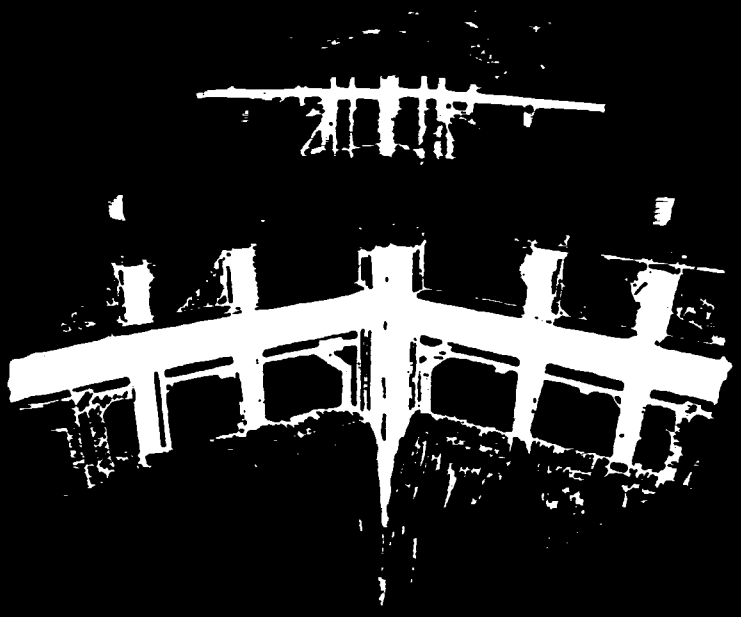
BIOLOGICAL SURVEY

OF THE ROYAL CANA

FINAL REPORT 1990



ECOLOGICAL SURVEY
of the
ROYAL CANAL

Final Report 1990

Part 1 : Survey Report

Prepared for:
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SUMMARY

1. Part 1 contains the report of an ecological survey of the entire length of the Royal Canal, carried out over two years, 1989 and 1990. The main objectives were to assess the values of the canal corridor for nature conservation and to make recommendations for restoration and management of the canal taking these values into account. For the purposes of this survey the waterway was divided into three management units which were: Unit I. Recently dredged and navigable channel; Unit II. Watered channel but not recently dredged; and Unit III. Dry channel. There are 10 listed Areas of Scientific Interest (ASI) along the length of the Royal Canal.

2. The habitats of the canal corridor were divided, in cross-section, into four zones - boundary, towpath, bank and channel. Hedgerows are the dominant habitats of the boundary but in places there are small areas of native woodland and scrub which have developed due to lack of grazing. Wetland habitats on the boundary include small areas of fen, carr woodland and raised bogs with a number of drains and ditches. The towpath is generally a grassy track dominated by trample-resistant species but there are some areas of meadow and nutrient-poor limestone grassland. The canal bank includes transitional habitats between dry grassland at the top and the emergent fringe at the base. The channel habitats are arranged in a series of parallel bands from the emergent vegetation in the shallow water to the submerged and floating-leaved plants in the centre of the channel. The stonework of locks, bridges and harbours provides a range of wall habitats.

3. The vascular flora was surveyed in detail on every section of the canal. A total of 398 species was recorded with the greatest diversity in the boundary and bank zones. The frequency of occurrence of each species along the canal and its preference for particular zones was calculated in order to provide an index of occurrence within the canal system. The boundary zone of Unit II contains many more of the rarer species than the other units. The greatest diversity in the towpath zone occurs where there are adjacent harbours, locks, woodland or nutrient-poor grassland. The greatest diversity in the bank zone occurs where the slope is gradual and incorporates a range of habitat types. Lowest bank diversity is found in urban areas and sections which have recently been dredged. In the channel the greatest diversity occurs in the semi-aquatic sections of Units II and III which may include open water, muddy bed, grassland and scrub. The locks, bridges and harbours along the canal support a range of plants typical of wall habitats and are especially diverse in the derelict sections. A number of nationally rare species were found in the canal corridor mainly in habitats such as fens which are themselves scarce. Two species, Groenlandia densa and Orchis morio, which are protected under the Wildlife Act, 1976, were recorded. A number of plant species are confined to the Dublin city sections of the canal because of their proximity to gardens, waste ground and the coast .

4. The revegetation of dumped spoil one year after dredging was recorded in 12 sample sections along Unit I of the canal. The resulting vegetation was more diverse on the bank than in the other zones. The rate of revegetation on the towpath and boundary was negatively correlated with spoil depth and compaction caused by heavy machines travelling on drying spoil. The revegetation with species present prior to dredging was most rapid where spoil was shallow or where it was mixed with topsoil. Vegetation was slower to recolonise the boundary zone when this was damaged by machinery during dredging operations.

5. The breeding bird communities of the canal were surveyed. A complete census of riparian species was undertaken in May and June 1990 and a mapping census of non-riparian species was carried out on a sample of 25km of canal boundary. Overall, the canal had a very low density of breeding riparian birds by comparison with other waterways. This is due to the recent disruption of the channel and banks by dredging in Unit I and the lack of water in Unit III. Unit II held the highest density of water birds, especially in the sections west of Mullingar where there was a combination of open water, thick marginal vegetation and undisturbed banks with overhanging trees. Moorhens were especially sensitive to dredging. The density of non-riparian breeding birds in the canal boundaries was similar to that found in mature hedgerows in other parts of Ireland. The community was dominated by five species, Robin, Blackbird, Wren, Willow Warbler and Chaffinch, which together accounted for about 80% of all breeding territories. The community structure and species diversity were very similar to those found in hedgerows on farmland.

6. A sample survey of dragonflies and damselflies (Odonata) was carried out in five study areas chosen to represent the full range of habitat types and management regimes on the canal. Previous records from the canal have also been reviewed. A total of 13 species has been recorded, representing over half of the Irish Odonata, although none of those found is nationally rare. The species composition was similar to that found in still-water habitats (including canals) in lowland Britain. A significant difference in species richness was found between the study areas and this was related to the intensity of management with the removal of emergent vegetation and bankside trees having the most drastic effects. Recovery of the Odonata one year after dredging at Clonsilla, Co. Dublin was only partial with the absence of shelter and emergent vegetation limiting the return of some species.

7. Previous surveys of freshwater molluscs and water beetles in the canal system have been reviewed. A total of 28 mollusc species has been recorded from the canal between 1975 and 1983 representing over half the Irish freshwater gastropod and bivalve fauna. The continuous waterbody of the canal has enabled many species to expand beyond their normal range and several are unknown outside the canal systems of south-east Ireland. The rare snail Myxas glutinosa has been recorded from one locality only on the canal. Water beetle

assemblages in six localities on the Co.Westmeath section of the canal were sampled in 1986. A total of 49 aquatic and semi-aquatic species was recorded including several which are scarce in similar habitats in Britain. One species, Eubrychius velutus, has not been recorded elsewhere in Ireland in recent years. The water beetle fauna in most of the sites sampled was dominated by those species which live in deep open water among vegetation. It was impoverished because of eutrophication (water pollution) and the absence of well-vegetated and structurally complex banks to the canal. An exception was found along the canal feeder supply from Lough Owel which held over twice as many species as the other localities.

8. The impacts of management on nature conservation throughout the canal system have been reviewed. These were considered under the general headings of restoration, maintenance and recreational use. Dredging and dumping of spoil can have significant impacts on flora and fauna as can tree-cutting and scrub clearance. Changing the grazing regime may reduce species diversity on the towpath and boundary habitats. Maintenance of high water quality is essential for nature conservation and fisheries while the use of aquatic herbicides has reduced species diversity in the channel. Fisheries management is limited at present but is likely to increase in future. The most significant potential impacts of angling are disturbance to nesting birds and contamination with lead weights. Increased boat traffic is likely to reduce the abundance of some aquatic and semi-aquatic plant species but this is preferable to chemical means of keeping the channel clear.

9. Part 2 of this report contains general guidelines for conservation management on the Royal Canal and recommendations for each section of the entire system. This should allow nature conservation to be given equal priority with other values of the canal, to maximise diversity and to allow flexibility in management to take account of the variability of nature.

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ACKNOWLEDGEMENTS

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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 towpath and the channel.

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

Nearside (ns): The bank of the canal carrying the towpath.

Offside (ofs): The bank opposite the towpath side.

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
MGW	:	Midland Great Western Railway
NCC	:	Nature Conservancy Council
OPW	:	Office of Public Works
RCAG	:	Royal Canal Amenity Group
RCN	:	Royal Canal News

1. MANAGEMENT OBJECTIVES

- To give nature conservation equal priority with other values.
- To maximise diversity by varying management practices over space and time.
- To allow flexibility in management to take into account the variablity of nature.

2. GENERAL GUIDELINES FOR CONSERVATION MANAGEMENT

2.1 RESTORATION

2.1.1 General

- Because of the conservation value of the western section of the canal a full-time ecologist should be employed to monitor the remaining restoration work.

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 the present system.

- 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.

Channel design

- This refers specifically to the restoration of unwatered sections of the canal.

- A deep central channel should be created to prevent the growth of rooted plants which obstruct navigation and to obviate the need for herbicide spraying.

- Where feasible submerged berms should be created in the channel bank to facilitate the growth of shallow water marginal vegetation outside the navigation area.

- Silt traps should be restored and maintained at intervals in the channel so that the resulting accumulations of silt may be selectively dredged.

- 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 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

- Early colonising plants should be mowed at least twice in the first year and the cuttings removed. In subsequent years a single late summer moving should be sufficient.

2.1.3 Repair work

Bank protection

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

Changing water levels

- Drastic changes of water level should be avoided in the months of March to July to minimise disturbance to nesting water birds.

- Coffer dams may be needed to reduce the length of devatered sections and hence the impact on marginal plants and animals.

2.1.4 Towpath revegetation

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

2.2 MAINTENANCE

2.2.1 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.

2.2.2 Scrub

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

2.2.3 Hedgerows

Management methods

- Hedgerows should be trimmed on 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 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.

2.2.4 Grassland

Grazing

- Grazing of individual sites either by sheep or cattle should be consistent from year to year to vary the height of the resulting sward.

- 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.

- In general stock should be removed from the land not later than 30 October in any year to avoid overgrazing during the non-growing season.

Mowing

- Where grazing cannot be continued, mowing should be introduced to prevent invasion of grassland by woody species. Species-rich grasslands should be mown once per year after mid-August when the main flowering season is over.

- 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.

- 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.

2.2.5 Wetlands

- Wetland areas such as fens which occur on or close to the canal should be fenced to give control over grazing.

• Grazing in such areas should be limited to light stocking in late summer and autumn only to allow full flowering of the wetland species and to avoid poaching.

Sensitive habitats

• Sensitive small habitats such as fens and woodland should be left intact (see Part I, Chapter 2)

2.2.6 Aquatic vegetation

Environmental control

• Water depth should be managed to limit the growth of aquatic vegetation in the navigation channel (see Section 2.1.2).

• Boat traffic should be encouraged during the summer months as a means of keeping the navigation channel clear of plant growth.

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 the above methods of controlling plant growth have been tried and have failed. Before being widely used on the Royal Canal, the environmental impact of any herbicides should be carefully assessed.

Biological control

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

2.2.7 Masonry

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

2.2.8 Water quality

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

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	*	*	*

2.3 RECREATIONAL MANAGEMENT

2.3.1 Boat traffic

- Speed limitations should be placed on all boat traffic to prevent damage to canal banks from wash.

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

2.3.2 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 as they affect invertebrate populations.

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

- Herbicide spraying as a fisheries management method should be discontinued (see Section 2.2.6).

- 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.

M. Dromey

Plate 1. 11th August 1990. Section 96 looking eastwards just west of Kiddy's Bridge. The channel is in water at this point and there is a stream running parallel to it, to the left of the picture. The photograph also shows the wide boundary verge dominated by Senecio jacobaea. A dredged stream forms the boundary to the right of the picture.

M. Dromey

Plate 2. 23rd July 1990. Section D13. Looking eastwards and taken east of Callaghan Bridge. A nutrient-poor limestone grassland can be seen in the boundary. The photograph is taken in the Deep Sinking - so called where the channel was cut through solid limestone. The bank at this point is steep and high (2.5m). Species on the boundary include Origanum vulgare, Galium verum, Knautia arvensis and Bromus erectus. (ASI, Dublin No. 20).

M. Dromey

Plate 3. 9th August 1990. Section 81, east of Shandonagh Bridge, looking westwards. The photograph shows the diverse range of habitats in the boundary - limestone grassland, fen. This section is lightly grazed. This stretch forms part of an ASI on the Royal Canal. (Westmeath No. 25).

M. Dromey

Plate 4. 8th August 1990. Looking westwards in Section 78, just west of Mullingar. The photograph shows the diversity of species which can be found at the hedgerow edge of the boundary zone. Knautia arvensis, Centaurea nigra and Galium verum are easily seen. This stretch forms part of an ASI on the Royal Canal. (Westmeath No. 25).

B. Johnston

Plate 5. 16th August 1990. Section 118. Looking east across the canal showing Cloonbreany Bog. This bog forms the boundary along the west of the canal at this point. The bog is draining into the canal here. The canal along this stretch is part of an ASI on the Royal Canal.
(Longford No. 19).

M. Dromey

Plate 6. 11th August 1990. Looking westwards at the beginning of Section 97. Ballymaglavy Bog forms part of the boundary. The towpath has been made of calcareous soil. The species of the acid bog and calcareous towpath exist side by side. The canal is breached one kilometre west of the view shown. This stretch is part of an ASI on the Royal Canal.
(Longford No. 19).

M. Dromey

Plate 7. 10th August 1990. Section 94 beyond Ballynacarrigy and looking westwards towards Kiddy's Bridge. The photograph shows the meadow-like vegetation of the towpath. Many calcareous species are present. The channel at this point is almost dry and supports Cladium mariscus, Typha latifolia, Sparganium erectum and, in the distance Phragmites australis.

M. Dromey

Plate 8. 5th July 1990. Section 116 between Cloonbreany and Foygh Bridges. The picture shows the meadow grassland of the towpath. The channel at this point is dominated by Sparganium erectum. Scrub of the offside bank is beginning to encroach on to the channel. This stretch is part of an ASI. (Longford, No. 19).

M. Dromey

Plate 9. 23rd May 1990. Section 118 looking south towards Cloonbreany Bridge. The channel is very muddy at this point with many pools of water. The towpath is a limestone embankment built between the channel and Cloonbreany Bog. Cattle graze this section. This stretch is part of an ASI. (Longford No. 19).

M. Dromey

Plate 10. 21st May 1990. Section 113 - Mullawornia, looking west from the south bank. The towpath supports calcareous limestone species. The channel is grazed and scrub is encroaching into it. To the right is Mullawornia Hill of solid limestone.

B. Johnston

Plate 11. 17th May 1990. Section 108 looking westwards on the approach to Toome Bridge. The photograph shows encroachment of scrub from boundary on to towpath. The bank consists of trees and scrub while the channel is almost dry.

M. Dromey

Plate 12. 3rd July 1990. Section L2 of the Longford Branch Picture shows the west side of the channel and looking northwards in the direction of Longford town. The towpath consists of grasses. The boundary is Hazel Woodland and the bank is overgrown with trees and shrubs. The channel at this point is muddy and overgrown.

M. Dromey

Plate 13. 15th May 1990. Section 80 between Ballinea and Shandonagh Bridges. The view eastwards shows the towpath which is lightly grazed and supporting many cowslips. The reed fringe here supports Irises, Sedges and Orchids in addition to other species. The north bank shows scattered scrub. This stretch forms part of an ASI on the Royal Canal.

M. Dromey

Plate 14. 8th August 1990. Section 80 between Ballinea and Shandonagh Bridges. The photograph shows wide emergent vegetation consisting of Sedges, Irises, Spearworts, Orchids and Bogbean. Meadow species can be seen on the lightly grazed towpath. This stretch forms part of an ASI on the Royal Canal. (Westmeath, No. 25).

M. Dromey

Plate 15. 16th July 1990. Section D4 immediately east of Liffey Junction and looking eastwards. The photograph shows a large band of emergent vegetation dominated by Glyceria maxima. The vegetation at the top of the bank supports Valeriana officinalis and Filipendula ulmaria. The picture also shows an ideal grass cutting regime where only part of the grass strip is mown. The remainder should be cut once a year and the cuttings removed. (ASI, Dublin No. 20).

M. Dromey

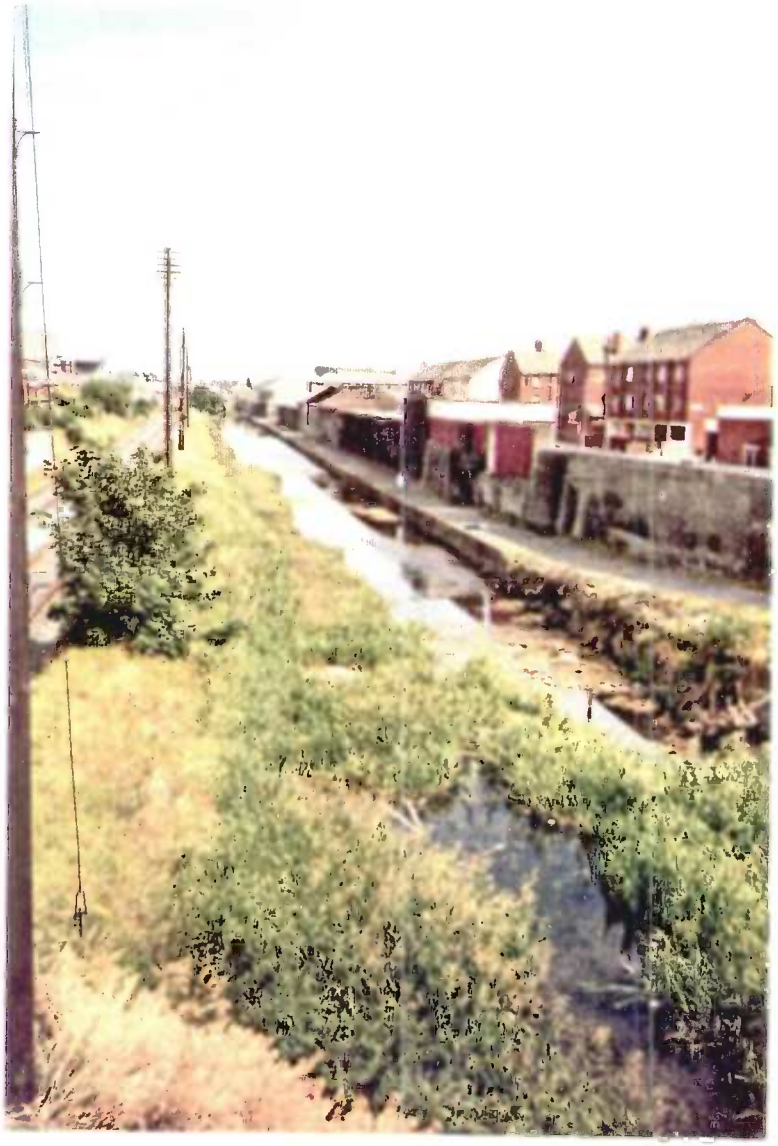
Plate 16. 8th August 1990. Looking eastwards in Section 72 in Mullingar. There is a wide band of emergent vegetation dominated by Glyceria maxima. The wall forms the boundary between gardens and canal property.

B. Johnston

Plate 17. 1st August 1990. Section 37 immediately west of Kilmore Bridge and looking westwards. This stretch was dredged in 1989. The photograph shows vegetation growing on a berm. Nuphar lutea is growing in the deeper water just beyond it.

M. Dromey

Plate 18. 18th July 1990. Section 68/69 east of Mullingar. Photograph shows characteristic species of nutrient-poor limestone grassland - Galium verum, Brizia media, Cynosurus cristatus, Avenula pubescens and Centaurea nigra.



E. Johnston

Plate 19. 16th July 1990. Section D1/2 taken from Binn's Bridge and looking east. The canal is bordered on the north side by the railway track and on the south by a walkway. There is much litter in the canal at this point. A swans nest can be seen in the reed fringe on the north bank. 4 cygnets were hatched in 1990. (ASI Dublin, No. 20).

M. Dromey

Plate 20. 26th July 1990. Section D3 looking east towards Cross Gun's Bridge and Lock 5. The water is very shallow at this point with much of the bed exposed. There is potential for screening using native tree and shrub species on both sides of the canal boundary. (ASI Dublin No. 20).

M. Dromey

Plate 21. 23rd July 1990. Section D12 which is between Kennan and Kirkpatrick Bridges. The photograph shows a view looking eastwards. The canal passes through the Deep Sinking - solid limestone through which the channel had to be cut - at this point and the banks are high and steep. Dense scrub can be seen on the north bank - a haven for birds and invertebrates. (ASI Dublin No. 20).

M. Dromey

Plate 22. 7th June 1990. Section 79 - immediately east of Ballinea Bridge and harbour and looking eastwards. The picture shows a mixed deciduous woodland on the south bank. There is scrub/woodland on the north bank. There is a healthy emergent vegetation in the harbour and many damselflies and dragonflies are to be found here. There is a wet meadow on the north bank which provides a habitat for many other invertebrates. This stretch forms part of an ASI on the Royal Canal. (Westmeath, No. 25).

M. Dromey

Plate 23. 9th August 1990. Section 82 west of Shandonagh Bridge and looking to the north bank. The photograph shows a diversity of species on the bank, in the emergent vegetation of both sides of the channel and in the channel itself. The emergent vegetation on the north bank is characterised by Carex rostrata and Ranunculus flammula. This stretch forms part of an ASI on the Royal Canal (Westmeath, No. 25).

M. Dromey

Plate 24. 25th June 1990. Section L6 of the Longford Branch of the canal between Churchland's and Farranyoogan Bridges, and looking northwards. The picture shows the channel which is almost dry. It supports Orchids, Sedges, Buttercups and Meadowsweet among others.

M. Dromey

Plate 25. 29th June 1990. Section 110. The picture is taken from within Ballybrannigan Harbour looking east towards Chaigneau Bridge. There is a large diversity of marsh plants in the harbour.

B. Johnston

Plate 26. 15th August 1990. Section 112. A view eastwards from Archie's Bridge. Boundary, towpath and bank of both sides of the channel are totally overgrown. The channel is also overgrown and no longer holds water.

B. Johnston

Plate 27. 10th August 1990. Section 93 west of Ballynacarrigy and looking westwards. The channel at this point was not in water during 1990 probably as a result of a breach (Plate 35) in Section 98). The channel was dammed immediately east of Plate 27 (Plate 32) stopping the inflow of water. Glyceria maxima is taking over the channel bed.

M. Dromey

Plate 28. 10th August 1990. Section 90 showing the view west from Balroe Bridge. Ash and sycamore trees have totally taken over both banks. The water level is very low. This stretch forms part of an ASI on the Royal Canal. (Westmeath, No. 25).

M. Dromey

Plate 29. 23rd May 1990. Section 117 from Cloonbreany Bridge looking south towards Foygh Bridge. The channel at this point is muddy and soft underfoot with isolated pools of water. A Hazel Wood forms the west boundary. This stretch is part of the ASI on the Royal Canal. (Longford, No. 19).

B. Johnston

Plate 30. 1st August 1990. Section 37 west of Kilmore Bridge and looking westwards. This stretch was dredged in 1989. The photograph shows part of the silt trap which supports reeds and rushes still intact.

B. Johnston

Plate 31. 4th May 1990. Section 51 between Darcy's and Ballasport Bridges and looking westwards. This section was dredged early 1990. There is a very large silt trap, now vegetated, on the bend. It supports a large diversity of plants including White Water-lily (Nymphaea alba).

B. Johnston

Plate 32. 16th May 1990. Lock 36 in Section 93, west of Ballynacargy. The lock is dammed to prevent water flowing out of the Ballynacarrigy stretch as there is a breach further along the canal in Section 97. The walls of the lock chamber support many species - Phylltis scolopendrium, Taraxacum spp. Festuca rubra and Galium verum. Primula veris (cowslip) is growing in the crevice on top of the wall. Wetland species are growing on the lock sill.

B. Johnston

Plate 33. 11th August 1990. Section 98 which traverses Ballymaglavy Bog. The bridge is known as Bog Bridge supports Ivy Elder and Hawthorn. The waterlevel at this point is very low due to a breach a few hundred meters eastwards. The bank supports Epilobium hirsutum, Filipendula ulmaria, Centaurea nigra, Sonchus asper and many more. The towpath supports meadow species and the bog forms the boundary.

B. Johnston

Plate 34. 21st May 1990. Lock 40 at Mullawornia Bridge in Section 113 and looking eastwards in the direction of Longford and Archie's Bridges. The lock has fallen into disrepair and the channel is completely dry at this point. The walls support calcareous species as does the towpath.

M. Dromey

Plate 35. 12th June 1990. Section 97 showing the canal where it is breached. The bank has been eroded and undercut. The canal at this point traverses the Raised Ballymaglavy Bog. Some Nuphar lutea can be seen on the dry section of channel bed. This stretch of the canal forms part of an ASI on the canal (Longford No. 19).

M. Dromey

Plate 36. 11th August 1990. Section 97 showing a close up picture of the site of the breach (seen in less detail Plate 35).

M. Dromey

Plate 37. 8th August 1990. Section 74 west of Mullingar and looking eastwards. The photograph shows the wide band of emergent vegetation and tall grasses of the Bank. The channel is dominated by Lemna minor and L. trisulca. This stretch provides a suitable habitat for the many moorhens, dragonflies and damselflies found here. It is also part of an ASI on the Royal Canal.(Westmeath, No. 25).

M. Dromey

Plate 38. 2nd August 1990. Section 67 east of Baltrasna Bridge and looking westward. This stretch was dredged in early 1990 and the spoil moved to the bank, or, deposited on it. It is supporting many species and almost covered over. A very small reed fringe exists.

B. Johnston

Plate 39. 31st July 1990. Section 1 at Clonsilla just west of the disused pipe across the canal. This stretch was dredged in 1989 and the spoil dragged up the bank and deposited on the towpath. Many species are growing on the bank including Eupatorium cannabinum, Epilobium hirsutum, Cirsium arvense and Senecio jacobaea. The reed fringe of the south bank remains intact. (ASI, Dublin No. 20).

B. Johnston

Plate 40. 31st July 1990. Looking eastwards from the disused Railway Bridge of Section 1, just west of Callaghan Bridge at Clonsilla. This stretch was dredged in 1989, the spoil dragged up the bank and deposited on the towpath and later levelled when it was dry. The picture shows compaction and non-vegetation of the towpath. The bank is high and steep with very little revegetation. (ASI, Dublin No. 20).

B. Johnston

Plate 41. 1st August 1990. Section 40 east of Ribbontail Bridge and looking westwards. This stretch was dredged early 1990 using a hydraulic machine and the spoil deposited on the bank. Revegetation is particularly evident where cracks have occurred in the spoil. The spoil or mud dredged from the channel has solidified upon drying. This makes it difficult for germinating vegetation to emerge.

B. Johnston

Plate 42. 1st August 1990. Section 40. Looking west towards Ribbontail Bridge. This stretch was dredged early 1990 using a hydraulic machine and the spoil deposited on the bank and in the boundary. The spoil has solidified on both areas with little revegetation. There is sufficient room in the boundary to have excavated a trench, deposited the spoil there and covered it with topsoil.

M. Dromey

Plate 43. 18th May 1990. Section 45 at Blackshade Bridge and looking west. This section was dredged using a hydraulic machine early 1990 and the spoil moved to the bank except in the vicinity of the bridge where it was levelled into the bank. The boundary consists of Hazel Woodland and Whitethorn.

B. Johnston

Plate 44. 1st August 1990. Section 45 at Blackshade Bridge and looking west. Vegetation is growing on the spoil especially at the bank base. The revegetation is not as dense where the bank is high and steep.

M. Dromey

Plate 45. 2nd August 1990. Looking westwards in Section 66. This stretch was dredged early 1990 and the spoil deposited in the boundary. Mud was brought into the area in order to build up the bank. The mud has solidified upon drying with very little revegetation occurring.

E. Johnston

Plate 46. 31st July 1990. Section 14 at the back of Maynooth College and looking eastwards. This section was dredged early on 1989, the spoil deposited on the towpath and levelled off a few months later. The channel at this point was practically dry prior to dredging and dominated by the reed Glyceria maxima. The vegetation of the towpath one year after dredging is still dominated by this reed. Cutting the vegetation in the first growing season (1989) may have reduced this dominance (ASI, Kildare No. 11).

B. Johnston

Plate 47. 31st July 1990. Section 11 looking eastwards to Deey Bridge. This stretch was dredged early in 1989, the spoil deposited on the towpath and later levelled. Some topsoil from the boundary hedge was mixed in with the spoil. The revegetation of the towpath one year after dredging was abundant and diverse with no evidence of compaction. There are some nuisance species such as thistles but the characteristic vegetation is that of grassland.(ASI)

B. Johnston

Plate 48. 31st July 1990. Section 12 immediately west of Pike Bridge and looking westwards towards Maynooth. This stretch was dredged early in 1989, the spoil deposited on the bank and levelled off a few months later. Soil compaction of the towpath is evident. The bank vegetation is diverse. (ASI, Kildare, No. 11).

B. Johnston

Plate 49. 31st July 1990. Section 12 immediately west of Pike Bridge and just west of the view in Plate 48. This stretch was dredged early in 1989, the spoil deposited on the bank and levelled a few months later. The vegetation is dominated by thistles (Cirsium vulgare). The seeds of thistles are very easily dispersed by wind and will colonise bare soil quickly. The field to the right of the picture supports many thistles. This vegetation should be cut early in the growing season before flowering. (ASI, Kildare No. 11).

B. Johnston

Plate 50. 31st July 1990. Section 2 west of Pakenham Bridge and looking westwards. This stretch was dredged in 1989, the spoil dragged up the bank and deposited on the towpath and later levelled off. Compaction of the soil (spoil) is taking place with little revegetation. (ASI)

B. Johnston

Plate 51. 3rd May 1990. Section 59. The photograph is taken from Footy's Bridge and looking westwards towards Thomastown. The towpath is on the north bank. This stretch was dredged late in 1989 and the spoil deposited on the bank. It then flowed down on to the level ground. See Plate 52 to show revegetation.

M. Dromey

Plate 52. 8th June 1990. Section 59 (Follow on from Plate 51). Vegetation is coming through the cracks in the solidified spoil. By August (no photograph the vegetation cover was much greater). This is a calcareous grassland site and Orchis morio was found here in 1989 prior to dredging (Conn Breen pers. comm). It is a protected species.

B. Johnston

Plate 53. 2nd August 1990. Section 66 west of Downs Bridge. This section was dredged late 1989 and the spoil deposited in the boundary. The spoil was not covered with topsoil. Vegetation is growing where the spoil was cracked.

M. Dromey

Plate 54. 1st August 1990, Section 44 east of Blackshade Bridge and looking eastwards. This stretch was dredged early 1990 using a hydraulic machine and the spoil deposited on the bank and boundary. The spoil has solidified (as in Plates 42, 43 and 53) and vegetation is not growing upon it. There was sufficient room to have buried the spoil and covered it with topsoil.

M. Dromey

Plate 55. 16th July 1990. Section D 10 west of Granard Bridge in Castleknock and looking eastwards towards Dublin City. This stretch was dredged in mid 1990 and the spoil deposited in the boundary without much damage to the bank. Bank vegetation was cut back prior to dredging (see Plate 56 for revegation of this section). Some reed fringe on the north bank remains intact. (ASI, Dublin No. 20).

B. Johnston

Plate 56. 14th September 1990. Section D10 west of Granard Bridge at Castleknock and looking westwards. The spoil deposited in the Boundary (Plate 55) is now supporting Glyceria maxima and Polygonum amphibium. Topsoil was not mixed with the spoil. Some bank side trees remain (ASI, Dublin No. 20).

M. Dromey

Plate 57. 30th May 1990. Section D6 at Lock 8 just west of Reilly's Bridge and looking westwards towards Lock 9. The channel at this point supports a wide band of emergent vegetation dominated by Glyceria maxima. (ASI, Dublin No. 20).

M. Dromey

Plate 58. 16th July 1990. D6 as for Plate 57). This stretch was dredged mid 1990, the spoil scooped out and dragged up the bank and deposited on the south bank. (ASI, Dublin No. 20).

B. Johnston

Plate 59. 14th September 1990. D6 (as for Plate 57). The bank of the north side of the channel and the deposited spoil of the south bank support a Glyceria dominated vegetation two months after dredging.

B. Johnston

Plate 60. October 1989. Section 68/69 looking eastwards between Saunders and Baltrasna Bridges. The photograph was taken prior to dredging by the OPW. The picture shows the canal passing through a limestone cutting. The boundary (to the right of the picture) consists of calcareous embankments. This stretch is grazed.

B. Johnston

Plate 61. 14th May 1990. Section 68/69 between Saunders and Baltrasna Bridges and looking westwards. This stretch was dredged late 1989 early 1990. The towpath had to be widened to facilitate the machinery being used and part of the calcareous embankment of the boundary was cut away. The photograph also shows scattered scrub of the north bank. (See Plate 60).

M. Dromey

Plate 62. 18th July 1990. Section 68/69 between Saunders and Baltrasna Bridges and looking eastwards. The picture shows the limestone vegetation at the top of the bank, the damaged boundary (still not revegetating (See plate 61), the limestone embankment of the boundary and the scattered scrub of the north bank.

M. Dromey

Plate 63. 16th July 1990. Section D8. Looking westwards on the south side of the canal between Ashtown (Lock 10) and Lock 11 prior to dredging which took place August/September 1990. The picture shows a hedgerow supporting a dense growth, a narrow towpath, the bank supporting Iris pseudacorus, Filipendula ulmaria and many more and the mature Beech trees (Fagus sylvatica) of the north bank. (ASI, Dublin No. 20).

B. Johnston

Plate 64. 14th September 1990. Section D8 as for Plate 63 though the picture shows the view eastwards. This photograph was taken 2-6 weeks after dredging. Much of the vegetation of the boundary was cut back and the spoil deposited there. The lush bank vegetation is no longer present and the towpath is considerably wider. Glyceria maxima is growing in the spoil on the boundary. (ASI, Dublin, No. 20).

M. Dromey

Plate 65. 23rd July 1990. Section D11. Looking east from Kirkpatrick Bridge and showing part of the Limestone cutting (solid limestone rock through which the channel had to be cut). There is dense scrub growth on both banks with a narrow towpath. (ASI, Dublin No. 20).

M. Dromey

Plate 66. 12th June 1990. Section 92 at Ballynacarrigy Harbour - looking westwards. There is very little emergent vegetation or channel vegetation. This stretch forms part of an ASI on the Royal Canal (Westmeath, No. 25).

Chapter 1. INTRODUCTION

1.1 General description

An ecological survey of the entire length of the Royal Canal was carried out during 1989 and 1990 in order to incorporate nature conservation into the future management and restoration of the canal by the Office of Public Works. The history of the Royal Canal has been well documented (Delaney and Delaney 1966; Delaney 1986). It was built during the years 1790 to 1830 to link the River Liffey in Dublin to the River Shannon in Co. Longford. The main line of the canal is 145km in length with 46 locks. The Longford Branch line is 8.4km with no locks. There is a total of 109 bridges on the canal including footbridges, railway bridges and road culverts (Fig. 1.1).

During the 1950s the canal became disused and was officially closed to navigation in 1961. Over the following decades long stretches, especially in the western part of the canal, became dry. The locks fell into disrepair and road culverts were built through the bed of the canal in a number of places. During all of this time natural vegetation succession was taking place with reduction in water depth, silting of the channel and colonisation of the towpaths by trees and shrubs. As a result the canal now supports a range of semi-natural habitats and a diversity of wild plants and animals which might not otherwise survive in a heavily managed waterway.

1.2 Canal restoration

In 1974 the Royal Canal Amenity Group (RCAG) was founded with the aim of restoring navigation on the canal from Dublin to the Shannon. Local branches of the RCAG worked to improve the amenity value of the canal in individual towns and villages. With the help of CIE and local authorities, volunteers cut hedgerows, cleared towpaths and removed a large amount of refuse from the channel. Restoration work on a large scale began in 1986 when the Office of Public Works (OPW) took over management of the canal system and began dredging and rebuilding the eastern section of the Royal Canal. Plans for the reopening of the entire length of the canal were based on a

management and development survey commissioned by the OPW from Brady, Shipman, Martin (1987). This report recommended that the ecology of all the canals should be surveyed including a comprehensive inventory of flora and fauna on the system. Unfortunately, by the time the present study began in August 1989 a major dredging programme on the eastern section of the Royal Canal from Clonsilla to Mullingar was already under way and much valuable base-line data on the habitats and their associated flora and fauna was lost.

Management Units

As restoration work has taken place unevenly throughout the entire length of the canal it was decided for the purposes of this survey to subdivide the waterway into three principal management units as follows:

Unit I. Recently dredged and navigable channel.

Unit II. Watered channel but not recently dredged.

Unit III. De-watered or dry channel.

The distribution of these units is shown on Figure 1.1 and their dimensions are given in Table 1.1.

Table 1.1 Management units used in the ecological survey of the Royal Canal

Unit	Length (km)	Section Numbers	Area Limits	Present Status
I	72	1-72	Clonsilla-Mullingar	Navigable
II a	13	D1-D13	Liffey-Clonsilla	Watered
II b	30	73-102	Mullingar-Abbeyshrule	Watered
IIIa	31	103-133	Abbeyshrule-Shannon	Dry
IIIb	8	L1-L8	Longford branch	Dry
Total	154		Liffey-Shannon	

Importance of nature conservation

The Royal Canal traverses the midlands of Ireland and thus provides a continuous corridor for the dispersal of wetland plants and animals between the Shannon valley and the east coast. The low intensity management and virtual absence of boat traffic during the past three decades has favoured the development of a diverse semi-natural flora and fauna on many sections. This is often in contrast to the surrounding countryside which is highly modified either by agriculture or urban development. Thus the canal could be regarded as linear refuge and surviving example of the natural flora and fauna of the midlands. State ownership offers a unique opportunity to incorporate nature conservation into the restoration and maintenance of the canal. Conservation should be seen as a priority policy, since it is upon the ecosystems that the canal depends for bank protection and fisheries and as attractive environments for cruising, walking and other leisure uses (Murphy and Eaton 1990). A number of sections of the canal and bordering lands are designated Areas of Scientific Interest (ASI) which are listed for special protection in the relevant County Development Plans

1.3 Ecological survey

Objectives

The objectives of the present survey were as follows:

- To assess the present value of the canal corridor for nature conservation by documenting its biological resources.
- To determine what factors influence the present distribution and abundance of plant and animal communities on the canal.
- To use these findings to draw up detailed recommendations for management of each section of the canal taking nature conservation as one of the main priorities.
- To prepare a manual of general principles of nature conservation management to be used in the restoration and subsequent maintenance of the canal.
- To promote an awareness of the nature conservation value of the canal corridor.

Timescale and subjects covered

This survey was carried out in two phases by the following personnel: Marie Dromey, Brigid Johnston, Philip Buckley and Richard Nairn.

Phase 1:	*August to December 1989*		*Personnel*
	Unit I	Habitat survey	MD/BJ
		Survey of late flowering plants	MD/BJ
		Winter bird survey	PB
Phase 2:	*April to December 1990*		
	Units II & III	Habitat survey	MD/BJ
		Botanical survey	MD/BJ
	Unit I	Survey of early flowering plants	MD/BJ
	Units I, II, III	Breeding bird survey	RN
		Dragonfly survey	RN
		Winter bird survey	RN

The report of Phase 1 was published in two volumes (Dromey, Johnston and Buckley 1990) which is referred to below as Royal Canal Survey 1989 (or R.C.S. 1989).

Methods

The methods of survey are given in detail under each section of the report which follows. However, some general terms used throughout the survey are defined here. Four basic structural **zones** were recognised on either side across the canal corridor. These were termed the channel, bank, towpath and boundary. For the botanical survey the length of the canal was subdivided into 1km units which are referred to below as **sections**. In the case of the bird surveys and dragonfly surveys a number of **study areas** were selected as representative of the three management units (see Chapter 4).

1.4 Study Area

Topography

The Royal Canal runs from east to west for 150km across the central plain of Ireland linking the River Liffey in Dublin to the River Shannon in Co. Longford (Figure 1.1). It varies in altitude from 0 to 100m above sea level with the summit level around Mullingar. From Leixlip to Kilcock the canal follows the valley of the Ryewater River, a tributory of the Liffey, while from Abbeyshrule to Ballymahon it follows the valley of the River Inny. The surrounding landscape is predominantly flat but there are a number of prominent esker ridges in the valley of the River Boyne.

Geology and soils

The canal passes through the central plain of Ireland 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. This has a major influence on the composition of the plant and animals of the terrestrial habitats as well as the aquatic communities which inhabit water derived mainly from limestone lakes and rivers. 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 some extensive areas of peatland in counties Meath, Westmeath and Longford. These include fen peat, as for example Ballynabarney Fen, west of the River Boyne, and raised bog such as that at Ballymaglavy Bog, north of Ballymahon.

Water quality

The quality of water in any freshwater system has important implications for the plant and especially the animal communities which it supports. The main source of water is from Lough Owel via the feeder which joins the canal in Mullingar (Figure 1.1). Water

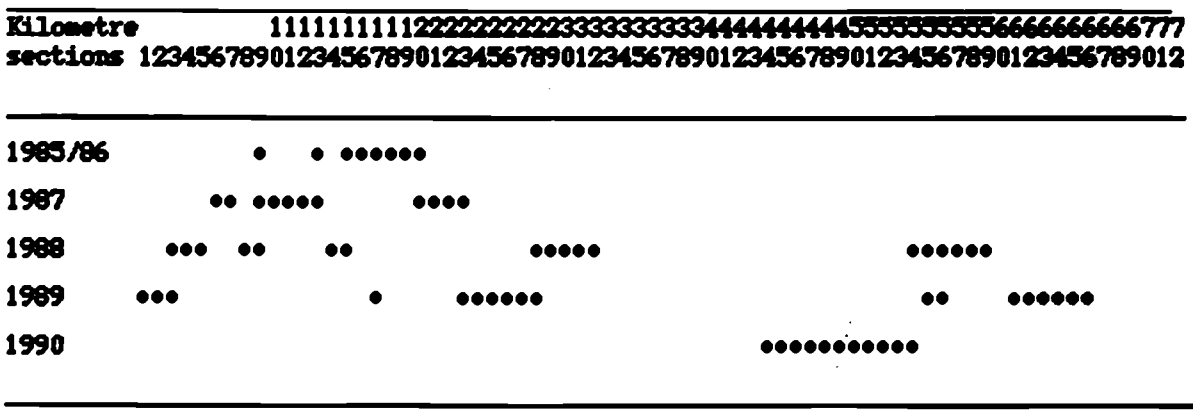
quality in the Royal Canal and its feeders and abstractions has been studied by the Central Fisheries Board and is reported in detail elsewhere (Caffrey 1990). Water quality on the canal is generally quite good with Molybdate reactive phosporus (MRP) concentrations mostly below 0.01 mg/l P. Only one section (Shaws Bridge to Lock 17) has MRP concentrations above 0.05 mg/l and this is due to the Ryewater feeder which is enriched from intensive agricultural practices. Nitrate/Nitrite levels show a number of peaks up to 3.5mg/l along the canal length which correspond to areas where the canal is either level with the surrounding land or is below ground level in a cutting. The source of of nitrates/nitrites is probably due to runoff and the leaching of nitrates from artificial fertilizer applications on surrounding fields (Caffrey 1990).

Management regimes

The most significant management practices from the point of view of nature conservation are dredging, spreading of spoil, herbicide application, grazing and the cutting of trees and shrubs.

Dredging: Most recent dredging has been concentrated in Unit I with the sections involved shown in Table 1.2.

Table 1.2. Dredging in Unit I of the Royal Canal up to the time of this study.



The spoil in most areas was dumped on the towpath although in some places a floating dredger was used to transport the spoil away from the site. The effects of the dredging have been to remove the majority of submerged and emergent plants in the channel and to supress the growth of bankside and towpath vegetation at least on one side of the canal.

Herbicide application: Herbicides, mainly diclobenil (Casoron), are applied annually on the watered sections of the canal (Units I and II) for the control of aquatic plants to permit unimpeded movement of water and boats and easy access for anglers. A survey of the Grand and Royal Canals has demonstrated that this treatment is unnecessary as environmental conditions in much of the canal system are unfavourable for the use of certain herbicides (Murphy and Eaton 1990). It is also suggested that the prolonged reliance on a single herbicide leads to the channel vegetation becoming dominated by species tolerant of the chemical, or by quickly regroving opportunist species such as filamentous algae. A further problem associated with the spring application of herbicides is that it causes disturbance to nesting birds during the sensitive period of incubation.

Areas of Scientific Interest

A number of areas along the route of the Royal Canal are listed as Areas of Scientific Interest (ASI) by An Foras Forbartha (Anon, 1981) and by the Wildlife Service (1989). Brief details of these ASIs are given in Table 1.3.

Table 1.3. Areas of Scientific Interest on the Royal Canal (after Wildlife Service 1989)

County (ASI no.)	Name Grid ref.	Km Sections	Area/ Length	Habitat	Rating
Dublin (20)	Royal Canal O0738 to O0732	D1-D13 1-5	16km	Canal	Regional
Kildare (11)	Royal Canal O000375	7-19	10km	Canal	Regional
Kildare (21)	Louisa Bridge N995368	7	3ha	Marsh	Local
Meath (24)	Ballynabarney Fen N687459	43-44	2ha	Fen	Local
Meath (32)	Lerick Bog N6747	45-46	60ha	Raised bog	Local
Meath (33)	Mount Hevey Bog N6348	49-51	190ha	Raised bog	Local
Westmeath (7)	Lough Owel N3957	-	950ha	Lake	National
Westmeath (25)	Royal Canal Mullingar to Ballynacarrigy N3653	74-92	17km	Canal	Local
Longford (6)	Cloondara Bog N0874	132	250ha	Raised bog	Regional
Longford (19)	Royal Canal N234598, N123637, N168585	96-102 105-111 116-122	15km	Canal	Local

CHAPTER 2 HABITATS

2.1 INTRODUCTION

Along the entire length of canal, plants are found in associations or communities typical of a particular habitat. These habitats can be large as are the hedgerow and scrubland along the canal or barely discernible as with a small fen or small area of nutrient-poor limestone grassland. Most of the plants found in the habitats are influenced by the alkaline conditions of the limestone geology of the Central Plain.

The purpose of this chapter is to list the various habitats found and to discuss the associated flora found within them. The habitats of each canal zone are discussed. There are four canal zones within the canal corridor easily distinguished when looking at a cross section of canal corridor - boundary, towpath, bank and channel. Locks, bridges and harbours form another habitat - namely that of Stonework.

In discussing the habitats it must be remembered that the associated communities are not steadfast and stable. Instead one community of organisms gives way to another in a series from coloniser to climax. This is known as natural succession. To maintain the diversity of habitats encountered along the canal - all the stages in the succession from a coloniser to climax - it is important that the climax stage not be reached everywhere and other stages and associated communities choked out.

2.2 HABITATS OF THE BOUNDARY

The boundary is defined as the edge of canal property and the area between it and the towpath. This area generally comprises of grassland and herbaceous species usually bordered by a hedgerow, scrubland, fence etc. and can vary in width from 1-7 metres. When a hedgerow/woodland is not cut back and managed it can completely take over this boundary verge to the detriment of the grassland and herbaceous species (Plates 26 and 28). Where the boundary verge is not invaded, a pattern of definite layering consisting of

a) a carpet layer comprising of low grasses.

b) a field layer comprising of herbaceous flowering plants and taller grasses (Plate 4).

c) small shrubs and bushes

can be seen. Along other sections of the boundary of the canal, fens, bogs (Plates 5 and 6), drains and

streams (Plate 3) can be seen.

2.2.1. Hedgerow

The hedgerow habitat is dominant along both sides of the canal. They are man-made and therefore artificial habitats. They provide a partial substitute for lost woodlands. They are essentially woodland edges without the woods. Species that preferred wood edge conditions have been able to dominate hedges. In addition hedgerows form a border between ecosystems and can often share much of the flora and fauna of these systems.

Over the years, planted Hawthorn (Crataegus monogyna) hedges have been joined by other shrubs such as Blackthorn (Prunus spinosa), Alder (Alnus glutinosa) and Dog rose (Rosa canina agg.) and on the calcareous soils by several of the limeloving shrubs such as Privet, (Ligustrum vulgare), Spindle (Euonymus europaeus) and Guelder rose (Viburnum opulus). Where tree saplings have been allowed to grow up in the shelter of the hedge, Oak (Quercus agg.), Ash (Fraxinus excelsior), Sycamore (Acer pseudoplatanus) and Beech (Fagus sylvatica) appear at intervals. The limeloving shrubs do not grow along the canal where heavy grazing is carried out. These are very weak shrubs and not able to withstand this pressure unless protected by other stronger shrubs around them. (Agate and Brooks, 1988).

In some ways, it is not the shrubs, but the climbing plants which really characterise hedges. They tend to choke out shrubs but they thrive on sunlight, support for their weak stems and on occassional cutting back if the hedge is not to be weighed down with them. Some such climbing species of the hedge include Calystegia spp. Rubus spp, Rosa spp, Clematis vitalba, Hedera helix, Lonicera spp, Solancum dulcamara, Lathyrus pratensis, Viccia spp and Galium aparine.

Advantages of Hedges

a) They provide a valuable habitat for flowers, birds, insects and other wildlife.

b) They are a visual amenity, enhancing and diversifying the landscape.

c) They provide a windbreak for canal boaters and crops and shelter for stock, wild animals and walkers.

d) They provide fruit and other useful products.

e) They are not expensive to maintain.

2.2.2. Woodland

There are small areas of woodland along the Royal Canal (Fig 2.1). In some places the neglected hedgerow has grown into a habitat similar to a woodland or woodland margin, although lack of space has prevented the development of a true woodland habitat.

Woodland trees form a continuous canopy of foliage under which there is an understorey of small trees or large shrubs such as Ilex aquilifolium or Corylus avellana. Lower, still is the herb layer, composed of herbaceous flowering plants and ferns such as Primula Vulgaris, Viola spp., and Hyacinthoides non-scriptus. These flowers concentrate their growth in spring and early summer before the tree leaves have fully expanded and blocked out the light. A fourth layer - the moss layer - may form a carpet over the woodland floor. The growth of the mosses is helped by the fact that the humidity is high and constant and direct exposure to the sun is prevented.

Woodlands found along the canal are very few and shown on the maps in Part 2 and on Fig 2.1. Four types of woodland were found along the canal.

- Oak
- Birch on dried cut over peat
- Hazel on limestone (Plate 43)
- Mixed Deciduous (Plate 22)

Plants found in the understorey of all these woodlands are listed in Appendix 1. This list of plants can also be found in expanded hedgerows where there is plenty of shade. The climbing plants of the woodland are similar to those of the hedgerow of 2.2.1.. The advantages of woodlands for plants, animals and people are similar to those of the hedgerow.

2.2.3. Associated habitat of Hedge and Woodland.

Few hedges do not have a bank or strip of grassland on which wild flowers can grow and most hedges along the Royal Canal have quite broad verges which constitute one of the principal refuges for wild flowers, (Plates 3 and 4). The boundary verge was often covered with Primula veris (Cowslip) early in the year. From May onwards the white umbellifers such as Anthriscus sylvestris and Heracleum sphondylium appear. Other species are listed in Appendix 1.

2.2.4. Scrubland

This is defined as poor quality woodland which has a poor stocking of marketable tree species, other than for firewood. Scrub can include recent semi-natural woods which have grown up on previously cleared land, or previously managed woods where management has been

discontinued. Examples can include woods where fences are dilapidated and animals are allowed uncontrolled access to graze and browse and where there is consequently no regeneration. Scrub that has grown on previously cleared land is only temporary and if left will usually succeed to woodland, (Plates 29 and 11). On some sites scrub can be the natural climax vegetation, due to limiting factors of site or soil.

The species of scrubland are the many shrubs of the hedgerow now growing less densely and the more light-demanding woodland herbs associated with the hedge or woodland edge (Section 2.2.3.). Scrub along the Royal Canal, especially when close to rivers provides shelter and refuge for otters which may live in a river but use the canal for feeding.

2.2.5. Fens

The fens along the Royal Canal are very small and few in number (Fig 2.2). Fen is a layer of peat fed with alkaline ground water. It lacks the acidity of bogs and because of this the vegetation is typically more like that of a marsh often containing a great many diverse communities wherever there are small variations in relative soil acidity or the height of the water table. Here rare plants or plants with restricted ranges flourish. A list of plants of the fens along the canal is given in Appendix 1. Fens if left unmanaged gradually succeed to mixed carr which is relatively dry and contains a variety of shrubs and trees.

2.2.6. Carr

Carr is present along few sections of the canal. Carr can be mixed or dominated by one tree type such as Alnus glutinosa. It can be accompanied by Betula and Salix spp. The ground flora is more related to marshes than to woodlands and comprises of such species as Filipendula ulmaria, Epilobium hirsutum and Agrimonia eupatoria, many tussock forming sedges and many of the fen plants.

2.2.7. Bog

There are many stretches of the Royal Canal bordered by bogs (Fig 2.2) and Plates 5 and 6. These raised bogs formed when a fen peat layer became so thick that the roots of plants growing on the surface were no longer in contact with the calcium - rich ground water. Plants which were able to grow in the mineral-poor habitat on the surface of this peat invaded. Such a species is Sphagnum. It tends to decompose slowly and to release acids during decomposition. The typical Sphagnum bog is covered almost completely with bog-moss of several species, through which projects a stunted growth of various grassy and sedgy plants,

Calluna vulgaris, Erica tetralix, Myrica gale and Andromeda polifolia. Other bog species are listed in Appendix 1.

When the Sphagnum bog becomes degraded due to climatic effects or human interference, mixed moor results. Here the moss carpet is absent and Eriophorum spp. are prominent.

2.2.8. Drains or Ditches

The drains and ditches along the Royal Canal (Fig 2.2) are, like the canal itself, slow moving and often stagnant with muddy bottoms. Because so much dead matter has fallen to the bottom, these habitats are also nutrient-rich. The vegetation of these habitats, as in the canal itself occurs in bands and is due to plants of differing growth - form adapting to different water depths. Emergent plants such as reeds and rushes occur at the edge. These are plants which can tolerate water-logged soil but must have their leaves in the air. In deeper water plants with floating leaves such as water-lilies can be found. In the next zone completely submerged plants for example, pondweeds, (Potamogeton spp.) and Milfoils (Myriophyllum spp.) can be found. In addition to plants rooted in sediment, unattached plants such as Duckweeds (Lemna spp.) which float on the surface, also occur. The drains and ditches do not support as many submerged species as does the canal but on the other hand they comprise many additional species characteristic of a marshy habitat. Species found in the different vegetation bands of the drains/ditches are given in Appendix 1.

2.2.9. Nutrient-poor Limestone Grassland

As the underlying parent material found along the route of the Royal Canal is limestone, there are many examples of limestone grassland to be seen. In general it is a nutrient-poor habitat. It is especially evident where little soil has built up on the gravelly-limestone, (Plate 2). Such species as Knautia arvensis, Pimpinella saxifraga, Primula veris, Sanguisorba minor and Anacamptis pyramidalis are good indicators of soil rich in lime and are quite common along the canal. (Fig 2.1 shows the limestone grasslands). Other species such as * Orhis morio, Ophrys apifera, Carlina vulgaris, Coeloglossom viride and Antennaria dioica, also lime-loving, are confined to one or two sections along the canal (Tables 3.5 and 3.9). A list of the species found on a limestone grassland are given in Appendix 1.

* protected species.

2.3 TOWPATH HABITATS

The towpath was formerly used by the horses who pulled the barges along the canal. Since the western end of the canal was dammed in 1961 much of the towpath there is covered in scrub, (Plate 11). Along the remainder of the canal the towpath, usually not more than a car width wide, can consist of a tarred track, a road, or a grassy track. The grassy track may be grazed (Plates 9, 10 and 13), or may comprise of tall meadow grassland where it is not used too frequently (Plates 7 and 8). Around the urban centres the towpath is well used and often consists of trample resistant species.

2.3.1. Well Used Grass Track

Along the towpath there are many sections which are frequently used. At these places the towpath may pass by a diversity of habitats of the boundary and bank. However, the species remaining on the well used towpath will be trample resistant. A list of these species is given in Appendix 1. Plants on the used towpath are adapted to resist the trampling effect by having a basal rosette of leaves, being tufted, mat forming and reproducing by seed or stolon.

Trampling combines vertical pressure with a twisting action as the ball of the foot leaves the ground. Mild trampling has little effect but as it becomes more intense it causes damage to the leaves and eventually may uproot or kill plants. The centre of a well used towpath is therefore bare, but beside it there is a zonation of plants progressively less able to withstand trampling. The most resistant, nearest the middle, are Plantago major and Poa annua followed by Poa pratensis, Lolium perenne and Trifolium repens.

2.3.2. Meadow

Meadow habitat produces fine floral displays especially if it has not been ploughed or treated with chemicals for many years.

The principal difference between meadow and limestone grassland is that the vegetation is more dense in the meadow than on the nutrient-poor soil (Plates 17 and 23). At its peak in late May and early June these stretches are characterised by the yellow of Ranunculus acris, a little later by the red Rumex acetosa and a little later by the white of Leucanthemum vulgare.

