped create. Many invertebrates and birds were present throughout 1991. This habitat provides a refuge and cover for falcons and owls.

(13) West of Naas Harbour.

This stretch is not open to navigation and stretches of the towpath have become impassable. The path has been kept open where livestock has been grazing. The grazing is intensive only just west of Connaught Bridge. Along the other stretches the boundary verge and towpath have remained intact without disturbance - except grazing for almost 50 years (CIE files). The soil consists of leached spoil heaps and is now nutrient-poor and species-rich. The grazing regime prevents scrub encroachment.

(14) Milltown Feeder west of Pluckerstown Bridge.

A leached esker ridge along the west bank between Pluckerstown and Milltown Bridges supports a high diversity of species characteristic of nutrient-poor soils. There is also a colourful and diverse reed fringe south of Milltown Cross Bridge. South of this stage is Pollardstown Fen - an ASI of International Importance because of its Biological, Geologicaal and Ornithological interest. The springs of this fen supply Milltown Feeder in turn supplying the Grand Canal.

(15) Kilbeggan Branch - see end of Part 2 of this report where there is a description of a walk along the Branch.

3.7 CONCLUSIONS

As noted by Brady Shipman and Martin (1987) "in the years since their construction a series of natural habitats has developed along the canals. They have changed the character of the canal from an artificial manmade channel to a natural ecosystem". This was certainly the case in 1990 along the western stretch of the Royal Canal with its many habitats, (Dromey et al., 1991), and is still the case along the southern end of the Naas Branch and parts of the Barrow Line and all the Kilbeggan Branch (Plates 42, 46 and 48 of the Naas Branch, Plates 34, 36, 38 and 39 along the Barrow Line and Plates 50-55 along the Kilbeggan Branch). However other stretches of the Barrow Line (Plates 34, 40 and 56-60) and much of the Mainline (Plates 13, 21, 22 25 and 31) have been intensively managed in the recent past with the result that a uniform habitat of species-poor grassland often stretches across bank, towpath and boundary. Other habitats are bulldozed out of existence or have their seed bank reduced by continuous cutting. Should this trend continue, Ireland will have lost a feature of considerable nature conservation value, both as a refuge and as a network of migratory routes for wildlife linking different parts of the country. It ought to be possible and is possible to reach a compromise solution where nature and wildlife, boaters, fishermen and walkers can use the facilities a canal has to offer without any one amenity aspect being over-developed to the detriment of any other aspects. Management options suiting this ideal are outlined in Chapter 5 and in Part 2 of this report.

TABLE 3.1
Sites showing high and low diversity in the boundary zone of (a) short 1 km sites and (b) 4 km long sites along the Grand Canal and its Branches.

Site	Mainline a	Mainline b	Site	Barrow L. a	Barrow L. b	Site	Naas Br. a	Naas Br. b	Site	Milltown F a	Milltown F b
HIGH DIVERSITY											
26- 29	-	46	B11-14	-	50	N6-9	-	52	M9-12	-	65
41- 44	-	46	B16-19	-	48						
31- 34	-	43									
86- 89	-	36									
101-104	-	36									
55	46	-	B15	44	-	N1	29	-	M3	57	-
80	37	-	B25	40	-						
75	34	-									
15	33	-									
85	25	-									
LOW DIVERSITY											
2- 4	-	2	B41-44	-	23	N11-12	-	17	M4-7	-	62
111-114	-	11	B26-29	-	33						
116-119	-	14									
11- 14	-	16									
56- 59	-	18									
120	8	-	B1	11	-	N5	12	-	M13	20	-
70	8	-	B10	11	-						
60	12	-									
30	13	-									
50	13	-									
# of sites	25	24		9	8		3	2		2	3

TABLE 3.2
Sites showing high and low diversity in the boundary verge zone of (a) short 1 km sites and (b) 4 km long sites along the Grand Canal and its Branches.

Site	Mainline a	Mainline b	Site	Barrow L. a	Barrow L. b	Site	Naas Br. a	Naas Br. b	Site	Milltown F a	Milltown F b
HIGH DIVERSITY											
16- 14	-	94	B6-9	-	106	N6-9	-	72	M1-2	-	56
26- 29	-	87	B11-14	-	89						
61- 64	-	84	B16-19	-	78						
41- 44	-	80									
85	96	-	B15	71	-	N10	48	-	M3	37	-
20	82	-	B20	71	-						
130	79	-	B10	67	-						
75	73	-									
LOW DIVERSITY											
2- 4	-	22	B41-44	-	27				M9-12	-	31
96- 99	-	36	B31-34	-	51						
6- 9	-	40	B26-29	-	58						
66- 69	-	40									
1	14	-	B46	32	-	N5	28	-	M13	12	-
5	26	-	B1	35	-						
50	28	-	B45	35	-						
105	28	-									
# of sites	26	25		9	8		3	2		3	3

TABLE 3.3
Sites showing high and low diversity on the towpath of (a) short 1 km sites and (b) 4 km long sites along the Grand Canal and its Branches.

Site	Mainline a	Mainline b	Site	Barrow L. a	Barrow L. b	Site	Naas Br. a	Naas Br. b	Site	Milltown F a	Milltown F b
HIGH DIVERSITY											
31- 34	-	45	B21-24	-	42	N 6-9	-	39	M 1-2	-	27
121-124	-	36	B11-14	-	40						
126-129	-	36									
75	38	-	B15	37	-	N 5	27	-	M 8	22	-
65	34	-	B25	32	-						
40	32	-									
LOW DIVERSITY											
61- 64	-	1	B41-44	-	9				M 4-7	-	17
46- 49	-	2									
101-104	-	20									
45	6	-				N 1	6	-	M13	7	-
20	7	-									
70	14	-									
# of sites	12	13		5	6		3	2		2	3

TABLE 3.4
Sites showing high and low diversity in the bank verge zone of (a) short 1 km sites and (b) 4 km long sites along the Grand Canal and its Branches.

Site	Mainline a	Mainline b	Site	Barrow L. a	Barrow L. b	Site	Naas Br. a	Naas Br. b	Site	Milltown F a	Milltown F b
HIGH DIVERSITY											
126-129	-	93	B26-29	-	103	N6-9	-	85	M1-2	-	66
111-114	-	91	B 2-4	-	101						
56- 59	-	86	B31-34	-	97						
121-124	-	85									
25	72	-	B30	81	-	N10	62	-	M3	57	-
55	71	-	B40	73	-						
60	65	-	B 5	64	-						
110	65	-									
LOW DIVERSITY											
66- 69	-	57	B16-19	-	74	N11-12	-	58	M4-7	-	62
86- 89	-	61	B11-14	-	78						
96- 99	-	62	B21-24	-	79						
91- 94	-	62									
H	16	-	B10	46	-	N5	56	-	M13	20	-
1	26	-	B46	47	-						
70	34	-	B45	49	-						
50	37	-									
# of sites	28	27		11	9		3	3		3	3

TABLE 3.5

Sites showing high and low diversity in the channel of (a) short 1 km sites and (b) 4 km long sites along the Grand Canal and its Branches.

Site	Mainline a	Mainline b	Site	Barrow L. a	Barrow L. b	Site	Naas Br. a	Naas Br. b	Site	Milltown F a	Milltown F b
HIGH DIVERSITY											
6- 9	-	32	B 2-4	-	22	N 6-9	-	38	M 9-12	-	28
31- 34	-	31	B21-24	-	16						
41- 44	-	29	B36-39	-	15						
56- 59	-	25									
26- 29	-	21									
30	24	-	B40	12	-	N 5	22	-	M 8	20	-
65	23	-	B35	11	-						
10	22	-	B 1	11	-						
15	21	-									
20	20	-									
LOW DIVERSITY											
91- 94	-	3	B31-34	-	8	N11-12	-	5			
86- 89	-	5	B26-29	-	9						
96- 99	-	5	B 6-9	-	10						
66- 69	-	6									
71- 79	-	7									
70	3	-	B20	3	-				M13	7	-
75	4	-	B10	4	-						
90	4	-	B30	6	-						
80	5	-									
125	5	-									
# of sites	28	27		11	9		3	3		3	3

TABLE 3.6

Species showing the highest and lowest occurrence (%) in the boundary zone of the Grand Canal - Mainline and Barrow Line.

LOW OCCURRENCE	Mainline		Barrow	
Species	#	%	#	%
Aegopodium podagraria	2	4	NF	NF
Ajuga reptans	1	2	NF	NF
Alisma plantago-aquatica	2	4	2	12
Alliaria petiolata	2	4	NF	NF
Allium ursinum	3	6	NF	NF
Andromeda polifolia	1	2	NF	NF
Apium nodiflorum	5	10	2	12
Arum maculatum	9	18	3	18
Asplenium ruta-muraria	1	2	1	6
A. trichomanes	NF	NF	1	6
Berula erecta	NF	NF	3	18
Blackstonia perfoliata	NF	NF	1	6
Bromus erectus	2	4	3	18
B. ramosus	2	4	1	6
Callitriche spp.	3	6	2	12
Calluna vulgaris	2	4	NF	NF
Carex demissa	NF	NF	1	6
C. elata	1	2	2	12
C. lepidocarpa	NF	NF	2	12
C. pulicaris	1	2	1	6
Catabrosa aquatica	NF	NF	2	12
Centaurium erythraea	NF	NF	1	6
Ceterach officinarum	NF	NF	1	6
Charaphytes	2	4	1	6
Circaea lutetiana	2	4	NF	NF
Clematis vitalba	3	6	2	12
Cymbalaria muralis	NF	NF	1	6
Eleocharis palustris	1	2	NF	NF
Erica cinerea	1	2	NF	NF
E. tetralix	1	2	NF	NF
Eriophorum angustifolium	1	2	3	18
Fragraria vesca	5	10	4	23
Geum urbanum	6	12	NR	NR
Hippuris vulgaris	NF	NF	1	6
Hydrocotyle vulgaris	1	2	1	6
Juncus bufonius	1	2	NF	NF
Lapsana communis	NF	NF	1	6
Larix sp.	1	2	1	6
Lemna minor	4	8	1	6
L. trisulca	1	2	NF	NF
Menyanthes trifoliata	2	4	3	18
Molinia caerulea	1	2	NF	NF
Myosotis scorpioides	1	2	NF	NF
Myrica gale	NF	NF	1	6
Narthecium ossifragum	1	2	NF	NF
Orchis mascula	1	2	NF	NF
Parnassia palustris	NF	NF	1	6
Pedicularis palustris	NF	NF	1	6
Phalaris arundinacea	2	4	1	6
Phragmites australis	1	2	4	23

HIGH OCCURRRENCE	Mainline		Barrow	
Species	#	%	#	%
Acer pseudoplatanus	NC	NC	13	76
Brachypodium sylvaticum	NC	NC	9	54
Corylus avellana	NC	NC	10	60
Crataegus monogyna	48	98	14	84
Fagus sylvatica	NC	NC	12	71
Fraxinus excelsior	36	73	14	82
Galium aparine	37	75	12	71
Geranium robertianum	26	53	10	60
Hedera helix	40	80	15	88
Ligustrum vulgare	33	67	11	66
Prunus spinosa	26	53	11	66
Rosa spp.	32	65	10	60
Rubus fruticosus	41	84	12	71
Sambucus nigra	37	75	13	76
Ulmus agg.	23	47	NC	NC
Urtica dioica	NC	NC	9	54
Number of sites	49		17	

TABLE 3.6 (contd.)

Phyllitis scolopendrium	NR	NR	3	18
Pinus sylvestris	5	10	2	12
Polygonum amphibium	2	4	2	12
Polypodium vulgare	1	2	1	6
Potamogeton coloratus	1	2	NF	NF
P. crispus	1	2	NF	NF
Potentilla sterilis	1	2	NF	NF
Primula veris	3	6	1	6
Ranunculus flammula	2	4	3	18
R. lingua	NF	NF	1	6
Rhamnus catharticus	1	2	NF	NF
Ribes uva-crispa	1	2	NF	NF
Rubus idaeus	1	2	NF	NF
Salix repens	3	6	NF	NF
Sanicula europaea	1	2	NF	NF
Schoenus nigricans	NF	NF	1	6
Scirpus caespitosus	1	2	NF	NF
Scrophularia nodosa	NF	NF	1	6
Sorbus aucuparia	3	6	1	6
S. hibernica	2	4	NF	NF
Stachys sylvatica	NF	NF	1	6
Symphytum officinale	1	2	NF	NF
Taxus baccata	1	2	NF	NF
Torilis japonica	3	6	2	12
Triglochin palustris	1	2	NF	NF
Typha latifolia	2	4	NF	NF
Veronica anagallis-aquatica	NF	NF	1	6
V. beccabunga	NF	NF	1	6
V. catenata	1	2	NF	NF
V. montana	2	4	NF	NF
Viola spp.	7	14	3	18
Number of sites	49		17	

KEY: NF = not found
NR = not rare
NC = not common

TABLE 3.7

Species showing the highest and lowest occurrence (%) in the boundary verge zone of the Grand Canal - Mainline and Barrow Line.

LOW OCCURRENCE Species	Mainline #	Mainline %	Barrow #	Barrow %
Anacamptis pyramidalis	7	14	NF	NF
Andromeda polifolia	1	2	NF	NF
Antennaria dioica	1	2	1	6
Aquilegia vulgaris	2	4	NF	NF
Artemisia vulgaris	1	2	1	6
Blackstonia perfoliata	2	4	3	18
Bromus erectus	4	8	2	12
B. hordeaceus	1	2	1	6
B. ramosus	1	2	NF	NF
Carex caryophyllea	4	8	3	18
C. demissa	1	2	1	6
C. echinata	1	2	NF	NF
C. elata	1	2	NF	NF
C. lepidocarpa	3	6	NF	NF
Carlina vulgaris	3	6	NF	NF
Coronopus didymus	1	2	NF	NF
Cytisus scoparius	1	2	NF	NF
Dactylorhiza incarnata	NF	NF	1	6
D. maculata	5	10	NF	NF
Danthonia decumbens	1	2	1	6
Deschampsia caespitosa	NR	NR	1	6
Drosera rotundifolia	1	2	NF	NF
Empetrum nigrum	1	2	NF	NF
Epipactis palustris	2	4	1	6
Epilobium parviflorum	2	4	2	12
Equisetum telmateia	NF	NF	1	6
E. variegatum	2	4	NF	NF
Erica cinerea	4	8	2	12
E. tetralix	3	6	1	6
Eriophorum angustifolium	4	8	NF	NF
Euphorbia peplus	2	4	NF	NF
Fumaria officinalis	3	6	NF	NF
Galium uliginosum	NF	NF	2	12
Gentianella amarella	NF	NF	1	6
Geranium dissectum	NF	NF	1	6
G. pyrenaicum	1	2	1	6
Hieracium pilosella	5	10	1	6
Hordeum murinum	2	4	NF	NF
Hyacinthoides non-scriptus	1	2	NF	NF
Hypericum maculatum	NR	NR	2	12
H. perforatum	2	4	NF	NF
H. pulchrum	NR	NR	1	6
Lamium album	1	2	1	6
Lapsana communis	1	2	NF	NF
Linum bienne	1	2	NF	NF
Listera ovata	6	12	NF	NF
Lithospermum officinale	1	2	NF	NF
Myrica gale	4	8	3	18
Narthecium ossifragum	4	8	NF	NF
Orchis mascula	1	2	1	6

HIGH OCCURRENCE Species	Mainline #	Mainline %	Barrow #	Barrow %
Achillea millefolium	36	71	14	82
Arrhenatherum elatius	43	84	17	100
Briza media	27	54	10	60
Centauria nigra	37	72	13	76
Cirsium arvense	37	72	13	76
Dactylis glomerata	44	86	16	94
Festuca rubra	49	96	16	94
Holcus lanatus	42	82	16	94
Lathyrus pratensis	36	71	NC	NC
Lolium perenne	NC	NC	NC	NC
Rubus fruticosus	41	80	13	76
Trifolium pratensis	NC	NC	16	94
Urtica dioica	32	63	13	76
Vicia cracca	NC	NC	NC	NC
Number of sites	51		17	

TABLE 3.7 (contd.)

Origanum vulgare	2	4	NR	NR
Parnassia palustris	1	2	3	18
Pedicularis palustris	3	6	1	6
P. sylvatica	2	4	NF	NF
Pinguicula vulgaris	NF	NF	1	6
Platanthera bifolia	NF	NF	1	6
Polygala vulgaris	2	4	NF	NF
Potentilla palustris	1	2	NF	NF
Primula vulgaris	3	6	NF	NF
Reseda luteola	3	6	2	12
Rhynchospora alba	1	2	NF	NF
Sanguisorba minor	3	6	1	6
Saponaria officinalis	1	2	1	6
Schoenus nigricans	NF	NF	3	18
Scirpus caespitosus	3	6	NF	NF
Scrophularia nodosa	2	4	NF	NF
Senecio erucifolius	3	6	NF	NF
Sherardia arvensis	1	2	NF	NF
Silene alba	NF	NF	2	12
S. vulgaris	2	4	1	6
Tragopogon pratensis	2	4	NF	NF
Trisetum flavescens	4	8	NF	NF
Veronica hederifolia	2	4	NF	NF
V. serpyllifolia	4	8	NF	NF
Number of sites	51		17	

KEY: NF = not found
NR = not rare
NC = not common

TABLE 3.8
Species showing the highest occurrence (%) on the towpath of the Grand Canal - Mainline and Barrow Line.

HIGH OCCURRENCE	Mainline		Barrow	
Species	#	%	#	%
Anthoxanthum odoratum	13	52	8	73
Arrhenatherum elatius	15	60	9	82
Bellis perennis	18	72	10	91
Carex flacca	NC	NC	8	73
C. hirta	NC	NC	9	82
Cynosurus cristatus	13	52	10	91
Dactylis glomerata	19	76	8	73
Euphrasia spp.	10	40	9	82
Festuca rubra	21	84	10	91
Holcus lanatus	18	72	9	82
Plantago lanceolata	14	56	11	100
P. major	16	64	9	82
Poa pratensis	19	76	9	82
Prunella vulgaris	11	44	8	73
Ranunculus bulbosus	NC	NC	10	91
Trifolium pratense	17	68	9	82
T. repens	15	60	7	63
Number of sites	25		11	

TABLE 3.9

Species showing the highest and lowest occurrence (%) on the bank verge along the Grand Canal - Mainline and Barrow Line.

LOW OCCURRENCE	Mainline		Barrow	
Species	#	%	#	%
Anacamptis pyramidalis	2	4	NF	NF
Antennaria dioica	2	4	NF	NF
Anthemis cotula	1	2	NF	NF
Baldellia ranunculoides	NF	NF	1	5
Blackstonia perfoliata	1	2	NF	NF
Bromus sterilis	1	2	NF	NF
Carex acuta	3	5	NF	NF
C. caryophyllea	3	5	3	15
C. echinata	1	2	NF	NF
C. elata	NF	NF	1	5
C. lepidocarpa	1	2	2	10
C. otrubae	1	2	NF	NF
C. paniculata	2	4	NR	NR
C. pendula	NF	NF	1	5
Carlina vulgaris	1	2	NF	NF
Centaurium erythraea	1	2	NF	NF
Cladium mariscus	1	2	2	10
Dactylorhiza incarnata	NF	NF	1	5
D. maculata	1	2	NF	NF
Epilobium parviflorum	2	4	NF	NF
Equisetum fluviatile	NR	NR	NF	NF
E. telmateia	NF	NF	1	5
E. variegatum	NR	NR	4	20
Hydrocotyle vulgaris	NF	NF	2	10
Juncus bulbosus	1	2	NF	NF
Knautia arvensis	3	5	NR	NR
Lamium album	1	2	NF	NF
Listera ovata	NR	NR	2	10
Lycopus europaeus	6	11	NF	NF
Lysimachia nemorum	1	2	NF	NF
Lythrum salicaria	NR	NR	4	20
Myosotis scorpioides	3	5	NF	NF
Nasturtium officinale	1	2	1	5
Ononis repens	1	2	1	5
Orchis mascula	NF	NF	1	5
Parnassia palustris	1	2	1	5
Primula vulgaris	3	5	NF	NF
Pulicaria dysenterica	5	9	NR	NR
Ranunculus flammula	1	2	4	20
R. lingua	NF	NF	1	5
Scrophularia nodosa	1	2	1	5
Senecio aquaticus	NF	NF	1	5
S. erucifolius	2	4	NF	NF
Sherardia arvensis	1	2	NF	NF
Sparganium erectum	4	7	1	5
Triglochin palustris	2	4	2	10
Tripleurospermum maritimum	1	2	NF	NF
Typha latifolia	2	4	1	5
Veronica anagallis-aquatica	NF	NF	NF	NF
V. beccabunga	NF	NF	NF	NF
Number of sites	55		20	

HIGH OCCURRENCE	Mainline		Barrow	
Species	#	%	#	%
Achillea millefolium	45	82	17	85
Agrostis stolonifera	42	76	NC	NC
Angelica sylvestris	48	87	16	80
Anthoxanthum odoratum	41	74	14	70
Arrhenatherum elatius	53	96	20	100
Briza media	NC	NC	14	70
Calystegia sepium	NC	NC	17	85
Carex flacca	39	71	13	65
Centauria nigra	NC	NC	17	85
Crataegus monogyna	39	71	NC	NC
Dactylis glomerata	48	87	18	90
Dactylorhiza fuchsii	NC	NC	15	75
Equisetum arvense	49	89	17	85
Festuca rubra	55	100	19	95
Filipendula ulmaria	52	94	20	100
Fraxinus excelsior	47	85	17	85
Galium palustre	NC	NC	13	65
G. verum	48	87	18	90
Holcus lanatus	46	84	20	100
Iris pseudacorus	44	80	18	90
Juncus inflexus	47	85	20	100
Lathyrus pratensis	NC	NC	17	85
Lotus corniculatus	45	82	19	95
Mentha aquatica	NC	NC	14	70
Phleum pratense	NC	NC	14	70
Plantago lanceolata	48	87	19	95
Poa pratensis	44	80	19	95
Polygonum amhibium	44	80	15	75
Potentilla anserina	46	84	NC	NC
Ranunculus acris	39	74	18	90
R. bulbosus	NC	NC	18	90
R. repens	47	85	17	85
Salix spp.	NC	NC	17	85
Trifolium pratensis	52	94	20	100
T. repens	45	82	NC	NC
Valeriana officinalis	46	84	18	90
Vicia cracca	42	76	19	95
Number of sites	55		20	

KEY: NF = not found
NR = not rare
NC = not common

TABLE 3.10

Species showing high and low occurrence (%) in the channel of the Grand Canal - Mainline & Barrow Line

LOW OCCURRENCE Species	Mainline #	Mainline %	Barrow #	Barrow %
Agrostis stolonifera	1	2	1	5
Alisma plantago-aquatica	NR	NR	2	10
Baldellia ranunculoides	NF	NF	1	5
Berula erecta	6	11	NF	NF
Callitriche spp.	NR	NR	NF	NF
Ceratophyllum demersum	7	13	NF	NF
Cladium mariscus	1	2	1	5
Elodea canadensis	NR	NR	3	15
Equisetum fluviatile	5	9	NF	NF
Galium palustre	5	9	NR	NR
Groenlandia densa *	5	9	NF	NF
Hippuris vulgaris	NR	NR	1	5
Lemna minor	5	9	1	5
L. trisulca	NR	NR	NF	NF
Mentha aquatica	NR	NR	3	15
Myosotis scorpioides	2	4	NF	NF
Nasturtium officinale	NR	NR	1	5
Oenanthe crocata	4	7	NF	NF
Potamogeton crispus	5	9	2	10
P. natans	4	7	4	20
P. perfoliatus	2	4	NF	NF
Ranunculus circinatus	NR	NR	2	10
R. flammula	NF	NF	1	5
R. lingua	NF	NF	2	10
Sagittaria sagittifolia	NR	NR	1	5
Sparganium erectum	NR	NR	2	10
Zannichellia palustris	NR	NR	2	10
Number of sites	55		20	

HIGH OCCURRENCE Species	Mainline #	Mainline %	Barrow #	Barrow %
Carex rostrata	23	42	11	55
Glyceria maxima	47	83	15	75
Myriophyllum spp.	35	64	8	40
Nuphar lutea	51	93	17	85
Phragmites australis	49	89	16	80
Polygonum amphibium	37	67	14	70
Potamogeton lucens	21	38	10	50
P. pectinatus	19	34	8	40
Scirpus lacustris	48	87	17	85
Sparganium emersum	39	71	11	55
Number of sites	55		20	

KEY: NF = not found
NR = not rare
NC = not common
* = protected plant

TABLE 3.11

Species showing the highest and lowest occurrence (%) on the locks and bridges of the Grand Canal - Mainline and Barrow Line.

LOW OCCURRENCE Species	Mainline #	Mainline %	Barrow #	Barrow %
Anacamptis pyramidalis	2	5	NF	NF
Aphanes arvensis	NF	NF	1	7
Arabis hirsuta	NF	NF	1	7
Briza media	5	12	1	7
Clematis vitalba	NF	NF	1	7
Ceterach officinarum	4	10	2	13
Cymbalaria muralis	6	15	2	13
Desmazeria rigida	1	2	1	7
Erophila verna	1	2	1	7
Festuca pratensis	1	2	1	7
Geranium lucidum	1	2	NF	NF
G. molle	1	2	1	7
G. pyrenaicum	NF	NF	1	7
G. robertianum	2	5	NF	NF
Hieracium pilosella	3	7	1	7
Hordeum murinum	1	2	1	7
Linum catharticum	2	5	1	7
Origanum vulgare	1	2	1	7
Parietaria judaica	2	5	1	7
Polypodium vulgare	5	12	1	7
Sagina apetala	NF	NF	1	7
S. procumbens	1	2	NF	NF
Sedum acre	1	2	NF	NF
S. anglicum	1	2	NF	NF
Tripleurospermun maritimum	1	2	NF	NF
Valerianella locusta	1	2	NF	NF
Verbena officinalis	NF	NF	1	7
Number of sites	40		15	

HIGH OCCURRENCE Species	Mainline #	Mainline %	Barrow #	Barrow %
Angelica sylvestris	21	52	6	40
Asplenium ruta-muraria	26	65	7	47
A. trichomanes	17	42	6	40
Filipendula ulmaria	18	45	5	33
Festuca rubra	26	65	8	53
Hedera helix	18	45	11	73
Phyllitis scolopendrium	17	42	NC	NC
Rubus fruticosus	NC	NC	6	40
Taraxacum spp.	26	65	4	27
Number of sites	40		15	

KEY: NF = not found
NR = not rare
NC = not common

CHAPTER 4 IMPACTS OF MANAGEMENT

4.1 MAINTENANCE

Some level of maintenance is essential if the canal system is to fulfil all its various functions - as a navigable waterway and a footpath, as a local amenity and 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 the species-richness and diversity of the flora, including herbaceous species in the under-storey. The flora in turn will determine 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 produced in autumn are a valuable source of food for many animals and birds. The height of the hedgerow is important in determining its suitability as a nesting site - nesting birds in low (3 ft/92 cm) hedges are subject to predation from the ground (Brooks and Agate, 1988). Dense growth at the base of the hedgerow provides vital cover for field mice (Apodemus sylvaticus) and other animals.

Table 4.1

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

(Newbold, Honnor and 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 management 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 (BWB, 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 years' regrowth as well as a newly-trimmed section.

A flail is the most efficient means of mechanically 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 hedgerow that is very susceptible to die-back and fungal attach (BWB, 1981). Trimming, like pruning, encourages regrowth and maintains the dense, bushy cover that is important for wildlife. An A-shaped hedgerow, approximately 1.8 - 2.0m high, provides secure nesting sites for birds and dense cover at its broad base for animals, making it a valuable habitat (Mabey, 1980).

Trimming carried out in spring and early summer will seriously disturb the nesting and breeding success of the hedgerow birds. Trimming in late summer or autumn will remove the berries that are an important part of the food-chain of the hedgerow habitat.

Continuous trimming tends to accelerate and exaggerate the ageing of the shrubs (Brooks and Agate, 1988). The hedge initially becomes bushier due to the increasingly dense outer growth and the interlocking of each plant's branches with those of its neighbours. Eventually, the bottom and inner branches die back, leading to the development of gaps at the base and a shell-like growth form. The hedgerow gradually loses vigour - regrowth after trimming is slow, and weaker plants die. Gaps occur between shrubs, and the hedgerow loses its continuity.

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

Laying also encourages regrowth from the base of the hedge, but it is a labour-intensive and highly skilled operation (Brooks and Agate, 1988).

A derelict hedge with extensive gaps and relatively few healthy shrubs may need replanting to restore its

wildlife value (Table 4.2).

Hedgerow trees add to the diversity of the habitat, and of the canal 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

The soils along the Grand Canal are for the most part low in nutrients and infertile, and with appropriate management produce a grass sward which is species-rich and slow-growing. Without management floral diversity decreases rapidly, and the system loses much of its ecological interest. A small number of coarse, vigorous grasses soon dominate the sward at the expense of the less productive grass and herb species. Rapid invasion of scrub follows, and the non-climax vegetation is lost (Jefferson and Usher, 1986).

4.1.2.1 Grazing

Grazing is one of the oldest and simplest methods of maintaining grass cover. It reduces the dominance of coarse vegetation, creating a more open sward where non-grass species can flourish. Treading of the channel margins by grazing animals can encourage the growth of emergent plants by creating a shallow, marshy shelf along the water's edge, increasing the range of habitats of the canal system.

Over-stocking on the other hand has a negative impact on grasslands, resulting in over-grazing and an impoverished grass sward. Physical damage to the vegetation and to the soil structure also becomes a problem, with the most severe poaching occurring at gates and where the animals get access to the water. Even a small number of animals can cause serious poaching where the ground is wet or the soil poorly-drained.

Grazing is a selective process, and different animals will produce a different grassland structure. Cattle tear the vegetation rather than biting it, producing a varied and tufted sward (Mabey, 1980). Sheep trim the pasture to within a few centimetres of the soil, biting cleanly through the vegetation (Packham, 1989) and producing a tight, even sward of low-growing herbs and fine grasses. Being lighter than cattle they cause little poaching, and are less likely to cause physical damage to the banks of the waterway (Lewis and Williams, 1984).

Table 4.2

Native Trees and shrubs suitable for planting

	Acid	Neutral	Alkaline
<5m metres in height			
Alder		*	*
Birch	*		*
Blackthorn		*	*
Crab apple		*	*
Spindle		*	*
Guelder rose		*	*
Hawthorn	*	*	*
Hazel		*	*
Holly	*	*	*
Rowan	*	*	
>5 metres			
Ash		*	*
Oak	*	*	*
Willows	*	*	*

Native Trees and Shrubs suitable for planting (cont.)

Species to be avoided -

Sycamore - seeds prolifically when mature and can invade areas with dense stands of saplings.

Poplar - species tend to produce suckers which can cause problems for access.

Suitable species

Alder - a small tree capable of growing in wet or waterlogged conditions. It has a dense fibrous root system that binds soil well.

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

Birch - both downy and silver birch can be planted and will form slender graceful trees which are aesthetically pleasing. Downy birch is tolerant of damp sites. Both are light-demanding and should not form part of a mixture of trees for this reason.

Blackthorn - a low dense shrub that is valuable as cover for birds and useful for hedging and faggots.

Spindle - an attractive open shrub with very striking scarlet and orange fruits.

Guelder rose - an attractive open shrub with striking white, many-flowered heads and good autumn colour.

Hawthorn - a dense medium sized tree or hedgerow shrub useful for faggots. It establishes easily from whips and gives a good stock proof barrier. The white bunches of flowers provide a rich nectar source for insects. Birds benefit from the cover for roosting and nesting whilst the fruit is a valuable food in autumn.

Hazel - a medium to low open shrub that gives an early pollen source and edible nuts in the autumn. It coppices well and the coppice stakes and whips can be used in hedging or sold for pea sticks or for thatching spars.

Holly - this is an evergreen tree or shrub. Male and female flowers are normally on separate trees. The fruit is popular with birds. Its dense shade will kill vegetation beneath so it should not be used where this could be critical. Holly is an excellent hedging shrub and will also coppice well.

Oak - a large open-crowned tree, but slow growing. It is a valuable tree for insects.

Rowan - a medium to tall, open tree, light-demanding. The groups of white flowers provide a good nectar source and the fruit is taken by birds.

Willows - they are all fast-growing and tolerant of wet conditions. There are two native tree species and the remainder are shrubs or small trees. Many willow crosses occur and identification can be difficult. Tree species can be pollarded. All can be coppiced. Willow stakes and whips can be used to protect banks from erosion and stabilise embankments. Willows are the foodplant of many moth caterpillars.

Tree species - white willow, crack willow.

Shrubs and small trees - osier, goat willow, common sallow, purple willow.

(after: Newbold et al, 1989)

Horses are very selective grazers and on their own produce a sward dominated by the unpalatable species that they won't eat. When grazed with cattle a more balanced sward is produced. Goats on the other hand are non-selective grazers, and will damage both the grass cover and the hedgerow by over-grazing, even in small numbers.

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 or 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 largely replaced by less diverse grass swards grown for silage. Taller plants, removed by grazing in pastures, have a competitive advantage in hay meadows.

Although mowing on an annual basis and light grazing produce grass swards that are similar in structure, their species composition is very different. A study of grasslands in Oxford in the 1930s recorded thirty-nine species growing only in the hay meadows, twenty-six restricted to pastures and thirty species common to both (Rackham, 1987). For example, Filipendula ulmaria and Rumex acetosa are easily destroyed by grazing but can withstand mowing ; while Achillea millefolium and certain species of Ranunculus can tolerate grazing but are not found in hay meadows. The differences are due to the difference in timing of the two processes, and the fact that grazing is selective while mowing is not.

