County Offaly Esker Survey 2006

Bee orchid; a rare and protected plant found at two locations on the Clonmacnoise Esker in 2006

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Summary

This study was carried out on an esker system traditionally considered part of the "Esker Riada" which is found in the north of the county.

It has also been identified by the Irish Geological Heritage Programme as meriting designation as a Geological Natural Heritage Area. The biodiversity interest of several discrete sections has been recognized by their designation as Natural Heritage Areas or Special Areas of Conservation. Policies contained in the current County Development state the Offaly County Council's intention to protect the system. While these policies exist no comprehensive surveys have been carried out to characterize its geodiversity or biodiversity interest.

The objective of this study is to examine the nature, quality and management priorities for the system. It was carried out through fieldwork and examination of soils and subsoils mapping, unpublished reports, consultations with landowners, local naturalists and the Heritage Forum.

The segments which constitute the esker system were characterised and mapped using the EPA Soils and Subsoils GIS (previously Forest Inventory Parcel System (or FIPS) and fieldwork. The analysis of FIPS revealed 27 segments. Following fieldwork this number was increased to 40, to include adjacent sand and gravel hills which share many of the characteristics of esker system.

The biodiversity interest of these segments was characterized by mapping habitats, compiling a plant list and taking a photographic record. The methodology followed the classification system promoted by the Heritage Council (Fossitt, 2000) and modifications suggested by a recent study of eskers in south Westmeath (Tubridy and Meehan, 2005).

Habitat mapping was carried out field by field along each esker segment and land was only examined directly after permission was obtained. Particular efforts were made to locate a priority type grassland which is protected under the EU Habitats Directive (92/43/EEC). During fieldwork the condition of sites listed in the Records of Monuments and Places when obvious was examined.

The geodiversity review revealed that:

Eskers cover 0.83 % of the land area in Offaly.

The esker system under examination for this study, which for the purposes of this study was called the Clonmacnoise esker is the largest esker system in the county and covers 5.79 km^2. This comprises one-third of the area of all eskers in the county.

The Clonmacnoise esker is a stunning example of an esker system as it comprises forty segments varying in size from 362sqm to 70ha. As it covers a large area it provides evidence for deglaciation over a large area in the Midlands.

The esker segments illustrate all the features classically associated with eskers. They vary in height, size and profile type from low, voluminously-small, single crested eskers to high, large, multi-crested eskers.

While the esker system only covers 579 hectares its effect on the landscape is disproportionate to its area. Some sections form large upstanding hills and their dominance in the landscape is indicated by their name such as Esker (Fighting) Hill, Bishops Hill and Rushes Hill. Heights vary from 3-4 metres to 25 m. The length of individual esker segments vary from less than 50m to that found southeast of Clara which is 5.8 kilometres long

The principal results of the biodiversity review are:

Habitat diversity is high on eskers. Twenty four habitats (classified to Level 3) were found. This is three less than the number located on eskers in Westmeath (Tubridy and Meehan, 2005) and six more than that found in the esker system examined in Laois (Muyllaert and Tubridy, 2005)

The majority of land on eskers is covered in improved grassland. While this is of relatively low biodiversity interest the fields in which it is found are surrounded by hedgerows of high value. Scrub is a common features on eskers and is particularly common around Clara and the western part of the esker system. Habitat diversity is associated with old pits.

Semi-natural habitats cover 32 % of esker land (excluding hedgerows). This is considerably more than the cover of semi-natural habitats, 6%, in lowland farmland in Laois (Hickey and Tubridy, in prep 2006).

Eleven sites with priority grassland covering 4.6ha were found within and outside designated areas. These are associated with fields which have a history of low intensity management, in particular the absence of fertilizer.

There are several small semi-natural oak-ash-hazel woodlands of high biodiversity value. Esker hedgerows and grassy verges of roadsides are particularly species rich. Many of the fields with improved grassland had higher species diversity than that generally associated with intensively managed land while inaccessible sections of "improved eskers" could still retain many elements of the semi-natural species rich calcareous grassland flora.

Associated with high habitat diversity is high species diversity. While plant recording was not the principal purpose of this survey a total of 206 species were found. These included the protected bee orchid *Orchis apifera* and regionally rare plants such as belladonna, *Atropa belladonna* and the sedge *Carex spicata.*

Fieldwork revealed the names of individuals who are knowledgeable on local history aspects of eskers. There is particular awareness of the value of the esker system as a transport route in the vicinity of Durrow and Clonmacnoise.

The overall conclusion of the study is that the esker system is of international importance. In confirms the value of policies contained in the Offaly County Development and supports the designation of the system as a pNHA.

Sustainable development along this esker system requires the maintenance of the policies contained in the County Development Plan, educational initiatives to inform landowners, the public and agencies of the nature of esker geodiversity and biodiversity, careful scrutiny of planning applications affecting semi-natural habitats and the integrity of the esker system. Other esker segments in Offaly should be characterised to support a county wide strategy. Particular initiatives should be planned and implemented in conjunction with farmers and agencies involved in land use management. The value of eskers are linking features should be promoted in the context of the EcoNet related approach which underpins the County Biodiversity Action Plan.

The Heritage Forum is the obvious forum to co-ordinate initiatives which will ensure the maintenance and improvement of esker values.

1 The brief

The brief requested that the study establish the nature, extent, and location of the Esker Riada complex of eskers, their associated habitats, noting their historical usage and archaeological features andpropose guidelines for their future care and management. The Esker Riada complex of eskers was identified within the following areas:

Ballycaghan – Durrow – Tara – Ashfield – north of Clara Bog (Erreg) – Clonshanny – Ballycumber – Cappanlosset – Doon – Bishopshill – Pilgrims Road – Clonmacnoise – Creevagh – Clorhane – Shannonbridge.

According to the brief the study should involve field study, background research, consultations and report writing.

Field work should address the following information needs:

- The extent and condition of eskers
- Their condition including pits both used and disused
- Associated habitat types and quality and constraints/modifiers to conservation status. Habitats shall be mapped at 1: 10,560 scale and classified to Level 3 of the Guide to Habitats (Fossitt 2000) as per the Heritage Council Habitat Survey Guidelines 2002.
- Archaeological and historical sites will be noted, along with associated townland names and folklore.
- Associated ecosystems / heritage areas

Desk based research, consultations and report writing to include;

- The collation of existing information on eskers in the county.

- Consultations with the relevant government departments, statutory agencies and NGOs.

- The preparation of a report describing the nature, extent and condition of eskers and their associated habitats including photographic report of surveyed sites, and recommendations for future management including a review of current management, trends and optimal management strategies.

The project supports the objectives of the Heritage Plan, County Offaly Development Plan and the Biodiversity Action Plan.

The Heritage Plan includes an objective to give increased recognition to esker sites of geological interest.

Council policies recognise the geodiversity, biodiversity and historical interest of eskers.

Section 2.10 of the County Development Plan 2003-2009 states that "the Council recognises the unique importance of the County's landscape deriving from its scientific, botanical, archaeological and historical value. All proposals for sand and gravel extraction at Eskers will be determined by reference to the need to conserve the environment, character and scientific value and the extent to which the proposed development would be damaging to these qualities".

A list of esker segments is contained in Table 28 and Map 8a. This lists the esker system under study as an esker system worthy of preservation and where sand and gravel extraction would not be permitted.

Section 2.10.1 states that this system is worthy of conservation due to its geomorphologic, scientific, historical, recreational and amenity value and uniqueness and that the Council will seek, in consultation with Duchas, to have the entire Eiscir Riada system designated as a World Heritage Site to ensure its future conservation.

The plan makes references to specific parts of this esker system:

2.10.2 states it shall be Council policy to "protect and conserve the Esker system in the vicinity of Clonmacnoise and the internationally renowned Clara Bog".

The Biodiversity Action Strategy ('the Tullamore Declaration") recognizes the need for research on local biodiversity and the importance of ecological networks or EcoNets (www.offaly.ie). Particular initiatives relate to the identification and promotion of EcoNets, areas of high biodiversity value, for special interest tourism and environmental education.

2 Background

2.1 Esker formation

The term "esker" is an English rendering of the Gaelic word *eiscir* which means ridge. The Irish origin of the word is not surprising given the abundance of eskers in the Midlands of Ireland (Fig. 2.1).

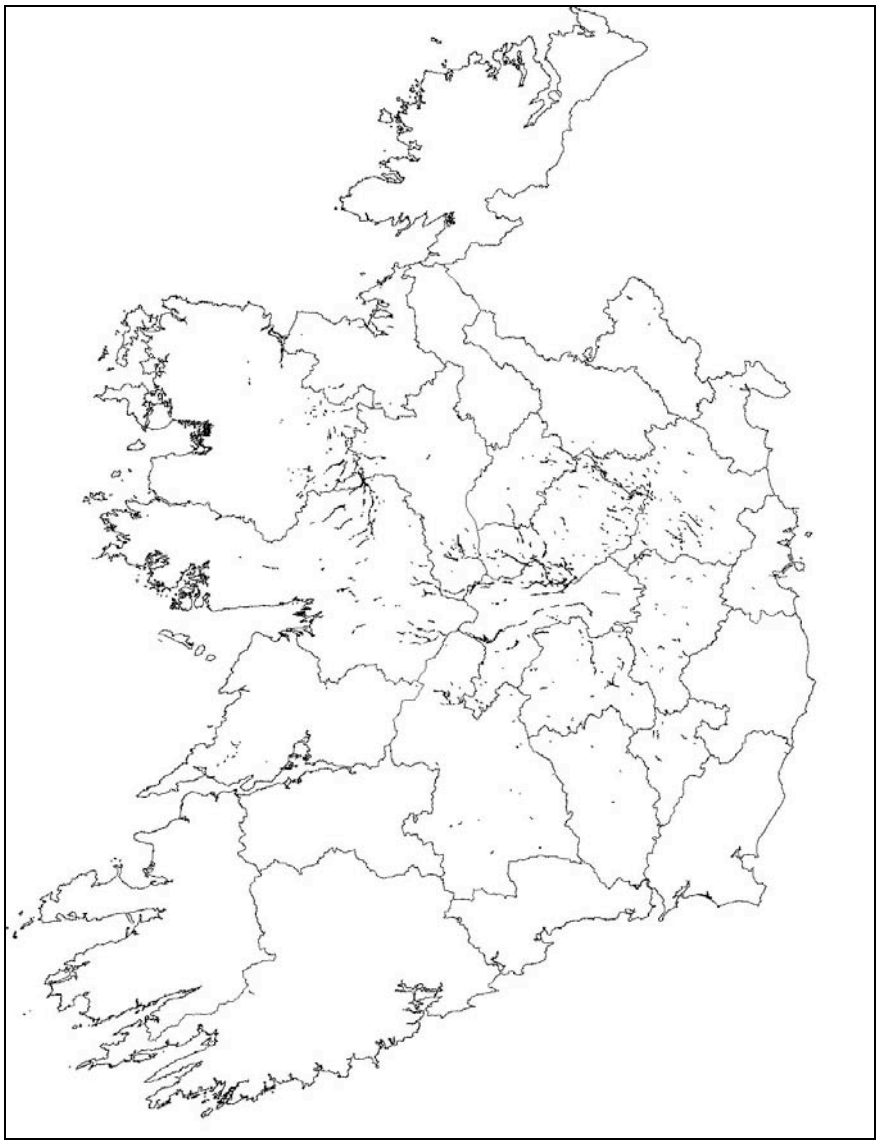


Figure 2.1: The eskers of Ireland. Mapped photogrammetrically as part of EPA Soil and Subsoil mapping project (formerly FIPS-IFS, Teagasc, Kinsealy, 1998-2005).

Eskers have been reported from all over the mid-latitudes, and are particularly common in Ireland, Britain, Scandinavia (where they are termed *osar*), Canada, Alaska, the northeastern U.S., and Patagonia. The most extensive esker formations in the world are found in Canada, in the Districts of Keewatin in Nunavut, Mackenzie in the Northwest Territories, Manitoba, northern Quebec and Labrador; some of these eskers are up to 800 kilometres long. In Ireland, eskers range from a few tens of metres to over a hundred kilometres in unbroken length.

Eskers are one of several types of landforms associated with deglaciation. They formed in water filled tunnels beneath, above and within the ice (Fig. 2. 2).

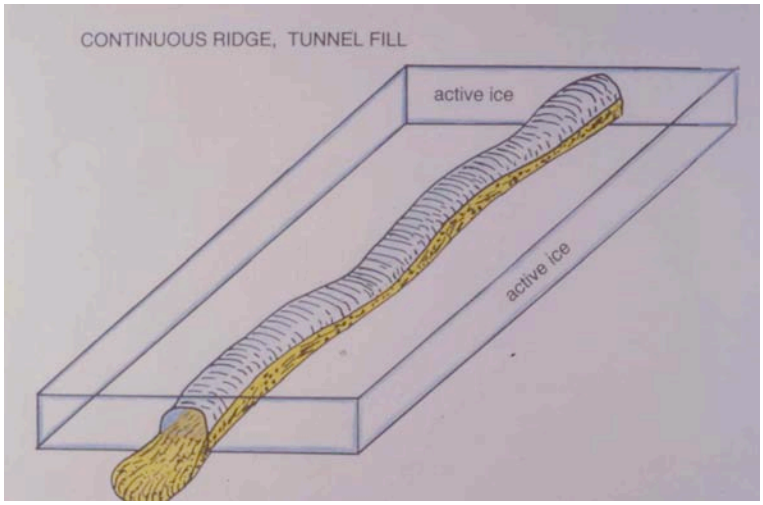


Fig. 2.2: Diagrammatic representation of esker formation in a water filled tunnel in the ice

Just as rivers on land carry and deposit sediment, meltwater that flows in the openings beneath, above and within a glacier also carries and deposits sediment. This sediment was collected by the ice which at one time covered the entire area of Offaly and was at least 260m thick; it may have been as much as 700m thick. As the ice flowed over the ground loose debris became incorporated into its base and was also sheared up into the ice sheet itself.