2.4 BANK HABITATS

The canal bank varies in all respects - gradient, height, width, whether managed or unmanaged - along its length. Consequently, there is a wide range of habitats to be found there. Emergent vegetation can be found at the base of those banks with gentle gradients (Plates 13-16), sometimes a berm exists at the edge of the canal upon which a marshy habitat can be found (Plate 17). Higher up the bank, a transitional habitat between emergents of the bank base and the plants of the drier habitats at the top of the bank exists (Plate 15). This is referred to in the present survey as the Mid Bank Transitional Habitat. At the top of a high wide bank small grassland habitats such as nutrient-poor limestone grassland and meadow can be found (Plates 14 and 18). In other sections of similar topographical structural characteristics scrub/woodland and hedge/hedge-edge habitats are to be found (Plates 26 and 28). Most of these habitats are also to be found in the boundary zone and have already been discussed in Section 2.2.

2.4.1. Mid Bank Transitional Habitat

This bank habitat is found where conditions are neither too dry nor too wet. It is not present on all banks because in some cases the banks are too steep and the soil too dry. Where it does exist it is characterised by tall herbs with a great display of colour. Such species include Epilobium hirsutum, Eupatorium cannabinum, Filipendula ulmaria, Valeriana officinalis, Lythrum salicaria and Iris pseudacorus.

2.5 CHANNEL HABITATS

The canal itself is similar in structure to the drains and ditches already described in Section 2.2.10. Along Unit I of the canal the vegetational bands are clearly defined but not very diverse. In Unit II a diverse emergent band is very much in evidence (Plates 14, 22 and 23) with many examples of marsh type habitats in those sections of canal which support terrestrial habitats (Plate 7). In Unit III the submerged and floating leaved plant bands are almost absent and replaced again by dry terrestrial and marshy habitats (Plates 24, 25 and 29).

Silt traps along the channel were a feature of the canal when it was prosperous. They are deep excavations in the bed of the channel and usually found on a bend. The bend was widened and the bottom of it deepened. The purpose of these traps was to enable silt particles travelling in the water, as a result of the disturbance caused by the barges, to fall to the bottom of the trap. In this way, an accumulation of silt in the navigable channel was prevented. When the canal was closed to navigation

the full silt traps provided an ideal habitat for those species which enjoy shallow, wet nutrient-rich conditions. The silt traps of Unit II and III no longer provide such a habitat. The habitats only exist along Unit I. Some were dredged during 1989 and the accumulated silt removed and some still remain (Plates 30 and 31).

2.6 STONEWORK STRUCTURED HABITATS

These are to be found in the many locks, bridges and harbours along the Royal Canal. These provide typical wall habitats. However, derelict locks, harbours and bridges will also support hedgerow and woodland species, emergents and plants of the mid-bank transitional habitat. The crevices between the limestone blocks used in the construction of lock chambers and harbours support plants characteristic of nutrient-poor limestone soils (Plates 32-34). All these with the exception of the wall habitat have been discussed.

Walls are extremely well drained habitats. Their particular aspect as much as their general situation determines just how dry they become. The south face of a wall may present virtual desert conditions in summer, while the north face remains cool and relatively moist. Thus south-facing walls support true dry plants such as Cymbalaria muralis, while north-facing walls are colonised by species more normally associated with the surrounding area.

Walls heat up very much on a hot summer's day and then provide a basking place for such butterflies as the Peacock, Small Tortoise-shell and Red Admiral. When the wall is so neglected that bricks or stones start to fall out of it, the resultant cavities provide nesting places for such birds as the Robin and Wren and the Grey Wagtail in the damaged lock chamber.

A very characteristic group of mosses and lichens grow on walls or old stonework but these have not been surveyed along the canal. Typical wall plants found along the stonework of the canal are listed in Appendix 1.

2.7 SUMMARY

There is quite a large diversity of habitat to be found along the canal corridor and some of these such as drains and ditches consist in turn of many further separate vegetational bands.

The hedgerow/scrub/woodland habitat is dominant along the canal corridor and as such would not be lost to the canal ecosystem if sections of it were to be removed during the restoration process of parts of Units II and III. Likewise, if scrub/hedgerow is removed from the towpath and bank no great loss of habitat will be incurred.

Most of the habitats which exist at present along the channel of Units II and III such as the marsh and berm will be lost during reconstruction of these Units. However, provision can be made to encourage these habitats to develop - even if on a lesser scale than exists at present - at the channel edge. Emergent vegetation and other typical bank vegetation presently along parts of Unit II do not appear in the drier dewatered channel sections. It is essential that the character of these habitats be preserved along Unit II and provision be made for their development.

Fens, nutrient-poor limestone grasslands, meadows, bogs and carr occur very infrequently along the canal. For this reason, extra care is necessary to ensure they are not damaged and their characteristics altered either by machinery, nutrient-rich spoil or, should the possibility occur, reseeding. The infrequency of occurrency and the small area of these habitats should act in their favour in that the areas to be safeguarded are small. They are all drawn on the relevant maps in Part 2 and recommendations for their continuance outlined.

CHAPTER 3 FLORA OF THE ROYAL CANAL

3.1 INTRODUCTION

The flora of the Royal Canal was surveyed in detail throughout 1990. Unit I of the canal was surveyed in 1989 (R.C.S., 1989). This stretch of canal was re-opened to boat traffic and the towpaths cleared by early 1990. The revegetation of dredging spoil at selected sites was recorded in this stretch.

The purposes of the study of the flora was to

(a) carry out a baseline survey of the vascular plants which exist in the canal corridor.

(b) to map plant associations typical of all habitats within the canal corridor and to determine the factors which contribute to the characteristic flora.

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

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

(e) to compare the effects on the flora of the management strategies in operation along the canal.

(f) to provide information on the revegetation of canal dredging spoil after one year.

(g) to devise suitable management options to maintain floristic and habitat diversity.

3.2 METHODOLOGY

The canal was divided into sections each a kilometre long. There are a total of 154 sections (Fig 2.1). Within each section excluding section 1 at Spencer Dock the presence of plant species in the boundary, towpath, bank and channel were noted on a separate recording card. This follows the method devised by the British Waterways Board (B.W.B.) (Tandy, 1989). Plants of the locks and bridges were also recorded. The revegetation of dredging spoil was surveyed at 13 sites in Unit I of the canal. The presence of species within the affected zone in each section was recorded as above.

Maps of each individual kilometre, based on the scale 1:2500, were drawn and expanded laterally as in the B.W.B. survey (Briggs, pers. comm.). The maps were

used in the field to record ecological information such as vegetation structure as well as such features as roads, locks, bridges, the width and height of the zones and other relevant data. The maps are contained in Part 2. All qualitative surveying was carried out on the original towpath side of the canal.

3.3 RESULTS

A total of 379 and 265 species was recorded in 1990 and 1989 throughout the system giving a total of 398 altogether. Table 3.1 gives a breakdown of the number of species to each zone.

TABLE 3.1

Numbers of species recorded in each zone of the 3 Units along the canal. Numbers of species in revegetated zones also shown.

Year	1989	1990	1990*
Canal Unit	I	II and III	I
Boundary	193	331	40
Towpath	201	196	68
Bank	184	273	126
Channel	35	155	NS
Locks and Bridges	34	129	NS
TOTAL	265	379	128

NS = Not surveyed
* = survey of revegetated dredged areas.

The diversity (species richness) of plants in each zone is given in Table 3.2. The division of the canal corridor into the three separate management units (See Chapter 1) is further supported by floristic data.

The occurrence (% occurrence) of species within each zone along the canal was calculated (Appendix 2). It is possible to determine a zonal preference (% preference) of each species as a proportion of the total population of three zones (boundary, towpath and bank) in each section. The zonal preference for each species is also given in Appendix 2.

TABLE 3.2

The Diversity of Species found along each zone and on the stone structures of each Km Section along the three Units of the Royal Canal.

I Surveyed late in 1989. KM	Bd.	Tp.	Bk.	Ch.	St.	II Surveyed throughout 1990. KM	Bd.	Tp.	Bk.	Ch.	St.	III Surveyed throughout 1990. KM	Bd.	Tp.	Bk.	Ch.	St.
1	34	24	31	7	17	D1	NR	NR	NR	NR	NR	103	60	NA	61	19	7
2	20	65	37	11	3	D2	26	NA	49	12	23	104	56	34	64	15	NA
3	19	65	25	7	NA	D3	61	NA	35	9	25	105	44	60	53	16	10
4	25	49	32	15	3	D4	86	NA	49	7	18	106	63	38	48	18	1
5	15	48	24	14	5	D5	53	NA	50	5	25	107	66	62	68	35	NA
6	17	56	40	18	NA	D6	51	NA	41	5	12	108	71	37	76	36	5
7	17	75	46	20	9	D7	54	NA	53	9	16	109	83	39	68	24	NA
8	15	87	67	13	NA	D8	71	NA	54	6	NA	110	57	45	78	52	6
9	18	58	45	9	15	D9	54	NA	62	8	23	111	59	25	55	44	1
10	18	NR	NR	7	NA	D10	41	NA	58	9	21	112	65	47	89	33	8
11	19	NR	NR	12	3	D11	60	NA	79	5	5	113	53	49	84	38	14
12	25	NR	NR	8	NA	D12	83	NA	79	6	9	114	38	31	89	33	1
13	17	53	36	15	14	D13	85	NA	82	9	7	115	37	61	78	19	NA
14	12	40	30	2	12	72	26	NA	47	25	NA	116	51	75	74	29	20
15	14	16	18	4	13	73	27	NA	34	18	17	117	67	53	79	38	11
16	NR	NR	NR	NR	NA	74	41	NA	58	10	2	118	69	67	62	52	NA
17	8	38	31	4	7	75	95	NA	71	12	NA	119	70	69	76	28	10
18	21	34	31	10	NA	76	70	NA	61	9	NA	120	85	75	73	23	NA
19	16	27	32	8	21	77	94	NA	70	9	2	121	79	NA	57	23	24
20	12	54	34	11	4	78	64	NA	66	12	8	122	75	NA	60	19	8
21	19	59	26	15	NA	79	93	35	83	16	5	123	74	NA	72	25	18
22	27	43	28	13	NA	80	76	34	71	22	NA	124	50	27	60	27	10
23	35	63	43	14	16	81	89	45	78	24	NA	125	37	52	62	19	7
24	21	72	28	7	NA	82	61	41	79	17	3	126	38	42	58	38	NA
25	14	67	23	9	NA	83	67	43	59	19	NA	127	35	55	51	43	23
26	15	31	34	7	NA	84	80	37	83	23	31	128	25	34	45	47	11
27	25	52	53	12	NA	85	63	34	65	39	20	129	36	45	50	36	14

TABLE 3.2 cont.

The Diversity of Species found along each zone and on the stone structures of each Km Section along the three Units of the Royal Canal.

I Surveyed late in 1989. KM	Bd.	Tp.	Bk.	Ch.	St.	II Surveyed throughout 1990. KM	Bd.	Tp.	Bk.	Ch.	St.	III Surveyed throughout 1990. KM	Bd.	Tp.	Bk.	Ch.	St.
28	20	46	48	8	NA	86	61	43	60	25	NA	130	53	45	48	43	NA
29	50	0	55	11	5	87	66	44	69	35	24	131	50	50	63	38	14
30	50	10	30	5	NA	88	65	41	65	39	14	132	34	30	50	37	NA
31	30	43	41	6	NA	89	60	34	45	37	25	133	52	45	57	22	18
32	27	34	49	9	0	90	48	NA	56	21	20						
33	49	0	40	9	NA	91	55	NA	54	18	NA						
34	19	25	34	13	NA	92	64	45	68	12	23						
35	28	44	37	9	NA	93	50	56	68	30	22						
36	23	37	42	12	NA	94	54	57	74	17	21	L1	29	35	65	41	3
37	35	49	42	13	9	95	71	40	80	34	19	L2	37	51	60	24	10
38	37	41	41	13	2	96	93	53	69	16	NA	L3	14	35	52	16	7
39	56	10	48	6	NA	97	64	53	47	14	NA	L4	53	35	57	22	6
40	40	23	56	8	4	98	75	48	72	10	8	L5	47	26	64	26	3
41	20	33	33	8	NA	99	88	44	91	13	12	L6	59	49	65	18	NR
42	24	39	37	11	NA	100	43	42	64	6	30	L7	56	31	53	12	NR
43	54	20	42	8	NA	101	59	46	74	7	NA	L8	63	NA	58	28	NA
44	34	45	48	14	NA	102	69	51	76	22	16						
45	34	34	29	12	11												

TABLE 3.2 cont.

The Diversity of Species found along each zone and on the stone structures of each Km Section along the three Units of the Royal Canal.

I Surveyed late in 1989.						II Surveyed throughout 1990.						III Surveyed throughout 1990.					
KM	Bd.	Tp.	Bk.	Ch.	St.	KM	Bd.	Tp.	Bk.	Ch.	St.	KM	Bd.	Tp.	Bk.	Ch.	St.
46	43	31	41	14	NA												
47	52	43	42	12	7												
48	40	6	45	13	NA												
49	39	28	38	12	7												
50	49	27	48	10	NA												
51	56	24	58	15	NA												
52	60	27	44	16	NA												
53	63	10	35	11	NA												
54	46	11	32	15	NA												
55	35	14	34	8	6												
56	17	40	37	20	12												
57	34	48	20	5	5												
58	22	54	40	8	18												
59	29	33	46	11	16												
60	52	0	12	9	NA												
61	39	26	25	5	1												
62	21	64	41	9	0												
63	12	27	35	3	NA												
64	15	46	30	4	8												
65	22	38	20	2	0												
66	8	49	30	9	NA												
67	7	39	32	12	NA												
68	8	34	57	12	3												
69	0	44	46	13	NA												
70	10	44	52	16	NA												
71	14	34	50	11	5												
72	9	16	29	9	0												

NR denotes not recorded; NA = not applicable.
Bd. = Boundary, Tp. = Towpath, Bk. = Bank, Ch. = Chan[redacted], S[redacted] = [redacted]he [redacted]uc[redacted]s.

3.3.1 Flora of the Boundary

A total of 331 species was recorded in the boundary zone of Units II and III of the canal in 1990 (Appendix 3b) and 193 in Unit I in 1989 (R.C.S., 1989), (Appendix 3a). The low number of species at Unit I of the canal can be accounted for by the following:

(a) the boundary as defined along this Unit (R.C.S., 1989) was confined to the boundary edge and did not include boundary verge and herbaceous grassland plants between it and the towpath. These are included as part of the boundary in the present survey and contribute to the greater diversity.

(b) the timing of the survey late in the growing seasons when many species were no longer flowering and could not be recorded.

For these reasons the diversity in the boundary of Unit I of the canal is not compared with the diversity of Units II and III.

Diversity

Table 3.3 shows the 16 sections at Units II and III with the highest and lowest species diversities.

The greatest diversity of Units II and III occurs at these sections which support many habitats (Table 3.4), (Plates 1,2,3,21 and 22).

The remaining sections with high species diversity along Units II and III of the canal contain wide margins between the towpath and boundary edge. In these areas an additional grassland flora adds to the diversity at the zone, (Plate 4).

The greatest diversity along Unit I of the canal also occurred at those sections which supported additional habitats to those of woodland and hedgerow (R.C.S., 1989).

The lowest diversity along Units II and III of the canal occurs in those sections where encroachment by scrub takes place and also in the Urban sections where the canal boundary property is often shared by Industrial or Community interests and consists of a high wall or a fence, (Plates 16,19 and 20). The lowest diversity along Unit I occurs where the boundary edge was damaged during dredging operations and where the boundary edge was not easily defined.

TABLE 3.3

Sections with the highest and lowest diversities along Units II and III of the canal in the Boundary, Towpath and Bank Zones, (82, 56 and 82 sections respectively).

(High diversities given in descending order and low diversities in ascending order).

ZONE	BOUNDARY		TOWPATH		BANK	
Sect. No.		Div.	Sect. No.	Div.	Sect. No.	Div.
75		95	120	75	99	91
77		94	116	75	122	89
79		93	119	69	114	89
96		93	118	67	113	84
81		89	107	62	79	83
99		88	115	61	84	83
D4		86	105	60	D13	82
120		85	94	57	95	80
D13		85	93	56	82	79
D12		83	127	55	117	79
109		83	96	53	D11	79
84		80	97	53	D12	79
121		79	117	53	81	78
80		76			110	78
98		75			115	78
122		75			102	76
			LOW	DIVERSITY		
L3		14	111	25	73	34
128		25	L5	26	D3	35
D2		26	124	27	D6	41
72		26	114	31	89	45
L1		29	L7	31	128	45
73		29	80	34	72	45
132		34	89	34	97	47
127		35	104	34	106	48
129		36	128	34	130	48
115		37	79	35	D2	49
125		37	L1	35	D4	50
L2		37	L3	35	129	50
114		38	L4	35	132	50
126		38			D5	50
74		41			127	51
D10		41			L3	52

Div = diversity i.e. no. of species

Table 3.4

Habitats which add to the diversity of species in the Boundary zone of the Royal Canal

HABITAT	SECT.NO.	DIV.	HABITAT	SECT.NO.	DIV.
FEN	75	95	CALCAREOUS GRASSLAND	79	93
	77	94		81	89
	81	89		D4	86
	109	83		120	85
DRAINS AND STREAMS	96	93		D13	85
	84	80		D12	83
WOODLAND	79	93		109	83

TABLE 3.7

Rare species of the canal towpath showing (a) a high zonal preference (%) for the towpath zone (b) occurrence (%) in the towpath and (c) refers to the number of sections at which the species occurs along Units II and III of the Royal Canal.

UNIT	II			III		
NO. OF SECTIONS	22			34		
SPECIES	a	b	c	a	b	c
Anacamptis pyramidalis		*		-	12	4
Carex caryophyllea	-	4	1	-	6	2
Dactylorhiza fuchsii	-	9	2		&	
Geranium molle		*		100	6	2
Gymnadenia conopsea	-	4	1	-	9	3
Hieracium pilosella	-	9	2	-	3	1
Knautia arvensis	-	4	1	-	9	3
Leontodon autumnalis		&		100	6	2
L. hispidus		&		-	12	4
Linum catharticum	-	18	4		&	
Myosotis arvensis		*		-	6	2
Orchis mascula		*		-	9	3
Polygala serpyllifolia		*		-	6	2
P. vulgaris	-	9	2	-	6	2
Potentilla erecta	-	9	2	-	9	3
Rumex acetosa	-	9	2	-	3	1
Sanguisorba minor		&		-	6	2
Sherardia arvensis		*		-	3	1
Silybum marianum		*		100	3	1
Succisa pratensis	-	14	3	-	12	4
Trisetum flavescens		&		-	6	2
Veronica hederifolia	100	5	1		*	
V. persica	-	5	1	-	12	4
V. serpyllifolia	-	5	1	-	9	3

* not recorded

- denotes a zonal preference less than 80% * not recorded
& not rare along the canal.

Rare Species

Table 3.5 (at the end of the chapter) lists the many species of the three canal units which show a high zonal preference but low % occurrence in the boundary zone. This table also lists other species which occur at very few sites but do not indicate a high zonal preference for the boundary. This latter group of plants occur particularly in Units II and III. They do not show a high zonal preference for the boundary because they also occur where scrub and woodland have encroached on to the towpath and bank zones. All the plants listed in Table 3.5 are associated with small habitats found in the boundary zone and are rare within the zone.

Unit II supports many more of these rare species of the other two units. The boundary along this Unit supports many small habitats. These habitats have already been mentioned in Chapter 2 and the associated species lists given in Appendix I. The boundary along Unit III of the canal does not support as many of the rarer species of the canal corridor. Plant associations typical of a habitat are not well represented because many of the species and habitats have been choked out by encroaching scrub and woodland and by the species such as Rubus fruticosus agg. which are associated with the early stages of plant succession.

The boundary along Unit I supports some rare species typical of woodland understorey and of bogs. Both these habitats and others which may not have been recorded due to limitations imposed by time are rare along Unit I of the canal. Rare species and associated habitats and section locations along the 3 canal units are also given in Table 3.5. Some sections are continually being listed as supporting more than one habitat where a rare species occurs, e.g. Sections 109,117 and 120.

Species not found

Table 3.5, (at the end of the chapter) also highlights those rare species not found in the boundary zone of each canal unit. Those listed in Unit I will not be discussed as they may have flowered before the survey took place. 14 and 44 rare species respectively were not found in the boundary zones of Units II and III. Those not found along Unit II include woodland species such as Ajuga reptans, Euonymus europaeus, Lysimachia nemorum, Oxalis acetesolla and Viburnum opulus whilst those not found in Unit III are associated with the habitats which have been lost to encroachment such as marshes, drains, calcareous grasslands and fens.

3.3.2. Flora of the Towpath

196 species were recorded in the towpath zone in 1990 (Appendix 4b) and 201 in the survey of Unit I in 1989 (R.C.S., 1989), (Appendix 4a). The towpath zones of both surveys are not comparable as they were defined differently. The towpath extended to the boundary edge during the survey in 1989 and included a variety of habitats more typically part of the boundary verge. In the survey of 1990, the towpath is confined to the path or track width which is easily defined in the field. Where the towpath is a surfaced track or roadway it has not been surveyed in the survey of 1990. There are 72, 22 and 34 towpath zones respectively in Units I, II and III of the canal.

Diversity

Table 3.3 shows the 13 sites with the highest and lowest diversities in the towpath zones of Units II and III. The three sections with the greatest diversities contain harbours, locks, and pass by nutrient-poor grassland and woodland. At sections 118 and 97 the acid condition of the bog in the boundary influences the otherwise alkaline condition of the towpath and adds to the species diversity, (Plate 6). The towpath in sections 105, 107, 115 and 117 passes through ungrazed nutrient-poor grassland which is interspersed with scrub.

TABLE 3.6

Species with the highest occurrence (%) in the Towpath of Units II and III of the Royal Canal.

UNIT	II	III
NUMBER OF SECTIONS	22	34
Anthoxanthum odoratum	100	73
Cynosurus cristatus	95	100
Festuca rubra	100	82
Dactylis glomerata	95	91
Plantago lanceolata	95	82
Trifolium pratense	95	88
T. repens	95	79
Achillea millefolium	91	71
Bellis perennis	91	*
Centaurea nigra	91	76
Lotus corniculatus	91	*
Ranunculus bulbosus	91	*
Holcus lanatus	86	73
Odontites verna	86	*
Poa annua	86	*
Phleum pratense	*	82
Potentilla anserina	*	76
Galium verum	*	73
Hypocharis radicata	*	73
Prunus spinosa	*	71

* denotes that the % occurrence of the species in that canal unit is not among the first 15 highest.

The remaining sections supporting a high diversity are in Unit II and lightly grazed (Plates 6 and 11).

Sections with the lowest diversities are to be found where some of the towpath becomes a road - sections 111 and 124; where it is difficult to progress along the towpath because of scrub encroachment as at sections L5, 114, 104, 128 and L1; and where the towpath is used for vehicular access to fields as in sections 80, 79, L3 and L4.

Sites with the greatest diversity in Unit I along the canal include those supporting many habitats especially a disturbed habitat. Where few species were recorded in this zone in 1989 (R.C.S., 1989), it was because the section had been dredged or levelled immediately prior to the survey or because the towpath for the most part, consisted of a road.

Frequency of Occurrence

A comparison of the 15 species with the highest occurrence figures in the towpaths zones of Units II and III (Table 3.6) reveals that typical towpath species such as Bellis perennis, Odontites verna and Poa annua do not occur in many sites west of Draper's Bridge (Unit III). Instead species such as Phleum pratense, Potentilla anserina and Prunus spinosa take their place.

Rare species

Rare species, of the towpath zone of Units II and III defined as those with a high Zonal preference (% preference) but low % occurrence, and also those which occur at very few sites but do not show a high zonal preference, are listed in Table 3.7. The species listed are associated with a nutrient-poor grassland and are rare in both Units.

3.3.3 Flora of the Bank

A total of 278 species was recorded in Units II and III in 1990 (Appendix 5b), and 184 in Unit I in 1989 (R.C.S., 1989) (Appendix 5a). Table 3.3 shows the 16 sites of Units II and III with the highest and lowest diversities in this zone. A comparison is not made with the species diversity of Unit I as this stretch was surveyed late in the year when fewer plants were to be seen.

Diversity

The greatest diversity along Units II and III occurs where the bank is gradual in the height range 0.5m-2.0m and supports some scrubland, some nutrient-poor grassland where there is no poaching by cattle. Such

sections include 112, 114, 113 and 110 of Unit III. Many other sections with a high species diversity brought about by similar conditions exist in Unit III. The high diversity at the sections listed from Unit II of the canal were brought about because they too have gentle gradients and many support nutrient poor grassland especially at the top of the bank (Plates 14 and 23). Sections D11 - D13 have a high diversity although the banks are high and steep. The banks are also terraced and in these circumstances species gain a foothold and add to the diversity (Plate 21).

The greatest diversity in Unit I of the canal can be found in sections 7 -9, 27, 29, 32, 39, 40, 48, 51, 57, 59 and 68 - 71. There is no correlation with any one habitat type or influencing factor. Sections 68 and 69 with a relatively high diversity of 57 and 46 species respectively occur in the limestone cutting east of Mullingar on a nutrient-poor but species rich limestone soil, (Plate 62).

The lowest diversity along Units II and III of the canal occurred in the urban areas of Mullingar and Dublin where low steep banks, verge trimming, mowing and pressure from user numbers ensure that only the resistant and competitive species survive (Plates 15, and 16). Diversity is also low where plant succession progresses to the extent that habitats are choked out. This is the case in Unit III. The lowest diversity along Unit I of the canal occurred in those sections which had recently been dredged.

Frequency of occurrence

Table 3.8 lists the 15 species with the greatest % occurrence in each of the three canal units. Species such as Valeriana officinalis, Plantago lanceolata, Lathyrus pratensis, and Vicia cracca occur more frequently in Units II and III along the canal but are not among the top 15 species showing the highest % occurrence in Unit I. Carex rostrata, Phalaris arundinacea, Filipendula ulmaria, Iris pseudacorus, and Agrostis stolonifera are among the top 15 plants occurring most frequently in this Unit.

The species showing the greatest % occurrence in the bank of Unit II are of grassland - Festuca rubra, Dactylis glomerata, Lathyrus pratensis, and Plantago lanceolata - and of typical bank verge, such as Filipendula ulmaria, Glyceria maxima and Iris pseudacorus.

TABLE 3.8

Species with the highest occurrence (%) on the Bank of Units I, II and III of the Royal Canal.

UNIT	I	II	III
NO. OF SECTIONS	72	43	39
Festuca rubra	76	100	97
Filipendula ulmaria	92	100	100
Fraxinus exelsior	*	86	100
Dactylis glomerata	93	100	97
Crataegus monogyna	*	*	97
Lathyrus pratensis	*	93	97
Angelica sylvestris	62	95	95
Glyceria maxima	67	95	*
Iris pseudacorus	76	*	*
Rubus fruticosus agg.	*	93	95
Juncus inflexus	76	93	*
Plantago lanceolata	*	93	*
Viccia eracca	*	*	*
Phleum pratense	*	*	92
Prunus spinosa	*	91	92
Valeriana officinalis	*	91	92
Arrhenatherum elatius	62	*	*
Agrostis Stolonifera	86	88	90
Holcus lanatus	*	*	87
Potentilla anserina	*	88	88
Ranunculus Repens	64	*	88
Centaurea nigra	71	*	*
Carex rostrata	72	*	*
Trifolium pratense	67	*	*
T. repens	64	*	*
Phalaris arundinacea	62	*	*

* denotes that the % occurrence of the species along the canal unit is not among the first 15 highest.

Unit III supports many sections where woodland/scrub species occur in the bank zone - Fraxinus excelsior, Crataegus monogyna, Rubus fruticosus, Prunus spinosa, while typical bank species do not occur as often as along the other two units.

preference with these species is explained by the presence of similar species in similar habitats in the boundary zone.

The habitats, associated rare species and section locations are given in Table 3.9 (at the end of the chapter). In all three units the rare plants represent either a marsh or a nutrient poor grassland habitat. Each rare species along the bank occurs at less than 5 sites within any canal Unit. Small wetland habitats on marshy ground on berm like structures were not well represented along Unit I of the canal. They were lost during the dredging operations. As with the boundary zone, some few sections are continually listed as supporting more than one habitat and the associated rare species.

3.3.4 Flora of the Channel

The flora of the channel of Units II and III was surveyed in detail during 1990. A total of 155 species (Appendix 6b) was found along the two units. The flora of the channel of Unit I was surveyed in 1989 (R.C.S., 1989) (Appendix 6a) and 35 species were found. Species found in the dry and overgrown canal bed and the semi-aquatic species of Units II and III are recorded as present in the channel and account for the large difference in species richness between Units I and Units II and III.

Diversity

The greatest diversity (Table 3.10) occurred in those sections of the channel which included a range of habitat such as open water, muddy bed, grassland and scrub (Plates 8,25 and 29). These semi-aquatic sections are 85 - 91 in Unit II and all of Unit III excluding sections 118, and 131 - 133. A high diversity in watered sections, of Unit III of the canal, is only found in sections 118 and 131 both influenced by a bog. The greatest diversity along Unit I of the canal was found at Thomastown Harbour (Section 56) which is fed by a small stream.

There was a low diversity of species found in Sections 96, 97, 98. The canal runs through Ballymaglavy Bog at this point and was breached in Section 97 in early 1990 (See Plates 35 and 36) with the loss of submerged and floating leaved species.

TABLE 3.10

Sections with the highest and lowest diversities along Units II and III of the canal in the Channel and on the Locks and Bridges of the Royal Canal.

ZONE	CHANNEL				LOCKS AND BRIDGES			
NO. OF SECTIONS	82				58			
DIVERSITY	HIGH		LOW		HIGH		LOW	
	Section No.	Div	Section No.	Div.	Section No.	Div.	Section No.	Div.
	110	52	D5	5	84	31	106	1
	118	52	D6	5	100	30	111	1
	128	47	D11	5	89	25	114	1
	111	44	D8	6	D3	25	74	2
	127	43	D12	6	D5	25	77	2
	130	43	100	6	87	24	82	3
	L1	41	D4	7	121	24	L1	3
	85	39	101	7	92	23	L5	3
	88	39	D9	8	127	23	79	5
	113	38	D3	9	D2	23	108	5
	117	38	D7	9	D9	23	D11	5
	116	38	D10	9	93	22	110	6
	131	38	D13	9	94	21	L4	6
	126	38	76	9				
	89	37	77	9				
	132	37	74	9				

DIVERSITY	WATERED SECTIONS OF CHANNEL			
	HIGH		LOW	
	Section No.	Div.	Section No.	Div
	118	52	D11	5
	81	24	D12	6
	84	23	100	6
	80	22	101	7
	133	22	D8	6
	83	19	D9	8
	73	18	D10	9
	82	17	D13	9
	79	16	76	9
	99	13	77	9

Div = diversity i.e. no. of species

The lowest diversity along Unit I was in those sections dredged prior to the survey. The diversity of those sections dredged in 1988 was similar to undredged sections (R.C.S., 1989).

Ten sections showing the greatest species diversity and ten showing the lowest among the watered sections of Unit II and III of the canal are also shown in Table 3.10. The pattern emerging from the diversities of these watered sections is not highlighted when they are compared with those of the drier sections. Sections 79 - 84 support a high species diversity (Plates 14,22 and 23). The urban sections of Dublin, Ballynacarrigy and Abbeyshrule by contrast support very low diversities, (Plates 20 and 66). There is an abundant growth of Algae in Abbeyshrule. All watered sections except 74 -76 were treated with Casoron in April 1990 (John McKeown, pers. comm).

Frequency of occurrence

Fifteen of the aquatic and senic aquatic plants of the channel which occur most frequently in each of the three canal units are listed in Table 3.11. Plants of the wettest conditions which occur frequently in the three units include Carex rostrata, Nuphar lutea, Ranunculus lingua, Myriophyllum sp. and Phalaris arundinacea. It appears that Phragmites australis prefers the open water conditions of Unit II. However, this is not so as the sections where it is most abundant are dry with only a narrow channel of water in the middle of the canal bed. Many of the remainder of the plants of the table have their highest % occurrence in Unit III. Here, the water is not very deep, is stagnant and there is a ready supply of nutrients in the mud which has been accumulating each year. These conditions suit Menyanthes trifoliata, Galium palustre, Mentha aquatica, Sparganium erectum, Rumex hydrolapathum, Equisetum fluviatile, Myosotis scorpioides, Berula erecta and Typha latifolia. These same plants show a very low % occurrence in Unit I. However, this finding may not be conclusive as some sections of Unit I were surveyed immediately after dredging. Unit I contains five species more commonly found in deep water and not present in many sections of Units II and III of the canal.

Rare species

Table 3.12 shows aquatic plants which are rare along the channel. The plants which are indicated by * occur more frequently in the deeper water (>10 cms) of Units I and II.
Groenlandia densa is a protected species only found in the Dublin city section. The remaining rare species are emergents preferring the shallower semi-aquatic conditions at Units II and III. Some such as

TABLE 3.11

Species with the highest occurrence (%) in the Channel of Units I, II and III of the Royal Canal.

UNIT	I	II	III
NO. OF SECTIONS	72	43	39
Glyceria maxima	85	98	100
Menyanths trifoliata	32	39	90
Galium palustre	*	49	87
Mentha aquatica	*	44	85
Carex rostrata	71	77	49
Iris pseudacorus	*	42	77
Nuphar lutea	80	77	51
Sparganium erectum	33	58	74
Ranunculus lingua	51	72	69
Rumex hydrolapathum	-	23	72
Equisetum fluviatile	*	-	69
Phalaris arundinacea	29	65	*
Myriophyllum sp.	86	63	*
Agrostis stolonifera	*	42	62
Myosotis scorpioides	-	*	62
Berula erecta	-	-	56
Typha latifolia	39	37	56
Polygonum amphibium	*	26	51
Scirpus lacustris	74	49	51
Nasturtium officinale	*	*	*
Ranunculus flammula	*	*	*
Phragmites australis	*	33	*
Carex acutiformis	43	*	*
Sparganium emersum	36	*	*
Potamogeton natans	38	*	*
Alisma plantago-aquatica	22	*	*
Hippuris vulgaris	22	*	*

- denotes species not found along the canal unit
* denotes that the % occurrence of the species in that canal unit is not among the first 15 highest.

TABLE 3.12

Rare species (species showing low % occurrence) of the channel of the Royal Canal (a) % occurrence (b) sections.

CANAL UNIT		I		II		III	
NO. OF SECTIONS		72		43		39	
SPECIES	HABITAT	a	b	a	b	a	b
Alisma plantago-aquatica	MB	-		7	81,90,102	-	
Apium nodiflorum	M/B	3		5	81,82	-	
Baldellia Ranunculoides	M/B	*		2	81	8	107,118,L5
Callitriche sp.	W	1	56	2	74	8	117,118,132
Ceratophyllum demersum	W	*		2	97	*	
Chara sp.	W	*		*		5	133, L8
Cladium mariscus	Fen	1	66	12	92,94,97,98		
Eleocharis palustris	M/B	1	57	5	99,80,90	-	
Elodea canadensis	W	-		9	72,73,74,75	3	133
Equisetum palustre	M/B	*		*		5	130,131
E. variegatum	M/B	*		*		-	
Glyceria plicata	W/B	*		*		3	L6
Groenlandia densa	W	*		5	D2, D3	*	
Hippuris vulgaris	W/B	-		9	89,90,91,95	-	
Lemna trisulca	F	*		5	73,74	3	L6
Nymphaea alba	W	3	50,51				
Oenanthe aquatica	M/B	*		2	72	-	
O. crocata	M/B	*		2	D2	-	
O. fistulosa	M/B	*		5	72,73	-	
Potamogeton crispus	W	-		7	72,73,74	3	123
P. perfoliatus	W	*		2	72	3	133
Potamogeton sp.	W	-		2	72	5	118,133
Ranunculus scleratus	M/B	4	7,25,40	7	D3,D4,D9	*	
Sparganium emersum	W	-		-		3	133
Ultricularia sp.	W	5	69,70,71,72	*		3	132
Veronica anagallis-aquatica	M/B	*		*		5	125, L5
V. beccabunga	M/B	*		*		8	118,128,133
V. scutellata	M/B	*		*		3	126
Fontinalis antipyretica	W	-		7	72,73,74	*	

* denotes species not found in the channel along the unit
\- denotes that the species in that unit does not have a low occurrence and is not rare.

M = Marsh, B = Berm, W = deep water - deeper than 10cms, F = Floating plant

Potamogeton sp, and Ranunculus sceleratus occur as commonly in both deep and shallow water. Lemna trisulca, though rare throughout the length of the canal channel occurs in abundance with Lemna minor in Sections 73 and 74. (See Plate 37).

3.3.5 Flora of Locks, Bridges and Harbours

129 species were recorded in 1990 on the Locks and Bridges of Units II and III of the canal (Appendix 7b). 34 species were recorded on the Locks and Bridges of Unit I (R.C.S., 1989) (Appendix 7a). There are 34 sections which contain bridges or Locks along Unit I, 31 in Unit II and 29 in Unit III. Two bridges on the Longford Branch of the canal were not surveyed. When both bridge and lock are present with a section their associated species are not listed separately.

Diversity

The greatest diversity along Units II and III (Table 3.10) occur where there is a combination of locks, bridges and harbours within the section as is the case for the 14 sections with the greatest diversities. The walls of locks, chambers and harbours provide further habitats in the crevices and on the wet walls. Section 89 supports a diverse flora yet there is only 1 Lock in this section. Lime loving plants grow at the top of the chamber and wetland species can be found in the chambers of derelict locks. This is especially true for all locks west of Lock 26 at Coolnahay Harbour in Section 84 (Plates 32 and 34).

The greatest diversity along Unit I of the canal also occurs where there are locks or harbours as at Kilcock Section 19, Locks 22 and 23 at Footy's Bridge of Section 58 and Lock 17 near McLoughlins Bridge Section 23.

The lowest diversity along Unit I of the canal was at Allen, Moyvalley and McNeads Bridges all new or widened. Dredging operations contributed to a low diversity (R.C.S., 1989). The lowest diversity along Units II and III of the canal occurs at those sections which contain bridges only such as Fowlard'a Longford, Pake, Green and Kirkpatrick Bridges. These bridges are on roads frequently travelled and two of them are also culverted. The greatest number of species recorded on Bridges was at Ballydrum and Begnagh Bridges where 14 species were found on both. Both bridges are very old and only used by pedestrians or for farming purposes.

Frequency of Occurrence

Many of the bridges are covered in Ilex aquifolium, Rubus fruticosus agg., trees and shrubs. These provide good cover for birds. A study of the plants

occurring most frequently (Appendix 2) reveals plants typical of an old wall habitat of nutrient-poor limestone soils and of woodland. Plants of these habitats which are found along the canal are listed in Appendix 1. Plants of Locks are similar to those of bridges but with the addition of wetland species such as Angelica sylvestris, Filipendula ulmaria and Valeriana officinalis. There are many species occurring only once on the bridges and locks along the canal but they are neither typical of the wall habitat nor rare in other canal zones.

3.4 DISCUSSION

The collected floristic information has been used to locate features of conservation importance along the zones of the canal so that they may be managed carefully in the course of works. Brady and Shipman and Martin (1987) note that "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. As urbanisation has increased and agriculture has become more intensive, the importance of the canals as nature reserves has grown." Some of the many conservation aspects are discussed below.

Two protected species and many other nationally rare (as defined by Webb 1977) species and others with restricted distributions were found. One species noted by Webb (1977) as being occasional in E. Centre, and very rare elsewhere - Hydrocharis morsus-ranae - occurred quite frequently in the canal in Co. Longford. This is a new county record for this species.

The many nationally rare species which were found along the canal (Tables 3.5,3.9,3.12) have been assigned to particular habitats as it is much more ecologically sound to conserve the habitat. Habitats with rare species are also likely to be species rich (Nilsson et al., 1988). The nationally rare species are found primarily in habitats which are scarce along the canal e.g. Galium uliginosum of the fens.

Unit II represents a canal falling into disrepair but which is still being maintained by local landowners with some official input from the O.P.W. Hedges have been trimmed back, the towpaths grazed and footpaths maintained along them. Small habitats survive in these conditions where natural vegetational succession and invasion will not choke them out. These small habitats support the nationally rare species in addition to being species rich (Sections 3.3.2, 3.3.3 and 3.3.4).

Unit I is used more frequently by the public, planners and landowners and has recently been dredged. These

factors result in a more uniform, neater canal along this Unit where there are fewer small habitats to be found in relation to its length. Unit III of the canal was dammed in 1961 and many culverts built across it during the 70's and 80's. There was no interest in keeping the towpaths open and gradually over time the hedges and scrub grew out on to the towpath, down the bank and in places across the channel. The canal itself has dried up except during the winter months when rain water accumulates in the bed.

Because the many habitats are located at random along the canal corridor and in different zones it is important to be aware of where they are. All the habitats are drawn on the relevant maps of Part 2. Drains, fens, ditches, bogs, woodland, woodland understorey, hedge, marsh and many grasslands are well represented along the Boundary of Unit II. Only raised bogs and woodland habitat species are well represented along the same zones of Units I and III. Many of the raised bogs of the three units are ASI's (Section 2.7) and Brady, Shipman and Martin (1987) urge that liaison is required with Bord na Mona to press for the retention of the remaining undisturbed bogs.

Towpaths

Habitats of the towpath include grasslands and trample resistant species along the worn towpath. Because the underlying geology is predominantly limestone (Herries Davies and Stephens, 1978) there are many places where there is potential for a nutrient-poor limestone grassland. However, species of limestone grassland are more limited than would be expected on such terrain. There are reasons for this. Scrub and grass invasion and overgrazing by cattle are some of the reasons why it is not much more in evidence. The soil layer of a nutrient-poor limestone grassland is very thin and the resultant vegetation sparse, delicate but very colourful.

Bank

The habitats of the bank are grasslands, marsh/berm, emergent and a habitat in the transitional area between emergent and bank top vegetation. Where the channel bed is dry the wetter habitats are not present to any great extent on the bank. Instead they are in the channel. Grassland and woodland/hedgerow species occur most frequently in Units II and III while emergents and species of the transitional zone of the bank occur most frequently along Unit I. The marshy berm habitat at the base of the bank is not much in evidence along Unit I of the canal except at Kilmore Bridge and between Saunders and Baltrasna Bridges. It was lost during dredging operations in 1989/90. The emergent species and those of the marsh act as a

buffer when waves from low to moderate traffic levels wash towards the bank (Haslam, 1978; Hoogerkcamp and Rozenboom, 1978; Murphy and Eaton 1983 and 1990.

Channel

It is the channel as it exists at present which presents the greatest contrasts of species composition between the three units. It is watered along Unit I and parts of Unit II and with the appearance of an elongated marsh stretch in parts of Units II and III and completely dried out in parts of Unit III.

Channel Species of Unit I occurring most frequently are of deep water habitats - Nuphar lutea and Myriophyllum sp. They, in addition to some emergents (Glyceria maxima, Carex rostrata and Scirpus lacustris) had grown quickly after dredging whereas some other emergents (Sparganium erectum, Phalaris arundinacea and Typha latifolia) and marsh plants (Alisma plantago-aquatica and Menyanthes trifoliata) did not show such recovery. This finding may not be conclusive as these species may not have been present to a great extent prior to dredging. Further study of aquatic species of Units I and II after dredging should be carried out.

The difference in the species diversities in the watered sections of Unit II of the canal cannot be accounted for. The diversity is very low in the urban areas and quite high where the channel flows through non urban areas (compare maps 92, 93, 99 and 100 with maps 79 - 84 and Plates 14, 16 and 23 with Plate 66). It has been found that these urban areas of channel are nutrient-rich probably as a result of leaching from the banks. Studies are ongoing to try to determine the source of these nutrients. The nutrient-rich waters should lead to an increase in plant biomass or to the dominance by algae. The latter is only true for Abbeyshrule. The other urban areas have a low species diversity and support very little plant growth.

All areas except 2 kilometres at Mullingar have been sprayed with herbicide. There is no comparative data from the Royal Canal prior to herbicide treatment but it is generally accepted that prolonged treatment using chemicals is detrimental to the ecology of the canal (Harbott and Rey, 1981; Murphy and Eaton 1981 and Murphy et al. 1987) Murphy and Eaton, (1990), found that there was much needless use of herbicide treatment along the Royal Canal. Herbicides have been sprayed annually since the OPW took over the canals in 1986. Prior to that herbicides were sprayed along watered sections of the canal for ten years from 1976 - 1986 (Liam Maher pers. comm.).

Locks, Harbours and Bridges

The stone structures along the Royal Canal, namely the 86 bridges, 46 locks and many harbours provide a series of small habitats already discussed in sections 2.7 and 3.3.5. The species found on the locks and harbours which have fallen into disrepair are for the most part also found elsewhere along the canal corridor. The restoration and rebuilding of some of these structures along Units II and III of the canal will necessitate the loss of some of the species presently found there otherwise their root systems would damage the brickwork further or displace the mortar. Small limeloving plants and typical wall plants which should colonise restored sections (Appendix 1) will not damage the stone structures.

3.5 PLANTS GENERALLY CONFINED TO THE DUBLIN CITY STRETCH OF THE ROYAL CANAL.

Some of the plants associated with the Dublin city stretch of the canal (Sections D1 - D13) are influenced by factors not in evidence further inland. Such factors include the following

a) proximity to the coast
b) proximity to gardens
c) proximity to waste sites.

Plants present as a result of these influences are listed in Table 3.13. The four species listed under "other" have already been mentioned as being rare. They are all native and rare (Webb, 1977) with restricted distributions. Groenlandia densa is a protected species (Curtis and McGough, 1988).

The section of canal which connects with the Liffey at Spencer Dock was not surveyed by the team engaged on the present project. However, it has been noted that several coastal species, Desmazeria marina, Lepidium latifolium and Parietaria diffusa grow on the walls at the junction of the canal and Liffey (Wyse Jackson and Sheehy Skeffington, 1984).

TABLE 3.13

Plants peculiar to the Dublin City stretch of the Royal Canal as a result of external influences.

COASTAL INFLUENCE	GARDEN ESCAPE
* Malva sylvestris	Cyclamen hederfolium
Senecio erucifolius	* Fuchsia magellanica
* Smyrnium olusatrum	* Hypericum hircinum
* Foeniculum vulgare	* Tanacetum vulgare
ESCAPE FROM WASTE SITE	**OTHER**
* Armoracia rusticana	Groenlandia densa
Artemisia vulgaris	Linum bienne
* Hordeum murinum	Oenanthe crocata
* Tanacetum vulgare	Tragopogon pratensis

*introduced species (Webb, 1977)

3.6 REVEGETATION OF DREDGED AREAS

3.6.1. Introduction

A study of the revegetation of dredging spoil was undertaken in 1990. The deposition of dredging spoil along the canal banks and towpath can have a negative impact on both the ecology and the public image of the canal if not carried out in a controlled manner. The aim of the present survey is to list the species which colonise the spoil after one growing season and to determine what factors influence revegetation at different sections.

3.6.2. Methods

The revegetation of dredging spoil was recorded at 12 sections -defined as a kilometre length - along Unit I of the canal in mid August 1990. The dredging at the selected sections had been carried out in late 1989 or early 1990 in preparation for the reopening of this stretch of canal to navigation on 28th May 1990. Within each section the revegetation of the affected zone or zones was recorded. There were 19 affected zones along the 12 sections.

The surveying procedure involved noting the presence of a species on a separate recording card (for each affected zone) and the taking of photographs before and after dredging where possible and during the growing season of 1990.

3.6.3 Results

The grouping of the nineteen affected zones at the twelve sections was as follows:-

eleven bank zones
six towpath zones
two boundary zones

128 species were recorded (Appendix 8) - 126, 68, and 40 respectively in the bank towpath and boundary zones. The frequency of occurrence (%) of a species at each zone is also given in Appendix 8.

Diversity

The diversities of the 19 affected zones are given in Table 3.14. The highest diversity generally occurs in the bank zone. However, the lowest diversity was also recorded there at sections 15, 44 and 66. Other sections with low diversities were the towpaths of sections 1, 15 and 14. The revegetation at both the bank and towpath was noted at six sections (1, 2, 11, 12, 14 and 15) and it was higher on the towpath at three of these sections (11, 12 and 15). The very

slight contrasts between the diversities at two of these sections (12 and 15) do not merit discussion.

Frequency of Occurrence

Agrostis stolonifera, Glyceria maxima, Polygonum amphibium, Viccia cracca, Cirsium arvense, Phalaris arundinacea and Ranunculus repens are the most common species on the dredging spoil of all three zones during the first growing season, (Table 3.15). Other common species on the bank are Arrhenatherum elatius, Filipendula ulmaria, Juncus inflexus, Calystegia sepium, Rubus fruticosus agg. and Urtica dioica. Some typical towpath species such as Daucus carota, Plantago lanceolata, P. major and Poa annua are common at the six sections whilst Achillea millefolium, Centaurea nigra and Potentilla anserina are on both boundary zones. Other species such as Holcus lanatus, Phleum pratense and Senecio jacobea appear at 50% or three of the towpath zones.

TABLE 3.14

Diversities on the dredging spoil of the Royal Canal after one growing season.

ZONE BOUNDARY		BANK		TOWPATH	
Section No.	Div.	Section No.	Div.	Section No.	Div.
1	75	11	41	66	23
2	58	2	33	59	22
67	45	12	26		
40	40	1	19		
45	31	15	18		
11	28	14	17		
14	20				
12	20				
15	16				
44	16				
66	16				

Diversity i.e. no. of species

TABLE 3.15

Species occurring most often (%) on the dredging spoil of the bank, towpath and boundary along Unit I of the Royal Canal.

ZONE NO. OF SECTIONS	BANK 11	TOWPATH 6	BOUNDARY 2
Arrhenatherum elatius	82	-	-
Agrostis stolonifera	63	-	*
Calystegia sepium	63	-	100
Filipendula ulmaria	82	-	-
Glyceria maxima	73	67	100
Juncus inflexus	73	-	-
Polygonum amphibium	73	-	100
Potentilla reptans	73	-	*
Rubus fruticosus agg.	73	-	-
Urtica dioica	73	-	*
Viccia cracca	91	67	*
Cirsium arvense	82	100	100
Ranunculus repens	91	67	-
Centaurea nigra	-	-	100
Daucus carota	-	67	*
Lapsana communis	-	83	*
Lathyrus pratensis	-	67	-
Phalaris arundinacea	54	83	-
Plantago lanceolata	-	67	-
P. major	*	83	*
Poa annua	-	67	*
Achillea millefolium	-	-	100
Potentilla anserina	-	-	100

* denotes species not found
\- denotes the occurrence (%) of a species which is not sufficiently high for the table.

3.6.4. Discussion

Bank

The bank verges of Section 1, 2 and 67 support a very high species diversity. These banks are low and gentle. Species adapted to the wetter conditions of the bank base and those preferring the drier conditions higher up the bank can live and grow together. (Plate 39). Though the bank in Section 1 supports the greatest diversity (75 species) there is little vegetation where the bank is steep. A comparison of Plates 39 and 40 will illustrate this.

The diversity of the bank in Section 40 is quite high (Plate 41). The channel was dredged using a hydrolic machine in April of 1990 and surveyed in August of the same year. Here the bank is again low and gentle.

Light poaching by sheep and cattle occurs which helps break up the hardened spoil and this enables plants to grow. The spoil from this point of the channel has a high clay content. Where it is thick and has hardened the revegetation is not progressing as fast as at other sections (Plate 42).

Sections 44 and 45 with a relatively high diversity were also dredged in April of this year (1990) (Plate 43). Section 45 supports double the diversity of Section 44 though both sites show a similar pattern and amount of vegetation (Plate 44). However, the soil at Section 44 is more gravelly and nutrient-poor than at Section 45 and at Section 44 the spoil was dragged up the bank by a Hydrolic machine whereas it was pulled to the edge in Section 45. The diversity at these two banks was 26 and 48 respectively prior to dredging (R.C.S., 1989). Both sites seem to be recovering well.

Low diversities were recorded where the banks are high and steep and where there was little emergent vegetation left in the channel after dredging (Sections 11, 12 and 15). Non emergent species will have to colonise the bank from the top down. This method of revegetation is slower than plants colonising from the base as has already been shown in Section 1 (Plate 39).

The diversity of the revegetation of the bank in Section 66 is the lowest. This section was dredged and an embankment built with clay from outside the area in February 1990 (Plate 45). Revegetation of the embankment is very slow. The new banks are structurally sound. However, the clay is very hard and seeds cannot germinate. The clay may soften and the soil structure be altered during the winter months as a result of weathering. Plants may then colonise.

The diversity of Sections 14 and 15, at the back of Maynooth College, was low on both bank and towpath. (Plate 46). The channel at this location was covered from bank to bank with Glyceria maxima, prior to dredging. The vegetation of the spoil was allowed to grow and set seed before levelling took place. The dominance of the aquatic Glyceria maxima may be related to the fact that there was no top-soil mixed with the spoil as there was no room to do so. However, some terrestrial species are gaining a foothold and with proper management may be encouraged.

Towpath

The vegetation of the towpath at Sections 11 and 12 showed quite an interesting contrast. Section 11 (Plate 47) supported 41 species made up of grasses, reeds, tall herbs and calcareous species. Section 12 supported very little vegetation at its eastern end

(Plate 48). Further along, a mixture dominated by Cirsium vulgare, Cirsium arvense and Senecio jacobaea was found (Plate 49). These were interspersed with grass and tall herb species. Both these sites were dredged July 1989 spoil was deposited on the towpath, left to dry and was then levelled off.

To gain access with the machines used, to carry out the dredging operations, much of the hedgerow was removed and the soil mixed in with the spoil in the levelling operation. While this had a positive effect on the revegetation at Section 11, other factors affected the vegetation at Section 12. Initially, the soil of the first stretch is compacted and little vegetation grows. The remainder is colonised by seeds from the Thistles and Ragworts of the adjoining fields.

Compaction is also evident along the towpaths of Sections 1 and 2, with very few species recorded for a kilometre length (Plates 40, 48 and 50).

Boundary

The diversity in the boundary was recorded along the length of Section 66 and in a small area just west of Footy's Bridge in Section 59. 23 and 22 species were recorded respectively. The site at Section 59 was nutrient-poor supporting such species as Bromus erectus, Orchis morio, (Conn Breen pers. comm.), Carlina vulgaris and Ceterach officinarum whilst that at 66 was characteristic of unimproved meadow. Neither site supports a great diversity growing on the spoil (Plates 51, 52 and 53). This can be due to the fact that the spoil was thick, was not mixed in or covered over with topsoil and that not many of the aquatic species from the canal and in the spoil will grow in the dry boundary zone whereas they will on the wetter bank. A similar pattern emerges at the boundaries of Sections 44 (Plate 54) and 45 (not surveyed). The boundaries here and at many other sections are wide enough where excavated trenches could have been dug, filled with spoil and covered with topsoil.

Species Occurring most Frequently

The emergent species occurring most frequently in the spoil (Table 3.15) are capable of withstanding the trauma of being uprooted and deposited on what will soon be a drier habitat. The buds and vegetative parts are near the ground and they each have aeration tissue in their underground organs. They are, as a result able to revegetate and are not smothered by the spoil. These same species such as Glyceria maxima, Polygonum amphibium and Calystegia sepium were growing on the spoil along section D10 and D6 after a few weeks (Plates 55 and 56; Plates 57-59).

Cirsium arvense is one of the earliest colonisers of disturbed habitats. The seeds are light enough to be carried by the wind. Nutrient rich spoil provides an ideal substrate for them to germinate. Viccia cracca is a liana type plant and climbs across the spoil. The hydromorphic emergent species in addition to nuisance species such as Thistles, Ragworts and Brambles can be eliminated by cutting before they set seed.

As the spoil settles, other plants begin to emerge. Those listed as being the most common on the towpath of the 6 sections surveyed include Daucus carota, Lapsana communis, Plantago lanceolata, P. major and Poa annua. Urtica dioica, Calystegia sepium and grasses are common on the bank and Centaurea nigra on the boundary.

Damage by machinery

During dredging operations the machines used damaged the vegetation cover in sections where the towpath was not sufficiently wide (Plate 61). This occurred at sections 44, 68 and 69 where there is a very nutrient-poor calcareous soil with a very delicate flora. The damage occurred in early 1990, and by August of the same year, the scars were still very much in evidence.

In some cases, (Plate 62) the slope where the topsoil has been scarred is quite steep. Under these circumstances erosion can occur. Runoff from above washes away the soil and small particles. To rectify this it is necessary to lessen the gradient.

3.6.5. Conclusions

The revegetation of spoil is more diverse and quicker on the bank than on other zones. The speed at which the vegetation reverts to that which was there prior to dredging depends on the thickness of the spoil, whether the spoil is mixed or covered with topsoil, whether or not compaction of the spoil occurs and whether or not clay is brought up from the canal bed and deposited on the bank. Compaction of spoil occurs when too much pressure either from machines or walkers is exerted upon it. Compaction does not come about as easily once vegetation is present.

When the spoil has begun to support vegetation it is important to cut the earlier nuisance species before they set seed.

Physical damage to the boundary zone of the canal during dredging operations caused, principally by machinery width, can be quite severe and the vegetation is often slower to recolonise these areas than on spoil.