Cutting every 2 - 3 years will allow a coarser vegetation to develop, with tall herbaceous plants such as Heracleum sphondylium, Urtica dioica and Epilobium spp. in the sward. This management technique will lead to a 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 species-rich limestone grasslands that predominate along the canal are dependent on the relative poverty of the soil, which is low in nitrogen and

phosphorus. Enrichment of the soil, either by fertilisation or the accumulation of plant litter, including cut vegetation, changes its nutrient status, increases the productivity of the system and allows a small number of aggressive and highly competitive species to dominate the sward (Ratcliffe, 1977 ; Newbold et al., 1989).

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 (Lewis and Williams, 1984). Like fertilisers, herbicides eliminate the more sensitive, slow-growing plants and allow a few vigorous species to dominate the sward.

4.1.3 Control of Aquatic Vegetation

Plants have a variety of roles in an aquatic system, including primary production, nutrient cycling, stabilisation of sediments, habitat diversification and as a food source (Mitchell, 1974). They also help to maintain water quality - in a nutrient-poor system aquatic plants can compete successfully with algae although algae will dominate under eutrophic conditions (Marshall and Westlake, 1978).

Control of the aquatic plants has a number of impacts on the system. Destruction of 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 (Marshall and Westlake, 1978). Removal of the marginal fringe of emergent plants also has a physical effect, leading to destabilisation of the bank sediments and increased erosion.

The reduction of 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 invertebrate species most closely associated with macrophytes being the most seriously affected (Murphy and Eaton, 1981). Loss of emergent vegetation will result 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 fringe.

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 central channel of the canal so that it no longer forms a suitable habitat for emergent reeds restricts the spread of vegetation from the margins to the centre of the canal (Newbold et al., 1989 ; Brooks and 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 and 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. The orientation of the channel to the sum will affect the success of shade as a control mechanism, and determine which side of the channel should be planted if a new shade-belt is to be created (fig 4.1). For a wide channel shade is likely to be effective on one side only, allowing the vegetation on the south-facing bank to flourish (fig 4.2).

The input of extra organic matter and nutrients to the system 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. This would affect aquatic plant and animal communities, putting them under stress, and if very severe could lead to algal blooms.

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

4.1.3.2 Chemical control

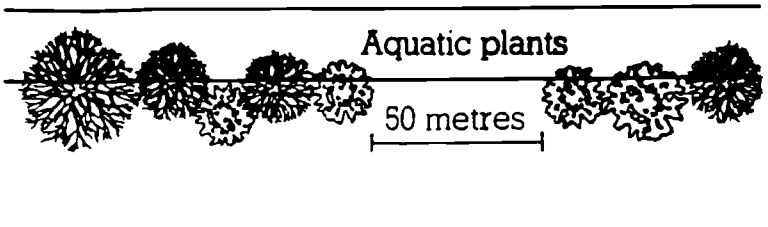
Herbicides are the most common means of controlling aquatic vegetation today. They are relatively quick and easy to use, and cost less than traditional, labour-intensive methods. The main disadvantage of herbicides is that they are broad-spectrum, targeting not a single species but a range of species with similar growth forms (Table 4.3). Some species are more susceptible to herbicides than others (Table 4.4)

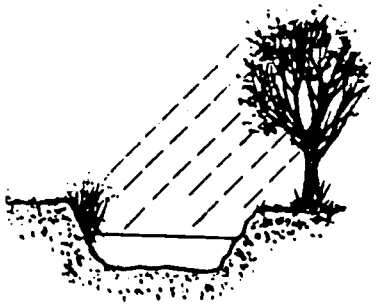
Figure 4.1 Channel Orientation and Planting for Shade

Orientation of Channel	Bank for Shade Belt	Effectiveness of Weed Control
W ——— E	South	Maximum
NE / SW	South-east	Moderate to Good
NW \ SE	South-west	Moderate to Good
N | S	East or West	Poor
	East and West	Moderate

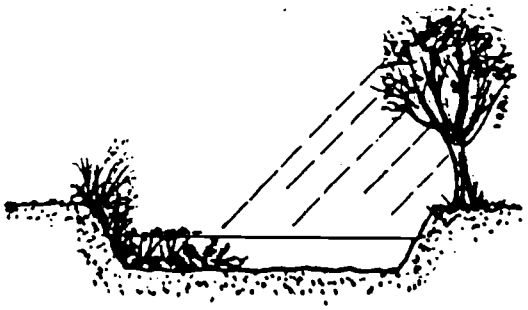
(after : Lewis and Williams, 1984)

Shade in major drainage channels.





Where trees shade the full width of the canal, leave variable gaps as above.



Where trees give only partial shade a continuous line is acceptable.

Figure 4.2 Manipulation of Shading.

(Newbold et al., 1989)

Table 4.3 Target spectra of selected herbicides.

'Weed groups'	Terbutryn	Dichlobenil	Dichlobenil GSR	Dichlobenil, dalapon	Diquat/diquat alginate	Dalapon	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 Susceptibility of Aquatic Plants to Dichlobenil.

a) Emergent spp.

Susceptible
Equisetum fluviatile
Equisetum palustre
Glyceria fluitans
Rumex hydrolapathum
Sagittaria sagittifolia
Stratiotes aloides

Moderately susceptible
Alisma plantago-aquatica
Glyceria maxima
Iris pseudacorus
Nasturtium officinale

Resistant
Butomus umbellatus
Carex spp.
Juncus spp.
Oenanthe aquatica
Phragmites communis
Typha spp.

b) Submerged spp.

Susceptible
Ceratophyllum demersum
Chara spp.
Elodea canadensis
Hottonia palustris
Lemna trisulca
Myriophyllum spp.
Potamogeton crispus
Potamogeton pectinatus
Zannichellia palustris

Moderately susceptible
Utricularia vulgaris
Potamogeton lucens

Resistant
All algae except chara

c) Floating spp.

Susceptible
Callitriche stagnalis
Hydrocharis morsus-ranae
Ranunculus spp.

Moderately susceptible
Potamogeton natans
Nuphar lutea
Nymphaea alba
Polygonum amphibium

Resistant
Lemna spp.

(after Duphar B.V.)

and will therefore be the first to be lost. However, plant species react differently to herbidices under different geographical and water chemistry conditions (CFB, 1991 ; Table 4.5).

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 and Eaton, 1981). The tendency of herbicide treatment to be followed by the rapid growth of filamentous algae is due to the opportunistic growth potential of algae in exploiting the niches left by the removal or suppression of their vascular plant competitors.

The downstream drift of herbicides in the water results in a reduction of plant growth at sites not treated with the chemical (Eaton et al, 1981). Spot-treatment of isolated areas using herbicides tends therefore to be unsatisfactory.

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

One of the main disadvantages of herbicide use in ecological terms is the speed at which they can be applied. The speed or rate of change per unit area in part determines the impact on plant and animal communities, and herbicides can bring about a rapid and massive change in habitat in a waterway (Newbold, 1984). Recolonisation of the herbicide-treated area from non-treated areas is unlikely to be a significant factor in the development of post-herbicide communities. Firstly, 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. Secondly, the rapid spread of resistant species, in 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 canal vegetation, composed only of resistant species that cannot be readily controlled. Indiscriminate use of herbicides on Irish canals in the past has lead to the ecological degradation of some stretches (Caffrey, 1988).

Herbicides, if used according to the manufacturer's specifications, 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

Table 4.5 Susceptibility of Aquatic Plant Species to Casoran (dichlobenil) and Clarosan (terbutryne) based on trials conducted in Ireland and the U.K.

CASORAN

	Ireland	U.K.
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

	Ireland	U.K.
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
MR = moderately resistant
R = resistant

from CFB, 1991

growth and reproduction. If food production is suddenly inhibited, the animal must either switch to an alternative source of food or migrate. Species that are plant-specific are particularly vulnerable (Murphy and Eaton, 1981 ; Newbold, 1984). 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 and Rey, 1981).

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 can be relatively selective, leaving small stands of more desirable plants while removing the bulk of the problem species. Maximum selectivity is achieved by hand-cutting, but even mechanical cutting is more selective than chemical control.

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 and Agate, 1990) and may therefore 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 over-wintering success of the target plant, and as a result less severe control measures will be required the following year. Long-term management of the aquatic vegetation of a canal 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 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 and Eaton, 1981).

4.1.3.4 Biological control

The possibility of introducing herbivorous species such as Grass Carp (Ctenopharyngodon idella) to the canal system has been discussed (Van Dam and Eysten, 1987). There is no way of predicting in advance how the introduction of a alien species will affect the natural balance of a system, and once established the exotic species is often harder to control than the original nuisance species.

4.1.4 Dredging

4.1.4.1 Impacts of Dredging

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

Impacts on the channel

The removal of silt from the bed of the canal deepens the channel, affecting the range of aquatic wildlife that can inhabit it. The most obvious changes will occur in the plant community, with a reduction in shallow-water, emergent plants such as Alisma plantago-aquatica and Phragmites australis and a corresponding increase in species with a deeper, open water requirement (e.g. Nuphar lutea and Potamogeton spp.). Changes in the plant population will lead to changes in the aquatic invertebrate communities that depend upon them, while bird and fish communities will also be affected by the loss of shelter and by changes in the available food supply

As well as being affected indirectly by changes in channel depth, plant populations are affected directly by the removal of vegetation with the silt during 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 during dredging and float downstream. The effect on emergent plants, in particular those of the reed fringe, is usually less beneficial. Where land-based dragline plant is used the bucket is dragged up the bank, removing all the vegetation on the side of the canal from which the machine is working. It is official OPW policy under these circumstances that the reed fringe on the opposite bank should be preserved intact. The presence of a diverse and undamaged source of material for recolonisation will reduce the possibility of a single, highly competitive species such as Glyceria maxima establishing a monoculture along the banks at the expense of a more balanced community.

Disturbance of the sediments on the bed of the canal releases some of the nutrients they hold, and the nitrogen and phosphorus levels of the canal water can increase significantly as a result of dredging (Haslam, 1978). This fact, together with the removal of the plants that generally compete for these nutrients, can lead to algal blooms, which will in turn affect the rate of recolonisation of the waterway by higher plants.

Physical disturbance such as increased turbidity will also affect recolonisation, in particular by submerged plants, as they are sensitive to the level of light penetration of the water, but this effect is relatively short-lived as the silt in suspension resettles rapidly and the water becomes clear again.

Dredging generally increases the area of open water, and often leads to an increase in species diversity within the channel. However, habitat diversity can be reduced, as dredging tends to increase the uniformity of the system, removing berms and shallow margins and creating banks that are all alike in profile. In particular there seems to be a tendency to make banks that are too high and too steep to support a healthy and diverse community of emergent reeds and associated plants.

Invertebrates

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. A reduction in habitat diversity, in particular the loss of trampled margins and reed beds, will result in the impoverishment of invertebrate communities. Removal of vegetation can lead ot 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 and 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 large areas of the canal over a relatively short period of time.

Fish

Fish populations on the canal are actively managed, and fish are removed from a level scheduled for

dredging. Loss of submerged and marginal vegetation and changes in invertebrate populations can all have a negative impact on the fish community upon re-stocking. In contrast, the dredging and re-watering of a level previously over-grown with reed-grasses and not containing sufficient water to support any fish will increase the area available for colonisation by fish as well as other aquatic organisms.

4.1.4.2 Recovery after dredging

Channel

The vegetation of the central channel appears to recover relatively rapidly. The expansion of the area of open water often leads to an increase in the diversity of the plant community (Briggs, 1989). The increase in diversity may be due to the re-appearance of species from a dormant state, or to a rapid surge of growth of relatively rare species upon the removal of their dominant and highly aggresive competitors.

Marginal zone

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 channel. Recovery is quickest where the bank slope is gentle, and where some marginal vegetation was left on the nearside after dredging. Working from one bank and leaving the other intact cannot benefit the system if the disturbed bank is made so inhospitable that few if any species can establish themselves along it.

4.1.4.3 Disposal of spoil

Dredging also has a number of impacts on the terrestrial canal 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 vegettion cover on the bank and towpath. However, the major impact of dredging on the terrestrial habitats is caused by spoil deposition. Dredging spoil is rich in nutrients, in contrast to the less grand fertile soils that predominate along the Grand Canal. In terms of the nature conservation value of the canal the most appropriate means of disposal would be to remove the spoil from the system altogether, but in practice this is not feasible.

In most dredging operations the spoil is spread thinly over the land adjacent to the channel, and in general this is satisfactory (Lewis and Williams, 1984). However, it does tend to increase uniformity by eliminating hollows and irregularities in the ground,

all of which add to the diversity of the system. Spreading spoil will have a particularly serious impact where the adjacent land is either a nutrient-poor, botanically-rich grassland or a species-rich wetland (Lewis and Williams, 1984). Both these habitats are very sensitive and can be damaged even by low levels of enrichment or fertilisation. Dumping a layer of nutrient-rich silt over them could destroy the site permanently. Scrub on the other hand is less sensitive, and spreading spoil in a thin layer over a patch of scrub would not damage it irreparably.

Depositing spoil in a trench dug between the towpath and the boundary would have a less severe impact, particularly if the top-soil is kept and spread over the in-filled trench to aid revegetation.

4.1.4.4 Revegetation of spoil

The first species to colonise any area of bare ground are invasive species such as Rumex spp., Cirsium spp. and Urtica dioica. On dredging spoil aquatic plants are also among the early colonists - Glyceria maxima and Phalaris arundinacea being particularly persistent. In time natural success 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 recovery of terrestrial habitats after dredging depends on a number of factors. It is most rapid where the disturbance was purely physical, caused only by the movement of heavy machinery. Where the drainage capability and nutrient status of the soil are affected by spoil deposition and compaction recovery will be slower. Where a thin layer of spoil covers a relatively smalll area recovery can be relatively quick. The vegetation that is left undisturbed when dredging acts as a focus for recolomisation of the disturbed areas. It is therefore important that a significant proportion of each habitat at the dredging site remains intact in order to improve the rate of recovery of the vegetation.

The plant cover on the land outside the canal boundary will also affect the revegation of the disturbed canal, as it also provides a source of seed. Its significance will vary, depending on the amount of vegetation left on the towpath and on the seed mixture itself.

Invertebrates

The recovery of the invertebrate populations will depend largely on the recovery of the vegetetion, and on the amount of shelter left after the dredging

operations cease.

4.1.5 Bank Stabilisation

Bank erosion is a common feature along the Grand Canal, and on some stretches the undercutting or slipping of the bank is approaching a critical level. Clay has been used to build up the banks in some places, particularly at Edenderry. Clay when it sets is absolutely solid, and revegation is very slow. If soil from the same area is spread over the new clay bank the rate of recovery is increased. The topsoil will contain a appropriate mix of seeds (which clay doesn't) and in addition is a much more suitable medium for germination.

The reed fringe is often also slow to re-establish after bank stabilisation works. An experimental planting of reeds and reed grasses was carried out by CFB in the summer of 1991, but it will not be possible to judge the success or otherwise of the project until after one complete growing season.

Sheet piling can also be used in bank stabilisation works. However, it has no ecological value and will detract from the value of the canal in terms of both nature conservation and visual amenity.

4.1.6 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 towpath (cutting once a year in August/September or grazing) will ensure that scrub does not encroach from the boundary. The habitat diversity, and therefore the ecological value of the canal, can be improved by leaving scrub in the boundary verge and on the offside or by allowing it to develop in place where the canal corridor is wide enough to support it.

Trees between the towpath and the channel can reduce the diversity of the aquatic habitat by over-shading, particularly if there is a continuous line of trees on the south bank (Newbold et al., 1989). However, they 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 valuable in their own right. Selective removal of trees from the bank reduces the negative impact of shading and allows dredging and maintenance work to be carried out while still retaining the wildlife advantage.

4.1.7 Masonry

A bridge that is covered with ivy can support very little else in the way of vegetation. When the ivy is cleared away as part of a restoration programme other

plants such as Asplemium spp. and Cymbalaria muralis can take advantage of the newly-available niche. Unlike ivy these will not damage the stonework of the old canal bridges.

If terrestrial herbicides are used to clear the vegetation on and around locks and bridges, they will enter the water and cause serious ecological damage.

4.2 RECREATION

4.2.1. Introduction

This section is concerned only with the impacts of recreation (Figure 4.3), in particular with changes in habitat and with disturbance. It does not deal with the impacts of the general maintenance regime, even though one of the primary functions of canal maintenance is to facilitate recreation. The main recreational activities on the Grand Canal are navigation, angling and walking. Each activity has a series of impacts on the canal system - some negative, some positive but all inter-related. Although each activity is treated independently it must be realised that they are not isolated in practice - anglers walk along the towpath; boaters may also fish; and some of those walking along the banks may have arrived by boat.

4.2.2. Navigation

4.2.2.1. Physical Impacts:

There are a number of physical impacts associated with navigation (Figure 4.4), making the final effect of any one component difficult to quantify. In a canal, which is both shallow and narrow, these physical impacts will have a very strong influence on the channel and the banks.

Wash:

Canals were designed for slow-moving horse-drawn barges which generated very little wash. Boats using the canals to-day tend to be high-powered and capable of generating significant wash. The energy transmitted by a boat's wash depends largely on the speed and power of the boat, the shape of the hull, and its displacement in the water. The primary impact of wash is the erosion of plants from the canal margins. Different plants have different susceptibilities to erosion (Table 4.6) and so the species composition of the marginal vegetation will change as the more sensitive species are eliminated and the reed fringe becomes less diverse. Lightly-used canals can support species-rich and diverse reed fringes, while heavy boat traffic may result in the absence of any marginal vegetation. Between these two extremes lies a critical value, above which significant changes occur in the aquatic ecosystem. For most English canals this critical value, above which significant changes occur in the aquatic ecosystem lies between 2,000 and 4,000 my (movements/hectare/metre depth/year) (Murphy and Eaton, 1983). It seems likely, however, that the

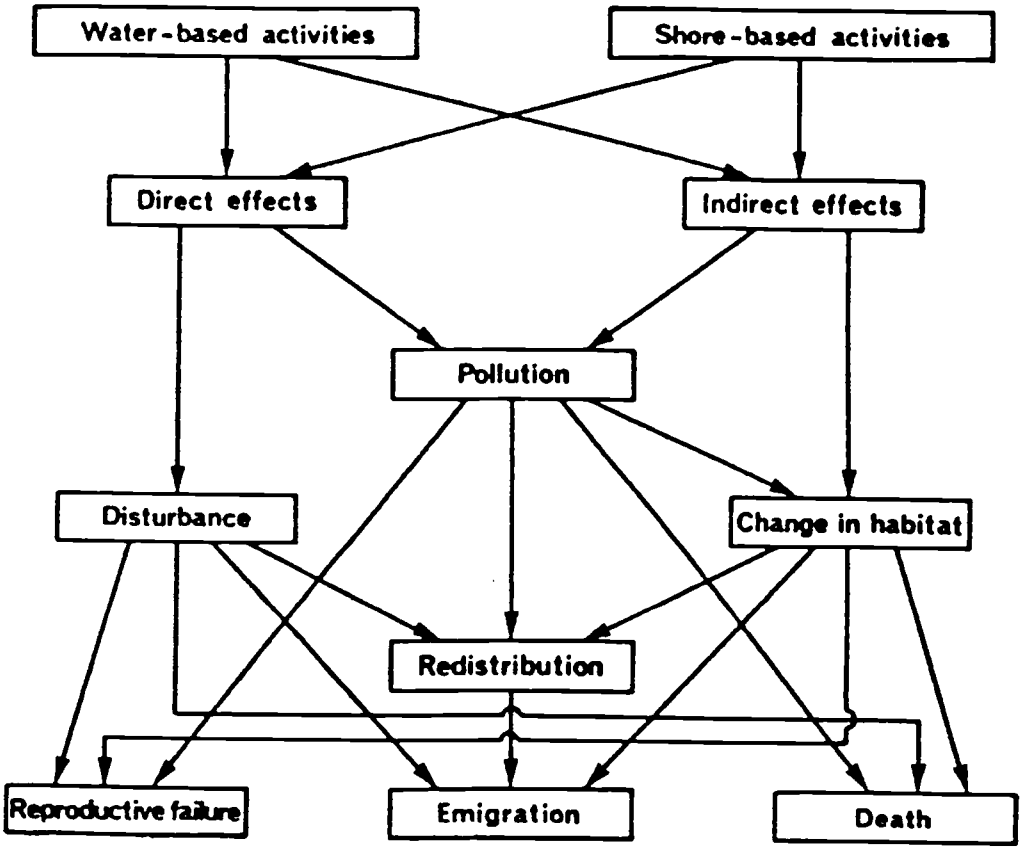


Figure 4.3

The impacts of recreation (excluding management) on animals.

(Liddle and Scorgie, 1980)

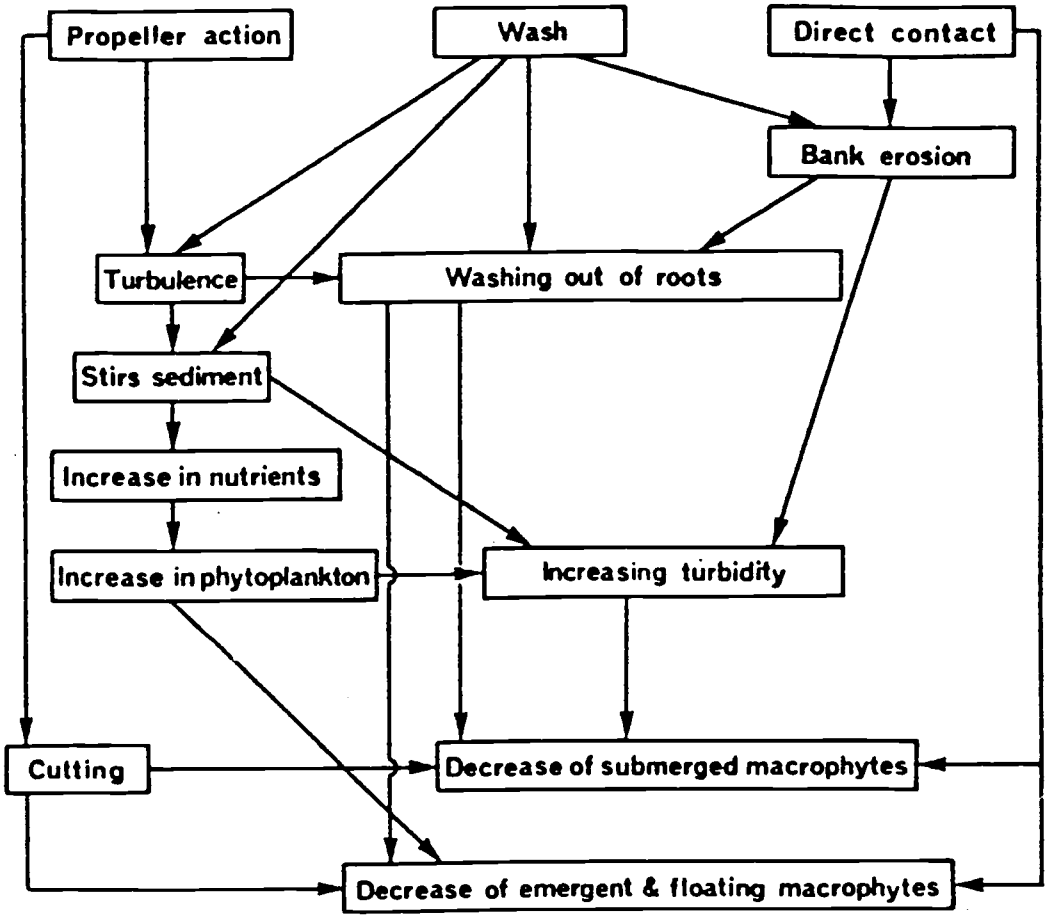


Figure 4.4

The impacts of boats on plants.

(Liddle and Scorgie, 1980)

TABLE 4.6 The susceptibility of aquatic plants to erosion.

A: Very easily eroded -
- Agrostis stolonifera (submerged)
- Epilobium hirsutum (rooting fragments)
- Ceratophyllum demersum
- Elodea canadensis
- Rorippa amphibia
- Nasturtium officinale

B: Easily eroded -
- Callitriche spp.
- Epilobium hirsutum
- Myosotis scorpioides
- Myriophyllum spicatum
- Sparganium erectum
- Zannichellia palustris

C: Rather difficult to erode -
- Apium nodiflorum
- Berula erecta
- Potamogeton crispus
- P. perfoliatus
- Scirpus lacustris
- Sparganium emersum

D: Difficult to erode -
- Glyceria maxima
- Nuphar lutea
- Oenanthe fluviatilis
- Phalaris arundinacea
- Phragmites australis
- Potamogeton pectinatus
- Ranunculus pencillatus
- R. trichophyllus

(Liddle and Scorgie, 1980)

critical value for Irish Canals will be considerably lower than that found in England, due to the instability of the peat through which much of the canal network was cut.

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

Loss of marginal vegetation will lead to a decrease in invertebrate populations, both aquatic (e.g. water beetles) and water-associated species (e.g. dragonflies and damselflies). Species that are associated with a particular macrophyte are usually more sensitive to ecological change that those that occupy a broader ecological niche, and are therefore the first to be lost as the system changes. Loss of plant cover may also result in a reduction in the number of birds along the canal, in particular those that nest in the reed beds. Fish populations are also affected, as they depend on the reed fringes for both food and cover.

Turbulence/Turbidity:

Turbulence, like wash, depends on the power and design of the boat and its propeller. The main impacts of turbulence are the washing out of plant roots form the banks and bed of the channel, and an increase in the turbidity of the water. The amount of turbidity caused by boats depends on a number of factors - the depth of the water, the proportion of fine clay in the sediment, and the size and horse-power of the boats. In a relatively shallow canal turbidity can be a serious problem resulting in decreased light penetration and a subsequent reduction in the biomass of submerged vegetation. Studies on canals in England have indicated a significant association between boat traffic, submerged crop and turbidity (Murphy and Eaton, 1983).

A reduction in submerged vegetation will in turn lead to a reduction in the diversity and biomass of the invertebrate populations, with those species that are most closely associated with macrophytes being the most seriously affected (Murphy and Eaton, 1981).

Propeller Action:

The stems and leaves of submerged and floating-leaved plants can be cut by propellers, again resulting in a decrease in the biomass of the channel vegetation and a subsequent reduction in invertebrate fauna. Loss of submerged flora and fauna will also affect fish populations, as this represents a reduction in both

food supply and cover.

Many submerged plants can regenerate from sections cut or broken from the parent plant. Propeller action and boat traffic may therefore help some species to spread and to colonise navigable waterways at a much greater rate than would be possible otherwise. The rapid spread of Elodea canadensis is thought to be due to the fact that with numerous growing points and little or no dependence on roots, it is very tolerant of boat traffic.

Myriophyllum species on the other hand are more vulnerable to propeller action, and are common along the unnavigated Royal Canal but not along the Grand Canal, except in the Corbally Branch which was closed to navigation in 1953 by the building of a low bridge at Jigginstown, just outside Naas.

Direct Contact:

The reed fringe may also be damaged by the collision of boats with the marginal vegetation on the banks. The subsequent effects are the same as when the reduction or loss of vegetation cover is caused by wash, but the impacts are often restricted to well-defined sections of the waterway. Submerged plants are usually less seriously affected that emergents as boat-users tend to avoid areas where propellers or even oars may get entangled in underwater vegetation (Liddle and Scorgie, 1980).

Disturbance:

Disturbance generally results in the redistribution of animal populations, or a movement away from the affected area (Figure 4.3). The only water fowl species occurring in significant numbers along the canal are mute swan, mallard and moorhen, all of which are relatively tolerant of disturbance. However the limited area of surface water to provide refuges on the canal would make even these three species intolerant of high levels of boat traffic. Disturbance of nests during the breeding season, either from the wash of passing boats or by the mere presence of human activity, is likely to have the most significant impact on bird populations along the canal.

Fish populations do not appear to be disturbed by boating activities (Liddle and Scorgie, 1980) but are affected more by changes in the vegetation, and by loss of habitat. The same is true for invertebrate populations.

4.2.2.2. Chemical Impacts:

Plants and animals are affected by the introduction of chemicals into their environment, whether intentional or unintentional. In terms of boat traffic the main chemical inputs would be sewage and fuel/oil. Sewage pollution would lead to the eutrophication of the water and a change in the aquatic plant community as opportunistic species such as algae gained a competitive advantage over slower-growing and more stable species. This in turn would lead to changes in the aquatic fauna of the canal.

Contamination by fuel or oil is most significant in areas where a number of boats are using a relatively small area, e.g. at mooring sites or marinas. There the impacts may be significant, but in general fuel pollution is not a problem (Liddle and Scorgie, 1980).

4.2.3. Angling

4.2.3.1. Fish Stocking:

The practice of introducing fish to the canal is designed to elevate stretches of canal to the status of fisheries of national or international importance. The introduction of fish that are of the same species as those already present in the canal will produce impacts that are less significant in ecological terms than the introduction of non-indigenous species. There may be a reduction in the biomass of aquatic plants due to overgrazing by herbivorous fish if the stocking level is too high. Invertebrate populations may also be affected, either by increased predation or indirectly as a result of changes in the aquatic flora. The increase in fish stocks is likely to benefit predatory birds and mammals such as heron, otter and mink.

4.2.3.2. Disturbance:

The waterfowl most common along the canal are those species that are used to human disturbance - e.g. mallard. However disturbance during the breeding season (March to July) may be a problem along intensively used stretches of canal, due to increased nest predation when the parent birds are kept away from the nests for long periods of time. Hedgerow birds will also be affected in this way, but the problem will be more serious for the water birds which have limited cover for nesting.

Disturbance of otters by anglers may be significant in areas which lack bankside trees and scrub for cover. As otters are mostly nocturnal in their activities they can tolerate certain levels of disturbance and

areas with little cover, but they cannot tolerate a combination of the two (King and Potter, 1980). An analysis of survey data from Ireland found no significant correlation between disturbance and otter distribution (Chapman and Chapman, 1982), although there was some evidence that otters changed their sprinting habits (territory marking) when disturbance levels were high.

4.2.3.3. Discarded lead weights:

A study of mute swans in Ireland has shown lead poisoning to be the cause of death in up to 68% of post-mortem examinations from a number of sites (O'Halloran et al., 1988). Lost or discarded anglers' weights were identified as the source of contamination at two of the sites. Up to 50% of live birds at one famous coarse-fishing site showed elevated lead levels. This has been shown to have sub-lethal effects on co-ordination, causing the birds to collide with over-head cables (O'Halloran et al., 1989). The problem began with the change from cotton to nylon fishing lines in the 1960s so that lead weights are often stripped off after a day's fishing (O'Halloran et al., 1987). Up to 125 lead shot per square metre of surface area have been found at one coarse fishery in South Wales (Bell et al., 1985). While the density of coarse fishing in Ireland is considerably lower, some areas of intensively-used water could become badly contaminated over a number of years.

4.2.3.4. 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 and Pearce, 1987). In addition to cutting the vegetation they may also cut out sloping banks to create a flat space near the water's edge to keep nets and other equipment. The effect of this would be to change the tall bank-verge vegetation to a short sward consisting of tolerant species such as Lolium perenne, Poa pratensis, Plantago major and Polygonum aviculare (Liddle and Scorgie, 1980).

4.2.4. Trampling:

The towpath along the Grand Canal varies from a narrow track through scrub to an official road maintained by the Local Authority. In most cases however, access is restricted to pedestrians, and the only motorised traffic on the banks is occasional maintenance vehicles. All movements along the bank, pedestrian

and vehicular, contribute in some degree to the impact on the flora and fauna.

4.2.4.1. Impacts on vegetation:

With the exception of activities carried out by or on behalf of anglers (4.2.3.4.) the bankside vegetation is not usually affected by pedestrians or vehicles on the bank. The level of damage caused by trampling on the level path will depend on the substrate and on the wetness of the soil. The vegetation on a well-drained bank is better able to withstand trampling than that in a poorly-drained area. Experimental trampling on Scottish lock shores found that the taller reed grasses such as Phragmites and Glyceria were more susceptible to damage than the shorter sedges on drier, firmer substrate (Rees and Tivy, 1977). On well-worn paths the softer plants tend to be replaced by harder-wearing species such as Agrostis spp. and Poa spp, with Polygonum amphibium, P. aviculare and Myosotis spp. on the margins (Rees, 1978).

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 the path and walk through the adjacent vegetation, creating a meandering network of paths. By the time this stage is reached, very little of the original vegetation is undisturbed.

4.2.4.2 Impacts on animal life:

There is little published information on the effects of trampling on the fauna of grasslands. One study in sand dunes found that trampling at the rate of 13 people/metre/hour was sufficient to reduce the soil fauna by about 90% (Buchanan, 1976). Even at low intensities trampling has a serious effect on the surface-dwelling animals such as beetles, molluscs, ants, and caterpillars of moths and butterflies. The survival of many of the flying insects depends on a variety of food for the adult and larval stages and this may be significantly reduced by heavy trampling which tends to reduce the percentage cover, height and species-richness of the natural vegetation. However if the trampling is limited to those parts of the towpath which do not contain rare or sensitive species then no long-term damage should result. It is unlikely that the trampling on towpaths will have any significant impact on passerine bird species.