Tunnels near the base of retreating glaciers filled with transported sands and gravels. Once the ice melted they remained as sandy or gravelly ridges. The ice that formed the sides and roof of the tunnel disappeared, leaving behind sand and gravel deposits in ridges with long, winding, sinuous shapes.

Plate 2*:* The sinuous form of the scrub-covered esker south of Clara is clearly seen in this aerial photograph. The surrounding ice 'smothered' the tunnel in which the sand and gravel was deposited leaving an upstanding ridge after the ice melted.

Depending on the pattern of the glacier's inner tunnels, eskers can interconnect in a pattern of central ridges and tributaries, just like a branching river system. Large esker systems often radiate out from a central, core ridge, like the spokes of a wheel; this pattern therefore reflects large, once-used, complex river systems comprised of major and tributary eskers which drained the last ice sheet in that area, and trends generally in the main direction of late-glacial ice flows.

Internally, eskers are composed of a wide variety of materials, ranging from fine lacustrine silts and clays, sorted silts, sands, gravels and large boulders. The commonly held notion that eskers are formed completely of sand and gravel is erroneous, with sand and gravel beds often having up to 5%-10% silt and clay. Large rocks, clayey or silty diamict units often forming considerable portions of single ridges.

A general genetic classification of eskers proposed by Warren and Ashley (1994) recognised six basic types of esker; four formed parallel to ice flow, and two formed perpendicular to ice flow. Those parallel to ice flow were:

(a) ***tunnel fills***, formed in conduits under and within ice, and exposed following ice melting;
(b) ***ice channel fills***, deposited in open, ice walled channels (with no roof) between glacier bodies;
(c) ***segmented tunnel fills***, formed during pulsed glacier retreat; and

(d) ***beaded eskers***, consisting of a line of successive hills of sand and gravel deposited during pulsed glacier retreat, under water ponded at the edge of the ice, and oriented parallel to ice flow.

The two types of long, sinuous ridge, composed of sands and gravels that are formed perpendicular to ice flow were:

(e) ***linear ridges formed of deltas and fans*** deposited under lake water at the edge of the ice;
(f) ***linear ridges formed of fans*** deposited at the mouth of open tunnels "subaerially" at the edge of the ice.

This interpretation has been changed as a result of fieldwork in areas including Offaly. Technically, the 'eskers' formed perpendicular to ice flow should be termed 'moraines', as they define an ice margin rather than a subglacial tunnel (Warren and Ashley, 1994). The initial description of the feature from the 1800's focussed on the fact that it was a 'ridge of sand and gravel', and the term was purely descriptive, whereas in modern times with more scientific geological interpretation used in classification, eskers exclude 'ridges of sand and gravel' formed perpendicular to an ice margin. ***Only is the feature is sinuous, high-sided and was formed in an ice walled channel should it be termed an esker***. This is the basis upon which we classify eskers in Offaly.

As eskers can be confused with moraines, deltas, outwash fans and kames some of which also form hills, a description of these glacial features is contained in Appendix 1.

2.2 Geodiversity

Eskers provide a visible record of the glaciers last actions by revealing a footprint of the drainage system at the base of the ice. The volumes of sediment show the power of the meltwater and their internal structure (bedding and size of clasts) provides a detailed record of fluctuating meltwater flows over time.

Although there are other landscape features associated with glaciation; because of their size, distribution and importance, both geologically and economically, they are the most readily identifiable signs of the last glaciation in the landscape of the Midlands.

To geomorphologists the basic unit of study is the esker system as this describes a complete drainage system and all the deposits resulting from it. Esker systems can comprise one or more individual *segments* which share a similar history.

Eskers are directly important to the local economy. Sand and gravel extraction forms one of the areas biggest primary industries. They are important sources of groundwater. Such sources provides much of the Midlands with its domestic, agricultural and industrial water supply.

Their primary economic use for many thousands of years has been for farming. Esker soils exhibit many variations which affect their value for farming and biodiversity (see Appendix 2).

The geodiversity interest of eskers is recognized nationally by a programme which has been put in place to identify areas which could be designated as geological Natural Heritage Areas under the Wildlife Amendment Act 2000. This initiative is known as the Irish Geological Heritage Programme (IGH) and is a partnership between the Geological Survey of Ireland (GSI) and the National Parks and Wildlife Service of the Department of Environment, Heritage and Local Government. It aims to identify, document, and protect the wealth of geological heritage in the Republic of Ireland and conserve it and promote its value to landowners and the public. The GSI provides scientific appraisal and interpretative advice on geological and geomorphological sites with the assistance of expert panels. The National Parks and Wildlife Service of The Department of Environment, Heritage and Local Government has the responsibility of designating and managing sites with appropriate advice from the GSI.

Esker heritage has been considered and evaluated within an overall framework of the Quaternary theme by a panel of experts. This process has led to the drawing up of an indicative list of eskers which are worthy of more detailed assessment within the relevant themes. Sites were listed as being of either international/national or county importance. Those in the former category are recommended as NHA's and the latter are suggested for listing as County Sites of Geological Interest in County Development Plans. The esker system under examination by this study has been recommended for designation as a Natural Heritage Area which may, depending on the the fieldwork phase of the process, achieve a ranking of International Importance. Other important IGH 7 sites in Offaly include the glaciofluvial fan at Screggan, and the Ballyduff esker at Tullamore.

While the IGHP has communicated the list of proposed sites to the National Parks and Wildlife Service in the DOEHLG no action has as yet been taken. As a result no detailed fieldwork has been commissioned to verify this esker system and no official recognition has been given to its importance for geodiversity. While initiatives seem stalled nationally some counties have carried out further research on their geological heritage in the context of implementing Heritage Plans or the County Development Plan. Clare commissioned the GSI to produce a report on geological heritage (Parkes et al 2005) and Westmeath has commissioned studies of esker geodiversity and biodiversity in the south of the County to inform its policies for the management of eskers (Tubridy and Meehan, 2005). An esker system examined and mapped in south Westmeath (so called "Clara esker" is part of the system being examined by this study. Appendix 3 contains a summary of this esker system (from Appendix 6 in Tubridy and Meehan, 2005) Hand drawn habitat maps were prepared for this section of the system.

2.3 Biodiversity

The eskers which were formed after the last glaciation about 20,000 years ago were 10,000 years later covered in woodland. Over the years, this woodland has been cleared and replaced by intensively managed grassland.

Due to their steep slopes and shallow soil, small patches of woodland type habitats and unimproved esker grassland have survived on certain sections. Where land is abandoned or managed less intensively scrub and semi-natural vegetation return. The presence of these types of areas on eskers makes them of high value for biodiversity.

Habitat mapping provides a means of recording the status of biodiversity. A habitat such as a woodland, scrub or grassland is defined area which supports a particular collection of plants and animals. All species are either associated generally or particularly with habitats. By mapping habitats in an area information can be gathered about the plants and animals, common or rare which use it. Habitats can vary in naturalness, depending on the extent to which they have been modified by development. A methodology has been promoted by the Heritage Council to identify and map habitats in the field (Fossitt, 2000 and the Heritage Council Draft Mapping Guidelines). The list includes 89 types associated with terrestrial environment. This includes four different grassland types and seventeen woodland types.

Identification of habitats is particularly important to the implementation of the most important piece of wildlife legislation which applies in Ireland; the Habitats Directive (92/43/EEC). The Habitats Directive was brought into force in Ireland through the European Communities (Natural Habitats) regulations 1997 (SI /97/094) and The Planning and Development Regulations 2001 (S.I. 600 of 2001) made under the Planning and Development Act, 2000.

Under this Directive there is a legal obligation on Ireland to protect good examples of habitats, so called priority and non priority types, and species listed in annexes to this directive. Among the priority habitats is a type of grassland found on eskers "semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuca-Bromotea) (*important orchid sites) (6210)" This grassland is characterized by a high diversity of species, including orchids which are rare in other grasslands due to intensive management.

Eskers are known for several rare plants which are rare and/or protected under the Wildlife Act and are found on shallow calcareous soils. The Red Data Book for plants (Curtis and McGough, 1988) singles out eskers as sites for the following rare species: *Acinos arvensis, Erigeron acer, Orchis morio, Galeopsis angustifolia* and *Cardamine impatiens*. Information obtained from the BSBI confirms that the following rare species have been found recently (2006) in the Clonmacnoise esker:

Anthriscus caucalis

Carduus tenuifolius
Orchis morio (Red Data Book species)

Records of the following species date from the 1990's:
Koeleria macrantha

Galeopsis angustifolia is present on a nearby esker system in the Roscoe area, Clara.

Plate 3 *Galeopsis angustifolia*. (Protected under the Wildlife Act through S.I. No. 94 of 1999)

Due to the presence of rare semi-natural habitats several sections of the Clonmacnoise system are recognized for their biodiversity value. The characteristics of these areas are summarized in Table 1.

Table 2.1 Designated sites on the Clonmacnoise esker system

Designated site	Status	Features of Esker Biodiversity Interest
Clara Bog and Esker No. 572	SAC	Part of esker added to an SAC designated to protect a raised bog (priority habitat under the Habitats Directive) as an example of an ecotone (bog/esker interface) and site for calcareous grassland
Pilgrims Road Esker No. 1776	SAC	Supports priority type grassland (mapped) and largest population of *Orchid morio* in Ireland.
Clonfinlough Esker No 892	NHA	Small areas (unmapped) with species rich calcareous grassland (priority grassland type?) on Esker Hill and Turloughmore Hill
Lough Nanag Esker No. 910	NHA	Esker adjacent to small wetland with some species rich grassland and *Orchis morio*.

Other designated areas adjacent to the system include the Shannon Callows, limestone pavement at Clorhane, Mongan Bog, Fin Lough and Doon esker wood in Offaly. Several parts of the system are designated in County Westmeath.

Habitat maps have been produced for one of these sites, the Pilgrims Road Esker as part of research to inform the preparation of the management plan (Dr. Rebecca Jeffrey, pers. comm.). This map shows the location of priority grassland in this area.

Much of the focus of research on esker biodiversity has been on woodlands (Cross, 1992) as they are typically dominated by native species, and their principal characteristics can be easily described. Less attention has been paid to grasslands or other aspects of biodiversity.

Habitat mapping can identify grasslands of biodiveristy importance as it involves the identification of different grassland types. A methodology developed in Westmeath to identify the priority habitat type (Tubridy and Meehan, 2005) can be applied in Offaly. For background information on calcareous grassland on eskers see Appendix 4.

NPWS has commissioned a survey of SAC's to identify areas with priority grassland types (Marie Dromey, pers.comm.). Survey work has taken place in 2006 to identify dry calcareous grasslands and particularly the priority type of grassland in the Clara Bog and Pilgrims Road SAC's. Results should be available in early 2007.

2.4 Environmental education and special interest tourism

Eskers are an educational resource of international value to geomorphologists and ecologists. This is reflected in the fact that many specialists from Ireland and abroad visit Ireland and Offaly to study eskers. Many geology and geography departments from Irish Universities, as well as Universities abroad (*e.g.* University of Sheffield, University of Amsterdam, University of Stockholm), visit these eskers with students for teaching purposes, and to carry out geological research, on a regular basis. Student ecologists are regularly brought to accessible esker sites (usually quarries or road cuttings) to inspect esker flora and fauna.

The landscape importance of eskers and their obvious interpretative potential has resulted in a suggestion to designate the Eiscir Riada as a World Heritage Site or/and the midlands eskers as the centre of a GEOPARK. Both initiatives are sponsored by UNESCO. World Heritage sites such as Giants Causeway and the Boyne Valley have now become synonymous with the conservation, protection and promotion of important sites.

There are two GEOPARKS in Ireland; the Copper Coast Geopark in Waterford and the Marble Arch Geopark in Fermanagh. Clare County Council with the assistance of the Geological Survey have made an application to recognise the Burren and the Cliffs of Moher as a GEOPARK (Congella McGuire, Heritage Officer, pers. comm.)

Within Offaly there have been several initiatives to provide interpretation and access to eskers. A chapter in the Heritage of Clonmacnoise (Tubridy 1988) contained information on the geo and biodiversity of eskers. The community in Clara have provided information and access to the esker system south of the town and the Heritage Council is sponsoring the development of a long distance walk along a "pilgrims path" from Leamonaghan to Clonmacnoise which runs along eskers.

2.5 Local history

The historical interest of eskers focusses on their value as territorial boundaries and ancient roads, particularly as part of the legendary 'Esker Riada', or Slí Mhór ('Great Road') which acted as a routeway running from east to west through Central Ireland. Historical accounts tell of pilgrims traveling the esker to Tara, and the Rath of Feerwore near Athenry and even Newgrange (during the Neolithic period). A television series and book (Geissel, 2006) have described a possible route for the Sli Mhor along some of the esker segments under study.