TABLE 3.5

Rare species of the canal boundary zone so classified by (a) a high zonal preference (%) for the Boundary Zone; (b) a low occurrence (%). (c) refers to the number of sections at which the species occurs along Units I, II and III of the Royal Canal.

SPECIES	HABITAT	(a)	(b)	(c)	SECTIONS	(a)	(b)	(c)	SECTIONS	(a)	(b)	(c)	SECTIONS	COMMENTS
			I				II				III			
Ajuga reptans	Wood	*	*	*		*	*	*		88	5	2	117,120	
Alisma plantago-aquatica	Drain	-	6	4	24,25,45,46	86	12	5		*	*	*		
Allium vineale	Hedge	*	*	*		100	7	3	D4,D5,D9	-	3	1	115	Rare, local, confined to S.
Anacamptis pyramidalis	L. grass	*	*	*		-	12	5	78,80,81,82,83	-	15	6	109-111,117,124,L6	Frequent in C.
Andromeda polifolia	Bog	*	*	*		100	5	2	97,98	100	3	1	118	Frequent in C.
Antennaria dioica	L. grass	100	2	2	68,69	*	*	*		*	*	*		
Anthyllis vulneraria	L. grass	*	*	*		-	2	1	D13	*	*	*		
Apium nodiflorum	Drain	*	*	*		&	&	&		-	3	1	107	
Armoracia rusticana	Dry bank	*	*	*		100	2	1	D4	*	*	*		Waste places, rather rare
Artemisia vulgaris	Dry bank	*	*	*		-	7	3	D3,D4,D6	*	*	*		
Arum maculatum	Wood	100	4	3	10,11,33	&	&	&		&	&	&		
Asplenium trichomanes	Wall	*	*	*		100	7	3	D3,77,85	*	*	*		
Baldellia ranculoides	Marsh	*	*	*		100	5	2	89,96	*	*	*		
Bromus erectus	L. grass	&	&	&		-	14	6	D11-D13,77,80,88	*	*	*		Found around Dublin
B. ramosus	0.00	&	&	&		-	2	1	D13	100	3	1	L2	
Callitriche spp.	Drain	*	*	*		100	5	2	90,96	*	*	*		
Calluna vulgaris	Bog	*	*	*		100	5	2	97,98	-	5	2	118,119	
Caltha palustris	Marsh	*	*	*		&	&	&		-	3	1	120	
Calystegia silvatica	Hedge	*	*	*		100	9	4	D3,D4,D5,D6	*	*	*		Occasional
Cardamine flexuosa		-	1	1	21	100	2	1	79	*	*	*		
C. pratensis	Marsh	-	1	1	46	&	&	&		-	3	1	109	
Carex caryophyllea	L. grass	*	*	*		-	2	1	88	-	3	1	109	
C. diandra	Fen/Bog	*	*	*		100	2	1	75	*	*	*		Frequent in C.
C. echinata	Fen/Bog	*	*	*		100	5	2	75,81	100	3	1	118	
C. elata	Marsh	*	*	*		-	2	1	91	*	*	*		Frequent in C.
C. lepidocarpa	Fen	-	4	3	7,8,62	-	2	1	81	-	3	1	109	Frequent in W. and C.
C. pulicaris	Bog/Fen	100	1	1	69	100	2	1	88	100	3	1	109	
C. remota	Wood	-	7	5	36,37,52,53,54	-	12	5	D12,D13,86,88,96	&	&	&		
C. sylvatica	Wood	&	&	&		-	5	2	D12,D13	&	&	&		

TABLE 3.5 cont.

Rare species of the canal boundary zone so classified by (a) a high zonal preference (%) for the Boundary Zone; (b) a low occurrence (%). (c) refers to the number of sections at which the species occurs along Units I, II and III of the Royal Canal.

SPECIES	HABITAT	(a)	(b)	(c)	SECTIONS	(a)	(b)	(c)	SECTIONS	(a)	(b)	(c)	SECTIONS	COMMENTS
			I				II				III			
Centaurium erythraea	L. grass	*	*	*		*	*	*		100	3	1	109	Frequent near sea
Ceterach officinarum	Wall	*	*	*		*	*	*		100	3	1	L4	
Corylus avellana	Wood/Hg	&	&	&		100	5	2	79,93	&	&	&		
Cymbaleria muralis	Wall	100	1	1	36	100	5	2	83,82	*	*	*		
Danthonia decumbens	Bog	*	*	*		100	2	1	81	*	*	*		
Dactylorhiza maculata	Bog	*	*	*		*	*	*		-	3	1	118	Common in N. and W.
Drosera rotundifolia	Bog	*	*	*		100	5	2	97,98	100	5	2	118,119	
Echium vulgare	Dry bank	*	*	*		100	2	1	79	*	*	*		Occasional on E. coast
Elodea canadensis	Drain	*	*	*		100	2	1	90	*	*	*		
Eupetrum nigrum	Bog	*	*	*		100	2	1	98	100	5	2	118,119	
Equisetum palustre	Marsh	100	1	1	26	-	5	2	81,89	-	8	3	104,105,109	Common in N, occasional in S
E. telmateia	Wood	*	*	*		*	*	*		-	5	2	L4,L5	Abundant but local
E. variegatum	Marsh	-	3	2	7,8	-	5	2	77,89	*	*	*		Occasional in C.,
Erica tetralix	Bog	100	1	1	65	100	5	2	97,98	100	5	2	118,119	
Eriophorum angustifolium	Bog	100	4	3	7,8,65	100	7	3	75,97,98	-	5	2	118,119	
E. latifolium	Bog/Fen	*	*	*		100	7	3	76,81,89	*	*	*		Rare but widespread
E. vaginatum	Bog	100	1	1	65	100	5	2	97,98	-	3	1	119	
Euonymus europaeus	Wood/Hg	100	7	5	6,37,42,47,49	*	*	*		&	&	&		Frequent in C.
Euphrasia spp.	L. grass	-	1	1	33	&	&	&		-	5	2	107,109	
Foeniculum vulgare	Dry bank	*	*	*		100	2	1	83	*	*	*		Occasional near coast in S.
Fuchsia magellanica	Hedge	*	*	*		100	5	2	84,85	*	*	*		
Galium uliginosum	Fen	*	*	*		100	2	1	77	*	*	*		Rare and in C.
Geranium dissectum	Roadside	*	*	*		100	2	1	84	*	*	*		
G. molle	L. grass	*	*	*		100	2	1	84	*	*	*		
Glechoma hederacea	Wood	100	1	4	44	100	5	2	82,83	&	&	&		
Glyceria plicata	Drain	*	*	*		100	2	1	96	*	*	*		Occasional
Gymnadenia conopsea	L. grass	*	*	*		-	12	5	75,78,79,81,102	-	3	1	109	Frequent in C., rare elsewhere
Hieracium pilosella	L. grass	*	*	*		-	12	5	81,83,86,88,92	-	12	5	109,L4	
Hippuris vulgaris	Drain	*	*	*		100	5	2	90,91	*	*	*		
Hyacinthoides non-scriptus	Wood	*	*	*		100	9	4	84,811,813,79	100	3	1	79	

TABLE 3.5 cont.

Rare species of the canal boundary zone so classified by (a) a high zonal preference (%) for the Boundary Zone; (b) a low occurrence (%). (c) refers to the number of sections at which the species occurs along Units I, II and III of the Royal Canal.

SPECIES	HABITAT	(a)	(b)	(c)	SECTIONS	(a)	(b)	(c)	SECTIONS	(a)	(b)	(c)	SECTIONS	COMMENTS
			I				II				III			
Hypericum androsaemum	Wood/Hg	*	*	*		100	5	2	D8,78	-	5	2	L2,L4	
H. hircinum	Garden	*	*	*		-	2	1	D2	*	*	*		
H. perforatum	Wood/Hg	-	3	2	11,20	-	9	4	D12,82,83,85	-	5	2	108,L2	Frequent in C. and S.E.
Lemna minor	Drain	100	7	5	22,23,24,53,55	100	7	3	90,91,96	100	5	2	120,121	
L. trisulca	Drain	*	*	*		100	2	1	90	*	*	*		Rare in W.
Leontodon autumnalis	L. grass	*	*	*		*	*	*		*	*	*		
L. hispidus	L. grass	*	*	*		*	*	*		-	5	2	116,117	
L. taraxacoides	L. grass	*	*	*		-	5	2	D4,95	-	5	2	109,117	Frequent in S. and C.
Linum bienne	L. grass	*	*	*		-	2	1	D4	*	*	*		Rare
L. catharticum	L. grass	-	4	3	46,47,61	-	7	3	79,96,102	-	8	3	107,109,L5	
Listera ovata	Wood	*	*	*		-	7	3	82,88,102	-	13	5	106,107,109	
Lychnis flos-cuculi	Marsh	*	*	*		100	7	3	D8,77,84	-	3	1	120	
Lysimachia nemorum	Wood	*	*	*		*	*	*		-	5	2	117,120	
Lythrum salicaria	Bank	-	4	3	24,28,31	*	*	*		-	10	4	119-121,133	
Melampyrum pratense	Bog	*	*	*		100	2	1	98	100	3	1	118	Rare in lowlands
Menyanthes trifoliata	Drain	-	1	1	50	-	5	2	75,91	-	5	2	118,120	
Molinea caerula	Bog	-	1	1	50	-	12	5	89,91,96,97,98	-	5	2	109,118	
Myrica gale	Bog	*	*	*		-	5	2	97,98	-	8	3	118,119,130	
Narthecium ossifragum	Bog	100	1	1	66	100	5	2	97,98	100	5	2	118,119	
Nasturtium officinale	Drain	*	*	*		100	12	5	D8,80,84,90,96	*	*	*		
Ophrys apifera	L. grass	100	1	1	69	*	*	*		*	*	*		Local and rare on limestone
Origanum vulgare	L. grass	*	*	*		-	5	2	D12,D13	-	3	1	123	Locally frequent,
Oxalis acetosella	Wood	2	3	_	38,35	*	*	*		-	5	2	L2,L5	
Parnassia palustris	Fen	100	3	2	7,8	100	7	3	75,77,81	-	3	1	109	Common in W. and C.
Pedicularis palustris	Marsh	-	1	1	8	-	2	1	89	*	*	*		
P. sylvatica	Bog	*	*	*		100	2	1	97	100	5	2	118,119	
Phragmites australis	Fen/Drain	-	3	2	28,31	-	12	5	75,77,89,91,92	-	3	1	127	
Pinguicula lusitanica	Bog	*	*	*		*	*	*		100	3	1	118	Frequent in N, rare elsewhere
P. vulgaris	Bog/Fen	*	*	*		100	2	1	89	*	*	*		Frequent in N.W. and C.
Polygala serpyllifolia	Heath	*	*	*		100	5	2	97,98	-	5	2	118,119	

TABLE 3.5 cont.

Rare species of the canal boundary zone so classified by (a) a high zonal preference (%) for the Boundary Zone; (b) a low occurrence (%). (c) refers to the number of sections at which the species occurs along Units I, II and III of the Royal Canal.

SPECIES	HABITAT	(a)	(b)	(c)	SECTIONS	(a)	(b)	(c)	SECTIONS	(a)	(b)	(c)	SECTIONS	COMMENTS
			I				II				III			
Potamogeton natans	Drain	*	*	*		100	5	2	90,96	*	*	*		
Potentilla erecta	Heath	-	6	4	66,68,69,70	&	&	&		-	10	4	109,118,119,130	
P. palustris	Marsh	*	*	*		*	*	*		-	3	1	118	
P. sterilis	Wood	&	&	&		-	9	4	77,80,81,93	-	3	1	117	
Pulicaria dysenterica	Marsh	&	&	&		-	5	2	88,96	*	*	*		
Ranunculus ficaria	Wood	*	*	*		&	&	&		-	8	3	117,L5,L6	
Rhynchospora alba	Bog	100	1	1	66	*	*	*		-	3	1	118	Common in W. and part of C.
Rumex hydrolapathum	Drain	100	1	1	21	-	2	1	96	*	*	*		Rather rare
Sanicula europaea	Wood	100	1	1	43	*	*	*		-	8	3	117,120,L2	
Schoenus nigricans	Bog/Fen	*	*	*		100	7	3	77,89,91	-	8	3	109,118,119	Common in W. and C.
Scirpus caespitosus	Bog	*	*	*		100	5	2	97,98	100	5	2	118,119	
Scrophularia nodosa	Hedge	*	*	*		-	2	1	79	-	5	2	112,132	
Senecio erucifolius	Bank	*	*	*		-	5	2	B10,B11	*	*	*		Dry banks near E. coast, local
Silene alba	Hedge	100	1	1	27	100	5	2	B12,82	*	*	*		Frequent in C. and S.E.
Solanum dulcamara	Hedge	-	6	4	3,22,23,31	-	7	3	B6,B7,75	100	3	1	L8	Occasional
Sparganium emersum	Drain	100	4	3	21,23,56	100	3	1	90	*	*	*		
Stellaria holostea	Hedge	*	*	*		*	*	*		100	3	1	117	Frequent in E., local in W.
Symphytum officinale	Marsh	*	*	*		-	5	2	B8,75	*	*	*		
Tanacetum vulgare	Dry bank	*	*	*		100	3	1	B4	*	*	*		
Tragopogon pratensis	Hedge	*	*	*		100	3	1	B10	*	*	*		C., occasional
Trifolium dubium	L. grass	*	*	*		&	&	&		-	3	1	118	
Triglochin palustris	Marsh	-	1	1	62	-	5	2	81,83	*	*	*		
Veronica beccabunga	Marsh	100	4	3	22,50,52	-	7	3	88,80,96	*	*	*		
V. catenata	Marsh	100	3	2	22,56	100	3	1	96	*	*	*		Occasional
V. montana	Wood	&	&	&		-	5	2	77,81	-	13	5	117,120,123,127,131	
Viburnum opulus	Wood/Hg	100	4	3	56,65	*	*	*		&	&	&		

* denotes species not found; - denotes that the zonal preference is <80%; & denotes that the species is not rare along the canal.
Comments are from Webb (1977).

TABLE 3.9

Rare species of the canal bank zone so classified by (a) a high zonal preference (%); (b) a low occcurrence (%). (c) refers to the number of the sections at which the species occurs along Units I, II and III of the Royal Canal.

SPECIES	HABITAT	(a)	(b)	(c)	SECTIONS	(a)	(b)	(c)	SECTIONS	(a)	(b)	(c)	SECTIONS	COMMENTS
			I					II			III			
Alisma plantago-aquatica	Berm/marsh	-	3	2	34,35	-	2	1	B1	*	-*	*		
Anacamptis pyramidalis	L. grass	*	*	*		-	9	4	D11,B0,B1,102	-	10	4	109,110,112,113	Frequent in C.
Anthyllis vulneraria	L. grass	*	*	*		-	2	1	D13	*	*	*		
Apium nodiflorum	Berm/marsh	*	*	*		-	2	1	B2	-	5	2	112,115	
Blackstonia perfoliata	L. grass	100	1	1	68	*	*	*		*	*	*		Locally frequent in C.
Caltha palustris	Berm/marsh	*	*	*		&	&	&		-	10	4	107,109,114,121	
Carex aquatilis	Berm/marsh	*	*	*		100	2	1	94	*	*	*		Rare
C. caryophyllea	L. grass	*	*	*		*	*	*		-	5	2	113,116	
C. demissa	Bog	*	*	*		*	*	*		100	3	1	118	
C. elata	Fen	100	1	1	55	&	&	&		*	*	*		Frequent in C.
C. lepidocarpa	Fen	-	6	4	34,49,59,69	-	2	1	B4	-	3	1	118	Frequent in C. and W.
C. otrubae	Berm/marsh	&	&	&		*	*	*		100	3	1	L1	Rare inland
C. paniculata	Berm/marsh	&	&	&		100	7	3	75,78,87	&	&	&		
Carlina vulgaris	L. grass	*	*	*		100	2	1	D11	*	*	*		Frequent in C.
Cladium mariscus	Fen	*	*	*		100	7	3	91,92,98	*	*	*		Mainly in W. and local
Coeloglossum viride	Dry lime.	*	*	*		100	5	2	B0,B1	*	*	*		
Dactylorhiza maculata	Bog/marsh	*	*	*		*	*	*		-	3	1	118	Common in N. and W.
Eleocharis palustris	Berm/marsh	*	*	*		-	9	4	B0,B1,90,91	-	8	3	114,115,117	
Equisetum palustre	Berm/marsh	*	*	*		-	2	1	91	-	13	5	105,109,127,130,131	Common in N., occasional in S.
E. variegatum	Berm/marsh	-	6	4	47,69,70,71	-	7	3	79,83,98	100	8	3	124,L4,L5	Occasional in C.
Eupatorium cannabinum	Transit.	&	&	&		&	&	&		100	8	3	103,112,120	Frequent in S., rare N.
Euphrasia spp.	L. grass	-	4	3	36,68,69	&	&	&		-	8	3	109,113,120	
Hieracium pilosella	L. grass	*	*	*		-	5	2	D10,D13	-	3	1	110	
Hydrocotyle vulgaris	Berm/marsh	100	1	1	40	*	*	*		-	3	1	110	
Lamium purpureum	Waste	100	1	1	64	-	2	1	D5	100	3	1	112	
Leontodon hispidus	L. grass	&	&	&		&	&	&		-	8	3	109,110,117	
L. taraxacoides	L. grass	*	*	*		-	2	1	78	-	10	4	109,110,117,118	Frequent in S. and C.

TABLE 3.9 cont.

Rare species of the canal bank zone so classified by (a) a high zonal preference (%); (b) a low occcurrence (%). (c) refers to the number of the sections at which the species occurs along Units I, II and III of the Royal Canal.

SPECIES	HABITAT	(a)	(b)	(c)	SECTIONS	(a)	(b)	(c)	SECTIONS	(a)	(b)	(c)	SECTIONS	COMMENTS
Linum bienne	L. grass	‡	‡	‡		-	2	1	D13	‡	‡	‡	Rare	
L. catharticum	L. grass	-	3	2	20,21	&	&	&		-	10	4	107,110,118,130	
Listera ovata	Wood	‡	‡	‡		-	2	1	102	-	10	4	116,L5,L7,L8	
Lychnis flos-cuculi	Marsh	‡	‡	‡		‡	‡	‡		-	3	1	125	
Lycopus europaeus	Bare/marsh	‡	‡	‡		100	2	1	D2	‡	‡	‡		Frequent but local
Menyanthes trifoliata	Bare/marsh	&	&	&		-	7	3	79,95,98	-	3	1	117	
Myosotis scorpioides	Bare/marsh	-	4	3	28,62,63	-	5	2	72,93	100	8	3	113,114,117	
Nasturtium officinale	Bare/marsh	-	1	1	38	-	5	2	D2,B8	100	13	5	107,113-115,133	
Oenanthe crocata	Bare/marsh	‡	‡	‡		100	9	4	D2-D5	‡	‡	‡		Rare in C.
O. fistulosa	Bare/marsh	‡	‡	‡		100	2	1	72	100	3	1	117	Rare and only in E.
Origanum vulgare	Dry lime.	&	&	&		-	9	4	D11-D13,102	-	5	2	103,123	Rare N. and S.W.,
Pedicularis palustris	Bare/marsh	-	1	1	70	-	2	1	93	100	3	1	110	
Potentilla palustris	Bare/marsh	100	1	1	60	‡	‡	‡		-	3	1	118	
Pulicaria dysenterica	Bare/marsh	-	4	3	6,7,38	-	7	3	D7,D8,95	‡	‡	‡		
Ranunculus trichophyllus	Bare/marsh	‡	‡	‡		‡	‡	‡		100	3	1	114	Frequent in C. and S.E.
Rumex hydrolapathum	Bare/marsh	‡	‡	‡		&	&	&		100	10	4	112,114,115,118	Rather rare
Sanguisorba minor	L. grass	&	&	&		-	2	1	B1	-	5	2	110,113	Frequent on limestone
Schoenus nigricans	Fen/marsh	‡	‡	‡		‡	‡	‡		-	3	1	118	Common in N. and C.
Scrophularia nodosa	Waste area	100	3	2	31,62	-	2	1	B1	-	5	2	110,113	
Scutellaria galericulata	Wet stone	‡	‡	‡		‡	‡	‡		100	8	3	131,132,133	Occasional
Triglochin palustris	Marsh	-	3	2	62,64	-	12	5	B0,B1,B3,B5,93	100	5	2	116,130	
Typha latifolia	Marsh	&	&	&		100	7	3	72,92,97	100	3	1	103	Frequent but local
Veronica anag.-aquatica	Marsh	‡	‡	‡		‡	‡	‡		100	3	1	113	Frequent in C.

‡ denotes species not found; - denotes that the zonal preference is <80%; & denotes that the speccies is not rare along the canal.
Comments are taken from Webb (1977).

CHAPTER 4. FAUNA

4.1 MAMMALS

No special study of mammals was undertaken but observations made during the other ecological surveys were recorded.

Bats
A search was made without success in June 1990 for bat roosts under a number of bridges in the western section of the canal. The conclusion reached was that most bridges are unsuitable for bat roosts because they are too narrow and there are not sufficient crevices. Bats are regularly seen hunting for insects over the canal at dusk in summer but they were not identified to species.

Red Squirrel *Sciurus vulgaris*
A single individual was seen on the canal bank near Blackshade Bridge, Co. Meath. This species is normally found only in woodland bordering the canal.

Fox *Vulpes vulpes*
A single fox was disturbed in long grass on the canal bank between Kilcock and McLoughlin Bridge on 24 May 1990.

Mink *Mustela vison*
A single mink was seen swimming in the canal west of Moyvalley Bridge in August 1990. This introduced species is probably now widespread in the watered sections of the canal. It has been blamed for declines in populations of nesting moorhen but there is no direct evidence for this.

Otter *Lutra lutra*
Although no sightings have been recorded on the canal otter spraints (droppings) were found at several places, usually on the towpath under bridges. This species probably feeds on the fish in the canal and in adjacent rivers and streams. It prefers to breed in areas where bankside tree roots support the underwater exit to a holt.

4.2 BIRDS

4.2.1 Introduction

The overall objective of the bird surveys was to document the breeding and wintering bird communities on the Royal Canal and to relate their distribution and abundance to management practices. Previous knowledge of the birds was confined to a single sample survey carried out in the autumn of 1989 by P. Buckley (RCS 1989).

4.2.2 Methods

Two separate methods were used in the breeding bird surveys. Firstly, three study areas were chosen to represent the three management units on the canal. These study areas included a total of 25km of canal (approximately 16% of its entire length). The dimensions and general habitat characteristics of these areas are given in Table 4.1. Each of these study areas was visited six times during the breeding season from mid-April to early July at intervals of approximately 14 days. All visits were made by one observer on foot or by bicycle. All territorial birds seen or heard within the canal boundaries of these study areas were plotted on visit maps. At the end of the fieldwork all registrations were transferred to species maps. In the analysis three or more registrations of a species in the same location was regarded as a confirmed territory. For summer migrants (many of which do not begin breeding until May) two or more registrations in the same location was regarded as a confirmed territory.

Secondly, two complete censuses of riparian birds only were carried out on the entire canal, one in late May and the second in late June-early July. These census visits involved a team of volunteer observers and were carried out on foot or by bicycle. The three study areas mentioned above were included in the complete census visits allowing a check to be made on the accuracy of the census results.

Finally, two complete censuses of wintering waterfowl were carried out on the entire canal, one in each of the months November and December.

4.2.3 Results

Riparian species are those which are wholly dependent on the canal as a waterway during the breeding season. The results of the two complete breeding season censuses allow population estimates to be made for five key riparian species as shown in Table 4.2. Other riparian species were recorded on the canal but were not confirmed as breeding there. Reed Bunting* is generally associated with wet habitats but is not confined to them. It is treated as a non-riparian species in this survey

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* Scientific names of all breeding bird species are given in Tables 4.2 and 4.3.

The estimated populations of all non-riparian species censused in the three study areas are given in Table 4.3. These are almost all found breeding in the hedgerows, scrub and occasional woodlands which border the canal. For comparative purposes the results for all study areas are presented as the number of territories per 10km length of canal.

4.2.4 Discussion

Riparian species

In general the populations of riparian species on the Royal Canal are low in number of species and in terms of density of breeding territories. Certain riparian species commonly found breeding on lowland rivers in Ireland are conspicuously absent. These include Common Sandpiper Tringa hypoleucos, Kingfisher Alcedo atthis and Sand Martin Riparia riparia, all of which require bare earth or gravel banks for nesting. Dipper Cinclus cinclus could nest under the many bridges on the canal but it requires fast-moving water in which to feed. Coot Fulicra atra and Tufted Duck Aythya fuligula, which occasionally nest on rivers, are probably absent because of the limited area and depth of water in the canal for feeding.

Those species which do nest are present in very low numbers by comparison with other canals (Marchant and Hyde, 1980; Briggs, 1988). The highest densities for all species (with the exception of Grey Wagtail) are found in Unit II which offers a combination of open water, thick marginal vegetation and undisturbed banks with overhanging trees. Individual species are discussed below:

Mallard

The Mallard is a difficult species to census because males are only loosely territorial and they have a prolonged breeding season. The breeding population on the Royal Canal was assessed on the basis of territorial males present in the complete census in late May and additional broods present in June and July.

The total breeding population is estimated at 11 pairs with a heavily clumped distribution. The majority were in three areas - Dublin City, Maynooth and Ballymahon areas with isolated pairs in the Ballynacarrigy and Abbeyshrule areas.

As well as breeding pairs there were small flocks of non-breeding mallard present throughout the year. The largest number of non-breeders were recorded in the Dublin City area where they supplement their diet with artificial food. The total number of Mallard (including breeding pairs) on the Dublin sections of the canal between the second and eighth locks varied between 18 and 22 throughout the year. The only other area where artificial feeding regularly attracts a small flock of Mallard is the harbour at Maynooth.

Mute Swan

There are at least seven breeding territories for Mute Swans on the Royal Canal as shown in Table 4.2. The overall density at 0.5

pairs/10km is low by comparison with populations on canals in Britain. Regular census work on 17 sample plots in Britain totalling 75km in length gave an average of 1.5 pairs/10km (Marchant and Hyde, 1980). The Montgomery Canal held 8 breeding pairs in 56km (average 1.4 pairs/km)(Briggs, 1988). A lower average density (1.2 pairs/10km) was found in a sample of 8 disused canals in Britain (totalling 35.5 km in length) (Marchant and Hyde, 1980). Unit II provides the optimum breeding conditions on the Royal Canal with an average of 1.2 pairs/10km. The main attractions here are adequate open water for safety, an abundance of aquatic plants for feeding and nest sites which are secure from disturbance.

Table 4.4 gives historical data for three of the territories (R. Collins, pers comm) which shows that these territories are used for breeding every year with varying degrees of success. The most consistently successful territory is that at Maynooth where the nest is built on an artificial island created by the OPW in the harbour. The pair at Coolnahay attempted to breed in 1990 on a raft floating in the harbour having deserted an earlier nest on the canal bank due to disturbance. In the other territories the nests are built on the banks of the canal where they are regularly prone to disturbance and predation. A Fox Vulpes vulpes was recorded on the canal bank within 500m of the nest site at Kilcock shortly after hatching.

Of the seven pairs which attempted to breed on the canal in 1990, five (71%) succeeded in hatching young. This is close to the average hatching success (76%) found by Collins (1990) for 34 canal nests in the Dublin area. The exact reasons for breeding failure in the remaining two pairs is unknown but it is suspected that disturbance to the nests was involved. Collins (1990) found a higher rate of egg loss from nests in urban areas (41%) compared with rural locations (17%) but no other significant differences in breeding success.

The distribution of breeding territories along the canal may also be influenced by the availability of food. Swans are entirely vegetarian, feeding mainly on the leaves and stems of submerged aquatic plants such as crowfoot Ranunculus and pondweed Potamogeton. Emergent vegetation is not often taken but the stems and leaves of a few species are sometimes eaten (Birkhead and Perrins, 1986). In areas such as Maynooth where dredging has reduced the abundance of submerged aquatic plants the swans are clearly supplementing their diet with artificial food supplied by local people. There are, however, some good natural feeding areas, such as the Mullingar to Ballinea area, which hold considerable numbers of swans in winter. A pair of Mute Swans was present here in May 1990 but no breeding was attempted. This is probably due simply to the absence of a secure nest site.

It is suggested that artificial islands could be easily created at several locations to increase the chances of breeding success in existing territories and to provide the focus for new territories. Suitable sites might include Spencer Dock in Dublin, Kilcock

Harbour, Thomastown Harbour, the harbour at Scanlan's Bridge in Mullingar, Ballinea Bridge Harbour, Coolnahay Harbour, Ballinacarrigy Harbour, Ballybrannigan Harbour, Archie's Bridge Harbour, Foygh Bridge Harbour, Mosstown Harbour, and Richmond Harbour. A total of 6 individuals or pairs of non-breeding swans were also present on the canal during the spring of 1990.

Most of the established breeding pairs maintained their territories during the winter period. Additional pairs without young were present in November and December near Binns Bridge in Dublin, near Downs Bridge in Westmeath and near the Green Bridge in Mullingar. The only sizeable flock of wintering swans in 1990 was found in November in the 2km section west of Mullingar. The peak count here was 24 birds including 7 juveniles.

The origins of most of these winter swans is unknown except for one ringed bird (4BY) which was present in the flock at Mullingar in November. It was hatched at the nest at Binn's Bridge in Dublin in 1989 and was the only one of the offspring of that pair to fledge that year (see Table 4.4). On 4 October 1990 it was with a flock of swans on the Liffey at Inchacore, Dublin and so it is likely that other unmarked birds in the Mullingar flock may also have originated in Dublin (R. Collins, pers comm.).

Moorhen

The total breeding population on the Royal Canal is estimated at 62 pairs in 1990 (Table 4.2). This is based on the census in June when many broods had hatched and were more obvious than than at any other time in the season. This gives an overall density of 4 pairs/10km. This is extremely low by comparison with a sample of 17 canals in Britain which held an average of 30 pairs/10km (Marchant and Hyde, 1980) and a lowland river and disused canal system in Northern Ireland which held 50 pairs/10km (Bailey, 1982).

The highest densities of Moorhen on the Royal Canal were found in Unit II which provided both open water for feeding and marginal vegetation for nesting and cover from predators (Table 4.2). Table 4.5 gives some comparative data on Moorhen from two study areas, one each in Units I and II. Optimum conditions occurred in the 5km section from Mullingar-Bellmont Bridge with an average density of 30 pairs/10km. This section is not yet open to navigation and has not been recently dredged. It has abundant submerged aquatic plants and a wide (up to 2m) fringe of emergent vegetation on both banks. Marchant and Hyde (1980) also found higher densities of Moorhen territories on disused canals in Britain compared to used canals attributing this to the greater degree of cover provided by disused waterways. Taylor (1984) found that, following management works on the Grand Union canal in England, the number of Moorhen territories was reduced by 25%. The absence of low branches on overhanging trees and the slow spring growth of emergent vegetation following dredging were considered to be the main factors which restricted and delayed the breeding of birds on the managed stretches. Campbell

(1988) found a 65% reduction in Moorhen territories after heavy engineering works on an English lowland river.

Grey Wagtail

The total breeding population of Grey Wagtail on the Royal Canal is estimated at 21 pairs (Table 4.2). The peak count of this species was recorded on the first census in May which probably coincided with the fledging of first broods (Tyler, 1972). Breeding territories were commonly associated with bridges and locks where fast-flowing water occurred. Nests were often built in holes in the masonry or on tree roots growing out of the canal banks.

Grey Wagtail is a widespread breeding species on fast-flowing rivers and streams but is relatively uncommon on canals. The highest densities of 6-8 pairs/10km are found on rivers with a gradient in excess of 5m/km. On slower rivers the average density is about 3-4 pairs/10km (Marchant and Hyde, 1980). The overall density on the Royal Canal at 1.4 pairs/10km is limited by the availability of suitable nest sites and feeding areas. On long level sections few territories occured while in the series of eight locks near Killucan five territories were concentrated in 4km of canal. The lowest density of territories was found in the western section of the canal where there is little flowing water and where most of the locks are disused.

Sedge Warbler

A total of 34 Sedge Warbler territories was recorded during the complete census in May with the majority in Units I and II (Table 4.2). However comparison with the results from the intensive study areas (Table 4.3) indicates that this is a substantial underestimate of the true population. Territorial birds are usually located by their song. Peaks of song in the population are highly synchronised and of short duration. Thus, without frequent census visits it is easy to underestimate the population. The highest density of Sedge Warbler recorded was 12 territories in 8 km (15/10km) between Ballynacarrigy and Abbeyshrule. Marchant and Hyde (1980) found a higher density of Sedge Warbler on disused canals (7.5 territories/10km) compared to used canals (5.4 territories/10km).

Other non-breeding riparian species

Heron Ardea cinerea use many parts of the canal system for feeding but there are no nesting colonies within the canal corridor. They prefer to feed in shallow water pools such as occur in parts of Unit III or on the gently shelving banks which are common in Unit II. The canal between Leixlip and Maynooth is extensively used by Herons as there is a breeding colony in the nearby Carton Estate.
No Snipe Gallinago gallinago nests were recorded on the canal itself but there were a number of territories on neighbouring land. Territorial birds were distinguished by their aerial drumming display during the census in May. A total of 12 territories were recorded in May all in the area west of Moyvalley. The most frequent occurrence of Snipe was in the vicinity of raised bogs such as those north of Ballymahon.

There were individual sightings of Kingfisher Alcedo atthis on the canal around Leixlip and Abbeyshrule but no breeding territories were confirmed. These are likely to have been breeding birds from the nearby rivers (Ryewater and Inny respectively) which occasionally feed on the canal. Vertical sand or earth banks suitable for nesting by Kingfishers are absent on the Royal Canal. For similar reasons Sand Martins Riparia riparia did not breed on the Royal Canal. However, there are nearby breeding colonies in the Mullingar and Abbeyshrule areas from which birds fly to feed on the canal.

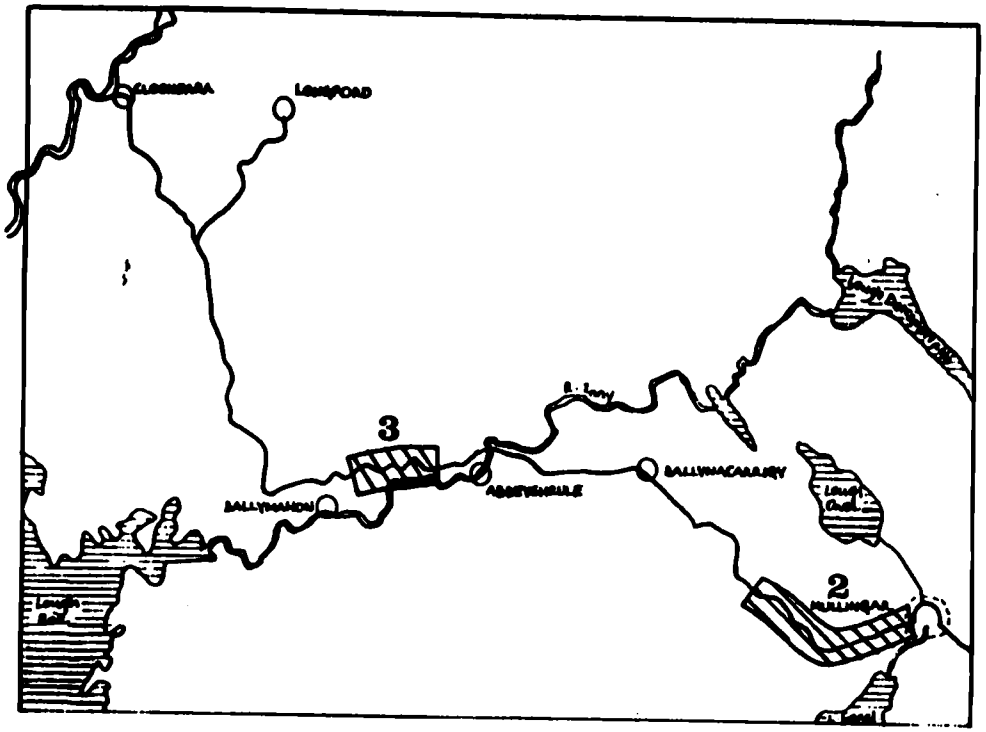
Non-riparian species

Total number of breeding territories estimated for non-riparian species are given in Table 4.3 for three study areas, one in each of the three management units I, II and III. Each of the study areas (fig 4.1) included a 10km length of canal, with the exception of Study Area 3 which, due to difficulties of access, included only 5km. For comparative purposes results for all study areas are presented in Table 4.3 in terms of territories per 10km.

The species in Table 4.3 are ranked in order of the total number of territories estimated for 30km of canal. The breeding bird community is dominated by five species, Robin, Blackbird, Wren, Willow Warbler and Chaffinch, which together account for some 79% of all territories. The community structure is very similar to that found in 5 farmland census plots around Limerick (Lysaght, 1989) except that Dunnock occupied a higher position in the latter study. The species diversity was very similar in both studies when riparian species were included.

The canal may be considered as a double line of hedgerows crossing the country although in places there are sizeable gaps especially where the canal crosses areas of raised bog. It is surprising that the species diversity and population density are both lowest in Area 3 which has the most continuous cover of trees. Of the more typical woodland species both Song Thrush and Bullfinch were more common in the dry sections of Area 3 but Chaffinch was conspicuously scarce here. Both Blue Tit and Great Tit, which require older trees for their hole-nests, were relatively low in the community structure overall.

A breeding colony of Rook Corvus frugilegus was located on the edge of the canal in Study Area 1 but this was excluded from the analysis. A number of additional species were recorded in the canal corridor but were not considered to hold territories there. These included Kestrel Falco tinnunculus, Sparrowhawk Accipiter nisus, Redshank Tringa totanus, Black-headed Gull Larus ridibundus, Swallow Hirundo rustica, House Martin Delichon urbica, and Starling Sturnus vulgaris.



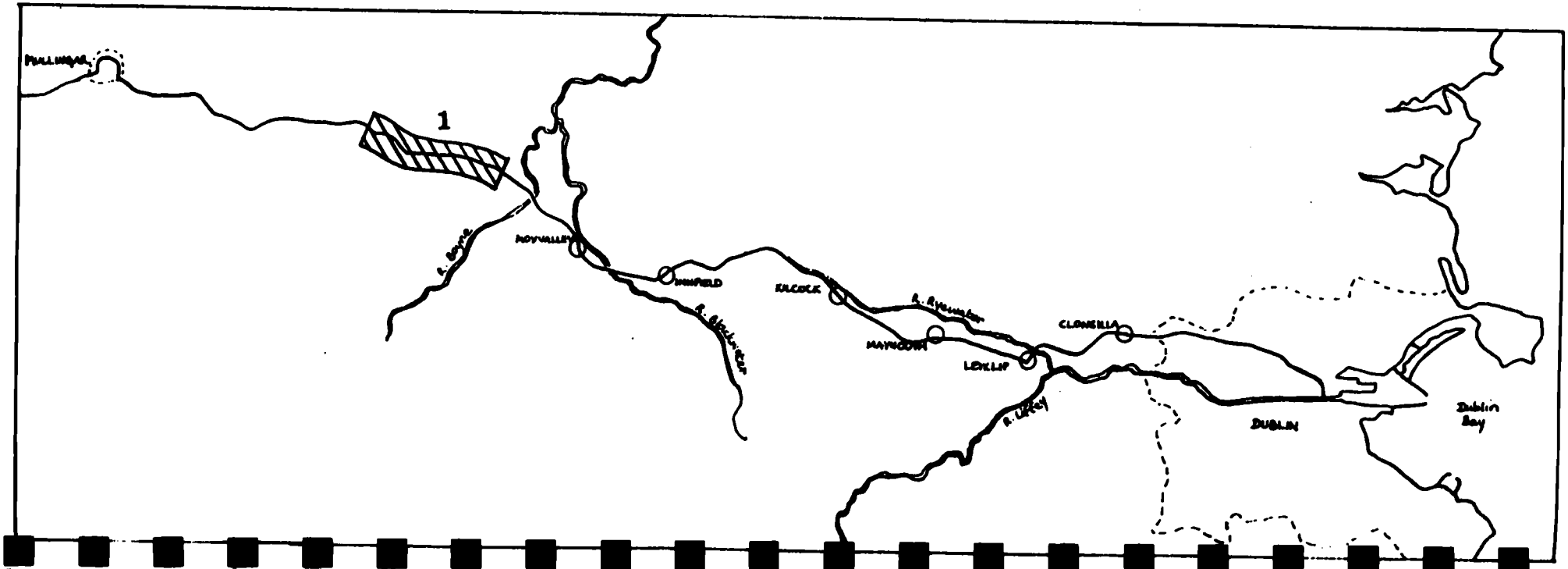


Figure 4.1. Study areas for the census of non-riparian breeding birds

4.2.5 Overall Evaluation

As a habitat for birds at present the Royal Canal is relatively unexceptional. The diversity and density of breeding birds is low especially on the heavily managed stretches of Unit I and the dry and overgrown sections in Unit III. Unit II offers the greatest variety and density of birds because it combines open water, abundant aquatic and emergent plant cover and overhanging trees.

Table 4.1 Study areas for breeding bird census on the Royal Canal, 1990.

No.	Limits	Length (km)	Habitats
1.	Blackshade Bridge to D'Arcys Bridge	10	Recently dredged. Nearby bog and woodland.
2.	Green Bridge, Mullingar to Coolnahay Harbour	10	Not recently dredged. Good marginal fringe.
3.	Drapers Bridge to Fowlards Bridge	5	Devatered except around locks. Dense emergent vegetation and continuous hedges.

Table 4.2 Breeding populations of riparian bird species (pairs) and density of territories (pairs/10km) on the Royal Canal, 1990.

Species	Unit I (72km)		Unit II (43km)		Unit III (39km)		Total (154km)	
	pr	pr/10km	pr	pr/10km	pr	pr/10km	pr	pr/10km
Mallard *Anas platyrhynchos*	3	0.4	5	1.2	3	0.8	11	0.7
Mute swan *Cygnus olor*	2	0.3	5	1.2	0	0	7	0.5
Moorhen *Gallinula chloropus*	22	3.0	32	7.4	8	2.0	62	4.0
Grey wagtail *Motacilla cinerea*	13	1.8	6	1.4	1	0.3	21	1.4
Sedge warbler *Acrocephalus schoenobaenus*	16	2.2	16	3.7	2	0.5	34	2.2

Table 4.3 Breeding territories of non-riparian birds on the Royal Canal (figures in pairs/10km).

Study Areas	1	2	3	Total
Length of Study Area	10km	10km	10km*	30km
Robin Erithacus rubecula	64	61	72	197
Blackbird Turdus merula	49	82	52	183
Wren Troglodytes troglodytes	58	53	60	171
Willow Warbler Phylloscopus troch	35	46	46	127
Chaffinch Fringilla coelebs	38	46	10	94
Song Thrush Turdus philomelos	7	11	18	36
Sedge Warbler Acrocephalus schoen	8	9	6	23
Chiffchaff Phylloscopus collybita	13	9	0	22
Wood Pigeon Columba palumbus	9	6	4	19
Bullfinch Pyrrhula pyrrhula	0	6	10	16
Blue Tit Parus caeruleus	1	7	8	16
Magpie Pica pica	6	5	2	13
Pheasant Phasianus colchicus	2	2	4	8
Hooded Crow Corvus corone	6	0	2	8
Great Tit Parus major	4	3	0	7
Greenfinch Carduelis chloris	2	5	0	7
Pied Wagtail Motacilla alba	5	1	0	6
Yellowhammer Emberiza calandra	2	3	0	5
Reed Bunting Emberiza schoeniclus	1	3	0	4
Cuckoo Cuculus canorus	4	0	0	4
Mistle Thrush Turdus viscivorus	2	1	0	3
Linnet Acanthis cannabina	3	0	0	3
Meadow Pipit Anthus pratensis	0	2	0	2
Dunnock Prunella modularis	0	1	0	1
Whitethroat Sylvia communis	1	0	0	1
Total pairs	320	362	294	976
Total number of species	22	21	13	25

* Results for Study Area 3 are given in pairs/10km for comparison.

Table 4.4 Mute Swan breeding territories on the Royal Canal

No.	Nest Location (Grid Reference)	Year	Ring No. M	F	Outcome
1.	Binn's Bridge, Dublin O 159 360	1987	2DN x	1UD	Eggs infertile.
		1988	2XD x	2ZF	Nest vandalised. Replacement clutch destroyed 2ZF killed by dog
		1989	2XD x	2UH	7 eggs. 1 young. 2UH died.
		1990	2XD x	3IL	8 eggs. 4 young.
2.	Broom Bridge, Dublin O 132 352	1988	2TN x	3TP	Nested. 3 young.
		1989	same pair		Adults oiled in February. No breeding.
		1990	same pair		Nest failed. 3TP killed in November.
3.	Maynooth Harbour N 937 373	1986	1BS x	2BX	9 eggs. 5 young.
		1987	same pair		10 eggs. 8 young
		1988	same pair		9 eggs. 5 young.
		1989	same pair		7 eggs. clutch lost - flooded
		1990	same pair		9 eggs. 1 young
4.	McLochlin Bridge,Kilcock N 860 415	1990	unringed		> 1 young
5.	Coolnahay Harbour N 355 540	1990	unringed		Early nest abandoned. Late nest on raft with 3 eggs. Deserted.
6.	Balroe Br., Ballynacarrigy N 320 580	1990	unringed		5 young
7.	Bog Bridge, Abbeyshrule N 245 595	1990	unringed		Nest on canal abandoned. Later nested on R. Inny

Source: Pre-1990 data from R. Collins

4.3 INVERTEBRATES

4.3.1 INTRODUCTION

Up to 1990 little was known of the invertebrate life in the Royal Canal. Considering the large number of invertebrate groups and the short time available for this study it was decided to concentrate on those aquatic invertebrates which could be used as indicators of species richness and which would therefore provide a baseline for future monitoring. A sample survey of dragonflies and damselflies (Odonata) was carried out in 1990. Previous sampling of water beetles (Coleoptera) and freshwater snails (Mollusca) in restricted sections of the canal were summarised by the relevant specialists in the following sections.

4.3.2 DRAGONFLIES AND DAMSELFLIES

Introduction

Dragonflies and damselflies (Odonata) were selected for study on the canal because there are relatively few species recorded in Ireland (24 in total of which 9 are rare)(Hammond 1983). Disadvantages include the difficulty of identifying species in flight and the relatively short flight period in some species.

Methods

Three separate approaches to the survey were adopted. The first was a search of the database of the Irish Odonata Recording Scheme for species recorded from the Royal Canal. This produced a large number of records with six-figure grid reference some dating back to the 1940s. Secondly, a field survey was undertaken during June to August 1990 to establish the species present under various management regimes. In view of the total length of the canal (150km) and the short flight period it was decided to concentrate on a number of study areas which were considered to be representative of the full range of management regimes on the canal. Thirdly, a special study was made of a section of the canal at Clonsilla, Co. Dublin for which there was good historical data, in order to measure the rate of recovery of Odonata species after dredging in 1989.

Species were identified in the adult stage, either in flight or at rest on vegetation or on the ground. When doubt existed about the identification of the species, individuals were captured in a net for closer examination and subsequently released. The primary reference work was Hammond (1983). Where relevant a note was made of copulating adults or ovipositing females which provide positive evidence of breeding at the location in question.

Study Areas

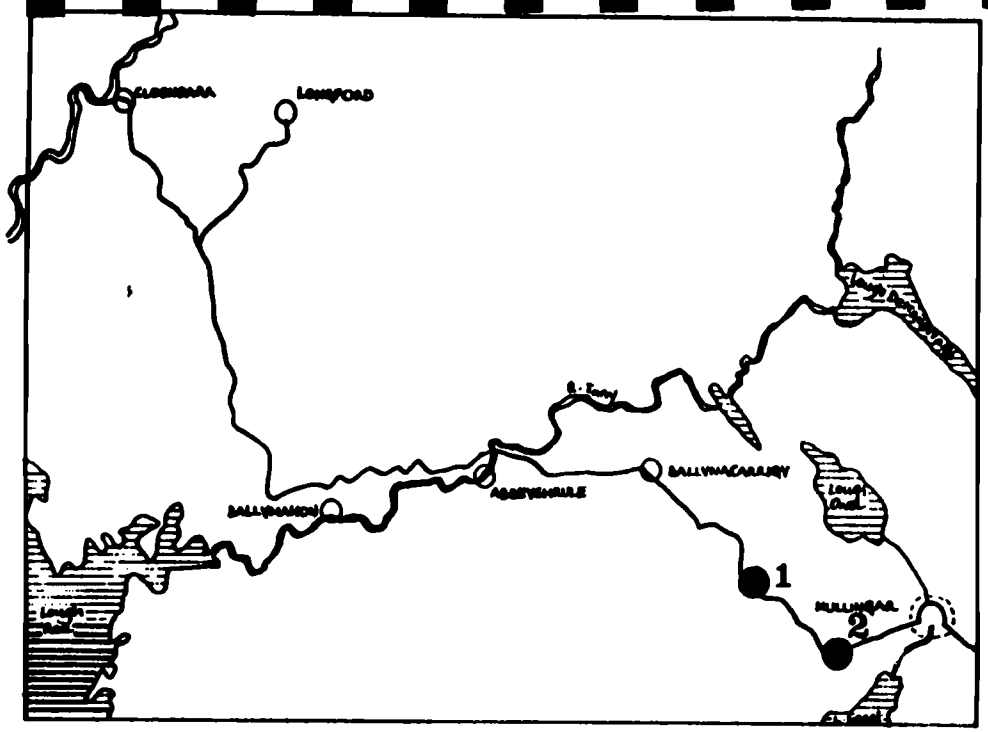
Five study areas were chosen for sampling. These are shown on Figure 4.2 and their habitat characteristics are summarised in Table 4.6. Each study area was 1km in length and included the channel, one bank, towpath and boundary. Two of the study areas were in the watered but disused section of the canal west of Mullingar (Unit II) and the remaining three were in the dredged and navigable section between Mullingar and Dublin (Unit I).

Each of the five study areas was visited three times at intervals spread throughout July and August 1990. Days with warm, calm weather were chosen where possible as the maximum number of species and individuals fly in such conditions. June 1990 was unusually wet and cold and fieldwork had to be abandoned on several occasions.

Results

Species recorded

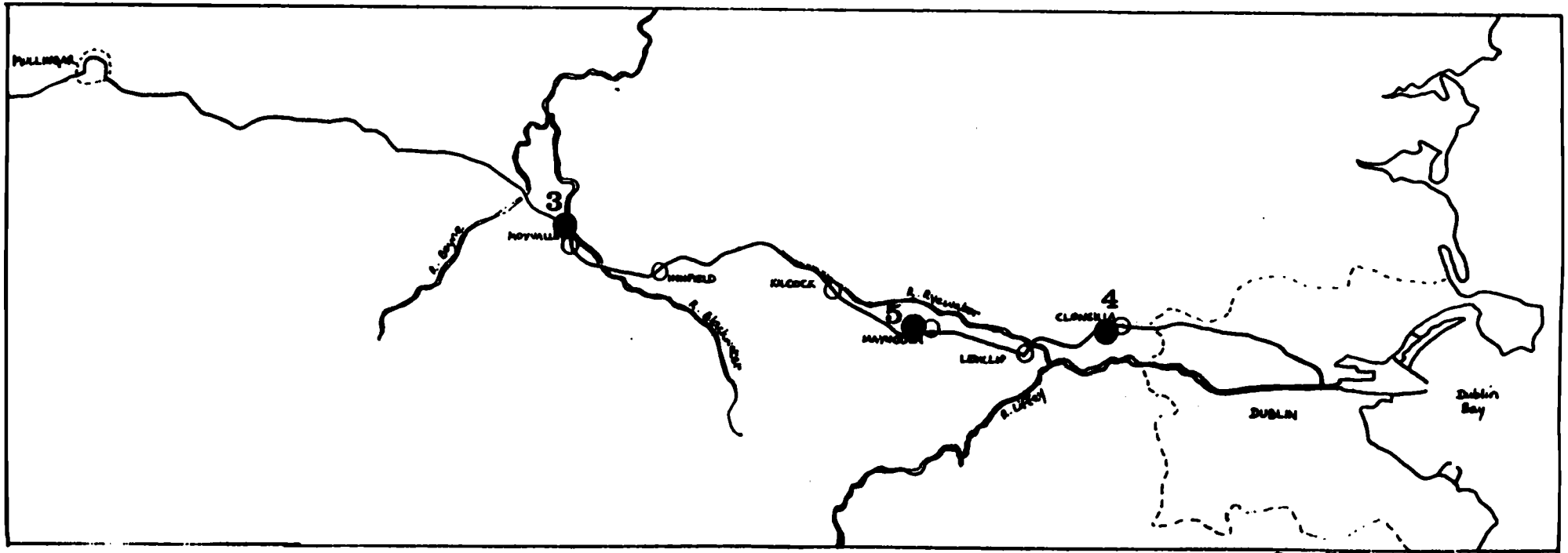
A total of 13 species of Odonata has been recorded from the Royal Canal as shown in Table 4.5. None of these species is rare in Ireland although two species, Sympetrum sanguineum and Brachytron



Royal Canal

10 km

Figure 4.2. Study areas for survey of dragonflies and damselflies



pratense are local in distribution and the latter is rare in Britain (Hammond 1983). This species list comprises over half the species known from Ireland and all of the common species except for Orthetrum coerulescens, Sympetrum scoticum and Calopteryx virgo..

Table 4.5. Odonata records from the Royal Canal

IBRC code	Species	Navigable sections UNIT I	Watered sections UNIT II	Dewatered sections UNIT III
0103	Calopteryx splendens	•	•	
0404	Lestes sponsa	•	•	
0601	Pyrrhosoma nymphula		o	•
0801	Ichnura elegans	•	•	
0901	Enallagma cyanthigerum	•	•	
1006	Coenagrion pulchellum	o	o	o
1007	Coenagrion puella	•	•	
2101	Brachytron pratense	o	•	
2204	Aeshna juncea		•	
2207	Aeshna grandis	•	•	
3204	Libellula quadrimaculata	o	o	
3803	Sympetrum striolatum	•	o	
3810	Sympetrum sanguinium	o	•	
Total number of species		11	13	2

• 1990 records

o pre-1990 records from the Irish Odonata Recording Scheme

Navigable sections: Clonsilla to Mullingar

Watered sections: Liffey to Clonsilla *and* Mullingar to Abbeyshrule

Dewatered sections: Abbeyshrule to Shannon

IBRC code: Computor code of Irish Biological Records Centre

Eleven of the species shown in Table 4.5 were recorded in 1990. The remaining two were last recorded in the Irish Odonata Recording Scheme prior to 1986 when the present programme of canal restoration began. Of these Coenagrion pulchellum was the most widespread species being recorded from a total of 5 sites spread thoughout the three management units. The similarity of this species to C. puella suggests that it may have been overlooked in 1990. The second species Libellula quadrimaculata was previously recorded from Units I and II in a total of 5 sites. This is a large and relatively distinctive species which is unlikely to have been overlooked in 1990.

Among the species not yet recorded on the Royal Canal is Lestes dryas which is rare and declining throughout its range in Britain and Ireland (Moore 1980). It has been recorded from only a few sites in Ireland including one on the Grand Canal at Robertstown. Here it is found at the dry end of a disused arm of the canal among reeds Phragmites australis and reedmace Typha latifolia (B. Nelson, in litt.). Similar habitats on the Royal Canal were investigated in 1990 but only the common and closely-related species L. sponsa was found. It is worth noting that N.W. Moore, who has studied L. dryas in some detail, visited the Royal Canal in 1986 without recording the species.

Presence/absence in study areas

Table 4.6 shows the distribution of the ten species recorded in the five study areas in 1990 together with one additional species recorded outside the study areas. There was considerable variation in the number of species recorded at each study area although each received even coverage. The study area with the greatest number of species (8) was at Ballinea although the Coolnahay and Moyvalley study areas showed almost as great a diversity with 7 species each. No species of Odonata was recorded at the study area in Maynooth.

Recovery of Odonata after management

A special effort was made to record the species present in 1990 in the study area 1km west of Callaghan Bridge in Clonsilla, Co. Dublin. This area had been the subject of detailed recording in previous years from 1977 to 1983 when five species were recorded (J.Shackleton, in litt.). The canal was dredged in April 1989 and the spoil spread on one bank. A total of five visits was made in July and August 1990 but only three species were recorded (Table 4.7). This included one species Calopteryx splendens, previously unrecorded from the area but excluded three species which were previously known from the site. Of these, Brachytron pratense is generally an early-flying species and may have been missed during the bad weather in June. However Enallagma cyathigerum and Ichnura elegans were considered to have been genuinely absent.

Table 4.6. Distribution of adult Odonata on the Royal Canal in 1990.