CHAPTER 5. CONCLUSIONS

5.1 NATURE CONSERVATION AND MANAGEMENT

Canals are not natural systems, but they do have a role to play in nature conservation to-day. In the two hundred years since the canal was built a series of wildlife habitats has developed in the channel and along the banks. The decreasing area of semi-natural habitats in the country as a whole, due to the intensification of agriculture and the increase in urbanisation, has made those areas that have survived into significant reserves for communities and species that were once common but are becoming less so. The Grand Canal with suitable management, could fulfil a vital nature conservation role without decreasing its recreational and public amenity value.

Management is essential if the semi-natural habitats along the canal are to survive, as a number of them, in particular grassland and open water, are non-climax stages in vegetational succession. Over-management on the other hand will lead to a decrease in the ecological value of the canal system. For example the inappropriate use of aquatic herbicides since the early 1970s has resulted in an impoverished channel flora. The high floral diversity of the channel between locks 8 and 19 of the Main Line, a stretch that has never been sprayed, demonstrates the potential of the remainder of the canal, if a more selective method of controlling aquatic vegetation is introduced.

In order for the full nature conservation value of the canal to be realised there will need to be a change in policy at all levels within the OPW. This change is beginning to take effect, albeit slowly. The first and most important step is to give nature conservation equal priority with navigation and engineering criteria (which in the past have been the only factors taken into account in developing and managing the Grand Canal). Exchanging inappropriate and often costly management practices for less intensive and more environmentally friendly approaches will improve the conservation value of the canal habitats and will probably reduce management costs. Close co-operation between the Waterways Section, engineers and administration, and the Wildlife Service is essential. Employing a full-time ecologist to liaise between the two Departments, and to monitor developments on the ground, is essential if the long-term potential of the system is to be realised.

5.2 CANAL AS ASIs

There is a need to re-assess all canal ASIs in view of changes in policy and management. The Circular Line

in Dublin is one of the few remaining sites where Groenlandia densa (a rare and protected aquatic plant) is found, yet it does not appear to be part of ASI 20 in Dublin. Ceratophyllum demersum, although not protected, is relatively rare on a national basis and within the canal system. It is however abundant on the Circular Line and in Ringsend Harbour. The presence of these two species should be acknowledged and protected in some way, for the diversity of the channel would be greatly diminished if either were lost from the system.

Given the ecological value of the canal, and the fact that it should be treated as a unit, the full length of the Grand Canal and all its branch lines, should be designated as an ASI of at least local importance. Specific areas or stretches of canal could be given further protection by raising their rating to regional or even national level.

Designation of the entire canal network, Grand and Royal, as an ASI would be a first step towards formally recognising the ecological value and nature conservation potential of the system. Incorporating nature conservation into a long-term development and management plan would then follow as a logical step.

BIBLIOGRAPHY

AFF. 1981. Areas of Scientific Interest in Ireland. An Foras Forbartha. Dublin.

Bell, D.V. and Austin, L.W. 1985. The Game-fishing Season and its effects on overwintering wildfowl. Biological Conservation 33: 65-80.

Brady, Shipman, Martin. 1987. Grand Canal, Royal Canal, Barrow Navigation: Management and Development Strategy. Main Report. Dublin.

Briggs, J.D. 1989. Notes on the History of Nature Conservation on the Montgomery Canal. British Waterways Board. Gloucester.

Brooks, A. and Agate E. (3rd revision) 1988. Hedging: a practical handbook. British Trust for Conservation Volunteers. Wallingford.

Brooks A. and Agate E. (revised edition) 1990. Waterways and Wetlands: a practical handbook. British for Conservation Volunteers. Wallingford.

Buchanan, K. 1976. Some Effects of Trampling on the Flora and Fauna of Sand Dunes. Discussion Papers in Conservation 13. University College London.

BWB. 1981. Vegetation Control Manual. British Waterways Board. London.

Caffrey, J. 1988. The Status of Aquatic Plant Communities in the Royal and Grand Canals with Reference to Past and Future Weed Management Programmes. Central Fisheries Board. Dublin.

Caffrey, J. 1991. Agreed OPW work programme on weed management in 1991 and proposed canal weed management programme for 1992. Central Fisheries Board. Dublin.

CFB. 1990. A Water Quality Guide to the Grand and Barrow Canals; its Feeders and Abstractions. Central Fisheries Board. Dublin.

CFB. 1991. Aquatic Plant Management in Irish Canals: Annual Report 1990-1991. Central Fisheries Board. Dublin.

Chapman, P.J. and Chapman, L.L. 1982. Otter survey of Ireland 1980-1981. Vincent Wildlife Trust. London.

Dawson, F.H. 1981. The Reduction of Light as a Technique for the Control of Aquatic Plants - An Assessment. Proceedings: Aquatic Weeds and their Control, 157-164. Oxford.

Delany, V.T.H. and Delany, D.R. 1966. The Canals of the South of Ireland. David and Charles. Newton Abbot.

Delany, R. 1973. The Grand Canal of Ireland. David and Charles. Newton Abbot.

Dromey, M., Johnston, B. and Nairn, R. 1991. Ecological Survey of the Royal Canal: Final Report 1990. Office of Public Works, Dublin.

Eaton, J.W., Murphy, K.J. and Hyde, T.M. 1981. Comparative Trials of Herbicidal and Mechanical Control of Aquatic Weeds in Canals. Proceedings: Aquatic Weeds and their Control, 105-116. Oxford.

Gardiner, M.J. and Radford, T. 1980. Soil Associations of Ireland and their Landuse Potential. Soil Survey Bulletin 36. An Foras Taluntais. Dublin.

Harbott, B.J. and Rey, C.J. 1987. The Implications of Long-term Aquatic Herbicide Application: Problems Associated with Environmental Impact Assessment. Proceedings: Aquatic Weeds and their Control, 219-231. Oxford.

Haslam, S.M. 1978. River Plants. Cambridge University Press. Cambridge.

Herries Davies, G.L. and Stephens, N. 1978. The Geomorphology of the British Isles - Ireland. Methuen, London.

Jefferson, R.G. and Usher, M. 1986. Ecological Succession and the Evaluation of Non-climax Communities. IN: Wildlife Conservation Evaluation, 69-91. (ed. M. Usher). Chapman and Hall. London.

Johnston, B. 1985. The Grand Canal and its Potential for Developmeant. M.Sc. Thesis. Trinity College Dublin.

King, A. and Potter, A. 1980. A Guide to Otter Conservation for Water Authorities. Vincent Wildlife Trust. London.

Lewis, G. and Williams, G. 1984. Rivers and Wildlife Handbook: A Guide to Practices which Further the Conservation of Wildlife on Rivers. Royal Society for the Protection of Birds/Royal Society for Nature Conservation. Sandy.

Liddle, M.J. and Scorgie, H.R.A. 1980. The Effects of Recreation on Freshwater Plants and Animals: A Review. Biological Conservation 17, 183-206.

Mabey, R. 1980. The Common Ground: A Place for Nature in Britain's Future. Hutchinson. London.

Marshall, E.J.P. and Westlake, D.F. 1978. Recent Studies on the Role of Aquatic Macrophytes in their Ecosystems. Proceedings: EWERS 5th Symposium on Aquatic Weeds.

Mawhinney, K.A. 1975. Survey of Outdoor Recreational Activities in Dublin City and County. An Foras Forbartha. Dublin.

Mitchell, D.S. (ed.) 1974. Aquatic Vegetation and its Use and Control. UNESCO. Paris.

Murphy, K.J. and Eaton, J.W. 1981. Ecological Effects of Four Herbicides and Two Mechanical Clearance Methods for Aquatic Weed Control in Canals. Proceedings: Aquatic Weeds and their Control, 201-217. Oxford.

Murphy, K.J. and Eaton, J.W. 1983. Effects of Pleasure Boat Traffic on Macrophyte Growth in Canals. Journal of Applied Ecology 20, 713-729.

Murphy, K.J. and Eaton, J.W. 1990. The Ecology and Vegetation Management of the Grand and Royal Canals. University of Glasgow and University of Liverpool.

Murphy, K.J. and Pearce, H.G. 1987. Habitat Modification associated with Freshwater Angling. IN: Angling and Wildlife in Fresh Water, 31-46. (eds. P.S. Maitland and A.K. Turner). ITE. Cumbria.

NCC. 1985. Surveys of Wildlife in River Corridors: Draft Methodology. Nature Conservancy Council. Peterborough.

Newbold, C. 1984. Aquatic and Bankside Herbicides. IN: Rivers and Wildlife Handbook, 209-214. (eds. G. Lewis and W.Williams). RSPB/ RSNC. Sandy.

Newbold, C.,Honner J. and Buckley, K. 1989. Nature Conservation and the Management of Drainage Ditches.Nature Conservancy Council.Peterborough.

O'Halloran, J., Myers, A.A. and Duggan, P.F. 1987. Lead Poisoning in Mute Swans and Fishing Practices in Ireland. IN: Biological Indicators of Pollution, 183-191. (ed. D.H.S. Richardson). Royal Irish Academy. Dublin.

O'Halloran, J., Myers, A.A. and Duggan, P.F. 1988. Lead Poisoning in Swans and Sources of Contamination in Ireland. Journal of Zoology 216, 211-223.

O'Halloran, J., Myers, A.A. and Duggan, P.F. 1989. Some Sub-lethal Effects of Lead on Mute Swan Cygnus olor. Journal of Zoology 218, 627-632.

Packham, C. 1989. Grassland and Scrub. Collins. London.

Potter, H. 1992. Barrow Boating: Part 1. Waterways World 21 (no.2, February 1992),56-59.

Rackham, O. 1986. The History of the Countryside. Dent. London.

Rees, J.R. 1978. A People-counter for Unsurfaced Wetland Footpaths. Environmental Conservation 5, 66-68.

Rees, J. and Tivy, J. 1977. Recreational Impact on Lochshore Vegetation. Journal of the Scottish Association of Geography Teachers 6, 8-24.

Scannell, M.J.P. and Synnott, D.M. 1987. Census Catalogue of the Flora of Ireland. Stationery Office. Dublin.

Spencer-Jones, D.H. 1974. Dichlobenil - A Means of Controlling Aquatic Weeds. Journal of the Institute of Fisheries Management 5, 10-15.

Tandy, C.E. 1989. Ecological Surveys of Canal Corridors: A Methodology. British Waterways Board. Gloucester.

Van Dam, H. and Eysten, P. 1987. The Grand Canal in the Robertstown Countryside Area: A Study of the Landscape, Vegetation and Water Quality along the Canal. An Foras Taluntais. Dublin.

Webb, D. A. 1977. An Irish Flora. Dundalgan Press. Dundalk

Wildlife Service. 1989. Index to Areas of Scientific Interest. Office of Public Works. Dublin.

APPENDIX 1

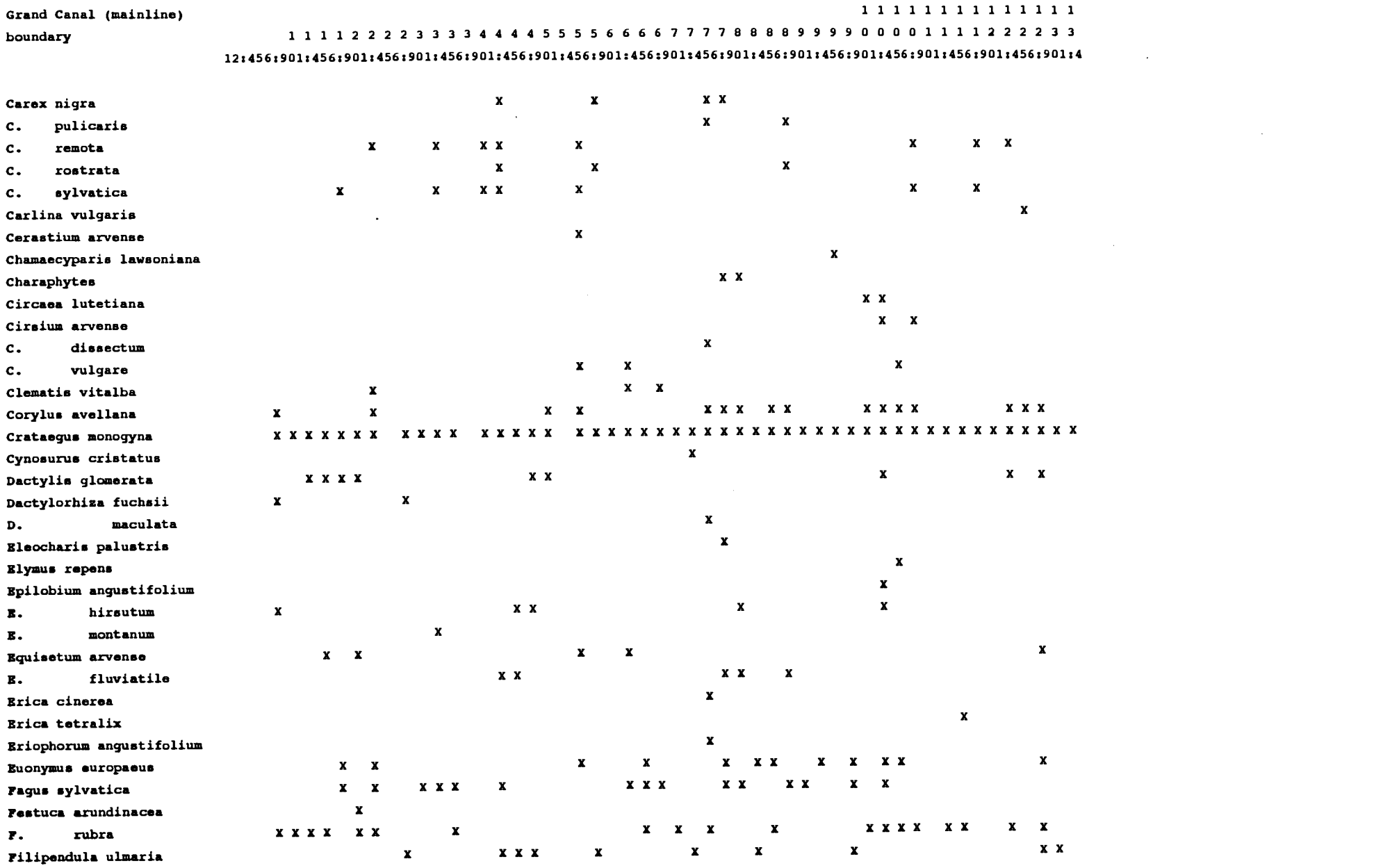
Flora of the Boundary - Main Line

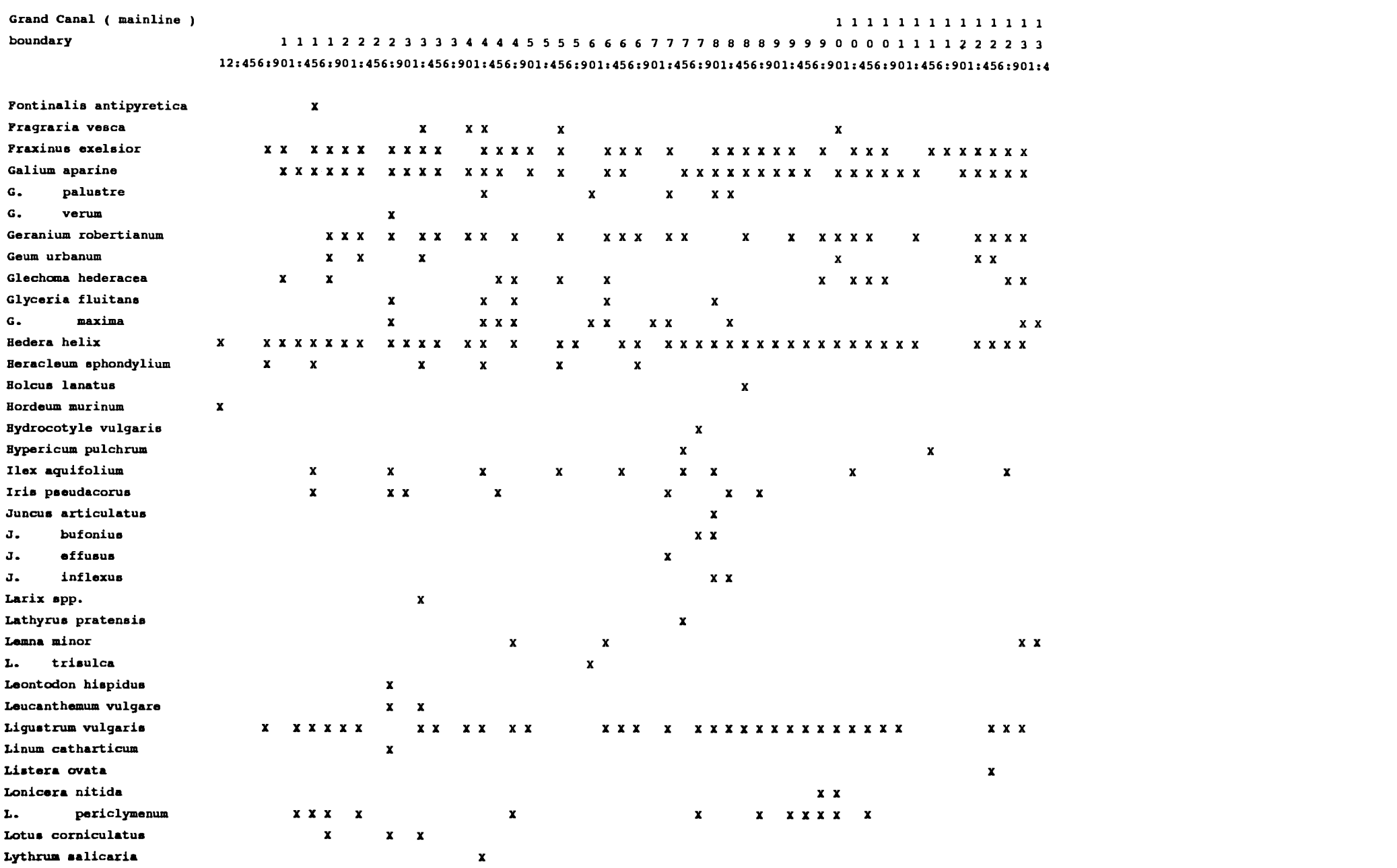
GRAND CANAL : MAINLINE 1991

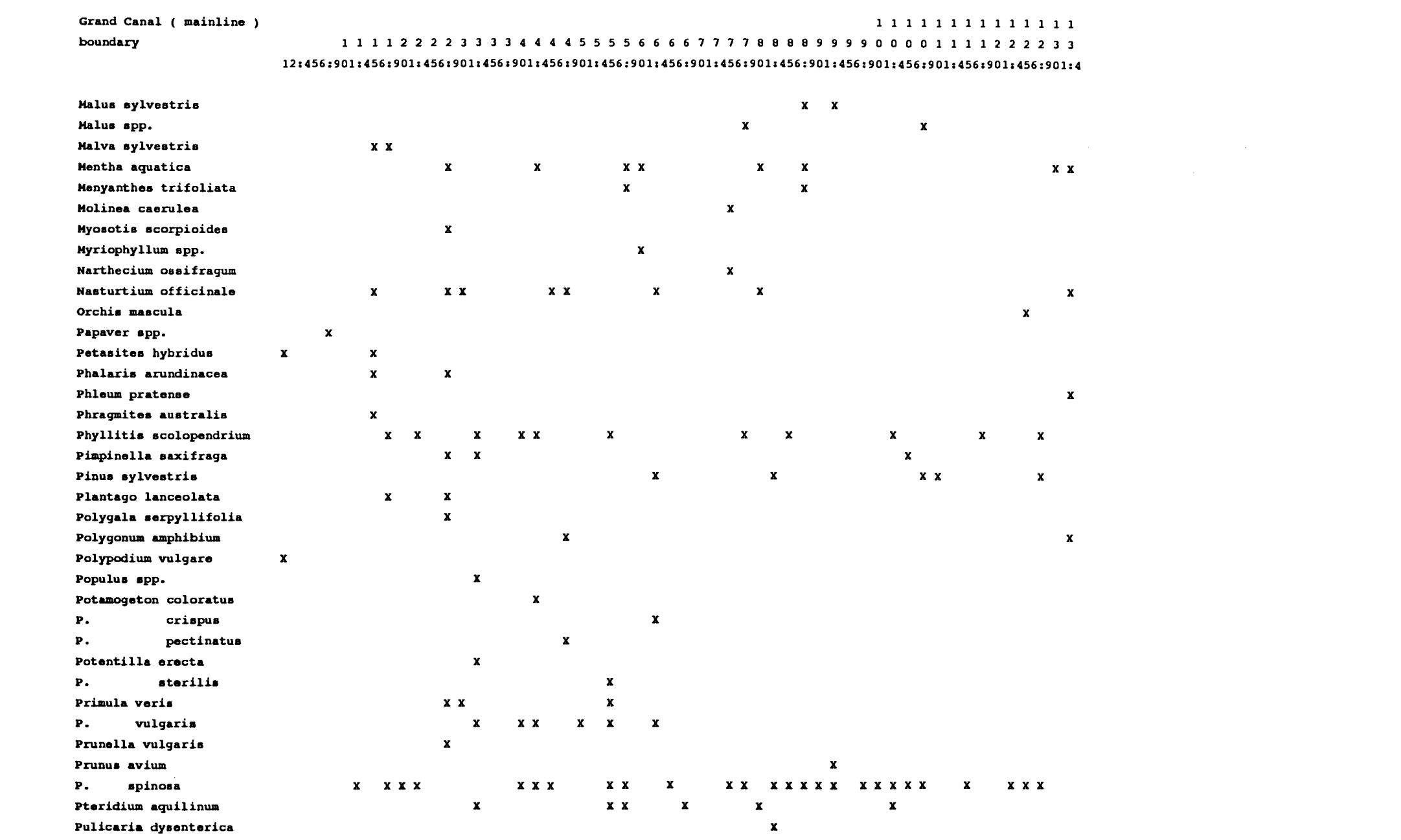
BOUNDARY

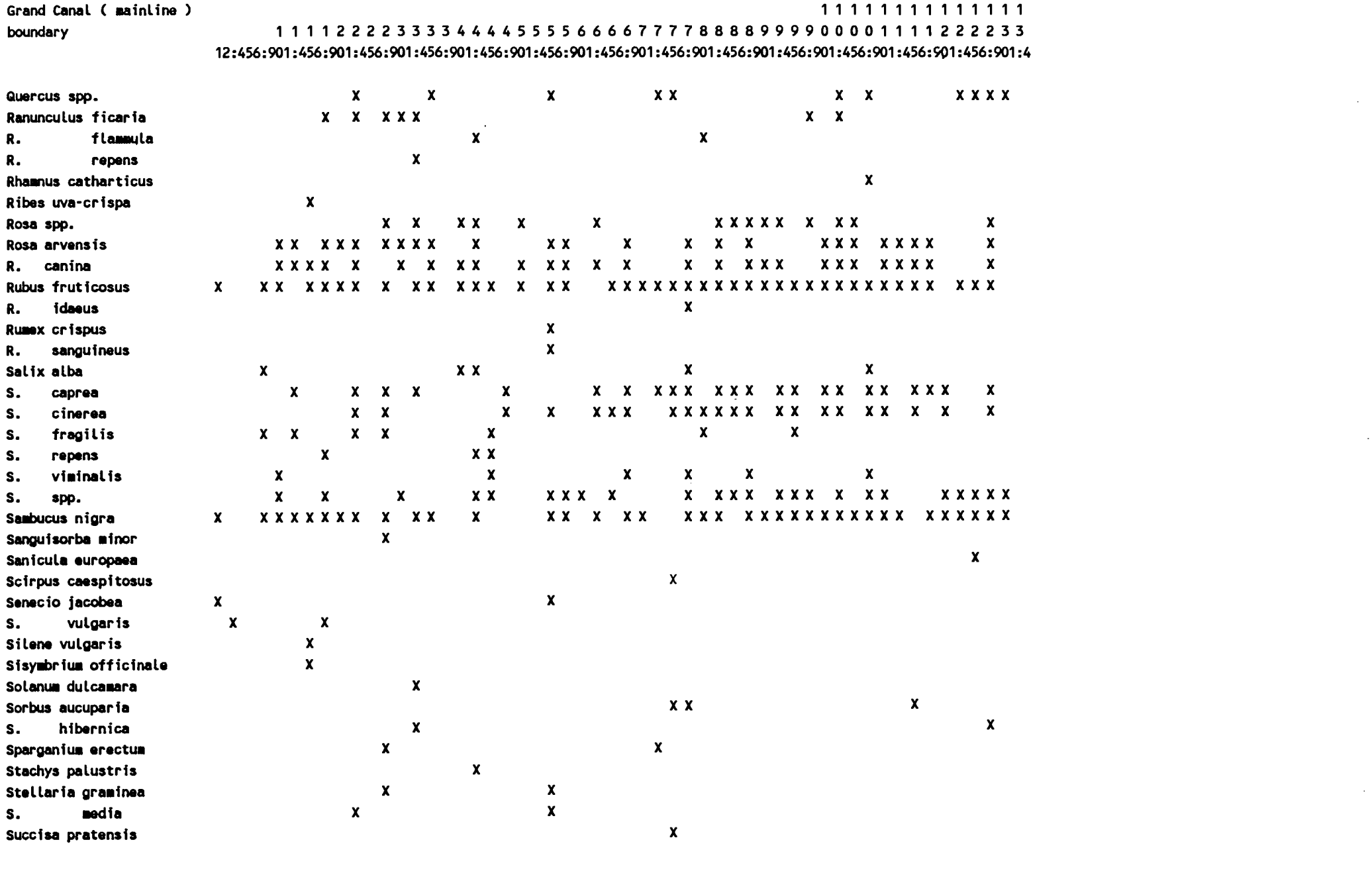
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4

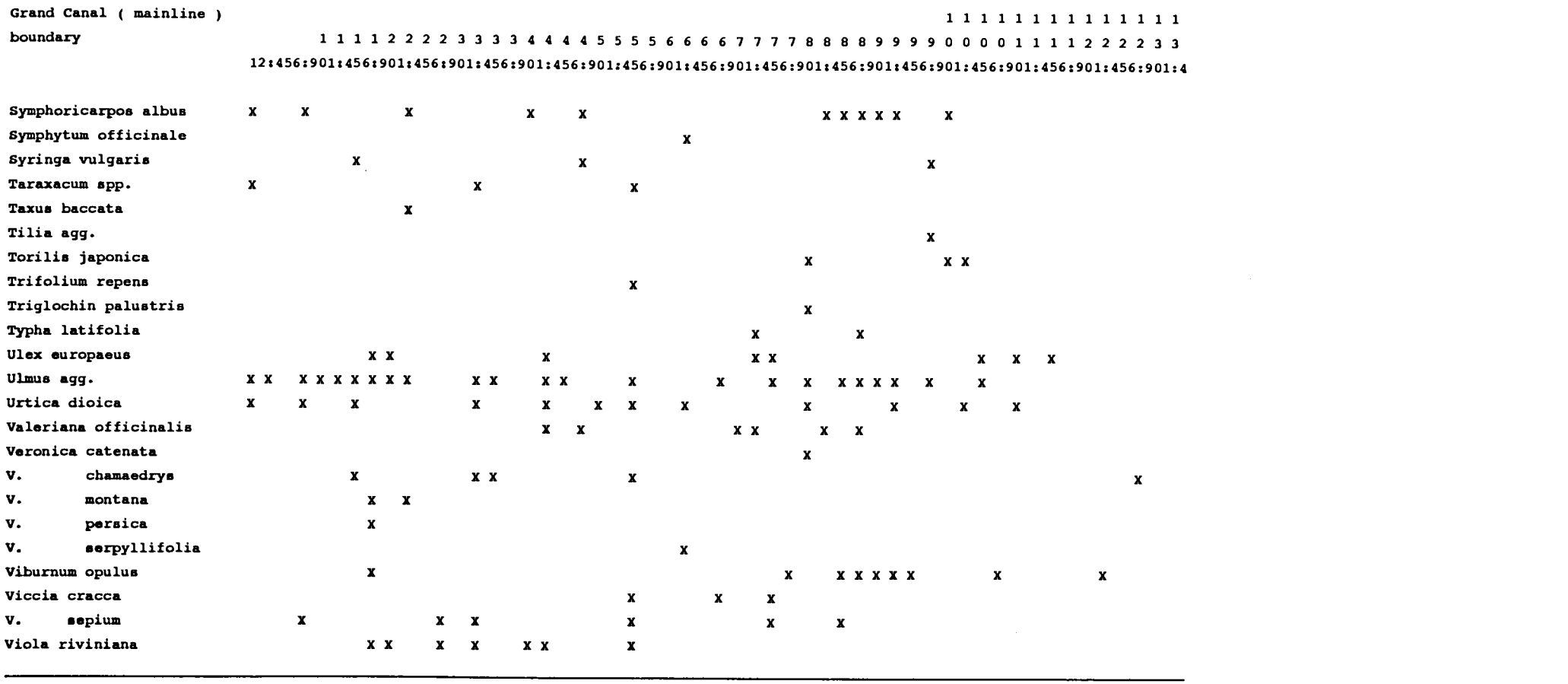
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	10	10	10	10	11	11	11	11	12	12	12	12	13	13
Acer pseudoplatanus				x	x	x	x	x		x				x	x					x	x			x		x		x					x		x	x		x	x	x	x	x						x		x		x		
Achillea millefolium							x		x														x																															
Aegopodium podagraria														x												x																												
Aesculus hippocastanum																																x	x			x							x											
Agrostis stolonifera																																x	x					x															x	
Ajuga reptans																																																			x			
Alisma plantago-aquatica																																x	x																					
Alliaria petiolata				x																																					x													
Allium ursinum							x																																	x		x												
Alnus glutinosa												x	x																	x	x				x									x								x		
Anacamptis pyramidalis												x																																										
Andromeda polifolia																															x																							
Angelica sylvestris	x											x						x	x	x																																		
Anthoxanthum odoratum																																															x							
Anthriscus sylvestris							x						x	x						x			x	x																x														
Apium nodiflorum												x							x	x					x	x																												
Arum maculatum								x		x				x			x				x		x												x					x		x												
Asplenium ruta-muraria	x																																																					
Betula spp.																								x	x	x		x	x	x	x	x	x		x	x									x	x	x	x	x	x				
Brachypodium sylvaticum						x		x		x		x											x													x	x	x						x				x		x	x	x	x	
Brizia media												x																																										
Bromus erectus														x																																						x		
B. ramosus										x																															x													
Callitriche spp.												x														x							x																					
Calluna vulgaris																															x																x							
Caltha palustris																		x		x					x	x							x			x																		
Calystegia sepium	x			x			x													x							x	x	x	x	x	x	x	x		x		x	x			x		x		x	x	x						
Cardamine pratensis																		x							x																													
Carex acutiformis																	x								x																													
C. disticha																		x						x																														
C. echinata																															x																							
C. elata																		x																																				
C. flacca												x						x																																				
C. hirta														x																																								


Grand Canal (mainline)
boundary
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Carex nigra
C. pulicaris
C. remota
C. rostrata
C. sylvatica
Carlina vulgaris
Cerastium arvense
Chamaecyparis lawsoniana
Charaphytes
Circaea lutetiana
Cirsium arvense
C. dissectum
C. vulgare
Clematis vitalba
Corylus avellana
Crataegus monogyna
Cynosurus cristatus
Dactylis glomerata
Dactylorhiza fuchsii
D. maculata
Eleocharis palustris
Elymus repens
Epilobium angustifolium
E. hirsutum
E. montanum
Equisetum arvense
E. fluviatile
Erica cinerea
Erica tetralix
Eriophorum angustifolium
Euonymus europaeus
Fagus sylvatica
Festuca arundinacea
F. rubra
Filipendula ulmaria


Grand Canal (mainline)
boundary
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Fontinalis antipyretica
Fragraria vesca
Fraxinus exelsior
Galium aparine
G. palustre
G. verum
Geranium robertianum
Geum urbanum
Glechoma hederacea
Glyceria fluitans
G. maxima
Hedera helix
Heracleum sphondylium
Holcus lanatus
Hordeum murinum
Hydrocotyle vulgaris
Hypericum pulchrum
Ilex aquifolium
Iris pseudacorus
Juncus articulatus
J. bufonius
J. effusus
J. inflexus
Larix spp.
Lathyrus pratensis
Lemna minor
L. trisulca
Leontodon hispidus
Leucanthemum vulgare
Ligustrum vulgaris
Linum catharticum
Listera ovata
Lonicera nitida
L. periclymenum
Lotus corniculatus
Lythrum salicaria


Grand Canal (mainline)
boundary
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Malus sylvestris
Malus spp.
Malva sylvestris
Mentha aquatica
Menyanthes trifoliata
Molinea caerulea
Myosotis scorpioides
Myriophyllum spp.
Narthecium ossifragum
Nasturtium officinale
Orchis mascula
Papaver spp.
Petasites hybridus
Phalaris arundinacea
Phleum pratense
Phragmites australis
Phyllitis scolopendrium
Pimpinella saxifraga
Pinus sylvestris
Plantago lanceolata
Polygala serpyllifolia
Polygonum amphibium
Polypodium vulgare
Populus spp.
Potamogeton coloratus
P. crispus
P. pectinatus
Potentilla erecta
P. sterilis
Primula veris
P. vulgaris
Prunella vulgaris
Prunus avium
P. spinosa
Pteridium aquilinum
Pulicaria dysenterica