Mythological Celtic sun gods are said to have used the line of the Esker Riada as the arena for their daily battles; and the relative transients of their power struggles was displayed in terms of various strengths of light and shade along the ridge (Cross and Slover 1996). Again according to legend, a battle at

Maynooth around the year 123 AD led to the subdivision of Ireland politically into two parts, north and south of the esker riada. These were known as "Leath Cuinn" (Conn's Half), and "Leath Mogha"(Mogha's Half). Medieval Latin texts refer to a natural mound which transversed Ireland as "*Via Magna*".

While the 'esker riada' of legend consisted of one continuous raised ridge even a cursory examination distribution shows that the eskers in the Midlands are mostly discontinuous. Therefore the road must have used several esker systems all of which had the common characteristic of providing dry, natural routeways.

The identification of esker features which may been used as a route is difficult as the importance of particular features would have changed over time. What was an important route locally at any one time in one area may not have seemed to important to those from outside that locality. Only the longest of the esker systems, which offers a route above wetland such as the esker adjacent to Clonmacnoise has probably remained consistently important through time on a regional or national level.

Evidence for the value of the system as a routeway in the vicinity of Clonmacnoise is shown by the naming of a routeway as a 'Pilgrim's Road'. The Shannon river provided the settlers here with an easy means of travelling north and south, so the Esker Riada and the Shannon therefore formed a natural 'crossroads' in the heart of Ireland, with routes radiating out from the monastery to the north, the south, the east and the west. The Pilgrims Road at Clonmacnoise now forms part of a proposed walking route from Leamanaghan to Clonmacnoise.

The significance of eskers to local history is further confirmed by the use of or incorporation of the word esker in local townland names such as 'Esker', 'Esker More' and 'Esker Beg'. The townlands of Clonascra. Clonroosk Big, Clonroosk Little, Derryesker, Gortanisky, Lissaniska, Lissanisky, Luganiska, Magheranaskeagh, Roosk and Screggan (all which host eskers except Derryesker, Gortaniska, Lissaniska, Luganiska, Magheranaskeagh, Roosk and Screggan, which are all either close to eskers of host other gravelly ridges) are probably derived from the 'esker' name.

For the purposes of this report the esker system under study is named as the Clonmacnoise esker. This reflects its historical and landscape associations with Clonmacnoise.

2.6 Protection and management

At the national level priority has only been given to the recognition and protection of small sections of esker segments which support rare habitats or species. No comprehensive survey work has been carried out on esker biodiversity.

As a result of designation owners, managers and local authorities must consider the impact of development on these sites. An Environmental Impact Assessment is required for any development which might affect an SAC. No statutory protection is given to biodiversity outside designated areas.

Management plans are being prepared by NPWS for designated sites. However only one management plan has been prepared in Offaly. NPWS management plans do not contain esker boundaries. They use a wide diversity of physical features particularly field boundaries to mark the limit of the areas mapped.

The designation of geological NHA's will protect entire esker systems. However, as geological NHA's have been designated statutory protection is not offered to esker systems and the geodiversity interest of eskers is not recognized.

In the absence of any initiatives from central government Heritage Fora and local authorities have been taking local actions to recognize these important features of local heritage.

This project offers an opportunity to characterize an esker system which is offered particular recogntion within the County Offaly Development Plan, of which small sections are already known to be important for biodiversity.

Such a study will address national,regional and local priorities. It will address national policy as it will characterize an esker system already proposed for designation as a geological NHA by the GSI programme, thus determining if it is of international or national importance. It will support regional initiatives as this esker system spans Offaly, Westmeath and Galway. It will inform local policy and research needs as it will provide a comprehensive baseline account of the biodiversity interest of an important esker system which is given strong local protection. By providing a review of the main development pressures it should assist in the development of more detailed local policies to support sustainable development, improve interpretation and manage the conflicts between the heritage value of this system and the main economic sectors.

3 Methodology

3.1 Locating esker segments by desk research

The segments within the esker system were characterised using the EPA Soils and Subsoils GIS (previously Forest Inventory Parcel System (or FIPS) and fieldwork. Esker mapping was produced as part of a project initiated by the Forest Service of the Department of Agriculture and Food (FIPS-IFS Project, 1998-2001), and further funded by the Department of Environment and Local Government and managed by the Environmental Protection Agency (EPA Soil and Subsoil Mapping Project, 2002-2005). The results of this mapping are freely available (in digital form) to local authorities and researchers. Appendix 5 contains an account of the methodology to identify eskers using FIPS/EPA.

3.2 Ancillary data

The National Parks and Wildlife Service (NPWS) files on designated areas on the esker system (Table 1) were consulted and requests were made to Drs Naomi Kingston and Rebecca Jeffrey for access to NPWS data bases and management plans. The Offaly county recorder of the Botanical Society of the British Isles was asked for plant records. The Bord Pleanala web site was interrogated for planning decisions related to quarrying on eskers in Offaly.

3.3 Consultations

Consultations principally took place with landowners. A leaflet providing information about the project was distributed to libraries, local authority offices and to all landowners and rural residents encountered during fieldwork (**Appendix 6**). Landowners were asked for information on past and current land management practices, their aspirations for further development and familiarity with historical sites and folklore associated with eskers.

3.4 Fieldwork

3.4.1 Geodiversity

The initial identification of esker segments remotely through FIPS/EPA was validated by fieldwork. This involved travelling around the study area, often on foot, and surveying quarries, gravel pits, stream cuttings, drains, house foundations, trenches, or any other cutting into the subsurface to determine the composition of the eskers.

Where exposures existed, digital photographs were taken of the profile. Photos are also taken of specific landforms and landscapes to serve as an accurate visual record of the esker landscape that can be easily accessed and reviewed.

3.4.2 Biodiversity

Methodologies to identify habitats and characterise the biodiversity of eskers followed Heritage Council guidelines and procedures developed in Westmeath in 2005 (Tubridy and Meehan 2005) including the following modifications which had been suggested by a review of the results of that study.

- The location and identity of all esker segments were printed in outline on the 1:50,000 Discovery map as a means of identifying esker segments for detailed survey.

- The esker outline was added to all maps and aerial photographs (1:6,000 scale) used in the field.

Map packs were prepared for each section of an esker being examined. These map packs (54) contained a 6" OS map, vector map and aerial photograph (Year 2000) and were cross referenced to the Discover Map. This scale printed out at A4 size provided adequate space to record, date and notes about features or species. All maps and photographs showed the location of sites in the Record of Monuments and Places.

Before land was examined on a section of esker possible location of certain habitats and areas of potential interest were identified. Homogenous large dark green fields were identified as (probable) improved grassland (GA1) of lesser priority for field examination. Woodland and scrub on the OS map which appeared to be present on modern vector maps were considered high priority for field examination.

Before starting fieldwork on an esker landowners were first located by identifying the nearest farmhouse or other premises on aerial photos or maps. They were appraised about the purpose of the survey, offered an information leaflet and asked for permission to survey their land. If the landowner could not be located, or if they refused permission their land was not surveyed unless it was easily visible from an accessible area.

Once the fields on individual esker segments were identified habitats were mapped using procedures in Fossitt (2000) and the Draft Habitat Mapping Guidelines (2005).

GSI grassland was identified in fields which contained little evidence of intensive management (fertiliser usage, cutting, scrub clearance), where vegetation had a low cover of rye grass and a high diversity of broad leaved herbs were present.

The priority type grassland was identified if the vegetation contained at least six of the following species.

Grass and Sedge species

Helictotrichon pubescens
Briza media
Festuca rubra
Agrostis capillaris
Bromopsis erecta
Carex caryophyllea
Trisetum flavescens

Other Flowering Plants

Leontodon hispidus
Anthyllis vulneraria
Antennaria dioica
Lotus corniculatus
Blackstonia perfoliata
Origanum vulgare
Knautia arvensis
Succisa pratensis
Centaurea scabiosa
Daucus carota
Pimpinella saxifraga
Trifolium dubium
Centaurea erythraea
Gentianella amarella
Primula veris
Alchemilla xanthochlora
Linum catharticum
Pimpinella saxifraga

A field or area was also identified as the priority habitat type if it contained any of these species but less than six of the previous list:

Pilosella officinarum
Plathantera chlorantha
Carlina vulgaris
Ophrys apifera
Orchis mascula
Anacamptis pyramidalis
Gymnadenia conopsea
Danthonia decumbens
Koeleria macrantha
Orchis morio
Galeopsis angustifolia
Erigeron acer
Cardamine impatiens

The land was surveyed by walking along the esker, through different areas such as grassland, scrub or woodland and in some cases along the road where this followed the esker. Habitat codes were added to the vector map. All habitats even those which occupied an area less than 50m X 50m were mapped as small scale habitat diversity is common on these eskers.

Target notes were taken as a means of compiling a record of species associated with particular habitats or uncommon features. Photographs were taken of features of interest and habitats.

3.5 Mapping of pits

As sites of pits (used and disused) are habitats they are indicated on maps as either ED4 (active quarries and mines) or ED3 (recolonising bare ground where revegetation is occurring). However their outline is not exact as most did not follow field boundaries and detailed surveying was outside the scope of this project. It would have required 2005 aerial photography.

3.6 Local history

The presence of sites in the RMP was examined where they were easily visible and occurred on esker segments. Landowners were questioned about the use of eskers as old roads, placenames for esker fields, location of sites of historical interest and the identity of local sources of historical information

3.7 Data recording and presentation

During fieldwork, a large amount of data was gathered. This included species lists, digital photographs and annotated OS maps (54). The species lists were typed up within one or two days of fieldwork. Photos were uploaded immediately and titled by reference to esker segment.

Information on habitats was digitised and the files were delivered to Offaly County Council IT section.

3.8 Review of methodology

Features which worked well and should be repeated:

Field inspection of all esker segments by an ecologist and a geomorphologist. In surveys in Westmeath and Laois all esker segments were not inspected by both and therefore additional segments were not identified.

Features of the methodology which could be improved:

Field inspection **first** by a geomorphologist to ground truth the location of esker segments and locate other unmapped esker segments.

Access to up to date aerial photography. This survey used 2000 aerial photography. As a result features which had changed since then, such as pit boundaries could not be mapped accurately by this study.

In further studies where resources allowed fieldwork should take place selectively in areas with particular habitats at the most appropriate times of the year. Woodland sites should be prioritised for examination in Spring. Potentially good grassland sites should be visited in early summer (pre July). Other habitats can be seen at any time.

The methodology used to identify priority grassland by this study and that used by NPWS should be compared when report and mapping associated with the NPWS survey should be completed in early 2007.

4 Results

4.1 Geodiversity

4.1.1 Esker systems in Offaly

The eskers in Offaly are typical of the eskers found in the Midlands (Fig. 4.1). They include a northwest-southeast oriented system of parallel-trending eskers which lies immediately south of the main drumlin belt (located in counties Meath, Offaly, Roscommon, Longford, Cavan, Mayo and Galway); and an east-west oriented system which lies south of these, and is dendritic. Many of the esker systems transgress county boundaries, so only portions of some entire systems have been depicted on the map of Offaly.

There are twenty esker *systems* in Offaly containing 208 segments. Each esker system comprises a landform or series of landforms (esker segments) having a single process history, in a specific zone. For instance, there may be three esker segments which were deposited in the same tunnel under the ice over a distance of a kilometre. This is one system containing three esker segments formed in the same process environment.

The esker systems cover 16.59 square kilometres, 1,669 hectares or 4,099 acres. Despite their high visibility the total cover of eskers amounts to only 0.83 % of the land area. Based on information contained in FIPS/EPA these twenty systems are comprised of 208 individual esker segments. The largest of these segments covers 1.18 square kilometres; the smallest esker segment covers 362 square metres.

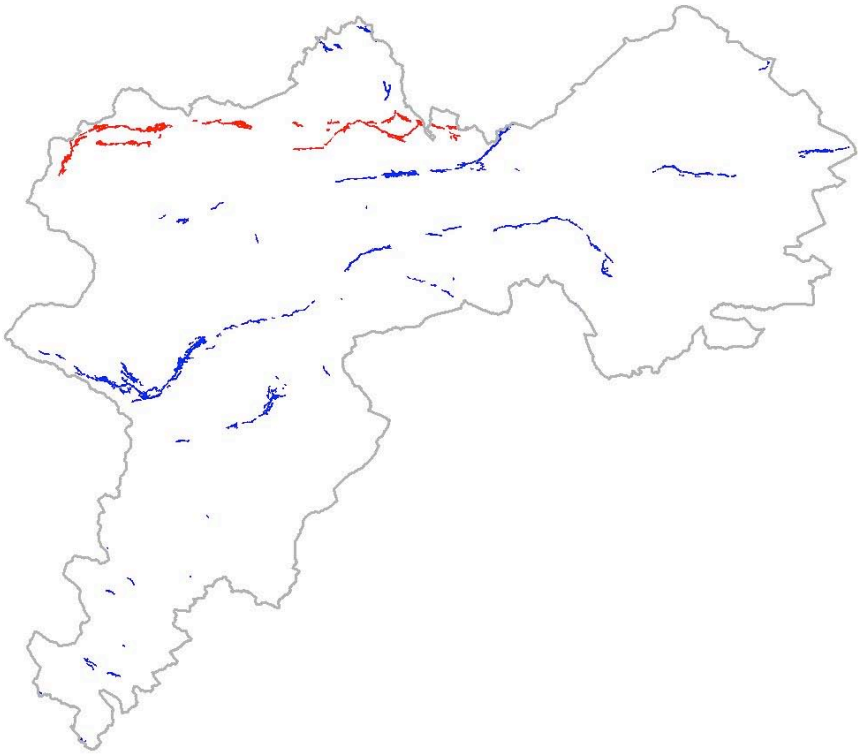


Figure 4.1 The eskers of County Offaly. The Clonmacnoise system is coloured red. Mapped photogrammetrically as part of EPA Soil and Subsoil mapping project (formerly FIPS-IFS, Teagasc, Kinsealy, 1998-2005).