Species	Study Areas 1	2	3	4	5	X
Brachytron pratense	•	•				
Aeshna juncea	•					
Aeshna grandis	•	•	•	•		
Sympetrum striolatum			•	•		
Sympetrum sanguineum	•	•				
Calopteryx splendens		•	•	•		
Lestes sponsa	•	•	•			
Pyrrhosoma nymphula						•
Ichnura elegans	•	•	•			
Enallagma cyathigerum		•	•			
Coenagrion puella	•	•	•			
Total number of species	7	8	7	3	0	1

Study Areas

1. Coolnahay Harbour: Partly watered; dense emergent vegetation; few trees; undredged; herbicides used April 1990; water depth 700mm.
2. Ballinea Bridge: Open water; emergent vegetation; overhanging trees; undredged; herbicides used April 1990; water depth 700mm.
3. Moyvalley Bridge: Open water; sparce emergent vegetation; few trees; dredged May 1990; herbicides used April 1990; water depth 1400mm.
4. Callaghan Bridge: Open water; sparse emergent vegetation; overhanging trees; dredged April 1989; spoil levelled September 1989; herbicides used April 1990; water depth 1400mm.
5. Maynooth Harbour: Open water; no emergent vegetation; no trees; dredged April 1988; spoil levelled April 1990; herbicides used April 1990; water depth 1400mm.

X. Outside study areas:

Table 4.7. Adult Odonata recorded in the Callaghan Bridge study area before and one year after dredging.

Species	Before* (1982-83)	After (1990)
Brachytron pratense	•	o
Aeshna grandis	•	•
Sympetrum striolatum	•	•
Calopteryx splendens	o	•
Enallagma cyathigerum	•	o
Ichnura elegans	•	o
Total number of species	5	3

• indicates presence

o indicates unrecorded in three visits

* 1982-83 records supplied by J. Shackleton.

Discussion

Species present in comparison to similar habitats elsewhere

The Odonata of Scragh Bog, Co. Westmeath, a small (*c.*23ha) valley fen approximately 6km north of the Royal Canal, have been described by Speight and Legrand (1984). Here 13 species were also found with 11 species in common between the fen and the canal. The two species found at Scragh Bog but not on the Royal Canal were Ischnura pumilio, a rare species associated with bog pools (Hammond 1983), and Coenagrion lunulatum, a rare species also found in peatlands and only recently added to the Irish list (Cotton 1982).

There are no other published studies of Odonata on canal systems in Ireland but a survey of the Montgomery Canal in England/Wales in 1985-1988 gave comparable results (Wistow 1989). This canal was also partly disused but contained water for 44km of its total 57km length. The Montgomery Canal contained 14 species of which 5 are unrecorded in Ireland. Of the remaining 9 species 8 have been recorded on the Royal Canal. The unrecorded species, Calopteryx virgo, was considered by Wistow (1989) to have wandered from fast flowing streams which pass under the Montgomery Canal and not to have bred there.

A survey of Odonata on the Gwent and Somerset Levels and Moors, another still-water habitat, found a total of 17 species, of which only 12 are recorded from Ireland (Drake 1987). The correlation between the species lists for these sites and the Royal Canal is high with 11 species in common. The only Irish species found on the Gwent and Somerset Levels and not on the Royal Canal was Orthetrum cancellatum and this was rare on the former sites.

Given the intensity of the surveys on the Montgomery Canal and the Gwent and Somerset Levels and Moors this suggests that the species recorded from the Royal Canal are typical of a canal system in Ireland which contains a range of still-water habitats but no exceptional features. The Nature Conservancy Council considers any site in Britain north of the Severn Estuary to the Thames Estuary containing 12 or more species of Odonata to be an outstanding assemblage worthy of protection as a Site of Special Scientific Interest (Anon. 1989). In view of the relative paucity of the Irish dragonfly fauna this suggests that the Royal Canal has a reasonably diverse community at present.

Important habitat features on the canal

All species of Odonata are dependant on both the condition of their aquatic breeding site and the nature of the surrounding area frequented by the adults (Chelmick et al 1980). The distribution of species between the five study areas (Table 4.6) demonstrates some preferences for certain habitat features.

Emergent vegetation: The complete absence of emergent vegetation at Maynooth was probably the most unfavourable factor for all species. Two species Brachytron pratense and Sympetrum sanguineum were found only at Coolnahay and Ballinea where the water depth was less than 700mm and where there was dense submerged and emergent vegetation. The latter species is known to have an association with the plants burreed Sparganium and bulrush Typha (Chelmick et al 1980) which are abundant at both sites. Aeshna juncea was recorded only at Coolnahay at the dryest end of the canal where a pool of water surrounds a disused lock (no. 28). In Britain it is known to prefer well-reeded ponds in coniferous woodland (Hammond 1983).

Bankside trees: The absence of bankside trees at Maynooth may also have been a negative factor for most species as shelter from the wind is important to the adults and open windswept sites are rarely important (Chelmick et al 1980). A significant difference between the study areas 3 and 4 was the presence of well-spaced trees on both banks at Moyvalley leaving ample sheltered, sunny patches while at Clonsilla the trees had been completely removed from the north bank but were tall and overhanging on the south bank creating dense shade on this half of the canal.

Bare ground: Sympetrum striolatum was recorded only in study areas 3 and 4 and most frequently seen resting on patches of bare ground which were plentiful on the dredging spoil spread on the canal

banks. This species is known to favour patches of bare ground (Hammond 1983) which were completely absent in study areas 1 and 2.

Effects of canal management

The most obvious effects of canal management on the Odonata were seen in Maynooth where all emergent vegetation and all bankside trees had been removed within the preceding two years. This area was unsuitable for recolonisation by all species. Dredging was probably the most important factor in restricting Sympetrum sanguineum to study areas 1 and 2 which were undredged and contained abundant emergent vegetation. The only record of this species from the presently dredged area (Unit I) was from an area east of Maynooth in 1948. The retention of a sparse growth of emergent vegetation and occasional bankside trees at Moyvalley has clearly increased the range of species which can survive after dredging (Table 4.6). Recovery of the fauna at Clonsilla, one year after dredging, is only partial and the absence of two small species Enallagma cyathigerum and Ichnura elegans here may be due to the absence of shelter on the north bank and the dense shade, reducing the growth of emergent plants on the south bank (Table 4.7).

FRESHWATER MOLLUSES by DECLAN DOOGUE

4.3.3. Introduction

Between 1975 and 1983 collections of freshwater molluscs were made along the Royal Canal in V.C. Dublin (H.21) and Kildare (H.19). The initial impetus for this research was provided by the accidental discoverty of the rare freshwater snail, Myxas glutinosa, a single freshly-dead shell of which was discovered in the canal near Ashtown. Attempts were made subsequently to determine the range of this species both locally and further afield. In the process, numerous samples were taken from twenty sites in the two counties and most of the material encountered in the course of this fieldwork was retained for further examination. This report is founded on an analysis of that separate material, most of which was collected in 1980, 1981 and 1982.

Limitations

Because of the opportunist nature of fieldwork and the variation in sampling techniques on different occasions, quantitative comparisons of the molluscan fauna of individual sites are invalid. The main thrust of earlier sampling, mainly in Co. Dublin, was directed towards gastropods, and in particular the search for Myxas glutinosa. As a consequence small bivalves are not well represented in some samples. Despite these shortcomings a preliminary analysis of the material is possible. A base-line of limited value is provided against which the impact of recent dredging operations can, at least in part, be assessed.

Field Methods

Collecting by pond nets and a variety of sieves of varying mesh size was conducted from the bank or vegetation fringe. Site selection was determined more by factors such as accessibility and safety than scientific objectivity. In general, sites were selected either because they included a band of emergent vegetation or because the true aquatic flora of the area was well represented. Opportunist collecting also took place in the course of other unrelated fieldwork.

In a number of cases, a grab was employed to haul vegetation from the centre of the canal. This material was swirled in a basin in order to dislodge adhering gastropods. These were subsequently extracted by passing the water through a fine sieve.

Recent canal cleanings were also examined. These

cleanings consisted in the main of vegetable matter that had accumulated around lock gates, been removed and placed on the bank. This proved to be a rich source of gastropod material but contained few bivalves. More intensive dredging, related to engineering operations, at Louisa Bridge and Maynooth produced material from the canal bed which included vast numbers of Sphaerium, Pisidium and occasional Anodonta juveniles.

Material was killed using boiling water, left to dry naturally and subsequently stored in cardboard boxes. A few of the larger gatherings were killed by the above method and stored, unsorted in 70% Alcohol.

Identification

Specimens were identified to species level using Macan (1969) for gastropods and Ellis (1978) for bivalves. Nomenclature follows Ross (1984).

Few difficulties were encountered in identifying gastropod material. Juvenile Bithynia tentaculata was separated from B. leachi, using a combination of "umbillicus almost completely closed" vs. "umbillicus open", as well as the more usual suture characters.

Several of the larger populations of Planorbis carinatus contained individuals whose keel position and aperture character were reminiscent of Planorbis planorbis. No pure P. planorbis material was encountered in the canal, although typical material is known from Kildare water-bodies unconnected to the Royal Canal. Accordingly, all keeled ramshorns of this species-pair were classified as P. carinatus.

Among the mussels, all juvenile Anodonta material was assigned to A. cygnea on the basis of the posterior adductor muscle character illustrated on P.73 of Ellis (1978). (Young material cannot be distinguished reliably on shell outline characters). Mature specimens of the genus Sphaerium presented no difficulties although juvenile material required careful examination of the hinge teeth. Pisidium however was more difficult. A small sample, selected on the basis of shell morphology and external sculpturing was taken form each gathering. These specimens were subsequently identified using characters of the ligament pit and hinge teeth. This was particularly necessary for the minute species (< 2 mm). Smaller material was not identified.

The Species

A commentary is provided based on the performance of the species within the study area. Additional observations, based on the results of the author's independent fieldwork are also included where

appropriate.

Valvata cristata

When present, it can occur in great numbers, particularly in water with a mixture of true aquatics and emergent flora.

Valvata piscinalis

Similar in habitat preference to V. cristata, but within the Royal Canal, seldom as common.

Potamopyrgus jenkinsi

This species has spread in the last century throughout Ireland. It is however most characteristic of small streams where it is often abundant. It is therefore something of a surprise to realise its comparative rarity in the Royal Canal. It may belong to the so-called "slum" group of species, none of which is well represented in the canal. These constitute a group of species that inhabit temporary pools and can tolerate occasional periods of desiccation. Their numbers often fluctuate spectacularly from year to year.

Bithynia tentaculata

Abundant throughout the canal, usually one of the three dominant gastropods, in terms of numbers as well as biomass, both among emergent vegetation and in more open-water conditions.

Bithynia leachi

Present in small quantities throughout the study area, but most common at sites with a well-developed true aquatic flora.

Aplexa hypnorum

A single individual of this species was found in the Croke Park stretch of the canal. No other specimens, - not even dead shells were encountered elsewhere. It is often found in large numbers in temporary water-bodies and on the shores of reservoirs, along with Planorbis leucostoma, and may also be a "slum" species.

Physa fontinalis

Present in small numbers throughout the sample area in both well-vegetated and "poor" habitats. It was often the only species collected from aquatic vegetation (as distinct from emergent) pulled from the water. In several inner city samples it was often the commonest gastropod present.

Lymnaea truncatula

Not really a true aquatic species, more usually associated with muddy ground and vegetation fringing ponds and small lakes. However a few specimens were included in the samples and may have fallen from canal-side vegetation.

Lymnaea palustris

Occasional and usually in small numbers, in marginal emergent vegetation rather than in deeper open water.

Lymnaea stagnalis

Occasionally present in great quantity, and can sometimes be found swarming in stagnant pools and reservoirs. In the royal Canal, large specimens that are such a feature of the Grand Canal were not encountered.

Lymnaea peregra

Abundant and usually in large quantity throughout the canal.

Planorbis carinatus

Abundant throughout the system. This species, in combination with Lymnaea peregra and Bithnyia tentaculata comprise the overwhelming bulk of the living gastropod biomass of the Royal Canal.

Anisus vortex

Rare and only found at Ferns Lock, where it was occasional and at Maynooth Station as a single freshly dead individual.

Bathyomphalus contortus

This distinctive small Planorbid is common to abundant, even in the poorest looking habitats, i.e. areas virtually devoid of vegetation. It was even encountered (albeit in small quantity) in slightly brackish water at the point where the Royal Canal enters the R. Liffey.

Gyraulus albus

Present in small quantity, usually as shells with the appearance of being dead for some time.

Armiger crista

This species was surprisingly uncommon, as it is often found in large numbers in quite muddy and dirty water and leaf-filled drains, as well as in cleaner small

pools.

Hippeutis complanatus

Rare; the specimens from Confey were collected from the underside fo the floating leaves of Nuphar lutea.

Planorbarius corneus

This large and conspicuous species is scattered in small numbers along the canal and associated drains. It is considered by some workers to be an introduction in Ireland, possibly released originally from aquaria. Few mature living individuals were collected, but numerous dead adult shells were encountered.

Anodonta cygnea

The only specimens found were juveniles, generally damaged, in canal cleanings. They are usually encountered in deeper water than was examined in the present survey.

Sphaerium corneum

The most conspicuous of the smaller bivalves; present throughout the sampling area.

Pisidium

Data for these species is insufficient to comment.

Discussion

The conchological importance of the Royal Canal is well known and has been recognised by various workers (Stelfox, 1911; Kerney, 1976). The fortuitous circumstances that facilitated the spread of certain plant species from the Central Plain lakes to areas with little open water, e.g. Kildare and Dublin are well known (Praeger, 1934). Many freshwater invertebrates were similarly enabled to expand their natural range. In recent years the relative conservation value of the Royal Canal has increased further, following the drainage of the Boyne and Broadmeadow catchments. At present several species exhibit canal-type distrivutions and are virtually unknown outside the canals and canalised rivers of S.E. Ireland. Chief among these is Bithynia leachii but many other species are also noticeably commoner within the canal systems. Macan (1969) defined a group of hard-water species common in S., E. and C. England many of which have become common in the Royal Canal.

The present report, despite being based on material collected for a different purpose under a variety of collecting conditions, confirms the presence of 28 of

the 45 Irish gastropod and bivalve species (excluding Succinea and other water-margin species) in the Royal Canal between 1975 and 1983.

Missing Species

Two species groupings are not well represented in the samples. These are the species associated with temporary aquatic habitats, (the "slum" species), and species known form base-poor waers, ("soft-water" species).

Planorbis leucostoma

This small ramshorn, (common throughout Ireland) and Pisidium casertanum are well-known "slum" species. In conjunction with Aplexa hypnorum and Potamopyrgus jenkinsi, they may exhibit a strategy that is related to competition for certain resources (See Boycott, 1936).

Margaritifera margaritifera

The Freshwater Pearl Mussel is a well-known "soft" water species, often found in streams and rivers running off mountains.

Ancylus fluviatilis

The River Limpet has similar habitat requirements though more tolerant of more eutrophic conditions. Other species associated with base-poor conditions, and also not found in the samples, include Pisidium lilljeborgii and P. conventus.

Myxas glutinosa

Apart from the single record of Myxas from Ashtown, which prompted the gatherings upon which this report is based, no further specimens were encountered. It is a rare species in Ireland, and has a reputation for fleeting appearances. Anderson (1982), considered that it favoured the deeper parts of rivers and canals.

Theodoxus fluviatilis

The non-appearance of this species in the samples is surprising, given its frequency and occasional abundance in the Grand Canal, where it is often encountered on submerged stones and rocks. The bed of the Royal Canal in the areas sampled may have been too silted.

Sampling technique may explain the failure to find Pisidium pseudosphaerium, a very small bivalve, recorded from the Royal Canl in Co. Kildare, H.19 (Kerney, 1976).

Table 4.8 Species/Site Table for Royal Canal Mollusca.

A species by sample table is presented, with the sites ordered along an axis running from dublin City to Moyvalley in Co. Kildare. Species presence is indicated by P.

SITE NO.	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20
Valvata cristata	.	.	.	.	P	.	.	.	.	P	P	P	.	.	P	.	P	P	P	.
Valvata piscinalis	.	.	.	.	P	.	.	.	.	P	.	.	P	.	P	.	P	P	.	.
Potamopyrgus jenkinsi	P	P	P	P	.	P	P	P	.	.	.	.	.	.	.	.	.	P	.	.
Bithynia tentaculata	P	P	P	P	P	.	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Bithynia leachii	.	P	.	.	.	.	P	.	P	P	P	P	P	.	P	.	P	.	.	P
Aplexa hypnorum	.	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Physa fontinalis	.	P	P	.	.	.	.	P	.	.	.	.	P	.	.	.	P	.	.	.
Lymnaea truncatula	.	.	.	.	.	.	.	.	.	.	.	.	.	.	P	P	.	.	.	.
Lymnaea palustris	.	.	.	P	.	P	.	.	.	.	.	.	.	.	.	.	.	P	.	.
Lymnaea stagnalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	P	.	.
Lymnaea peregra	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Planorbis carinatus	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Anisus vortex	.	.	.	.	.	.	.	.	.	.	.	.	P	.	.	.	P	.	.	.
Bathyonphalus - contortus	P	P	P	P	.	.	P	.	.	.	.	.	P	.	.	.	P	P	.	P
Gyraulus albus	.	.	.	.	.	.	.	.	P	P	P	.	P	P	.	.	P	.	.	P
Armiger crista	.	.	.	.	.	.	.	P	.	P	.	.	.	.	.	.	P	.	.	.
Hippeutis complanatus	.	.	.	.	.	.	.	.	.	P	.	.	.	.	.	P	.	.	.	.
Planorbarius corneus	.	.	.	.	P	P	.	.	.	.	.	.	.	.	.	.	P	P	.	.
Anodonta cygnaea	.	.	.	.	.	.	.	.	.	P	.	P	.	.	.	.	.	P	P	
Sphaerium corneum	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P
Pisidium amnicum	.	.	.	.	.	.	.	.	.	.	.	.	P	.	P	.	P	P	.	
Pisidium casertanum	.	P	P	.	.	.	.	P	.	.	P	.	.	P	.	P	.	P	P	P
Pisidium personatum	.	P	P	.	.	.	.	P	.	.	P	.	.	.	.	.	.	.	.	.
Pisidium obtusale	.	.	.	.	.	.	.	.	.	.	.	.	P	.	.	.	.	.	.	.
Pisidium milium	.	.	.	.	.	.	.	.	.	.	.	.	P	.	.	.	.	P	.	
Pisidium subtruncatum	.	.	.	.	.	.	.	.	.	.	P	.	.	P	.	.	.	P	P	
Pisidium hibernicum	.	.	.	.	.	.	.	.	.	.	P	.	.	P	.	.	.	P	P	
Pisidium nitidum	.	.	.	.	.	.	.	.	.	.	P	.	P	P	.	P	.	P	P	.

Table 4.9 Locations of Survey Sites, with sample-type where known.

SITE	LOCATION	VC	DATE	SAMPLE TYPE
1.	E. OF BALLYBOUGH BRIDGE	21	1981	BANK HAND-NET
2.	CROKE PARK	21	1981	BANK HAND-NET
3.	W. OF CROSS GUNS BRIDGE	21	1979	CANAL CLEANINGS
4.	IONA GARAGE	21	1979	CANAL CLEANINGS
5.	ASHTOWN BRIDGE	21	1975	BANK HAND-NET
6.	DRAIN W. OF ASHTOWN BRIDGE	21	1975	BANK HAND-NET
7.	CLONSILLA	21	1979	BANK HAND-NET
8.	PACKENHAM BRIDGE	21	1979	DRAGGED VEGETATION
9.	COLDBLOW/LUCAN BRIDGE	21	1983	NOT RECORDED
10.	CONFEY BRIDGE	19	1980	BANK HAND NET
11.	LOUISA BRIDGE	19	1982	DREDGED MATERIAL
12.	DEEY BRIDGE	19	1981	NOT RECORDED
13.	MAYNOOTH STATION	19	1980	CANAL-BED DREDGINGS
14.	MAYNOOTH (POND BRIDGE)	19	1980	NOT RECORDED
15.	JACKSON'S BRIDGE	19	1978	NOT RECORDED
16.	KILCOCK BRIDGE	19	1982	NOT RECORDED
17.	FERNS LOCK	19	1982	CANAL CLEANINGS
18.	CLONCURRY (TRACK E. OF)	19	1982	BANK HAND-NET
19.	E. OF MOYVALLEY	19	1982	BANK HAND-NET
20.	MOYVALLEY BRIDGE	20	1982	BANK HAND-NET

WATER BEETLES by DAVID BILTON

4.3.4 Introduction

Water beetle assemblages in the Royal Canal were sampled in August 1986 during a visit made to Co. Westmeath. The principle aim of this visit was to record aquatic Coleoptera from primary fens in this region of Ireland. Water beetles of all habitats were extremely poorly known in Ireland at the start of this decade (Foster, 1981), a situation which has been partly rectified (Bilton and Lot in press). For this reason initial surveys were also undertaken of a representative selection of aquatic biotopes in the areas visited (Bilton, 1988). Among the habitats visited were six sites on the Royal Canal system. Aquatic Coleoptera are excellent indicators of habitat type, age, diversity and disturbance, and have been used elsewhere in the conservation assessment of wetlands (Eyre and Foster, 1989; Foster et al., 1990). Past problems encountered by many in the identification of species have been overcome in many cases by the availability of an up-to-date identification guide (Friday, 1988). The results presented here are limited in scope, and do not allow for much extrapolation to the Royal Canal system as a whole. It is likely, however that most managed sections of the canal will contain a fauna similar to that present in these Westmeath localities.

Sampling Methods

Aquatic Coleoptera were sampled using a D-frame pond net. At each site all available microhabitats were investigated in this way. Trampling of bank edges and hand searching were also employed to find smaller Hydrophilid water beetles. A stretch of canal roughly 50-100m long was examined at each station. Sampling was carried out until no further species could be found, such a process taking from 30 mins to one hour. Jeffries (1987) has shown that such a sampling regime is more cost effective than repeated timed samples, a result which is backed up by the extensive field experience of the author and others. Most specimens were identified in the field, but some groups (eg. most Gyrinus spp.) were taken home for closer examination. As well as the traditional water beetles of the families Haliplidae, Noteridae, Dytiscidae, Gyrinidae, Hydrophilidae and Hydraenidae, semi aquatic members of the Staphylinidae, Chrysomelidae and Curculionidae were also recorded..

At each site notes were made concerning the habitats present with water beetles, and the dominant forms of vegetation above, below, and beside the water.

Sampling Localities

As stated all these were in the vicinity of Mullingar in Co. Westmeath. They were situated as follows:-

1. Royal Canal at Saunders Bridge N4553. Muddy edges with marginal grasses, Sparganium and Myosotis.

2. Canal Supply N4454. Richly vegetated margins with grasses, Carex, Juncus and mosses.

3. Royal Canal at Shandonagh Bridge N3653. Vegetated canal with Myriophyllum in open water and marginal Myosotis and Juncus.

4. Royal Canal at Coolnahay Bridge N3554. Dense Glyceria maxima (Hartman) bed over silt.

5. Royal Canal at Ballyncarrigy N3053. G. maxima, algae and Myriophyllum in canal edge.

6. Royal Canal at Kilpatrick Bridge N4152. G. maxima in canal edge.

Results and Discussion

In total 49 species of aquatic and semi-aquatic Coleoptera were recorded from the six sampling sites on the Royal Canal system. These are given by locality in Table 4.10.

Species of Note

Hygrotus quinquelineatus (Zetterstedt). This northern European species is rare in Britain, occuring in fen drains and ancient lochs. In Ireland, however, the species is far more widespread, being found in a range of habitat types such as rivers, drains, loughs and turloughs. Other northern insect species with restricted distributions in Britain are also more widespread in Ireland, such as the carabid Pelophila borealis Paykull.

Rhantus grapii (Gyllenhal). This medium-sized dytiscid is usually associated with sites containing rich fen vegetation, particularly in old fens, or after drainage in ditches on the site of such fens. R. grapii occurred in the Canal supply in dense bankside vegetation.

Eubrychius velutus (Beck). One of the few weevils to live underwater as an adult, E. velutus feeds on Myriophyllum. The species is scarce in the British Isles, and is most often found in relatively deep, clear waters. In Ireland its distribution is practically unknown, the present record appearing to be the only one made during recent years.

Effects of Management on Aquatic Coleoptera

Of the localities listed all except site two on the Canal Supply showed evidence of dredging and some degree of eutrophication.

The water beetle fauna of these five sites is a direct result of management. It is dominated by Haliplidae and small Dytiscidae which live in deep open water amongst vegetation. Large dytiscids and Hydrophilidae are largely absent due to the lack of a well-vegetated and structurally complex bank edge, which is favoured by many species belonging to these groups. The aquatic Coleoptera fauna of these sites on the Royal Canal is very similar to that found in large drains in the East of England (Bilton, 1987; Foster et al., 1990). Management in the form of dredging or weed cutting is essential to maintain such a species assemblage.

The one unmanaged site in the study, the Canal Supply, contained a far more diverse beetle community. In addition to the species of open water the fen-like conditions in the water's edge supported extra species such as Rhantus grapii and Chaetarthria seminulum (Herbst). Obviously dredging and extensive weed cutting would drastically reduce the faunistic interest of sites such as this, resulting in a water beetle community resembling those found in most of the Royal Canal itself.

Table 4.10 Distribution of Aquatic Coleoptera on the Royal Canal in 1986.

Species	Locality 1	2	3	4	5	6
Haliplus flavicollis		•				
H.fulvus		•			•	
H.immaculatus					•	•
H.lineatocollis	•	•	•	•		
H.lineolatus	•					•
H.obliquus			•			
H.ruficollis	•	•	•	•		•
H.wheneker		•				
Noterus crassicornis						•
Laccophilus minutus		•				
Hyphydrus ovatus	•	•	•	•	•	
Hygrotus inaequalis		•	•	•		•
H.quinquelineatus	•		•		•	•
H.versicolor		•				
Hydroporus palustris	•			•	•	•
H.planus		•			•	
H.pubescens		•		•		
H.striola				•		
Porhydrus lineatus		•	•	•		•
Graptodytes pictus	•	•			•	
Stictonectes lepidus		•	•	•		
Potamonectes assimilis	•	•	•		•	
P. depressus		•	•			
Agabus bipustulatus		•				
A. sturmi		•	•			
Ilybius ater		•				
I. fuliginosus		•	•	•	•	•
I. quadriguttatus		•	•		•	•
Rhantus exsoletus		•	•		•	
R. grapii		•				
Colymbetes fuscus		•				
Dytiscus marginalis		•	•	•		
D. semisulcatus			•			
Gyrinus aeratus		•				
G.marinus	•					
G. substriatus				•		
Helophorus brevipalpis		•	•	•	•	•
Anacaena globulus		•				
A.limbata	•					
A.lutescens		•				
Laccobius bipunctatus						•
Cercyon ustulatus		•				
Cheetarthria seminulum		•				
Hydraena riparia			•			
Limnebius truncatellus		•	•			
Stenus nitidiusculus		•				
Donacia simplex		•				
D.versicolorea	•					
Eubrychius velutus					•	
Totals: 49	**11**	**34**	**18**	**13**	**13**	**12**

CHAPTER 5 IMPACTS OF MANAGEMENT

5.1 RESTORATION

Unlike a river a canal is neither a stable nor a natural system, and if it is abandoned the processes of vegetational succession come into play. The reed fringe extends from the water's edge into the channel, and the canal silts up and gradually dries out. In time wet woodland (alder/willow carr) can become established along the old canal bed, or the reeds and reed grasses can give way to meadow or pasture grasses if grazing is a feature of the system. The towpath also changes - non-herbaceous species invade from the boundary and grassland becomes scrub, and can develop into woodland if time and space permit.

Restoration has a number of impacts on a disused canal system. It increases the area of open water at the expense of the established reed bed, grassland or carr. Reeds in the restored channel are confined to the margins, and the deeper water is open to colonisation by floating-leaved and submerged macrophytes - species which are usually the first to be lost as the system dries out. The area of scrub is reduced as Willow, Alder and Ash are removed from the banks and bed of the disused canal, and Blackthorn and Hawthorn are cut back or removed to allow access for the dredging plant and to re-open the towpath.

If these changes are to benefit the system in the long-term then the restoration programme itself must be carefully planned and monitored in order to reduce the short-term negative impacts and to ensure that the subsequent development of the canal and its habitats follows the desired course.

5.1.1 Dredging

5.1.1.1 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 (eg. *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 to the elimination of specialist plant-feeding species, while the reduction in food supply and loss of shelter can result in a decrease in the number of individuals as well as the species richness of the system (Lewis 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.

5.1.1.2 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, restoring a wildlife value that was lost in the overgrown system (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 aggressive competitors. The unexpected discovery of Groenlandia densa, a submerged water plant protected by the 1976 Wildlife Act, in the Royal Canal where it has never previously been recorded may have been as a result of one or other of these factors. However, in this case it is also possible that a piece or pieces of the plant were carried on the dredger from the Grand Canal, where it is known to occur, to the Royal when both were dredged in 1988. Whatever the reason,

a healthy population of Groenlandia is now to be found in the Royal Canal as a result of dredging (Dromey, in press).

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.

Immediately west of Blackshade Bridge (km 45), where the spoil was pulled in to the bank but not dragged up through the existing vegetation, recovery has been rapid and species diversity is high. In contrast, re-establishment of the reed fringe is proceeding slowly in Clonsilla (km 1) where the bank is both high and steep and was scraped clean during the dredging operations. Glyceria maxima is the dominant species here, in spite of the presence of a more diverse reed fringe on the offside. It is clear from this that leaving one bank intact cannot benefit the system if the other bank is made so inhospitable that few if any species can establish themselves along it.

5.1.1.3 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 vegetation 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 infertile, limestone soils that predominate along the Royal 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.

5.1.1.4 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 succession will restore a more balanced vegetation cover but it is a slow process. Cutting this vegetation before it sets seed reduces the dominance of these species, and so encourages the growth of less vigorous grasses and herbs.

The 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 small area recovery can be relatively quick, as can be seen at the site between the canal and the railway immediately west of Footy's Bridge (km 59). The spoil was deposited at the top of a slope, and flowed down to the base, leaving most of the area unaffected. The thin layer of spoil on the slope recovered more rapidly than the thicker patch at the toe.

In contrast, revegetation of the Clonsilla stretches of the canal bank (km 1) is slow and unsatisfactory. Here there was nearly 100% removal of the vegetation cover during dredging (1989) and a thick layer of spoil was deposited on the towpath. By the end of the 1990 growing season the site was still only sparsely vegetated.

The plant cover on the land outside the canal boundary will also affect the revegetation of the disturbed canal, as it provides a source of seed. Its significance will vary, depending on the amount of vegetation left on the towpath and the seed mixture itself. It was noticed during the 1989 Royal Canal survey that a number of fields adjacent to the canal between Pike Bridge and Maynooth (km 12) were poorly maintained and dominated by Cirsium spp. resurveying

this stretch in 1990, it was found that the towpath east of Pike bridge (km 11) had developed a grass cover dominated by Holcus lanatus with a variety of non-grass species. However, west of the bridge (km 12) relatively large areas of the towpath were covered with nearly impenetrable stands of Cirsium vulgare.

The management and maintenance regime in use on the towpath and banks will also affect the rate of recovery and the composition of the vegetation cover (see 5.2).

Invertebrates.

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

5.1.2 Removal of trees and scrub

Restoring a canal involves re-opening the towpath as well as the channel. This involves clearing scrub from the path, as well as the removal of bank-side trees to facilitate dredging. During the period of neglect of the waterway these features may have become valuable wildlife habitats.

The hedgegrow is not usually removed, but if treated insensitively as part of a programme of scrub clearance it can be severely damaged. Inefficient trimming with unsuitable tools leaves the hedge ragged, and susceptible to fungal attack and die-back (BWB, 1981).

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.

Removal of scrub from the banks and towpath can have a severe impact on the system, as it forms a valuable wildlife habitat and adds greatly to the diversity of the system (Moles, 1982), providing food and shelter for a wide variety of birds and animals.

5.1.3 Restoration of 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 Asplenium 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.

In contrast to the over-grown bridges, disused locks tend to support a wide variety of plants. The only patches of open water to be found along long stretches of the Royal Canal in Unit III are in the old lock chambers. Submerged, floating-leaved and emergent plants can all be found, together with plants typical of drier habitats. Restoration will drastically reduce this diversity, although it will increase the area of open water in the system as a whole.

Grey Wagtails often nest in cracks and crevices in the walls of lock chambers, or on tree roots which have become established in the masonry (for example, lock 41 at Coolnahinch - km 121). Restoration will probably lead to a reduction in the number of Grey Wagtails nesting along the canal, but it is unlikely to eliminate them altogether.

5.1.4 Reconstruction of the channel.

Channel design.

For most of Unit III dredging will not be enough to re-open the canal, and the channel will need to be reconstructed. This will be a major engineering task, and one that will result in widespread habitat destruction not just along the channel but also on both banks. Conservation of the existing wildlife will be difficult, and maybe impossible in some circumstances, but it will be possible to incorporate into the new canal system features that will increase its wildlife value and nature conservation potential for the future. In the long-term the major impact of reconstruction will be a change form a primarily terrestrial series of habitats to a mixture of aquatic and terrestrial habitats.

The design of the channel itself will have an impact on the aquatic communities that it can support (Hanbury, 1986). A channel with straight, steep sides (Fig 5.1, a) has very little potential as a wildlife habitat as it is unable to support a diverse reed fringe, due to the fact that most emergent plants require relatively shallow water. A channel that is shallow, with a gentle underwater slope (Fig 5.1, b), rapidly becomes overgrown as the reeds encroach from the margins, eliminating the open-water communities and blocking the navigational channel. A canal combining shallow margins with a deep central channel (Fig 5.1, c) supports both emergent and submerged aquatic vegetation and their associated invertebrates, and requires less maintenance as the marginal reeds are slow to colonise the navigational channel due to

a:

b:

c:

FIGURE 5.1 Channel Design

its depth.

Water supply.

Extension of the waterway into the currently dry western section may also affect the water chemistry of the canal as it is likely that alternative sources of water will be needed to supplement the Lough Owel supply. Migration of plant and animal species new to the canal via the new feeders may also have an effect on the ecology of the full length of the canal. It is impossible to quantify the changes at this stage, without detailed information about the possible sources of supply.

5.2 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 as a national resource. In order to maximise its potential for nature conservation it is important that the management practices used are sympathetic. Inappropriate management leading to a uniform, over-maintained and sterile system would be even less desirable in wildlife terms than a policy of abandonment.

5.2.1 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 5.1). 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 5.1

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.

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.

5.2.2. Grassland

The soils along the Royal Canal are for the most part limestone-based (Conry et al., 1970 ; Finch and Gardner, 1977 ; Finch et al., 1983) which, 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).

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).

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 balance 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.

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 are 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.

Laid up for hay, and therefore ungrazed between March and July/August, these grasslands can support not just the usual plants of unimproved pasture but also many other species that rely on flowering and setting seed during the early summer. 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 dependant 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).

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.

5.2.3 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).

Management of aquatic vegetation is essential if the habitat and species diversity of the canal habitat are to be maintained - an abandoned canal becomes overgrown and gradually loses its biological interest (Briggs, 1989).

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.

5.2.3.1 Environmental control

Deepening the central channel of the canal (5.1.4) 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 5.2). 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 5.3).

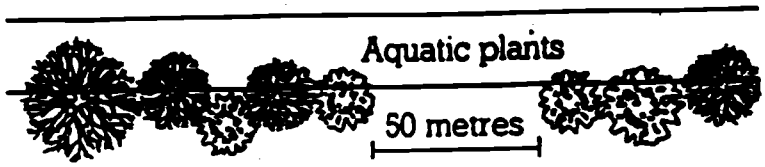
The input of extra organic matter and nutrients to the system in the form of leaf litter could lead to an increase in the Biological Oxygen Demand (BOD) and a lowering of the dissolved oxygen concentration of the water. This would affect aquatic plant and animal communities, putting them under stress, and if very severe could lead to algal blooms.

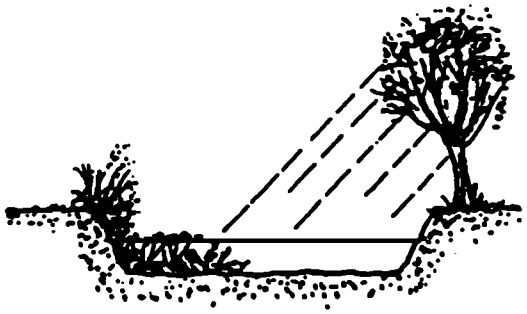
FIGURE 5.2 Channel Orientation and Planting for Shade

Orientation of Channel	Bank for Shade Belt	Effictiveness 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

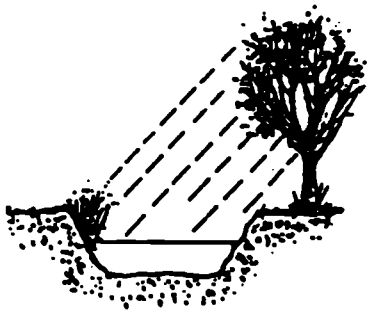
(after : Lewis and Williams, 1984)

Shade in major drainage channels.





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



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

FIGURE 5.3 Manipulation of shading

(Newbold et al, 1989)

Increased boat traffic along the canal would also help to control the growth of aquatic plants (Murphy and Eaton, 1983 ; 5.3.1).

5.2.3.2 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 5.2). Some species are more susceptible to herbicides than others (Table 5.3) and are therefore the first to be lost.

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

TABLE 5.2 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 5.3 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.)

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 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).

5.2.3.3 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 B.O.D. 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).

5.2.3.4 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.

5.2.4 Maintenance Dredging

Dredging will have to form part of the on-going management programme in order to maintain the deep-water habitat and keep the channel navigable. The impacts will be similar to those described in 5.1.1 but the time-scale will be longer and the dredging programme less intensive than that required to re-open the canal.

5.3 RECREATIONAL USE

5.3.1 Fisheries management

The limited amount of fisheries management which has taken place so far on the Royal Canal falls into the following categories: fish stocking, fish relocation and aquatic plant control. The ecological impacts of angling and anglers are also considered here.

Existing fish stocks

Fish stocks in the Royal Canal have been assessed during the period 1987-1990 by means of electrofishing (Central Fisheries Board, 1990). The most abundant species found were Pike, Perch, Roach and Eel while Tench were significant in terms of biomass. Other species present in small quantities included Rudd and Bream with three hybrid varieties - Rudd/Roach, Roach/Bream and Rudd/Bream.

Fish stocking

This practice of introducing fish into the canal from external waters is designed to elevate as many canal sections as possible to the status of fisheries of national or international importance. The species introduced in 1990 were Tench and Carp. The only known location for the latter species on the canal prior to 1990 was near Maynooth. A total of 50 Tench and 40 Carp were released in July 1990 at four locations between Leixlip and Coolnahay.

The ecological impact of introducing an additional species of fish to the canal has not been studied. However, unless the prey spectrum of Carp is radically different from that of the other fish species already present it is unlikely to be significant. However, increased numbers of predatory fish may change the balance of invertebrate populations in the canal. The increase in fish stocks as a whole is likely to benefit predatory birds and mammals such as herons, otters and mink as well as anglers.

Fish relocation

Due to a breach in the canal east of Quinn's Bridge at Abbeyshrule approximately 700 fish (80% Perch and 20% Pike) were removed alive in early May 1990 and transferred alive to a dammed section of the canal closer to Abbeyshrule. A small number of Tench and a large number of Eels were also found but the latter were not relocated (Caffrey et al, 1990). The ecological impact of such a relocation of stocks is unknown but it is expected that the main effect would be to provide a more concentrated food source for predators such as Herons and Otters.

Aquatic plant control for fisheries management

The present practice and impacts of aquatic plant control which is principally for the purpose of fisheries management are described in Section 5.2 above. It is worth restating the findings of Murphy and Eaton (1990) that much of the current herbicide treatment is a waste of money and that environmental conditions in much of the canal system are unfavourable for the use of certain herbicides.

Angling

Present levels of angling activity on the Royal Canal are very low despite the presence of significant stocks of course angling fish. During bird surveys in April-August 1990 small numbers of individual anglers were encountered mainly around the towns such as Leixlip, Maynooth, Mullingar and at several isolated stretches such as that between Ballinea and Belmont bridges. The only coarse angling competition monitored on the canal in 1990 was held 1.5km east of Enfield on 20 May. A total of 34 pegs (or angling points) were fished and 310 fish (mostly Roach and Rudd) were caught on the day (Central Fisheries Board, 1990). It is likely that the level of angling activity (both individual and competition) will increase in future as restoration and restocking of the canal proceed. Environmental impacts of such activity would include increased disturbance and possible contamination with discarded lead weights.

Disturbance

Disturbance of overwintering wildfowl by game-fishing anglers at two reservoir sites in South Wales was reported by Cryer et al (1987). However, this occurred at average levels of 27-31 anglers per day in October and the only species involved which occurs on the Royal Canal was mallard which is, in any case, strongly habituated to human disturbance in urban locations. Tuite, Hanson and Owen (1984) concluded that course-fishing had the highest impact of various recreational activities on overwintering wildfowl although the species most affected were teal, wigeon and shoveler which do not occur regularly on the Royal Canal due to lack of suitable feeding areas.

Disturbance of nesting birds by course anglers is not considered to be a problem on the canal at present. However if certain stretches are subject to intensive use (especially in the period March to July) there is the possibility of breeding failure due to increased nest predation when parent birds are kept away from the nest for long periods of time. This is especially likely for water birds such as mute swan, mallard and moorhen which have a limited amount of cover for nesting.

Disturbance of otters by anglers may be significant especially in areas which lack mature bankside trees 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). Observations made in the urban areas of Dublin, Cork, Limerick and Galway indicate that otters will tolerate high levels of disturbance. A statistical analysis of survey data in Ireland found no significant correlation between disturbance and the distribution of otters (Chapman and Chapman, 1982). However, there was some evidence that otters changed their sprainting (territory marking) habits while disturbance levels were high.

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, Myers and Duggan, 1988). Lost or discarded anglers' weights were identified as the source of lead contamination at two sites. Up to 50% of live birds at one famous course-fishing site showed elevated lead levels. This has recently been shown to have sub-lethal effects on co-ordination in the birds causing them to collide with overhead cables (O'Halloran, Myers and Duggan, 1989). The problem began with the change from cotton to nylon fishing line in the 1960s so that lead weights and hooks are frequently stripped off after a days fishing (O'Halloran, Myers and Duggan, 1987). Up to 125 lead shot per m2 of surface area have been found at one coarse fishery in South Wales (Bell et al, 1985) and, while the density of course fishing in Ireland is considerably lower, some areas of intensively used water could become badly contaminated over a number of years.

5.3.2 Increased boat traffic

Restoration of navigation on the canal is designed to encourage greater use of the waterway by boats and this could be expected to have some ecological effects. However, the degree of impact will be related to the level of traffic.

Levels of traffic : Past, present and future

In the early years of the nineteenth century the Royal Canal carried between six and eight passenger boats plying regularly between Dublin and Mullingar. By 1923 the number of trading boats on the canal had reduced to thirteen and by 1946 there were only two horse-drawn boats at work on the waterway. The last trader ceased to operate his boats in 1951 and the last complete journey from Dublin to the Shannon was made by a 30-foot pleasure boat in 1955. The canal was officially closed to navigation in 1961 (Delaney, 1966).

Since then the level of boat traffic even on the navigable sections has been virtually nil although there has been an increased level of activity in 1989 and 1990. In May-June 1990 a boat rally was held to mark the bicentenary of the construction of the canal and a total of six boats of various sizes made the return journey from the 12th lock at Blanchardstown to Mullingar. The only regular boat traffic on this section of canal in the period 1986-1990 has been those used by the Office of Public Works in annual herbicide applications.

It is difficult to predict the future level of boat traffic as this will depend on how soon the canal is opened at both ends. However, if the Grand Canal is used as a predictive model then it might be estimated that ultimately about 300-400 boats would use the Royal Canal throughout the year (Brady, Shipman, Martin, 1987). The main activity could be expected around Mullingar (the main population centre) and at Richmond Harbour where the canal connects into the Shannon navigation. If the circular route involving the Shannon, the Grand and Royal Canals ultimately becomes available to boat traffic it could be speculated that all of the privately owned boats

including barges (estimated at 1200) and the 400 hire cruisers on the Shannon would be potential users of the canal in the summer months (information from Emerald Star Line).

Impacts on aquatic plants

Boat traffic can have a significant negative impact on freshwater plant communities through physical forces such as wash, turbulence, propellor action (cutting effects) and direct contact. Chemical impacts generated by increased boat traffic may include pollution, either from fuel or sewage (Liddle and Scorgie, 1980).

A significant reduction in abundance of submerged aquatic vegetation in British canals has been demonstrated through increased levels of water turbidity caused by boat traffic during the summer months (Murphy and Eaton, 1983). However, this only became significant when a 'critical' level of 2000-4000 craft movements per hectare per metre depth per year (my) was reached. Direct physical damage by boats is also a factor in limiting the abundance of submerged plant cover and is the main factor in the control of floating and emergent plants however, in the case of emergents, the relationship with boat traffic is weaker (Murphy and Eaton, 1983).

Certain species of submerged plants such as Elodea canadensis are more tolerant of heavy boat traffic because they have numerous growing points and little or no dependance on roots. With low densities of boat traffic other more sensitive submerged species are favoured especially in the deeper water of the centre of the canal in which floating-leaved plants are at a competitive disadvantage due to their vulnerability to propellor damage. These include Myriophyllum spp., which is abundant in the Royal Canal, Potamogeton crispus and Fontinalis antipyretica (Murphy and Eaton, 1983). Of special interest here is the occurrence of the rare pondweed Groenlandia densa at a clean, deep-water site on a disused stretch of the Royal Canal (Dromey, in press and see Section 3.2). It can be expected that an increase in boat traffic would limit the distribution of the more sensitive species but is unlikely that boat traffic would reach the high densities required to seriously limit the abundance of all submerged species.

Of the emergent plants Glyceria maxima, which is abundant on the Royal Canal, is well-adapted to survive disturbance by boats and is quick to re-establish after physical damage (Murphy and Eaton 1983). Phalaris arundinacea is also relatively difficult to erode. Some emergent species such as Sparganium erectum are more easily eroded by the wash from high-powered motor boats (Liddle and Scorgie, 1980). Competition from vigorous growth of Glyceria maxima on the canal margins may also cause more sensitive species to decline.

Impacts on aquatic animals

Little is known of the effects of boating activities on freshwater animals other than birds and fish. However, it could be assumed that a reduction in diversity and abundance of aquatic plants would have indirect effects on the invertebrate life in the canal.

Of particular importance would be the loss of cover for the larval stages of some insects, such as water beetles, and the absence of emergent plants on which the nymphs of dragonflies and damselflies emerge from the water. Similarly an increase in turbidity could have detrimental effects by reducing the feeding opportunities for some aquatic invertebrates and fish.

Direct disturbance to water birds from boat-based recreation has been well studied but mostly in the context of wintering wildfowl on open waters such as reservoirs and lakes (Batten, 1977; Tuite et al, 1984). The only waterfowl species occurring in significant numbers on the Royal Canal are mute swan, mallard and moorhen. These species are relatively tolerant of disturbance from boats compared with the more sensitive grebes and diving duck such as goldeneye and tufted duck do not occur on the canal. However, the limited area of surface water available to provide refuges in the canal would make even these three species intolerant of high levels of boat-based recreation.

Disturbance of nests during the breeding season may be a problem, especially for mute swan, but this is not considered to bear any relationship at present to boat-based activities. However, the wash created by fast-moving boats could pose a problem for breeding moorhens which tend to build their nests at or near water level. The low incidence of breeding moorhen at present on the navigable sections of the Royal Canal is related to dredging activities (see Section 4.2).

5.3.3 Trampling on towpaths

The restoration of the canal also involves the re-opening to public access of many sections of the towpath which had become overgrown during the past 30 to 40 years. This will be mostly restricted to pedestrians, anglers or cyclists but it may involve vehicular access at certain points for maintenance of the canal and to facilitate farmers. All of these uses have ecological impacts.

Impacts on vegetation

Because of the steep banks associated with the canal it is unlikely that increased public access will involve damage to the plants growing on the water's edge or immediately above it. The exception to this would be anglers who would normally cut bank and marginal vegetation at their regular 'pegs'. They may also dig out sloping banks to make space near the water's edge for keep nets and other equipment. The effect of this may be to change the tall bank vegetation to a short sward containing such tolerant species as Lolium perenne, Poa pratensis, Plantago major and Polygonum aviculare (Liddle and Scorgie, 1980).

The level of damage caused by trampling on the level path will depend partially on the substrate and the wetness of the soil. A experimental trampling on Scottish loch shores found that the taller reed grasses such as Phragmites or Glyceria were more susceptible to damage than the shorter sedges on drier, firmer substrate (Rees and

Tivy, 1977). On well worn paths Rees (1978) found that the softer plants were replaced by harder-wearing species including Agrostis spp. and Poa spp. with Polygonum amphibium, P.aviculare or Myosotis spp. in the margins.

Impact 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 natural vegetation. However if the trampling is limited to only 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.

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APPENDICES 1-10

APPENDIX 1
PLANTS OF THE ROYAL CANAL ACCORDING TO HABITAT

PLANTS OF THE WOODLAND UNDERSTOREY

Aegopodium podagraria	Hedera helix
Ajuga reptans	Hyacinthoices non-scriptus
Arum maculatum	Listera ovata
Brachypodium sylvaticum	Lysimachia nemorum
Bromus ramosus	Oxalis acetosella
Carex remota	Phyllitis scolopendrium
C. sylvatica	Potentilla sterilis
Dryopteris dilatata	Primula vulgaris
D. felix-mas	Ranunculus auricomus
Equisetum telmateia	R. ficaria
Fragraria vesca	Sanicula europaea
Geranium robertianum	Veronica montana
Geum urbanum	Viola riviniana
Glechoma hederacea	

PLANTS ASSOCIATED WITH THE WOODLAND/HEDGEROW EDGE

Aegopodium podagraria	Hypericum androsaemum
Alliara petiolata	H. perforatum
Anthriscus sylvestris	Lathyrus pratensis
Arrhenatherum elatius	Leucanthemum vulgare
Avenula pubescens	Phleum pratense
Brachypodium sylvaticum	Ranunculus repens
Brassica rapa	Rumex sanguineus
Centaurea nigra	Silene alba
Chenopodium album	Sinapsis arvensis
Cirsium arvense	Sisymbrium officinale
Dactylis glomerata	Sonchus arvensis
Daucus carota	S. asper
Deschampsia caespitosus	S. oleraceus
Elymus repens	Stachys silvatica
Epilobium angustifolium	Stellaria graminea
E. parviflorum	Torilis japonica
Equisetum arvense	Tragopogon pratensis
Festuca arundinacea	Ulex europaeus
F. rubra	Urtica dioica
Heracleum sphondylium	Veronica chamaedrys
Holcus lanatus	Viccia cracca

APPENDIX 1 cont.

PLANTS FOUND ON A MARSH

Agrostis stolonifera	Lycopus europaeus
Alisma plantago-aquatica	Mentha aquatica
Alnus glutinosa	Myosotis scorpioides
Baldellia ranunculoides	Oenanthe aquatica
Caltha palustris	O. crocata
Cardamine pratensis	Pedicularis palustris
Carex appropinquata	Polygonum amphibium
C. elata	Potentilla palustrtis
C. nigra	Ranunculus sceleratus
C. panicea	Rumex hydrolapathum
Dactylorhiza fuchsii	Salix spp.
D. incarnata	Scutellaria galericulata
Eleocharis palustris	Triglochin palustris
Equisetum palustris	Veronica anagallis-aquatica
E. variegatum	V. beccabunga
Galium palustre	V. catenata
Hydrocotyle vulgaris	V. scutellata
Juncus articulatus	
J. inflexus	

EMERGENT SPECIES

Alisma plantago-aquatica	Hippuris vulgaris
Apium nodiflorum	Iris pseudacorus
Berula erecta	Mentha aquatica
Carex acuta	Menyanthes trifoliata
C. acutiformis	Phalaris arundinacea
C. aquatilis	Phragmites australis
C. rostrata	Ranunculus flammula
Cladium mariscus	R. lingua
Equisetum fluviatile	Scirpus lacustris
E. palustre	Sparganium erectum
E. variegatum	Typha latifolia
Glyceria maxima	

SUBMERGED PLANTS AND PLANTS OF SURFACE WATERS

Callitriche spp.	Nuphar lutea
Ceratophyllum demersum	Nymphaea alba
Elodea canadensis	Polygonum amphibium
Glyceria fluitans	Potamogeton crispus
G. plicata	P. lucens
Groenlandia densa	P. natans
Hydrocharis morsus-ranae	P. perfoliatus
Lemna minor	P. polygonifolius
L. trisulca	Ranunculus trichophyllus
Myriophyllum spp.	Sparganium emersum
Nasturtium officinale	Zanichellia palustris
Algae	Fontinalis antipyretica
Chara spp.	

APPENDIX 1 cont.

PLANTS OF THE FENS

Agrostis stolonifera	Holcus lanatus
Alnus glutinosa	Hydrocotyle vulgare
Anthoxanthum odoratum	Hypericum pulchrum
Brizia media	Juncus acutiflorus
Cardamine pratensis	J. articulatus
Carex demissa	J. subnodulosus
C. diandra	Lychnis flos-cuculi
C. disticha	Mentha aquatica
C. echinata	Menyanthes trifoliata
C. flacca	Molinea caerulea
C. lepidocarpa	Parnassia palustris
C. nigra	Pedicularis palustris
C. panicea	Phragmites australis
C. pulicaris	Pinguicula vulgaris
Centaurea nigra	Potamogeton colortatus
Dactylorhiza incarnata	Potentilla erecta
Equisetum fluviatile	P. palustris
Eriophorum latifolium	Salix spp.
Festuca rubra	Succisa pratensis
Filipendula ulmaria	Triglochin palustris
Galium uliginosum	Valeriana officinalis
Gymnadenia conopsea	Veronica beccabunga

PLANTS OF BOGS

*Andromeda polifolia	Juncus bulbosus
Calluna vulgaris	Melampyrum pratense
Carex diandra	Menyanthes trifoliata
C. echinata	Molinea caerulea
C. panicea	Myrica gale
C. pulicaris	Narthecium ossifragum
Danthonia decumbens	Pedicularis sylvatica
Dactylorhiza maculata	Pinguicula lusitanica
Drosera rotundifolia	P. vulgaris
Empetrum nigrum	Potentilla erecta
Ericea cinerea	Rhynchospora alba
Erica tetralix	Schoenus nigricans
Eriophorum angustifolium	Scirpus caespitosus
E. vaginatum	

* protected in Northern Ireland under the Wildlife (NI) Order 1985 (Curtis and McGough, 1988).

WALL PLANTS

Asplenium ruta-muraria	Geranium lucidum
A. trichomanes	hedera helix
Centranthus ruber	Hypericum hircinum
Ceterach officinarum	Linaria purpurea
Crepis capillaris	Poa pratensis
Cymbalaria muralis	Phyllitis scolopendrium
Festuca rubra	Sedum album

PLANTS OF NUTRIENT-POOR LIMESTONE GRASSLAND

Agrimonia eupatoria	Knautia arvensis
Anacamptis pyramidalis	Leontodon autumnalis
Anthyllis vulneraria	L. hispidus
Avenula pubescens	L. taraxacoides
Brizia media	Leucanthemum vulgare
Bromus erectus	Linum bienne
Carex caryophyllea	Linum catharticum
C. flacca	Listera ovata
Carlina vulgaris	Lotus corniculatus
Centaurium erythraea	Ononis repens
Ceterach officinarum	Orchis mascula
Cynosurus cristatus	Origanum vulgare
Dactylorhiza fuchsii	Plantago lanceolata
Daucus carota	Primula veris
Euphrasia spp.	Prunella vulgaris
festuca rubra	Rhinanthus minor
galium verum	Sanguisorba minor
Geranium lucidum	Trifolium dubium
Gymnadenia conopsea	Trisetum flavescens
Hieracium pilosella	

TRAMPLE RESISTANT SPECIES

Achillea millefolium	Plantago lanceolata
Agrostis stolonifera	P. major
Bellis perennis	Poa annua
Bromus erectus	P. pratensis
Carex flacca	P. trivialis
Convolvulus arvensis	Polygonum aviculare
Cynosurus cristatus	Potentilla anserina
Dactylis glomerata	P. reptans
Festuca rubra	Taraxacum officinale
Hieracium pilosella	Prunella vulgaris
Holcus lanatus	Rumex acetosella
Hypocharis radicata	Sagina procumbens
Leontodon hispidus	Sanguisorba minor
L. taraxacoides	Trifolium pratense
Lolium perenne	T. repens
Lotus corniculatus	Trisetum flavescens
Luzula campestris	Veronica chamaedrys
Medicago lupulina	

APPENDIX 2

The (a) Occurrence (%) of species found in all zones and stonemark along the three Units of the Royal Canal: (b) the Zonal Preference (%) of each of the species found on the Boundary, Towpath and Bank zones as a proportion of the total population of each species of the three zones within a km section.