Grand Canal (mainline)
boundary
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Quercus spp.
Ranunculus ficaria
R. flammula
R. repens
Rhamnus catharticus
Ribes uva-crispa
Rosa spp.
Rosa arvensis
R. canina
Rubus fruticosus
R. idaeus
Rumex crispus
R. sanguineus
Salix alba
S. caprea
S. cinerea
S. fragilis
S. repens
S. viminalis
S. spp.
Sambucus nigra
Sanguisorba minor
Sanicula europaea
Scirpus caespitosus
Senecio jacobea
S. vulgaris
Silene vulgaris
Sisymbrium officinale
Solanum dulcamara
Sorbus aucuparia
S. hibernica
Sparganium erectum
Stachys palustris
Stellaria graminea
S. media
Succisa pratensis

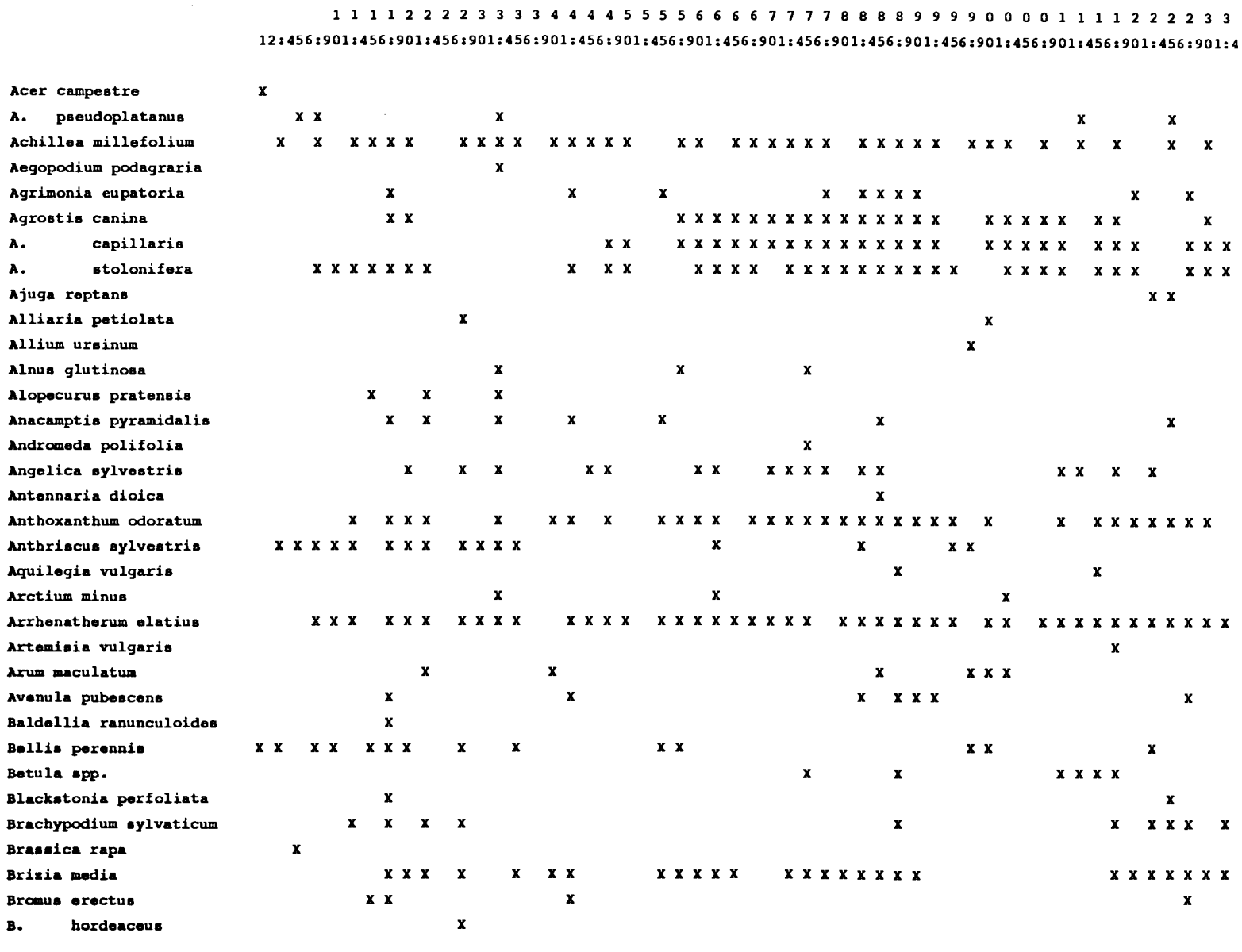

Grand Canal (mainline)
boundary
1 1 1 1 2 2 2 2 3 3 3 3 4 4 4 4 5 5 5 5 6 6 6 6 7 7 7 7 8 8 8 8 9 9 9 9 0 0 0 0 1 1 1 1 2 2 2 2 3 3
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Symphoricarpos albus
Symphytum officinale
Syringa vulgaris
Taraxacum spp.
Taxus baccata
Tilia agg.
Torilis japonica
Trifolium repens
Triglochin palustris
Typha latifolia
Ulex europaeus
Ulmus agg.
Urtica dioica
Valeriana officinalis
Veronica catenata
V. chamaedrys
V. montana
V. persica
V. serpyllifolia
Viburnum opulus
Viccia cracca
V. sepium
Viola riviniana

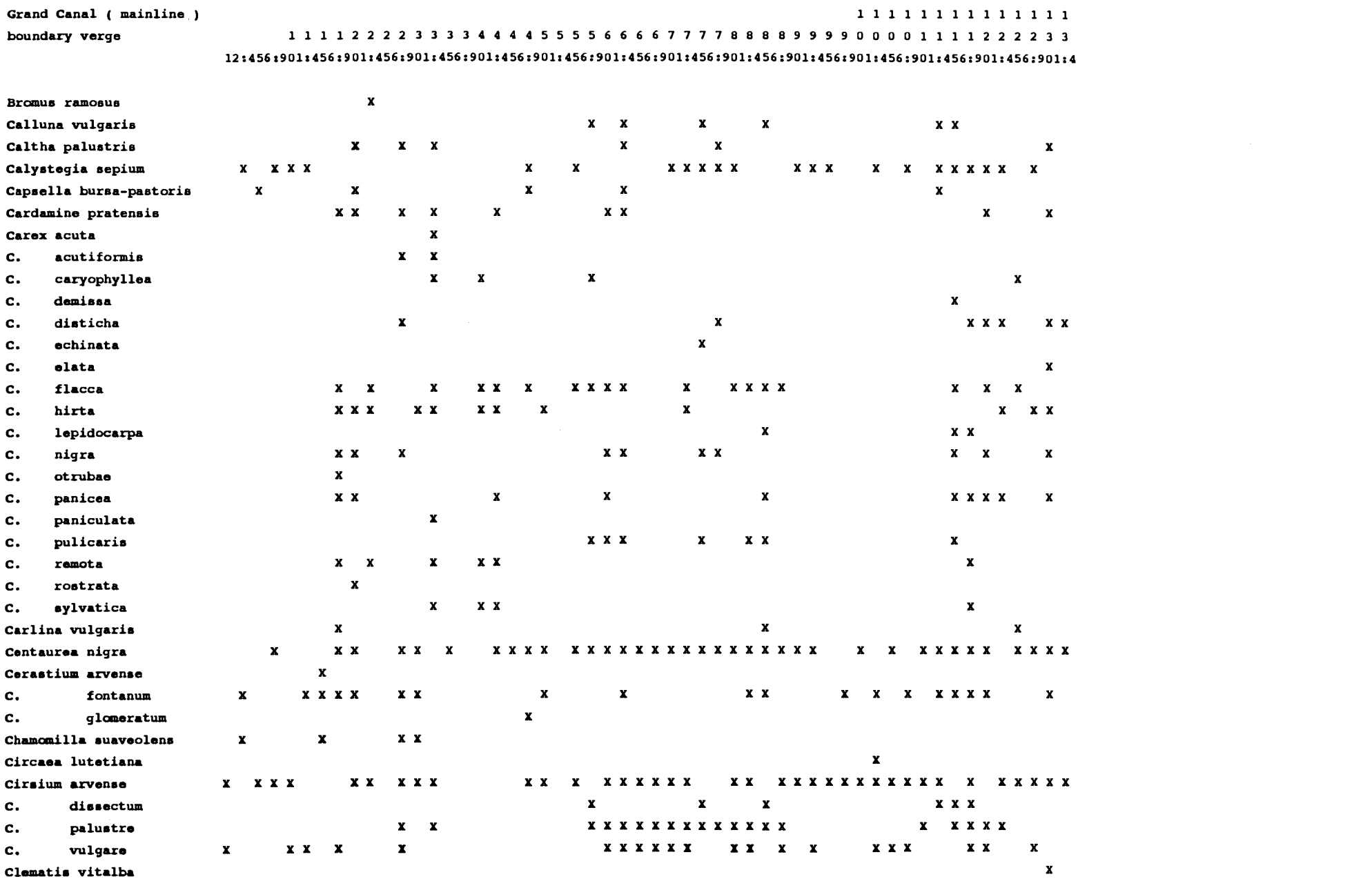
APPENDIX 2

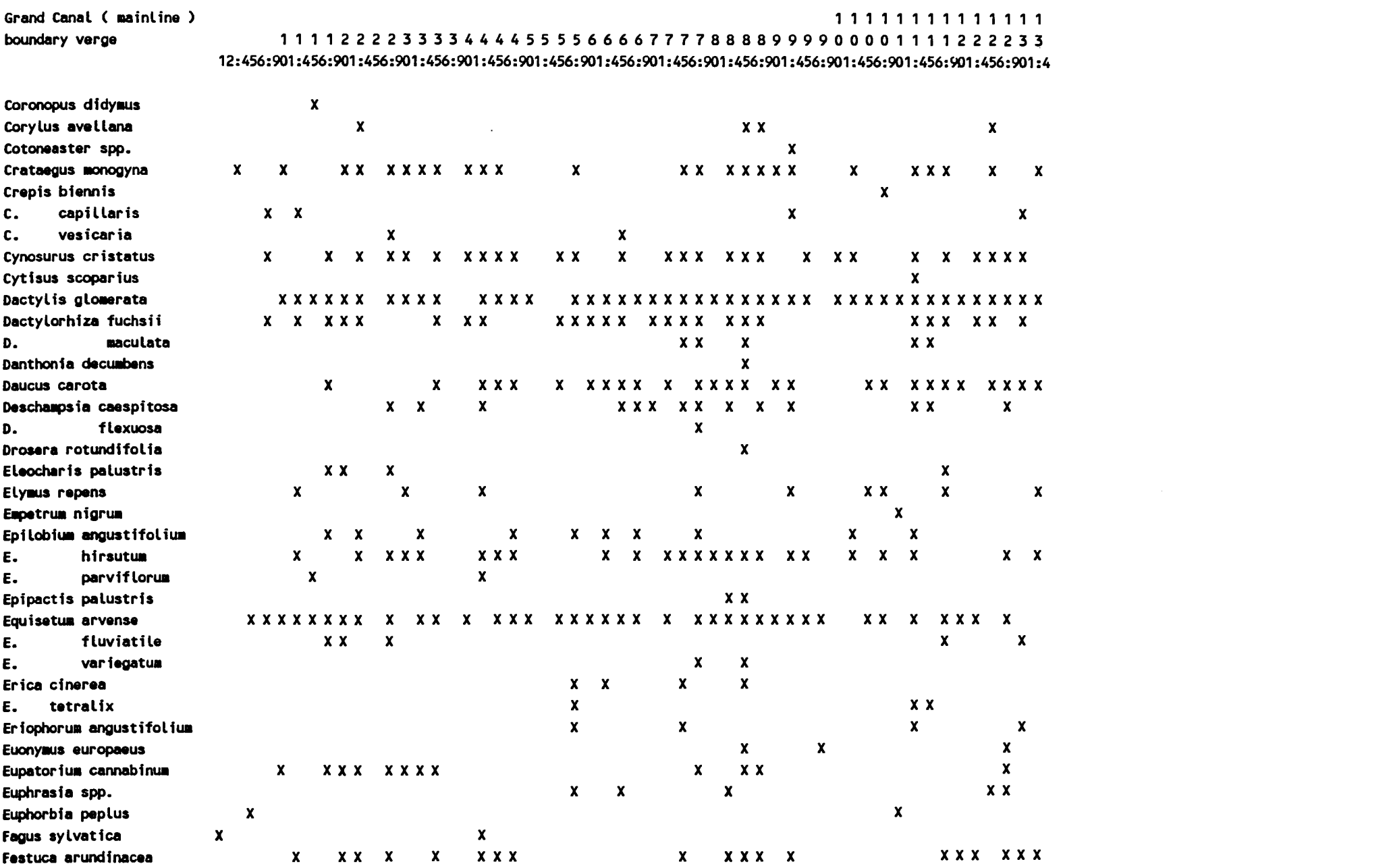
Flora of the Boundary Verge - Main Line

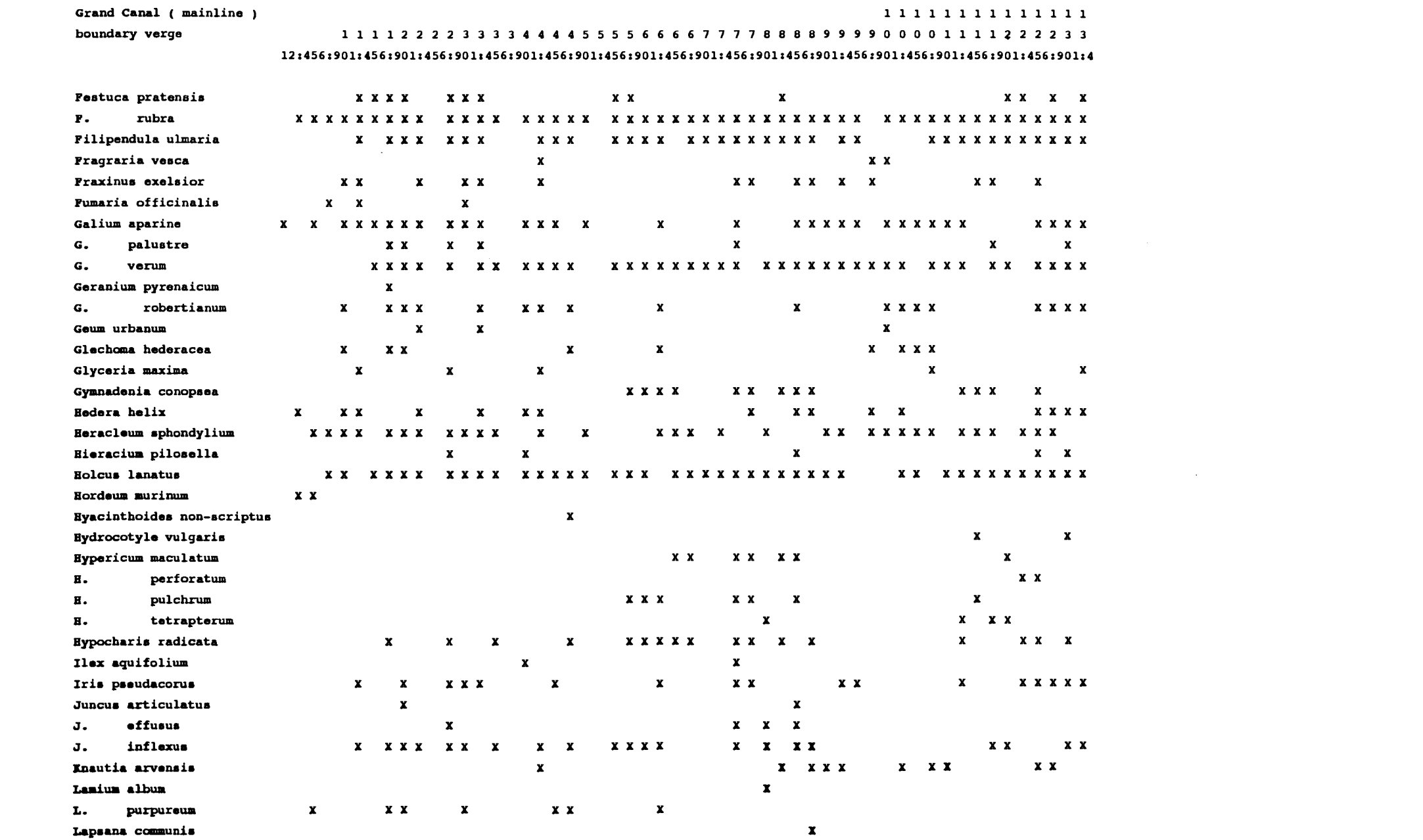
GRAND CANAL : MAINLINE 1991

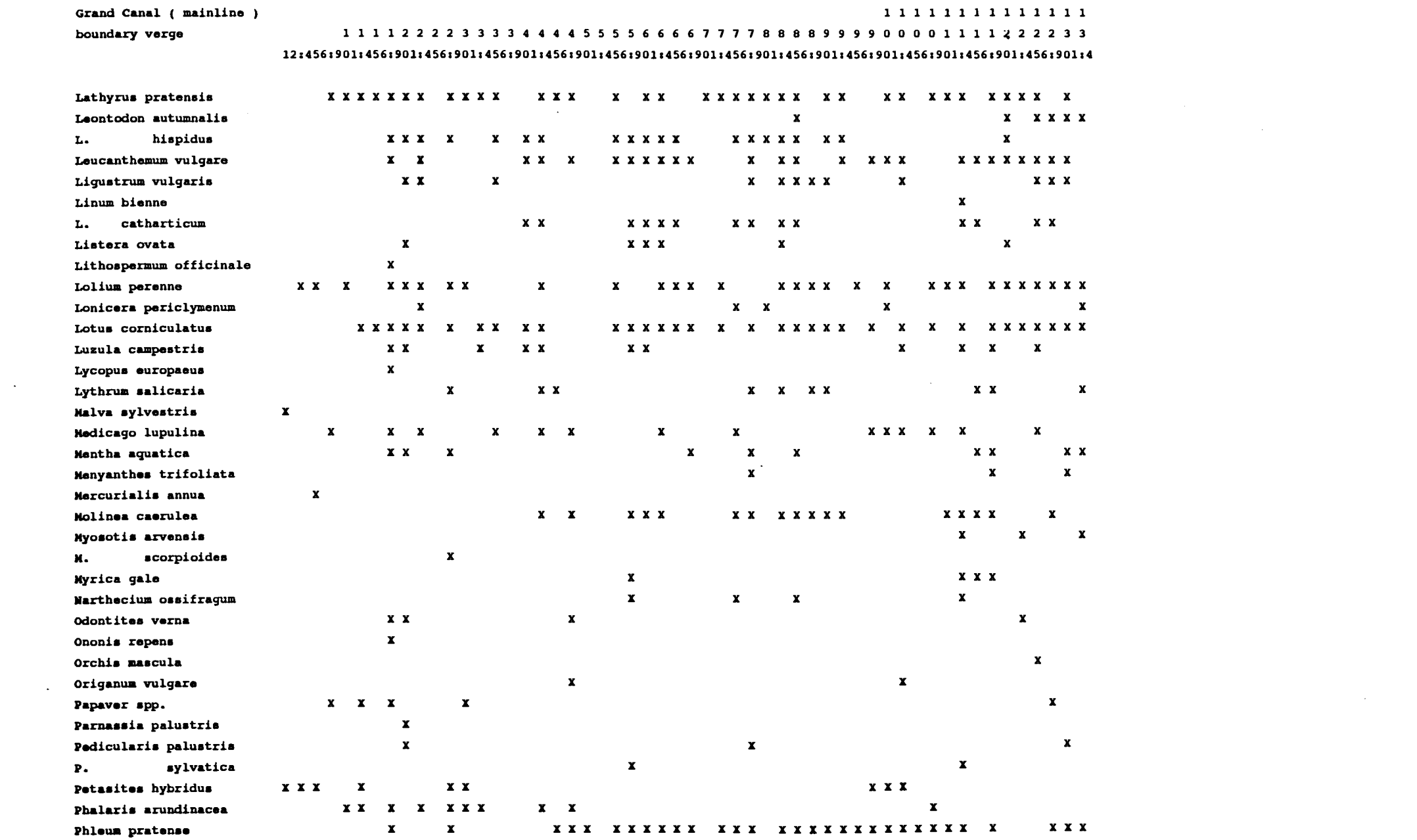
BOUNDARY VERGE

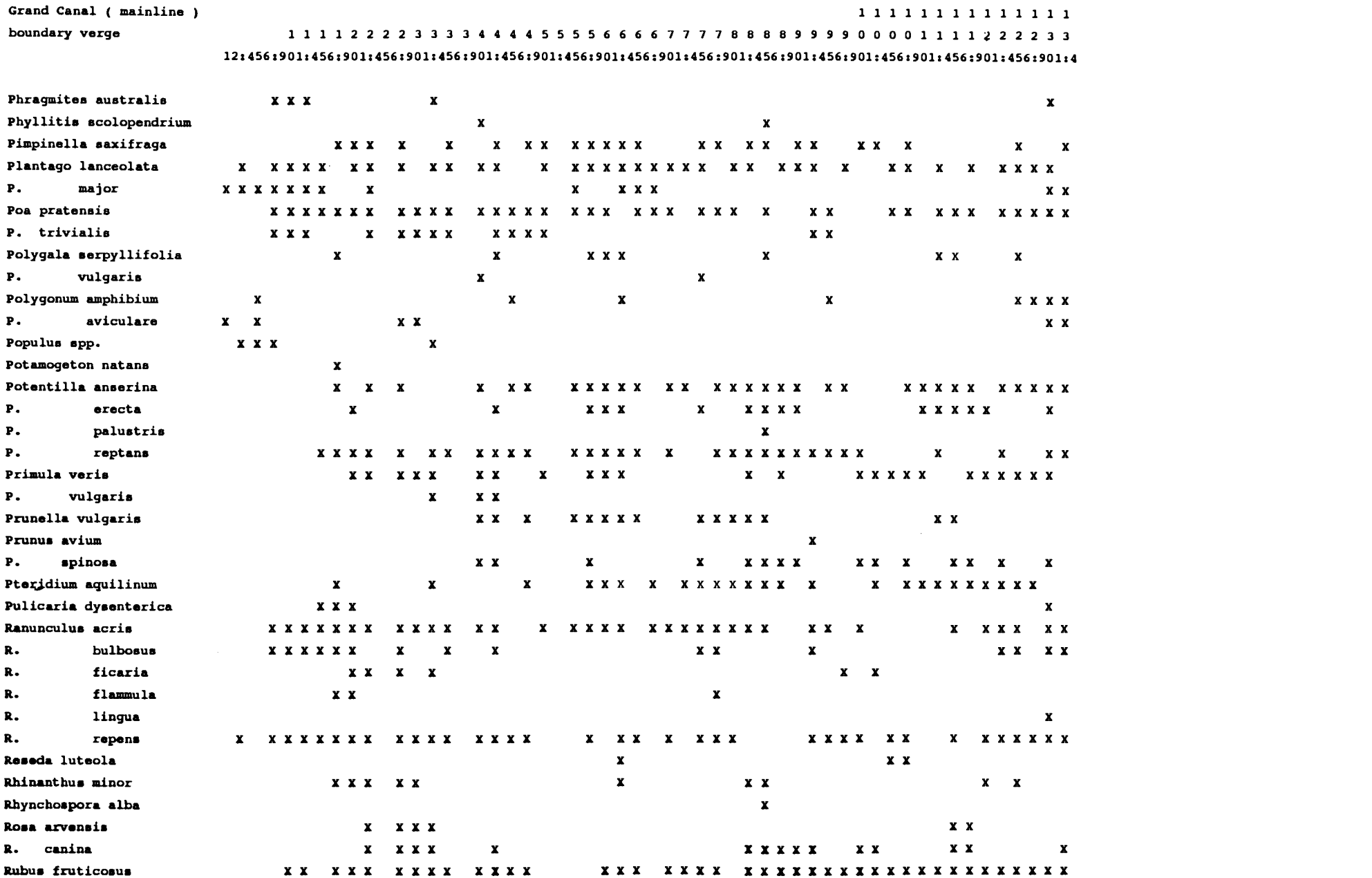


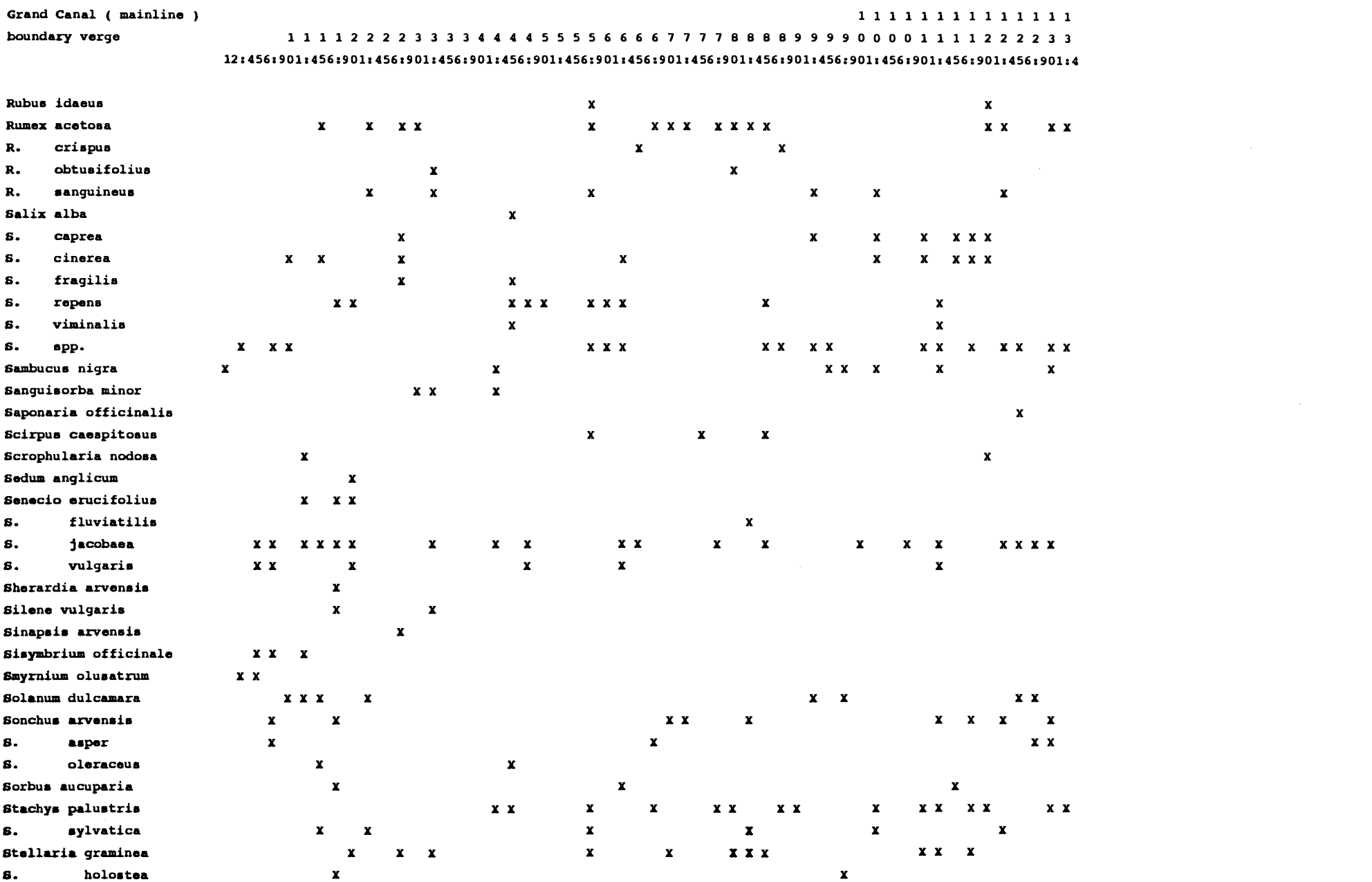

Grand Canal (mainline)
boundary verge
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Bromus ramosus
Calluna vulgaris
Caltha palustris
Calystegia sepium
Capsella bursa-pastoris
Cardamine pratensis
Carex acuta
C. acutiformis
C. caryophyllea
C. demissa
C. disticha
C. echinata
C. elata
C. flacca
C. hirta
C. lepidocarpa
C. nigra
C. otrubae
C. panicea
C. paniculata
C. pulicaris
C. remota
C. rostrata
C. sylvatica
Carlina vulgaris
Centaurea nigra
Cerastium arvense
C. fontanum
C. glomeratum
Chamomilla suaveolens
Circaea lutetiana
Cirsium arvense
C. dissectum
C. palustre
C. vulgare
Clematis vitalba

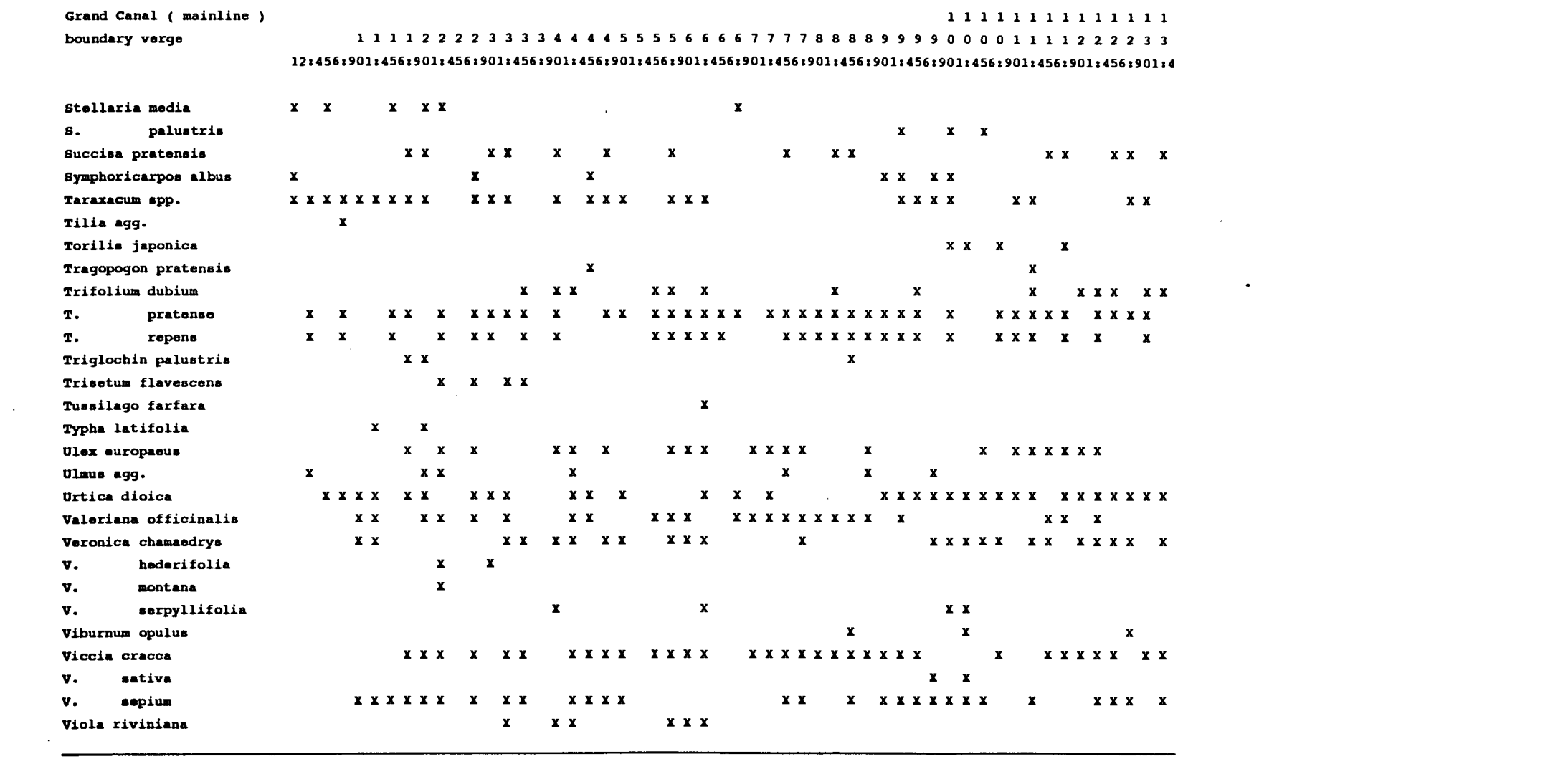

Grand Canal (mainline)
boundary verge
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Coronopus didymus
Corylus avellana
Cotoneaster spp.
Crataegus monogyna
Crepis biennis
C. capillaris
C. vesicaria
Cynosurus cristatus
Cytisus scoparius
Dactylis glomerata
Dactylorhiza fuchsii
D. maculata
Danthonia decumbens
Daucus carota
Deschampsia caespitosa
D. flexuosa
Drosera rotundifolia
Eleocharis palustris
Elymus repens
Empetrum nigrum
Epilobium angustifolium
E. hirsutum
E. parviflorum
Epipactis palustris
Equisetum arvense
E. fluviatile
E. variegatum
Erica cinerea
E. tetralix
Eriophorum angustifolium
Euonymus europaeus
Eupatorium cannabinum
Euphrasia spp.
Euphorbia peplus
Fagus sylvatica
Festuca arundinacea