4.1.2 The Clonmacnoise esker

The Clonmacnoise esker system is the largest in Offaly. It covers over five square kilometres (5.79 km^2) comprising one-third of all the area of eskers in Offaly. That part of the esker near Clara is called the Clara Esker. Within Westmeath it is also known as the Clara Esker or/and Derrygolan Esker (as part of the esker in Derrygolan townland is designated as an NHA). Characteristics of its individual segments are in Table. 4. 1.

Table 4.1. Segments within the Clonmacnoise esker system

Esker system name and number	*Overall area of system (hectares)*	*No. of segments*	*Individual segment notation*	*Area of individual segment (ha)*	*Local name (if any)*
Clonmacnoise Esker (*also called Clara esker, or Derrygolan esker*)	579.89	40	1a	65.33	
			1b	3.81	
			1c	5.98	
			1d	2.12	
			1e	55.29	*Bunthulla*
			1f	17.76	
			1g	5.97	
			1h	16.52	
			1i	69.56	
			1j	1.85	*Tully Hill*
			1k	2.34	*Tullaghm---re Hill*
			1l	10.88	
			1m	3.69	
			1n	1.87	*Esker (Fighting) Hill*
			1o	3.95	
			1p	1.67	*'Mannions Hill'*
			1q	1.93	*Bishops Hill*
			1r	2.05	*'Doon esker'*
			1s	61.95	
			1t	4.66	*Cooldor--ragh Hills*
			1u	11.14	
			1v	12.17	
			1w	4.15	*Rushes Hill*
			1x	3.44	
			1y	9.91	
			1y	28.08	
			1α	8.13	*Clara Esker*
			1β	69.79	
			1γ	10.97	
			1δ	5.38	
			1ε	1.29	
			1ζ	2.38	

Table 4.1. Segments within the Clonmacnoise esker system (contd)

Esker system name and number	*Overall area of system (hectares)*	*No. of segments*	*Individual segment notation*	*Area of individual segment (ha)*	*Local name (if any)*
			1η	28.97	*Eelweir Hill*
			1θ	0.04	*Clavins Hill*
			1ι	15.07	
			1κ	19.26	
			1λ	1.15	
			1μ	1.06	
			1ν	7.04	
			1ξ	1.29	

Figs 4.2-4.5- show the location and identity of individual esker segments and pits. Fig. 4.6-4.9 show designated areas.

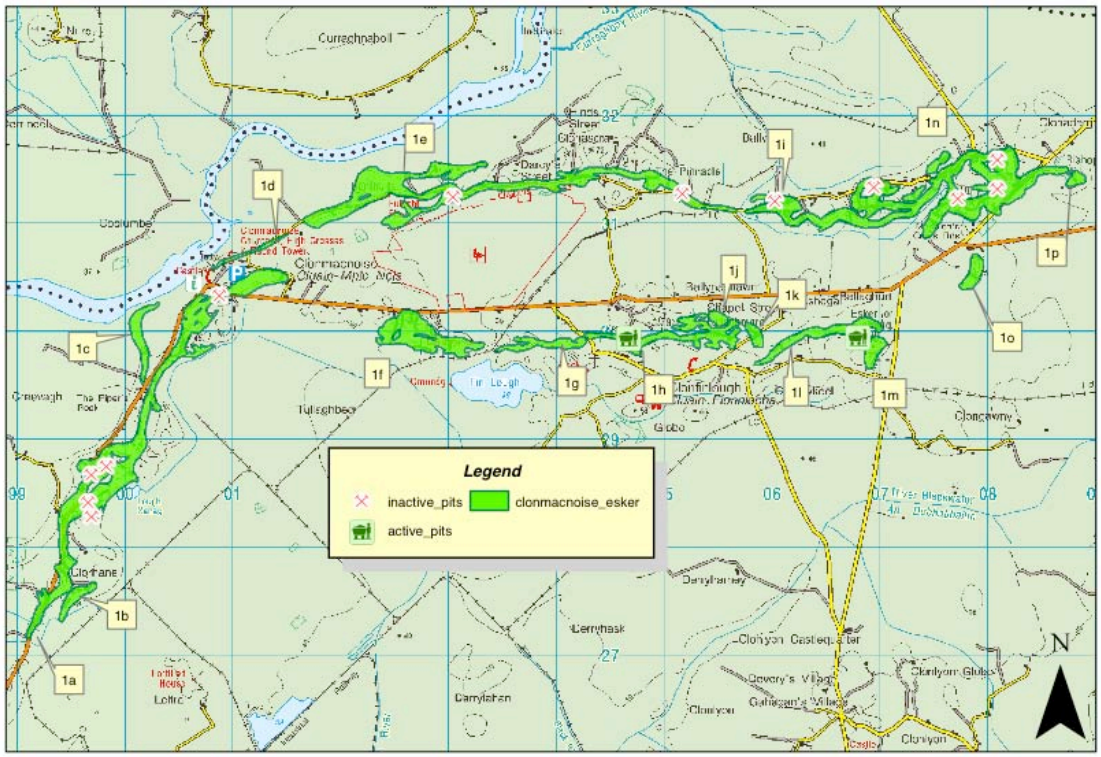


Figure 4.2: Inactive and active gravel pits on the western portion of the Clonmacnoise esker system.

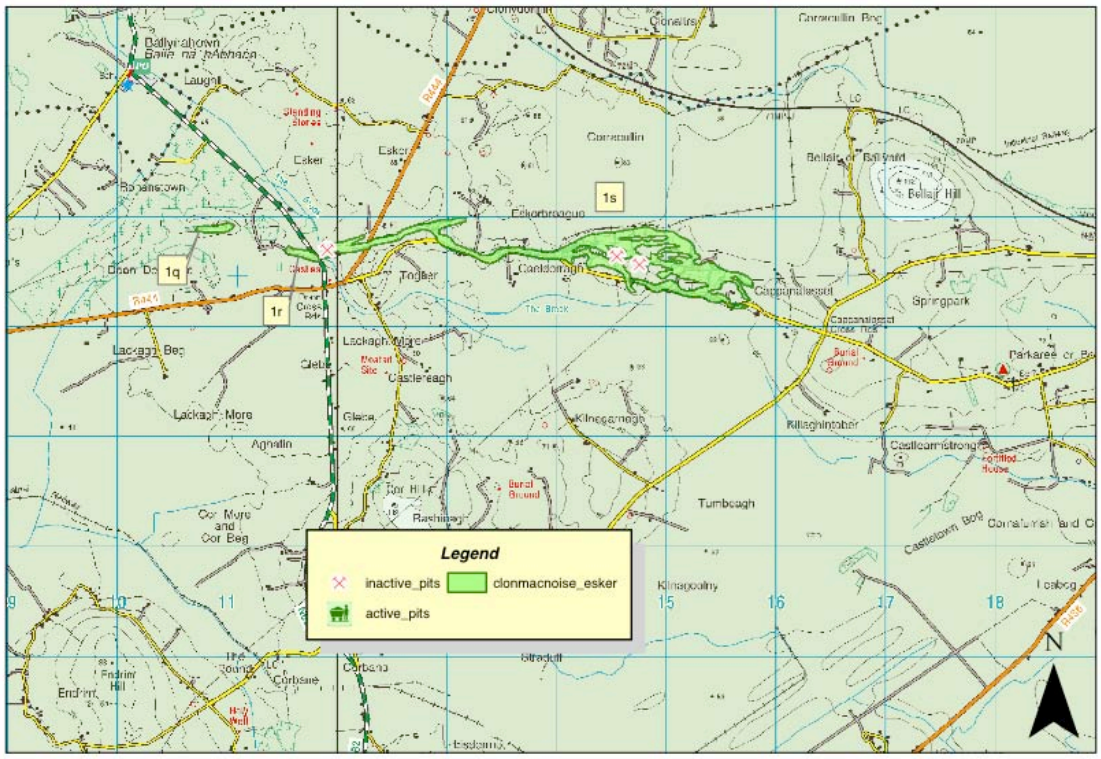


Figure 4.3: Inactive and active gravel pits on the mid-western portion of the Clonmacnoise Esker System.

Figure 4.4 Inactive and active gravel pits on the mid-eastern portion of the Clonmacnoise Esker System.

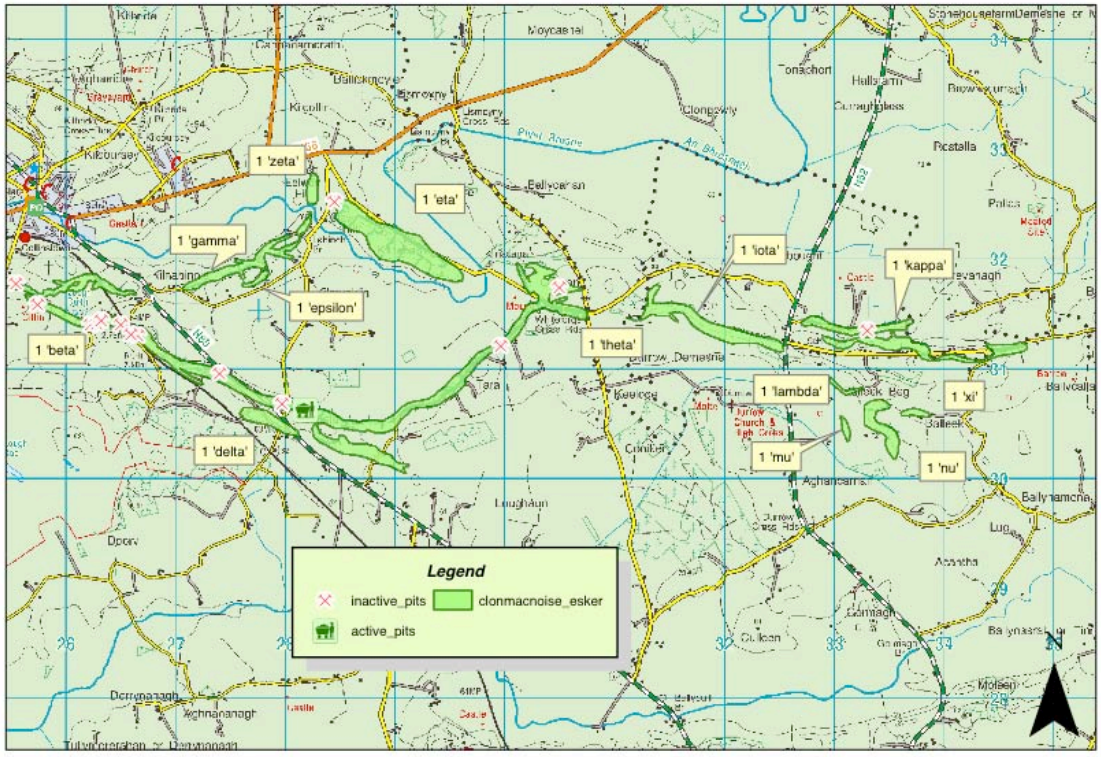


Figure 4.5 Inactive and active gravel pits on the eastern portion of the Clonmacnoise Esker System.

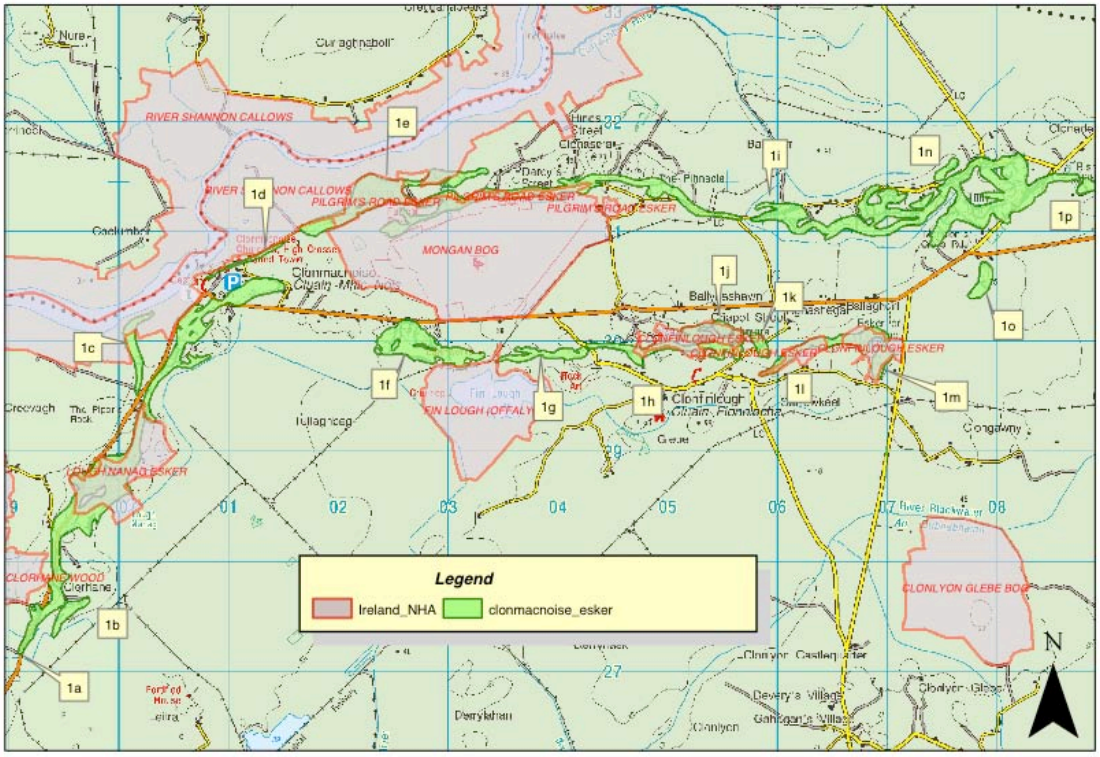


Figure 4.6: Natural Heritage Areas on the western portion of the Clonmacnoise Esker System.