UNIT	I						II						III						I	II	III	I	II	III
	Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Ch.	Ch.	Ch.	St.	St.	St.
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	a	a	a	a	a
SPECIES																								
Acer pseudoplatanus	61	80	3	4	12	16	46	66	*	*	23	33	46	53	*	*	41	47	*	2	3	17	39	18
Achillea millefolium	21	16	62	48	47	36	72	32	91	40	63	28	41	26	71	44	49	30	*	*	3	14	45	41
Aegopodium podagraria	14	62	6	25	3	13	14	100	*	*	*	*	8	100	*	*	*	*	*	*	*	*	*	*
Aesculus hippocastanum	10	87	*	*	1	13	*	*	*	*	*	*	3	100	*	*	*	*	*	*	*	*	*	*
Agrimonia eupatoria	*	*	1	13	10	87	14	28	18	35	19	37	20	19	35	32	54	49	*	*	5	*	3	*
Agrostis capillaris	*	*	*	*	*	*	35	42	18	22	30	36	41	32	38	30	49	38	*	*	5	*	*	*
A. stolonifera	43	30	89	41	86	39	42	26	41	24	84	50	20	16	18	14	90	70	*	42	62	5	10	*
Ajuga reptans	*	*	*	*	*	*	*	*	*	*	*	*	5	88	*	*	3	12	*	*	*	*	*	*
Alisma plantago-aquatica	6	66	*	*	3	33	12	86	*	*	2	14	*	*	*	*	*	*	22	7	18	2	*	*
Alliaria petiolata	*	*	*	*	*	*	16	76	*	*	5	24	3	33	3	33	3	33	*	*	*	*	*	*
Allium vineale	*	*	*	*	*	*	7	100	*	*	*	*	3	50	3	50	*	*	*	*	*	*	*	*
Alnus glutinosa	12	33	7	18	18	48	5	21	*	*	19	79	20	25	6	7	56	68	*	2	20	*	6	4
Anacamptis pyramidalis	*	*	*	*	*	*	12	57	*	*	9	43	15	41	12	32	10	27	*	*	*	*	*	*
Anagallis arvensis	*	*	4	75	1	25	*	*	*	*	*	*	*	*	3	100	*	*	*	*	*	*	*	*
Anagallis tenella	*	*	*	*	*	*	*	*	*	*	*	*	3	100	*	*	*	*	*	2	*	*	*	*
Andromeda polifolia	*	*	*	*	*	*	5	100	*	*	*	*	3	100	*	*	*	*	*	*	*	*	*	*
Angelica sylvestris	15	16	18	19	62	65	37	28	*	*	95	72	33	24	15	10	95	66	*	33	46	*	45	4
Antennaria dioica	1	100	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Anthoxanthum odoratum	4	9	31	63	14	28	77	32	100	40	70	28	46	24	73	37	77	39	*	5	5	*	3	4
Anthriscus sylvestris	15	46	12	37	6	17	44	46	14	15	37	39	33	46	9	12	30	42	*	*	3	*	6	*
Anthyllis vulneraria	*	*	*	*	*	*	2	50	*	*	2	50	*	*	*	*	*	*	*	*	*	*	*	*
Aphanes arvensis	*	*	*	*	1	100	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Apium nodiflorum	4	75	1	25	*	*	16	89	*	*	2	11	3	37	*	*	5	63	3	5	18	*	*	*
Arctium minus	3	8	25	72	7	20	14	56	4	16	7	28	8	21	21	57	8	22	*	*	*	*	*	*
Armoracia rusticana	*	*	*	*	*	*	2	100	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Arrhenatherum elatius	24	17	54	39	62	44	84	39	41	19	91	42	51	32	41	26	67	42	*	5	10	3	10	*
Artemisia vulgaris	*	*	*	*	*	*	7	50	*	*	7	50	*	*	*	*	*	*	*	*	*	*	3	*
Arum maculatum	4	100	*	*	*	*	14	88	*	*	2	12	49	60	12	15	20	25	*	*	*	*	*	*

APPENDIX 2 cont.

UNIT	I						II						III						I Ch.	II Ch.	III Ch.	I St.	II St.	III St.
	Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Bd.		Tp.		Bk.							
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	a	a	a	a	a
SPECIES																								
Asplenium ruta-muraria	‡	‡	‡	‡	‡	‡	5	100	‡	‡	‡	‡	3	100	‡	‡	‡	‡	‡	‡	‡	25	71	67
A. trichomanes	‡	‡	‡	‡	‡	‡	7	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	5	45	52
Atriplex spp.	‡	‡	8	75	3	25	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Avenula pubescens	‡	‡	‡	‡	‡	‡	67	35	45	24	77	41	30	22	53	37	59	41	‡	2	‡	‡	‡	‡
Baldellia ranunculoides	‡	‡	‡	‡	‡	‡	5	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	2	8	‡	‡	‡
Bellis perennis	‡	‡	53	97	1	3	51	27	91	47	51	26	18	15	65	55	35	30	‡	‡	‡	‡	3	4
Berula erecta	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	3	100	‡	‡	56	‡	‡	‡
Betula spp.	12	69	3	15	3	15	7	78	‡	‡	2	22	10	39	3	11	13	50	‡	‡	3	‡	‡	4
Blackstonia perfoliata	‡	‡	‡	‡	1	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Brachypodium pinnatum	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	3	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
B. sylvaticum	35	89	4	11	‡	‡	23	66	‡	‡	12	34	64	46	26	19	49	35	‡	‡	‡	‡	‡	‡
Brassica rapa	‡	‡	‡	‡	‡	‡	7	78	‡	‡	2	22	3	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Brizia media	10	31	35	55	18	14	53	29	77	41	56	30	20	17	68	55	35	28	‡	2	3	5	13	11
Bromus erectus	19	48	15	38	6	14	14	54	‡	‡	12	46	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
B. hordeaceus	‡	‡	‡	‡	‡	‡	2	18	9	82	‡	‡	3	25	6	50	3	25	‡	‡	‡	‡	‡	‡
B. ramosus	11	72	4	28	‡	‡	2	29	‡	‡	5	71	3	100	‡	‡	‡	‡	‡	‡	‡	2	‡	‡
Buddleja davidii	‡	‡	‡	‡	‡	‡	2	50	‡	‡	2	50	3	100	‡	‡	‡	‡	‡	‡	‡	‡	6	‡
Callitriche spp.	‡	‡	‡	‡	‡	‡	5	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	1	2	8	‡	‡	‡
Calluna vulgaris	‡	‡	1	100	‡	‡	5	100	‡	‡	‡	‡	5	63	‡	‡	3	37	‡	‡	‡	‡	‡	‡
Caltha palustris	‡	‡	‡	‡	‡	‡	19	46	4	9	19	45	3	22	‡	‡	10	77	‡	21	46	‡	‡	‡
Calystegia sepium	12	29	10	23	21	48	39	43	9	10	42	47	54	45	26	21	41	34	‡	‡	18	3	6	‡
Calystegia silvatica	‡	‡	‡	‡	‡	‡	9	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Capsella bursa-pastoris	6	15	26	73	4	12	2	17	18	66	7	16	8	35	15	65	‡	‡	‡	‡	‡	‡	‡	‡
Cardamine flexuosa	1	50	1	50	‡	‡	2	100	‡	‡	‡	‡	‡	‡	3	50	3	50	‡	‡	‡	‡	‡	‡
C. hirsuta	‡	‡	‡	‡	‡	‡	2	33	4	66	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
C. pratensis	1	33	1	33	1	33	19	24	18	23	42	53	3	18	12	30	25	62	‡	23	41	‡	3	7
Carduus acanthoides	1	20	1	20	4	60	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Carex acuta	‡	‡	‡	‡	‡	‡	2	19	4	36	5	45	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
C. acutiformis	46	10	4	8	44	82	7	23	‡	‡	23	77	‡	‡	‡	‡	15	100	43	16	28	‡	‡	‡
C. appropinquata	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	3	‡	‡	‡
C. caryophyllea	‡	‡	‡	‡	‡	‡	2	33	4	66	‡	‡	3	21	6	43	5	36	‡	‡	‡	‡	‡	‡
C. demissa	‡	‡	1	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	3	100	‡	‡	8	‡	‡	‡

APPENDIX 2 cont.

UNIT	I						II						III						I	II	III	I	II	III
	Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Ch.	Ch.	Ch.	St.	St.	St.
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	a	a	a	a	a
SPECIES																								
C. diandra	0	0	0	0	0	0	2	100	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
C. disticha	0	0	1	4	32	96	21	27	0	0	58	73	3	7	3	8	33	85	0	16	23	0	0	0
C. echinata	0	0	0	0	0	0	5	100	0	0	0	0	3	100	0	0	0	0	0	0	0	0	0	0
C. elata	0	0	0	0	1	100	2	13	0	0	14	87	0	0	0	0	0	0	0	5	5	0	0	0
C. flacca	8	11	42	56	25	33	28	24	36	29	58	47	30	25	50	41	41	34	0	0	0	3	3	7
C. hirta	3	7	14	36	22	57	39	28	59	44	39	28	25	22	50	43	41	35	0	0	0	0	0	0
C. lepidocarpa	0	0	4	43	6	57	2	50	0	0	2	50	3	50	0	0	3	50	0	0	5	0	0	0
C. nigra	0	0	4	11	35	89	5	35	9	17	26	48	5	19	6	23	15	58	12	14	3	0	0	0
C. otrubae	0	0	4	34	8	66	0	0	0	0	0	0	0	0	0	0	3	100	0	0	8	0	0	0
C. paniced	1	4	3	8	31	88	19	23	23	27	42	50	13	30	12	28	18	42	0	2	3	0	0	0
C. paniculata	1	100	0	0	0	0	0	0	0	0	7	100	0	0	0	0	15	100	0	2	5	0	0	0
C. pulicaris	0	0	4	100	0	0	2	100	0	0	0	0	3	100	0	0	0	0	0	0	0	0	0	0
C. remota	7	45	8	55	0	0	12	71	0	0	5	29	46	49	15	16	33	35	0	0	0	0	0	0
C. rostrata	0	0	4	6	72	94	7	11	0	0	58	89	10	32	3	10	18	58	71	77	49	0	0	0
C. sylvatica	10	100	0	0	0	0	5	42	0	0	7	58	59	48	26	21	38	31	0	0	0	0	0	0
C. spp.	0	0	0	0	17	100	0	0	0	0	0	0	0	0	0	0	0	0	17	0	0	0	0	0
Carlina vulgaris	0	0	0	0	0	0	0	0	0	0	2	100	0	0	0	0	0	0	0	0	0	0	0	0
Centaurea nigra	28	18	61	38	71	48	91	34	91	34	86	32	72	31	76	32	87	37	0	2	5	14	45	37
Centaurium erythraea	0	0	0	0	0	0	0	0	0	0	0	0	3	100	0	0	0	0	0	0	0	0	0	0
Centranthus ruber	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cirsium fontanum	6	13	25	60	11	27	12	12	77	79	9	9	18	19	56	56	25	25	0	0	0	5	13	0
C. glomeratum	1	50	1	50	0	0	2	25	4	50	2	25	2	20	9	60	3	20	0	0	0	0	3	4
Ceratophyllum demersum	0	0	0	0	0	0	2	100	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0
Ceterach officinarum	1	100	0	0	0	0	0	0	0	0	0	0	3	100	0	0	0	0	0	0	0	0	0	11
Chamaecyparis lawsoniana	10	100	0	0	0	0	12	100	0	0	0	0	8	73	0	0	3	27	0	0	0	0	6	0
Chamomille suaveolens	3	10	19	74	4	16	7	17	32	78	2	5	8	22	26	70	3	8	0	0	5	0	3	0
Chenopodium album	0	0	7	100	0	0	2	100	0	0	0	0	5	16	21	68	5	16	0	0	0	0	0	0
Cirsium arvense	24	24	39	44	26	30	74	35	86	40	53	25	51	36	44	32	44	32	0	2	18	0	3	0
C. palustre	0	0	15	55	12	45	37	52	32	28	46	40	18	22	29	35	35	43	0	2	13	0	0	0
C. vulgare	18	23	29	37	31	40	39	34	23	20	53	46	30	36	23	28	30	36	0	0	3	0	0	4
Cladium mariscus	0	0	0	0	0	0	0	0	0	0	7	100	0	0	0	0	0	0	0	12	0	0	0	0
Clematis vitalba	3	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4

APPENDIX 2 cont.

UNIT	I						II						III				I	II	III	I	II	III
	Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Ch.	Ch.	Ch.	St.	St.	St.
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	a	a	a	a	a
SPECIES																								
Coeloglossum viride	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	5	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Convolvolus arvensis	‡	‡	‡	‡	10	100	5	16	‡	‡	26	84	‡	‡	‡	‡	3	100	‡	‡	‡	‡	‡	‡
Corylus avellana	18	72	1	6	8	22	5	100	‡	‡	‡	‡	49	58	9	10	28	32	‡	‡	‡	‡	‡	‡
Cotoneaster spp.	1	50	1	50	‡	‡	5	100	‡	‡	‡	‡	3	34	3	33	3	33	‡	‡	‡	‡	6	‡
Crataegus monogyna	97	65	24	16	28	19	93	54	14	8	67	38	100	40	50	21	97	39	‡	2	3	2	29	44
Crepis biennis	‡	‡	‡	‡	‡	‡	5	71	‡	‡	2	29	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
C. capillaris	1	11	4	34	7	55	14	18	45	56	21	26	‡	‡	‡	‡	‡	‡	‡	‡	‡	2	3	4
C. vesicaria	‡	‡	‡	‡	‡	‡	16	44	4	12	16	44	8	25	15	45	10	30	‡	‡	‡	‡	10	4
Cyclamen hederifolium	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	2	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Cymbalaria muralis	‡	‡	1	100	‡	‡	5	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	8	26	4
Cynosurus cristatus	11	12	53	58	26	30	70	29	95	39	77	32	33	17	100	52	59	31	‡	‡	‡	‡	3	4
Dactylis glomerata	40	18	87	40	93	42	100	34	95	32	100	34	90	32	91	33	97	35	‡	‡	8	11	16	4
Dactylorhiza fuchsii	‡	‡	‡	‡	‡	‡	16	28	9	15	33	57	15	11	44	32	77	57	‡	2	25	‡	‡	‡
D. incarnata	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	5	‡	‡	‡
D. maculata	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	3	50	‡	‡	3	50	‡	‡	‡	‡	‡	‡
Danthonia decumbens	‡	‡	‡	‡	‡	‡	2	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Daucus carota	8	15	24	41	25	44	49	34	50	34	46	32	13	16	38	45	33	39	‡	‡	‡	2	6	11
Deschampsia caespitosa	11	28	17	44	11	28	21	34	14	23	26	43	20	37	9	17	25	46	‡	‡	‡	‡	‡	‡
Desmazeria rigida	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	4
Drosera rotundifolia	‡	‡	‡	‡	‡	‡	5	100	‡	‡	‡	‡	5	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Dryopteris filix-mas	19	93	1	7	‡	‡	42	82	‡	‡	9	18	33	72	‡	‡	13	28	‡	‡	‡	2	10	7
Echium vulgare	‡	‡	‡	‡	‡	‡	2	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Eleocharis palustris	‡	‡	‡	‡	‡	‡	2	18	‡	‡	9	82	3	27	‡	‡	8	73	1	5	31	‡	‡	‡
Elodea canadensis	‡	‡	‡	‡	‡	‡	2	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	15	9	3	‡	‡	‡
Elymus repens	26	39	33	49	8	12	14	40	9	26	12	34	15	42	6	16	15	42	‡	‡	‡	3	‡	‡
Empetrum nigrum	‡	‡	‡	‡	‡	‡	2	100	‡	‡	‡	‡	5	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Epilobium angustifolium	1	20	4	60	1	20	23	92	‡	‡	2	8	3	100	‡	‡	‡	‡	‡	‡	‡	‡	3	‡
E. hirsutum	24	30	24	30	32	40	39	44	4	4	46	52	‡	‡	‡	‡	3	100	‡	7	15	5	23	4
E. montanum	4	60	1	20	1	20	16	64	‡	‡	9	36	38	71	3	5	13	24	‡	‡	‡	2	16	‡
E. palustre	‡	‡	3	50	3	50	12	71	‡	‡	5	29	‡	‡	12	60	8	40	‡	5	35	‡	3	‡
E. parviflorum	4	15	10	33	15	52	2	100	‡	‡	‡	‡	5	100	‡	‡	‡	‡	‡	‡	‡	2	‡	‡

APPENDIX 2 cont.

UNIT	I						II						III						I	II	III	I	II	III
	Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Ch.	Ch.	Ch.	St.	St.	St.
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	a	a	a	a	a
SPECIES																								
Equisetum arvense	22	23	36	38	37	39	77	37	45	22	86	41	72	38	35	18	85	44	1	2	10	1	3	1
E. fluviatile	1	10	4	27	10	63	23	50	4	9	19	41	10	21	3	6	35	73	7	1	69	1	1	1
E. palustre	1	100	1	1	1	1	5	72	1	1	2	28	8	25	12	36	13	39	1	1	5	1	1	1
E. telmateia	1	1	1	1	1	1	1	1	1	1	1	1	5	50	1	1	5	50	1	1	1	1	1	1
E. variegatum	1	1	3	34	6	66	5	42	1	1	7	58	1	1	1	1	8	100	1	1	18	1	1	1
Erica tetralix	1	1	1	100	1	1	5	100	1	1	1	1	5	100	1	1	1	1	1	1	1	1	1	1
Eriophorum angustifolium	1	1	4	100	1	1	7	100	1	1	1	1	5	63	3	37	1	1	1	1	1	1	1	1
E. latifolium	1	1	1	1	1	1	7	100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
E. vaginatum	1	1	1	100	1	1	5	100	1	1	1	1	3	50	3	50	1	1	1	1	1	1	1	1
Euonymus europaeus	7	100	1	1	1	1	1	1	1	1	1	1	15	84	3	16	1	1	1	1	1	1	1	1
Eupatorium cannabinum	3	7	14	38	21	55	19	54	1	1	16	46	1	1	1	1	8	100	1	1	1	5	6	1
Euphorbia helioscopia	1	1	1	1	1	88	1	1	1	1	1	1	3	50	3	50	1	1	1	1	1	1	1	1
Euphorbia peplus	1	20	6	80	1	1	2	100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Euphrasia spp.	1	6	17	75	4	19	14	42	1	1	19	58	5	39	1	1	8	61	1	1	3	88	1	1
Fagus sylvatica	40	91	1	3	3	6	5	100	1	1	1	1	23	89	1	1	3	11	1	1	1	1	1	1
F. purpurea	1	100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Festuca arundinacea	7	17	21	54	11	29	21	39	4	7	30	54	28	30	15	16	51	54	1	5	13	1	1	1
F. pratensis	8	27	15	50	7	23	1	1	1	1	2	100	1	1	1	1	1	1	1	1	1	1	1	1
F. rubra	74	37	78	35	76	33	100	34	100	33	100	33	97	35	82	30	97	35	1	5	18	30	77	74
Filipendula ulmaria	21	14	44	28	92	58	77	41	9	5	100	54	49	28	26	15	100	57	1	33	82	8	61	7
Foeniculum vulgare	1	1	1	1	1	1	2	100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fragraria vesca	14	83	3	17	1	1	19	79	1	1	5	21	49	64	12	16	15	20	1	1	1	1	1	15
Fraxinus excelsior	92	57	15	10	53	23	84	50	1	1	86	50	95	44	21	10	100	46	1	5	5	5	52	48
Fuchsia magellanica	1	1	1	1	1	1	5	100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Fumaria officinalis	1	1	1	100	1	1	1	1	1	1	1	1	1	1	6	66	3	34	1	1	1	1	1	1
Galium aparine	12	23	25	45	18	32	77	58	4	3	51	39	97	49	18	9	85	42	1	1	1	1	6	4
G. palustre	1	1	4	10	39	90	14	18	1	1	63	82	5	12	1	1	36	88	1	49	87	1	3	1
G. uliginosum	1	1	1	1	1	1	2	100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
G. verum	15	22	49	47	39	31	79	37	54	26	79	37	56	26	73	34	87	40	1	1	1	13	39	22
Geranium dissectum	1	1	1	1	1	1	2	100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
G. lucidum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	6	100	1	1	1	1	1	1	1	4
G. molle	1	1	1	1	1	1	2	100	1	1	1	1	1	1	6	100	1	1	1	1	1	1	1	4

APPENDIX 2 cont.

UNIT	I						II						III						I	II	III	I	II	III
	Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Ch.	Ch.	Ch.	St.	St.	St.
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	a	a	a	a	a
SPECIES																								
G. pyrenaicum	1	20	4	60	1	20	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
G. robertianum	61	76	14	17	7	7	53	79	†	†	14	21	82	41	18	11	62	38	†	†	†	2	3	15
Geum urbanum	31	96	1	4	†	†	30	72	†	†	12	18	51	47	21	20	35	33	†	†	†	†	†	†
Glechoma hederacea	†	†	1	100	†	†	5	100	†	†	†	†	54	46	21	21	23	23	†	†	†	†	†	†
Glyceria fluitans	6	100	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
Glyceria maxima	21	18	29	25	67	57	19	17	†	†	95	83	8	20	†	†	33	80	85	98	100	†	†	†
G. plicata	†	†	†	†	†	†	2	100	†	†	†	†	†	†	†	†	†	†	†	†	3	†	†	†
Groenlandia densa	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	5	†	†	†	†
Gymnadenia conopsea	†	†	†	†	†	†	12	35	4	11	19	54	3	12	9	36	13	52	†	†	†	†	†	†
Hedera helix	87	91	8	9	†	†	84	86	†	†	14	14	92	53	9	5	72	42	†	†	†	29	58	70
Heracleum sphondylium	29	31	36	39	28	30	72	45	36	22	53	33	72	41	56	28	64	31	†	†	3	3	6	4
Hieracium pilosella	†	†	†	†	†	†	12	46	9	35	5	19	5	46	3	27	3	27	†	†	†	†	16	7
H. spp.	†	†	†	†	†	†	5	100	†	†	†	†	†	†	†	†	†	†	†	†	†	†	3	†
Hippuris vulgaris	†	†	†	†	†	†	5	100	†	†	†	†	†	†	†	†	3	100	22	9	15	†	†	†
Holcus lanatus	19	16	58	47	46	37	81	32	86	34	88	34	69	30	73	32	87	38	†	9	38	3	10	†
Hordeum murinum	†	†	†	†	†	†	5	50	†	†	5	50	†	†	†	†	†	†	†	†	†	†	3	†
Hyacinthoides non-scriptus	†	†	†	†	†	†	9	100	†	†	†	†	3	100	†	†	†	†	†	†	†	†	†	†
Hydrocharis morsus-ranae	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	23	†	†	†
Hydrocotyle vulgaris	†	†	†	†	1	100	†	†	†	†	†	†	3	50	†	†	3	50	†	†	38	†	†	†
Hypericum androsaemum	†	†	†	†	†	†	5	100	†	†	†	†	5	39	†	†	8	61	†	†	†	†	†	†
H. hircinum	†	†	†	†	†	†	2	50	†	†	2	50	†	†	†	†	†	†	†	†	†	†	†	†
H. perforatum	3	29	6	57	1	14	9	56	†	†	7	44	5	63	†	†	3	37	†	†	†	†	3	†
H. pulchrum	†	†	†	†	†	†	†	†	†	†	†	†	5	27	6	31	8	42	†	†	†	†	†	†
H. tetrapterum	†	†	11	30	26	70	14	21	9	13	44	66	8	17	3	6	38	77	†	2	3	2	6	†
Hypocharis radicata	1	20	6	80	†	†	37	22	77	47	51	31	33	20	73	43	62	37	†	†	8	†	16	4
Ilex aquifolium	26	95	1	5	†	†	7	100	†	†	†	†	28	74	†	†	10	26	†	†	†	†	†	†
Iris pseudacorus	11	11	19	18	76	71	39	29	†	†	95	71	18	17	3	3	85	80	12	42	77	†	†	†
Juncus acutiflorus	†	†	1	17	7	83	†	†	4	100	†	†	3	50	†	†	3	50	†	†	5	†	†	†
J. articulatus	1	4	11	30	25	66	12	27	4	9	28	64	8	32	9	36	8	32	†	16	13	†	†	†
J. bulbosus	†	†	†	†	†	†	5	100	†	†	†	†	3	100	†	†	†	†	†	†	†	†	†	†
J. conglomeratus	†	†	1	100	†	†	†	†	†	†	†	†	3	100	†	†	†	†	†	†	†	†	†	†
J. effusus	12	24	10	18	31	58	35	37	9	9	51	54	5	13	3	8	30	79	†	7	15	†	†	†

APPENDIX 2 cont.

UNIT	I						II						III						I	II	III	I	II	III
	Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Ch.	Ch.	Ch.	St.	St.	St.
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	a	a	a	a	a
SPECIES																								
J. inflexus	7	4	31	31	76	65	30	17	50	29	93	54	8	8	15	16	72	76	‡	19	15	‡	‡	‡
J. subnodulosus	1	13	‡	‡	10	87	16	41	‡	‡	23	59	3	100	‡	‡	‡	‡	‡	16	‡	‡	‡	‡
Knautia arvensis	6	29	10	50	4	21	51	68	4	5	21	27	51	66	9	11	18	23	‡	‡	‡	2	13	4
Lamium album	‡	‡	‡	‡	1	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Lamium purpureum	‡	‡	1	50	1	50	7	78	‡	‡	2	22	‡	‡	‡	‡	3	100	‡	‡	‡	‡	‡	‡
Lapsana communis	7	20	24	68	4	12	21	70	9	30	‡	‡	18	42	15	35	10	23	‡	‡	‡	3	6	‡
Larix spp.	‡	‡	‡	‡	‡	88	2	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Lathyrus pratensis	17	14	28	40	37	46	77	38	36	17	93	45	62	29	59	27	97	44	‡	2	5	2	6	‡
Lemna minor	7	100	‡	‡	‡	‡	7	100	‡	‡	‡	‡	5	100	‡	‡	‡	‡	11	39	38	‡	‡	‡
L. trisulca	‡	‡	‡	‡	‡	‡	2	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	5	3	‡	‡	‡
Leontodon autumnalis	‡	‡	‡	‡	‡	‡	19	24	36	44	26	32	‡	‡	6	100	‡	‡	‡	‡	‡	‡	3	‡
L. hispidus	17	20	47	58	18	22	35	38	27	29	30	33	5	20	12	48	8	32	‡	‡	‡	3	6	‡
L. taraxacoides	‡	‡	‡	‡	‡	‡	5	71	‡	‡	2	29	5	17	15	50	10	33	‡	‡	‡	‡	‡	‡
Leucanthemum vulgare	4	17	14	59	6	24	60	26	54	46	33	28	41	29	50	36	49	35	‡	‡	5	‡	42	30
Leycesteria formosa	‡	‡	‡	‡	‡	‡	5	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Ligustrum vulgaris	62	75	6	7	15	18	42	82	‡	‡	9	18	85	62	15	11	38	27	‡	‡	3	‡	‡	7
Linaria purpurea	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	2	‡	‡
Linum bienne	‡	‡	‡	‡	‡	‡	2	50	‡	‡	2	50	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
L. catharticum	4	23	11	61	3	16	7	17	18	44	16	39	8	20	21	54	10	26	‡	‡	‡	‡	0	4
Listera ovata	‡	‡	‡	‡	‡	‡	7	78	‡	‡	2	22	13	50	3	11	10	39	‡	‡	‡	‡	‡	‡
Lolium perenne	4	6	44	67	18	27	28	21	82	63	21	16	13	16	56	71	10	13	‡	‡	‡	‡	‡	‡
Lonicera nitida	8	75	‡	‡	3	25	9	100	‡	‡	‡	‡	8	73	‡	‡	3	27	‡	‡	‡	‡	6	4
L. periclymenum	18	72	4	17	3	11	21	70	9	30	‡	‡	67	64	15	14	23	22	‡	‡	3	‡	‡	‡
L. xylostrum	1	50	‡	‡	1	50	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Lotus corniculatus	11	20	29	54	14	26	77	33	91	38	70	29	33	24	56	40	51	36	‡	‡	‡	‡	6	7
Luzula campestris	‡	‡	‡	‡	‡	‡	14	20	50	68	9	12	10	15	48	59	18	26	‡	‡	‡	‡	‡	4
Lychnis flos-cuculi	‡	‡	‡	‡	‡	‡	7	100	‡	‡	‡	‡	3	50	‡	‡	3	50	‡	‡	5	‡	‡	‡
Lycopus europaeus	‡	‡	3	100	‡	‡	‡	‡	‡	‡	2	100	‡	‡	‡	‡	‡	‡	‡	5	8	‡	10	‡
Lysimachia nemorum	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	5	63	‡	‡	2	37	‡	‡	‡	‡	‡	‡
Lythrum salicaria	4	12	14	42	15	46	21	38	‡	‡	35	62	10	25	3	7	28	68	‡	19	25	‡	3	‡
Malus spp.	6	100	‡	‡	‡	‡	2	50	‡	‡	2	50	3	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Malva sylvestris	‡	‡	‡	‡	‡	‡	2	50	‡	‡	2	50	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡

APPENDIX 2 cont.

UNIT	I						II						III						I	II	III	I	II	III
	Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Ch.	Ch.	Ch.	St.	St.	St.
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	a	a	a	a	a
SPECIES																								
Medicago lupulina	4	10	25	58	14	32	16	17	59	60	23	23	5	8	50	71	15	21	‡	‡	‡	3	10	7
Melampyrum pratense	‡	‡	‡	‡	‡	‡	2	100	‡	‡	‡	‡	3	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Mentha aquatica	4	6	26	34	46	60	28	31	4	4	60	65	13	19	9	13	46	68	‡	44	85	3	23	‡
Menyanthes trifoliata	1	5	6	20	21	75	5	42	‡	‡	7	58	5	63	‡	‡	3	37	32	39	90	‡	‡	‡
Molinea caerulea	1	10	6	40	7	50	12	36	9	28	12	36	5	36	6	43	3	21	‡	5	3	‡	‡	‡
Myosotis arvensis	‡	‡	‡	‡	‡	‡	9	43	‡	‡	12	57	3	33	6	67	‡	‡	‡	‡	‡	‡	‡	‡
M. discolor	‡	‡	‡	‡	‡	‡	4	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
M. laxa	‡	‡	1	34	3	66	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
M. scorpioides	‡	‡	1	25	4	75	7	58	‡	‡	5	42	‡	‡	‡	‡	8	100	‡	12	62	‡	‡	‡
Myrica gale	‡	‡	‡	‡	‡	‡	5	72	‡	‡	2	28	8	50	3	19	5	21	‡	‡	3	‡	‡	‡
Myriophyllum spp.	‡	‡	‡	‡	‡	‡	2	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	86	63	8	‡	‡	‡
Narthecium ossifragum	‡	‡	1	100	‡	‡	5	100	‡	‡	‡	‡	100	5	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Nasturtium officinale	10	63	4	28	1	9	12	70	‡	‡	5	29	‡	‡	‡	‡	13	100	15	28	46	‡	3	‡
Nuphar lutea	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	80	77	51	‡	‡	‡
Nymphaea alba	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	1	‡	‡	‡	‡	‡
Odontites verna	3	5	35	61	19	34	33	21	86	56	35	23	3	3	56	60	35	37	‡	‡	5	‡	3	‡
Oenanthe aquatica	‡		‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	2	18	‡	‡	‡
Oenanthe crocata	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	9	100	‡	‡	‡	‡	‡	‡	‡	2	‡	‡	3	‡
O. fistulosa	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	2	100	‡	‡	‡	‡	3	100	‡	5	15	‡	‡	‡
Ononis repens	‡	‡	7	62	4	38	7	44	‡	‡	9	56	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Ophrys apifera	1	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
‡‡ Orchis morio	3	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Origanum vulgare	1	6	10	44	11	50	5	36	‡	‡	9	64	3	37	‡	‡	5	63	‡	‡	‡	‡	‡	‡
Oxalis acetosella	3	66	1	34	‡	‡	‡	‡	‡	‡	‡	‡	5	39	3	23	5	38	‡	‡	‡	‡	‡	‡
Papaver spp.	‡	‡	8	75	3	25	12	71	‡	‡	5	29	‡	‡	3	100	‡	‡	‡	‡	‡	‡	‡	‡
Parnassia palustris	‡	‡	3	100	‡	‡	7	100	‡	‡	‡	‡	3	50	3	50	‡	‡	‡	‡	‡	‡	‡	‡
Pedicularis palustris	‡	‡	1	50	1	50	2	50	‡	‡	2	50	‡	‡	‡	‡	3	100	‡	2	23	‡	‡	‡
P. sylvatica	‡	‡	‡	‡	‡	‡	2	100	‡	‡	‡	‡	5	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Petasites hybridus	‡	‡	‡	‡	‡	‡	12	27	9	21	23	52	3	33	3	33	3	33	‡	‡	‡	‡	13	‡
Phalaris arundinacea	24	20	36	29	62	51	28	33	‡	‡	58	67	5	34	‡	‡	10	66	29	65	8	‡	3	‡
Phleum pratense	21	20	60	47	47	33	58	34	54	31	60	35	56	24	82	36	92	40	‡	2	13	‡	‡	‡
Phragmites australis	‡	‡	3	40	4	60	12	32	‡	‡	26	68	3	17	6	31	10	52	7	33	23	‡	‡	‡

APPENDIX 2 cont.

UNIT	I						II						III						I Ch.	II Ch.	III Ch.	I St.	II St.	III St.
	Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Bd.		Tp.		Bk.							
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	a	a	a	a	a
SPECIES																								
Phyllitis scolopendrium	26	90	1	5	1	5	42	82	1	1	9	18	49	90	1	1	33	40	1	1	1	16	58	18
Picea spp.	3	100	1	1	1	1	2	100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	4
Pimpinella saxifraga	14	19	44	62	14	19	53	29	73	40	58	31	38	30	64	45	49	32	1	1	3	5	26	18
Pinguicula lusitanica	1	1	1	1	1	1	1	1	1	1	1	1	3	100	1	1	1	1	1	1	1	1	1	1
P. vulgaris	1	1	1	1	1	1	2	100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Pinus radicata	1	1	1	1	1	1	2	100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
P. sylvestris	14	90	1	10	1	1	5	100	1	1	1	1	5	100	1	1	1	1	1	1	1	1	1	1
Plantago lanceolata	24	16	67	46	56	38	77	29	95	36	93	35	62	27	82	36	82	37	1	1	1	5	32	1
P. major	4	5	64	78	14	17	7	8	77	85	7	7	18	20	59	66	13	14	1	1	1	1	1	1
Poa annua	14	11	75	62	32	27	79	32	86	35	81	33	38	29	50	38	44	33	1	1	1	1	10	1
P. pratensis	3	6	39	82	6	12	86	36	64	27	86	37	44	22	68	34	87	44	1	1	1	2	32	1
P. trivialis	7	45	8	55	1	1	88	36	73	29	86	35	38	21	56	31	87	48	1	1	1	1	1	1
Poa spp.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	12	3	1	1	1
Polygala serpyllifolia	1	1	1	1	1	1	5	100	1	1	1	1	5	36	6	43	3	21	1	1	1	1	1	1
P. vulgaris	1	1	1	1	1	1	7	25	9	32	12	43	5	36	6	43	3	21	1	1	1	1	1	1
Polygonum amphibium	1	1	19	24	61	76	14	14	23	22	67	64	8	9	21	25	56	66	17	26	51	1	1	1
P. aviculare	1	1	17	75	6	25	5	32	9	56	2	12	13	40	12	48	3	12	1	1	1	1	1	1
P. persicaria	1	17	4	50	3	33	1	1	1	1	1	1	13	26	21	43	15	31	1	1	13	1	1	1
Polypodium vulgare	1	1	1	1	1	1	1	1	1	1	2	100	1	1	1	1	1	1	1	1	1	1	1	1
Populus spp.	12	69	4	23	1	8	2	100	1	1	1	1	1	1	1	1	3	100	1	1	1	2	1	1
Potamogeton crispus	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	14	7	3	1	1	1
Potamogeton natans	1	1	1	1	1	1	5	100	1	1	1	1	1	1	1	1	1	1	37	44	10	1	1	1
P. perfoliatus	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	3	1	1	1
P. polygonifolius	1	1	1	1	1	1	5	100	1	1	1	1	3	100	1	1	1	1	1	2	5	1	1	1
Potamogeton spp.	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	5	1	1	1
Potentilla anserina	19	15	58	43	57	42	49	25	86	45	58	30	41	20	76	37	88	43	1	1	38	1	6	1
P. erecta	1	1	6	57	4	43	26	56	9	19	12	25	10	37	9	21	23	42	1	1	1	1	1	1
P. palustris	1	1	1	1	1	1	1	1	1	1	1	1	3	50	1	1	3	50	1	1	3	1	1	1
P. reptans	26	20	49	37	57	43	37	35	14	13	56	52	18	19	29	30	49	51	1	2	13	11	10	4
P. sterilis	11	100	1	1	1	1	9	100	1	1	1	1	3	16	3	16	13	68	1	1	1	1	1	1
Primula veris	1	1	1	1	1	1	35	30	54	47	26	23	29	27	56	52	23	21	1	1	1	1	1	1
P. vulgaris	12	100	1	1	1	1	28	50	14	25	14	25	33	64	9	17	10	19	1	1	1	1	1	1

APPENDIX 2 cont.

UNIT	I						II						III						I	II	III	I	II	III
	Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Ch.	Ch.	Ch.	St.	St.	St.
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	a	a	a	a	a
SPECIES																								
Prunus avium	‡	‡	‡	‡	‡	‡	5	66	‡	‡	2	34	3	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
P. spinosa	43	53	14	17	25	30	46	24	4	5	35	41	77	32	71	30	92	38	‡	‡	18	‡	6	21
Pteridium aquilinum	12	53	8	35	3	12	9	30	14	47	7	23	67	37	53	30	59	33	‡	‡	‡	‡	6	7
Pulicaria dysenterica	‡	‡	10	70	4	30	5	40	‡	‡	7	60	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Quercus agg.	26	76	4	12	4	12	5	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Ranunculus acris	7	13	25	47	21	40	65	30	68	31	86	39	44	30	53	36	49	33	‡	9	10	‡	‡	‡
R. bulbosus	‡	‡	‡	‡	‡	‡	33	22	91	60	28	18	8	17	32	66	8	16	‡	‡	‡	‡	6	4
R. circinatus	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	4	‡	‡	‡	‡	‡
R. ficaria	‡	‡	‡	‡	‡	‡	14	74	‡	‡	5	26	8	62	‡	‡	5	38	‡	‡	‡	‡	‡	‡
R. flammula	‡	‡	1	9	14	91	5	42	‡	‡	7	58	‡	‡	3	50	3	50	19	16	46	‡	‡	‡
R. lingua	‡	‡	3	16	15	84	5	10	‡	‡	44	90	‡	‡	‡	‡	3	100	51	72	69	‡	‡	‡
R. repens	31	21	50	35	64	44	72	33	59	27	88	40	59	30	53	26	88	44	‡	33	51	‡	‡	‡
R. sceleratus	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	4	7	‡	‡	3	‡
R. trichophyllus	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Reseda luteola	4	22	7	36	8	42	7	88	‡	‡	2	22	‡	‡	3	100	‡	‡	‡	‡	‡	‡	‡	‡
Rhinanthus minor	1	5	15	52	12	43	19	31	27	43	16	26	10	11	44	51	33	38	‡	2	20	‡	‡	‡
Rhynchospora alba	‡	‡	1	100	‡	‡	‡	‡	‡	‡	‡	‡	3	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Rosa canina agg.	81	72	14	13	17	15	67	69	‡	‡	30	31	79	59	18	13	38	28	‡	‡	‡	3	‡	7
Rubus fruticosus agg.	93	52	43	24	43	24	98	46	32	15	84	39	100	39	65	25	95	36	‡	7	35	27	61	63
R. idaeus	‡	‡	‡	‡	‡	‡	2	50	‡	‡	2	50	3	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Rumex acetosa	‡	‡	‡	‡	‡	‡	21	60	9	26	5	14	13	94	3	6	‡	‡	‡	‡	3	‡	‡	‡
R. conglomeratus	1	8	10	58	6	34	‡	‡	‡	‡	2	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
R. crispus	3	18	8	54	4	28	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
R. hydrolapathum	1	100	‡	‡	‡	‡	2	11	‡	‡	16	89	‡	‡	‡	‡	10	100	‡	23	72	‡	‡	‡
R. obtusifolius	4	8	29	52	22	40	35	26	36	37	26	27	13	40	12	36	8	24	‡	‡	10	‡	‡	‡
R. sanguineus	4	100	‡	‡	‡	‡	9	50	‡	‡	9	50	13	49	9	33	5	18	‡	‡	‡	‡	3	‡
Sagina nodosa	‡	‡	‡	‡	1	100	5	24	4	19	12	57	‡	‡	‡	‡	3	100	‡	‡	3	‡	‡	‡
S. procumbens	‡	‡	1	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	2	‡	‡
Salix alba	10	70	3	20	1	10	5	50	‡	‡	5	50	5	88	‡	‡	3	12	‡	‡	‡	‡	‡	4
S. aurita	‡	‡	‡	‡	‡	‡	2	8	‡	‡	9	82	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	3	‡
S. caprea	5	100	‡	‡	‡	‡	‡	‡	‡	‡	5	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
S. cinerea	12	45	4	15	11	40	9	56	‡	‡	7	44	5	12	‡	‡	38	88	‡	7	44	‡	‡	‡

APPENDIX 2 cont.

UNIT	I						II						III				I	II	III	I	II	III
	Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Ch.	Ch.	Ch.	St.	St.	St.
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	a	a	a	a	a
SPECIES																								
S. fragilis	15	33	10	22	21	45	5	42	†	†	7	58	5	38	†	†	8	62	†	†	13	†	†	†
S. purpurea	4	20	4	20	12	60	2	22	†	†	7	78	†	†	†	†	3	100	†	†	†	†	†	†
S. repens	†	†	†	†	†	†	5	100	†	†	†	†	3	50	3	50	†	†	†	2	3	†	†	†
S. viminalis	4	50	†	†	4	50	5	24	†	†	16	76	8	50	†	†	8	50	†	2	5	†	†	†
S. spp.	†	†	†	†	3	100	5	29	†	†	12	71	20	35	3	5	35	60	†	5	13	†	†	†
Sambucus nigra	74	84	8	9	6	7	74	74	†	†	26	26	56	82	3	4	10	14	†	†	†	11	26	11
Sanguisorba minor	10	18	31	56	14	26	14	32	27	63	2	5	10	47	6	29	5	24	†	†	†	3	†	†
Sanicula europaea	1	100	†	†	†	†	†	†	†	†	†	†	8	73	3	27	†	†	†	†	†	†	†	†
Schoenus nigricans	†	†	†	†	†	†	7	100	†	†	†	†	8	57	3	21	3	22	†	†	†	†	†	†
Scirpus caespitosus	†	†	†	†	†	†	7	100	†	†	†	†	5	100	†	†	†	†	†	†	†	†	†	†
S. lacustris	†	†	†	†	†	†	2	18	†	†	9	82	†	†	†	†	†	†	74	49	51	†	†	†
Scrophularia nodosa	†	†	†	†	3	100	2	50	†	†	2	50	5	50	†	†	5	50	†	†	†	†	6	†
Scutellaria galericulata	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	8	100	†	†	18	†	†	†
Senecio aquaticus	†	†	†	†	†	†	7	22	4	12	21	66	†	†	6	37	10	63	†	†	5	†	3	†
S. erucifolius	†	†	†	†	†	†	2	50	†	†	2	50	†	†	†	†	†	†	†	†	†	†	†	†
S. jacobaea	10	13	43	57	22	30	46	30	50	32	58	38	33	31	35	33	38	36	†	2	10	6	48	22
S. vulgaris	1	5	19	64	10	31	12	48	4	16	9	36	10	47	6	29	5	24	†	†	†	2	†	†
Sherardia arvensis	†	†	†	†	†	†	2	29	†	†	5	71	3	50	3	50	†	†	†	†	†	†	†	†
Silene alba	1	100	†	†	†	†	4	100	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
Silybum marianum	†	†	†	†	†	†	†	†	†	†	†	†	†	†	3	100	†	†	†	†	†	†	†	†
Sinapsis arvensis	1	8	12	992	†	†	2	18	4	36	5	45	5	29	12	71	†	†	†	†	†	†	†	†
Sisymbrium officinale	†	†	†	†	†	†	14	33	14	33	14	34	5	50	†	†	5	50	†	†	†	†	†	†
Smyrnium olusatrum	†	†	†	†	†	†	5	71	†	†	2	29	†	†	†	†	†	†	†	†	†	†	3	†
Solanum dulcamara	6	27	10	46	6	27	7	88	†	†	2	22	3	100	†	†	†	†	†	†	†	†	†	†
S. tuberum	†	†	†	†	†	†	†	†	†	†	†	†	3	100	†	†	†	†	†	†	†	†	†	4
Sonchus arvensis	7	29	14	59	3	12	19	51	4	11	14	38	20	52	6	15	13	33	†	†	5	2	3	†
S. asper	3	8	19	54	14	38	5	42	†	†	7	58	8	37	6	27	8	36	†	†	5	†	6	†
S. oleraceus	6	14	21	53	12	33	12	100	†	†	†	†	†	†	12	100	†	†	†	†	†	2	†	4
Sorbus aria	†	†	†	†	†	†	†	†	†	†	2	100	†	†	†	†	3	100	†	†	†	†	†	4
Sorbus aucuparia	3	100	†	†	†	†	5	71	†	†	2	29	†	†	†	†	†	†	†	†	3	†	†	4
Sparganium emersum	4	100	†	†	†	†	2	100	†	†	†	†	†	†	†	†	†	†	36	12	3	†	†	†
S. erectum	3	22	†	†	10	78	9	24	†	†	28	76	†	†	†	†	8	100	33	58	74	†	†	†

APPENDIX 2 cont.

UNIT	I						II						III						I	II	III	I	II	III
	Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Ch.	Ch.	Ch.	St.	St.	St.
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	a	a	a	a	a
SPECIES																								
Stachys palustris	1	10	6	37	8	53	21	36	‡	‡	37	64	8	20	3	7	30	73	‡	5	20	‡	10	‡
S. sylvatica	6	57	4	43	‡	‡	12	75	4	25	‡	‡	25	45	12	22	18	33	‡	‡	‡	‡	‡	‡
Stellaria graminea	‡	‡	1	100	‡	‡	7	64	4	36	‡	‡	8	50	3	19	5	31	‡	‡	‡	‡	‡	‡
S. holostea	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	3	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
S. media	6	18	19	64	6	18	5	15	27	79	2	6	10	22	26	56	10	22	‡	‡	3	‡	‡	‡
S. palustris	‡	‡	‡	‡	‡	‡	5	42	‡	‡	7	58	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Succisa pratensis	19	18	39	36	49	46	33	35	14	14	49	51	13	15	12	14	62	71	‡	5	3	‡	‡	‡
Symphoricarpos albus	21	83	1	6	3	11	39	71	9	16	7	13	35	71	6	12	8	16	‡	‡	‡	5	‡	‡
Symphytum officinale	‡	‡	‡	‡	‡	‡	5	71	‡	‡	2	29	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Syringa vulgaris	1	100	‡	‡	‡	‡	9	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	2	‡	‡
Tanacetum vulgare	‡	‡	‡	‡	‡	‡	2	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Taraxacum spp.	26	18	68	48	49	24	58	34	59	35	53	31	38	33	44	38	33	29	‡	‡	‡	32	58	15
Taxus baccata	6	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Tilia agg.	1	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	3	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Torilis japonica	‡	‡	‡	‡	‡	‡	19	49	4	10	16	41	20	40	12	24	18	36	‡	‡	‡	‡	3	‡
Tragopogon pratensis	‡	‡	‡	‡	‡	‡	3	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Trifolium dubium	‡	‡	‡	‡	‡	‡	19	34	23	41	14	25	3	10	26	90	‡	‡	‡	‡	‡	‡	3	4
T. pratense	22	13	79	47	67	40	70	28	95	37	88	35	49	23	88	41	77	36	‡	5	3	‡	16	‡
T. repens	22	14	76	47	64	39	51	27	95	47	53	26	41	22	79	43	64	35	‡	‡	15	‡	6	‡
Triglochin palustris	‡	‡	1	34	3	66	5	29	‡	‡	12	71	‡	‡	‡	‡	5	100	‡	7	8	‡	‡	‡
Trisetum flavescens	‡	‡	‡	‡	‡	‡	26	40	23	35	16	25	‡	‡	6	100	‡	‡	‡	‡	‡	‡	‡	‡
Tritonia crocosmiflora	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	3	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Tussilago farfara	3	6	24	50	21	44	7	39	9	50	2	11	5	36	6	43	3	21	‡	‡	‡	3	16	7
Typha latifolia	‡	‡	‡	‡	22	100	‡	‡	‡	‡	7	100	‡	‡	‡	‡	3	100	39	37	56	‡	‡	‡
Ulex europaeus	19	50	18	46	1	4	35	54	18	28	12	18	46	55	15	16	25	29	‡	‡	5	‡	‡	‡
Ulmus agg.	25	82	3	9	3	9	14	88	‡	‡	2	12	8	100	‡	‡	‡	‡	‡	‡	‡	‡	6	‡
Urtica dioica	51	35	46	30	51	35	86	47	32	17	67	36	79	40	41	21	77	39	‡	5	46	14	29	26
Utricularia spp.	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	6	‡	3	‡	‡	‡
Valeriana officinalis	8	10	17	19	61	71	39	30	‡	‡	91	69	23	19	6	5	92	76	‡	14	59	2	16	4
Verbascum thapsus	‡	‡	‡	‡	3	100	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Veronica anagallis-aquatica	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡	3	100	‡	‡	5	‡	‡	‡

APPENDIX 2 cont.

UNIT	I						II						III						I	II	III	I	II	III
	Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Bd.		Tp.		Bk.		Ch.	Ch.	Ch.	St.	St.	St.
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	a	a	a	a	a
SPECIES																								
Veronica beccabunga	†	†	4	100	†	†	7	78	†	†	2	22	†	†	†	†	†	†	†	†	8	†	†	†
V. catenata	3	100	†	†	†	†	2	100	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
V. chamaedrys	14	54	10	37	3	9	60	35	59	34	53	31	77	38	60	27	72	35	†	†	†	†	3	†
V. hederifolia	†	†	†	†	†	†	†	†	4	100	†	†	†	†	†	†	3	100	†	†	†	†	†	†
V. montana	8	100	†	†	†	†	5	50	5	50	†	†	13	54	6	25	5	21	†	†	†	†	†	†
V. persica	1	10	10	70	3	20	2	25	4	50	2	25	8	29	12	43	8	28	†	†	†	†	†	4
V. scutellata	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	3	†	†	†
V. serpyllifolia	†	†	†	†	†	†	7	54	4	31	2	15	8	32	9	36	8	32	†	†	†	†	†	†
Viburnum opulus	4	100	†	†	†	†	†	†	†	†	†	†	20	64	3	10	8	26	†	†	†	†	†	4
V[illegible]occa	24	22	26	24	60	54	70	36	32	16	93	48	72	39	29	15	87	46	†	12	49	†	3	†
V. sativa	†	†	†	†	†	†	2	50	†	†	2	50	3	50	†	†	3	50	†	†	†	†	†	†
V. sepium	33	32	33	32	39	36	86	47	23	12	77	41	72	42	23	13	77	45	†	7	3	2	3	†
Vinca minor	†	†	†	†	†	†	2	100	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†
Viola spp.	17	75	4	19	1	6	35	84	4	11	2	5	72	53	21	16	41	31	†	†	†	†	†	†
Zannichellia palustris	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	4	†	†	†	†	†
Algae	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	33	9	3	†	†	†
Charophytes	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	43	†	5	†	†	†
Fontinalis antipyretica	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	19	7	†	†	†	†

† denotes species not found

†† recorded by Conn Breen in 1989 (pers. comm.)

APPENDIX 3a

Plants of the Boundary Zone of the Royal Canal. Unit 1

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km sections                            111111111122222222223333333333444444444455555555556666666666777
                              123456789012345678901234567890123456789012345678901234567890123456789012

Acer pseudoplatanus           X XXXX X XXXXXX  X    X  XX X  X   XX XX  XX XXXX XXXXXXXXXX    X  X XXX
Achillea millefolium                     X                X  XXX        X   XX  XXXXX   X X
Aegopodium podagraria                                 X          XX   X        XX X   X  X  X
Aesculus hippocastanum             X   XX  XX                                   X                   X
Agrostis stolonifera          X  X         X    X    XX   XX  XX  X  XXXXXXXXXXXXXXX  X  XXX
Alisma plantago aquatica                               XX                    XX
Alnus glutinosa                                     X  XXXXX                   X XX
Angelica sylvestris             XX                      X    XX X       X X     X     X    X
Anthoxanthum odoratum                                             X   X           X
Anthriscus sylvestris                          X   X             X   X X     XX          XXX         X
Apium nodiflorum                                    XX                                 X
Arctium minus                                                         XX
Arrhenatherum elatius          X  X                  X     XX XX      X  XX    XXXX   X   XX   X
Arum maculatum                          XX                    X
Betula sp.                                X X            X                  X  XX X X       X
Betula pubescens                                         X
Brachypodium sylvaticum       XX       X                  X   XX XXXX XXXXXXX X XXXX  XX             X
Briza media                                                        X  X   XX     X XX
Bromus erectus                     X                    XXXX      XXX XXXXX    X
B. ramosus                                                        XXX   XXX   X     X
Calystegia sepium             X         XX      XXX                         X        X        X
Capsella-bursa-pastoris                                   X                  X    X       X
Cardamine flexuosa                                  X
C. pratensis                                                                 X
Carduus acanthoides                                                   X
Carex acutiformis                                   XX X                                 X
C. flacca                     X                             X        X        X   X X    X
C. hirta                                                 X      X
C. panicea                                             X
C. paniculata                                            X
C. remota                                                           XX             XXX
C. sylvatica                                                        XX     X  X    XXX
Castinea sativa                       X
Centaurea nigra                                  X          XX XX X   XX  X  XXXXXXXX     XXX
Cerastium fontanum                                          XX                    X        X
C. glomeratum                                                                           X
Chamaecyparis lawsoniana         X        X    X             X                    X                   XX
Cirsium arvense                 XX       XX     X  X      XX  X  X  X      X X  X      XX X
C. vulgare                    X XXX                 X      X X      X       XX  XX        X
Clematis vitalba                          X         X
Corylus avellana                    XXX   X                         XX    XXXXXX    X
Cotoneaster sp.               X
Crataegus monogyna            XXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXX
Crepis capillaris                                                                                X
Cynosurus cristatus                                             X      X  X   X  XXX  X
Dactylis glomerata             X                     X   XXXX XXX  X XXXXX  XXXXXXXXXX X XXX
Daucus carota                                                XXXX              X           X
Deschampsia caespitosa                                        XX             X  XXXXX
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APPENDIX 3a contd. - Boundary Zone

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                                   111111111122222222223333333333444444444455555555556666666666777
km sections                        123456789012345678901234567890123456789012345678901234567890123456789012

Dryopteris filix-mas                                         I      I I I     II  I      I       I  I II II
Elymus repens                       II   I        I I           I II     II I    II  I III   II
Epilobium angustifolium                                         I
E.        hirsutum                    I II            I   II   I  III I            I  II I II
E.        montanum                  II                                I
E.        parviflorum                                      I                        I         I
Equisetum arvense                                               III I I   I      II IIIIII     II
E.        fluviatile                                       I
E.        palustre                                           I
Euonymus europaeus                        I                              I    I    I I
Eupatorium cannabinum              I                              I
Euphorbia peplus                                                                            I
Euphrasia agg.                                                    I
Fagus sylvatica                     III   III   II       I             III  II   III IIII  III IIII I
F.        purpurea                               I
Festuca arundinacea                                           IIII                       I
F.        pratensis                                           IIII           I   I
F.        rubra                    IIIIIIIIII II     I I IIIIIIIII IIIIIIIIIIIIIIIIIIIIIII IIIII  II
Filipendula ulmaria                                    I  II   IIII             II  IIIII      I
Fragaria vesca                                               I         II   IIIII  I            I
Fraxinus excelsior                 IIIIIIIIIIIIIIIIIIIIIIII IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII IIII IIII III
Galium aparine                                                        I   II  I  I   I  II   I
G.        verum                                                 II  I     II  I   II  III
Geranium pyrenaicum                                       I
G.        robertianum                    I  IIII I    II I   II  IIIIIIIIII IIIIIIIIIIIII II  IIIII   I  I
Geum urbanum                                I          I      I     IIIIII   IIIII III  II  I    I
Glyceria fluitans                                       II                            I I
G.        maxima                   I  II    I I         IIII                         III  I   I    I
Hedera helix                       IIIIIIIIIIIIII  IIIIII   IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII IIIIIII    III
Heracleum sphondylium              I                          III  I    II  I III IIIII II II      I
Holcus lanatus                                I               II III               IIII  I    II   I
Hypericum perforatum                          I        I
Hypochoeris radicata                                              I
Ilex aquifolium                    I IIIIIIIII                  I     III I I  II    IIII I I   III
Iris pseudacorus                                      III I II                       I I
Juncus articulatus                                                               I
J.     effusus                                        II II II                   III
J.     inflexus                                       II                         II
J.     subnodulosus                                                                      I
Knautia arvensis                                   I          I   I                     I
Lapsana communis                   I I                      I       I                          I
Lathyrus pratensis                 I              II         III II         I     I I            I
Lemna minor                                            III                            I  I
Leontodon hispidus                 I                           II II I   I      II   I       II
Leucanthemum vulgare                                           I        I                 I
Ligustrum vulgare                    IIIII   II    I    I   III III I IIIIIIIIIIIIIIIIIIIIIIIIIIII II
Linum catharticum                                                              II             I
Lolium perenne                                              II                      I
Lonicera nitida                                                          I           I    II    I  I
L.       periclymenum                I                             III      I IIIII   I I    I
L.       xylosteum                                                               I
Lotus corniculatus                                                I     I   I    I IIII
Lythrum salicaria                                      I   I   I
```

APPENDIX 3a contd. Boundary Zone.

km sections	1111111111222222222233333333334444444444555555555566666666667777 12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
Malus sp.	I I I I I
Matricaria matricarioides	I I
Medicago lupulina	I I I
Mentha aquatica	I I I
Menyanthes trifoliata	I
Molinia caerulea	I
Nasturtium officinale	I I . II I I I
Odontites verna	I I
Oenanthe sp.	I I
Origanum vulgare	I
Oxalis acetosella	I I
Phalaris arundinacea	I II I II II I I IIII II I
Phleum pratense	I I II I I IIII I IIII
Phyllitis scolopendrium	II I I I I I III I IIII I II I
Picea sp.	II
Pimpinella saxifraga	II III II II I
Pinus sylvestris	III I I I I I I I I
Plantago lanceolata	II I II II IIIIIIIII I
P. major	I I I
Poa annua	II I I I IIIII
P. pratensis	I I
P. trivialis	I IIII
Polygonum persicaria	I
Populus sp.	I I II I I I I I
Potentilla anserina	I I I I IIIIII I II I
P. reptans	II I I I I I I I I II I III II II
p. sterilis	II I IIII I
Primula vulgaris	I II IIIII I
Prunella vulgaris	I I I
Prunus spinosa	I II III I I II I I III I IIIIIIIII I I II I I
Prunus sp.	I I I I I I II
Pteridium aquilinum	I II IIII I I
Quercus agg.	IIIII III I I I III III I I
Ranunculus acris	I I I I I
R. repens	III I I IIIII III II I I III I I
Reseda luteola	I I I
Rhinanthus minor	I
Ribes uva-crispa	I I
Rosa canina	IIII IIIIIIIIII IIIIII II IIIIIIIIIIIIIIIII IIIIIII I III IIII I II
R. pimpinellifolia	I I IIII I
Rubus fruticosus agg.	IIIIIIIIIIIIII IIIIIIII II IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII III
Rumex conglomeratus	I I I
R. crispus	I I
R. hydrolapathum	I
R. obtusifolius	I I I
R. sanguineus	I I I
Salix alba	I I I I II I
S caprea	I II
S. cinerea subsp. *oleifolia*	I I I I I I I I
S. fragilis	II II I I I I II I
S. purpurea	I I I
S. viminalis	II I

APPENDIX 3a contd. Boundary Zone.

In sections	1111111111222222222233333333334444444444555555555566666666677712345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
Sambucus niger	III II IIIIII IIIIII IIIIIIIIIIII IIIIII III IIIIIIIII IIII II
Sanguisorba minor	I II I I I I
Sanicula europaea	I
Senecio jacobea	I I I I I I I
S. vulgaris	I
Silene alba	I
Sinapsis arvensis	I
Solanum dulcamara	I II I
Sonchus arvensis	I I I I I
S. asper	I I
S. oleraceus	I I II
Sorbus aucuparia	I I
Sparganium emersum	I I I
S. erectum	II
Stachys palustris	I
S. sylvatica	I I I
Stellaria media	I I I
Succisa pratensis	II I I II I I II II II
Symphoricarpos albus	I I I IIII II I I II II I
Syringa vulgaris	I
Taraxacum agg.	I I II II I I II IIII III II
Taxus baccata	I I I
Tilia agg.	I
Trifollium pratense	II II III IIIIIII II
T. repens	II II III IIIIIII II
Tussilago farfara	I I
Ulex europaeus	I I II I IIII IIIII I
Ulmus agg.	II III II I I III I II II I
Urtica dioica	IIII I I I II I I II IIIIIII IIIII IIIIIIIIII I
Valeriana officinalis	I I I I I I
Veronica beccabunga	I I I
V. catenata	I I
V. chamaedrys	I I III IIII I
V. montana	I II II I
V. persica	I
Viburnum opulus	II I
Vicia cracca	I I II I II I I I IIII I II
V. sepium	I I I I I I II II II III I IIIII I I I
Viola sp.	II IIIIII I II I

APPENDIX 3b

Species found in each section along the Boundary Zone of Units II and III of the Royal Canal.