Grand Canal (mainline)
boundary verge
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Festuca pratensis
F. rubra
Filipendula ulmaria
Fragraria vesca
Fraxinus exelsior
Fumaria officinalis
Galium aparine
G. palustre
G. verum
Geranium pyrenaicum
G. robertianum
Geum urbanum
Glechoma hederacea
Glyceria maxima
Gymnadenia conopsea
Hedera helix
Heracleum sphondylium
Hieracium pilosella
Holcus lanatus
Hordeum murinum
Hyacinthoides non-scriptus
Hydrocotyle vulgaris
Hypericum maculatum
H. perforatum
H. pulchrum
H. tetrapterum
Hypocharis radicata
Ilex aquifolium
Iris pseudacorus
Juncus articulatus
J. effusus
J. inflexus
Knautia arvensis
Lamium album
L. purpureum
Lapsana communis


Grand Canal (mainline)
boundary verge
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Lathyrus pratensis
Leontodon autumnalis
L. hispidus
Leucanthemum vulgare
Ligustrum vulgaris
Linum bienne
L. catharticum
Listera ovata
Lithospermum officinale
Lolium perenne
Lonicera periclymenum
Lotus corniculatus
Luzula campestris
Lycopus europaeus
Lythrum salicaria
Malva sylvestris
Medicago lupulina
Mentha aquatica
Menyanthes trifoliata
Mercurialis annua
Molinea caerulea
Myosotis arvensis
M. scorpioides
Myrica gale
Narthecium ossifragum
Odontites verna
Ononis repens
Orchis mascula
Origanum vulgare
Papaver spp.
Parnassia palustris
Pedicularis palustris
P. sylvatica
Petasites hybridus
Phalaris arundinacea
Phleum pratense


Grand Canal (mainline)
boundary verge
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Phragmites australis
Phyllitis scolopendrium
Pimpinella saxifraga
Plantago lanceolata
P. major
Poa pratensis
P. trivialis
Polygala serpyllifolia
P. vulgaris
Polygonum amphibium
P. aviculare
Populus spp.
Potamogeton natans
Potentilla anserina
P. erecta
P. palustris
P. reptans
Primula veris
P. vulgaris
Prunella vulgaris
Prunus avium
P. spinosa
Pteridium aquilinum
Pulicaria dysenterica
Ranunculus acris
R. bulbosus
R. ficaria
R. flammula
R. lingua
R. repens
Reseda luteola
Rhinanthus minor
Rhynchospora alba
Rosa arvensis
R. canina
Rubus fruticosus


Grand Canal (mainline)
boundary verge
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Rubus idaeus
Rumex acetosa
R. crispus
R. obtusifolius
R. sanguineus
Salix alba
S. caprea
S. cinerea
S. fragilis
S. repens
S. viminalis
S. spp.
Sambucus nigra
Sanguisorba minor
Saponaria officinalis
Scirpus caespitosus
Scrophularia nodosa
Sedum anglicum
Senecio erucifolius
S. fluviatilis
S. jacobaea
S. vulgaris
Sherardia arvensis
Silene vulgaris
Sinapsis arvensis
Sisymbrium officinale
Smyrnium olusatrum
Solanum dulcamara
Sonchus arvensis
S. asper
S. oleraceus
Sorbus aucuparia
Stachys palustris
S. sylvatica
Stellaria graminea
S. holostea


Grand Canal (mainline)
boundary verge
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Stellaria media
S. palustris
Succisa pratensis
Symphoricarpos albus
Taraxacum spp.
Tilia agg.
Torilis japonica
Tragopogon pratensis
Trifolium dubium
T. pratense
T. repens
Triglochin palustris
Trisetum flavescens
Tussilago farfara
Typha latifolia
Ulex europaeus
Ulmus agg.
Urtica dioica
Valeriana officinalis
Veronica chamaedrys
V. hederifolia
V. montana
V. serpyllifolia
Viburnum opulus
Viccia cracca
V. sativa
V. sepium
Viola riviniana

APPENDIX 3

Flora of the Towpath - Mainn Line

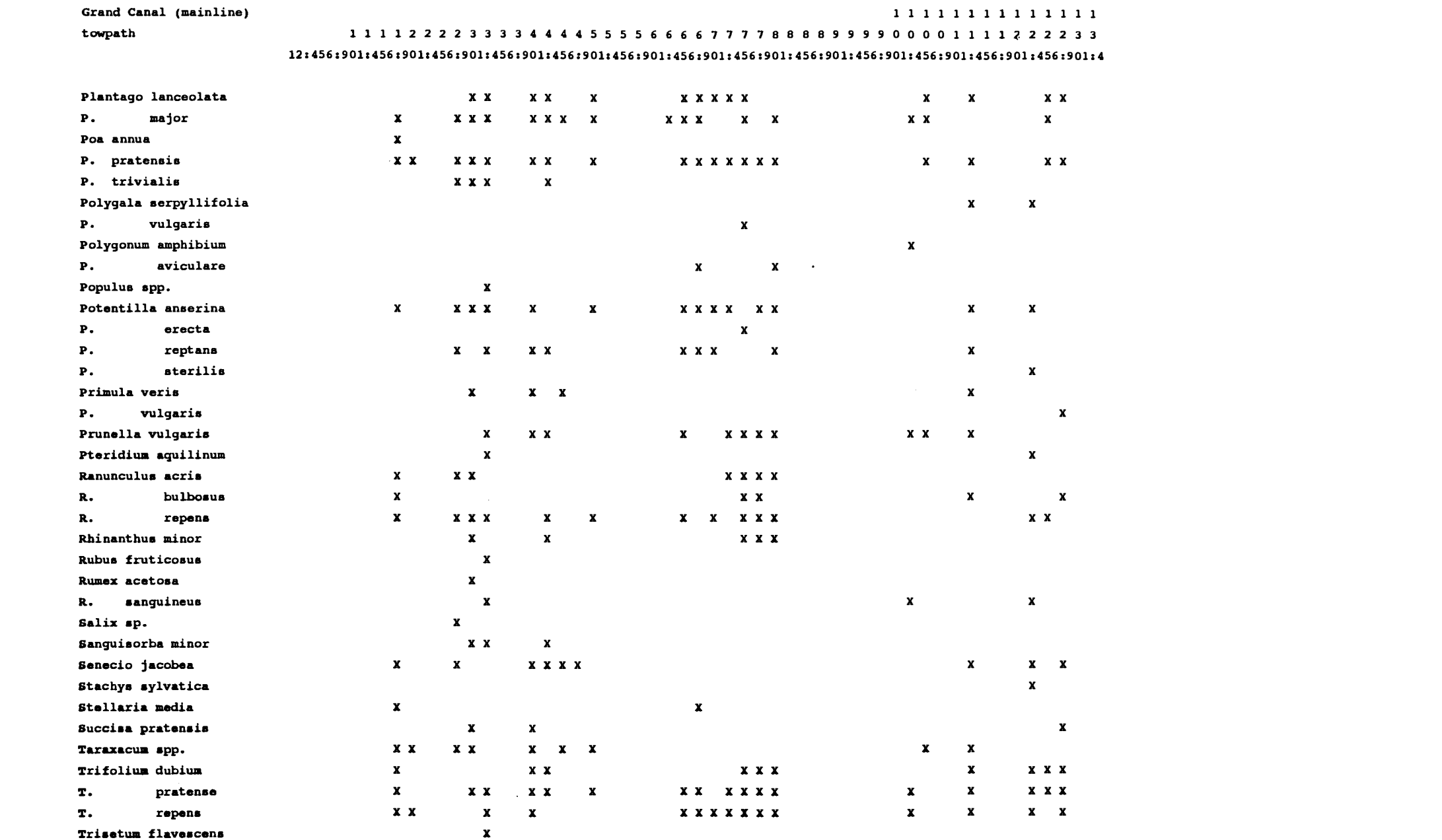
GRAND CANAL : MAINLINE 1991

TOWPATH	1	1	1	1	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	0	0	0	0	1	1	1	1	2	2	2	2	3	3
	12:	4	5	6	9	0	1	:	4	5	6	9	0	1	:	4	5	6	9	0	1	:	4	5	6	9	0	1	:	4	5	6	9	0	1	:	4	5	6	9	0	1	:	4	5	6	9	0	1	:	4
Acer pseudoplatanus									X																																									
Achillea millefolium							X	X				X	X								X			X	X	X	X														X				X	X				
Agrostis canina																					X	X	X	X	X	X	X									X	X											
A. capillaris																					X	X	X	X	X	X	X									X	X								X			
A. stolonifera																X					X	X		X	X	X									X	X								X			
Ajuga reptans																																											X					
Angelica sylvestris																								X																							
Anthoxanthum odoratum			X					X	X			X	X									X	X	X	X	X														X				X	X				
Arctium minus							X																																					X	X			
Arrhenatherum elatius							X	X	X							X					X	X	X	X	X		X									X				X				X	X	X			
Avenula pubescens									X																																								
Bellis perennis		X	X					X	X			X	X	X	X	X					X				X	X	X									X	X			X				X			X		
Brachypodium sylvaticum																																											X					
Brizia media									X			X	X											X	X	X	X														X				X	X	X			
Capsella bursa-pastoris		X																																														
Carex caryophyllea												X																																					
C. flacca							X					X	X											X																X				X		X			
C. hirta							X	X	X			X				X								X																						X		
Centaurea nigra													X								X				X	X	X													X					X	X			
Cerastium fontanum							X									X																					X	X		X								
Chamomilla suaveolens								X																																								
Chenopodium album																						X																									
Cirsium arvense		X					X	X	X																																		X	X	X			
C. vulgare								X																													X	X										
Conopodium majus																																										X						
Crataegus monogyna									X				X																																			
Crepis vesicaria																					X																						X					
Cynosurus cristatus		X						X	X			X	X								X				X	X	X													X				X	X	X			
Dactylis glomerata		X	X			X	X	X					X			X					X			X	X	X	X	X								X	X			X				X	X	X			
Dactylorhiza fuchsii																					X				X	X																							
Danthonia decumbens																																										X						
Daucus carota																					X				X												X			X					X	X			
Elymus repens								X																																									
Epilobium hirsutum							X																																										

Grand Canal (mainline) towpath

12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4

Grand Canal (mainline) towpath	1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	5	5	5	5	6	6	6	6	7	7	7	7	8	8	8	8	9	9	9	9	10	10	10	10	11	11	11	11	12	12	12	12	13	13
Equisetum arvense								x		x			x										x				x																					x		
Euphrasia spp.				x						x													x			x	x	x	x													x					x	x		
Festuca arundinacea								x																																										
F. pratensis								x	x	x																																								
F. rubra				x	x			x	x	x			x	x			x						x	x	x	x	x	x	x								x	x	x			x					x	x		
Filipendula ulmaria																										x																				x		x		
Fraxinus exelsior										x																																								
Galium aparine										x																																								
G. verum										x			x	x									x			x																x					x			
Gymnadenia conopsea																											x																							
Hedera helix										x																																								
Heracleum sphondylium										x							x						x															x								x	x			
Hieracium pilosella													x																																					
Holcus lanatus								x	x	x				x			x						x	x	x	x	x	x	x									x	x			x				x	x	x		
Hypericum maculatum																											x																							
H. perforatum																																														x	x			
Hypocharis radicata																							x																			x				x		x		
Juncus articulatus																							x																											
J. inflexus										x			x																																					
Lamium purpureum																								x																										
Lathyrus pratensis									x	x				x																																x				
Leontodon autumnalis																												x																				x		
L. hispidus									x				x	x													x	x																				x		
Leucanthemum vulgare										x					x								x				x	x	x													x				x	x	x		
Ligustrum vulgaris														x																																				
Linum catharticum				x						x			x										x				x	x														x				x	x	x		
Lolium perenne				x	x			x	x					x									x	x		x																x				x	x	x		
Lonicera periclymenum																											x																							
Lotus corniculatus										x			x	x									x	x		x		x														x					x	x		
Luzula campestris										x			x																																					
Medicago lupulina																																						x	x			x								
Molinea caerulea																											x	x																						
Odontites verna				x										x												x												x	x							x	x	x		
Phalaris arundinacea								x		x																																								
Phleum pratense				x				x									x							x		x	x	x										x	x									x		
Pimpinella saxifraga																							x				x	x	x																		x			


Grand Canal (mainline)
towpath
1 1 1 1 2 2 2 2 3 3 3 3 4 4 4 4 5 5 5 5 6 6 6 6 7 7 7 7 8 8 8 8 9 9 9 9 0 0 0 0 1 1 1 1 2 2 2 2 3 3
12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Plantago lanceolata
P. major
Poa annua
P. pratensis
P. trivialis
Polygala serpyllifolia
P. vulgaris
Polygonum amphibium
P. aviculare
Populus spp.
Potentilla anserina
P. erecta
P. reptans
P. sterilis
Primula veris
P. vulgaris
Prunella vulgaris
Pteridium aquilinum
Ranunculus acris
R. bulbosus
R. repens
Rhinanthus minor
Rubus fruticosus
Rumex acetosa
R. sanguineus
Salix sp.
Sanguisorba minor
Senecio jacobea
Stachys sylvatica
Stellaria media
Succisa pratensis
Taraxacum spp.
Trifolium dubium
T. pratense
T. repens
Trisetum flavescens

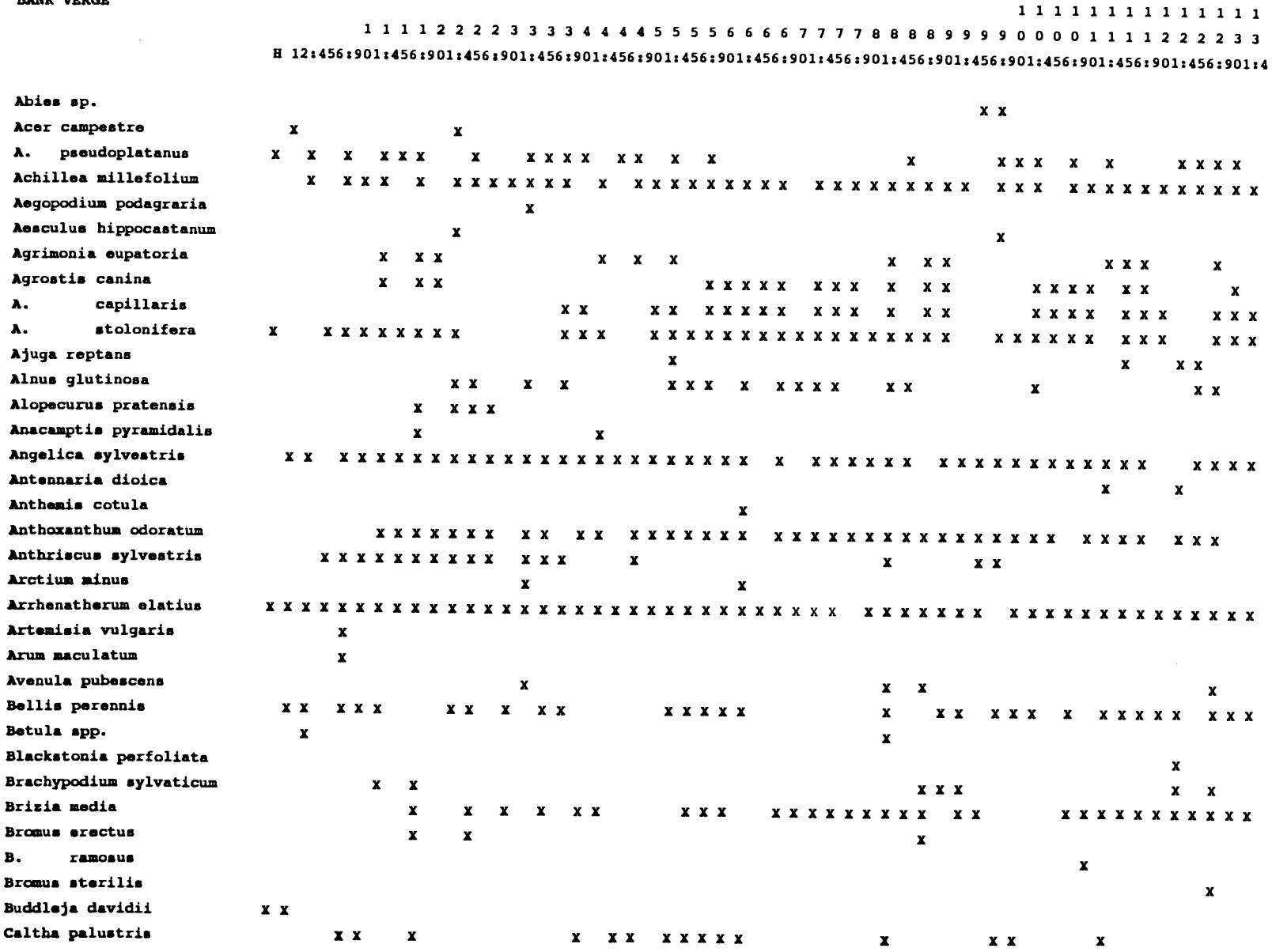
```
Grand Canal (mainline)                                                                                     1 1 1 1 1 1 1 1 1 1 1 1 1 1
towpath                            1 1 1 1 2 2 2 2 3 3 3 3 4 4 4 4 5 5 5 5 6 6 6 6 7 7 7 7 8 8 8 8 9 9 9 9 0 0 0 0 1 1 1 1 2 2 2 2 3 3
                           12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4

Ulex europaeus                                             x x                                                               x
Urtica dioica                                    x   x
Valeriana officinalis                                                                                     x
Veronica chamaedrys                                          x                           x                                     x
V.       serpyllifolia                                                                                                         x
Viccia cracca                                                                             x                                       x
V.     sepium                                            x
Viola riviniana                                            x
```

APPENDIX 4

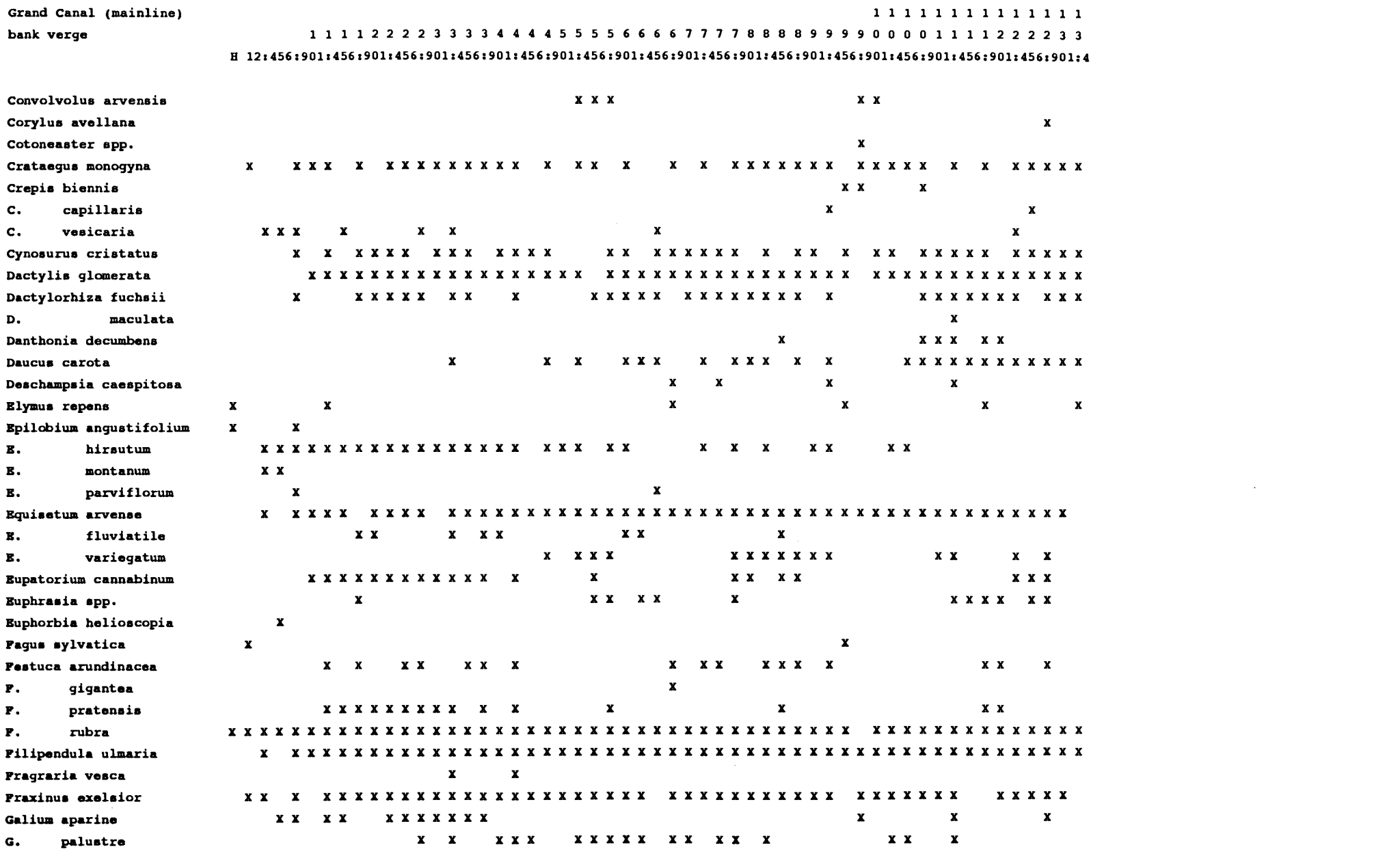
Flora of the Bank Verge - Main Line

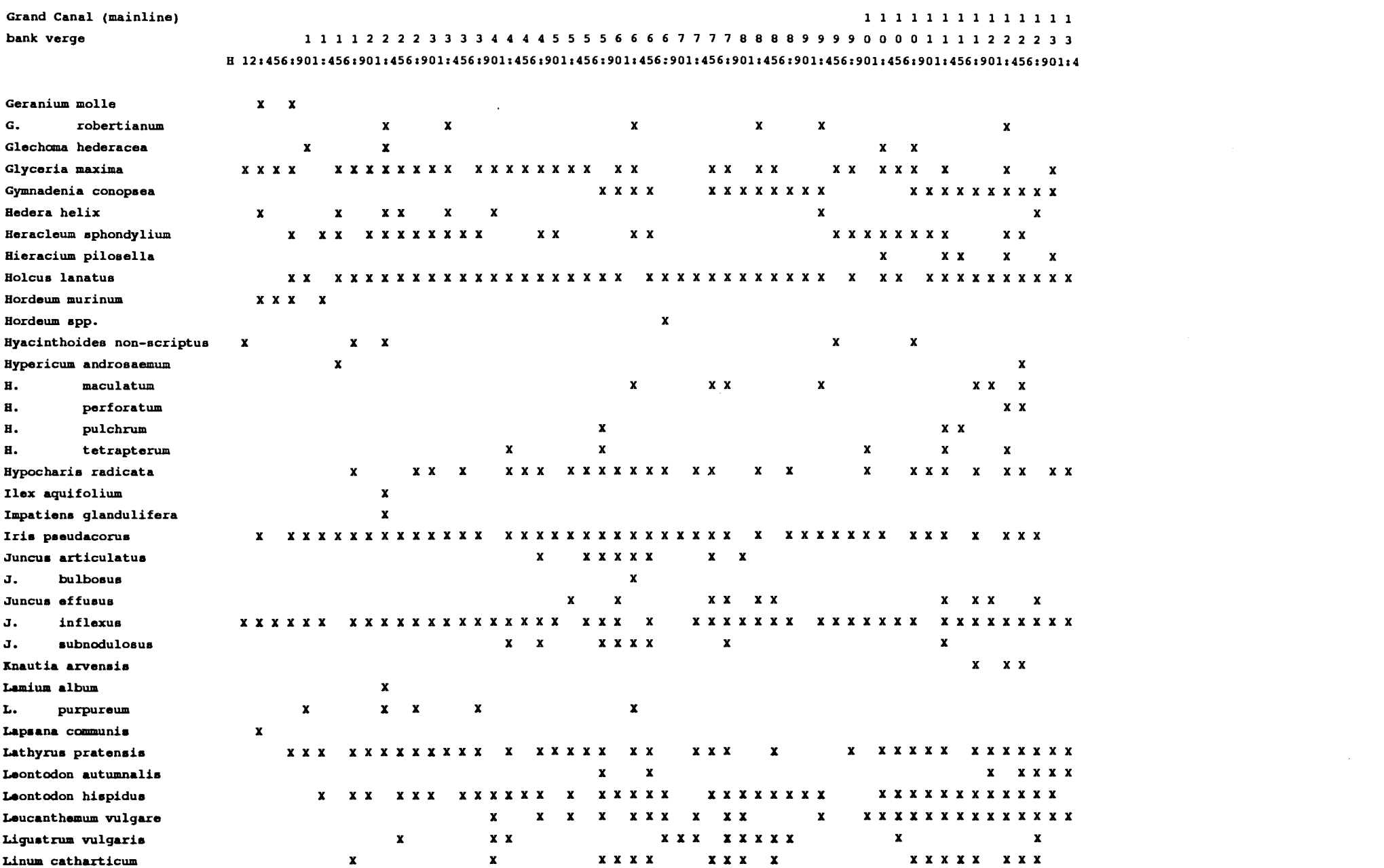
GRAND CANAL : MAINLINE 1991

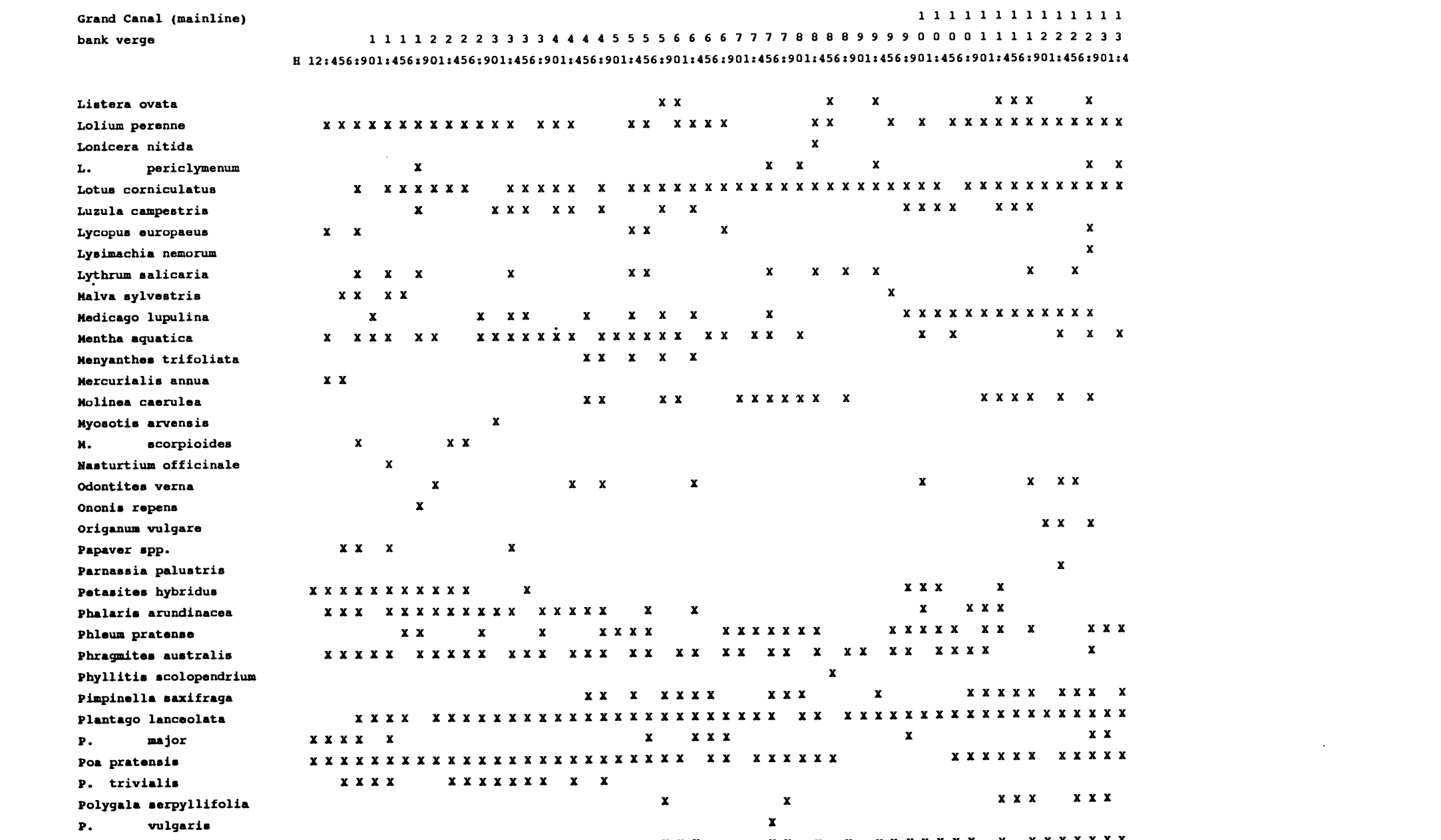
BANK VERGE

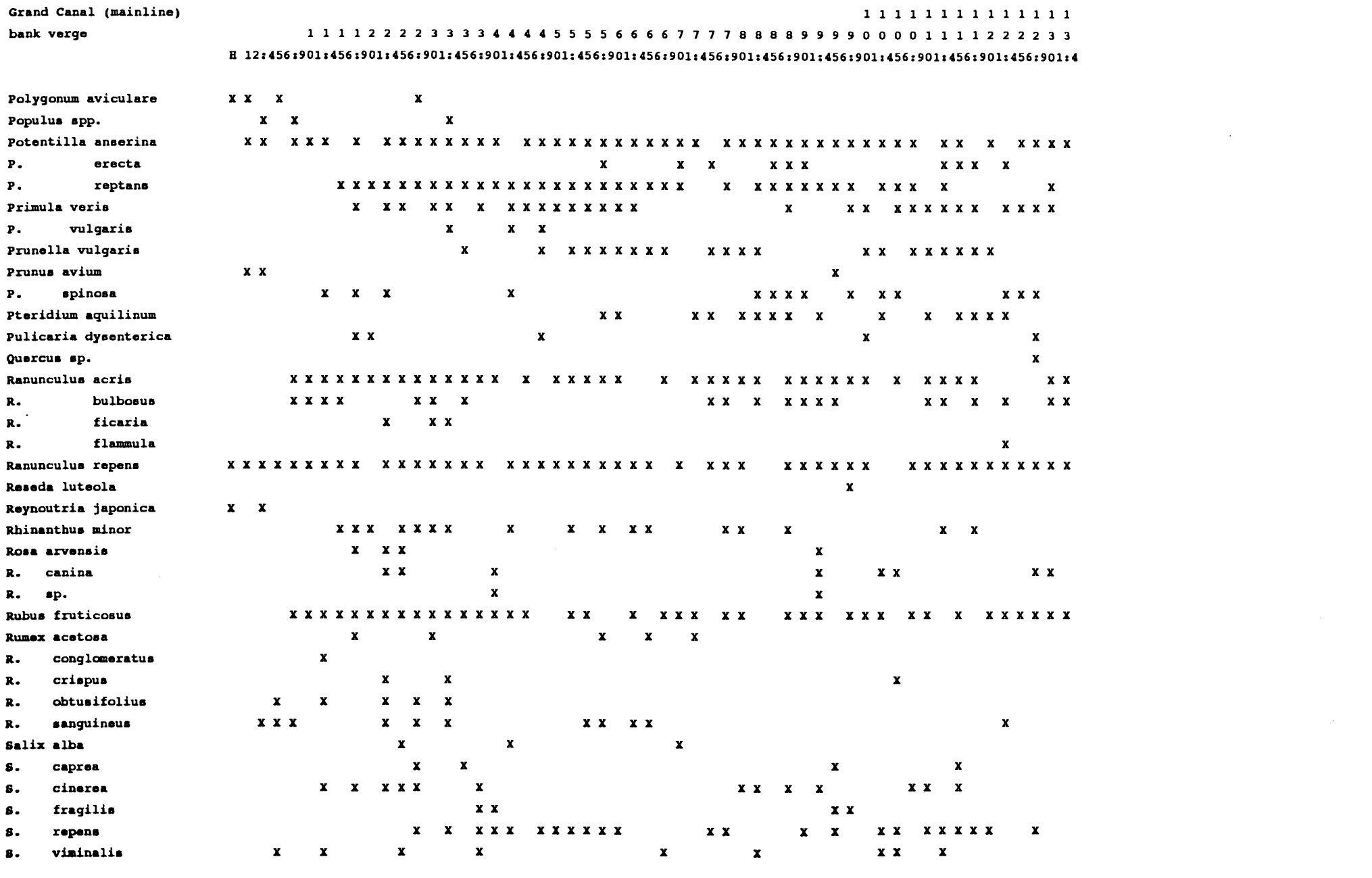


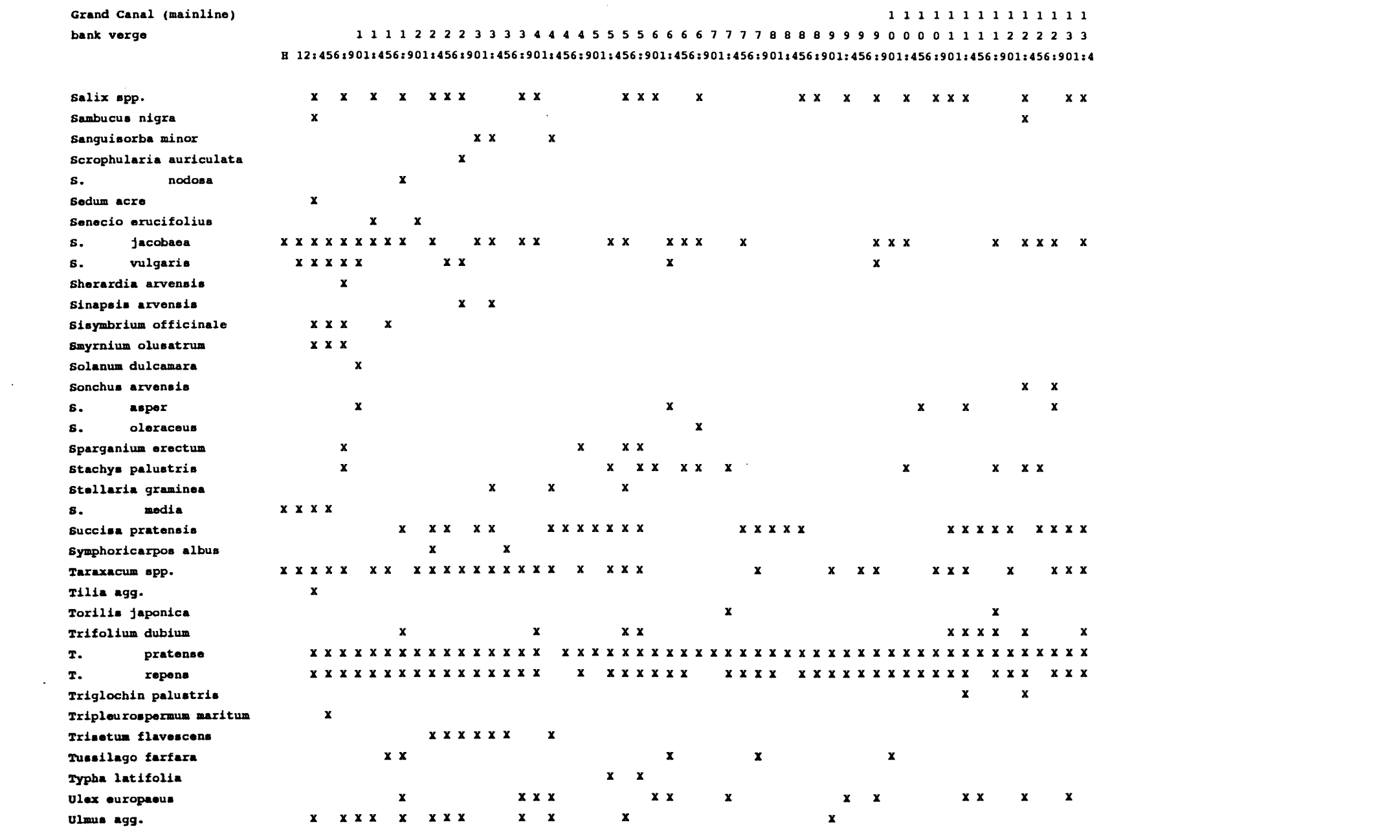

Grand Canal (mainline)
bank verge
H 12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Calystegia sepium
C. silvatica
Capsella bursa-pastoris
Cardamine pratensis
Carex acuta
C. acutiformis
C. caryophyllea
C. disticha
C. echinata
C. flacca
C. hirta
C. lepidocarpa
C. nigra
C. otrubae
C. panicea
C. paniculata
C. pulicaris
C. remota
C. rostrata
C. sylvatica
Carlina vulgaris
Centaurea nigra
Centaurium erythraea
Centranthus ruber
Cerastium arvense
C. fontanum
Chamomilla suaveolens
Chenopodium album
C. bonus-henricus
Cirsium arvense
C. dissectum
C. palustre
C. vulgare
Cladium mariscus
Clematis vitalba
Conopodium majus