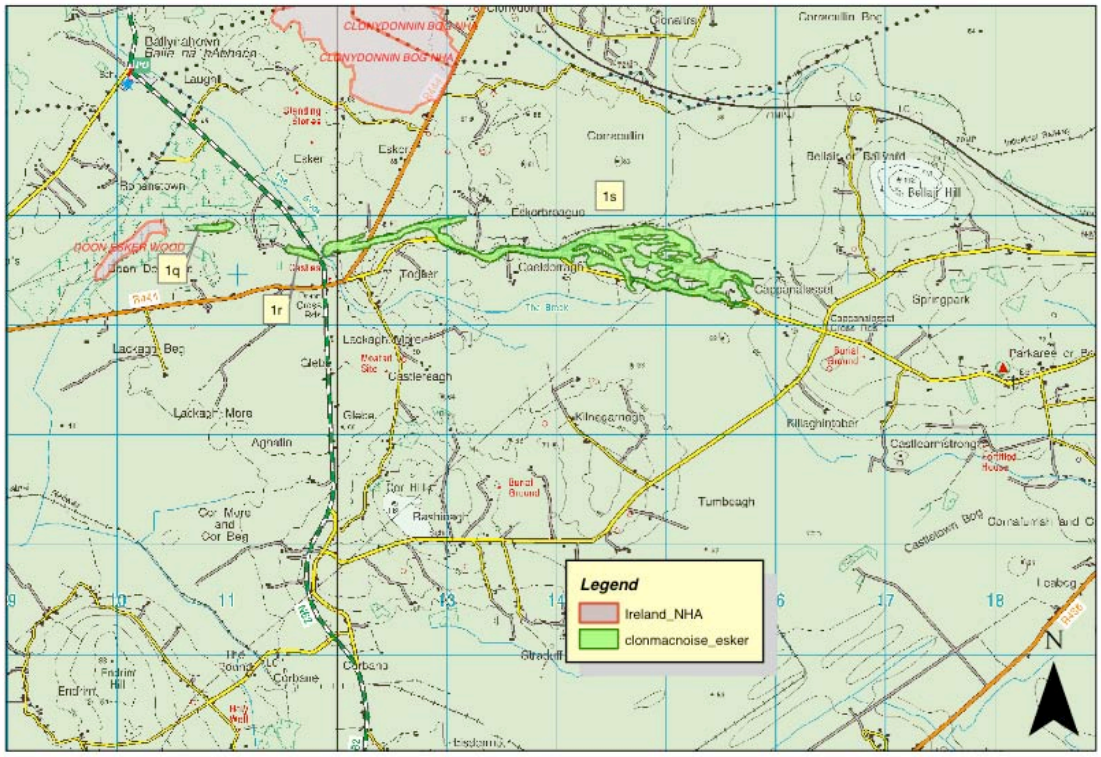


Figure 4.7: Natural Heritage Areas on the mid-western portion of the Clonmacnoise Esker System.

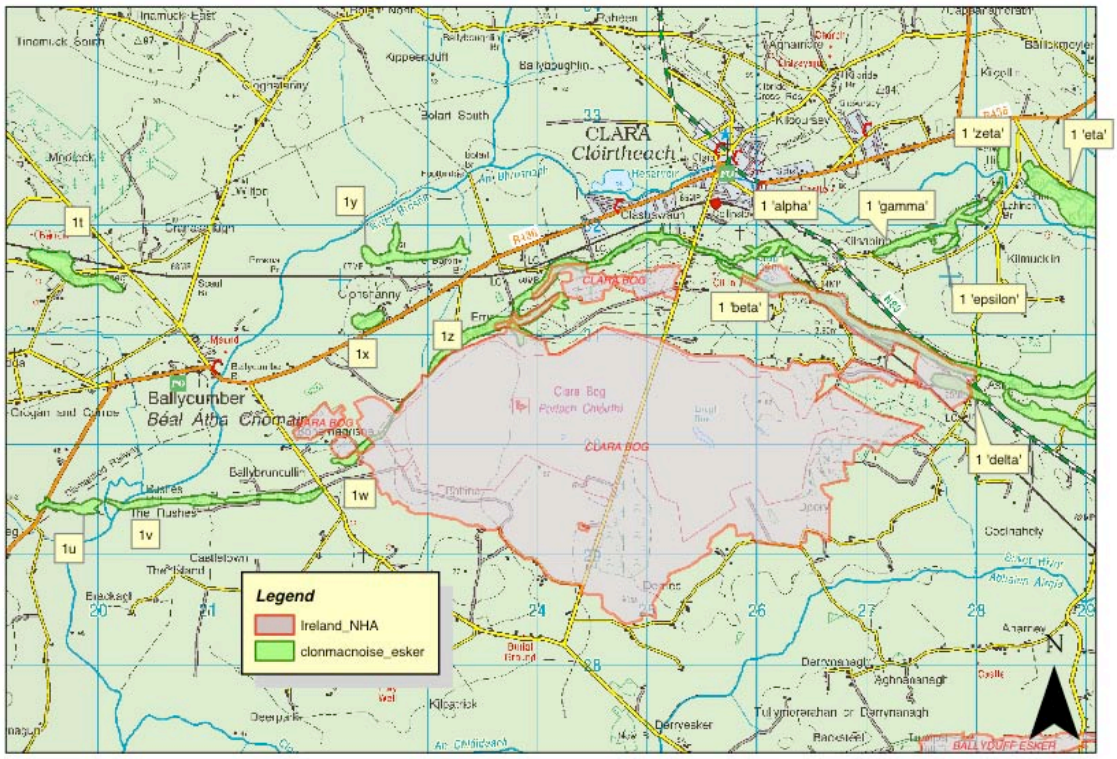


Figure 4.8 Natural Heritage Areas on the mid-eastern portion of the Clonmacnoise Esker System.

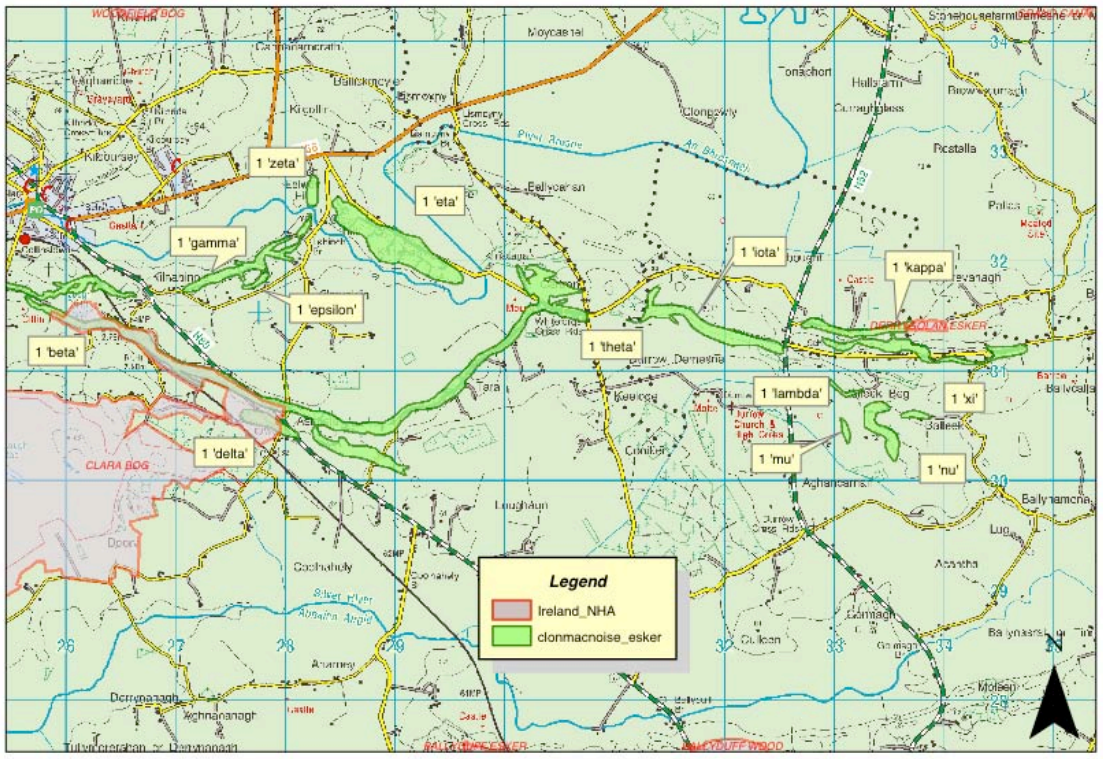


Figure 4.9 Natural Heritage Areas on the eastern portion of the Clonmacnoise Esker System.

While initial FIPS-IFS mapping showed that the Clonmacnoise esker comprised twenty seven segments, following field mapping, six additional esker beads were located and are shown on the Discovery Map. These were generally under forest canopy and could not be seen on the photogrammetric models within the Teagasc mapping.

In addition to these additional esker segments it is proposed to add another seven features genetically classified as fans and deltas to the Clonmacnoise system. Although are not technically eskers they form high, upstanding, steep-sided ridges, and are part of the topographic, cultural and folklore history of the Clonmacnoise esker system. These are (from west to east) the complex elongate, ridge north-west of Fin Lough, Tullaghmore Hill, Esker or Fighting Hill, the hill just south of Mannions Crossroads, Bishops Hill, Eelweir Hill and Clavins Hill.

This gives a revised system composition of 40 segments, the largest of which covers seventy hectares, and the smallest of which covers 362 square metres.

4.1.3 Geodiversity value of the esker system

The Clonmacnoise esker is an excellent example of one of the distinctive landforms in the landscape of the Irish Midlands for the following reasons:

It is an unusually large esker system which extends over 60km in counties Offaly, Westmeath and Galway. Therefore it provides geomorphologists with an opportunity to study meltwater in a large part of the area covered by ice at the end of the last glaciation in the Irish Midlands.

The system comprises forty segments which are very diverse in structure and sediments. Segments vary in height, size and profile type from low, voluminously-small, single crested eskers to high, large, multi-crested eskers. The presence of pits and cuttings have confirmed the diversity of materials which they contain.

Plate 4: Low hollow at Clonascra between the anabranching ridges of the Clonmacnoise esker, which is multi-crested at this point.

Multi-crested eskers are usually wide, hummocky and have haphazard surface forms as they are formed from a number of joined-up ridges. Therefore, these may have a number of summits, shoulders, backslopes, footslopes and toeslopes forming individual ridges, which interconnect with discrete or complex humps and hollows across the overall esker area. The segment of the Clonmacnoise esker, just northeast of the monastery site, with its hummocky surface and interspersed kettle holes, is an example of a multi-crested esker.

Single crested eskers have a straightforward profile, comprising one ridge with a summit, shoulder, backslope, footslope and toeslope.

Plate 5: The Clonmacnoise esker in 'Esker' townland, immediately northeast of Doon Crossroads; here the esker is single-crested. Photo taken from the hill to the southwest.

Parts of the Cooldorragh Hills esker segment and the Tully Hill esker segment have up to five individual ridge crests side-by-side in the esker. In fact, the geometry of these esker segments, as well as the esker at Clara, are so complex that it is difficult to separate individual crests, humps and hollows from each other. This reflects a highly dynamic environment at the base of, and at the edge of, the glacier in that area.