```
UNIT                                                      II                               III
                            DDDDDDDDDDDDD                              111  1111111111111111111111111111111  LLLLLLLL
                                     1111  7777777788888888889999999999000  0000000111111111122222222223333
                            1234567890123  2345678901234567890123456789012  3456789012345678901234567890123  12345678
Acer pseudoplatanus            XX XX  XXX  X   XX X   XXX XX    X     XXX   XX X       XXX  XXXXXXXXXX          X   X
Achillea millefolium         XXXXXX XX XX  XX XXXX  XXXX XXXX  X XX X X XX     XXXXXXX X X  XXX XX        X  X
Aegopodium podagraria               X  X X                             XXX     X              X            X
Aesculus hippocastanum                                                              X
Agrimonia eupatoria                    XX        X           XX   X         XX X      X      X  XX X
Agrostis capillaris                   XXX      XXXX            XXX XXX X X  X X XXXXXXX        XXX    X          XXX
A. stolonifera               XXXXXXX            X   X    XXXX    XXXXX         X  XXX   X         X                XX
Ajuga reptans                                                                             X  X
Alisma plantago-aquatica                           X        XX     XX
Alliaria petiolata            XXX     XXX                 X                                              X
Allium vineale                 XX   X                                                   X
Alnus glutinosa                                        X             X                  X   X XX      XX        X    X
Anacamptis pyramidalis                            XXXXX                           XXX     X      X              X
Anagallis tenella                                                                 X
Andromeda polifolia                                                     XX                 X
Angelica sylvestris           X    X          XX XX     X   X      XXXXXXX     XX     XX  XXXX  X  X   X X      X
Antennaria dioica
Anthoxanthum odoratum          X   XX XXX   X XXXXX XXXXXXXXX XXXXXXXXXXXX  XXXXXXXX     XXX X  X X             XXXX
Anthriscus sylvestris         XXXXXXXXXXX    X  X           X    XX   X XX  X  X XX X    X   XXXXX XX
Anthyllis vulñeraria                    X
Apium nodiflorum                   X            X      X     XX   XX            X
Arctium minus                AX X X        X  X                       X              XX        X
Armoracia rusticana             X
Arrhenatherum elatius        XXXX XXXXXXX  XXXXXXXX    X XXX XXXXXXXXXXXX   XXXX    XX  X      XXXX  XXXXXX       XXX
Artemisia vulgaris            XX X
Arum maculatum                     X  XXX       X X                              XX  XXXX X XXXXXXXXX   XX     X
Asplenium ruta-muraria        X                 X                                                                X
A. trichomanes                X                 X       X
```

APPENDIX 3b cont.

UNIT	DDDDDDDDDDDDD 1111 1234567890123	II 111 7777777788888888889999999999000 2345678901234567890123456789012	III 1111111111111111111111111111111 0000000111111111122222222223333 3456789012345678901234567890123	LLLLLLLL 12345678
Avenula pubescens	X X XXXXX	XXXX XXXXXX X XXXXXX XXXXX	X XXXXXXX XX X X	
Baldellia ranunculoides		X X		
Bellis perennis	XXX X	XXXXXXXXXXX XXXX X XX	XX X X X	XX
Betula spp.		XXX	XXX X	
Brachypodium pinnatum			X	
B. sylvaticum	X XXX	XX X X X X	XXXXXXXX XXXXXXXXXX XX	XX XX
Brassica rapa	X X	X	X	
Brizia media	X X X	XXXXXXXX XXXXXX XXXXXX	XX XXXX X	X
Bromus erectus	XXX	X X X		
B. hordeaceus		X	X	
B. ramosus	X			X
Buddleja davidii	X		X	
Callitriche spp.		X X		
Calluna vulgaris		XX	XX	
Caltha palustris		XXX X X XX X	X	
Calystegia sepium	XXXX XX	X XX XX X XX XXX	XX XXX XXXXX XXXXX XXX	XXX
C. silvatica	XXXX			
Capsella bursa-pastoris		X	XX X	
Cardamine flexuosa		X		
C. hirsuta		X		
C. pratensis	X	XXX X X X X	X	
Carex acuta		X		
C. acutiformis	X	X X		
C. caryophyllea		X	X	
C. diandra		X		
C. disticha		X X X X X XXX X	X	
C. echinata		X X	X	
C. elata		X		
C. flacca	X X	XXXXX XX XX X	XXXXX XXXXXX	X
C. hirta	X XX X	X XXX X X XXXXXXX	XXXXXX X	XXX
C. lepidocarpa		X	X	
C. nigra		X X	X X	

APPENDIX 3b cont.

UNIT	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	L1	L2	L3	L4	L5	L6	L7	L8
														II																															III																																							
C. panicea												X					X	X	X				X															X	X	X														X	X	X								X	X																							
C. pulicaris																																																	|X|																																								
C. remota												X	X					X		X								X																														X		X	X	X			X		X	X	X	X	X	X	X			X	X			X		X	X			X			
C. rostrata																		X	X				X																																												X		X											X								X		
C. sylvatica												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	
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	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			X		X			X	X	X		X	X	X
Centaurium erythraea																																																				X																																				
Cerastium fontanum																			X		X					X												X			X								X	X		X											X	X																						X	X
C. glomeratum																													X																																																								X	
Ceratophyllum demersum																																						|X|																																																		
Ceterach officinarum																																																																																				X				
Chamaecyparis lawsoniana												X	X											X																	X		X							X			X																															X			
Chamomille suaveolens							X									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	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	
C. palustre																	X	X	X		X	X	X				X	X		X			X			X		X	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		X	X			X	X		X					X		X	X				X	X			X				X	X								X	X								X		X
Convolvulus arvensis		X	X																																																																																		
Corylus avellana																					X														X											X							X			X	X	X	X	X	X	X	X	X	X			X					X			X	X	X	X	X			
Cotoneaster spp.																								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	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	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Crepis biennis											X	X																																																																											
C. capillaris													X								X			X	X		X	X																																																											
C. vesicaria		X	X	X	X	X																														X								X	X					X																																							X
Cymbalaria muralis			X																			X																																																																		
Cynosurus cristatus								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	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	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	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	
D. maculata																																																													X																							
Danthonia decumbens																							X																																																																
Daucus carota											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										
Deschampsia caespitosa																												X				X	X	X	X	X				X	X		X			X	X	X	X		X													X	X												X						

APPENDIX 3b cont.

UNIT	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	II 72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	III 103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	L1	L2	L3	L4	L5	L6	L7	L8
Drosera rotundifolia																																								X	X																							X	X																							
Dryopteris filix-mas							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
Echium vulgare																						X																																																													
Eleocharis palustris																								X																																								X																					
Elodea canadensis																																	X																																																			
Elymus repens						X							X							X								X	X		X														X									X							X	X		X	X																			
Empetrum nigrum																																									X																					X	X																						
Epilobium angustifolium				X			X		X	X							X	X				X				X													X	X								X																																			
E. hirsutum			X	X	X	X	X	X	X			X					X	X			X													X	X		X		X		X			X																																						
E. montanum											X	X	X		X						X	X					X																											X	X	X	X		X		X	X	X	X	X	X	X		X					X		X							
E. palustre																	X		X														X					X						X																																						
E. parviflorum					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	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
E. fluviatile								X										X	X				X				X				X	X						X	X		X								X											X		X													X								
E. palustre																									X								X																X	X				X																																
E. telmateia																																																																																	X	X			
E. variegatum																					X												X																																																	
Erica tetralix																																								X	X																							X	X																							
Eriophorum angustifolium																	X																						X	X											X										X																					
E. latifolium																		X				X							X																																																			
E. vaginatum																																								X	X																									X																						
Euonymus europaeus																																																										X			X	X		X															X				X
Eupatorium cannabinum			X			X	X		X	X	X	X	X																																																																			
Euphrasia spp.																		X	X		X	X	X																		X									X		X																															
Euphorbia helioscopia																																																										X																									
E. peplus																																									X																																												
Fagus sylvatica																						X	X			X				X											X				X			X		X							X					X	X		X																	X		X
Festuca arundinacea																	X								X								X	X				X	X	X	X		X					X	X		X				X				X			X		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	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	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	X	X	X	X	X		X	X		X	X							X		X	X	X	X	X	X						X			X				X	X	X	X	
Foeniculum vulgare			X																																																																																	

APPENDIX 3b cont.

UNIT	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	L1	L2	L3	L4	L5	L6	L7	L8
																							II																																									III																				
Fragraria vesca											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	
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		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	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Fuchsia magellanica				X	X																																																																																
Galium aparine		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	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	X	X	X	X	X	X
G. palustre								X										X		X				X								X							X																							X															X					
G. uliginosum																				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	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		
Geranium dissectum				X																																																																																	
G. molle				X																																																																																	
G. robertianum				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	X	X			X		X	X	X	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	X			X	X								X	X		X			X	X	X	X	X	X		X	X	X		X	X		X	X			X	X		
Glechoma hederacea																								X	X																												X				X	X	X	X		X	X	X		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	
G. plicata																																								X																																													
Gymnadenia conopsea																	X			X	X		X																					X							X																															
Hedera helix			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X		X		X	X	X	X	X	X	X	X	X		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	X	X	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	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	X	X				X	X					X	X	X	X	X
Hieracium pilosella																								X		X			X		X				X																			X																													X				
H. spp.			X	X																																																																															
Hippuris vulgaris																																	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	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
Hordeum murinum		X	X																																																																																		
Hyacinthoides non-scriptus				X							X		X								X																																						X																							
Hydrocotyle vulgaris																																																					X																																
Hypericum androsaemum								X												X																																																								X		X				
H. hircinum		X																																																																																			
H. perforatum												X												X	X		X																						X																												X						
H. pulchrum																																																													X								X																
H. tetrapterum																	X				X											X					X		X				X					X		X																															
Hypochaeris radicata																	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
Ilex aquifolium													X								X																				X				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	X	X	X																			X	X		X								X			X							X	X

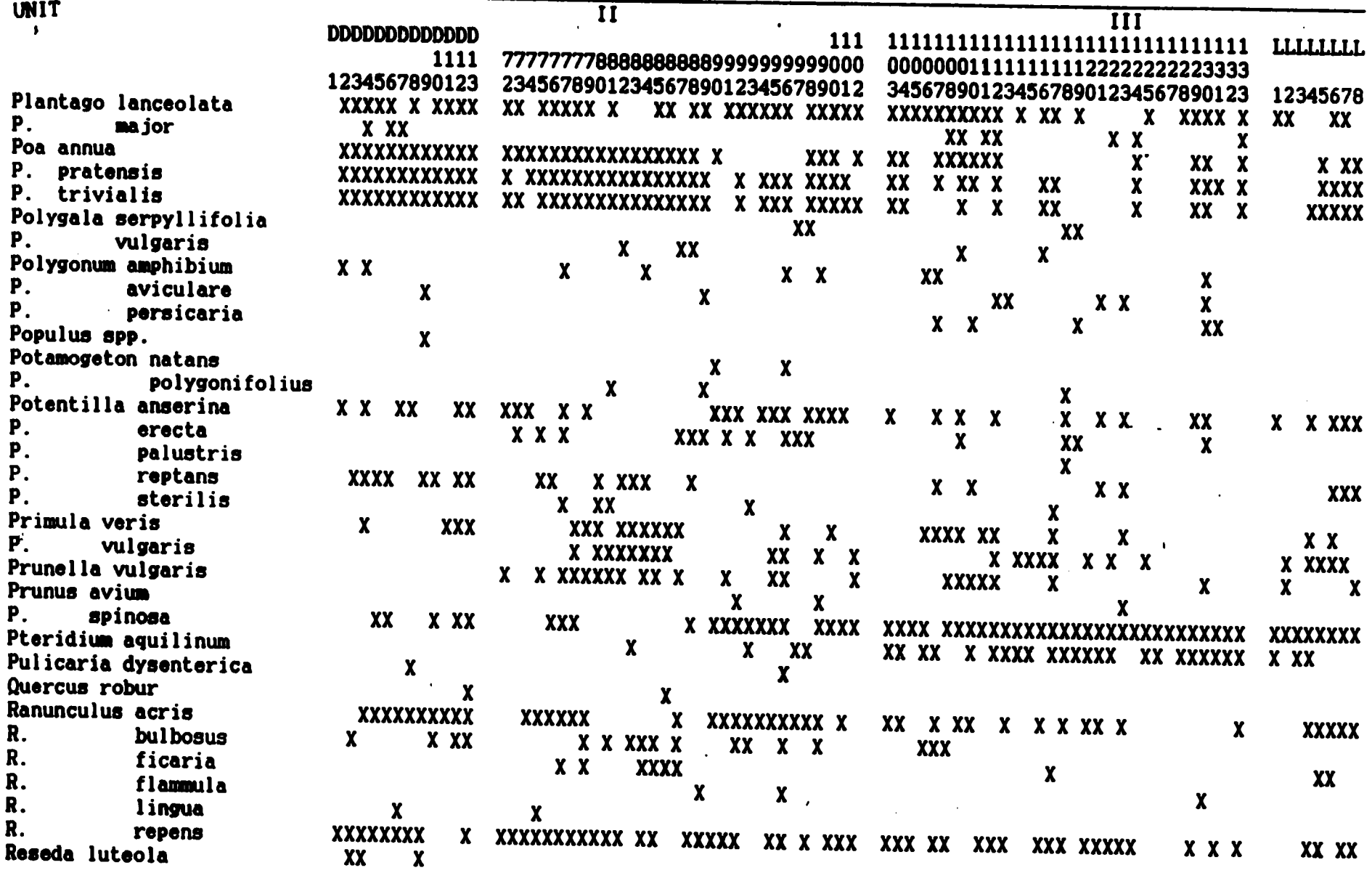
APPENDIX 3b cont.

UNIT	II	III	
	DDDDDDDDDDDD	111	1111111111111111111111111111	LLLLLLLL
	1111	777777778888888888999999999000	000000011111111112222222223333	
	1234567890123	2345678901234567890123456789012	3456789012345678901234567890123	12345678
Juncus acutiflorus			X	
J. articulatus	XX X XX	X	X X	
J. bulbosus	XX		X	
J. conglomeratus			X	
J. effusus	XX XX X X XXXXXXX X		X X	
J. inflexus	XX XX XX XXXXX XX		XX	X
J. subnodulosus	X XX X X XX	X		
Knautia arvensis	X XXX XXXXXXXXXXXXX X XX X	XXX X XXXX XXXXX X	XXX XXX
Lamium purpureum	X X X		
Lapsana communis	XXX X XXXX X	XXX X	X XX
Larix spp.	X		
Lathyrus pratensis	XXXXXXXXXXX XXXXXX X X XXX XXX XXXXX XXX	XXXXXX XX X X XXXXXXX XX X	X XXX
Lemna minor	XX X	XX	
L. trisulca	X		
Leontodon autumnalis	XX XXXX X		
L. hispidus	X X X XXXXX XXXX X X	XX	
L. taraxacoides	X X	X X	
Leucanthemum vulgare	X XXXXXXX XX X X	XXXXXXX XXX XXX X X	X
Leycesteria formosa	X X		
Ligustrum vulgaris	X X XX XXXXX XX XXX XXXX	XXXX XXXX XX XX XXXXXXXXX XXXX	XXXXXX
Linum bienne	X		
L. catharticum	X X X	X X	X
Listera ovata	X X X	XX X X X	
Lolium perenne	XXX X X X X XX XX X	X X X	XX
Lonicera nitida	XX X X	X X X	
L. periclymenum	X XX X X XX XX	XX X XXX X X XXXXXXXXX XXXX	XX XX
Lotus corniculatus	XX X XXXXX XXXXXXXXXXXXXXXXXX XX XXX	XXXXXXXXX X X	X X
Luzula campestris	X XX X XX	X X X X	
Lychnis flos-cuculi	X X X	X	
Lysimachia nemorum		X X	
Lythrum salicaria	X X X X XX X XX	XXX X	
Malus spp.	X	X	

APPENDIX 3b cont.

UNIT	DDDDDDDDDDDDD	II	III	LLLLLLLL
	1111	77777777888888888899999999990000	00000001111111111222222222333	
	1234567890123	2345678901234567890123456789012	3456789012345678901234567890123	12345678
Malva sylvestris	X X			
Medicago lupulina	XX X X X	X X	X	X
Melampyrum pratense		X	X	
Mentha aquatica	X	XXX XX XXX XX X	X X X X X	X
Menyanthes trifoliata		X X	X X	
Molinea caerulea		X X XXX	X X	
Myosotis arvensis	X XX	X	X	
M. scorpioides		X X X		
Myrica gale		XX	XX X	
Myriophyllum spp.		X		
Narthecium ossifragum		XX	XX	
Nasturtium officinale	X	X X X X		
Odontites verna		X XXXXXXX XX XX X	X	
Ononis repens	X XX			
Origanum vulgare	XX		X	
Oxalis acetosella				X X
Papaver spp.	X X XXX			
Parnassia palustris		X X X	X	
Pedicularis palustris		X		
P. sylvatica		X	XX	
Petasites hybridus	XX XX	X	X	
Phalaris arundinacea	X	X XXXX XX XX X	X	X
Phleum pratense	XXX	XXXXX X XXXXXXX XX XXXXXX	XXXXXXXXX XX XXXX X X X X XXX	
Phragmites australis		X X X XX	X	
Phyllitis scolopendrium	X XX XXX	XXX X XXX XXXX X	XXX X X XX X XXXXXX	XX XX
Picea spp.		X		
Pimpinella saxifraga	X XX	XXXXXXXXXXXXX XXXXXX	XXXXX XXXXX XX X X X X	X
Pinguicula lusitanica			X	
P. vulgaris		X		
Pinus radicata	X			
P. sylvestris		X X	X X	

APPENDIX 3b cont.



APPENDIX 3b cont.

```
UNIT                                                    II                               III
                           DDDDDDDDDDDDD                              111  1111111111111111111111111111111  LLLLLLLL
                                    1111  7777777788888888889999999999000  0000000111111111122222222223333
                           1234567890123  2345678901234567890123456789012  3456789012345678901234567890123  12345678
Rhinanthus minor              X              X   X X  X  X    X  X                 X                X           XX
Rhynchospora alba                                                                                   X
Ribes uva-crispa             XX                        X
Rosa canina agg.              X XX  XXXX      XXXXXX  X XXX XX XXXXXXXXXX  XXXXXXXXX   XXX XX  X XXXXXXXXX  XX XXXXX
Rubus fruticosus             XXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX  XXXXXXXX
R.    idaeus                                                        X                                   X
Rumex acetosa                                                XXXXXX          X XX      XX    X      X         X
R.    hydrolapathum                                                X
R.    obtusifolius          X XXXX X      X XX    X      X X  X      X  X           X        X       X X X
R.    sanguineus                     XX      X X                                     X X   XX           X
Sagina nodosa                        X             X
Salix alba                        X X                                                     X  X
S.    aurita                                      X
S.    cinerea                                              X            XXX                     X  X
S.    fragilis                    XX                                            X                  X
S.    purpurea                                                        X
S.    repens                                                         XX                     X
S.    viminalis                                                  X       X              X       X                      X
S.    spp.                                                   X       X         XX  X       X      X   X            XX
Sambucus nigra                 XXXXXXXX XX   XXXXXXXX   XXXXXXXXX XX   X XX  XXXXXXXXX X XX     XXX  X   X X     X XXX
Sanguisorba minor                                  XX  X   X     X       X       XXX  X
Sanicula europaea                                                                                           X  X                X
Schoenus nigricans                                 X           X X                   X        XX
Scirpus caespitosus                                                XX                     XX
S.      lacustris                                                   X
Scrophularia nodosa                                  X                                  X                   X
Senecio aquaticus                     X            X              X
S.      erucifolius                  XX
S.      jacobaea               XXX X    XX   XXXXX XXX          XXXXX    X    XXXXX X  X  XXX  XX                    X
S.      vulgaris               X X   X        X                        X                       XX       XX
Sherardia arvensis           X                                                                 X
Silene alba                            X             X
```

APPENDIX 3b cont.

UNIT	DDDDDDDDDDDDD	II	III	LLLLLLLL
	1111	111	11111111111111111111111111111	
	1234567890123	7777777788888888889999999990000	0000000111111111122222222223333	
		2345678901234567890123456789012	3456789012345678901234567890123	12345678
Sinapsis arvensis	X		X	X
Sisymbrium officinale	XXXX	XX		
Smyrnium olusatrum	XX			
Solanum dulcamara	XX	X	X	X
S. tubersum			X	X
Sonchus arvensis	XXX	X XXX X	X XX XX X X	
S. asper	XX		X X	X
S. oleraceus	XX X XX			
Sorbus aucuparia		XX		
Sparganium emersum		X		
S. erectum	X	X X X		
Stachys palustris	X	X X XXX XX X	X X X	
S. sylvatica	X X	X X X X X	X X XXXXX	X X
Stellaria graminea		X XX	X	X X
S. holostea			X	
S. media		X X	X X XX	
S. palustris		X X		
Succisa pratensis	X	X XXXXXX X X X XXX	X XX X X	
Symphoricarpos albus	XXXX X	X X XX XX XX XXXX X X XX X XXXX X X X	X	X X
Symphytum officinale	X	X		
Syringa vulgaris	X	X XX		
Tanacetum vulgare	X			
Taraxacum spp.	XXXX XXXXXXX	X XXXXXXX X X X X X X X X X X XX XXXX X		X X
Tilia agg.			X	
Torilis japonica		X X XX XX X X X X X XX X X	XX	
Tragopogon pratensis	X			
Trifolium dubium	XXXX XX	X X X		
T. pratense	XX XXX XXX	XXXXX XXX XXXXXX XXXX X XXX XX XXXX XX XX XXXXX X X		XX
T. repens	X X X X	XXXXX XXX X XX X XX XX XX X XX XXX X XX XXXX X X		XX
Triglochin palustris		X X		
Trisetum flavescens	X XX	X XX XX X X X		
Tritonia crocusmiflora			X	

APPENDIX 3b cont.

UNIT		II		III	
	DDDDDDDDDDDDD	111	1111111111111111111111111111111	LLLLLLLL
	1111	77777777888888888899999999990000	00000001111111112222222223333	
	1234567890123	2345678901234567890123456789012	3456789012345678901234567890123	12345678
Tussilago farfara	X X X		X	X
Ulex europaeus	XXX	X XXX X X XXX XXX	XXXXXXX X XXXX XX XXX	X
Ulmus agg.	X XX X	XX	X	X X
Urtica dioica	XXXXXXXXXXXX	XXXXXXXXXXXXXXX XX X XX XXXXX	XXXXXXXX XXXXXX XXXX XXXXX X	XX XXXXX
Valeriana officinalis	X X X	XXX X XX XXX XXXX X	X XX X XXX X	X
Veronica beccabunga	X	X X		
V. catenata		X		
V. chamaedrys	XXXXX	XXXXXX XXXXXXX X X XX XXXX	X XX XXXXXXXXXXXXXX XXX	X XXXXX
V. montana		X X	X X X X X	X
V. persica		X	XX X	
V. serpyllifolia		XX X	X XX	
Viburnum opulus			X XXXXXX	X
Viccia cracca	XXXX X XX	XXXXXXXX XXXXX X XXXXXXXXXX	XXXXX XXXXXXX XXXXXXXXX XXX	X XXX
V. sativa	X			X
V. sepium	XX XXXXXXXX	XXXXXXXXX XXXXX XXXXXXXXXXXXX	XXXX X XXXXXX XXXXXXXXX XXX	XXXXX
Vinca minor		X		
Viola riviniana	XXX	X XXXXXX X XXXX	XX XXX XXXXXX XX XXXXXXXXX	XX XXXX

APPENDIX 4a

Plants of the Towpath Zone of the Royal Canal – Unit I

km sections	1111111111222222222233333333334444444444555555555566666666677 12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
Acer pseudoplatanus	I I
Achillea millefolium	IIIIIII II II IIIII I I IIIII IIIIIIII II I IIII I IIIIII
Aegopodium podagraria	I I I I
Agrimonia eupatoria	I
Agrostis stolonifera	IIIIIIII III IIIIIIIIIIIII II IIIIIIIIIIIIIIIIIIIIIIIIII IIIIIIIIIII
Alnus glutinosa	II II I
Anagallis arvensis	II I
Angelica sylvestris	I III I I II I I II I
Anthoxanthum odoratum	I I II I III I I I III I IIIIII
Anthriscus sylvestris	II I I I I I
Apium nodiflorum	I
Arctium minus	IIII II II I III III I I I
Arrhenatherum elatius	IIIIIIII II III I I IIII I I III II II II I IIII I I II
Atriplex sp.	III I I I
Bellis perennis	IIIII II IIIII II II IIIIIII IIIIII I II III III
Betula sp.	I I
Brachypodium sylvaticum	II I
Briza media	II I IIIII I I I II IIII I I IIIIII
Bromus erectus	I I IIII I I I I I I
B. ramosus	I I I
Calluna vulgaris	I
Calystegia sepium	I I II I I I I
Capsella-bursa-pastoris	I II I III I II I I I II I I II
Cardamine flexuosa	I
C. pratensis	I
Carduus acanthoides	I
Carex acutiformis	I I I
C. denisa	I
C. disticha	I I
C. flacca	I III I I I I III I II IIIII IIII I I IIIII
C. hirta	I I IIIII I I I I
C. lepidocarpa	II I
C. nigra	II I
C. obtrubae	I I I
C. panicea	I
C. pulicaris	I
C. remota	II II II I
C. rostrata	III
Centaurea nigra	III IIII I I II III II II IIII III III IIII III II IIIIIII
Cerastium fontanum	IIII I I III I II II I I II
C. glomeratum	I
Chaenorhinum minus	I I I
Chenopodium album	II I I I
Cirsium arvense	II I I I IIIIIIII II IIII I I I II I I I I
C. palustre	I I II II II I II I
C. vulgare	III II I II I I I II I I I II II I
Corylus avellana	I
Cotoneaster sp.	I
Crataegus monogyna	II II IIIII I I I I IIII
Crepis capillaris	I I I

APPENDIX 4acontd. Towpath Zone.

km sections	1111111111222222222233333333334444444444555555555566666666677 12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
Cymbalaria muralis	I
Cynosurus cristatus	I I I IIIII III IIIII IIIIIII IIII I IIIIIII III
Dactylis glomerata	IIIIIIIII III IIIIIIIIIIII II IIIII IIIIIIIIIIIIIIIIIII IIIIIIIIIIII
Daucus carota	II III II III I I I IIII
Deschampsia caespitosa	IIII II I I IIII
Dryopteris felix-mas	I
Elymus repens	IIIII III II I I II II I I I I III I I
Epilobium angustifolium	I I I
E. hirsutum	III III III I I II I II I
E. montanum	I
E. palustre	I I
E. parviflorum	I II I I I I
Equisetum arvense	IIIIIII II I IIII I I I I I I I II I I I I
E. fluviatile	II I
E. variegatum	II
E. tetralix	I
Eriophorum angustifolium	II I
E. vaginatum	I
Eupatorium cannabinum	IIIIIIII I I
Euphorbia peplus	I I I I
Euphrasia agg.	II I I I II IIIII
Fagus sylvatica	I
Festuca arundinacea	I IIIIII I I IIIII
F. pratensis	I I I IIIII I I I I
F. rubra	II I I II III IIIIIII I IIIIIIIIIIIIIIIIIIIIIIII IIIIIIIIIII
Filipendula ulmaria	III I III II IIIII I IIII II I II II III III
Fragaria vesca	II
Fraxinus exelsior	II I I III I I I I
Fumaria officinalis	I
Galium aparine	I I I I II II I I I I I I I I I I
G. palustre	I I I
G. verum	I I IIII II II I I IIII III I II II II I II I IIIII
Geranium pyrenaicum	II I
G. robertianum	I I I II I II I I
Geum urbanum	I
Glechoma hederacea	I
Glyceria maxima	IIIIII II III II III I I I II
Hedera helix	I III I I
Heracleum sphondylium	III I II IIII IIII III I I I I I I I I II
Holcus lanatus	IIIII II II I IIIIIII I II III I II III IIIIIIIIIII
Hypericum perforatus	I I I I
H. tetrapterum	II I II I I I
Hypochoeris radicata	I I I I
Ilex aquifolium	I
Iris pseudacorus	I II IIII II I I III
Juncus acutifloris	I
J. articulatus	I I II I I I I
J. conglomeratus	I
J. effusus	I II I II
J. inflexus	IIIII I III II II I II I I I II III I I
Knautia arvensis	I II I I II
Lamium purpureum	I
Lapsana communis	II II I II I IIII I I II I

APPENDIX 4a contd. Towpath Zone.

km sections	1111111111222222222233333333334444444444555555555566666666677 12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
Lathyrus pratensis	XXX XXXX I II I I II I II
Leontodon hispidus	XI XXI I I XXI II XI XI I XXXI XXI XXI XXXXXXXXXX
Leucanthemum vulgare	I II II I I I II
Ligustrum vulgare	II I I
Linum catharticum	I I I I I XXI
Lolium perenne	XI XI I I XXI XXXXXXI XI XI I XXXI I I I XI I I
Lonicera periclymenum	I I I
Lotus corniculatus	XXI II XXI I I XI XI I II I XXI
Lycopus europaeus	I I
Lythrum salicaria	I I I II XI I I I I
Matricaria matricarioides	I I I I I I I I I XI I I I
Medicago lupulina	XXI XXI XI I XI I XI I XI I I
Mentha aquatica	XXI I XI II I XXI II XXXI I I I
Menyanthes trifoliata	II I I
Molinia caerulea	II I II
Myosotis laxa	I
M. scorpioides	I I
Narthecium ossifragum	I
Nasturtium officinale	I II
Odontites verna	XXI I I I XXI I II XXI XI II XI I I I I
Ononis repens	XI I XI
Origanum vulgare	XI XXXI I
Oxalis acetosella	I
Papaver sp.	I I I XXI
Parnassia palustris	II
Pedicularis palustris	I
Phalaris arundinacea	XXXXXXXI XI XI XI I I II I XXXI I I I
Phleum pratense	XXXXXXXXI I XXXXXXXI I XI XI XXXI XI XI XXI XXI XI XXXI
Phragmites australis	I I
Phyllitis scolopendrium	I
Pimpinella saxifraga	I II II XI I XI XXXI XXXXI XI I XI XXI I XXXI
Pinus sylvestris	I
Plantago lanceolata	I XXXXXXI I XXXXI XXI XI I I I XI XXXI XXXXXXXXI XI XXXI XXXI
P. major	XXXXI I XI XXXI XXI I I I XXXXXXXXXXXXXXXXXXXXXX XXXI
Poa annua	XXXXXI XI XXXXXXXXI XI XXXXXXXXXXXXXXXXXXXXXX XXXXXXI XI
P. pratensis	XI XI XI XXXXXXI XI I XXXXXI I XI I I I
P. trivialis	I I XXI I
Polygonum amphibium	XXI XI I I I XXI I XI I
P. aviculare	XXI I I I I I I I I I I
P. persicaria	XI I
Populus sp.	XI I
Potentilla anserina	I XI I XI XI XXXXXX XXXXI XXXXXXXX XXXXXXI XI I XI I I I
P. erecta	I XXI
P. reptans	XI XXXXI I I XXXXXXXXI I XXXI XI XXXI I I XI I
Prunella vulgaris	I XXI XXXXI XI I I I I I XXI I I I XXI
Prunus spinosa	XXI XI I XI I I
Pteridium aquilinum	I I I XXI
Pulicaria dysenterica	XI XI I I I
Quercus agg.	I I I
Ranunculus acris	XXI I I XXXXXI I XI XI I XI I I I
R. flammula	I
R. lingua	I I
R. repens	XXI I XI I XXXXXI I I XXI I I I I XI XI I I I I I XI XI XI I I

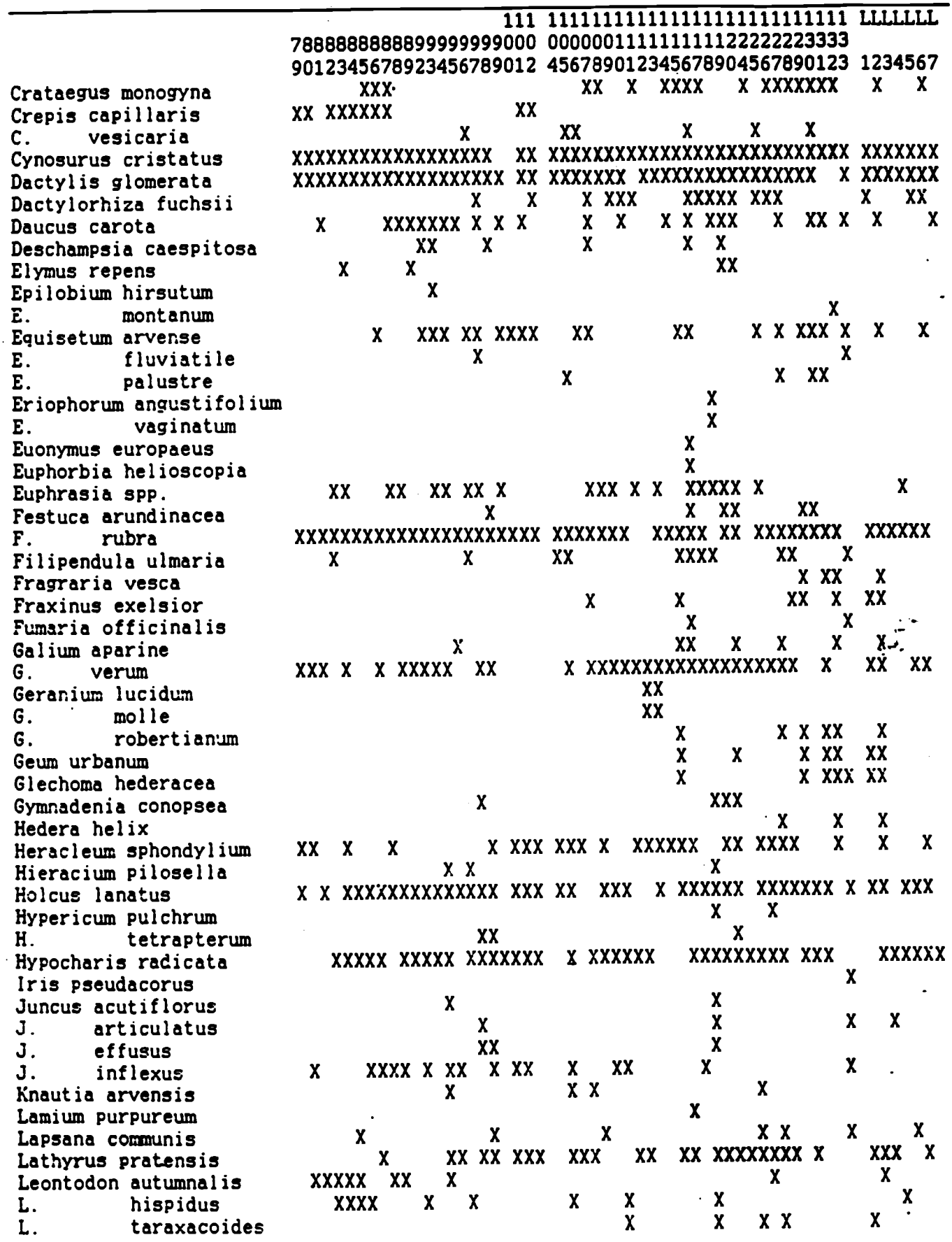
APPENDIX 4a contd. Towpath Zone.

km sections	1111111111222222222233333333334444444444555555555566666666677712345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
Ranunculus sceleratus	I
Reseda lutea	I I I I I
Rhinanthus minor	II I I I I I II III
Rhynchospora alba	?
Rosa canina	I I III I I I I
R. pimpinellifolia	I I
Rubus fruticosus agg.	III I I II I I IIIIII I III I I I I III IIIII
Rumex conglomeratus	III III I
R. crispus	I II I I I I
R. obtusifolius	II II I I I IIII I I I I I I I I II
Sagina procumbens	I
Salix alba	I I
S. cinerea subsp. oleifolia	I I I
S. fragilis	II I I I II II
S. purpurea	II I
Sambucus niger	I III I I
Sanguisorba minor	I II II I I III III I I I II IIII I
Senecio jacobea	I IIII III IIIIIIIII I II II I I II III I I
S. vulgaris	II I I II III II I I I I
Sinapsis arvensis	I III I I I I I I
Solanum dulcamara	I II II I I
Sonchus arvensis	II I I I II I I I
S. asper	III III I I I I I II
S. oleraceus	II I I I II I I I I I II
Stachys palustris	I I II
S. sylvatica	I I I
Stellaria media	I II I III II I II II
S. graminea	I
Succisa pratensis	II II I I II II IIIIII I III II I IIIII
Symphoricarpos albus	I
Taraxacum agg.	II IIII II IIIIIIIIIII II IIIIII IIIIII IIII III I IIII II
Trifollium pratense	IIII IIII I IIIIIIIIIIII II IIIII IIIIIII IIIIIIIIII II IIII IIII
T. repens	IIII IIII I IIIIIIIIIIII II IIIII IIIIIII IIIII IIII II IIII IIII
Triglochin palustris	I
Tussilago farfara	II III I II II I I II IIII
Ulex europaeus	III I I I I I I I I I I
Ulmus agg.	I I
Urtica dioica	III I II III II II IIIII I II I I I I I IIIIII II
Valeriana officinalis	II III II I II I II
Veronica chamaedrys	II I I I I I
V. persica	I I II I II I
Vicia cracca	IIIII II I III II I I I I I I
V. sepium	IIIIII I II III IIII I I I I I I II
Viola sp.	I I I I

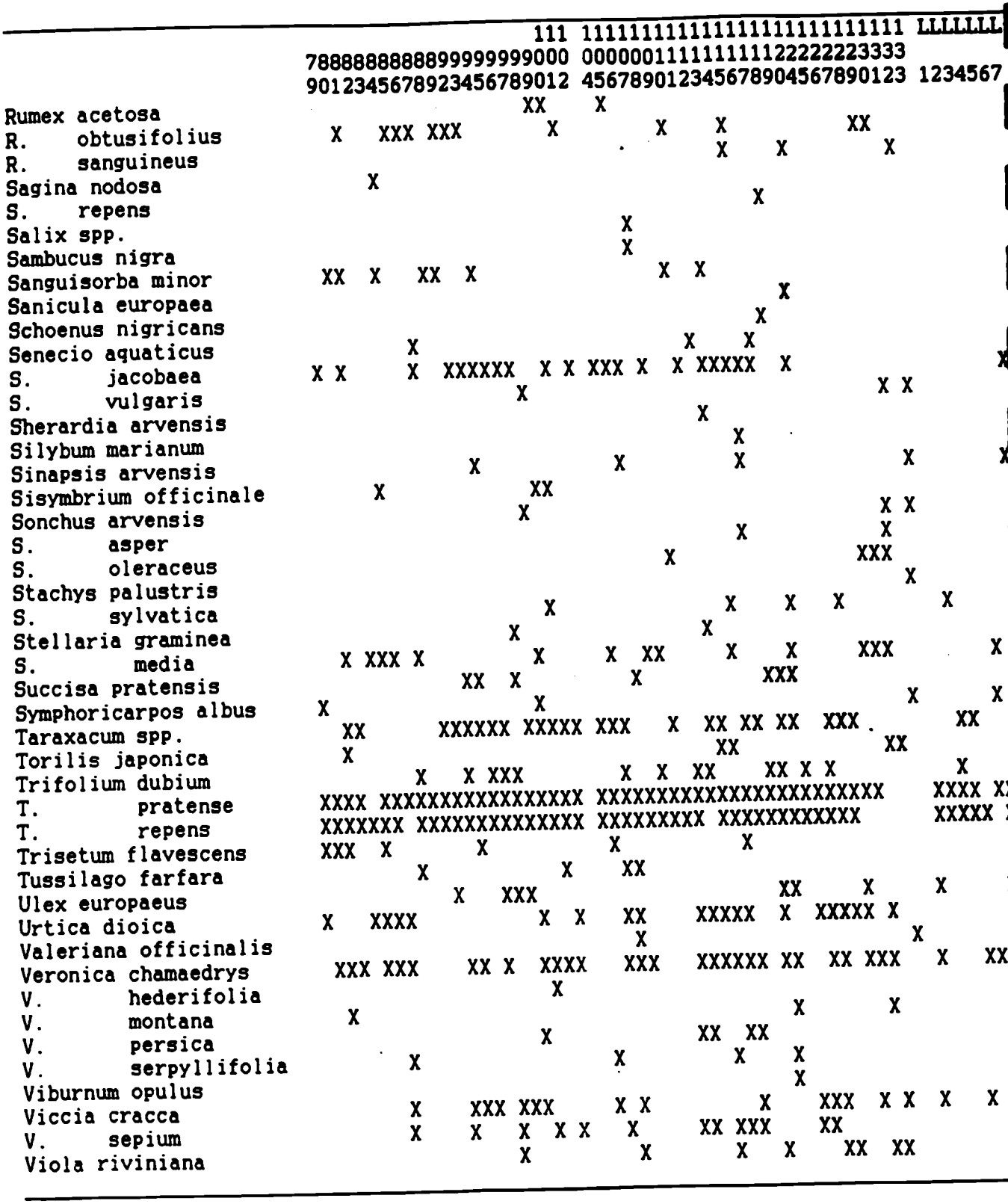
Species found in all sections of the Towpath Zone in Units II and III along the Royal Canal.

UNIT	II	III
	111	1111111111111111111111111111 LLLLLLL
	78888888888999999999000	00000011111111112222223333
	90123456789234567890 12	45678901234567890456789012 3 1234567
Achillea millefolium	XXXXX XXXXXXXXXXXXX XX	X XXXXXXXX XXXXXXXX XX X X X XX
Agrimonia eupatoria	X XXX	X X X X XXXXX X XX
Agrostis capillaris	XXX X	X X X XX XXXX X X XX
A. stolonifera	XX XXX X XX X	X X XXX X
Alliaria petiolata		X
Allium vineale		X
Alnus glutinosa		X
Anacamptis pyramidalis		X X
Anagallis arvensis		X X X X
Angelica sylvestris		X
Anthoxanthum odoratum	XXXXXXXXXXXXXXXXXXXXX	XXX XXX XX XXXXXXXXXXX X XXX XX
Anthriscus sylvestris	X X X X	X X
Arctium minus	X XXX	X X XX
Arrhenatherum elatius	XXXXXXX XX	X X XXXX XXX XX XX X
Arum maculatum		XX XX
Avenula pubescens	XXX X X XX X XX	X XXXX X XXX XXX X XXX XX
Bellis perennis	XXXXXXXXXXX XXXXX XXXX XXXXXXX	XXXXXXXXX X XX XX X
Betula spp.		X
Brachypodium sylvaticum		XXXX X XX X X
Brizia media	XXXXXX XXXXXXX XX XX XX X XX XX	XXXXXXXX XXXXXXX
Bromus hordeaceus	X X X X	X
Caltha palustris	X	X
Calystegia sepium	X X X	X X X XXX XX
Capsella bursa-pastoris	X X X X X	XXX X
Cardamine flexuosa		X
C. hirsuta	X	
C. pratensis	X X XX X	XX X
Carex acuta	X	
C. caryophyllea	X	X X
C. disticha	X	
C. flacca	X X XX XXX X XXX X	X XXXXXXX X XX XX
C. hirta	X X XXXXXXXXXXX X XX	X XXX XXX XX X X XXX
C. nigra	X X	XX
C. panicea	X X XX X X	XXX
C. remota		XX X X X
C. rostrata		X
C. sylvatica		XX X XX XX X X
Centaurea nigra	XXXXXXXXXXXXX XXXXXXX XX XXXXXX XXX XXX XXX XXXX	X XXXX
Cerastium fontanum	XXXXXXXX XXXXX XXXX XXX X XX XXXXXXXXX X	XX X
C. glomeratum	X X X X	
Chamomille suaveolens	XX X XXX X X XX X X X XX X	X . .
Chenopodium album	X X X	XXX X
Cirsium arvense	XXXXXXXXXXXXXXXX X XXX XXXXXXX XXXX X	XX X
C. palustre	X X X XXXX X X X X XXXX	XX
C. vulgare	XXX X X XX X X X	X X X
Corylus avellana		X X X
Cotoneaster spp.		X

APPENDIX 4b cont.



	111 111111111111111111111111111 LLLLLLL 7888888888899999999000 0000001111111111222222223333 9012345678923456789012 4567890123456789045678901 23 1234567
Leucanthemum vulgare	XXX X X X XXXXX XX X X X XXXX XXX X XXXX XX
Ligustrum vulgaris	X X XX X
Linum catharticum	XX X X XX XX X X X
Listera ovata	X
Lolium perenne	XXXXXX XXXX XXX XXXXX XXXX X X X XXXX X X XXXX XX
Lonicera periclymenum	X X X X XXX
Lotus corniculatus	XXXXX XXXXXXXXXXXXXX X X XX X XXXXXXXXXX X XX X
Luzula campestris	XXXX X XX X XXX XX X X X XXXXXXX XX
Lythrum salicaria	X
Medicago lupulina	X X X X XX XXXXX XX XXXXXX X XXXXXX X X X X
Mentha aquatica	X X X X
Menyanthes trifoliata	X
Molinea caerulea	XX X X
Myosotis arvensis	X X
M. discolor	X
Myrica gale	X
Odontites verna	XXXXXX XXXXXXXXXX X XX XXXXXXXXX XXXX X X X X XX
Orchis mascula	X XX
Oxalis acetosella	X
Papaver spp.	X
Parnassia palustris	X
Petasites hybridus	X X X
Phleum pratense	X X XXX XX XX XX X XXXXXXXXX XXXXXXX XXXX X X XXXXXX
Phragmites australis	XX
Pimpinella saxifraga	XXXXXXXXXXXXXX XX X X XXXXXXXXXXXX XX XX XXX X
Plantago lanceolata	X XXXXXXXXXXXXXXXXXXXX XXXXXXXXXX XXXXXXXX XXXX XXXX XX
P. major	XX XXXXX XXXXX XXXXX XXXX XX XX X XXX X XXX XXX X
Poa annua	XXXXXXXXXXXX XXX XXX X XX XXXX X X X XX XXX XX X
P. pratensis	X XX XXX X XXX XX XX X XXX XX XX X XX X XXXX XXXXXXX
P. trivialis	XX XX XXXX X XXX XXXX X XXX XXXXX X XX XXX XXXX
Polygala serpyllifolia	XX
P. vulgaris	X X X X
Polygonum amphibium	X X X XX X X X XX X X
P. aviculare	XX X XX X
P. persicaria	XX X X XX X
Potentilla anserina	XXXXXXXXXXXXXXXXXXXX XXXX XXXXXXXXXX XXX XX X XXXXXX
P. erecta	XX X XX
P. reptans	X XX X X X X XX X XX X
P. sterilis	X
Primula veris	XXX X X XXXXX XX XXX XX X XXXXX XXX X X XXX
P. vulgaris	X X X X X X
Prunella vulgaris	X XX XXXXXXXX XX X XX XXXX XXXXXXXXXXXX XXX XXXXXXX
Prunus spinosa	X X X XXXXXXX XXXXXXXXXXX XXXXXXX
Pteridium aquilinum	X XX X X XXXXXXX XX XXXXXX X
Ranunculus acris	XX X X XXXXXXX XXXX XXXX XXXXXX X XXXX X X X
R. bulbosus	XXXXXXX XXXXXXXX XXXXX X XX XX XXX XX X
R. flammula	X
R. repens	XXXX X XXX XX XXX XXXXX XX X X XXXX XXX X X
Reseda luteola	X
Rhinanthus minor	XXX X X X XX X XX X X XX X XXXXX
Rosa canina agg.	X X XX XX
Rubus fruticosus	XXX X XXX XXX XXXXXX XXXXXX XXXX XX X


111 1111111111111111111111111 LLLLLLL
78888888888999999999000 000000111111111122222223333
90123456789234567890123 4567890123456789045678901234567
Rumex acetosa
R. obtusifolius
R. sanguineus
Sagina nodosa
S. repens
Salix spp.
Sambucus nigra
Sanguisorba minor
Sanicula europaea
Schoenus nigricans
Senecio aquaticus
S. jacobaea
S. vulgaris
Sherardia arvensis
Silybum marianum
Sinapsis arvensis
Sisymbrium officinale
Sonchus arvensis
S. asper
S. oleraceus
Stachys palustris
S. sylvatica
Stellaria graminea
S. media
Succisa pratensis
Symphoricarpos albus
Taraxacum spp.
Torilis japonica
Trifolium dubium
T. pratense
T. repens
Trisetum flavescens
Tussilago farfara
Ulex europaeus
Urtica dioica
Valeriana officinalis
Veronica chamaedrys
V. hederifolia
V. montana
V. persica
V. serpyllifolia
Viburnum opulus
Viccia cracca
V. sepium
Viola riviniana

APPENDIX 5a

Plants of the Bank Verge of the Royal Canal. Unit 1

km sections	111111111122222222223333333333444444444455555555556666666666777 / 123456789012345678901234567890123456789012345678901234567890123456789012
Acer pseudoplatanus	I I III I I I I
Achillea millefolium	III I I III III II III I I IIIII IIIIIIII III
Aegopodium podagraria	II
Aesculus hippocastanum	I
Agrimonia eupatoria	II I I I II
Agrostis stolonifera	I III II III IIIIIIIIIIIII I IIIIIIIIIIIIIIIIIIIIIIIIIIIII IIIIIIII
Alisma plantago aquatica	II
Alnus glutinosa	I II IIIII I II I I
Anagallis arvensis	I
Angelica sylvestris	I I I I I IIIII IIII IIIIIIIIIIIIIIIIIIIII I I IIIIIIII
Anthoxanthum odoratum	I I III II III
Anthriscus sylvestris	I I I I
Aphanes arvensis	I
Arctium minor	I I I I I
Arrhenatherum elatius	II I I II III I IIII I I IIII IIIIIIIIIIIIIII II I I IIIIII
Atriplex sp.	I I
Bellis perennis	I
Betula sp.	I I
Blackstonia perfoliata	I
Briza media	I I III II I I IIII
Bromus erectus	I II I
Calystegia sepium	II II I II IIIII I I I
Capsella-bursa-pastoris	I II
Cardamine pratensis	I
Carduus acanthoides	I I I
Carex acutiformis	II IIIII IIIIIIIII II I IIIIII III II I I
C. disticha	IIIII II IIIIII II I III II
C. elata	I
C. flacca	I II I I II I I I II II IIIII
C. hirta	I I I I II I I IIIII I I I
C. lepidocarpa	I I I I
C. nigra	I I II I IIIII II I II IIII I IIIII
C. obtrubae	I I III I
C. panicea	IIIIII III I II IIII I IIIII
C. rostrata	IIIIIIIII I I IIIIIII IIIIIIIIIIIIIIIIIIIIIIII III I IIIII I
Carex sp.	III III IIIII
Centaurea nigra	II IIIII III I I IIIIIIIIII IIIII IIII IIII IIII I IIIIIIIIII
Cerastium fontanum	I I I I I III
Cirsium arvense	I I I III II II I I I I II II I
C. palustre	I II I I I II I
C. vulgare	I II III I I I I II II I I II II II
Convolvulus arvensis	I I IIIII
Corylus avellana	II II
Crataegus monogyna	III II II I I I III I I I I III
Crepis capillaris	I I I I I
Cynosurus cristatus	I I II III II IIII I I III I II
Dactylis glomerata	IIIIIIIII III IIIIIIII IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
Daucus carota	II II IIII IIII I I I II I
Deschampsia caespitosa	I II I I I II

APPENDIX 5a contd. Bank Verge Zone.

km sections	1111111111222222222233333333334444444444555555555566666666667777 12345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
Elymus repens	I I I I II
Epilobium angustifolium	I
E. hirsutum	IIIIIIIII I I I I II I IIII I II
E. montanum	I
E. palustre	I I
E. parviflorum	I I I I II I II I I I
Equisetum arvense	IIII II I I IIII II I II I II I I I IIII
E. fluviatile	I I I I I III
E. variegatum	I III
Eupatorium cannabinum	III II IIIIII I I II
Euphrasia agg.	I I I
Fagus sylvatica	I I
Festuca arundinacea	I I I II I II
F. pratensis	I I I I I
F. rubra	II IIIII III IIIIIIIIIIIII I I IIIIIIIIIIIIIIIIIIII I III IIII
Filipendula ulmaria	IIIIIIIII II IIIIIIIIIIIIIIIIIIIIIIII IIIIIIIIIIIIIIIIIII IIIIIII
Fraxinus excelsior	IIII IIII I I I IIIII I IIIII II III I I IIII IIII
Galium aparine	I I I II III II II I
G. palustre	I I IIIIIIII IIII IIIIII I III I III
G. verum	I IIII I II I I I I II I I II I II I IIIII
Geranium pyrenaicum	I
G. robertianum	I I I I
Glyceria maxima	III I III II IIII IIIIIIII IIIIII I IIIIIIIIIII I I II III
Heracleum sphondylium	I I I IIII I I I III III II I I
Holcus lanatus	II III II II II I II I III IIII I II IIII IIII
Hydrocotyle vulgaris	I
Hypericum perforatum	I
H. tetrapterum	I I II I I I II I IIIII II I I
Iris pseudacorus	IIII III III III IIIIIIIIII IIIIIIIIII IIIIIIIIIII II III II
Juncus acutiflorus	I I I I
J. articulatus	II I III I I III I I I
J. effusus	II I I IIIIIIIIIIII II III
J. inflexus	I IIIII II IIII II IIIII IIIIIIIIIIII IIIIIIIIIIIII IIII IIII I
J. subnodulosus	I II I I I I
Knautia arvensis	I II
Lamium album	I
L. purpureum	I
Lapsana communis	I II
Lathyrus pratensis	II I III I IIIII III II III I I I I I II
Leontodon hispidus	I I I II I I II I I II
Leucanthemum vulgare	I I I II
Ligustrum vulgare	II I I I II IIII
Linum catharticum	II
Lolium perenne	I I I I I I I I I II I I
Lonicera nitida	I I
L. periclymenum	I I
L. xylostrum	I
Lotus corniculatus	II I I I I IIIII
Lythrum salicaria	I III II II III
Matricaria matricarioides	I I I I
Medicago lupulina	I I II I II I I I I
Mentha aquatica	I I I IIII I II III IIII I I II II I I III III II

In sections	1111111111222222222233333333334444444444555555555566666666677712345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
Menyanthes trifoliata	I I III IIII I I II I I
Molinia caerulea	IIIII
Myosotis laxa	II
M. scorpioides	I II
Nasturtium officinale	I
Odontites verna	I I III I I I I I II II
Ononis repens	II I
Origanum vulgare	IIIII II
Papaver sp.	I I
Pedicularis palustris	I
Phalaris arundinacea	II III II II IIII IIIIIIIIIII II III II I I I II IIIIII I
Phleum pratense	I IIII I I I IIII II II III IIIII I I II I IIII
Phragmites australis	I I I
Phyllitis scolopendrium	I
Pimpinella saxifraga	I I I II II III
Plantago lanceolata	I I IIII II I I I II I IIII I IIIIIIIIII I II I IIIII
P. major	IIII I II I I I
Poa annua	I I I IIIII III IIIIII I III I
P. pratensis	I I I I
Polygonum amphibium	I III III IIII IIIIIII III IIIIII IIIIIIIIIIII I I
P. aviculare	I I I I
P. persicaria	I I
Populus sp.	I
Potentilla anserina	I II I I II III III III IIIIII IIIIII IIIIIIIII I I
P. erecta	I II
P. reptans	I I II II IIIIIIIII III IIII IIIIIIIIIII II I I I
Prunella vulgaris	II II I I I I I II
Prunus spinosa	I I I I I III III I I I II I
Prunus sp.	I
Pteridium aquilinum	I I
Pulicaria dysenterica	II I
Quercus agg.	I I I
Ranunculus acris	I II I IIIIIIIII I
R. flammula	III I II II I I
R. lingua	I I II I I III II I I II I I
R. repens	III I IIIIIII IIIII IIIIIIIIII IIIIIIII II I IIII I I III
R. sceleratus	I
Reseda luteola	I I II I I
Rhinanthus minor	I I I III III
Rosa canina	I I I I I III III
R. pimpinellifolia	I
Rubus fruticosus agg.	III II I I I IIIII II I IIII III II I I I I I I I I
Rumex conglomeratus	II I I
R. crispus	I I I
R. obtusifolius	I II I III I I I I I I I I I I
Sagina nodosa	I
Salix alba	I
S. cinerea subsp. oleifolia	II I I II I I
S. fragilis	I I II I I I I III II II
S. purpurea	II I II I I I I
S. viminalis	I I I

APPENDIX 5a contd. Bank Verge Zone.

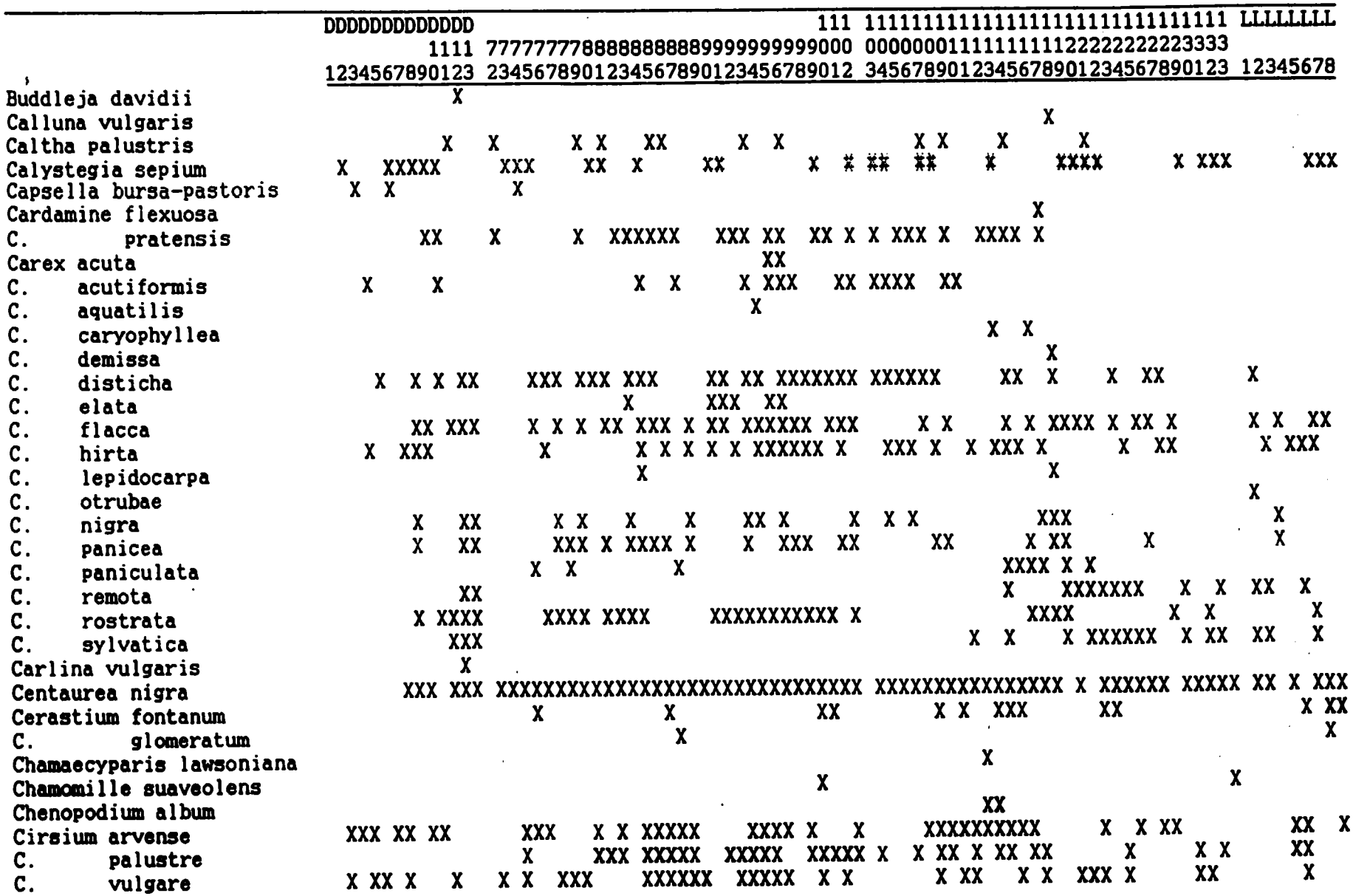
km sections	1111111111222222222233333333334444444444555555555566666666677712345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
Salix sp.	I I
Sambucus niger	I I I I
Sanguisorba minor	II I I II I II
Scrophularia nodosa	I I
Senecio jacobea	I IIIII I I II I I I I I I
S. vulgaris	I I IIII I
Solanum dulcamara	I I I I
Sonchus arvensis	I I
S. asper	I I I II IIII I
S. oleraceus	I I I I I I I I I
Sparganium erectum	I I I I I I I
Stachys palustris	I I I II I
Stellaria media	I I I I
Succisa pratensis	II II I II II I I I I I II III IIII IIIIIII IIII II
Symphoricarpos albus	I I
Taraxacum agg.	II I II II III I IIII I I II I I IIIIII II IIII II
Trifollium pratense	I IIIIIII II IIII II IIII IIIII IIIIII III IIIIII I III I I II
T. repens	I IIIIIII II IIII II IIII IIIII IIIIII III IIII I I III I II
Triglochin palustris	I I
Tussilago farfara	I II II I I I II I I I I I I
Typha latifolia	I I I III I I I I II II II
Ulex europaeus	I
Ulmus agg.	I I
Urtica dioica	I I II III IIII II IIIII I I I IIII IIIIIII I I I II
Valeriana officinalis	I I I I II I III I IIIIIIIIIIIIIIIIIIII I IIIII IIIIII
Verbascum thapsus	I I
Veronica chamaedrys	I I
V. persica	I I
Vicia cracca	IIIII I I I II II IIIIIIIIIIIIIII IIIIIIIII III I I I I
V. sepium	II I I III IIII I I III III II III I I I I
Viola sp.	I

APPENDIX 5b

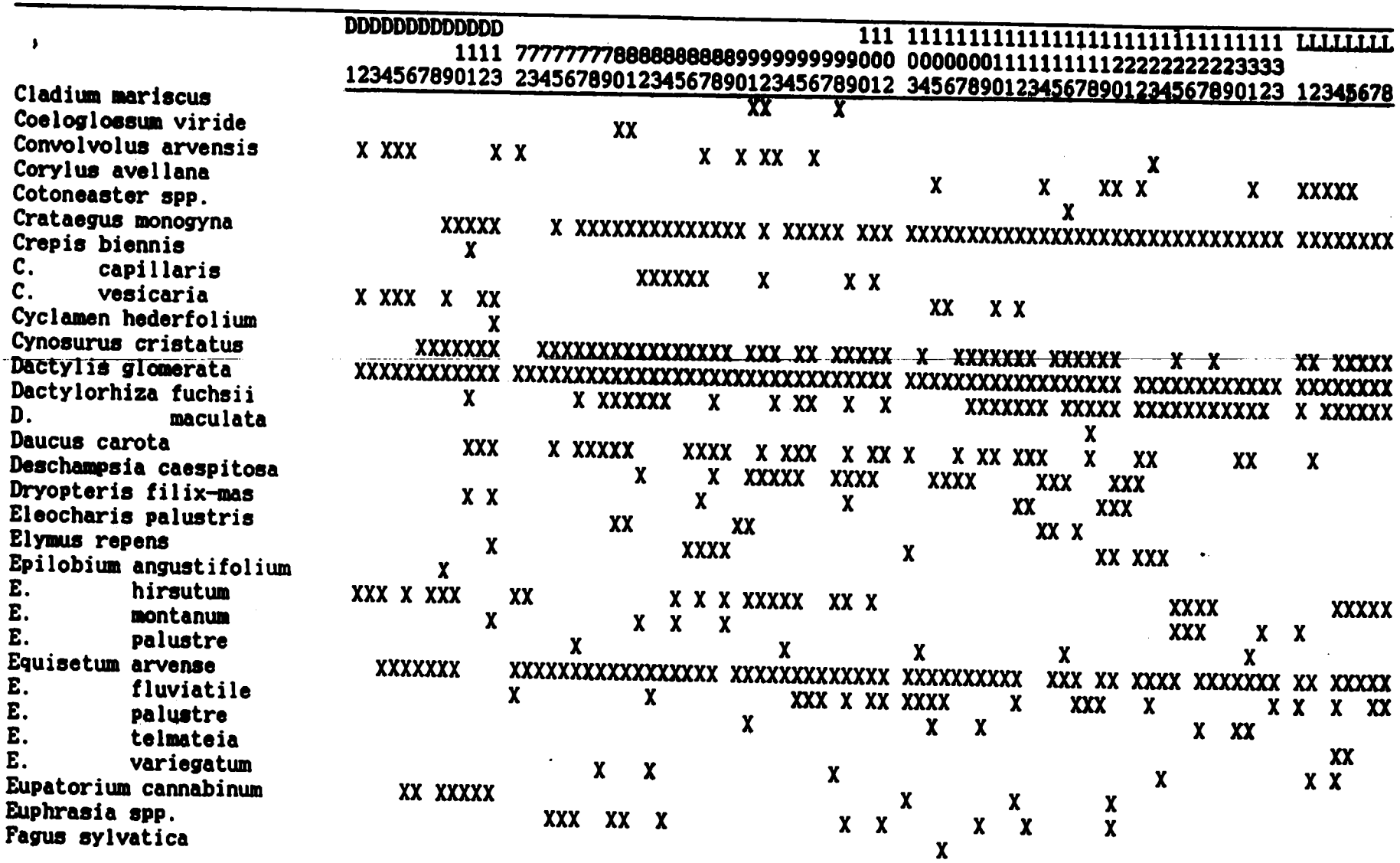
Species list for each section in the bank zone along Units II and III of the Royal Canal.