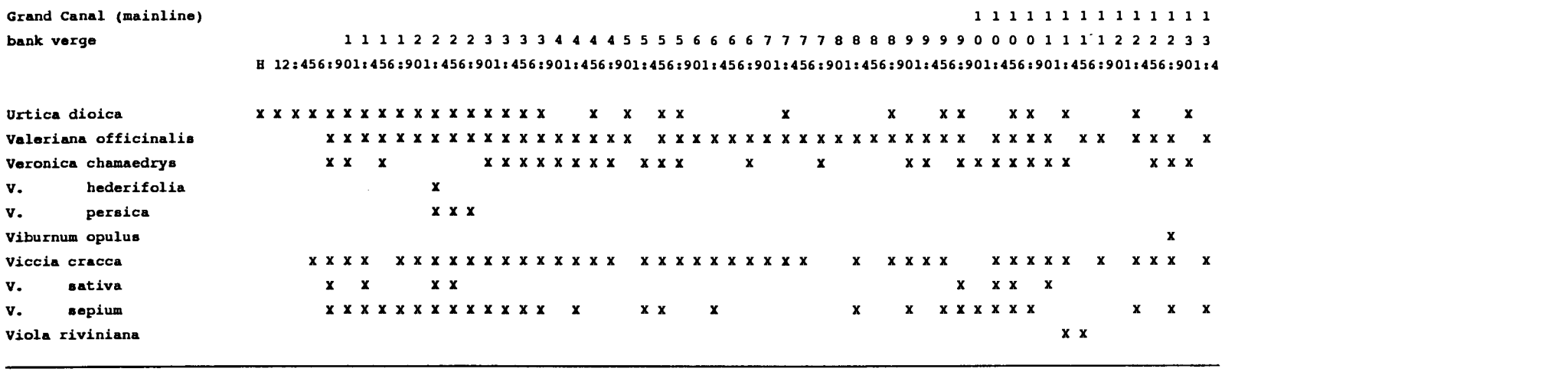

Grand Canal (mainline)
bank verge
H 12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Convolvolus arvensis
Corylus avellana
Cotoneaster spp.
Crataegus monogyna
Crepis biennis
C. capillaris
C. vesicaria
Cynosurus cristatus
Dactylis glomerata
Dactylorhiza fuchsii
D. maculata
Danthonia decumbens
Daucus carota
Deschampsia caespitosa
Elymus repens
Epilobium angustifolium
E. hirsutum
E. montanum
E. parviflorum
Equisetum arvense
E. fluviatile
E. variegatum
Eupatorium cannabinum
Euphrasia spp.
Euphorbia helioscopia
Fagus sylvatica
Festuca arundinacea
F. gigantea
F. pratensis
F. rubra
Filipendula ulmaria
Fragraria vesca
Fraxinus exelsior
Galium aparine
G. palustre
G. verum


Grand Canal (mainline)
bank verge
H 12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Geranium molle
G. robertianum
Glechoma hederacea
Glyceria maxima
Gymnadenia conopsea
Hedera helix
Heracleum sphondylium
Hieracium pilosella
Holcus lanatus
Hordeum murinum
Hordeum spp.
Hyacinthoides non-scriptus
Hypericum androsaemum
H. maculatum
H. perforatum
H. pulchrum
H. tetrapterum
Hypocharis radicata
Ilex aquifolium
Impatiens glandulifera
Iris pseudacorus
Juncus articulatus
J. bulbosus
Juncus effusus
J. inflexus
J. subnodulosus
Knautia arvensis
Lamium album
L. purpureum
Lapsana communis
Lathyrus pratensis
Leontodon autumnalis
Leontodon hispidus
Leucanthemum vulgare
Ligustrum vulgaris
Linum catharticum


Grand Canal (mainline)
bank verge
H 12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Listera ovata
Lolium perenne
Lonicera nitida
L. periclymenum
Lotus corniculatus
Luzula campestris
Lycopus europaeus
Lysimachia nemorum
Lythrum salicaria
Malva sylvestris
Medicago lupulina
Mentha aquatica
Menyanthes trifoliata
Mercurialis annua
Molinea caerulea
Myosotis arvensis
M. scorpioides
Nasturtium officinale
Odontites verna
Ononis repens
Origanum vulgare
Papaver spp.
Parnassia palustris
Petasites hybridus
Phalaris arundinacea
Phleum pratense
Phragmites australis
Phyllitis scolopendrium
Pimpinella saxifraga
Plantago lanceolata
P. major
Poa pratensis
P. trivialis
Polygala serpyllifolia
P. vulgaris
Polygonum amphibium


Grand Canal (mainline)
bank verge
H 12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Polygonum aviculare
Populus spp.
Potentilla anserina
P. erecta
P. reptans
Primula veris
P. vulgaris
Prunella vulgaris
Prunus avium
P. spinosa
Pteridium aquilinum
Pulicaria dysenterica
Quercus sp.
Ranunculus acris
R. bulbosus
R. ficaria
R. flammula
Ranunculus repens
Reseda luteola
Reynoutria japonica
Rhinanthus minor
Rosa arvensis
R. canina
R. sp.
Rubus fruticosus
Rumex acetosa
R. conglomeratus
R. crispus
R. obtusifolius
R. sanguineus
Salix alba
S. caprea
S. cinerea
S. fragilis
S. repens
S. viminalis

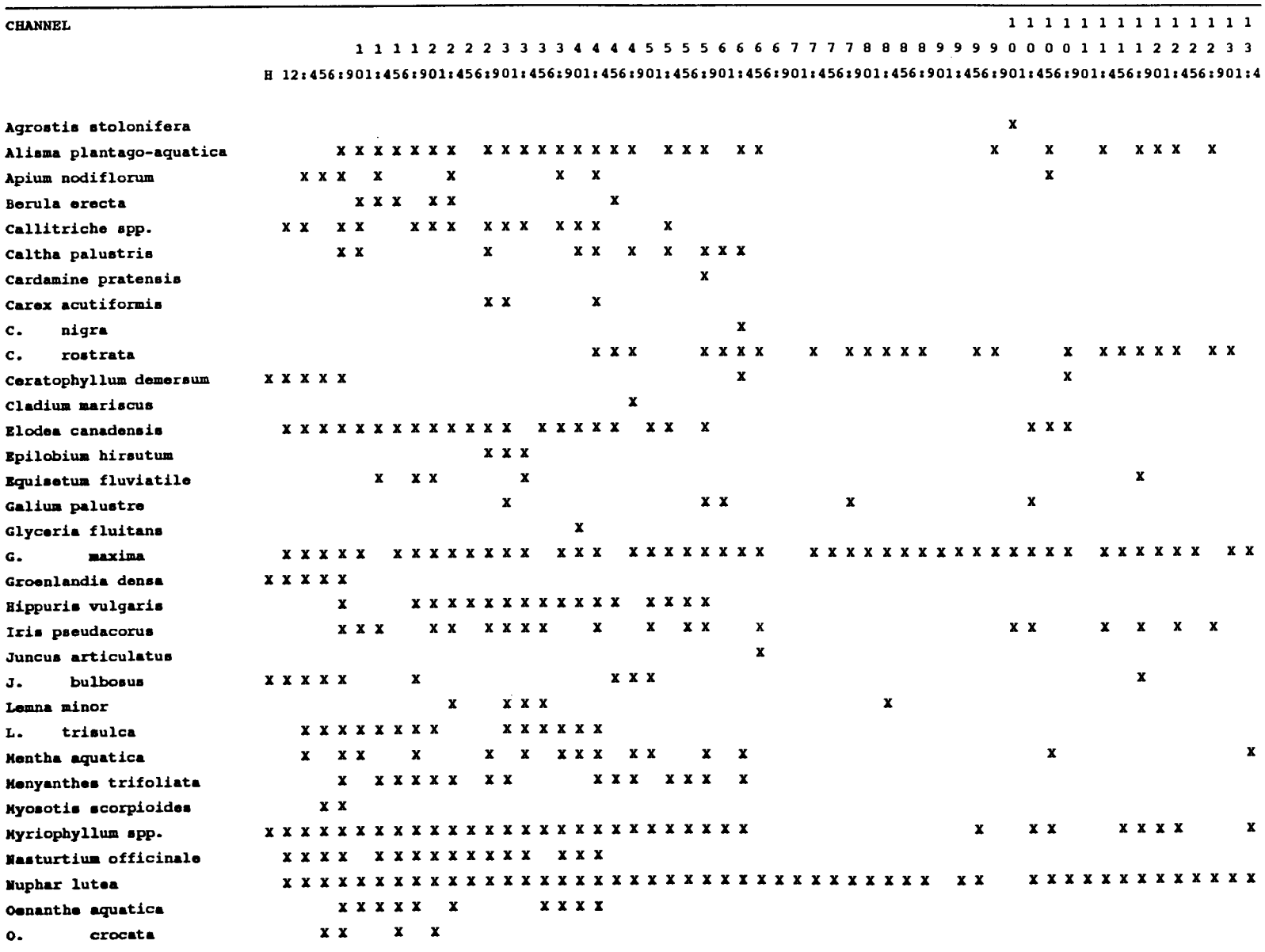

Grand Canal (mainline)
bank verge
H 12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Salix spp.
Sambucus nigra
Sanguisorba minor
Scrophularia auriculata
S. nodosa
Sedum acre
Senecio erucifolius
S. jacobaea
S. vulgaris
Sherardia arvensis
Sinapsis arvensis
Sisymbrium officinale
Smyrnium olusatrum
Solanum dulcamara
Sonchus arvensis
S. asper
S. oleraceus
Sparganium erectum
Stachys palustris
Stellaria graminea
S. media
Succisa pratensis
Symphoricarpos albus
Taraxacum spp.
Tilia agg.
Torilis japonica
Trifolium dubium
T. pratense
T. repens
Triglochin palustris
Tripleurospermum maritum
Trisetum flavescens
Tussilago farfara
Typha latifolia
Ulex europaeus
Ulmus agg.

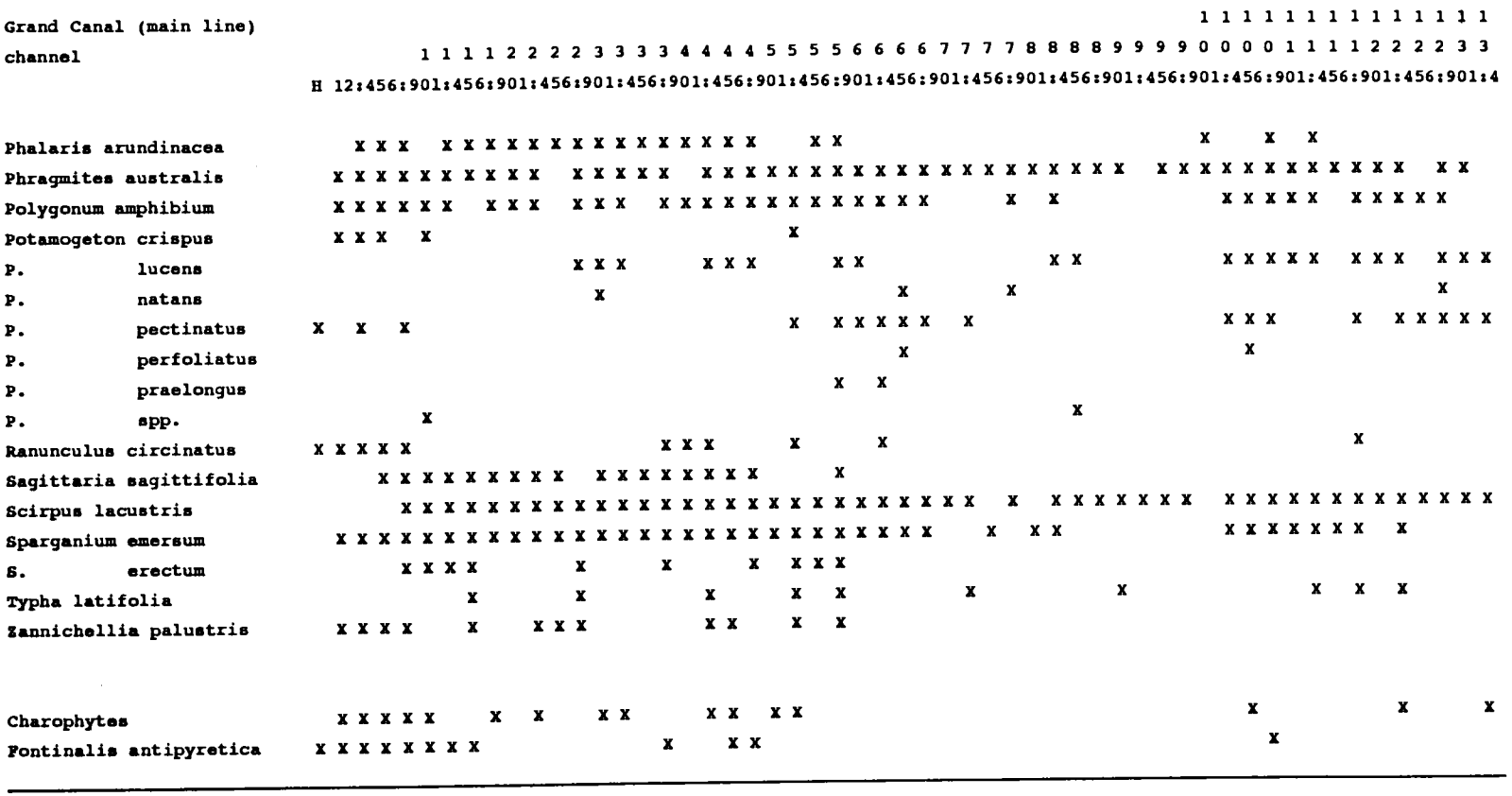

Grand Canal (mainline)
bank verge
H 12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Urtica dioica
Valeriana officinalis
Veronica chamaedrys
V. hederifolia
V. persica
Viburnum opulus
Viccia cracca
V. sativa
V. sepium
Viola riviniana

APPENDIX 5

Flora of the Channel - Main Line

GRAND CANAL : MAINLINE 1991



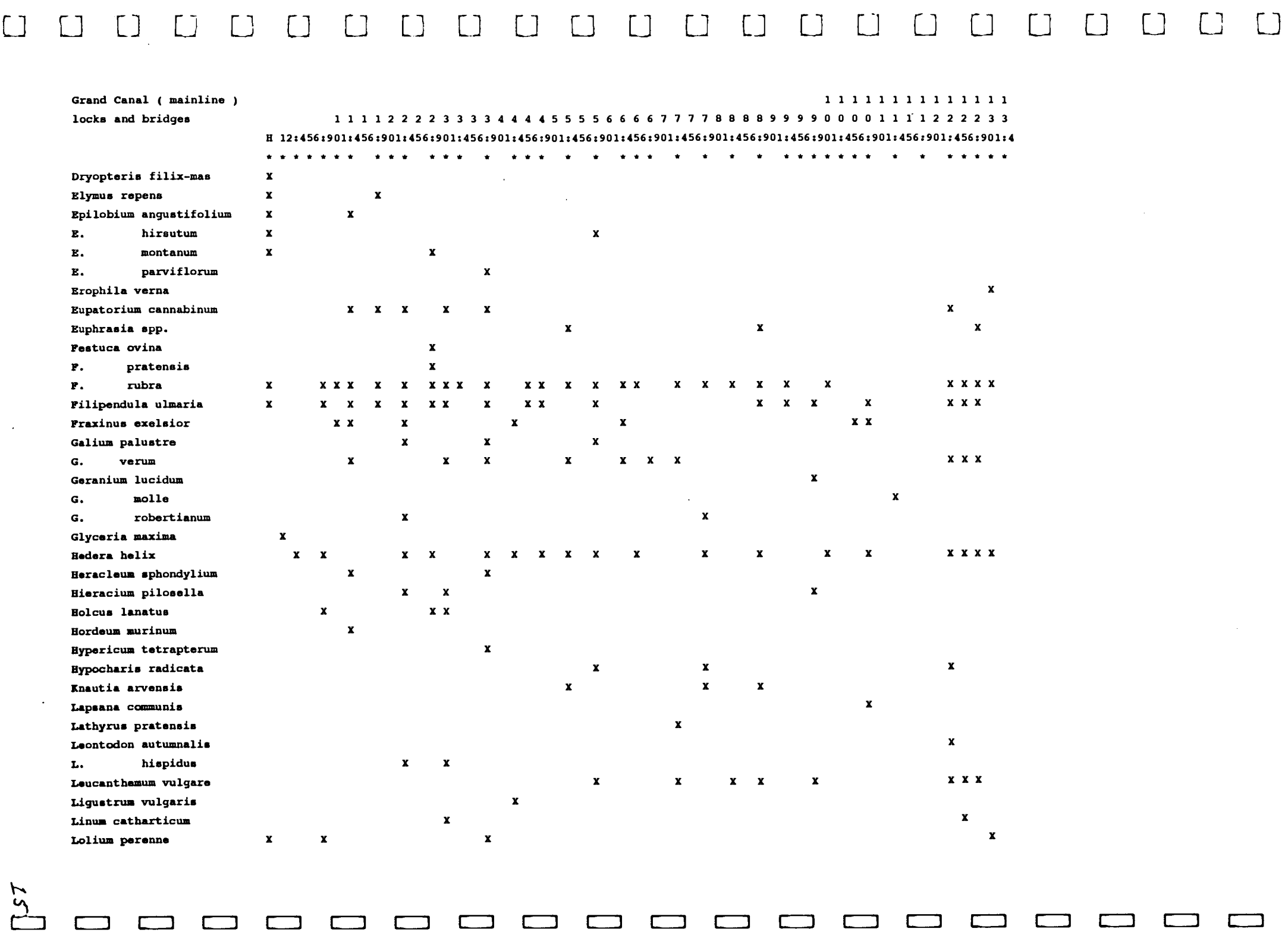

Grand Canal (main line)
channel
H 12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Phalaris arundinacea
Phragmites australis
Polygonum amphibium
Potamogeton crispus
P. lucens
P. natans
P. pectinatus
P. perfoliatus
P. praelongus
P. spp.
Ranunculus circinatus
Sagittaria sagittifolia
Scirpus lacustris
Sparganium emersum
S. erectum
Typha latifolia
Zannichellia palustris
Charophytes
Fontinalis antipyretica

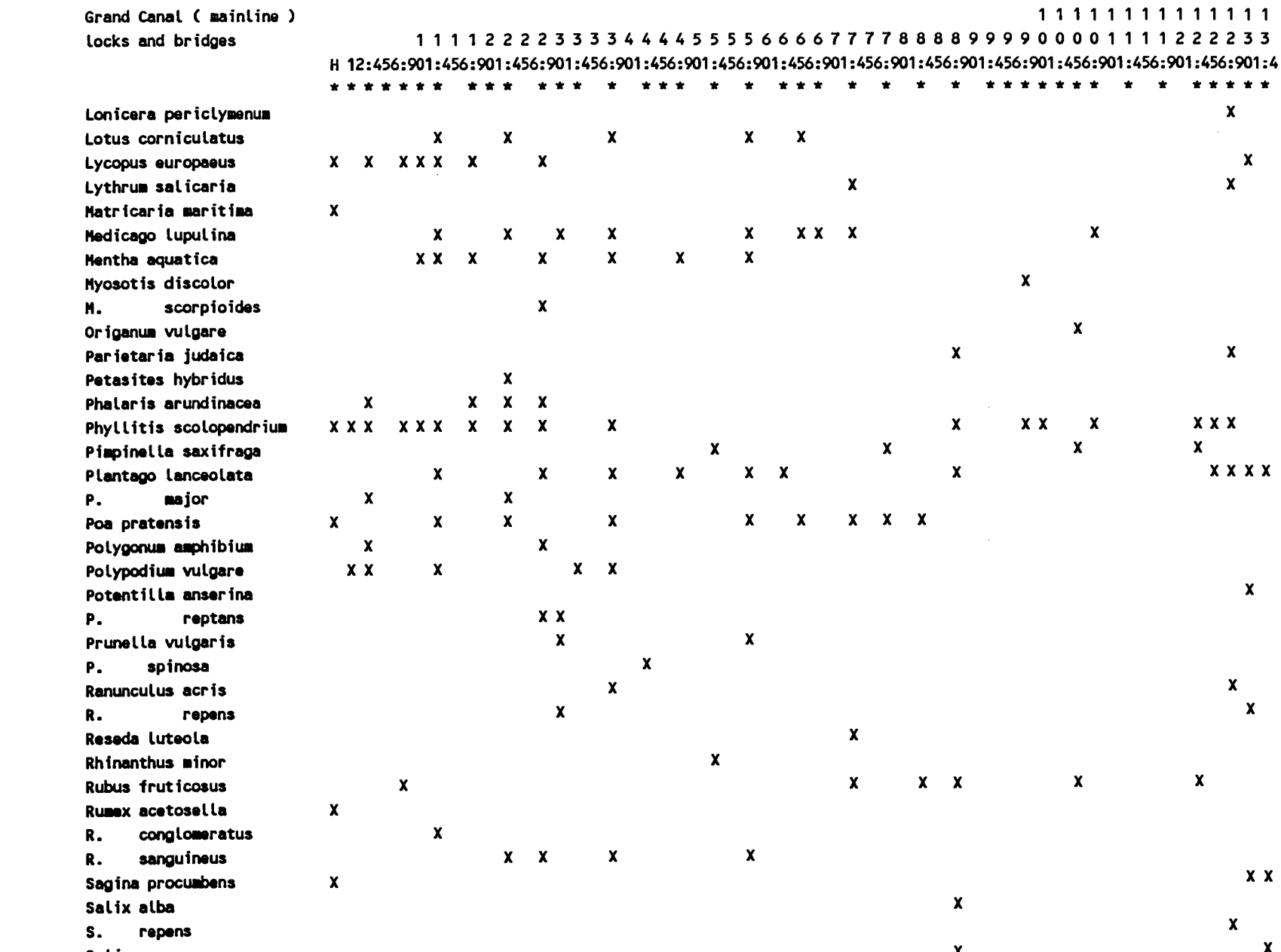
APPENDIX 6

Flora of the Locks and Bridges - Main Line

GRAND CANAL : MAINLINE 1991

LOCKS AND BRIDGES	H	12	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	4
Acer campestre		X				X																									
A. pseudoplatanus			X						X				X	X		X						X				X				
Achillea millefolium				X		X		X	X				X		X	X	X		X	X						X		X	X	X	
A. stolonifera				X						X																			X		
Anacamptis pyramidalis														X				X													
Angelica sylvestris		X	X	X	X	X	X	X	X	X	X	X	X		X						X	X	X	X				X	X	X	X	
Anthoxanthum odoratum													X															X			
Arrhenatherum elatius			X	X	X	X	X			X									X												
Asplenium ruta-muraria		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
A. trichomanes							X	X		X	X	X	X	X	X	X	X	X	X	X	X								X	X	X	X
Avenula pubescens							X																								
Bellis perennis					X														X										X	X	
Brizia media					X																							X	X	X	X
Buddleja davidii	X	X	X	X																											
Caltha palustris																						X									
Calystegia sepium											X																				
Capsella bursa-pastoris											X																				
Cardamine pratensis																												X		X	
Carex flacca								X																						X	
Centaurea nigra								X				X	X																		
Centranthus ruber		X	X																			X									
Cerastium fontanum				X	X																										
Ceterach officinarum						X					X			X					X												
Chamomilla suaveolens			X																												
Cirsium arvense						X																									
C. vulgare	X																											X			
Crataegus monogyna										X			X					X										X	X		
Crepis capillaris				X	X							X																X			
C. vesicaria																						X									
Cymbalaria muralis	X	X						X		X	X		X																	X	
Cynosurus cristatus									X							X															
Dactylis glomerata						X			X										X								X	X		X	
Daucus carota																													X		
Desmazeria rigida														X																	


Grand Canal (mainline)
locks and bridges
H 12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Dryopteris filix-mas
Elymus repens
Epilobium angustifolium
E. hirsutum
E. montanum
E. parviflorum
Erophila verna
Eupatorium cannabinum
Euphrasia spp.
Festuca ovina
F. pratensis
F. rubra
Filipendula ulmaria
Fraxinus exelsior
Galium palustre
G. verum
Geranium lucidum
G. molle
G. robertianum
Glyceria maxima
Hedera helix
Heracleum sphondylium
Hieracium pilosella
Holcus lanatus
Hordeum murinum
Hypericum tetrapterum
Hypocharis radicata
Knautia arvensis
Lapsana communis
Lathyrus pratensis
Leontodon autumnalis
L. hispidus
Leucanthemum vulgare
Ligustrum vulgaris
Linum catharticum
Lolium perenne


Grand Canal (mainline)
locks and bridges
H 12:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:456:901:4
Lonicera periclymenum
Lotus corniculatus
Lycopus europaeus
Lythrum salicaria
Matricaria maritima
Medicago lupulina
Mentha aquatica
Myosotis discolor
M. scorpioides
Origanum vulgare
Parietaria judaica
Petasites hybridus
Phalaris arundinacea
Phyllitis scolopendrium
Pimpinella saxifraga
Plantago lanceolata
P. major
Poa pratensis
Polygonum amphibium
Polypodium vulgare
Potentilla anserina
P. reptans
Prunella vulgaris
P. spinosa
Ranunculus acris
R. repens
Reseda luteola
Rhinanthus minor
Rubus fruticosus
Rumex acetosella
R. conglomeratus
R. sanguineus
Sagina procumbens
Salix alba
S. repens
Salix spp.