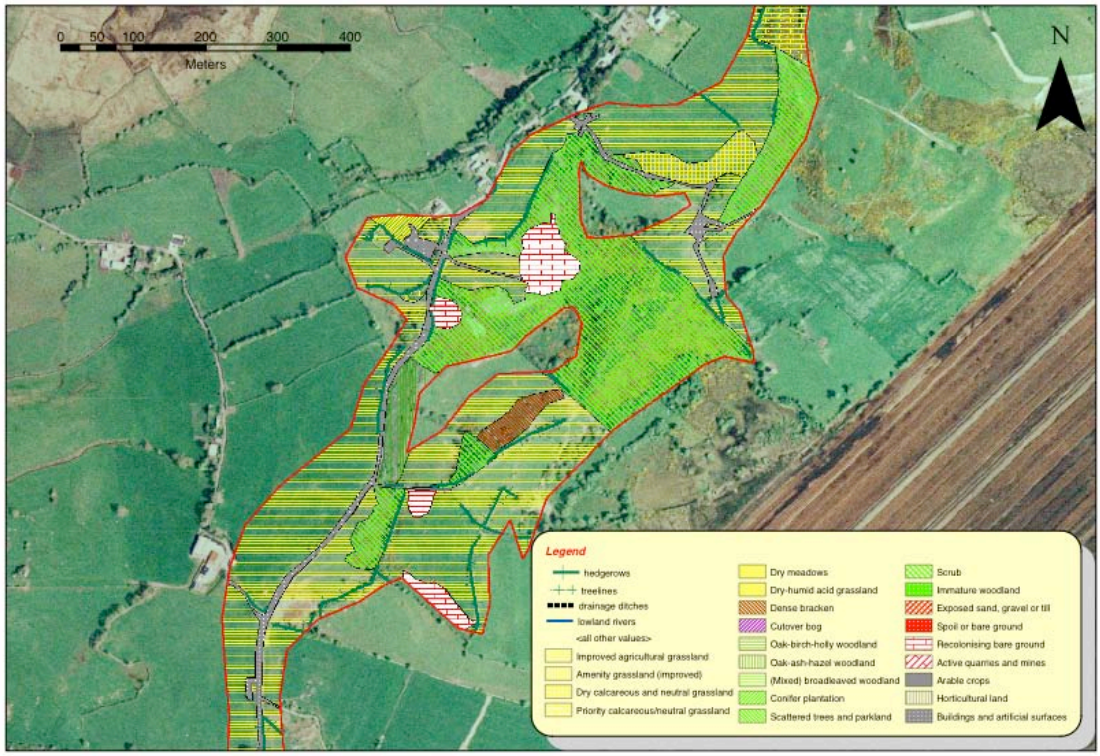
While the esker system only covers 579.87 hectares its effect on the landscape is disproportionate to its area. Esker heights vary from 3-4 metres (*e.g.* esker segment 1d,) to 25 m (*e.g.* the high point of Clavins Hill). They also provide connectivity and continuity in the landscape. The longest individual esker segment is 1beta, southeast of Clara which is 5.8 kilometres long. Many other segments (including the segment at Bunthulla northeast of the monastery) are over 4 kilometres long. Many important scenic areas derive their character from the nature of the underlying geology. Eskers in north Offaly define the landscape with the bogs. If associated gravels are added the amount of dry land above the bogland around Clara stretches for a distance of almost 15 kilometres, and that at Clonmacnoise for over 12 kilometres.

The esker segments contain significant reserves of materials the volume of which can be predicted from their physical characteristics. A conservative estimate for the volume of material deposited by the glacial meltwaters in the entire Clonmacnoise esker system, in County Offaly alone, is 80 million tonnes of sand and gravel sediment. This is contained in varying amounts in the various segments. Esker segment 1µ which is single-crest; 3m-4m high probably contains 30,000 tonnes of sediment deposited while the esker at Tully Hill which comprises a complex single to multi-crested esker; up to 20m high; probably contains 1.7 million tonnes of sediment.

4.2 Biodiversity

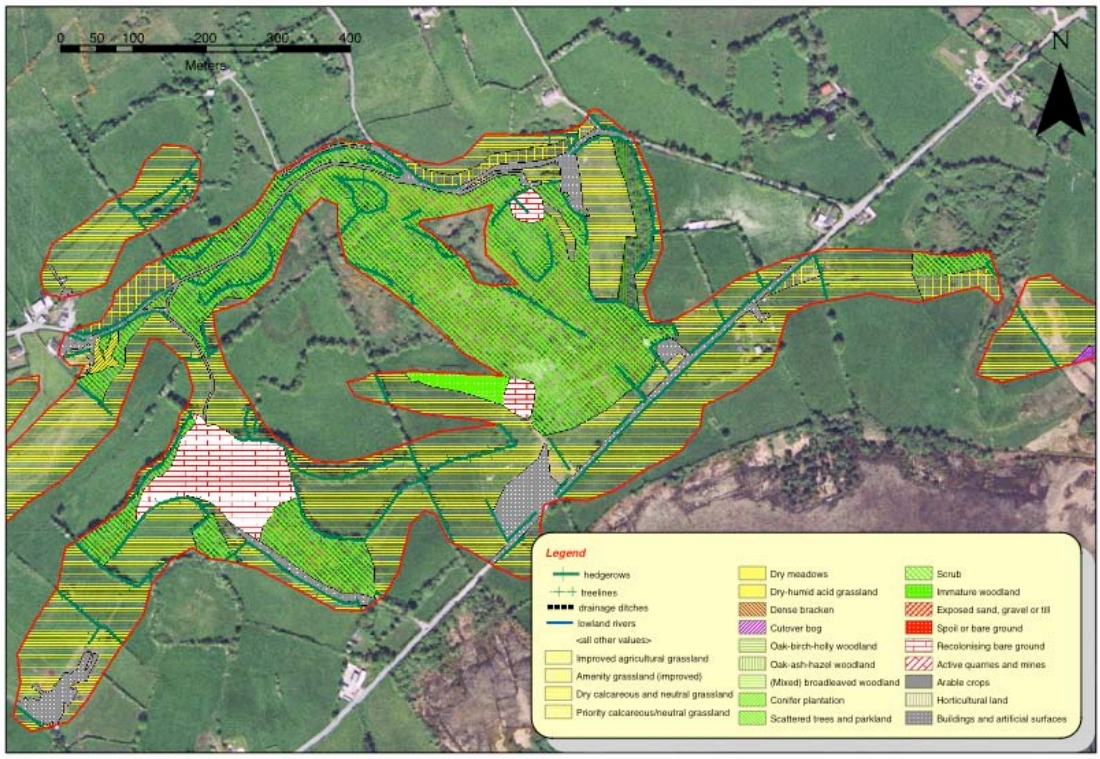
4.2.1 Introduction

Table 4.2 contains a list of habitats and their cover on the esker system. Habitat maps numbered 1-4-show a sample of the habitat types from parts of the esker system superimposed on aerial photography.

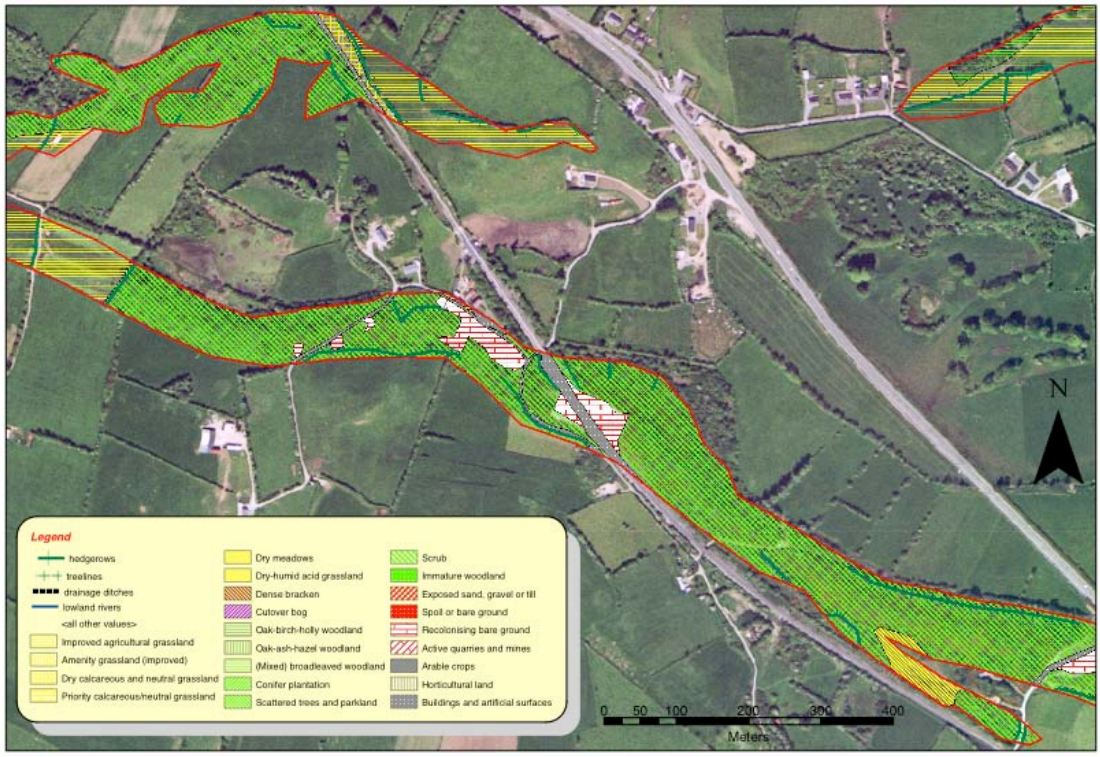


Habitat Map 1: Creevagh and Clorhane Townlands, Esker Segment 1a.

Fig. 4.10 Habitat Map 1

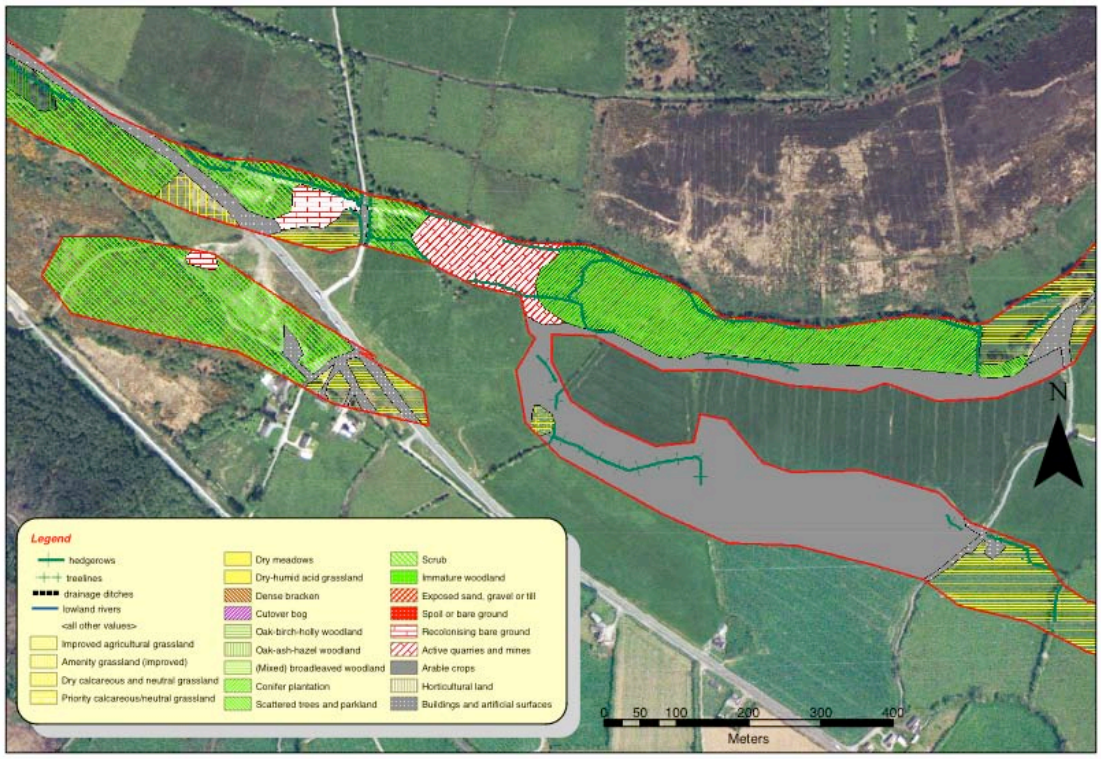


Habitat Map 2: Clonaderg Townland, Esker Segments 1i, 1n and 1p.

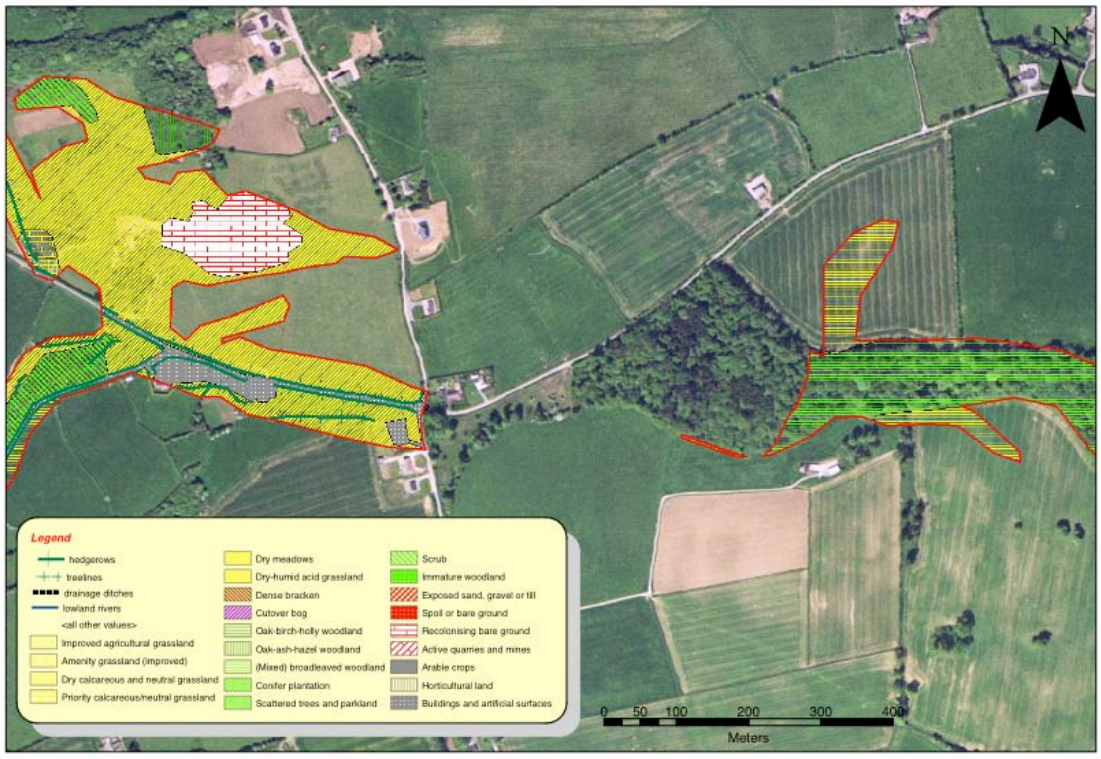


Habitat Map 3: Erry and Kilnabinna Townlands, Esker Segments 1'beta' and 1'delta'.