```
UNIT
                                                     II                                III
                          DDDDDDDDDDDDD                             111 1111111111111111111111111111111 LLLLLLLL
                                   1111 7777777788888888889999999999000 0000000111111111122222222223333
                          1234567890123 2345678901234567890123456789012 3456789012345678901234567890123 12345678
Acer pseudoplatanus         X       XXX  XXX  XX                      X XX X       XX   XX XXX  XX  X X    X X
Achillea millefolium       XX   X XX XX X X XXXXXXX XX XXX     X  XXXXX    XXXXXX X XXXXXX  XX   X    X   X X
Agrimonia eupatoria                  XX       X         X X XXX         XX X  X  XX X X XXX XXXXXX      XXXX
Agrostis capillaris                 XXX      XXX            XXX  X XX X XXX XXXX XXXXX  XX X      X          XXX
A.       stolonifera         XXX XX     XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX XXXXXX XX XX XXX XXXX
Ajuga reptans                                                                  X
Alisma plantago-aquatica                           X
Allium vineale               X    X                                             X
Alnus glutinosa                   X  XXXXX             X             X   XXX  X     XX XX X X X   XXXX   XXXXXXX
Anacamptis pyramidalis              X          XX                    X       XX XX
Angelica sylvestris        XXXXXXXXXXX  XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXX  XXXXXXXXXXX XXXX XXX
Anthoxanthum odoratum             XX XX     XXXXXXXXXXXXXXXXXXXXX  XXXXX XXXXXXXX XXXXXXXXX  XXXX X X    XXX XXXX
Anthriscus sylvestris         XXXXXXXXX   X  XX                X   XXX   X   X X   X X   XXXX   X   X          X
Anthyllis vulneraria                    X
Apium nodiflorum                                    X                              X  X
Arctium minus              X              X                        X      X        X      X
Arrhenatherum elatius      XXXXXXXXXXXX XXXXXXXX  XXX XXX XXXXXXXXXXXXX XXXX X XXX  X   XX XXXXX XXX XX X   XXXX
Artemisia vulgaris         XXX
Arum maculatum                         X                                          XXX       X X      XX   X
Avenula pubescens                XXXXXXX    XXXXXXXXXXXXXXXXX XX XXXXXXX XXXXXXXXXX   X XXX  XXXX      X X X  XX
Bellis perennis            XXX X XXX      XXXXXX XX XXXXXX     X        X      X XXX XXX  X  X    X         X XX
Berula erecta                                                                   X
Betula spp.                                                      X                     XXX     X     X
Brachypodium sylvaticum        X     XXX                    X                   X  XX   XXXXXXXXXXX XX  XX   X
Brassica rapa                X
Brizia media                        XXX    XX  XXXX XX XXXXXXXXXX XX  X  X XX XX  X  XXXXX         X     XX
Bromus erectus                     XXXXX
B.       hordeaceus                                                                      X
B.       ramosus                       XX
```

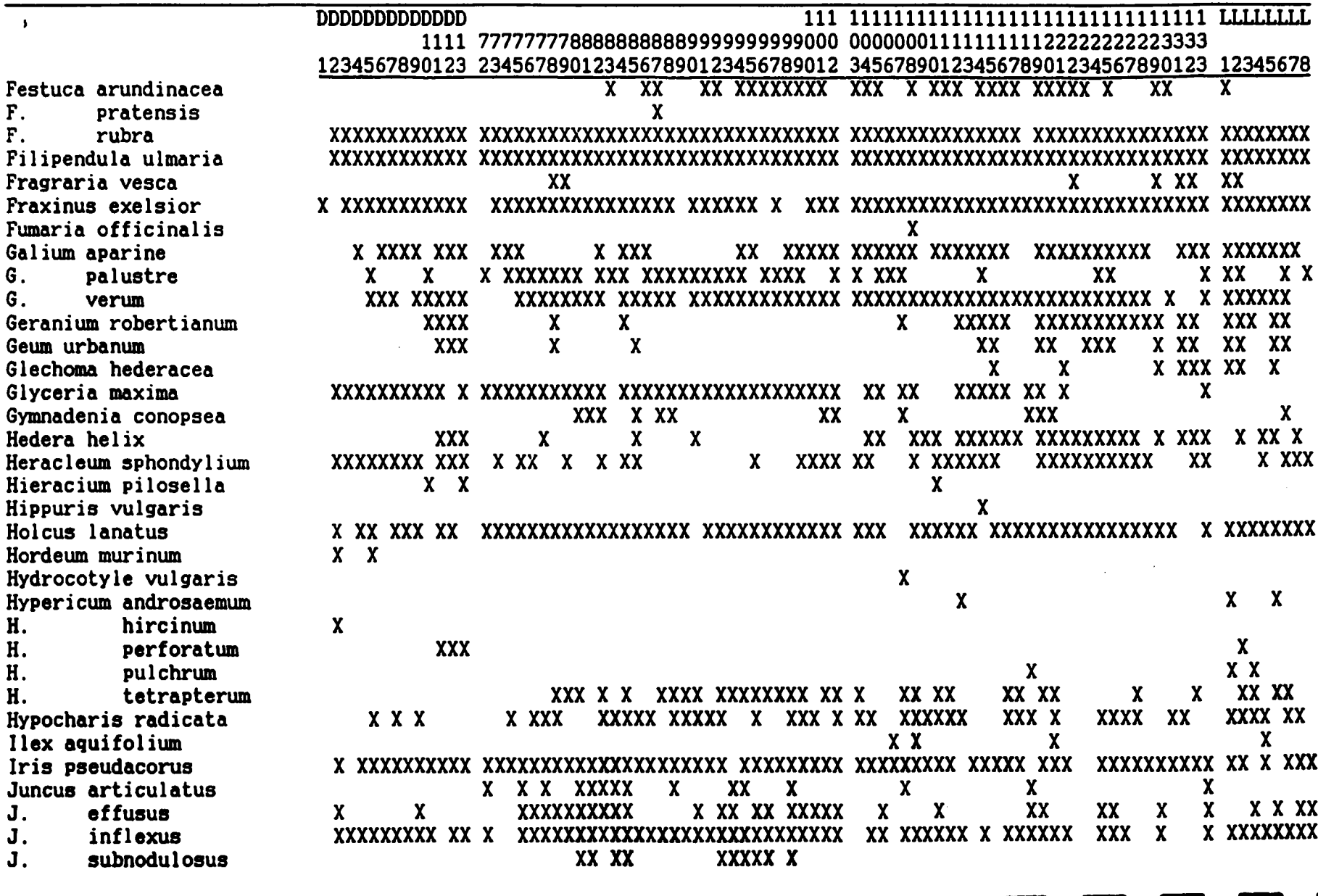
APPENDIX 5b cont.



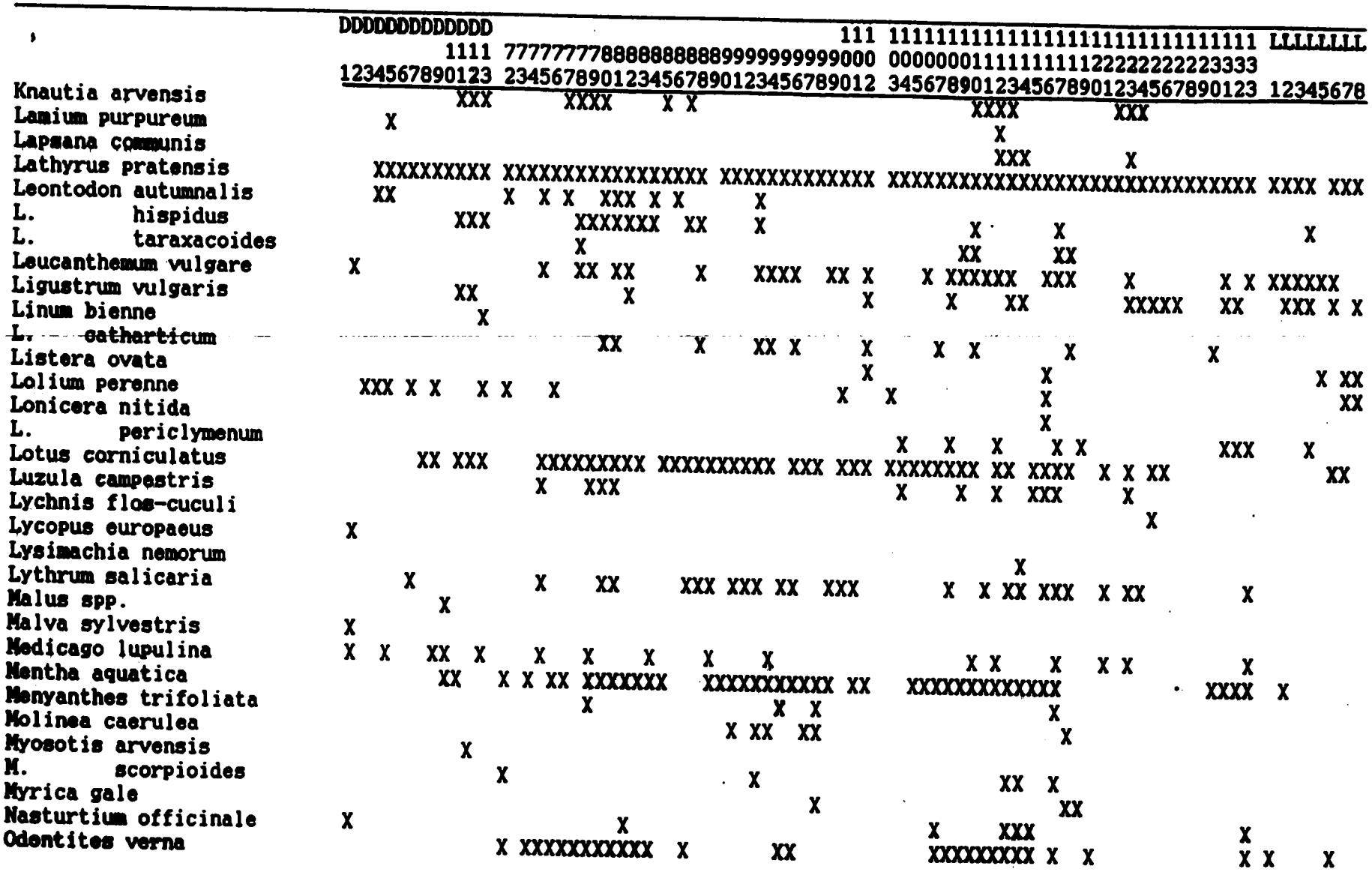
APPENDIX 5b cont.



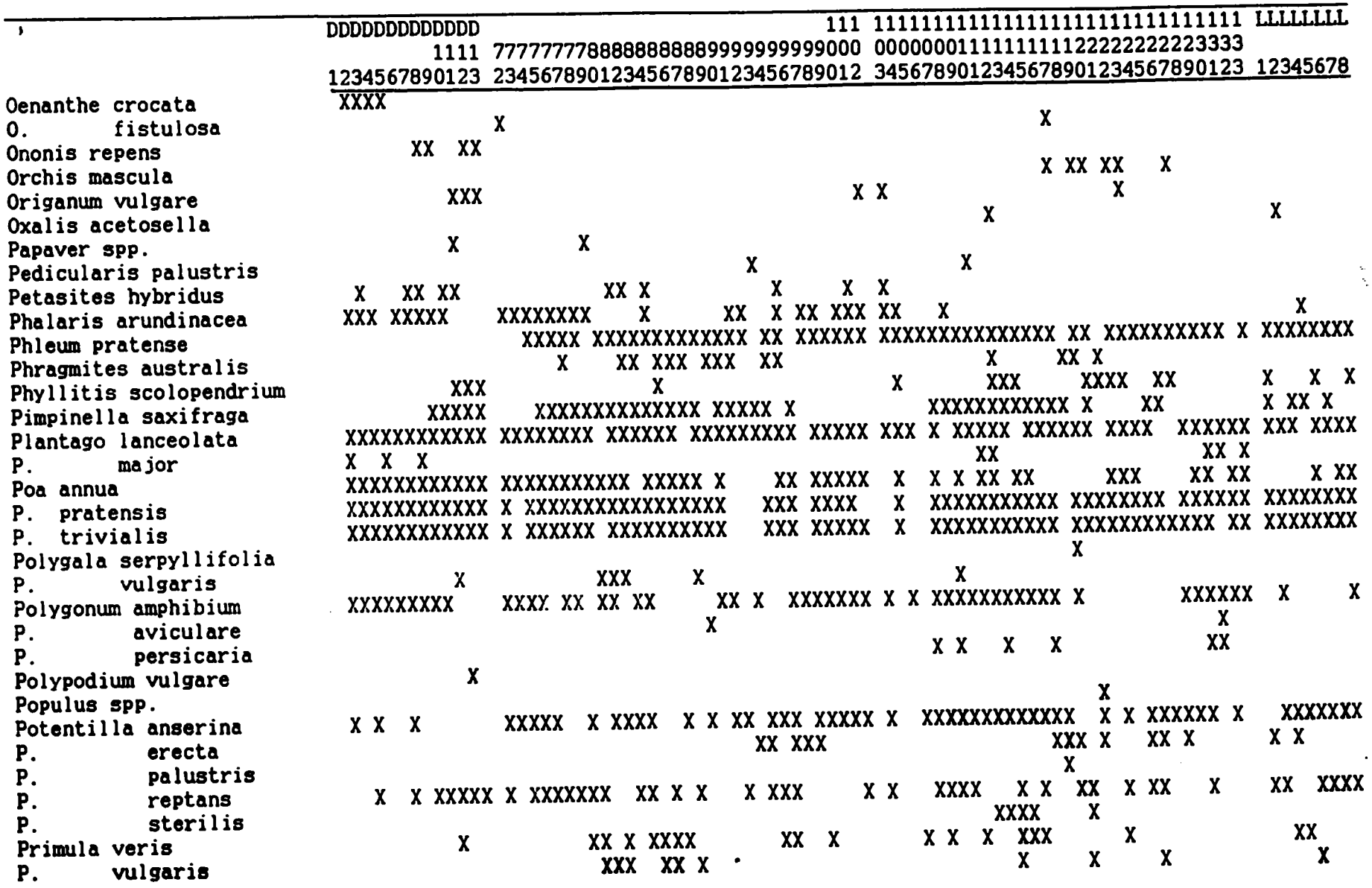
APPENDIX 5b cont.



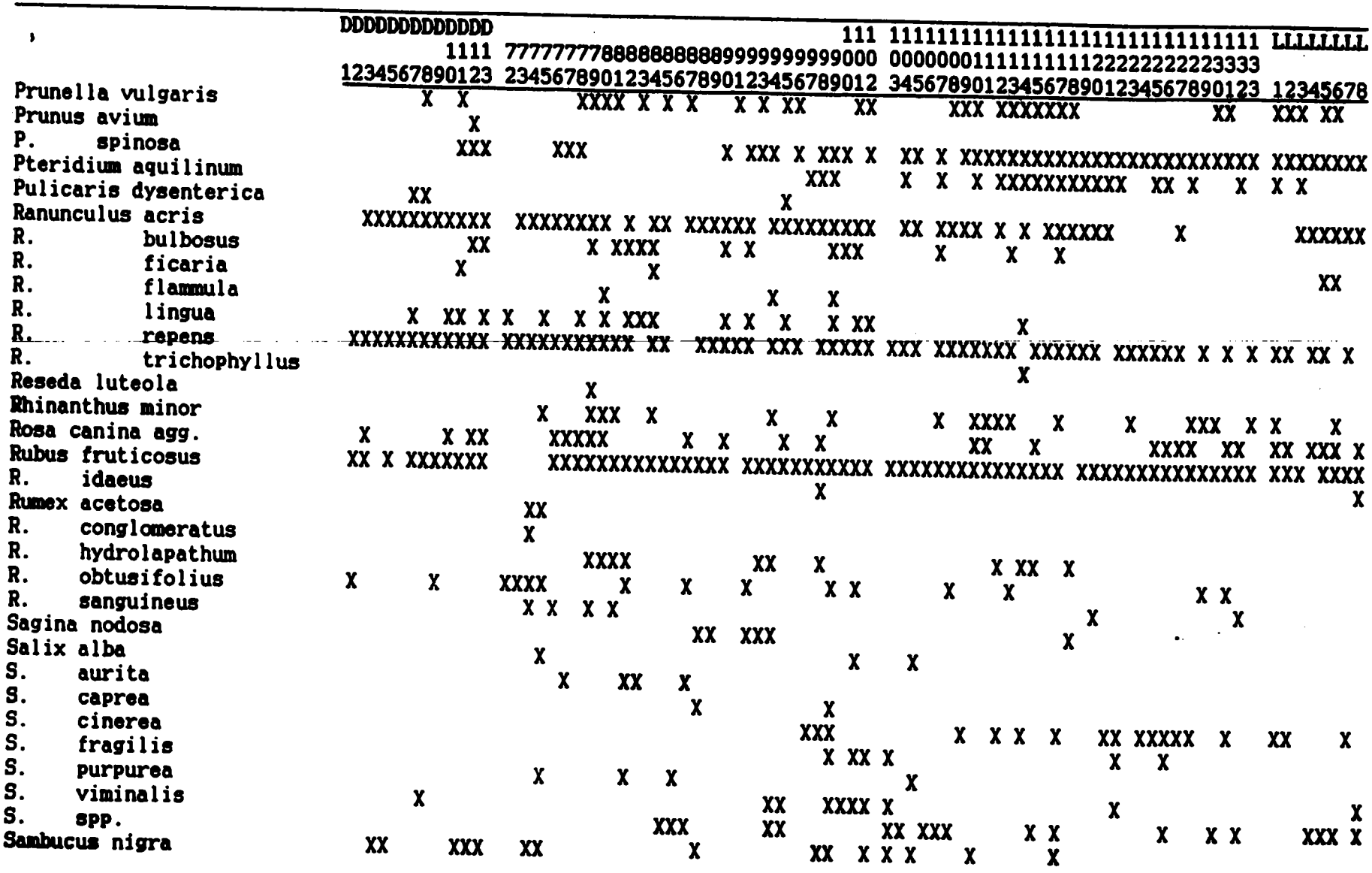
APPENDIX 5b cont.



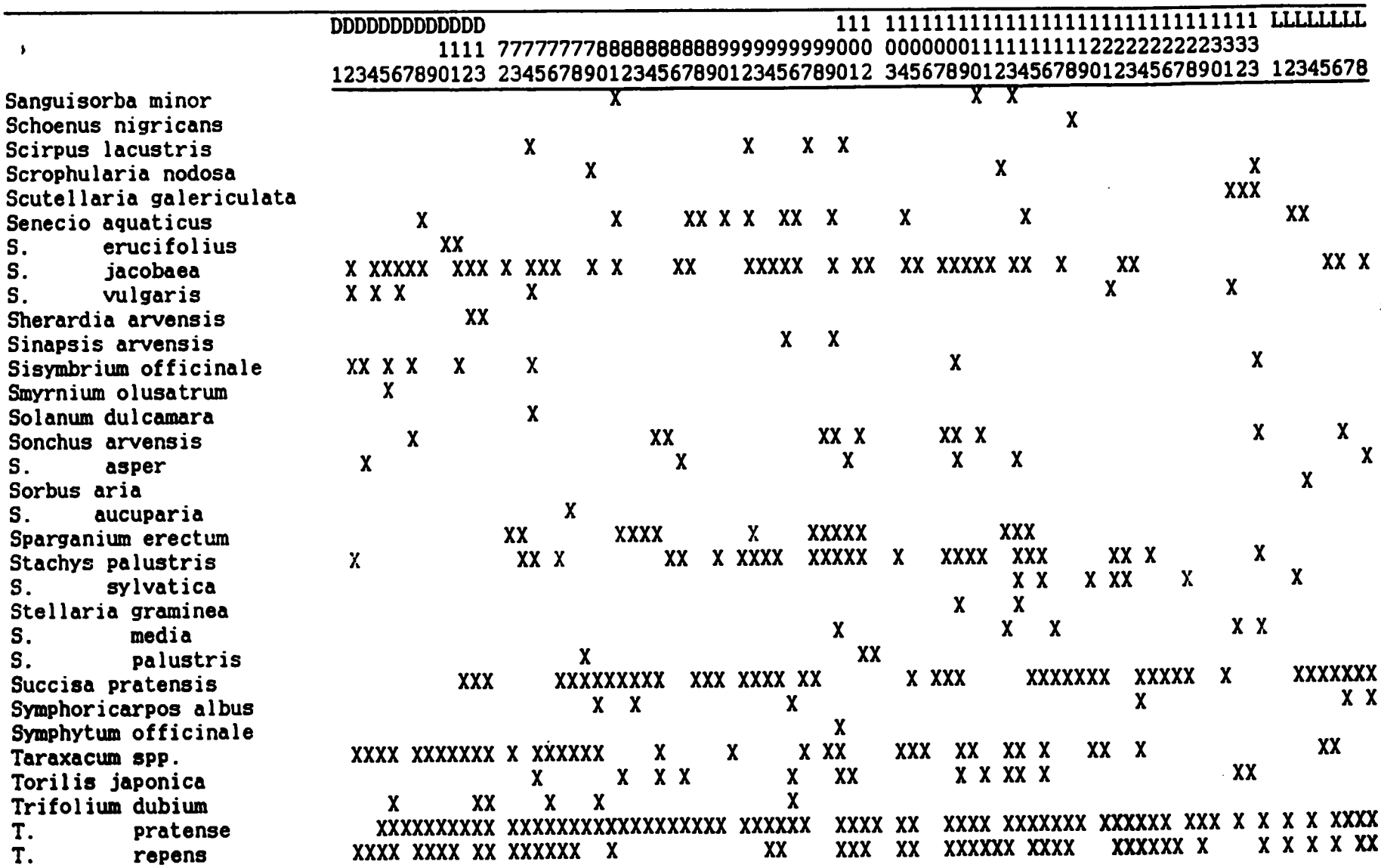
APPENDIX 5b cont.



APPENDIX 5b cont.



APPENDIX 5b cont.



APPENDIX 5b cont.

	DDDDDDDDDDDDD 1111 1234567890123	111 7777777788888888889999999999000 2345678901234567890123456789012	1111111111111111111111111111111 0000000111111111122222222223333 3456789012345678901234567890123	LLLLLLLL 12345678
Triglochin palustris		`        XX X X       X`	`             X             X`	
Trisetum flavescens	`      X`	`   XXXX XX`		
Tussilago farfara		`       X`		
Typha latifolia		`X                   X      X`	`X`	`  X`
Ulex europaeus	`          X X`	`       X         X       X`	`      XX X XX   X   X     XX`	`X`
Ulmus agg.	`         X`			
Urtica dioica	` XXXXXXXXXXXX`	`XXXX X X  XXXXXX  X   X    XXX`	`XXXXXX X XXX X  XXXXXXXXXXX X X`	`XX XXX X`
Valeriana officinalis	` XXXXXXXXXXXX`	` X XXXXXXXXXXX XX XXXXXXXXXXXXX`	`XXXXXXXXXXXXXXXXXXXXX XXXXXXXXX`	`XXXXXX`
Veronica anagallis-aquatica			`          X`	
V. beccabunga		`         X`		
V. chamaedrys	`   X   XXXXXX`	`  XXXX XX X XXXX    X  X   X XX`	`XXXX  X  XXXXXX XXXXXX XX XXX`	`X  XXXXX`
V. hederifolia			`         X`	
V. montana			`                            X`	`X`
V. persica		`                           X`	`         XX   X`	
V. serpyllifolia		`          X`	`           X  X             X`	
Viburnum opulus			`               XX`	`   X`
Viccia cracca	`   XXXXXXXXXX`	`XXXXXXXXXXXXXXXXX XXXXXXXXXXXXX`	`XXXXXX XXXXXXXX XXXXXXXXX XXXXX`	` XXXX XX`
V. sativa	`          X`			`   X`
V. sepium	`   XXXXXXXXX`	` X  XX X  XXXXXXX XXXXXXXXXXXXX`	`XXXX  XXXXXXXXX XXXXXXXXX X X`	`  XXXXXX`
Viola riviniana		`            X`	`         X XX   XX   XXXXXX XX`	`XX  X`

APPENDIX 6a

Plants of Channel of the Royal Canal - Unit I

km sections	1111111111222222222233333333334444444444555555555566666666677712345678901234567890123456789012345678901234567890123456789012345678901234567890123456789012
Alisma plantago aquatica	I IIIII I I I II I III
Apium nodiflorum	I I
Callitriche sp.	I
Carex acutiformis	IIIIIII IIII III IIII IIIIII I I IIIII
C. nigra	III I I IIII
C. obtrubae	
C. rostrata	IIIIIIII I I IIIIIIII IIIIIIIIIIIIIIIIIIIIIIII II I III II
Carex sp.	III III IIIIII
Eleocharis acicularis	I
Elodea canadensis	I I I IIII I III
Equisetum fluviatile	I I I II
Glyceria maxima	II IIIIIIIIIIIIIIIIIIIIIIIIIIII IIIIIIIIIIIIIIIIIIIII III IIIIII
Hippuris vulgaris	I III II I I II I II II
Iris pseudacorus	I I I I I I I I I
Juncus sp.	I I I II I I
Lemna minor	I III I I I I
Menyanthes trifoliata	I II IIII IIIIII IIIIII I III
Myriophyllum sp.	IIIIIIIIIIIII IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII II III I III
Nasturtium officinale	I I II I I I II II
Nuphar lutea	IIIIIIIIIIIII IIIIIII III IIIII IIIIIIIIIIIIIIIIII I III I IIIIII
Phalaris arundinacea	I I II IIII I III II II I I I I I I
Phragmites australis	II II I
Polygonum amphibium	I I I I I I I I I I I
Potamogeton crispus	I III I III II
P. natans	II I IIIII IIIIIIIIIII I IIIIIII
Ranunculus circinatus	I I I
R. flammula	II IIII I III II I I
R. lingua	IIIIIIII III II I I II III IIIIIII I I II I IIIII
R. sceleratus	I I I
Scirpus lacustris	IIIIIIIIIIII I IIIIIIIII IIIIIIIIIIIIIIIIIIII III I I I I
Sparganium emersum	I IIIIIIIII II I I I I IIIIII I I II
S. erectum	II III III I III IIII II I I IIII
Typha latifolia	III I I II I I I IIIIIIIIIII I II III
Utricularia sp.	IIII
Zannichellia palustris	I I I
Algae	IIII IIII IIIIII I IIII III I I
Charophytes	IIIIIIII III IIIIII I I I I IIIIIII I I
Fontinalis	I III I II IIIIIII

APPENDIX 6b

Species of each Section found along the Channel of Units II and III of the Royal Canal.

UNIT II

Species	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102
Acer pseudoplatanus																																											X
Achillea millefolium																																											
Agrimonia eupatoria																																											
Agrostis capillaris																																											
A. stolonifera						X		X	X							X					X	X	X	X	X	X	X	X	X	X				X		X	X					X	
Alisma plantago-aquatica																						X									X												X
Alnus glutinosa												X																															
Anagallis tenella																																		X									
Angelica sylvestris	X															X	X					X		X	X	X		X	X	X				X		X	X						
Anthoxanthum odoratum																										X		X	X	X													
Anthriscus sylvestris																																											
Apium nodiflorum																						X	X																				
Arrhenatherum elatius																													X	X													
Avenula pubescens																										X																	
Baldellia ranunculoides																						X																					
Berula erecta																																											
Betula spp.																																											
Brizia media																													X														
Callitriche spp.															X																												
Caltha palustris													X							X	X				X	X				X				X	X	X							
Calystegia sepium																																											
Cardamine pratensis													X							X	X			X		X	X	X	X	X					X								
Carex acutiformis																									X	X			X	X				X		X							X
C. appropinquata																																											
C. demissa																																											
C. diandra																																											
C. disticha																										X	X	X	X	X						X							X
C. elata																														X		X											
C. lepidocarpa																																											

UNIT III

Species	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133	L1	L2	L3	L4	L5	L6	L7	L8
Acer pseudoplatanus																									X														
Achillea millefolium											X																												
Agrimonia eupatoria											X																												X
Agrostis capillaris								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			X	X			
Alisma plantago-aquatica	X							X								X													X		X					X			X
Alnus glutinosa				X											X	X				X									X	X							X		X
Anagallis tenella																																							
Angelica sylvestris							X	X	X			X	X	X	X		X	X			X	X			X	X	X		X				X		X		X		
Anthoxanthum odoratum									X																	X													
Anthriscus sylvestris												X																											
Apium nodiflorum												X		X	X	X				X					X							X							
Arrhenatherum elatius								X	X	X	X																												
Avenula pubescens																																							
Baldellia ranunculoides						X										X																				X			
Berula erecta								X						X	X	X	X		X	X	X		X	X	X	X	X	X	X	X		X	X	X	X			X	X
Betula spp.																														X									
Brizia media								X																															
Callitriche spp.															X	X														X									
Caltha palustris												X		X	X	X	X	X	X	X	X	X		X	X	X			X	X	X	X					X		
Calystegia sepium						X				X		X	X				X		X						X														
Cardamine pratensis	X		X	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
C. appropinquata																												X											
C. demissa																X								X										X					
C. diandra																											X	X											
C. disticha					X	X	X	X													X			X	X		X					X							
C. elata																																X							X
C. lepidocarpa																X																		X					

APPENDIX 6b cont.

Species of each Section found along the Channel of Units II and III of the Royal Canal.

	DDDDDDDDDDDD		111	1111111111111111111111111111111	LLLLLLLL
	1111	7777777788888888889999999999000		0000000111111111122222222223333	
	234567890123	23456789012345678901234567890 12	3456789012345678901234567890123		12345678
C. nigra		XXXXX X		X	
C. otrubae				XXX	
C. panicea		X		X	
C. paniculata		X	X	X	
C. rostrata	X XXXX	XX XXXXXXXXXXXXXXXXXXXXXXXX	X XXXXXXX XXXX	X XX XX	XXX
Centaurea nigra		X	X X		
Ceratophyllum demersum		X			
Chara spp.				X	X
Cirsium arvense		X X	X X X X	XX	X
C. palustre		X	X	XXX	X
C. vulgare				X	
Cladium mariscus		X X XXX			
Crataegus monogyna		X		X	
Dactylis glomerata			XX	X	
Dactylorhiza fuchsii		X	X X X X	XXXX	X X
D. incarnata			X	X	
Eleocharis palustris	X	X	XXXX XXX X	X XX	X
Elodea canadensis	XXXX			X	
Epilobium angustifolium			X		
E. hirsutum		XX X	X X XX	XX	
E. palustre		X X	X X XX XX X	XXX	XXXX
Equisetum arvense		X		XX X	X
E. fluviatile			XXX XX	XXXXXXXXXXXXXXX	X XXXXX
E. palustre				XX	
E. variegatum			X	XXXX X	X
Euphrasia spp.			X		
Festuca arundinacea		XX	XX X	X X	
F. rubra		X X	XXX X X	X X	
Filipendula ulmaria	X X	X X XXXXXX X XX	X X XXXXXXXXXXXXXXX	XXXXXXXXXX	XXXX X X
Fraxinus exelsior		X	X X	X	
Galium palustre	X X	X X XX XXXXXXXXXXX X XX	X XXXXXXXXXXXXXXX	XXXXXXXXXX	XXXXXXXX

Species of each Section found along the Channel of Units II and III of the Royal Canal.

	DDDDDDDDDDD		111	1111111111111111111111111111111	LLLLLLLL
	1111	77777777788888888889999999999000		0000000111111111122222222223333	
	234567890123	234567890123456789012345678901 2		3456789012345678901234567890123	12345678
Glyceria maxima	XXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXXXXXXXXXX XXXX		XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXX
G. plicata					
Groenlandia densa	XX				X
Heracleum sphondylium					
Hippuris vulgaris				X	
Holcus lanatus		XXX X		X X X X X	X
Hydrocharis morsus-ranae		XXX X		X XX X X XXXXX	X XXX X
Hydrocotyle vulgaris				XXXX XXX X X	
Hypericum tetrapterum				XX X XXXX XXXXXXX	X
Hypocharis radicata		X		X	
Iris pseudacorus	X	XX XX XXXXXXXXX XXX X	X	X X X	
Juncus acutiflorus				XXXXXX XXXXXX XXXXXXX XXX	XXXX XXX
J. articulatus		X X XX XX X		X	X
J. effusus		XXX		X X XX X	
J. inflexus		XXX XXXX X		X X X	X XX X
J. subnodulosus		XX X XX X X		X X X X	X X
Lathyrus pratensis		X			
Lemna minor	XXXXXX	XXXXXX XX X X	XXXX	X X XXX X	
L. trisulca		XX		XX X XXX X X	XX X
Leucanthemum vulgare				X	
Ligustrum vulgaris				X X	
Lonicera periclymenum				X	
Lychnis flos-cuculi					X
Lycopus europaeus	XX			X	X
Lythrum salicaria		X XXXX X XX		X X X	
Mentha aquatica	X X X	XXXXXXXXX XX XX XX X	X	XXXXX XX X XX XXXXXXXXXXXXXXXXXXXXXXX X	XXXXXX X
Menyanthes trifoliata	X	XX XXXX XX XXXXXXX X	XXXXXXXXX	XXXXXXXXXXXXXXXXXX	XXXXXXXX
Molinea caerulea		X X		X	
Myosotis scorpioides		XXX XX		XX X XXX XXXXX XXXX X XX	XXXXX X
Myrica gale				X	

APPENDIX 6b cont.

Species of each Section found along the Channel of Units II and III of the Royal Canal.

Species	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12	D13
Myriophyllum spp.	X	X							X	X	X	X
Nasturtium officinale				X				X				
Nuphar lutea	X		X	X		X	X			X	X	X
Odontites verna												
Oenanthe aquatica												
O. crocata												
O. fistulosa												
Pedicularis palustris												
Phalaris arundinacea	X	X	X		X	X	X	X	X	X	X	X
Phleum pratense												
Phragmites australis												
Pimpinella saxifraga												
Poa spp.												
Polygonum amphibium	X			X	X	X		X	X			
P. persicaria												
Potamogeton crispus												
P. natans												X
P. perfoliatus												
P. spp.												
Potentilla anserina												
P. palustris												
P. reptans												
Prunella vulgaris												
Prunus spinosa												
Ranunculus acris												
R. flammula												
R. lingua						X	X	X	X			X
R. repens	X		X			X		X				
R. sceleratus		X	X					X				
Rhinanthus minor												
Rubus fruticosus												

Species	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102
Myriophyllum spp.	X	X	X	X	X	X	X	X	X		X	X		X	X				X	X	X				X	X			X	X	X
Nasturtium officinale							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		X
Odontites verna																															
Oenanthe aquatica	X																														
O. crocata																															
O. fistulosa	X																														
Pedicularis palustris																						X									
Phalaris arundinacea	X	X	X		X	X	X	X					X	X	X	X	X		X		X			X		X					X
Phleum pratense															X																
Phragmites australis									X	X	X	X		X	X	X	X	X	X	X			X	X	X						
Pimpinella saxifraga																															
Poa spp.													X	X		X	X	X													
Polygonum amphibium	X								X	X												X								X	
P. persicaria																															
Potamogeton crispus	X	X	X																												
P. natans	X	X	X	X	X	X	X	X	X	X	X	X							X	X	X	X				X		X			
P. perfoliatus	X																														
P. spp.	X																														
Potentilla anserina																															
P. palustris																															
P. reptans														X																	
Prunella vulgaris																	X														
Prunus spinosa																															
Ranunculus acris													X	X	X									X							
R. flammula									X	X								X				X	X				X				X
R. lingua	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. repens									X		X		X	X	X	X		X				X	X	X							
R. sceleratus																															
Rhinanthus minor																	X														
Rubus fruticosus														X		X															X

Species	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132	133
Myriophyllum spp.																X					X										X
Nasturtium officinale			X		X	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
Odontites verna									X	X																					
Oenanthe aquatica		X	X			X																X	X								
O. crocata																															
O. fistulosa		X					X	X							X	X	X														
Pedicularis palustris								X	X							X								X	X	X	X	X	X		
Phalaris arundinacea						X		X														X									
Phleum pratense									X	X			X															X	X		
Phragmites australis									X	X					X		X	X	X									X			
Pimpinella saxifraga											X																				
Poa spp.																														X	
Polygonum amphibium	X				X	X	X	X	X	X	X	X			X	X										X	X	X	X	X	X
P. persicaria					X	X			X	X	X																				
Potamogeton crispus																					X										
P. natans																X						X								X	
P. perfoliatus																															X
P. spp.																X															X
Potentilla anserina					X	X		X	X	X	X			X		X								X		X	X	X	X	X	
P. palustris																													X		
P. reptans								X	X												X			X							
Prunella vulgaris											X																				
Prunus spinosa									X		X	X	X												X	X					
Ranunculus acris							X					X		X																	
R. flammula	X	X	X	X	X	X									X	X								X	X	X	X	X	X	X	X
R. lingua	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. repens			X		X	X		X	X			X		X	X	X			X				X		X	X		X	X	X	X
R. sceleratus																															
Rhinanthus minor								X	X	X														X		X	X	X			
Rubus fruticosus					X			X	X	X		X	X						X				X	X	X	X			X	X	

Species	L1	L2	L3	L4	L5	L6	L7	L8
Myriophyllum spp.								
Nasturtium officinale	X			X	X	X		X
Nuphar lutea	X	X			X		X	
Odontites verna								
Oenanthe aquatica					X			X
O. crocata								
O. fistulosa								
Pedicularis palustris								
Phalaris arundinacea								
Phleum pratense								
Phragmites australis			X	X				
Pimpinella saxifraga								
Poa spp.								
Polygonum amphibium	X	X			X			
P. persicaria								
Potamogeton crispus								
P. natans								
P. perfoliatus								
P. spp.								
Potentilla anserina					X			
P. palustris								
P. reptans	X							
Prunella vulgaris								
Prunus spinosa		X						
Ranunculus acris						X		
R. flammula	X				X			
R. lingua	X							
R. repens	X				X	X		
R. sceleratus								
Rhinanthus minor	X							
Rubus fruticosus	X							

Species of each Section found along the Channel of Units II and III of the Royal Canal.

	DDDDDDDDDDD		111	1111111111111111111111111111111	LLLLLLLL
	1111	77777777788888888889999999999000		00000001111111111222222222333	
	234567890123	234567890123456789012345678901 2		34567890123456789012345678901 23	12345678
Rumex acetosa				X	
R. hydrolapathum		X XXX	XXX XX X	XXXXXXXXXX XX XXXXXXXXXXXXXXX	XX X
R. obtusifolius				X X XX	
Sagina nodosa				X	
Salix cinerea		X XX		XXXXXX X XX X XXX	XX XX
S. fragilis				X X X	XX
S. repens		X	X		
S. viminalis			X X X		
S. spp.		X X		X X X	XX
Scirpus lacustris	X X	X XXXXXXXXX XXXXXXXX X	XXXXXXX	XX XXXXXXXXX	XX
Scutellaria galericulata				XXXX XX	X
Senecio aquaticus			X	X	
S. jacobaea		X	XX XX		
Sonchus arvensis			XX		
S. asper			X X	X	
Sorbus aucuparia	X	XX			X
Sparganium emersum	X	XX XX XXXXXX XXXXXXX XXX XXXX	XXXXXX XXX	XXXXXXXXX X XXXXXX	XXXXX XX
S. erectum		X X	X X X XXXX	X	
Stachys palustris		X X	X	X	
Stellaria media		X	X	X	
Succisa pratensis		X X	X		
Trifolium pratense		X X	X		
T. repens		X	XX	XXX	X
Triglochin palustris		X X X	X	X	X
Typha latifolia	XX	X X XX XX XXXXXXX X	XXXXX X XX	XXXX XX X XXX X	X X X
Ulex europaeus		X X	X	X	
Urtica dioica			X	X	
Utricularia spp.		XX XXX X	X XXXXXX	X XXXX XXX	X X X
Valeriana officinalis			X XXXXXX	X X XXXX XXXXXXX	XX X
Veronica anagallis-aquatica				X	

APPENDIX 6b cont.

Species of each Section found along the Channel of Units II and III of the Royal Canal.

```
                           DDDDDDDDDDDD                              111  1111111111111111111111111111111  LLLLLLLL
                                   1111  7777777788888888889999999999000  0000000111111111122222222223333
                           234567890123  2345678901234567890123456789012  3456789012345678901234567890123  12345678
V.       beccabunga                                                                 X         X    X
V.       scutellata                                                                         X
Viccia cracca                                         X X X   X        X     XXX XXXXXXXXXXX     X XX      X  X
V.     sepium                                         X X X                                       X
Algae                            X        X                         XXX
Fontinalis antipyretica                   XXX
```

APPENDIX 7a

Plants of the Locks and Bridges along the Royal Canal – Unit I

km sections	1111112223334444555556666677 1245791345790392780579567891245812
Acer pseudoplatanus	x x x x x xxxx x x
Achillea millefolium	x x xx x x x x x
Agrostis stolonifera	x x x
Alnus glutinosa	x
Arrhenatherum elatius	x x
Asplenium ruta-muraria	x x x xx xx x xxxxx xx x
A. trichomanes	x x x
Briz[illegible]dia	x xx
Brom[illegible]mosus	x
Caly[illegible]s sepium	x x
Carex [illegible]oca	xx
Centa[illegible]a nigra	x x x x x xxx x
Centranthus ruber	x xx
Crataegus monogyna	x
Crepis capillaris	x
Cymbalaria muralis	xx x x x
Dactylis glomerata	x x x xx xx
Daucus carota	x
Dryopteris felix-mas	x
Elymus repens	x x
Epilobium hirsutum	x x x
E. montanum	x
E. parviflorum	x
Eupatorium cannabinum	x x x
Festuca rubra	x x xxxxx xx xxxxxxxxx x
Filipendula ulmaria	x x x x x
Fraxinus exelsior	x xx
Galium verum	x x x x x xx
Geranium robertianum	x
Hedera helix	xxx x xxxx xx xx xxxx xx x
Heracleum sphondylium	x x
Holcus lanatus	x x
Hypericum tetrapterum	x
Ilbautia arvensis	x
Lapsana communis	x x
Lathyrus pratensis	x
Leontodon hispidus	x x
Linaria purpurea	x
Medicago lupulina	x x
Mentha aquatica	x x
Phyllitis scolopendrium	x x xxx x x x xx
Pimpinella saxifraga	x x x
Plantago lanceolata	x xx
Poa pratensis	x
Populus sp.	x
Potentilla reptans	x x xxx xx
Prunella vulgaris	x
Rosa canina	x x
Rubus fruticosus agg. x	xx x x xxx xxx x xx x xx
Sagina procumbens	x

APPENDIX 7a contd. Locks and Bridges.

km sections	1111112223334444555556666777 1245791345790392780579567891245812
Sambucus niger	x x xxxx x
Sanguisorba minor	x x
Senecio jacobea	x x x x
S. vulgaris	x
Sonchus arvensis	x
S. oleraceus	x
Symphoricarpos albus	x x x
Syringa vulgaris	x
Taraxacum agg.	x xxxxx xxx xx x xxxxx x x x
Tussilago farfara	x x
Urtica dioica	x xx x xx x x x
Valeriana officinalis	x
Vicia sepium	x

APPENDIX 7b

Species of Locks, Bridges and Harbours along Units II and III of the Royal Canal.

UNIT	II	III
	DDDDDDDDDDDD	11 11111111111111111111
	11117777788888899999900	00001111111122222223LLLLL
	23456789012334789245789023458902	35680123467912345789131 2345
SPECIES		
Acer pseudoplatanus	X X XX X XXX X X X X X X X XX X	
Achillea millefolium	XXX X X XXX XXXXX X X X XX XX XXXXX	
Agrimonia eupatoria	X	
Agrostis stolonifera	X XX	
Alnus glutinosa	X X X	
Angelica sylvestris	XXXXX X XXXXXX XX X	
Anthoxanthum odoratum	X X	
Anthriscus sylvestris	X X	
Arrhenatherum elatius	X XX	
Artemisia vulgare	X	
Asplenium ruta-muraria	XXXXX XX X XXXXX XX XXX XX XX X X X X XXXXXXXXXX XXXX	
A. trichomanes	XXXXX XX X XXX X X X X X XXXXXXX XXXX	
Bellis perennis	X X	
Betula spp.	X	
Brizia media	XXXX X X X	
Buddleja davidii	X X	
Calystegia sepium	X X	
Cardamine pratensis	X X	
Carex flacca	X X X	
Centaurea nigra	X XXXXXXXXX XXX X XXXXX X X X X	
Centranthus ruber	X XX X	
Cerastium fontanum	X X	
Ceterach officinarum	X X X	
Chamaecyparis lawsoniana	X X	
Chamomille suaveolens	X	
Cirsium arvense		
C. vulgare	X	
Clematis vitalba	X	

APPENDIX 7b cont.