Grand Canal (mainline)

locks and bridges

	H	12	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	901	4
	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Sambucus nigra									X					X										X				X				
Scrophularia auriculata										X																					
S. nodosa							X																								
Sedum acre						X																									
S. anglicum			X																												
Senecio aquaticus			X																												
S. jacobaea				X	X			X		X				X	X														X		
S. vulgaris	X	X																					X								
Sisymbrium officinale					X																							X			
Smyrnium olusatrum				X																											
Sonchus arvensis																				X											
S. oleraceus																										X					
Stellaria medaia	X																														
Succisa pratensis								X							X				X												
Tanacetum parthenium			X																												
Taraxacum spp.		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
Torilis japonica																							X								
Trifolium dubium				X	X		X		X		X				X					X	X		X							X	
T. pratense				X				X							X																
T. repens					X											X		X												X	
Tripleurospermum maritimum	X																														
Tussilago farfara						X													X												
Ulmus agg.	X		X				X				X																				
Urtica dioica			X		X		X	X	X		X		X	X				X					X								
Valeriana officinalis				X	X	X	X		X		X				X				X	X		X	X		X				X	X	X
Valerianella locusta																					X										
Veronica hederifolia							X																								

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

APPENDIX 7

Flora of the Boundary - Branch Lines

BOUNDARY	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4					1	1								11
	12	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	7			12	456	901	2		1	2	1	234	789	23			
Acer pseudoplatanus	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	X	X	X
Achillea millefolium			X																														
Aesculus hippocastanum			X						X										X				X										
Agrostis capillaris				X							X									X													
A. stolonifera			X	X							X									X													
Alisma plantago-aquatica		X			X																												
Alnus glutinosa	X	X	X		X	X				X									X	X		X	X	X					X				
Angelica sylvestris	X			X															X														
Anthriscus sylvestris		X					X	X										X		X		X											
Apium nodiflorum			X	X																													
Arrhenatherum elatius				X	X	X	X	X	X	X										X		X		X							X		
Arum maculatum				X	X							X															X						
Asplenium ruta-muraria				X																													
A. trichomanes				X																													
Bellis perennis					X																												
Berula erecta				X	X	X																X											
Betula spp.	X	X			X				X		X											X											
Blackstonia perfoliata								X																									
Brachypodium sylvaticum				X	X			X	X	X	X	X						X	X		X			X	X								
Brizia media			X									X																					
Bromus erectus								X	X									X		X													
B. ramosus								X																									
Buddleja davidii																		X															
Callitriche spp.			X			X																											
Caltha palustris	X			X		X			X													X		X									
Calystegia sepium			X															X	X	X											X	X	
Cardimine pratensis			X	X	X		X																	X									
Carex acutiformis		X	X																													X	
C. demissa			X																														
C. disticha	X				X																												
C. elata			X			X																											
C. lepidocarpa				X		X																											
C. nigra			X																														
C. paniculata	X					X																X											
C. pulicaris				X																													
C. remota									X																								
C. rostrata			X			X																		X									
Catabrosa aquatica			X		X																												
Centaurium erythraea									X																								
Ceterach officinarum				X																													
Chara spp.								X																									
Cirsium arvense							X		X									X															X	
C. palustre	X		X																														
C. vulgare								X																									
Clematis vitalba								X		X																							
Corylus avellana	X		X				X	X	X	X	X	X						X	X							X						X	
Crataegus monogyna	X	X	X	X		X	X	X	X	X	X	X	X						X		X		X	X	X	X		X		X	X	X	X	X
Cymbalaria muralis					X																												
Cynosurus cristatus							X																										
Dactylis glomerata						X	X	X		X	X		X							X												X	X	

Grand Canal (branch lines)
boundary

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4					1	1								11
	12	456	901	456	901	456	901	456	901	456	901	456	901	456	7		12	456	901	2	1	2	1	234	789	23
Daucus carota										X																								
Elymus repens																														X		X		
Epilobium angustifolium										X																								
E. hirsutum		X			X		X				X			X									X											
E. parviflorum				X																														
Equisetum arvense								X																						X		X		
E. fluviatile	X		X		X	X																	X											
E. palustre																								X										
E. sylvaticum																								X										
Eriophorum angustifolium			X		X		X																											
Euonymus europaeus							X		X	X		X	X										X				X		X					
Fagus sylvatica		X	X		X	X	X		X	X		X	X			X	X	X		X		X			X		X		X		X		X	
Festuca rubra					X	X	X			X	X	X				X				X			X	X	X			X	X	X	X			
Filipendula ulmaria			X					X								X	X					X		X										
Fragraria vesca					X		X	X		X																								
Fraxinus exelsior	X	X		X		X	X	X	X	X	X	X		X	X	X		X		X		X	X			X		X	X	X	X	X		
Galium aparine		X			X	X		X	X	X	X	X		X	X	X						X	X			X		X	X	X	X	X		
G. odoratum																																X		
G. verum			X				X																											
Geranium robertianum		X		X	X	X	X	X		X	X	X										X		X	X			X		X	X		X	
Geum urbanum					X	X	X	X		X	X	X										X		X	X					X			X	
Glyceria fluitans		X																																
G. maxima		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	
Heracleum sphondylium				X		X	X	X		X	X			X									X	X					X					
Hieracium pilosella			X																															
Hippuris vulgaris			X																															
Holcus lanatus					X	X		X		X	X	X										X		X									X	
Hydrocotyle vulgaris							X																											
Hypericum androsaemum																								X										
H. perforatum									X																									
Ilex aquifolium			X							X	X		X			X							X				X							
Iris pseudacorus			X		X			X									X	X					X											
Juncus bulbosus			X		X																													
J. effusus																									X									
J. inflexus			X																															
Lapsana communis					X																									X				
Larix spp.			X																															
Lemna minor						X																												
Ligustrum vulgaris	X	X				X	X	X	X	X	X	X				X							X	X	X		X		X	X		X	X	
Lolium perenne																																X		
Lonicera nitida																							X											
Lonicera periclymenum										X		X				X							X	X						X				
Lotus corniculatus			X				X																											
Luzula campestris			X																															
Lythrum salicaria				X																														
Malus spp.	X																							X					X			X		
Mentha aquatica	X	X		X	X	X	X			X					X																			
Menyanthes trifoliata			X		X		X																											
Myrica gale					X																													
Myriophyllum spp.			X		X																													

Grand Canal (branch lines)
boundary

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	3	3	3	4	4	4	4						1	1							11
	12:	456:	901:	456:	901:	456:	901:	456:	901:	456:	901:	456:	901:	456:	7					12:	456:	901:	2			1:2	1:	234:	789:	23
Nasturtium officinale	X	X		X			X	X		X	X																					
Origanum vulgare										X																						
Parnassia palustris								X																								
Pedicularis palustris				X																												
Phalaris arundinacea																	X						X									
Phleum pratense										X		X	X							X		X									X	
Phragmites australis		X			X	X				X																						
Phyllitis scolopendrium						X				X	X											X					X				X	
Pinus sylvestris			X					X																								
Plantago lanceolata							X																									
Poa pratensis						X	X																									
Polygala serpyllifolia				X																												
Polygonum amphibium						X											X															
Polypodium vulgare						X																										
Populus spp.		X										X																				
Potentilla erecta				X																												
P. reptans						X	X																									
Primula veris				X																		X										
P. vulgaris																						X										
Prunus avium				X						X												X	X									
P. domestica										X													X									
P. laurocerasus																						X										
P. spinosa		X				X	X	X	X	X	X	X	X				X	X		X		X	X	X	X			X		X	X	X
Pteridium aquilinum			X																													
Pulicaria dysenterica										X																						
Quercus ilex											X																					
Q. spp.								X		X	X	X																				
Ranunculus acris	X			X																		X										
R. flammula				X				X		X																						
R. lingua				X																												
R. repens						X														X												
Rosa spp.			X			X	X	X		X	X	X	X				X	X								X						
Rosa arvensis		X						X	X			X					X	X		X		X		X		X				X	X	X
R. canina		X	X						X		X		X	X			X	X		X		X	X		X		X			X	X	X
Rubus fruticosus	X	X				X		X	X	X	X	X	X	X				X	X	X		X	X	X	X	X		X		X	X	X	X
Rumex sanguineus																				X												
Salix alba																				X		X	X	X								
S. caprea		X							X											X			X	X			X					
S. cinerea		X				X	X	X			X		X							X		X	X	X			X	X	X	X		
S. fragilis																									X							
S. purpurea																							X									
S. viminalis		X		X																		X									X	
Salix spp.	X	X				X	X	X	X	X	X	X	X									X			X		X					
Sambucus nigra		X		X		X	X	X	X	X	X	X					X	X	X	X			X		X		X	X	X	X	X	
Schoenus nigricans					X																											
Scrophularia nodosa						X																										
Senecio jacobea									X																							
Sinapsis arvensis						X																										
Solanum dulcamara																	X					X										
Sonchus arvensis					X																											
S. oleraceus						X																										

Grand Canal (branch lines)
boundary

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4					1	1								11
	1	2	4	5	6	9	0	1	4	5	6	9	0	1	4	5	6	9	0	1	4	5	6	9	0	1	2	1	2	3	4	7	8	9	2	3
Sparganium erectum				X			X	X		X																								
Sorbus aucuparia			X																														
S. hibernica																								X									
Stachys sylvatica						X																											
Symphoricarpos albus	X									X	X		X				X							X	X	X							
Syringa vulgaris																												X					
Taxus baccata																											X						
Torilis japonica						X	X																	X									
Trifolium pratense	X																																
Ulex europaeus									X															X									
Ulmus agg.				X		X				X		X					X	X	X					X	X			X	X	X	X		
Urtica dioica		X	X		X	X		X		X	X	X					X							X		X					X		
Valeriana officinalis					X																			X									
Veronica anagallis-aquatica							X																										
V. beccabunga						X																											
V. chamaedrys									X				X							X													
Viburnum opulus							X			X	X	X	X																				
Viccia cracca							X																							X			
V. sepium						X							X				X																
Viola riviniana		X					X	X												X					X								

APPENDIX 8

Flora of the Boundary Verge - Branch Lines

BOUNDARY VERGE

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B		N	N	N	N	N		E		M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4					1	1								11
	12	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	7			12	456	901	2			1	2		1	234	789	23	
Acer pseudoplatanus		X		X																													
Achillea millefolium	X	X	X	X		X	X	X	X	X	X		X	X				X	X				X	X	X				X	X	X	X		
Aegopodium podagraria												X							X														
Agrimonia eupatoria		X			X		X				X												X		X								
Agrostis canina																	X	X															
A. capillaris			X	X		X	X	X	X		X						X	X			X		X	X	X								
A. stolonifera				X	X	X			X		X										X		X	X	X				X		X	X		X
Ajuga reptans																							X	X		X							
Alnus glutinosa		X						X																									
Alopecurus pratensis										X	X															X							
Anacamptis pyramidalis																							X		X								
Angelica sylvestris					X				X																					X		X	X
Antennaria dioica							X																										
Anthoxanthum odoratum	X	X	X	X	X	X	X	X	X	X													X	X	X		X		X				
Anthriscus sylvestris		X	X	X		X	X			X								X		X			X						X	X			
Arctium minus							X																				X						
Arrhenatherum elatius	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
Artemisia vulgaris								X																									
Avenula pubescens				X	X		X	X		X	X																						
Bellis perennis		X				X		X														X	X			X							
Betula spp.			X		X								X																				
Blackstonia perfoliata								X	X	X															X								
Brachypodium sylvaticum						X			X	X										X			X					X					
Brizia media	X	X	X	X			X	X	X	X		X		X									X		X			X					
Bromus commutatus							X																										
B. erectus										X									X									X				X	
B. hordeaceus				X																													
Calluna vulgaris					X	X																											
Caltha palustris					X	X		X	X																								
Calystegia sepium				X					X	X		X					X	X										X	X		X	X	
Capsella bursa-pastoris							X				X																						
Cardimine pratensis			X		X	X	X	X	X	X										X		X	X		X								
Carex acutiformis													X									X											
C. caryophyllea		X					X	X															X		X								
C. demissa			X																														
C. disticha						X	X		X														X										
C. flacca	X	X		X	X	X	X	X	X	X		X								X			X	X	X				X				
C. hirta	X	X	X	X	X	X	X	X	X	X												X	X						X				
C. panicea			X	X	X		X	X																	X								
C. paniculata					X			X														X											
C. pulicaris			X	X	X	X	X																										
Centaurea nigra	X	X	X	X	X	X	X	X			X	X	X		X		X						X	X	X		X		X	X	X			
Cerastium fontanum			X	X		X	X											X				X				X							
Chamomille suaveolens								X																									
Chenopodium album									X																								
Cirsium arvense		X	X	X	X	X	X	X	X	X	X		X				X	X		X		X		X	X		X			X	X	X	X
C. dissectum				X	X	X	X	X	X																								
C. palustre				X	X	X	X	X														X	X							X			
C. vulgare				X	X	X			X		X	X											X			X				X	X	X	
Clematis vitalba													X																				

Grand Canal (branch lines)
boundary verge

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4					1	1							11
	12	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	7				12	456	901	2			1	2	1	234	789	23		
Corylus avellana										X																							
Crataegus monogyna	X	X	X	X		X	X	X	X	X		X				X					X		X					X	X				
Crepis capillaris											X																						
C. vesicaria					X												X															
Cynosurus cristatus	X	X	X	X	X	X	X		X		X		X										X	X	X			X					
Dactylis glomerata	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
Dactylorhiza fuchsii		X	X			X	X	X	X	X													X									
D. incarnata					X																											
Danthonia decumbens			X																													
Daucus carota	X	X	X	X		X		X	X	X		X											X	X	X			X		X		X	
Deschampsia caespitosa					X																X											
Elymus repens																		X										X		X	X	X	X
Epilobium angustifolium		X		X						X							X															
E. hirsutum		X	X		X	X			X	X	X	X					X						X					X	X			X	X
E. parviflorum			X		X																											
Epipactis palustris				X																												
Equisetum arvense	X			X		X	X	X	X		X	X	X			X	X						X	X	X	X		X	X	X	X		
E. telmateia											X																						
Erica cinerea					X	X																											
E. tetralix					X																												
Eupatorium cannabinum						X			X				X	X										X			X			X		X	
Euphrasia spp.	X			X	X	X		X	X	X	X			X											X	X							
Festuca arundinacea				X							X	X	X	X										X					X				
F. pratensis							X				X	X	X	X																			
F. rubra		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
Filipendula ulmaria	X	X	X	X	X	X		X		X	X	X						X						X					X	X	X		X	X
Fraxinus exelsior		X	X	X									X								X							X					
Galium aparine						X					X	X	X	X			X	X						X	X				X	X			X	
G. palustre		X						X																									
G. uliginosum				X	X																												
G. verum	X	X	X	X	X	X	X	X	X	X	X	X	X											X	X	X			X		X		X	
Gentianella amarella								X																		X								
Geranium dissectum					X																												
G. pyrenaicum									X																								
G. robertianum		X		X		X	X	X		X	X			X							X			X						X	X		
Geum urbanum				X				X													X		X										
Glyceria maxima																																X	
Gymnadenia conopsea		X	X	X	X	X	X	X				X												X		X							
Hedera helix				X				X					X	X							X			X									
Heracleum sphondylium		X		X		X			X	X		X				X	X	X			X		X		X		X		X				X
Hieracium pilosella								X																X	X	X							
Holcus lanatus	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
Hydrocotyle vulgaris								X																									
Hypericum maculatum		X														X															X		
H. pulchrum					X																												
H. tetrapterum				X		X																											
Hypocharis radicata	X	X	X			X		X															X	X			X		X				
Iris pseudacorus		X	X	X		X	X	X	X	X		X		X									X	X	X				X			X	
Juncus articulatus				X	X			X																									
J. effusus			X	X																													
J. inflexus	X	X				X		X																									

Grand Canal (branch lines)
boundary verge

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	3	3	3	4	4	4	4						1	1							11
	12	456	901	456	901	456	901	456	901	456	901	456	901	456	7	12	456	901	2	1	2	1	234	789	23
Juncus subnodulosus			X	X	X		X																								
Knautia arvensis			X					X		X												X		X							X
Lamium album															X																
Lapsana communis																												X			
Lathyrus pratensis	X	X		X		X		X	X	X	X	X	X			X	X			X		X	X			X	X	X			
Leontodon autumnalis						X	X	X	X			X										X		X							
L. hispidis	X	X	X	X	X		X	X	X		X	X										X	X	X			X				
Leucanthemum vulgare	X	X	X	X			X	X	X	X	X		X							X		X	X	X				X			
Ligustrum vulgaris	X	X		X			X		X	X			X									X	X	X			X				
Linum catharticum				X	X		X		X													X		X		X					
Listera ovata	X	X			X	X	X	X	X															X							
Lolium perenne		X	X			X					X						X	X							X		X		X	X	X
Lonicera nitida																						X									
L. periclymenum											X																				
Lotus corniculatus	X	X	X	X		X	X	X	X	X	X	X	X				X			X		X	X	X			X				
Luzula campestris		X	X	X	X	X	X	X	X	X												X	X	X							
Lythrum salicaria			X	X	X			X			X											X	X								X
Malus spp.									X																						
Medicago lupulina		X					X			X						X						X	X			X		X			
Mentha aquatica	X	X		X	X	X	X	X	X																						
Menyanthes trifoliata				X	X	X																									
Molinea caerulea	X	X		X	X	X			X																						
Myosotis arvensis										X														X							
Myrica gale					X	X			X																						
Odontites verna		X	X	X							X									X					X			X			
Ononis repens		X																													
Orchis mascula							X																								
Origanum vulgare					X			X	X	X	X																				
Papaver spp.					X					X			X																		
Parnassia palustris				X		X			X																						
Pedicularis palustris									X																						
Petasites hybridus				X																X											
Phalaris arundinacea										X																					
Phleum pratense	X	X	X	X	X	X	X	X		X		X	X							X		X	X	X	X	X		X	X	X	X	X
Phragmites australis				X	X	X																						X			X
Pimpinella saxifraga	X		X	X	X	X	X	X	X				X										X	X	X		X	X	X		X	
Pinguicula vulgaris									X																						
Plantago lanceolata	X	X	X	X	X	X	X	X		X		X	X	X		X	X	X				X	X	X	X		X		X			
P. major																X	X	X					X			X					
Platanthera bifida									X																						
Poa pratensis			X	X	X	X	X	X		X	X	X	X	X		X	X	X		X			X	X			X	X			
P. trivialis		X	X	X		X										X											X	X	X	X	X
Polygala serpyllifolia	X	X		X			X	X														X		X							
Polygonum amphibium			X						X		X						X	X												X	
P. aviculare									X		X																				
Populus spp.													X				X	X													
Potentilla anserina		X	X	X	X	X	X	X	X		X	X	X			X				X		X	X	X	X			X	X	X	X	X
P. erecta			X	X	X	X	X	X	X														X		X						
P. reptans	X	X	X	X			X	X			X	X				X	X	X		X				X				X	X		X	
Primula veris	X	X	X	X			X	X	X	X	X		X	X									X	X	X			X				
Prunella vulgaris		X		X	X			X	X	X													X	X	X		X		X		

Grand Canal (branch lines)
boundary verge

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4					1	1						11
	12	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	7			12	456	901	2		1	2	1	234	789	23		
Prunus avium										X																					
P. spinosa	X		X			X	X	X				X				X							X				X				
Pteridium aquilinum		X	X						X		X																				
Pulicaria dysenterica								X	X	X	X		X																		
Ranunculus acris	X	X	X	X	X	X	X	X	X	X										X		X	X	X	X		X		X		
R. bulbosus	X		X	X	X	X	X		X	X		X	X											X		X		X			
R. flammula					X		X	X																							
R. repens	X	X	X			X			X	X	X	X				X		X		X		X	X		X		X	X	X		
Reseda luteola					X			X																							
Reynoutria japonica																	X	X													
Rhinanthus minor			X			X	X	X			X							X				X	X							X	
Rosa spp.	X	X	X		X	X	X																								
Rosa arvensis			X																	X											
R. canina	X	X	X			X	X													X						X					
Rubus fruticosus	X	X	X		X	X	X		X	X		X	X			X	X	X		X		X	X	X	X		X		X	X		X
Rumex acetosa		X	X								X																X				
R. crispus											X													X							
R. obtusifolius																	X														
R. sanguineus			X	X														X				X			X		X	X			
Salix alba	X																					X									
S. caprea							X	X																							
S. cinerea						X																		X							
S. fragilis													X																		
S. purpurea																								X							
S. repens			X		X																										
S. viminalis																								X							
S. spp.			X		X	X	X	X		X		X													X							
Sambucus nigra		X	X			X				X																	X				
Samolus valerandi																								X							
Sanguisorba minor			X																												
Saponaria officinalis									X																						
Schoenus nigricans			X	X	X																										
Senecio aquaticus			X																			X	X								
S. jacobaea	X	X	X	X	X				X		X										X		X		X				X		X
Sherardia arvensis																							X								
Silene alba					X				X																				X		X
S. vulgaris									X																						
Sinapsis arvensis											X																				
Sisymbrium officinale					X																										
Solanum dulcamara			X							X	X															X					
Sonchus arvensis					X						X		X												X					X	
S. asper					X	X																									
S. oleraceus					X																									X	
Sorbus aucuparia		X																													
Stachys palustris	X		X								X																				
S. sylvatica										X			X																		
Succisa pratensis	X		X	X	X	X	X	X			X		X									X		X							
Symphoricarpos albus			X						X																						
Symphytum officinale																	X		X												
Tanacetum vulgare																										X					
Taraxacum spp.	X		X										X				X	X	X	X							X				

Grand Canal (branch lines)
boundary verge

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4					1	1						11
	12:	456:	901:	456:	901:	456:	901:	456:	901:	456:	901:	456:	901:	456:	7	12:	456:	901:	2	1:2	1:	234:	789:	23
Torilis japonica		X																								X			X	X		
Trifolium dubium		X			X			X					X								X				X			X				
T. pratense	X	X	X	X	X	X	X	X	X	X	X	X	X					X	X	X			X	X	X	X		X	X	X		
T. repens		X		X							X	X						X	X	X						X			X			
Triglochin palustris						X																										
Triticum aestivum																														X	X	
Tussilago farfara																								X								
Ulex europaeus			X	X	X			X															X		X							
Ulmus agg.																		X														
Urtica dioica		X	X	X		X	X	X		X	X	X	X	X				X	X	X	X		X		X		X	X	X	X	X	X
Valeriana officinalis				X		X			X		X	X								X											X	
Veronica chamaedrys		X	X	X	X	X	X	X		X	X									X	X	X	X	X			X					
Viburnum opulus						X		X																								
Viccia cracca		X		X	X	X	X	X	X	X								X	X				X	X		X		X	X	X		
V. sepium				X			X	X		X	X	X		X				X	X				X	X	X	X		X	X			
Viola riviniana			X					X												X												

APPENDIX 9

Flora of the Towpath - Branch Lines

TOWPATH

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E		M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4					1	1							11	
	12	:	456	:	901	:	456	:	901	:	456	:	901	:	456	:	901	:	456	:	7	12	:	456	:	901	:	2	1	:	2	1	:	234	:	789	:	23
Achillea millefolium				X	X	X	X	X	X	X														X		X				X					
Agrimonia eupatoria		X					X																												
Agrostis capillaris						X	X	X	X	X													X	X	X									
A. stolonifera						X				X													X	X	X				X			X		X
Anthoxanthum odoratum		X	X	X	X	X	X	X	X														X	X	X	X								
Arctium minus								X																X									X	
Arrhenatherum elatius	X	X	X	X		X	X	X	X	X													X	X		X			X		X	X	X	X
Avenula pubescens				X		X	X	X																										
Bellis perennis		X	X	X	X	X	X	X	X	X												X		X	X		X		X		X			
Brachypodium sylvaticum																								X										
Brizia media	X	X	X	X		X	X	X	X	X															X				X					
Bromus hordeaceus				X																														
Calystegia sepium																																X	X	
Capsella bursa-pastoris		X						X																										
Carex flacca	X			X	X	X	X	X	X	X														X		X								
C. hirta	X	X		X	X	X	X	X	X	X																								
Centaurea nigra	X		X	X	X	X	X	X									X						X		X	X			X			X		
Cerastium fontanum																					X	X			X									
Chamomille suaveolens								X																						X	X	X		
Cirsium arvense		X	X					X	X	X											X	X	X								X	X		
C. vulgare			X																						X						X			
Crataegus monogyna										X												X	X											
Crepis capillaris										X																								
C. vesicaria										X																								
Cynosurus cristatus	X	X	X	X	X	X	X	X	X	X													X	X	X	X			X		X			
Dactylis glomerata	X	X	X	X			X	X	X	X													X	X	X	X			X		X	X		X
Dactylorhiza fuchsii										X							X																	
Danthonia decumbens				X																														
Daucus carota	X					X		X	X	X														X	X	X			X		X		X	
Elymus repens																																X	X	X
Epilobium hirsutum																																	X	
Equisetum arvense										X													X	X								X		
Eupatorium cannabinum						X																												
Euphrasia spp.	X	X	X	X	X	X		X	X	X														X	X				X					
Festuca arundinacea										X																								
F. rubra		X	X	X	X	X	X	X	X	X							X						X	X	X	X			X		X	X	X	
Filipendula ulmaria			X																															
Galium aparine																							X											
G. verum		X	X	X	X	X	X	X	X														X	X										
Geum urbanum																							X											
Gymnadenia conopsea								X																										
Heracleum sphondylium										X													X	X	X						X		X	
Holcus lanatus	X	X	X	X		X	X	X	X	X													X	X	X	X			X		X	X	X	
Hypericum maculatum																	X																	
Hypocharis radicata	X	X	X				X		X														X		X				X		X			
Juncus articulatus																								X										
J. bufonius																																	X	
J. inflexus	X					X	X	X															X	X	X								X	
Lathyrus pratensis						X																	X	X										

Grand Canal (branch lines)
towpath

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4					1	1							11
	12:	456:	901:	456:	901:	456:	901:	456:	901:	456:	901:	456:	901:	456:	7		12:	456:	901:	2	1:2		1:	234:	789:	23
Leontodon autumnalis						X	X	X	X																								
L. hispidus	X	X	X	X	X	X	X		X																X			X			X		
Leucanthemum vulgare			X					X								X								X	X							
Ligustrum vulgaris																							X										
Linum catharticum	X		X			X		X																	X								
Lolium perenne		X	X	X			X		X	X															X	X		X		X	X	X	
Lotus corniculatus	X		X	X	X	X	X	X															X	X				X					
Luzula campestris					X	X		X															X										
Medicago lupulina		X		X		X			X														X										
Melampyrum pratense																																	
Mentha aquatica	X																																
Molinea caerulea		X																															
Odontites verna		X	X		X	X	X		X	X													X	X	X			X			X		
Origanum vulgare						X																											
Phleum pratense	X	X	X			X	X	X		X													X	X				X		X	X	X	X
Pimpinella saxifraga	X	X	X	X	X	X	X	X	X	X																					X		
Plantago lanceolata	X	X	X	X	X	X	X	X	X	X							X						X	X	X	X		X					
P. major	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					
P. trivialis																														X	X	X	
Polygala serpyllifolia				X			X																										
Polygonum amphibium																															X	X	
P. aviculare					X																									X	X	X	
Populus spp.					X																												
Potentilla anserina		X	X			X		X	X	X															X			X		X	X	X	X
P. reptans	X	X	X		X		X	X	X																						X	X	
Primula veris	X																																
Prunella vulgaris	X	X		X	X			X	X	X							X						X	X		X				X			
Ranunculus acris				X		X															X				X								
R. bulbosus	X	X	X	X	X	X	X	X	X	X													X					X					
R. repens		X	X	X			X			X													X					X					
Rhinanthus minor						X	X	X	X																							X	
Rosa spp.										X																							
Rubus fruticosus																							X	X							X		
Rumex sanguineus																								X									
Senecio jacobea				X		X	X			X													X	X									
S. vulgaris		X																															
Silene alba										X																							
Sisymbrium officinale																																X	
Succisa pratensis			X					X	X																X								
Taraxacum spp.					X																		X	X		X		X					
Trifolium dubium			X		X			X	X	X														X	X	X		X					
T. pratense	X	X	X	X	X	X	X	X	X														X	X	X	X					X		
T. repens		X	X	X		X		X		X							X							X	X			X		X			
Ulex europaeus				X																													
Urtica dioica		X								X																				X			
Veronica chamaedrys						X																		X									
Viccia cracca		X				X																											

APPENDIX 10

Flora of the Bank Verge - Branch Lines

BANK VERGE

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4					1	1							11
	12:	456:	901:	456:	901:	456:	901:	456:	901:	456:	901:	456:	901:	456:	7		12:	456:	901:	2	1:2		1:234:	789:	23								
Acer pseudoplatanus							X	X	X		X	X	X		X	X	X				X	X		X		X			X	X			
Achillea millefolium	X	X	X	X		X	X	X	X	X	X	X	X	X	X		X		X		X	X	X				X			X	X	X	
Aegopodium podagraria												X																					
Agrimonia eupatoria				X				X			X			X	X	X	X	X														
Agrostis canina																		X	X													
A. capillaris				X	X	X	X	X	X	X		X				X	X	X	X		X	X	X	X	X							
A. gigantea																X	X															
A. stolonifera					X	X	X		X	X		X	X	X		X	X	X			X	X	X	X	X		X		X	X	X	X	X
Ajuga reptans																									X								
Alnus glutinosa			X	X					X	X	X				X						X		X	X				X	X			
Alopecurus pratensis																						X	X		X							
Anagallis arvensis																													X			
Angelica sylvestris	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
Anthoxanthum odoratum	X	X	X	X	X	X	X	X	X	X		X			X	X	X					X	X	X	X	X		X					
Anthriscus sylvestris				X					X				X	X		X	X	X		X	X	X		X				X	X			
Apium nodiflorum																							X									
Arctium minus																														X		X
Arrhenatherum elatius	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	X	
Artemisia vulgaris								X																								
Arum maculatum													X																			
Avenula pubescens		X		X	X	X	X		X	X	X			X																		
Baldellia ranunculoides	X																															
Bellis perennis				X								X					X			X			X	X	X		X		X			
Betula spp.							X					X					X		X							X						
Brachypodium sylvaticum											X	X	X										X									
Brizia media	X	X	X	X	X	X	X	X	X	X	X		X					X						X	X			X	X			
Bromus erectus																	X															
B. hordeaceus								X			X								X													
B. ramosus																X	X															
Buddleja davidii																		X								X						
Caltha palustris	X	X	X	X		X		X															X	X								
Calystegia sepium	X	X	X	X	X	X		X		X	X		X	X	X	X	X	X	X	X	X	X						X	X		X	X	
Capsella bursa-pastoris												X							X													
Cardamine pratensis			X	X		X	X	X	X			X		X	X							X	X	X	X			X				
Carex acutiformis			X	X			X				X	X	X	X	X						X	X					X			X		
C. caryophyllea				X		X		X																	X							
C. demissa	X	X																														
C. disticha		X		X		X	X	X		X		X		X	X	X	X						X	X	X			X				
C. elata											X																					
C. flacca	X	X	X	X	X	X	X	X	X	X	X	X		X									X	X		X		X	X			
C. hirta	X	X	X	X		X	X	X	X	X	X	X										X	X	X				X	X			
C. lepidocarpa	X	X																														
C. nigra					X	X				X	X													X								
C. otrubae																										X						
C. panicea	X	X		X	X				X			X												X				X				
C. paniculata		X		X			X			X	X	X		X	X						X	X	X	X	X	X			X			
C. pendula													X																			
C. remota																					X											
C. rostrata		X	X	X		X					X				X	X						X	X		X		X		X			
Catabrosa aquatica																														X		

Grand Canal (branch lines)
bank verge

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4				1	1							11
	12	456	901	456	901	456	901	456	901	456	901	456	7		12	456	901	2	1	2	1	234	789	23
Centaurea nigra	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	
Cerastium arvense																X															
C. fontanum		X		X		X					X		X			X			X			X									
Chamomille suaveolens											X			X			X											X	X		
Chenopodium album									X																	X		X			
Cirsium arvense		X		X			X	X	X	X	X	X	X	X	X	X		X	X		X		X		X		X	X	X	X	X	
C. dissectum						X																									
C. palustre	X	X	X	X		X																X	X		X			X	X	X	
C. vulgare			X						X			X			X			X		X	X	X					X	X	X	X	
Cladium mariscus	X	X																													
Clematis vitalba											X	X					X														
Conopodium majus																		X													
Corylus avellana											X	X	X																		
Crataegus monogyna		X		X		X	X	X			X	X	X		X	X	X	X			X		X	X	X	X			X		
Crepis biennis										X												X						X			
C. capillaris									X		X	X	X	X																	
C. vesicaria									X									X	X												
Cynosurus cristatus	X	X	X	X	X	X	X	X	X	X	X		X									X		X			X		X	X	
Dactylis glomerata	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
Dactylorhiza fuchsii	X	X	X	X		X	X		X	X	X	X	X	X	X	X		X							X							
D. incarnata							X																								
Danthonia decumbens				X																											
Daucus carota	X	X		X		X	X	X		X			X										X	X	X			X	X	X	X	
Deschampsia caespitosa		X																										X			
Eleocharis palustris																							X								
Elymus repens																		X									X		X	X	X
Epilobium angustifolium													X																		
E. hirsutum		X		X				X	X	X	X	X	X	X	X	X		X		X	X	X	X	X	X		X	X	X	X	X	X
E. parviflorum																					X		X	X					X		
Equisetum arvense		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
E. fluviatile																				X				X							
E. telmateia											X																				
E. variegatum		X				X			X						X																
Eriophorum angustifolium		X																													
Euonymus europaeus													X				X														
Eupatorium cannabinum	X										X	X	X	X	X										X		X	X	X		X	X
Euphrasia spp.	X	X	X	X	X	X	X	X	X				X											X	X						
Fagus sylvatica																	X			X											
Festuca arundinacea		X		X		X		X	X	X	X		X	X	X	X											X				
F. pratensis										X	X	X	X		X																
F. rubra		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	
Filipendula ulmaria	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	X
Fragraria vesca													X																		
Fraxinus exelsior		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	
Galium aparine											X	X	X		X	X	X	X	X		X	X		X						X	X	
G. palustre	X	X	X	X	X	X	X	X			X		X	X	X	X							X		X	X				X	X	X	
G. verum	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	
Geranium molle																			X													
G. pyrenaicum																			X													
G. robertianum									X		X	X	X		X		X				X	X								X		X	
Geum urbanum			X								X	X	X										X									

Grand Canal (branch lines)
bank verge

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4				1	1							11
	12	:	456	:	901	:	456	:	901	:	456	:	901	:	456	:	901	:	456	:	7	12	:	456	:	901	:	2	1	:	2	1	:	234	:	789	:	23
Glechoma hederacea																								X													
Glyceria maxima		X	X	X		X			X		X	X	X	X	X		X		X			X	X	X	X	X			X			X	X	X	X	X	X
Gymnadenia conopsea	X	X	X			X	X	X					X		X																					
Hedera helix		X							X		X	X	X			X	X							X		X										
Heracleum sphondylium										X	X	X	X	X	X	X	X	X	X			X	X	X							X		X	X	X	
Hieracium pilosella				X		X					X														X											
Holcus lanatus	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	
Hordeum murinum																			X																	
Hydrocotyle vulgaris		X					X																													
Hypericum maculatum		X													X		X								X										
H. perforatum																							X													
H. tetrapterum	X	X	X		X	X	X	X		X		X			X								X	X					X	X	X	X	X			
Hypocharis radicata	X	X	X		X	X	X		X													X	X	X		X			X		X				
Ilex aquifolium													X																							
Iris pseudacorus		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	
Juncus articulatus	X	X	X	X		X					X		X											X	X		X					X	X	X		
J. bufonius																								X			X								X	
J. effusus				X						X	X												X	X			X					X	X	X		
J. inflexus	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		
J. subnodulosus	X		X	X	X	X	X				X													X	X		X					X	X	X		
Knautia arvensis		X		X							X						X	X						X										X		
Lamium purpureum															X																					
Lapsana communis															X							X								X	X					
Lathyrus 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	
Leontodon autumnalis					X	X	X	X	X		X		X												X											
L. hispidus	X	X	X	X	X	X	X		X		X	X		X											X							X	X	X		X	
Leucanthemum vulgare	X	X		X		X		X	X	X	X	X		X			X							X		X		X			X		X			
Ligustrum vulgaris		X					X				X	X	X		X	X								X	X											
Linum catharticum	X	X		X	X	X	X		X	X	X		X													X		X			X					
Listera ovata								X							X																					
Lolium perenne		X	X			X			X		X	X	X	X	X	X	X	X	X				X		X			X			X		X	X	X	
Lonicera periclymenum												X	X	X			X																			
Lotus corniculatus	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		
Luzula campestris			X	X		X	X		X				X												X											
Lycopus europaeus																						X														
Lythrum salicaria	X			X												X	X						X		X	X	X							X	
Medicago lupulina		X	X	X		X					X	X			X		X					X			X	X			X		X					
Mentha aquatica	X	X	X	X	X	X		X	X	X	X	X			X	X	X					X	X	X	X		X		X			X	X	X	X	
Menyanthes trifoliata	X	X		X		X					X														X						X					
Molinea caerulea	X	X		X	X		X																													
Myosotis scorpioides																																		X		
Nasturtium officinale															X									X												
Odontites verna		X	X			X			X		X											X		X	X			X			X					
Ononis repens		X																																		
Orchis mascula													X																							
Origanum vulgare						X			X	X	X						X																			
Papaver spp.											X				X																					
Parnassia palustris	X																																			
Petasites hybridus				X																		X	X												X	X
Phalaris arundinacea			X											X	X	X						X	X	X	X	X	X			X					X	
Phleum pratense	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