Figs 4.11 and 4.12 Habitat Maps 2 and 3



Habitat Map 4: Ashfield, Erry, Coolnahely and Tara Townlands, Esker Segments 1'beta' and 1'delta'.



Habitat Map 5: Cartron, Tara, Coniker, Ballybought, Durrow Demesne Townlands, Esker Segments 1'beta', 1'theta' and 1'iota', straddling the Westmeath county boundary.

Figs 4.13 and 4.14. Habitat Maps 4 and 5

Table 4.2. Habitats on the Clonmacnoise esker

Habitat code	***Habitat***	***Area (hectares)***	*% total area*	***Number of polygons***
BC1	Arable crops	9.0959	1.57%	2
BC2	Horticultural land	0.1916	0.33%	1
BL3	Buildings/other artificial surfaces	26.0345	4.49%	89
ED1	Exposed sand, gravel or till	0.1765	0.03%	2
ED2	Spoil or bare ground	0.0641	0.01%	2
ED3	Recolonising bare ground	12.5282	2.16%	39
ED4	Active quarries and mines	8.0569	1.39%	11
GA1	Improved agricultural grassland	335.6216	57.88%	214
GA2	Amenity grassland (improved)	0.9895	0.17%	3
GS1	Dry calcareous/neutral grassland	19.4272	3.35%	36
GS1*	Priority calcareous grassland	4.6385	0.8%	11
GS2a	Dry meadows	19.0941	3.29%	23
GS3	Dry humic-acid grassland	0.4565	0.08%	1
HD1	Dense bracken	2.0501	0.35%	6
PB4	Cutover bog	0.3391	0.06%	3
WD1	Mixed broadleaved woodland	14.0404	2.42%	5
WD4	Conifer plantation	9.8512	1.7%	9
WD5	Scattered trees and parkland	0.5030	0.09%	5
WN2	Oak-ash-hazel woodland	11.1603	1.92%	24
WS1	Scrub	104.9784	18.1%	87
WS2	Immature woodland	1.0400	0.18%	2
WL1	Hedgerows			
WL2	Treeline			
FW2	Depositing lowland river (Brosna)			
FW4	Drainage ditch			

The number of polygons is a guide to the number of sites (possibly fields) where habitats are found. Habitats include linear types such as hedgerows (WL1), treelines (WL2) and drainage ditches (FW4). However as the area occupied by these cannot be calculated no information is provided on the cover of these types. Table 4.3 provides details of the cover of semi-natural types. Appendix 7 contains a list of plants found during survey work.

From within these habitats, a total of 206 flowering plant species was recorded. Notable species found during fieldwork include the protected bee orchid, *Ophrys apifera* found at two locations and the regionally rare plants, belladonna *Atropa belladonna* (beside Doon Castle) and the sedge *Carex spicata.*

Table 4.3 Semi-natural habitats on the Clonmacnoise esker

Habitat code	*Habitat*	*Area (hectares)*	*% total area*	*No. of polygons*
ED1	Exposed sand, gravel or till	0.1765	0.03%	2
ED2	Spoil or bare ground	0.0641	0.01%	2
ED3	Recolonising bare ground	12.5282	2.16%	39
GS1	Dry calcareous/neutral grassland	19.4272	3.35%	36
GS1*	Priority calcareous grassland	4.6385	0.8%	11
GS2a	Dry meadows and grassy verges	19.0941	3.29%	23
GS3	Dry humic-acid grassland	0.4565	0.08%	1
HD1	Dense bracken	2.0501	0.35%	6
PB4	Cutover bog	0.3391	0.06%	3
WD1	Mixed broadleaved woodland	14.0404	2.42%	5
WN2	Oak-ash-hazel woodland	11.1603	1.92%	24
WS1	Scrub	104.9784	18.1%	87
WL1	Hedgerows			
WL2	Treeline			
FW2	Depositing lowland river (Brosna)			
FW4	Drainage ditch			
	TOTAL	188.507	32.49	

4.2.2 Habitats

The following is an account of the biodiversity interest of habitats found on the esker system. Sites are identified by esker segment and townland.

Grasslands and habitats associated with farmland;
Improved agricultural grassland (GA1)

This habitat was the dominant habitat type covering 57.4% of the land surveyed. Fields containing this habitat type were classified as improved on the basis of 1) plant species present and 2) evidence of potential for fertilisation (topography, presence or absence of scrub) or 3) other forms of management such as topping or herbicide use. Management factors were clarified after discussions with the farmer. Management typically included fertilisation (the degree of which depends on the nature of farming carried out in the holding), topping of tall herbs later in the season, reseeding (which has occurred less frequently in the last twenty years) and spraying with herbicide to control tall herbs. Almost all fields with GA1 are grazed.

Some improved grasslands could be easily identified from aerial photographs. If they were present on slopes, on shallow soils or had been improved within the last thirty years fieldwork was required to distinguish them. No recently reseeded fields were found.

Plate 6. GA1 on the low esker segment (1y) west of Clara.

Improved grassland on eskers is generally more species rich than types on other land. The grassland above is a typical example. Grasses include sweet vernal grass, soft brome, crested dog's tail, cock's foot, meadow fescue as well as rye grass. Depending on the degree of management clover cover may be high or low. The most intensively managed grassland was seen in Clorhane where a field is being used as a receptor for slurry.

On many esker segments such as Bunthulla which principally support improved grassland there are bands of dry calcareous and neutral grassland on the steeper sides which have not been treated with fertilizer, topped or ploughed. Therefore within or adjacent to fields which do not support improved swards there are reservoirs of the original native flora.

The cover of this type of habitat has probably been maintained since 2000 with the exception of some areas which have been planted with woodlands.

Dry calcareous and neutral grassland (GS1)

This type of grassland is found on 36 location on eskers occupying 19.4 ha and 3.3% of the total area.

Calcareous grassland (GS1) was distinguished from GA1 principally on the basis of the absence of the signs of management associated with GAI. GS1 grasslands

typically had most of the following species: crested dog's-tail, red fescue, sweet vernal grass, smooth meadow grass, common and creeping bent and cock's-foot. The following herbs were also common; cat's-ear, black knapweed, yarrow, red clover, dog daisy, lesser hawkbit, bird's-foot trefoil, wild carrot and selfheal. Where management in these fields is now lax the fields are being invaded by blackthorn and whitethorn.

GS1 grasslands are found in bands or discrete areas in fields in more intensively managed eskers and on roadside verges.

Plate 7. Semi natural grassland GS1 is found on the steep slope of the esker segment (1gamma); improved grassland at the base**.**

Priority type calcareous grassland

The species rich priority type was found in 11 locations covering 4.6ha or .8% of the study area. Sites containing this types of grassland showed no evidence of fertilizer usage. Typical sites were fields with old pits or on the steep sides of eskers with shallow soils. This habitat must be grazed to maintain its integrity. It is threatened by scrub invasion usually blackthorn.

Priority type grassland usually had downy oat-grass, quaking grass, spring-sedge, burnet saxifrage, wild marjoram, field scabious, cowslip, lesser trefoil, fairy flax, lady's bedstraw, spotted-orchids or bulbous buttercup. The protected bee orchid was found on the steep side of an esker which had recently been cleared of blackthorn scrub (by hand).

A number of less common species were also recorded, such as upright brome, fragrant orchid, various types of marsh orchids, pyramidal orchid and carline thistle. Typical sites for these are disturbed ground. While the recently developed grassland associated with the abandoned pits near Clara has a high cover of orchids and supports many indicator species this area was not characterised as a priority grassland site as the definition implies that the priority habitat is associated with "old grassland".

Plate 8 Species rich priority type grassland on esker segment 1 beta NW of Whiteforge cross roads.

Dry meadows and grassy verges (GS2)

This type of grassland is found at 24 locations occupying 19.1ha and 3.3%of the total area. It represents a less managed type of the previous two grassland types. Mowing might occur occasionally but grazing may be absent. As a result the vegetation starts to become dominated by a small number of tussock forming types and species diversity declines. At Ballybruncullion the GS2 there was dominated by cocks foot, hogweed, rye grass and red clover. However this type can also be more species rich such as on the causeway between the Nun's Church and Clonmacnoise. In all situations it is an indicator of poor management for farming and biodiversity.

Dry humic-acid grassland (GS3)

Only one example of this habitat was found in a wet field behind the mass rock at Ballinlough Big Rock near Clara. This is a rare type of grassland for eskers and was found in a wet depression between two segments.

Amenity grassland (improved) (GA2)

Amenity grassland is a type of intensively managed reseeded grassland found rarely on eskers (.98ha and 0.2%) in gardens and playing pitches. Cover is probably underestimated as gardens were only mapped where they were large and were found solely on an esker. Cover has probably increased since 2000.

Plate 9 Amenity grassland in an esker cutting at the site of the Mass Rock (1beta) south of Clara

Dense bracken (HD1)

This habitat is found at six locations occupying 2.05 ha or 0.35% of the area.It is characterised by the dominance of bracken and is almost always found on steep slopes as a result of abandonment or low levels of grazing. This habitat has increased in cover since 2000.

Arable crops (BC1) and Horticultural land (BC2)

Tillage is rare on eskers (9.3 ha and 1.9%) due to the low water holding capacity of esker soils. Wheat was sown in fields in the vicinity of Tara townland where the esker abuts large fields and potatoes were grown in a small plot near

Clonfinlough. These fields supported tillage weeds such as red poppy and fumitory.

Woodland and scrub;
Oak-ash-hazel woodland (WN2)

The commonest type of semi-natural woodland is characterised by the presence of hazel, ash with rare pedunculate oak and rusty willow. (It covers 1.9% of the eskers and is present in a large number (24) of very small copses, average size of 0.46ha. It is distinguished from less native and more managed woodlands by the absence of non-native trees. It is always found in situations where clearance and farming are difficult or soils are so shallow that cultivation would be impossible. Good examples are found near Clonmacnoise, at Ballyduff, Bohernagrisna and Erry. North of the esker at Belleek Beg was found a very good example of this type of woodland on a gravel ridge. This habitat is of high biodiversity value for plants, birds and invertebrates. Shrubs found in this location include blackthorn, hawthorn, elder and bramble with occasional spindle and field rose. The condition of the ground flora depends on the degree of grazing. Heavily grazed examples have a predominance of plants that tolerate or thrive on enriched soils, such as rough meadow-grass, wood dock, nettle, burdock and hogweed. There is usually a high proportion of bare ground and the esker sides may be eroding.

Where grazing intensity is low or absent, the shrub layer is more dense and the ground flora more varied. There will be a high cover of the typical calcareous woodland species plus wild strawberry, scaly male-fern, wood sedge, wild strawberry, bluebell, soft shield-fern, primrose, wood sanicle and violets. Wood melick, bugle, tutsan are locally frequent to occasional.

Comparison between cover in 2000 and the present reveals that the cover of this habitat is stable although damage by cattle to the understorey is still a feature of most sites. This is principally due to the use of these areas for shelter.

Plate 10 Woodland and scrub on the esker segment 1 beta south of Clara**.**

Mixed broadleaved woodland (WD1)

Old (demesne type) woodlands planted on eskers cover 14ha or 2.42% of the area at five sites. They usually contain a mixture of native and exotic broadleaves. Depending on the canopy species and management the understorey may still retain mainly native species. This type of woodland was found at five locations on the eskers including Durrow Demesne. At this location trees include the native ash (regenerating) with planted oak, beech and less occasionally sycamore. The associated flora in these woodlands is rich and in Durrow it included twenty five other species including bugle and wood sedge. An active badger sett was also present. A brief summary account of this woodland is contained in a strategic study of the house and demesne (Moriarty,).

Scattered trees and parkland (WD5)

This type of habitat is a combination of grassland and woodland. It is found at only five locations such as on the ringfort in Ballybeg. Very small patches are found average size 0.1ha and trees include a combination of native and non native types.

Conifers (WD 4)

Conifer plantations occupy 1.7% of eskers and represent the principal type of recently planted woodland. The youngest plantation is less than five years old. Areas planted are small (average size 1ha) except when the esker fields are also adjacent to large planted areas such as in Ashfield.

Plate 11 Conifers planted on the esker segment 1 beta SW of Whiteforge cross roads.

Immature woodland (WS2)

Where broadleaves have been recently planted in two locations this habitat is found. Areas planted are small, average size is 0.5ha. A good example was seen in Doon Demesne where the species mixture featured mainly beech.