```
UNIT                                        II                           III
                            DDDDDDDDDDDD                  11 1111111111111111111111
                                    111177777888888999999900 0000111111112222222233LLLLL
                            23456789012334789245789023458902 356801234679123457891312345
SPECIES
Cotoneaster spp.             X                    X
Crataegus monogyna           X     X XX       X XX    X  X   XX  X    XX  X XX   X XXX
Crepis capillaris                             X                     X
C.    vesicaria             XXX                                                   X
Cymbalaria muralis          XX      X      X   X XXX                              X
Cynosurus cristatus                                        X                    X
Dactylis glomerata           XX         X           X     X  X
Daucus carota                                   X     X                 XX       X
Desmazeria rigida                                                        X
Dryopteris filix-mas                    X        XX                   XX
Epilobium angustifolium                                 X                     X
E.         hirsutum          X                  XX XX XX
E.         montanum          X X           X        X     X
E.         palustre                X
Equisetum arvense                                 X
Eupatorium cannabinum            X  X
Festuca rubra               XXXXXX XX X X   X XXXXXXXXX XXXX XXX X  XX  XXXX XXXXXXXXXX
Filipendula ulmaria         XXXXXX XX   X       XXXXXXXX  XX     X     X
Fragraria vesca                                                       X       XX X
Fraxinus exelsior              XXX XXXXX      XXX   X  X XXX  X       XXXX  XXXXXXX X
Galium aparine                 X                     X                X
G.    palustre                                      X
G.    verum                 X  XX  XX         X X XXXX X            X    X    XXX X
Geranium lucidum                                                   X
G.       molle                                                     X
G.       robertianum                                      X  X         X X        X
Hedera helix                X  X X XXXXX  X XX XX   X  X XXX  X XX X  XXXXX X XXXXXXX XX
Heracleum sphondylium                             X       X     X
Hieracium pilosella                               XX XXX                      X X
H.         spp.             X
Holcus lanatus                                  X X   X
```

APPENDIX 7b cont.

UNIT	II	III
	DDDDDDDDDDD 11	11111111111111111111
	11117777788888899999900	00001111111122222223LLLLL
SPECIES	23456789012334789245789023458902	35680123467912345789131234 5
Hordeum murinum	X	
Hypericum perforatum	X	
H. tetrapterum	X X	
Hypocharis radicata	X X X XX X	
Knautia arvensis	XXX X X	
Lapsana communis	XX	
Lathyrus pratensis	X X	
Leontodon autumnalis	X	
L. hispidus	X X	
Leucanthemum vulgare	XXXXXXXXXXXXX X X XX XXX X	
Ligustrum vulgaris	X X X	
Linum catharticum	X	
Lonicera nitida	X X X	
Lotus corniculatus	X X X X	
Luzula campertris	X	
Lycopus europaeus	XX X	
Lythrum salicaria	X	
Medicago lupulina	X X X X X	
Mentha aquatica	X X X X XXX	
Nasturtium officinale	X	
Odontites verna	X	
Oenanthe crocata	X	
Petasites hybridus	X XX X	
Phalaris arundinacea	X	
Phyllitis scolopendrium	XXXXX XX X X X XXX X X X XX X X X XX	
Picea spp.	X	
Pimpinella saxifraga	XX X XX X XX X X X X X	
Plantago lanceolata	XXXX X XX X X X X	
Poa annua	X XX	
P. pratensis	XXX X XX XX X X	

APPENDIX 7b cont.

UNIT	II	III
	DDDDDDDDDDDD 11	11111111111111111111
	111177777888888999999900	00001111111122222223 3LLLLL
	234567890123347892457890234589 02	35680123467912345789131 2345
SPECIES		
Potentilla anserina	X X	
P. reptans	X X X X	
Prunus spinosa	X X X X X X X X XX X	
Pteridium aquilinum	X X X X X	
Ranunculus bulbosus	X X X	
R. repens	X X X	
R. scleratus	X	
Ribes spp.	X	
Rosa canina agg.	X X	
Rubus fruticosus agg.	XXXX XX XXX X XX X XXXXXX XX X X XXXXXXX X XXX X X	
Rumex sanguineus	X	
Salix alba	X	
S. aurita	X	
Sambucus nigra	X XXXX X X X X X X X	
Scrophularia nodosa	X X	
Sedum album	X	
Senecio aquaticus	X	
S. jacobaea	XXXXXX X X XXXXXX X X X X X XXX	
Smyrnium olusatrum	X	
Solanum tuberasum	X	
Sonchus arvensis	X	
S. asper	X X	
S. oleraceus	X	
Sorbus aria agg.	X	
S. aucuparia	X	
Stachys palustris	X X X X	
Taraxacum spp.	X XX X XX X XXX XXXXXX X X X X X	
Torilis japonica	X	
Trifolium dubium	X X	
T. pratense	X X X X X	
T. repens	X X	
Tussilago farfara	X X X XX X X	

APPENDIX 7b cont.

UNIT	II	III
	DDDDDDDDDDDD	11 11111111111111111111
	11117777788888899999900	00001111111122222223 3LLLLL
SPECIES	23456789012334789245789023458902	35680123467912345789 1312345
Ulmus agg.	X X	
Urtica dioica	XX XX XX X X X X XX X X X X	
Valeriana officinalis	X X X X X	X
Veronica chamaedrys	X	
Veronica persica	X	
Viburnum opulus	X	
Viccia cracca	X	
V. sepium	X	

APPENDIX 8

Species and Species Diversity recorded on some selected areas which were dredged during 1989 and 1990 along the Royal Canal. The % Occurrence of those species recorded on the bank and towpath are also given.

SECTION	Bk. 1	Tp. 1	Bk. 2	Tp. 2	Bk. 11	Tp. 11	Bk. 12	Tp. 12	Bk. 14	Tp. 14	Bk. 15	Tp. 15	Bk. 40	Bk. 44	Bk. 45	Bd. 59	Bk. 65	Bd. 66	Bk. 67	%Occ Bk.	%Occ Tp.
SPECIES																					
Acer pseudoplatanus	X		X																	18	-
Achillea millefolium	X		X			X														27	17
Agrimonia eupatoria	X		X																	18	-
Agrostis stolonifera	X		X	X	X				X					X	X	X	X	X		63	17
Allium vineale	X																			9	-
Anagallis tenella	X		X			X		X										X		27	33
Angelica sylvestris													X	X	X	X			X	36	-
Anthoxanthum odoratum	X												X						X	27	-
Arctium minus			X	X				X												9	33
Arrhenatherum elatius	X		X		X	X	X	X	X		X	X	X		X			X	X	82	50
Brachypodium sylvaticum	X																			9	-
Brizia media																			X	9	-
Calystegia sepium	X		X		X		X		X	X		X	X		X	X				63	33
Carex disticha						X							X		X					18	17
C. elata																			X	9	-
C. flacca																			X	9	-
C. rostrata	X												X	X	X			X	X	54	-
Centaurea nigra	X	X	X	X	X	X							X			X		X	X	54	50
Cerastium fontanum					X	X														9	17
Chenopodium album	X									X										9	17
Cirsium arvense	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		82	100
C. palustre														X		X		X	X	27	-
C. vulgare	X		X		X	X	X	X						X				X		45	33
Chamomille suaveolens		X		X		X		X												-	67
Convolvulus arvensis	X				X		X													27	-
Crepis vesicaria	X																			9	-
Cynosurus cristatus				X									X				X		X	27	17
Dactylis glomerata	X	X	X	X																18	33
Daucus carota	X	X	X	X		X		X												18	67
Elyaus repens	X	X	X						X	X										27	33
Epilobium angustifolium			X	X																9	17
E. hirsutum	X		X						X				X							36	-
E. parviflorum	X																			9	-
Equisetum arvense	X		X							X	X	X		X	X	X	X			54	33
Eupatorium cannabinum	X		X	X								X								18	33
Euphorbia peplus	X																			9	-
Festuca rubra										X			X						X	18	17
Filipendula ulmaria	X	X	X	X	X		X		X	X			X	X	X			X	X	82	50
Fraxinus excisior	X		X										X							27	-
Fumaria officinale										X										-	17
Galium palustre													X		X	X			X	27	-
G. verum	X		X	X								X	X					X	X	36	33
Geranium dissectum		X				X	X													9	33
G. robertianum	X					X														9	17
Geum urbanum	X																			9	-
Glyceria maxima	X	X	X	X					X	X	X	X		X	X	X	X	X	X	73	67
Heracleum sphondylium	X	X			X		X	X	X											36	33
Holcus lanatus	X		X	X	X	X	X	X					X						X	54	50
Hypericum perforatum													X							9	-

Species and Species Diversity recorded on some selected areas which were dredged during 1989 and 1990 along the Royal Canal. The % Occurrence of those species recorded on the bank and towpath are also given.

SECTION / SPECIES	Bk. 1	To. 1	Bk. 2	Tp. 2	Bk. 11	To. 11	Bk. 12	To. 12	Bk. 14	To. 14	Bk. 15	To. 15	Bk. 40	Bk. 44	Bk. 45	Bd. 59	Bk. 66	Bk. 66	Bk. 67	%Occ Bk.	%Occ Tp.
A. tetractenum			X		X										X					27	-
Hyacharis radicata																		X	X	9	-
Iris pseudacorus	X		X	X									X	X	X			X	X	54	17
Juncus acutiflorus																			X	9	-
J. articulatus													X		X				X	27	-
J. inflexus	X								X	X	X	X	X	X	X		X	X	X	73	33
Knautia arvensis	X																			9	-
Lapsana communis	X	X	X	X		X	X	X		X										27	83
Lathyrus pratensis	X		X	X		X		X	X			X			X	X	X		X	54	67
Leontodon hispidus		X		X																-	33
Leucanthemum vulgare	X					X	X	X								X		X		18	33
Linum catharticum													X							9	-
Lilium parenne	X	X	X														X			27	17
Lotus corniculatus																X			X	9	-
Lythrum salicaria			X	X															X	18	17
Medicago lupulina	X					X														9	17
Mentha aquatica	X		X	X						X		X	X					X	X	36	50
Menyanthes trifoliata															X			X		9	-
Myosotis arvensis	X																			9	-
Nasturtium officinale																			X	9	-
Nuphar lutea															X	X				9	-
Odontites verna	X		X	X		X							X							27	33
Oxalis repens	X		X															X		18	-
Origanum vulgare	X		X			X														18	17
Papaver spp.	X		X		X															27	-
Potamites hybridus	X		X		X	X		X	X		X									45	33
Phalaris arundinacea	X	X	X	X	X	X	X		X	X	X	X			X					54	83
Phleum pratense			X	X		X		X												18	50
Pimpinella saxifraga			X													X				9	-
Plantago lanceolata	X		X	X	X	X			X	X		X						X	X	45	67
P. major		X		X		X				X		X								-	83
Poa annua		X		X		X		X					X						X	18	67
P. trivialis		X				X		X					X						X	18	50
Polygonum amphibium	X		X			X	X	X	X				X	X	X	X		X		73	33
P. aviculare	X	X			X															9	17
Potentilla anserina	X														X	X	X	X	X	36	-
P. rectans	X		X					X				X	X	X	X		X			73	17
Prunella vulgaris	X					X													X	18	17
Prunus spinosa	X																			9	-
Pteridium aquilinum															X					9	-
Ranunculus acris			X	X									X	X	X			X		36	17
R. flammula													X	X						18	-
R. lingua	X			X									X	X				X	X	36	17
R. repens	X		X	X	X	X	X	X				X	X	X	X		X	X	X	91	67
R. sceleratus												X								9	-
Rumex hydrolapathum	X				X															18	17
Scrophularia auricularia																			X	9	-
Rosa canina agg.	X		X																	18	-
Rubus fruticosus agg.	X		X		X	X	X		X		X		X		X	X				73	17

Species and Species Diversity recorded on some selected areas which were dredged during 1989 and 1990 along the Royal Canal. The % Occurrence of those species recorded on the bank and towpath are also given.

	Bk.	Tp.	Bk.	Tp.	Bk.	Tp.	Bk.	Tp.	Bk.	Tp.	Bk.	Tp.	Bk.	Bk.	Bk.	Bd.	Bk.	Bd.	Bk.	%Occ	%Occ
SECTION	1	1	2	2	11	11	12	12	14	14	15	15	40	44	45	59	66	66	67	Bk.	Tp.
SPECIES																					
Rumex obtusifolius	X			X		X		X	X											18	50
R. sanguineus			X	X		X		X												9	50
Sagina nodosa																			X	9	-
Scirpus lacustris											X		X		X					27	-
Scutellaria galericulata																			X	9	-
Senecio aquaticus																			X	9	-
S. jacobaea	X		X	X	X	X	X	X										X		36	50
S. vulgare	X	X	X							X	X	X								27	50
Sinapsis arvensis	X																			9	-
Sisymbrium officinale						X	X	X												9	33
Solanum dulcamara			X	X	X	X	X	X												27	50
Sonchus arvensis	X		X		X															27	-
S. asper	X		X													X				18	-
S. oleraceus	X		X																	18	-
Sparganium erectus											X									9	-
Stachys palustris					X	X													X	18	17
S. sylvatica						X														-	17
Succisa pratensis																X			X	9	-
Taraxacum agg.																	X	X		9	-
Torilis japonica	X		X																	18	-
Trifolium pratense	X		X		X	X		X					X				X		X	54	33
Triglochin palustris													X	X			X		X	36	-
Tussilago farfara																X				-	-
Typha latifolia											X								X	18	-
Ulex europaeus	X																			9	-
Urtica dioica	X		X		X	X	X	X	X		X	X	X		X					73	50
Valeriana officinalis	X		X		X								X		X				X	54	-
Viccia cracca			X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	91	67
V. sepium	X															X				9	-
DIVERSITY	75	19	58	33	28	41	20	26	20	17	16	18	40	16	31	22	16	23	45		

Bk. = Bank, Bd. = Boundary, Tp. = Towpath.

APPENDIX 9

Species List of Plants recorded along the Royal Canal: Latin to English

Acer pseudoplatanus	Sycamore
Achillea millefolium	Yarrow
Aegopodium podagraria	Ground Elder
Aesculus hippocastanum	Horse Chestnut
Agrimonia eupatoria	Agrimony
Agrostis capillaris	Common Bent
A. stolonifera	Creeping Bent
Ajuga reptans	Bugle
Alisma plantago-aquatica	Water Plantain
Alliaria petiolata	Garlic mustard
Alnus glutinosa	Alder
Anacamptis pyramidalis	Pyrammidal Orchid
Anagallis arvensis	Scarlet Pimpernel
A. tenella	Bog Pimpernel
Andromeda polifolia	Bog Rosemary
Angelica sylvestris	Wild Angelica
Antennaria dioica	Mountain Everlasting
Anthoxanthum odoratum	Sweet Vernal-grass
Anthriscus sylvestris	Cow Parsley
Anthyllis vulneraria	Kidney Vetch
Aphanes arvensis	Parsley Piert
Apium nodiflorum	Fool's Water Cress
Arctium minus	Lesser Burdock
Armoracia rusticana	Horse-Radish
Arrhenatherum elatius	False Oat-Grass
Artemisia vulgaris	Mugwort
Arum maculatum	Wild Arum (Lords and Ladies)
Asplenium ruta-muraria	Wall Rue
A. trichomanes	Maidenhair Spleenwort
Atriplex spp.	Orache spp.
Avenula pubescens	Downy Oat-Grass
Baldellia ranunculoides	Lesser Water Plantain
Bellis perennis	Daisy
Berula erecta	Lesser Water Parsnip
Betula spp.	Birch spp.
Blackstonia perfoliata	Yellow Wort
Brachypodium pinnatum	Tor-Grass
B. sylvaticum	False Brome
Brassica rapa	Wild Turnip
Brizia media	Quaking Grass
Bromus erectus	Upright Brome
B. hordeaceus	Soft Brome
B. ramosus	Hairy Brome
Buddleja davidii	Butterfly Bush
Callitriche spp.	Water Starwort
Calluna vulgaris	Heather - Ling
Caltha palustris	Marsh Marigold
Hedge Bindweed	Hedge bindweed
C. silvatica	Large Bindweed
Capsella bursa-pastoris	Shepherd's Purse
Cardamine flexuosa	Wavy Bitter Cress
C. hirsuta	Hairy Bitter Cress
C. pratensis	Cuckoo Flower

APPENDIX 9 cont.

Carduus acanthoides	Welted Thistle
Carex acuta	Slender Tufted sedge
C. acutiformis	Lesser Pond-sedge
C. appropinquata	Fibrous Tussock Sedge
C. aquatilis	Water Sedge
C. caryophyllea	Spring Sedge
C. demissa	Common Yellow Sedge
C. diandra	Lesser Tussock Sedge
C. disticha	Brown Sedge
C. echinata	Star Sedge
C. elata	Tufted Sedge
C. flacca	Glaucous Sedge
C. hirta	Hairy Sedge
C. lepidocarpa	Long-stalked Yellow Sedge
C. nigra	Common Sedge
C. otrubae	False Fox Sedge
C. panicea	Carnation Sedge
C. paniculata	Greater Tussock Sedge
C. pulicaris	Flea Sedge
C. remota	Remote Sedge
C. rostrata	Bottle Sedge
C. sylvatica	Wood Sedge
Carlina vulgaris	Carline Thistle
Castinea sativa	Sweet Chestnut
Centaurea nigra	Common Knapweed
Centaurium erythraea	Common Centaury
Centranthus ruber	Red Valerian
Cerastium fontanum	Common Mouse-ear
C. glomeratum	Sticky Mouse-ear
Ceratophyllum demersum	Rigid Hornwort
Ceterach officinarum	Rustyback Fern
Chaenorhinum minus	Small Toadflax
Chamaecyparis lawsoniana	Lawson's Cypress
Chamomille suaveolens	Pineappleweed
Chenopodium album	Fat Hen
Cirsium arvense	Creeping Thistle
C. palustre	Marsh Thistle
C. vulgare	Spear Thistle
Cladium mariscus	Great Fen Sedge
Clematis vitalba	Traveller's Joy
Coeloglossum viride	Frog Orchid
Convolvolus arvensis	Field Bindweed
Corylus avellana	Hazel
Cotoneaster spp.	Cotoneaster
Crataegus monogyna	Hawthorn/White thorn
Crepis biennis	Rough Hawk's-beard
C. capillaris	Smooth Hawk's-beard
C. vesicaria	Beaked Hawk's-beard
Cyclamen hederifolium	Cyclamen
Cymbalaria muralis	Ivy-leaved Toadflax
Cynosurus cristatus	Crested Dog's Tail
Dactylis glomerata	Cock's-foot Grass
Dactylorhiza fuchsii	Common Spotted-Orchid
D. incarnata	Early Marsh Orchid
D. maculata	Heath Spotted orchid
Danthonia decumbens	Heath Grass

APPENDIX 9 cont.

Daucus carota	Wild Carrot
Deschampsia caespitosa	Tufted Hair Grass
Desmazeria rigida	Fern Grass
Drosera rotundifolia	Round-leaved Sundew
Dryopteris dilatata	Broad Buckler Fern
Dryopteris filix-mas	Male Fern
Echium vulgare	Viper's Bugloss
Eleocharis palustris	Common Spike-Rush
Elodea canadensis	Canadian Pondweed
Elymus repens	Common Couch
Empetrum nigrum	Crowberry
Epilobium angustifolium	Rosebay Willowherb
E. hirsutum	Great Willowherb
E. montanum	Broad-leaved Willowherb
E. palustre	Marsh Willowherb
E. parviflorum	Hoary Willowherb
Equisetum arvense	Field Horsetail
E. fluviatile	Water Horsetail
E. palustre	Marsh Horsetail
E. telmateia	Great Horsetail
E. variegatum	Variegated Horsetail
Erica tetralix	Cross-leaved Heath
Eriophorum angustifolium	Common Cotton Grass
E. latifolium	Broad-leaved Cottongrass
E. vaginatum	Hare's-tail Cotton Grass
Euonymus europaeus	Spindle
Eupatorium cannabinum	Hemp Agrimony
Euphrasia spp.	Eyebright spp.
Euphorbia helioscopia	Sun Spurge
E. peplus	Petty spurge
Fagus sylvatica	Beech
Festuca arundinacea	Tall Fescue
F. pratensis	Meadow Fescue
F. rubra	Red Fescue
Filipendula ulmaria	Meadowsweet
Foeniculum vulgare	Fennel
Fragraria vesca	Wild Strawberry
Fraxinus exelsior	Ash
Fuchsia magellanica	Fuchsia
Fumaria officinalis	Common Fumitory
Galium aparine	Cleavers
G. palustre	Common Marsh Bedstraw
G. uliginosum	Fen Bedstraw
G. verum	Lady's Bedstraw
Geranium dissectum	Cut-leaved Crane's-bill
G. lucidum	Shining Crane's-bill
G. molle	Dove's-foot Crane's-bill
G. pyrenaicum	Hedge Crane's-Bill
G. robertianum	Herb Robert
Geum urbanum	Wood Aven
Glechoma hederacea	Ground Ivy
Glyceria maxima	Reed Sweet-Grass
G. fluitans	Floating Sweet-Grass
G. plicata	Plicate Sweet-Grass
Groenlandia densa	Opposite Leaved Pondweed
Gymnadenia conopsea	Fragrant Orchid

Hedera helix	Ivy
Heracleum sphondylium	Hogweed
Hieracium pilosella	Mouse-ear Hawkweed
Hippuris vulgaris	Mare's Tail
Holcus lanatus	Yorkshire Fog
Hordeum murinum	Wall Barley
Hyacinthoides non-scriptus	Bluebell
Hydrocharis morsus-ranae	Frogbit
Hydrocotyle vulgaris	Marsh Pennywort
Hypericum androsaemum	Tutsan
H. hircinum	Stinking Tutsan
H. perforatum	Perforate St.John's Wort
H. pulchrum	Slender St.John's Wort
H. tetrapterum	Sq. stalked St. John's Wort
Hypocharis radicata	Cat's-ear
Ilex aquifolium	Holly
Iris pseudacorus	Yellow Iris
Juncus acutiflorus	Sharp-Flowered Rush
J. articulatus	Jointed Rush
J. bulbosus	Bulbous Rush
J. conglomeratus	Compact Rush
J. effusus	Soft Rush
J. inflexus	Hard Rush
J. subnodulosus	Blunt-Flowered Rush
Knautia arvensis	Field Scabnious
Lamium album	White Dead-Nettle
Lamium purpureum	Red Dead-Nettle
Lapsana communis	Nipplewort
Larix spp.	Larch
Lathyrus pratensis	Meadow Vetchling
Lemna minor	Common Duckweed
L. trisulca	Ivy-leaved Duckweed
Leontodon autumnalis	Autumn Hawkbit
L. hispidus	Rough Hawkbit
L. taraxacoides	Lesser Hawkbit
Leucanthemum vulgare	Oxeye Daisy
Leycesteria formosa	Himalayan Honeysuckle
Ligustrum vulgaris	Wild Privet
Linaria purpurea	Purple Toadflax
Linum bienne	Pale Flax
L. catharticum	Fairy Flax
Listera ovata	Common Twayblade
Lolium perenne	Perennial Rye-Grass
Lonicera nitida	Shining Honeysuckle
L. periclymenum	Honeysuckle
L. xylosteum	Fly Honeysuckle
Lotus corniculatus	Bird's-Foot Trefoil
Luzula campestris	Field Wood rush
Lychnis flos-cuculi	Ragged-Robin
Lycopus europaeus	Gipsywort
Lysimachia nemorum	Yellow Pimpernel
Lythrum salicaria	Purple Loosestrife
Malus spp.	Apple
Malva sylvestris	Common Mallow
Medicago lupulina	Black Medick

Melampyrum pratense	Common Cow-Wheat
Mentha aquatica	Water Mint
Menyanthes trifoliata	Bogbean
Molinea caerulea	Purple Moor Grass
Myosotis arvensis	Field Forget-me-not
M. discolor	Changing Forget-me-not
M. laxa	Tufted Forget-me-not
M. scorpioides	Water Forget-me-not
Myrica gale	Bog-Myrtle
Myriophyllum spp.	Milfoil
Narthecium ossifragum	Bog Asphodel
Nasturtium officinale	Water Cress
Nuphar lutea	Yellow Water Lily
Nymphaea alba	White Water Lily
Odontites verna	Red Bartsia
Oenanthe aquatica	Fine-leaved Water-Dropwort
O. crocata	Hemlock Water-Dropwort
O. fistulosa	Tubular Water-Dropwort
Ononis repens	Restharrow
Ophrys apifera	Bee Orchid
Orchis mascula	Early Purple Orchid
O. morio	Green-winged Orchid
Origanum vulgare	Marjoram
Oxalis acetosella	Wood Sorrel
Papaver spp.	Poppy
Parnassia palustris	Grass of Parnassus
Pedicularis palustris	Marsh Lousewort
P. sylvatica	Lousewort
Petasites hybridus	Butterbur
Phalaris arundinacea	Reed Canary Grass
Phleum pratense	Timothy Grass
Phragmites australis	Common Reed
Phyllitis scolopendrium	Hart's Tongue Fern
Picea spp.	Spruce
Pimpinella saxifraga	Burnet Saxifrage
Pinguicula lusitanica	Pale Butterwort
P. vulgaris	Common Butterwort
Pinus radicata	Monterey Pine
P. sylvestris	Scot's Pine
Plantago lanceolata	Ribwort Plantain
P. major	Greater Plantain
Poa annua	Annual Meadow Grass
P. pratensis	Smooth Meadow Grass
P. trivialis	Rough Meadow Grass
Polygala serpyllifolia	Heath Milkwort
P. vulgaris	Common Milkwort
Polygonum amphibium	Amphibious Bistort
P. aviculare	Knotgrass
P. persicaria	Redshank
Polypodium vulgare	Polypody
Populus spp.	Poplar
Potamogeton crispus	Curled Pondweed
P. lucens	Shining Pondweed
P. natans	Broad-Leaved Pondweed
P. perfoliatus	Perfoliate Pondweed
P. polygonifolius	Bog Pondweed

Potentilla anserina	Silverweed
P. erecta	Tormentil
P. palustris	Marsh Cinquefoil
P. reptans	Creeping Cinquefoil
P. sterilis	Barren Strawberry
Primula veris	Cowslip
P. vulgaris	Primrose
Prunella vulgaris	Selfheal
Prunus avium	Wild Cherry
P. spinosa	Blackthorn
Pteridium aquilinum	Bracken Fern
Pulicaria dysenterica	Fleabane
Quercus agg.	Oak
Ranunculus acris	Meadow Buttercup
R. bulbosus	Bulbous Buttercup
R. circinatus	Fan-Leaved Water-Crowfoot
R. ficaria	Lesser Celandine
R. flammula	Lesser Spearwort
R. lingua	Greater Spearwort
R. sceleratus	Celery Leaved Buttercup
R. trichophyllus	Thread-leaved Water-crowfoot
Reseda luteola	Weld
Rhinanthus minor	Yellow Rattle
Rhynchospora alba	White Beak Sedge
Ribes uva-crispa	Gooseberry
Rosa canina agg.	Dog Rose
Rubus fruticosus	Bramble
R. idaeus	Raspberry
Rumex acetosa	Common Sorrel
R. conglomeratus	Clustered Dock
R. crispus	Curled Dock
R. hydrolapathum	Water Dock
R. obtusifolius	Broad-Leaved Dock
R. sanguineus	Wood Dock
Sagina nodosa	Knotted Pearlwort
S. procumbens	Procumbent Pearlwort
Sagittaria sagittifolia	Arrowhead
Salix alba	White Willow
S. aurita	Eared Willow
S. caprea	Goat Willow
S. cinerea	Rusty Willow
S. fragilis	Crack Willow
S. purpurea	Purple Willow
S. repens	Creeping Willow
S. viminalis	Osier
Sambucus nigra	Elder
Sanguisorba minor	Salad Burnet
Sanicula europaea	Sanicle
Schoenus nigricans	Black Bog Rush
Scirpus caespitosus	Deer Grass
S. lacustris	Common Club Rush
Scrophularia nodosa	Common Figwort
Scutellaria galericulata	Skullcap
Sedum album	White Stonecrop

Senecio aquaticus	Marsh Ragwort
S. erucifolius	Hoary Ragwort
S. jacobaea	Common Ragwort
S. vulgaris	Groundsel
Sherardia arvensis	Field Madder
Silene alba	White Campion
Silybum marianum	Milk Thistle
Sinapsis arvensis	Charlock
Sisymbrium officinale	Hedge Mustard
Smyrnium olusatrum	Alexander
Solanum dulcamara	Bittersweet
S. tubersum	Potatoe
Sonchus arvensis	Perennial Sow Thistle
S. asper	Prickly Sow Thistle
S. oleraceus	Smooth Sow Thistle
Sorbus aria	Common Whitebeam
S. aucuparia	Rowan
Sparganium emersum	Unbranched Bur-Reed
S. erectum	Branched Bur-Reed
Stachys palustris	Marsh Woundwort
S. sylvatica	Hedge Woundwort
Stellaria graminea	Lesser Stitchwort
S. holostea	Greater Stitchwort
S. media	Common Chickweed
S. palustris	Marsh Stitchwort
Succisa pratensis	Devil's-Bit Scabious
Symphoricarpos albus	Snowberry
Symphytum officinale	Common Comfrey
Syringa vulgaris	Lilac
Tanacetum vulgare	Tansy
Taraxacum spp.	Dandelion
Taxus baccata	Yew
Tilia agg.	Lime
Torilis japonica	Upright Hedge Parsley
Tragopogon pratensis	Goat's Beard
Trifolium dubium	Lesser Trefoil
T. pratense	Red Clover
T. repens	White Clover
Triglochin palustris	Marsh Arrowgrass
Trisetum flavescens	Yellow Oat Grass
Tritonia crocusmiflora	Montbretia
Tussilago farfara	Colt's-Foot
Typha latifolia	Bulrush
Ulex europaeus	Gorse
Ulmus agg.	Elm
Urtica dioica	Common Nettle
Utricularia spp.	Bladderwort
Valeriana officinalis	Common Valerian
Verbascum thapsus	Great Mullein
Veronica anagallis-aquatica	Blue Water-Speedwell
V. beccabunga	Brooklime
V. catenata	Pink Water-Speedwell
V. chamaedrys	Germander Speedwell
V. hederifolia	Ivy-leaved Speedwell
V. montana	Wood Speedwell
V. persica	Common Field Speedwell

APPENDIX 9 cont.

V. scutellata	Marsh Speedwell
V. serpyllifolia	Thyme-leaved Speedwell
Viburnum opulus	Guelder Rose
Viccia cracca	Tufted Vetch
V. sativa	Common Vetch
V. sepium	Bush Vetch
Vinca minor	Periwinkle
Viola spp.	Violet
Zanichellia palustris	Horned Pondweed
Algae	
Charophytes	Stoneworts
Fontinalis antipyretica	Willow Moss

APPENDIX 10

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.

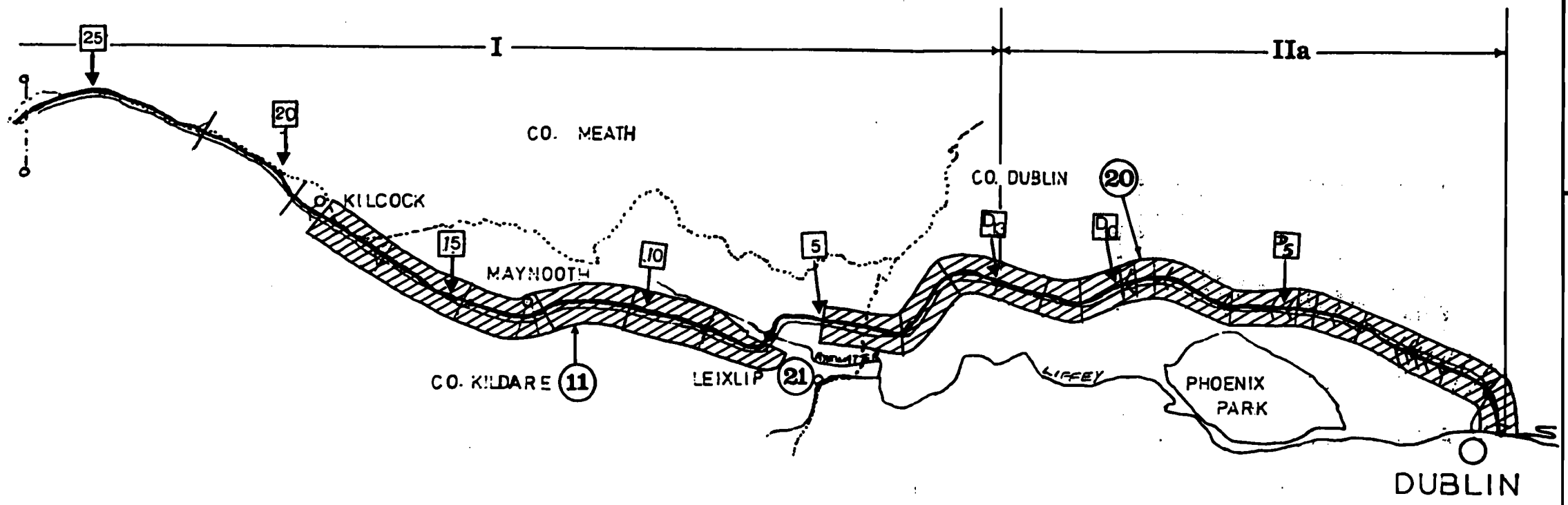
(after: Newbold et al, 1989)

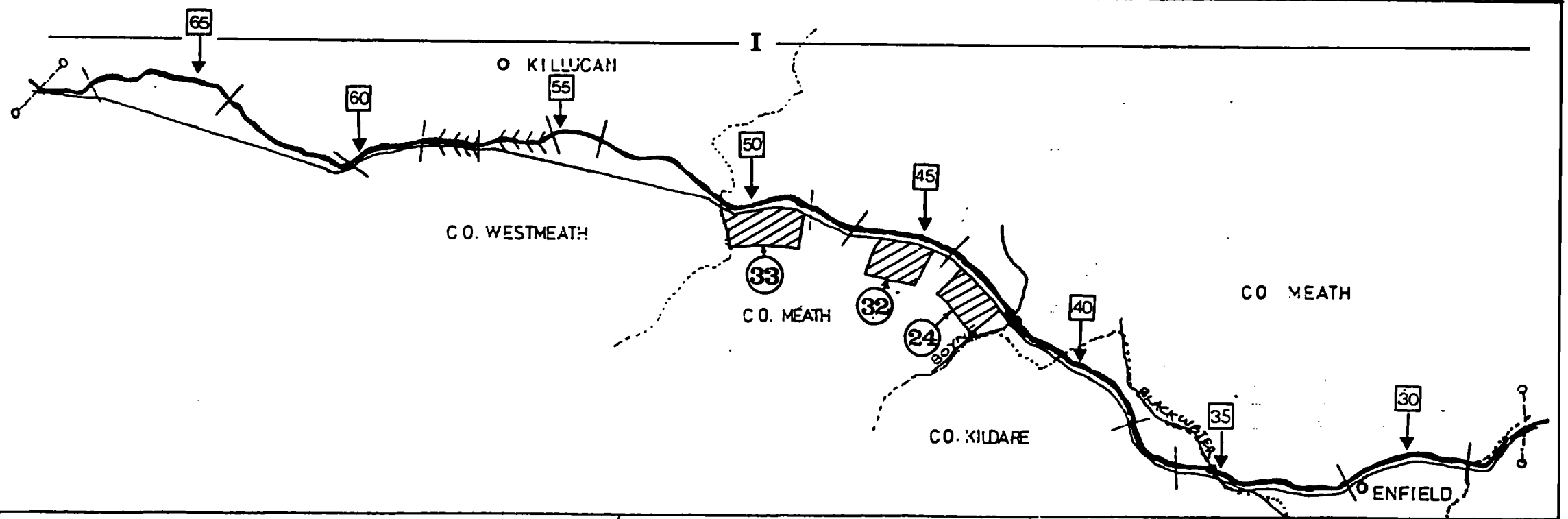
ROYAL CANAL

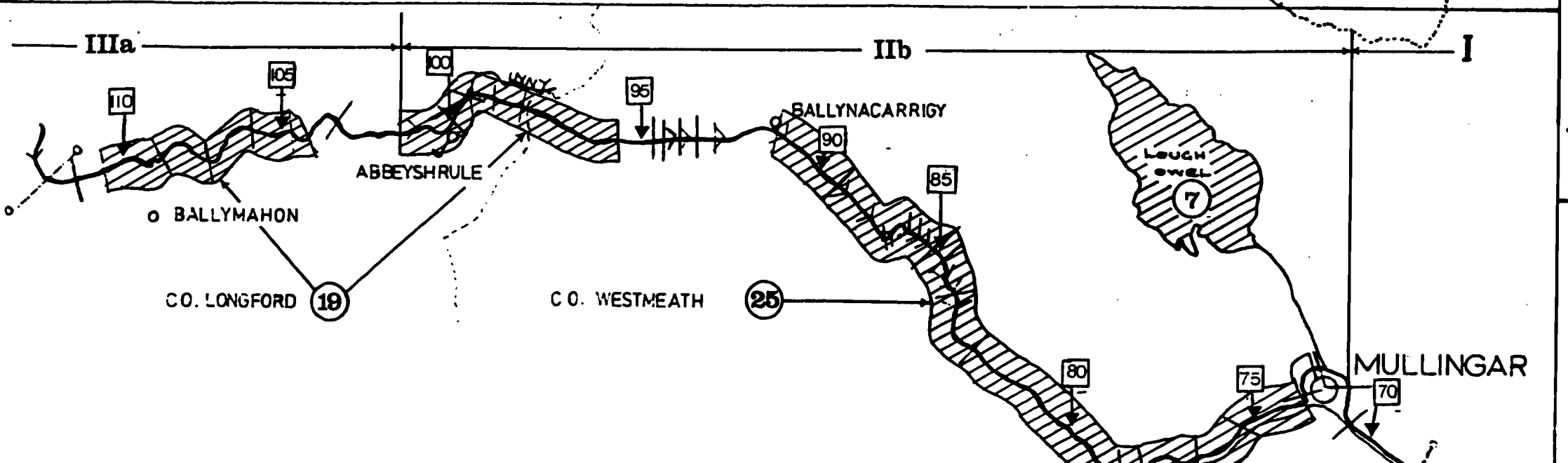
Figure 1.1

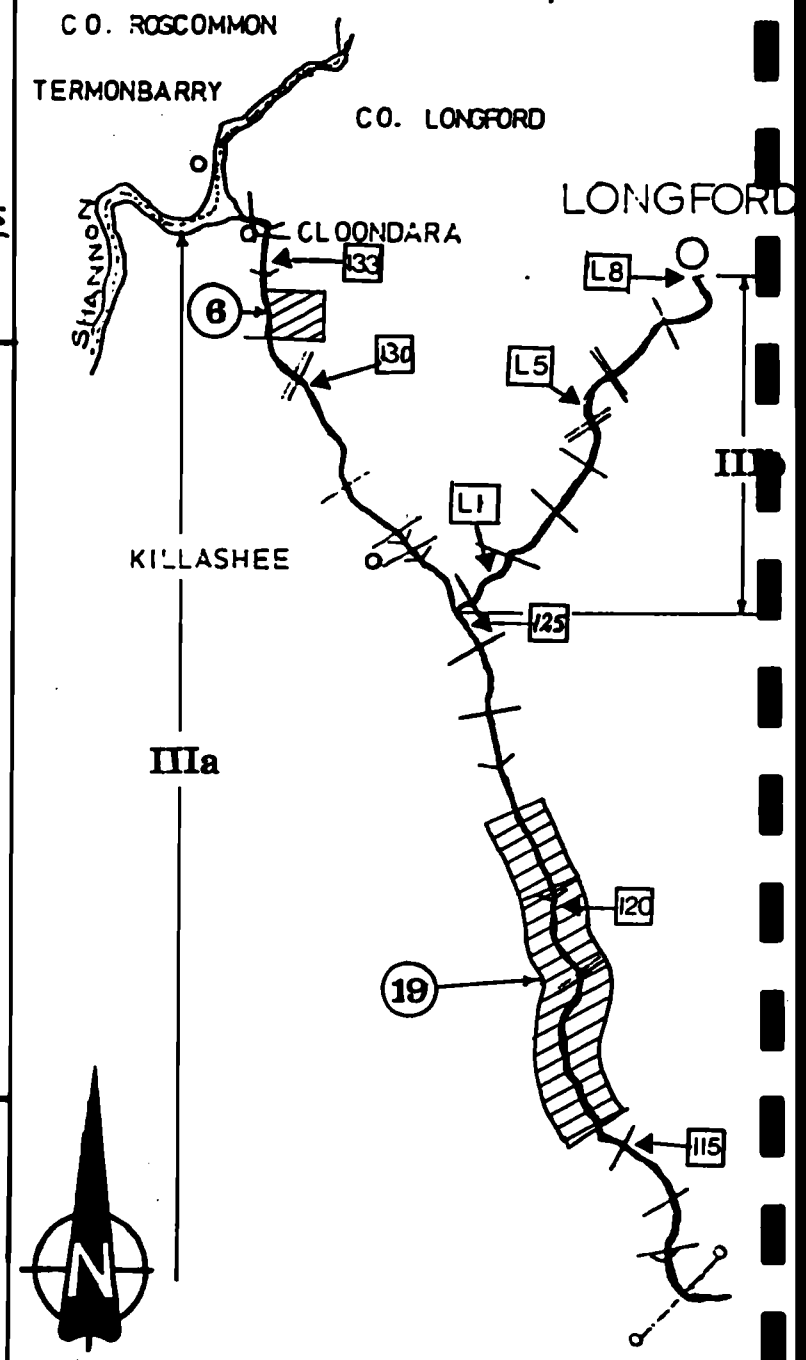
MANAGEMENT UNITS I, II, III

AREAS OF SCIENTIFIC INTEREST 33









LEGEND

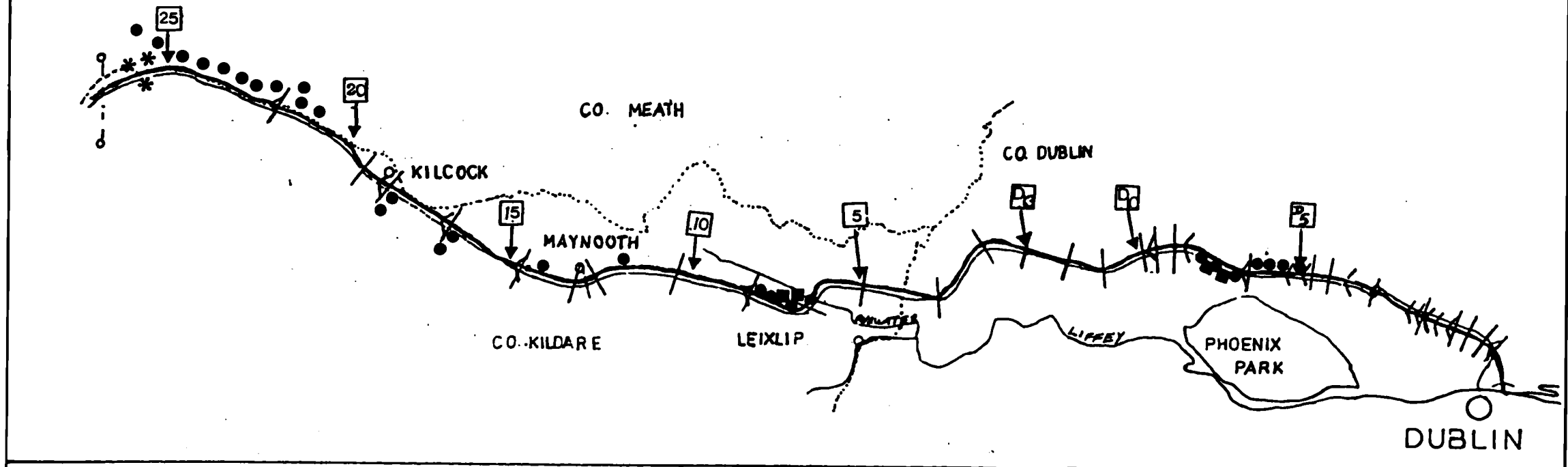
- LOCK
- BRIDGE
- TOWN
- AQUEDUCT
- COUNTY BOUNDARY

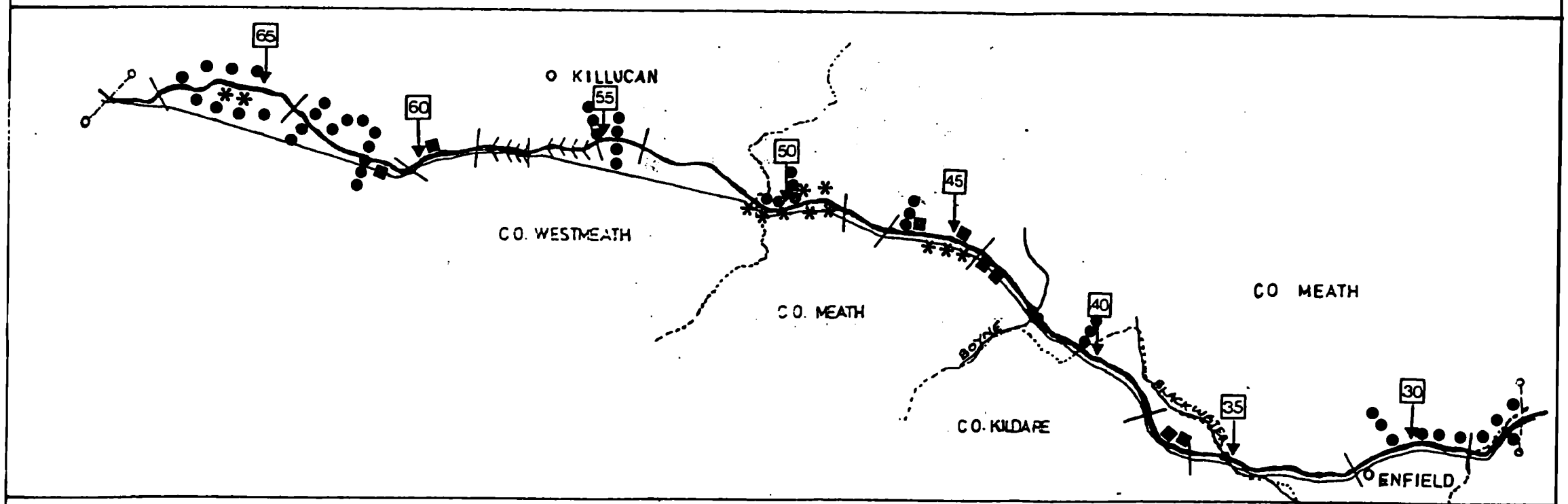
SCALE 0 1 2 3 4 5 Km

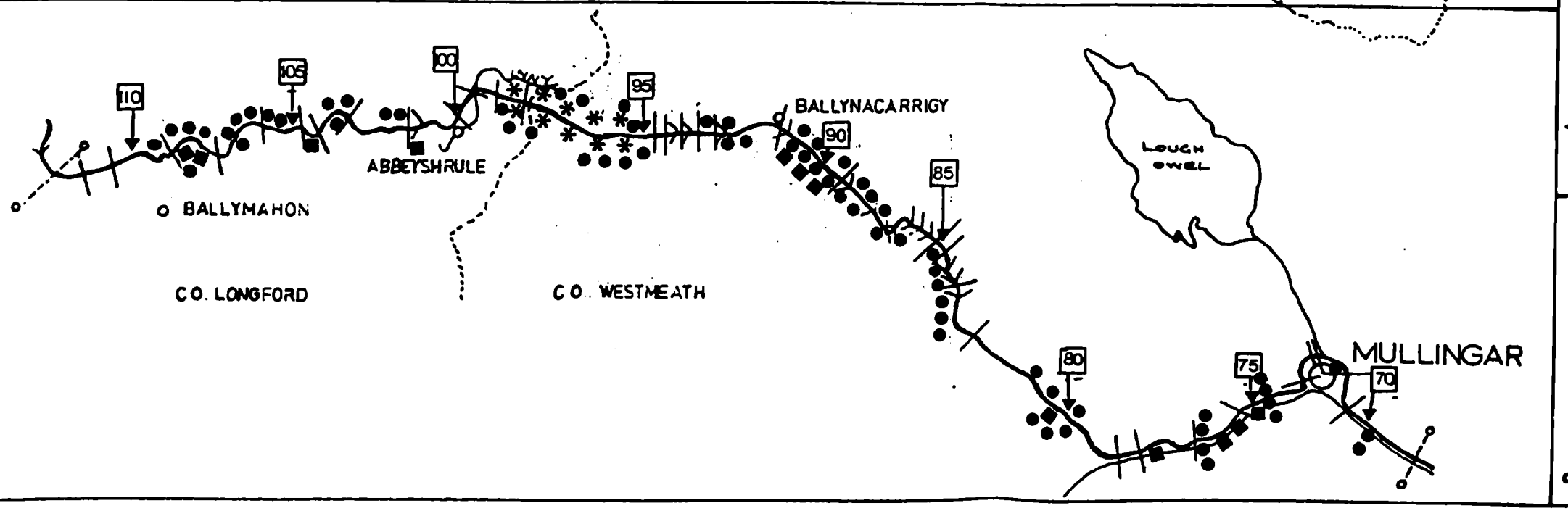
denotes the end of a kilometre section

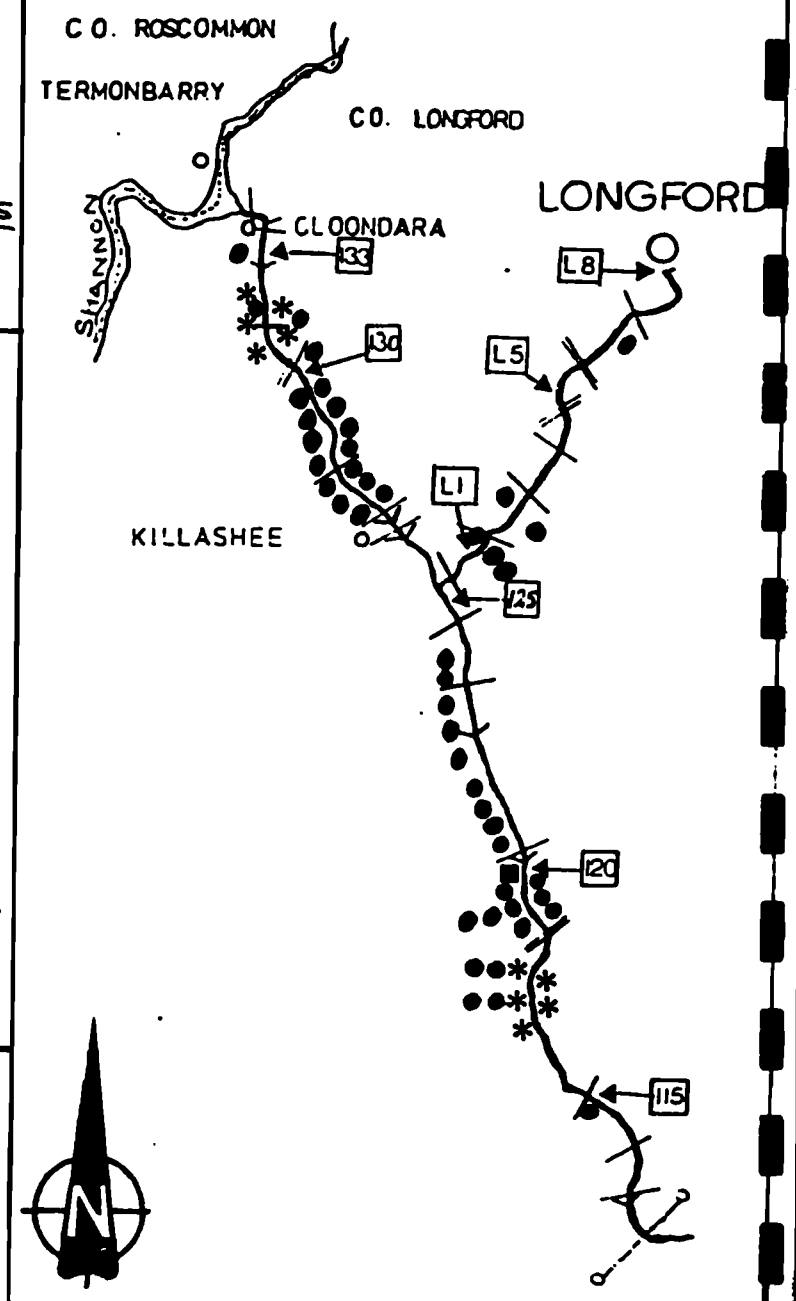
ROYAL CANAL

BOGS, FENS AND DRAINS ALONG THE ROYAL CANAL. Fig. 22







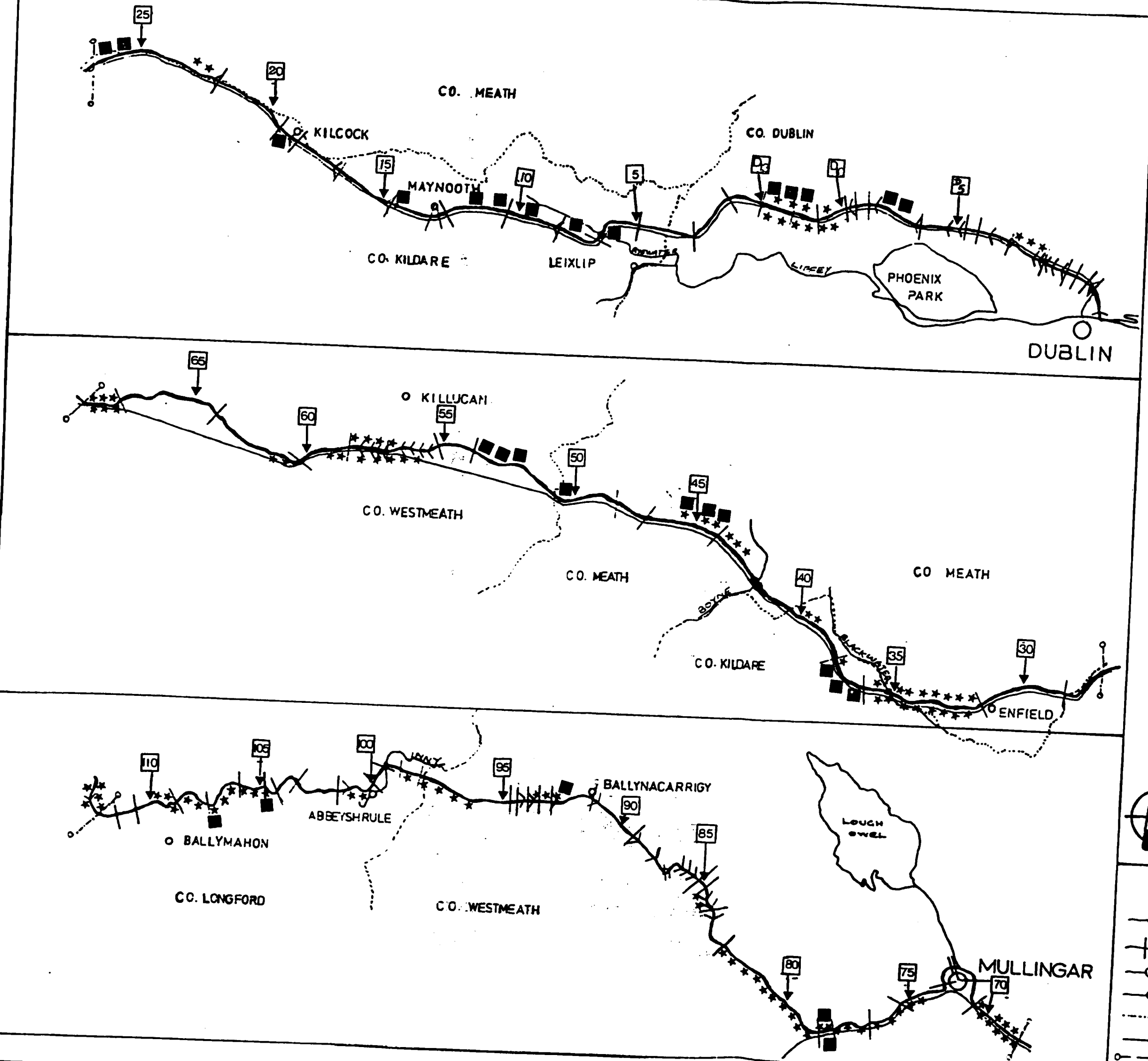


LEGEND

- LOCK
- BRIDGE
- TOWN
- AQUEDUCT
- COUNTY BOUNDARY
- RAILWAY
- MAP BOUNDARY
- VIADUCT
- SCALE 0 1 2 3 4 5 Km
- denotes the end of a kilometre section
- bog
- fen/marsh
- drain/stream

ROYAL CANAL

LIMESTONE GRASSLAND AND WOODLAND ALONG THE ROYAL CANAL. Fig. 2.1



LEGEND

- LOCK
- BRIDGE
- TOWN
- AQUEDUCT
- COUNTY BOUNDARY
- RAILWAY
- MAP BOUNDARY
- VIADUCT

SCALE 0 1 2 3 4 5 Km

denotes the end of a kilometre

section: limestone grassland, woodland