Grand Canal (branch lines)
bank verge

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B		N	N	N	N	N	N		E		M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4					1	1								11
	12:	456:	901:	456:	901:	456:	901:	456:	901:	456:	901:	456:	901:	456:	7		12:	456:	901:	2		1:2		1:	234:	789:	23
Phragmites australis	x			x	x		x		x		x	x	x		x	x	x	x				x	x	x	x	x		x		x		x	x	x
Pimpinella saxifraga	x	x	x	x	x	x	x	x	x		x		x								x							x	x	x	x	x		
Plantago lanceolata	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				
P. major					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	
P. trivialis				x						x							x								x	x			x	x	x	x	x	
Polygala serpyllifolia	x	x				x	x	x			x															x								
Polygonum amphibium	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
P. aviculare						x							x			x																		
Populus spp.														x																				
Potentilla anserina	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
P. erecta								x																									x	
P. reptans	x	x	x	x		x		x	x	x		x	x	x		x	x	x		x	x	x		x	x	x			x	x		x	x	
Primula veris		x	x	x		x		x	x	x		x		x	x									x	x			x						
Prunella vulgaris	x	x		x	x	x		x	x	x					x		x	x							x		x			x	x			
Prunus avium													x	x																				
P. spinosa		x				x	x	x	x			x	x	x			x	x						x								x		
Pteridium aquilinum													x																					
Pulicaria dysenterica		x				x	x	x	x	x				x	x																			
Quercus spp.											x																							
Ranunculus acris		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			
R. bulbosus	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x		x			x						x	x					
R. flammula	x	x	x			x																	x											
R. lingua		x																																
R. repens	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
R. sceleratus																							x											
Rhamnus cathartica														x																				
Rhinanthus minor	x	x	x	x	x	x		x	x		x	x	x	x																				
Rosa spp.		x							x		x	x	x			x	x																	
Rosa arvensis								x					x				x						x											
R. canina		x						x	x		x		x			x	x						x		x								
R. pimpinellifolia																x	x																	
Rubus fruticosus		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	
Rumex acetosa			x							x	x		x																					
Rumex crispus												x							x	x														
R. obtusifolius																			x								x							
R. sanguineus		x		x													x				x	x		x	x						x	x	x	
Sagina nodosa		x																																
Salix alba	x																				x	x			x									
S. caprea														x		x							x											
S. cinerea													x		x		x						x				x							
S. fragilis															x																			
S. repens	x					x	x	x			x					x		x					x			x		x	x			x		
S. viminalis		x		x									x				x	x	x					x								x		
S. spp.	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x							x		x		x		x		x		
Sambucus nigra												x	x			x		x																
Scrophularia nodosa				x																														
Senecio aquaticus							x																x											
S. jacobaea	x	x		x				x	x	x	x					x	x	x			x	x	x	x			x			x	x	x	x	
S. vulgaris																						x	x	x										
Silene alba										x	x																							

Grand Canal (branch lines)
bank verge

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	3	3	3	4	4	4	4					1	1							11
	12	456	901	456	901	456	901	456	901	456	901	456	901	456	901	456	7		12	456	901	2			1	1	234	789	23		
Sinapsis arvensis			X		X																										
Sisymbrium officinale																	X														
Solanum dulcamara									X						X																
Sonchus asper											X																				
S. oleraceus					X																										
Sparganium erectum								X																							
Stachys palustris	X	X	X	X				X		X	X	X	X									X	X		X	X					
S. sylvatica											X				X																
Succisa pratensis	X	X	X	X	X	X	X	X	X	X		X		X	X							X		X							
Symphoricarpos albus		X													X				X			X									
Symphytum officinale															X	X															
Taraxacum spp.		X		X						X		X		X	X	X			X	X		X					X			X	
Taxus baccata												X																			
Torilis japonica																											X	X			
Trifolium dubium			X	X		X	X				X											X		X			X	X			
T. pratense	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
T. repens				X		X			X	X	X	X	X	X	X	X	X	X	X	X					X			X				
Triglochin palustris				X		X																									X	
Trisetum flavescens														X	X	X															
Triticum aestivum																													X	X		
Tussilago farfara																					X										
Typha latifolia												X																			
Ulex europaeus		X		X															X				X								
Ulmus agg.											X	X		X		X					X									X	
Urtica dioica		X		X					X	X	X	X	X	X	X		X		X	X	X	X	X	X			X	X	X	X	X	X
Valeriana officinalis	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X		X	X		X	X		X		X					
Veronica anagallis-aquatica																												X		X		
Veronica beccabunga																						X		X							
V. chamaedrys		X	X		X	X	X		X		X	X			X				X	X	X	X	X				X	X			
V. montana										X																					
V. serpyllifolia																					X										
Viburnum opulus											X	X	X			X															
Viccia cracca	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
V. sativa										X																					
V. sepium				X			X	X	X	X	X	X	X	X	X	X	X		X	X	X		X		X		X	X	X		X	

APPENDIX 11

Flora of the Channel - Branch Lines

CHANNEL

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4				1	1							11
	1	2	:	4	5	6	:	9	0	1	:	4	5	6	:	9	0	1	:	4	5	6	7	1	2	1	2	:	2	1	:	2	3
Agrostis stolonifera																X																X
Alisma plantago-aquatica		X								X											X		X	X	X	X		X		X	X	X	
Apium innundatum																							X									
A. nodiflorum																						X		X	X					X		X	X
Baldellia ranunculoides	X																															
Berula erecta																					X	X		X	X	X				X	X		X	X	X
Callitriche spp.																					X	X			X	X				X	X		X	X
Caltha palustris		X		X		X		X																X		X							
Cardamine pratensis		X	X	X																												
Carex acutiformis																X		X												X			
C. nigra																								X									
C. panicea																								X									
C. paniculata																								X	X	X				X			
C. rostrata	X	X	X	X		X	X			X			X			X	X	X					X	X		X		X			X	X	X	
Catabrosa aquatica																										X					X		
Ceratophyllum demersum																							X										
Cladium mariscus		X																															
Elodea canadensis										X				X	X						X	X	X	X		X					X	X	X	
Epilobium hirsutum																										X							
Equisetum fluviatile																						X	X	X	X	X						X	
Eriophorum angustifolium																							X										
Galium palustre	X	X	X	X			X					X		X									X		X	X				X	X	X	
Glyceria maxima		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
Hippuris vulgaris											X										X	X		X	X	X		X			X	X	X	X
Iris pseudacorus			X		X			X		X				X		X	X	X				X	X		X	X	X	X			X			
Juncus articulatus																										X							
J. bulbosus																			X	X						X		X		X	X		
Juncus spp.																									X								
Lemna minor								X													X	X		X	X	X							
L. trisulca																					X	X	X	X	X	X						X	
Mentha aquatica		X							X							X						X	X	X	X	X	X		X		X	X		
Menyanthes trifoliata	X	X				X		X							X								X	X				X	X	X	X		
Myosotis scorpioides																									X						X	X	X	
Myriophyllum spp.	X					X				X	X		X	X			X		X		X	X	X	X	X	X		X		X	X	X	X	X
M. verticilatum																							X										
Nasturtium officinale																X					X	X	X	X	X	X				X	X	X	X	
Nuphar lutea	X	X	X	X	X	X		X		X	X	X	X	X	X	X	X	X	X		X	X	X	X	X		X		X					
Oenanthe aquatica																					X	X											
Oenanthe spp.																						X											
Phalaris arundinacea		X											X	X	X	X							X	X	X	X				X			
Phragmites australis	X	X	X	X	X	X	X	X		X		X	X	X		X	X	X	X			X	X	X	X	X		X		X		X	
Polygonum amphibium	X	X		X		X		X	X	X	X	X		X	X	X	X				X	X		X		X		X	X	X	X	X	
Potamogeton crispus						X				X																X							
P. lucens	X	X						X	X					X	X	X	X	X	X		X							X	X				
P. natans	X	X	X								X												X		X			X	X	X	X	X	
P. pectinatus						X	X	X		X		X			X				X	X						X							
P. perfoliatus																										X							
P. praelongus										X																							

Grand Canal (branch lines)

channel

	B 1 2	B 1 4	B 1 5	B 1 6	B 1 9	B 2 0	B 2 1	B 2 2	B 2 3	B 2 4	B 2 5	B 2 6	B 2 7	B 2 8	B 2 9	B 3 0	B 3 1	B 3 2	B 3 3	B 3 4	B 3 5	B 3 6	B 3 7	B 3 8	B 3 9	B 4 0	B 4 1	B 4 2	B 4 3	B 4 4	B 4 5	B 4 6	B 4 7	N 1 2	N 1 3	N 1 4	N 1 5	N 1 6	N 1 7	N 1 8	N 1 9	N 2 0	N 2 1	N 2 2	E 1	E 2	M 1	M 2	M 3	M 4	M 5	M 6	M 7	M 8	M 9	M 1 0	M 1 1	M 2	M 3
Ranunculus circinatus									X								X																											X												X	
R. flammula	X																																		X																						X	
R. lingua	X																		X																																						X	X	X	X	
R. repens																																																											X													
Sagittaria sagittifolia										X																								X	X	X	X										X										X													
Scirpus lacustris	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							
Sparganium emersum		X	X	X		X	X			X	X	X	X	X	X	X																		X	X	X	X										X										X		X	X	X	X						
S. erectum	X																					X															X	X	X	X																				X	X	X						
S. minimum																																																																	X						
Typha latifolia	X		X													X			X	X	X															X	X	X										X										X												
Veronica anagallis-aquatica																																																																										
V. beccabunga																																																																										
Zannichellia palustris					X				X																																																																		
Charophytes																																																																										
C. hispida v. hispida																																																																										
C. hispida v. rudis																																																																									
C. vulgaris																																																																									
Fontinalis antipyretica	X																																																																							

APPENDIX 12

Flora of the Locks and Bridges - Branch Lines

LOCKS AND BRIDGES

	B 12:	B *	B 456:	B *	B 901:	B *	B 456:	B *	B 901:	B *	B 456:	B *	B 901:	B *	B 456:	B *	B 456:	B *	B 7	N 12:	N *	N 456:	N *	N 901:	N *	N 2	E 1:2	M 1:	M *	M 234:	M *	M 789:	M *	M 23
Acer pseudoplatanus			X		X			X													X							X	X			X
Achillea millefolium	X		X														X			X	X	X				X				X		
Aegopodium podagraria																				X													
Agrostis capillaris																				X													
Alnus glutinosa																	X			X													
Angelica sylvestris	X			X			X				X				X	X				X								X				
Anthoxanthum odoratum	X						X														X												
Anthriscus sylvestris																				X	X							X					
Aphanes arvensis					X																												
Arabis hirsuta	X																																
Arenaria serpyllifolia																					X												
Arrhenatherum elatius							X										X	X			X												
Asplenium ruta-muraria	X		X	X		X		X		X		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		
Bellis perennis	X		X																														
Brizia media	X																																
Bromus erectus									X													X											
B. ramosus						X																											
Calystegia sepium																												X					
Cardamine pratensis			X	X																													
Carex flacca	X																																
C. nigra	X																																
C. remota																				X													
Centaurea nigra	X																X																
Cerastium fontanum			X				X																										
Ceterach officinarum	X						X																										
Clematis vitalba									X																								
Crataegus monogyna																						X	X					X					
Crepis capillaris																							X										
C. vesicaria				X																													
Cymbalaria muralis				X												X					X											X	
Cynosurus cristatus				X																													
Dactylis glomerata	X						X														X												
Daucus carota	X																						X							X			
Desmazeria rigida				X																													
Elymus repens																											X						
Epilobium angustifolium							X																										
E. montanum							X																										
E. parviflorum																					X												
Equisetum arvense																					X												
Erophila verna							X																										
Festuca pratensis	X																																
F. rubra	X		X	X		X		X				X			X	X				X	X			X	X		X		X	X		X	
Filipendula ulmaria	X		X				X								X	X				X	X	X	X					X	X				
Fraxinus exelsior	X						X								X								X		X		X		X				
Galium verum	X		X												X						X			X									
Geranium dissectum																							X										
G. molle									X												X												
G. pyrenaicum											X												X										
Hedera helix	X			X		X		X	X	X	X	X			X	X				X	X	X	X	X	X			X	X		X		

Grand Canal (branch lines)
locks and bridges

	B 12	B *	B 4	B 5	B 6	B *	B 9	B 0	B 1	B *	B 4	B 5	B 6	B *	B 9	B 0	B 1	B *	B 4	B 5	B 6	B *	B 9	B 0	B 4	B 5	B 6	B *	B 9	B 0	B 4	B 5	B 6	B *	B 9	B 0	B 4	B 5	B 6	B *	B 9	B 0	B 7	N 12	N *	N 4	N 5	N 6	N *	N 9	N 0	N 1	N 2	E 1	E 2	M 1	M 2	M 3	M 4	M 7	M 8	M 9	M 2	M 3	M 11
Heracleum sphondylium																																														X																															
Hieracium pilosella	X																																													X																															
Holcus lanatus																																														X																															X
Hordeum murinum																																																																											
Hypericum perforatum																																																																													
H. tetrapterum																																																																																	
Knautia arvensis																																																																																	
Lapsana communis																																																																																	
Lathyrus pratensis																																																																																	
Leontodon autumnalis																																																																																	
L. hispidus	X																																																																																	
Leucanthemum vulgare			X																																																																														
Linum catharticum																																																																																	
Lolium perenne			X		X																																																																													
Lycopus europaeus	X																																																																																	
Malva sylvestris																																																																																		
Medicago lupulina	X		X				X																																																																										
Mentha aquatica																																																																																		
Myosotis arvensis																																																																																		
Origanum vulgare																																																																																		
Parietaria judaica																																																																																	
Petasites hybridus																																																																																	
Phalaris arundinacea																																																																																	
Phyllitis scolopendrium	X		X				X																																																																											
Pimpinella saxifraga	X																																																																																				
Plantago lanceolata	X		X																																																																																
P. major																																																																																						
Poa pratensis	X		X		X																																																																																		
Polypodium vulgare					X																																																																																
Potentilla anserina					X																																																																																
P. reptans	X																																																																																						
Ranunculus acris																																																																																					
R. repens																																																																																						
Rosa canina			X																																																																																	
Rubus fruticosus					X		X						X			X																																																																						
Rumex sanguineus																																																																																						
Sagina apetala																																																																																					
S. procumbens																																																																																					
Salix repens																																																																																					
Sambucus nigra																																																																																					
Sedum acre																																																																																					
S. album																																																																																					
Senecio jacobea	X																																																																																				
S. vulgaris																																																																																					
Sonchus asper																																																																																				
S. oleraceus																																																																																				
Stachys palustris																																																																																				
Taraxacum spp.	X		X				X																																																																												
Trifolium dubium	X				X																																																																												
Trisetum flavescens																																																																																	
Tussilago farfara	X																																																																																

Grand Canal (branch lines)
locks and bridges

	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	B	N	N	N	N	N	N	E	M	M	M	M	M	M
					1	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4					1	1						11
	12:	456:	901:	456:	901:	456:	901:	456:	901:	456:	901:	456:	7	12:	456:	901:	2	1:2	1:2	34:	789:	23
	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Ulmus agg.																											X		X			
Urtica dioica		X		X																	X	X	X									
Valeriana officinalis		X		X						X												X										
Verbena officinalis										X																						
Veronica arvensis		X																		X												
Viccia cracca										X																						

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

APPENDIX 13 : Species Diversity at all sites on the Grand Canal

SITE	Bd	Bdv	Tp	Bkv	Ch
H	-	-	-	16	8
1	14	14	-	26	18
2-4	2	22	-	56	22
5	-	26	-	44	23
6-9	21	40	-	80	32
10	14	39	-	53	22
11-14	16	52	-	74	20
15	33	34	-	50	21
16-19	35	94	25	76	21
20	17	82	7	54	20
21-24	34	74	-	80	22
25	-	-	-	72	11
26-29	46	87	28	72	23
30	13	48	31	58	24
31-34	43	78	45	80	31
35	16	41	-	63	14
36-39	-	-	-	69	21
40	19	59	32	60	19
41-44	46	80	32	76	29
45	19	41	6	46	19
46-49	27	56	2	72	18
50	13	28	17	37	13
51-54	-	-	-	72	20
55	46	39	-	71	13
56-59	18	77	-	86	25
60	12	60	-	65	12
61-64	30	84	1	78	17
65	14	44	34	54	13
66-69	21	40	21	57	6
70	8	32	14	34	3
71-74	21	42	33	52	7
75	34	73	38	64	4
76-79	34	71	32	65	8
80	37	44	21	47	5
81-84	25	73	-	69	9
85	25	96	-	48	7
86-89	36	63	-	61	5
90	15	54	-	51	4
91-94	26	60	-	62	3
95	15	34	-	50	6
96-99	24	36	-	62	5
100	19	45	1	56	5
101-104	36	55	20	64	12
105	23	28	18	56	15
106-109	27	46	-	65	13
110	15	38	-	65	6
111-114	11	72	35	91	12
115	16	61	-	61	7
116-119	14	78	-	75	16
120	8	53	-	46	9
121-124	19	58	36	85	14
125	19	70	30	62	5
126-129	32	62	36	93	10
130	16	79	-	62	7
131	-	54	-	52	8
#	49	51	25	55	55

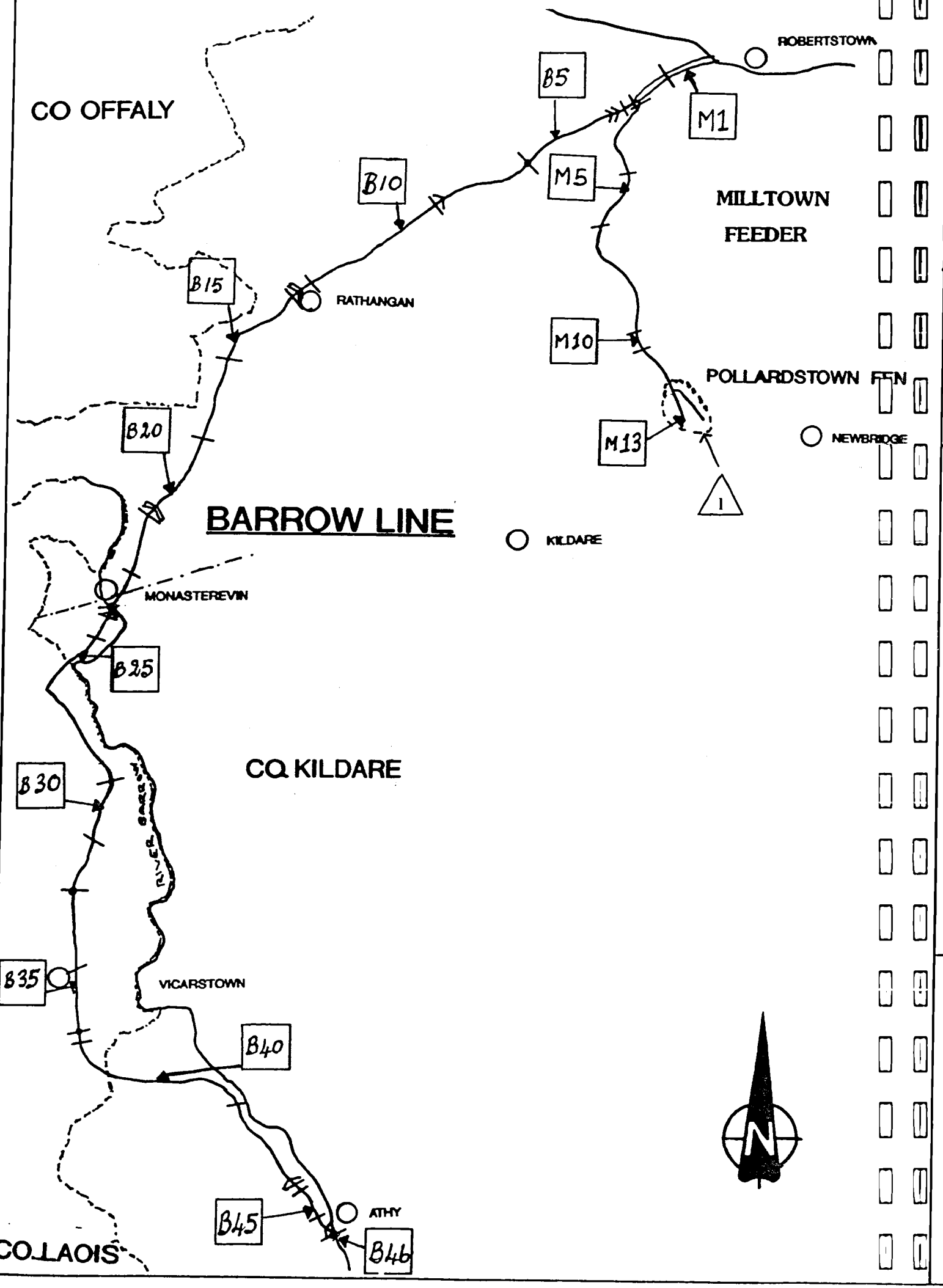
SITE	Bd	Bdv	Tp	Bkv	Ch
B1	11	35	25	63	11
B2-4	33	59	34	101	22
B5	13	61	32	64	7
B6-9	46	106	32	94	10
B10	11	67	25	46	4
B11-14	50	89	40	78	13
B15	44	71	37	56	7
B16-19	48	78	40	74	11
B20	28	71	26	58	3
B21-24	43	67	42	79	16
B25	40	54	-	59	9
B26-29	33	58	-	103	9
B30	28	46	-	81	6
B31-34	25	51	-	97	8
B35	-	-	-	57	11
B36-39	-	-	-	85	15
B40	-	-	-	73	12
B41-44	22	27	9	84	13
B45	24	35	-	49	7
B46	17	32	-	47	5
#	17	17	11	20	20

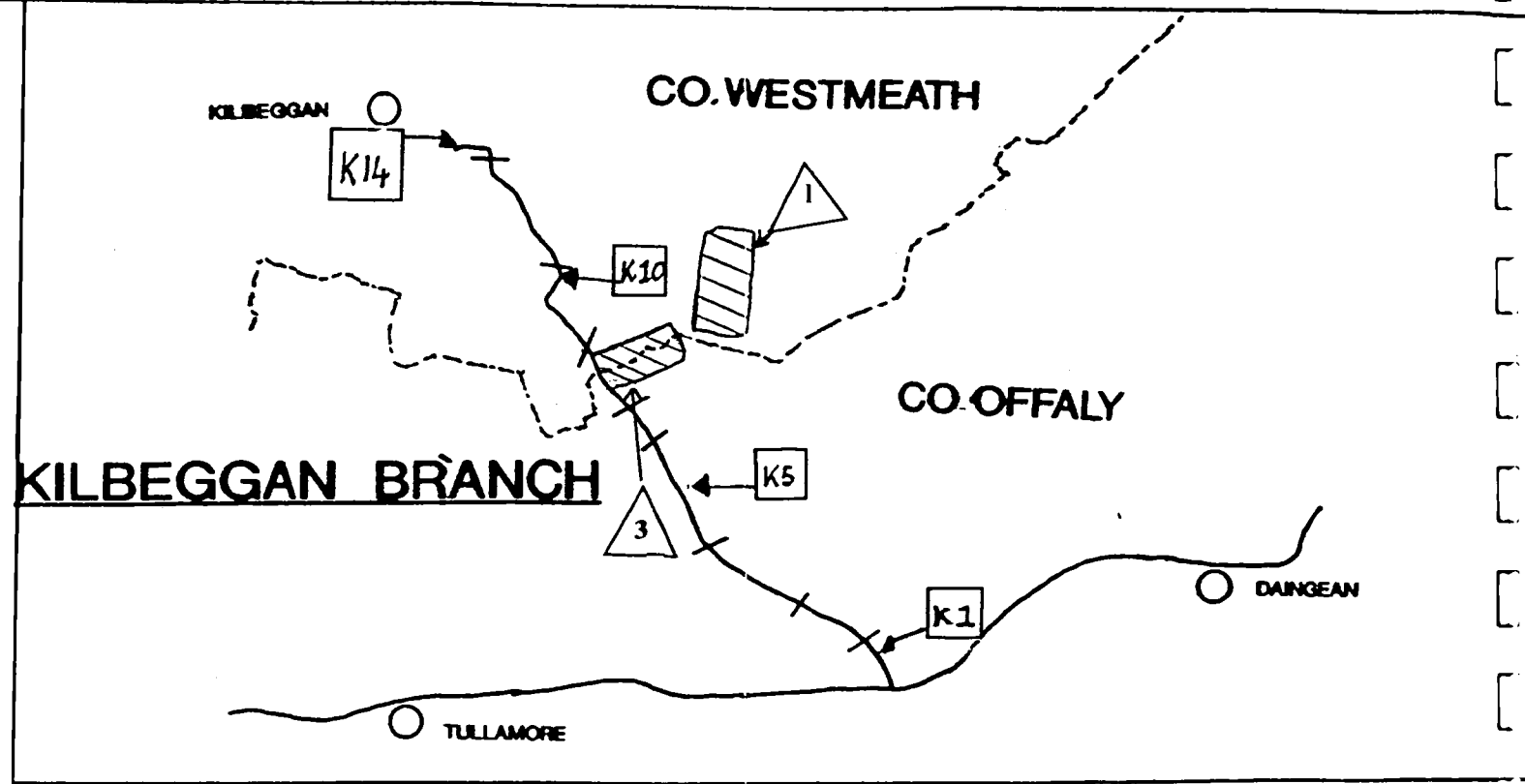
N1	29	41	6	58	16
N2-4	-	-	-	60	23
N5	12	28	28	56	22
N6-9	52	72	39	85	38
N10	26	48	27	62	21
N11-12	17	64	27	58	5
#	5	5	5	6	6

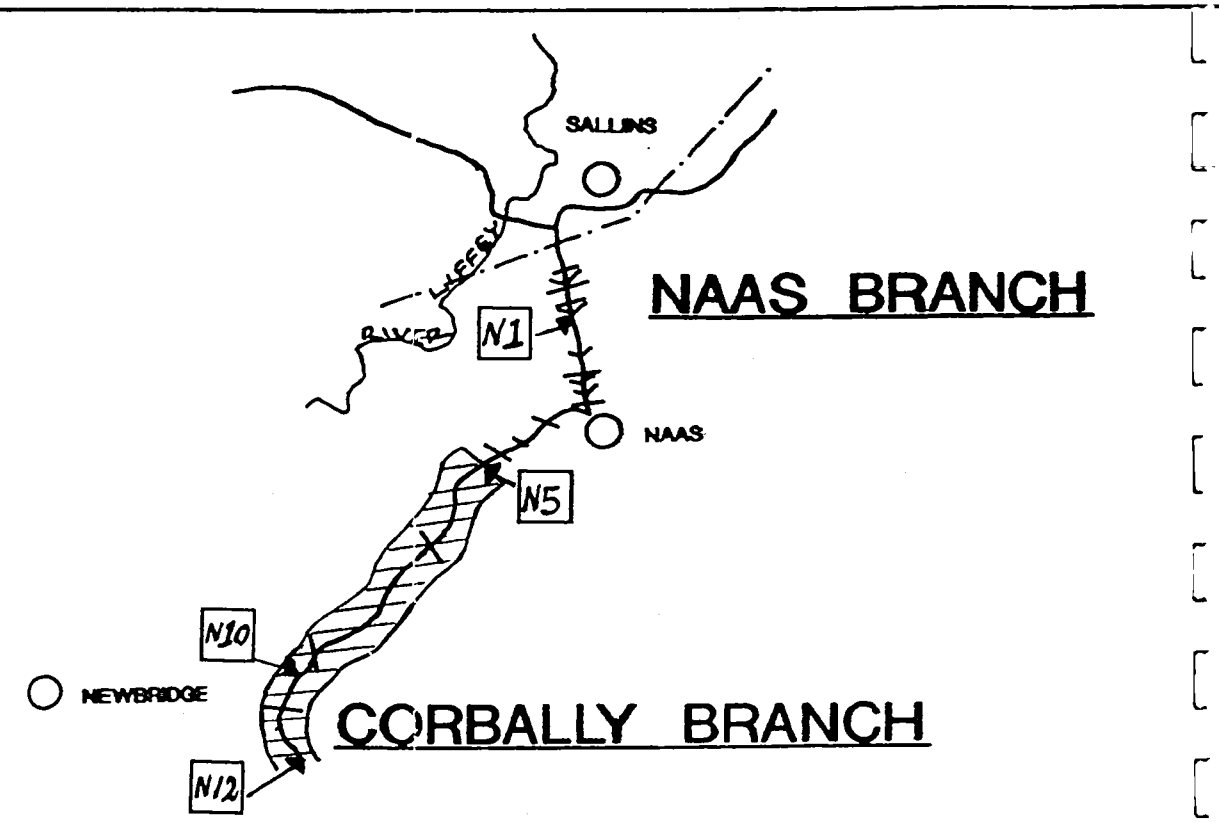
M1-2	21	56	27	66	20
M3	12	37	-	57	18
M4-7	20	40	17	62	18
M8	15	19	22	51	20
M9-12	31	31	26	65	28
M13	-	12	7	20	7
#	5	6	5	6	6

E1-2	18	36	-	59	21

Figure 1.3 Areas of Scientific Interest along the Grand Canal, Branch Lines.







GRAND CANAL BRANCHES BARROW LINE

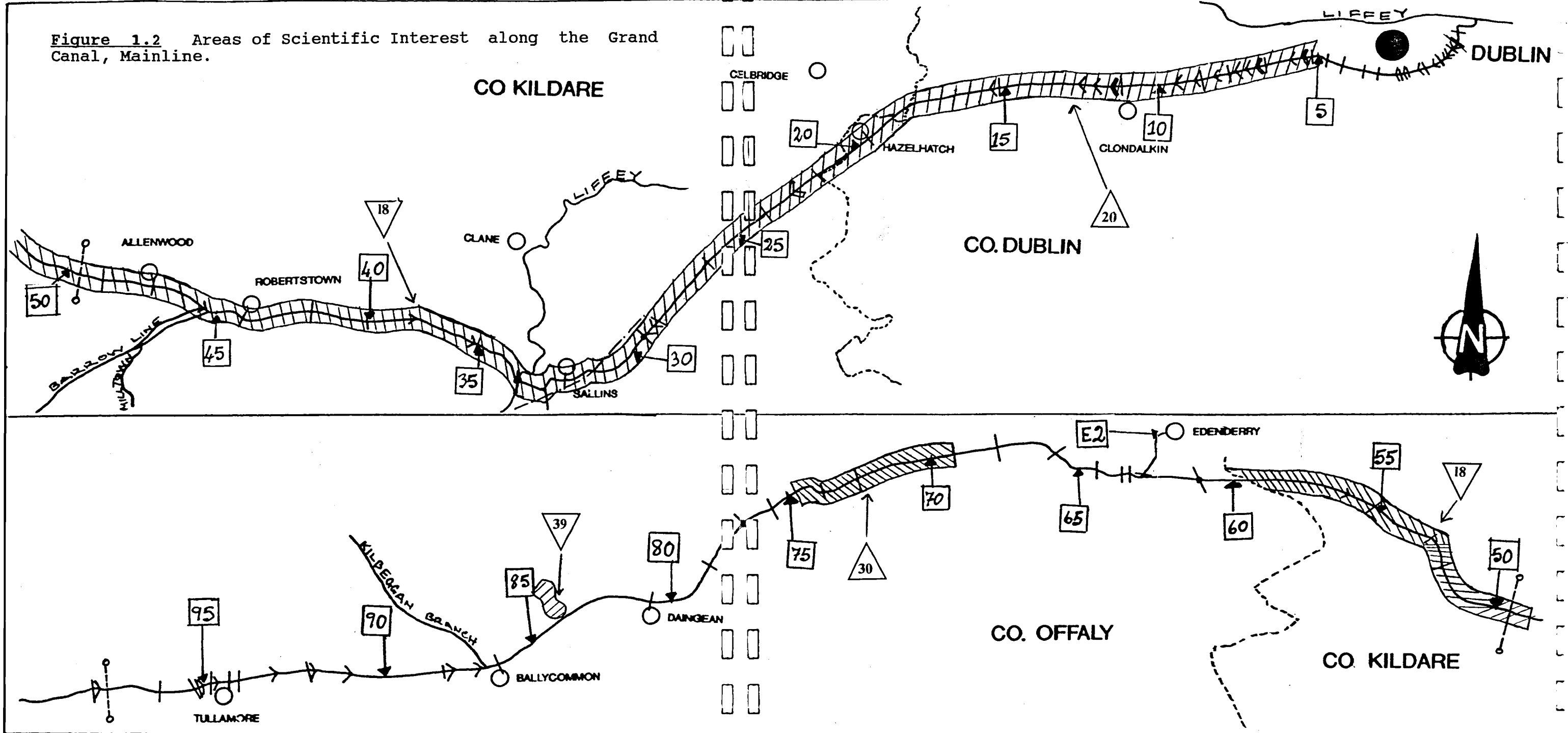
LOCK
BRIDGE
TOWN
AQUEDUCT
CO BOUNDARY
RAILWAY

SCALE
0 1 2 3 4 5
Km

Area of Scientific Interest

denotes the end of a km section

Figure 1.2 Areas of Scientific Interest along the Grand Canal, Mainline.



GRAND CANAL MAINLINE

- LOCK
- BRIDGE
- TOWN
- AQUEDUCT
- CO BOUNDARY
- MAP BOUNDARY
- RAILWAY
- denotes the end of a km section
- Area of Scientific Interest

SCALE

0 1 2 3 4 5 Km