Scrub (WS1)

Scrub is common on eskers, covering 18.1% at 87 locations. The average patch size is 1.2ha but this is probably skewed by the large cover around Clara. It is characterised either by the dominance of gorse or blackthorn/hawthorn. The former is more likely around Clara and in the west of the esker system. It is difficult to data and many eskers may have supported scrub for hundreds of years. It is found on the steep sides of eskers where management is lax, where they are held in commonage such as Clonfinlough or around abandoned pits. It may represent a serial stage before woodland, and patches of scrub and semi-natural woodland are usually close together. Dense scrub generally has a species-poor ground flora. It is particularly difficult habitat for farmers to manage and the area occupied has probably increased since 2000. Together with woodlands and hedgerows this is an important habitat for birds.

Hedgerows (WL1) and treelines (WL2)

Hedgerows are ubiquitous in the study area, bounding fields, roadsides and frequently running along townland or esker boundaries. Treelines represent hedgerows which are dominated by a line of mature trees. Unique features of esker hedgerows in comparison to other types are the abundance of hazel and their significantly higher diversity of trees and shrubs. As well as supporting many of the tree and shrub species described for oak-ash-hazel woodland, hedgerows contained some plant species which were not found in woodland such as snowberry, stitchwort, wood melick and sweet violet. The latter two species were only found in a townland boundary hedgerow at Coillnabinna.

Hedgerows are particularly important on small eskers where all the land has been improved or modified or surrounding large improved fields. On these sites they provide an excellent reservoir of native woodland flora and fauna.

While no signs of hedgerow removal were seen there is little evidence of active management or establishment with the exception of pruning carried out along roadsides which is usually excessive.

Plate 12 Dense hedgerows bounding an old road which cuts through esker segment 1kappa**.**

Wetlands

Wetlands are very rare on eskers and include types which are either man made (drainage ditches) or appeared as a result of a major change in the landscape after the esker appeared (such as the appearance of river or bog). Cutover bog (0.34ha) was found where bog has grown over the edge of the esker at Clara and Clonmacnoise. These habitats introduce increase species diversity. A drainage ditch at Ballybruncullin produced a record for a sedge, *Carex spicata* a rare species in Co. Offaly.

Pits and associated habitats

The following four habitat types (ED1, ED2, ED3 and ED4) are all associated with disturbance to esker soils caused by the exploitation of deposits, house building or its replacement with dumped material. They cover 10.78 ha or 4.03% of the esker system. They are often found in a mosaic.

Active quarries and mines were judged to be active on the evidence of commercial activity at the time of survey. However if sites were visited after working hours this ready assessment could not easily be made.

Locations of active quarries and mines covered 8.0ha on the eskers or 1.4% of the total area. The principal sites are at Clonfinlough where the exploitation of sand and gravel was also occurring on deposits adjacent to the esker.

Areas with active sand and gravel extraction are virtually devoid of vegetation cover due to continuous disturbance and are of little biodiversity interest.

Areas where exploitation has ceased and recolonisation is occurring were mapped as exposed sand, gravel and till (ED1) or recolonising bare ground (ED3). The category spoil or bare ground (0.06ha or 0.01%) refers to two areas where spoil has been dumped on an esker.

The survey found 39 locations where natural revegetation is occurring on eskers soils which had principally been disturbed through quarrying. Not all locations represent inactive pits. Some sites with ED3 had been disturbed land reclamation purposes.

Areas which were exploited in the past now support high species and habitat diversity. Very small ponds or wetlands (10mX 10m) may be found. Depending on the length of time since quarrying occurred many of these areas may be completely revegetated. Plant cover is usually a mixture of ruderals, calcareous grassland species, and scrubby trees and shrubs. They represent important habitats for birds by providing a mosaic of feeding and nesting areas which are

rarely disturbed.

Plate 13 Badger tracks lead to a set built into an exposed sand bed in a disused pit at Clavins Hill.

Calcareous grassland species could include quaking grass and carline thistle, the latter is only found in open vegetation on calcareous habitats.

Inactive sites may also be mapped as sites of scrub, semi natural grassland or woodland if they have been abandoned for a long time. A diverse mosaic of habitats is found near the abandoned pits at Clara.

Buildings and artificial surfaces (BL3)

This habitat was mapped where roads, houses and gardens occurred. It covers 26.03ha or 4.49% of the esker. Its cover may have been underestimated as new houses had been built since 2000. While the sites of new houses were indicated on the habitat map the area occupied was not mapped accurately. In many instances roads have followed the eskers, resulting in the top surface being covered in tarmac. Houses and farm outbuildings have also been built on eskers usually after hedgerows/stone walls have been removed or some sand and

gravel has been extracted to provide a level surface. This habitat supports few native plants and is low value for biodiversity.

4.2.3 Conclusions

This is the first survey which has characterised the biodiversity interest of a complete esker system and provided data on the cover of valuable semi-natural habitats based on fieldwork.

Habitat and species diversity is high on this esker system. Twenty four habitats were found. The total number of habitats is five less than the number found in a survey of all eskers in south Westmeath in 2005 (Tubridy and Meehan, 2005) and five more than that found in one esker system examined in Laois (Muyllaert and Tubridy, 2005). Wetlands are a feature of some esker dominated fields in south Westmeath and these contributed a number of extra habitats. The esker system in Laois was considerably smaller than the Clonmacnoise esker.

The majority of land on the esker system is covered in improved grassland (57.4%). While this is of relatively low biodiversity interest the fields in which it is found are surrounded by hedgerows of higher value in which hazel is a conspicuous component. Many of the fields with improved grassland had higher species diversity than that generally associated with intensively managed land. Scrub is the commonest semi-natural habitat on eskers (18%) and is particularly common around Clara and the western part of the esker system.

Semi-natural habitats (shown on Table 4.4) cover 33 % of the esker. This is high for farmland and can be compared with the results of a recent habitat survey in lowland farmland in Laois (Hickey and Tubridy, in prep 2006) which showed that semi-natural habitats covered 6% of the land and the commonest type was wet grassland.

Several examples were found of the priority grassland habitat inside and outside designated areas. Most of the examples were outside designated areas. These often occupy small areas on the steep sides of eskers or fields which have a history of low intensity management, in particular the absence of fertilizer.

Other semi-natural habitats of particular value are oak ash hazel woodlands and pockets of scrub. Esker hedgerows and some grassy verges on roadsides were particularly species rich, particularly near Clonmacnoise.

4.3 Local history

Information on history / local folklore was collected indirectly while fieldwork for biodiversity was being carried out. Therefore results are tentative.

Townland names incorporating references to eskers were identified (see section

Consultations revealed that landowners in the vicinity of Frevanagh in Westmeath; between Clashawaun and Erry near Clara and along the Pilgrims Road near Clonmacnoise were most familiar with the use of eskers for roads or Pilgrim Roads.

None of the landowners/local informants who were interviewed were familiar with a placename containing bother or sli along the esker system. Dan Edwards of Carrowkeel, Clonfinlough is particularly knowledgeable on the names of fields and features in the esker system in his locality.

The distribution of certain plants may indicate historical associations of certain sites. Yew trees were only found in roadsides and fields near Balleek Beg and at Tara.

Occasionally townland boundaries co-incided with esker boundaries. However there was no obvious correlation between them.

Plate 14 Yews on roadside SW of Whiteforge cross roads

5 Management for sustainable development

5.1 Management issues

A number of management practices affect this esker system in Offaly, in negative and positive ways.

5.1.1 Local awareness of esker systems

Consultations revealed that there is a low level of awareness of the geomorphological and biodiversity values associated with eskers among the community who live along them. No landowner was aware of the listing of this esker system in the County Development Plan. It was also obvious that residents, landowners and developers are interested in knowing where eskers occur, why they are special and what kind of management is best.

In contrast there is considerable international awareness of the value of esker systems as educational assets among geologists and geomorphologists

Landowners who owned land on designated sections are aware of the biodiversity designation but concerned about its impacts on farming. In almost all situations it was viewed as preventing improvements in productivity such as the removal of scrub.

5.1.2 Agriculture and forestry

The original woodland habitat on eskers has been removed principally to facilitate farming. The habitats which have developed and which are now considered to be of biodiversity value were developed under the influence of farming and need to be maintained by it.

The maintenance of the priority habitat species rich grassland depends on farming. A farming system should include grazing, absence of ploughing and fertilizer and lime usage. If grazing stops the grassland will revert to a less valuable type and the field will be invaded by scrub. If fertilizer is applied the diversity of native species will be reduced and the sward will be replaced by a less valuable type.

Intensive reclamation of esker land is not occurring at the rate at which it occurred in the mid to late 20$^{th.}$ Land use practises are conservative and there is little evidence for the direct removal of high value habitats such as woodland or reseeding of old grasslands. Some esker farmers are in REPS which should provide them with support to manage their land to maintain and enhance biodiversity.

Some land management practises give rise for concern. These are the use of small woodlands to provide shelter to cattle, planting up of eskers with conifers and reduction in grazing intensity which allows for the growth of scrub on semi natural grassland. Scrub will remove one semi-natural habitat which is rare with another which is very common. However scrub cover may improve biodiversity if the grassland being replaced is of low value and surrounding hedgerows are poor. Native woodland (under the Native Woodland Scheme) is a more appropriate type of woodland for eskers.

While some limited use of esker woodland is desirable to maintain an open woodland structure, excessive poaching will damage biodiversity as it will remove the native herb flora. Trees and shrubs cannot regenerate as animals damage seedlings.

Any suggestions for improved biodiversity management must respect the nature of esker biodiversity on each individual farm and the potential for management. There are opportunities to influence management on REPS farms in association with REPS planners, Teagasc and NPWS farm planners who are now delivering farm plans with a specific biodiversity option. This could also cover advice on how to manage abandoned pits. Under cross compliance landowners with part of their land in NHAs or SACs (Special Areas of Conservation) will have to join REPS or operate under conditions laid down under a National Parks & Wildlife Service farm plan. There is also a need to communicate with the large number of esker farmers who are not in REPS. This group do not attend training courses or may not be very active farmers.

Of particular importance is the need to engage with the small number of farmers who own land on which is found small patches of the priority grassland habitat. As most of these are outside designated areas a new scheme or approaches are needed.

Forestry needs more careful management on eskers so that new plantations will not affect valuable habitats and that appropriate woodland types are established. There is increasing interest in afforesting holdings. The planting of conifers will reduce the biodiversity interest of eskers and when mature the physical characteristics of eskers will be completely obscured.

5.1.3 Roads and housing

Many local roads run along or adjacent to eskers. These routeways have a unique quality and some may be very old. Many offer good views of the surrounding countryside and their marginal hedgerows and grassy verges usually contain areas of wildlife interest. Where the roads directly bisect eskers they offer convenient locations to examine sediments and biodiversity.

The management of these roads for traffic should take into the account their historical significance, the existence of exceptionally high quality hedgerows, species rich verges and the possible presence of woodland or scrub in adjacent

fields. Hedgerow management should be carried out following the code of best practise in hedgerow cutting.

Safety management is required to allow some of the quieter local roads be developed as walking/ cycling routes.

Traditional houses were built on the sides of eskers to take advantage of their shelter. Esker deposits are being affected by new housing, the extent of which has been mapped (as BL3) on the habitat map. Housing is a threat if is it associated with removal of deposits, semi natural grassland and hedgerows. Extra traffic is generated possibly leading to pressure for road widening resulting in the removal of valuable habitats.

Current practise of building on eskers needs to carefully consider the location, landscape impact, the vulnerability of groundwater resources and the need for appropriate landscaping to reflect local biodiversity values.

Eskers contain significant reserves of water. They are classed as 'locally important' aquifers by the Geological Survey of Ireland. Where they interconnect with other sand and gravel areas they may host enough water to be able to supply major regional water supply schemes. Many households obtain their water supplies from such aquifers.

Plate 15: Domestic well tapping into the esker aquifer at Ashfield, southeast of Clara

However as well as being important sources of freshwater they are ***extremely*** to ***highly*** vulnerable to groundwater pollution as sand and gravel are very porous.

Therefore householders and land managers need to be aware of the risks to groundwater from the disposal of farmyard and household wastes directly or indirectly into the eskers. Problems can arise from septic tank systems and disposal of farm wastes.

5.1.4 Exploitation of sand and gravel deposits

Approximately 33 pits were identified in the esker system of which 3 appear to be large active operations. At least two other pits appeared to have been active in the recent past. The exploitation of esker gravels is considerably more intense in Offaly than in south Westmeath where 46 pits were found in eskers covering 61km2.

The majority of the pits were characterised as small and inactive. They are associated with farms and are/ or were used exclusively by the landowner as a source of hard core for farm roads or foundations. Sections of all these derelict old pits are revegetating naturally and within them are areas of biodiversity interest. In the three large operations identified, two were exploiting adjacent sand and gravel deposits, however, Dooley's pit near Clara is totally confined to the esker. The evidence from aerial photography shows that all these operations have expanded since 2000.

Quarrying is not compatible with the maintenance of esker geodiveristy and biodiversity and the Council should continue to refuse permission for new quarries on this system. Quarrying leads to the removal of the entire ecosystem, sediments and biodiversity. While old pits may now be the sites of semi natural habitats or rare plants, the potential for such development does not outweigh the negative impact of the loss of part of the esker.

There are other alternatives for the extraction industry or for the expansion of pits which currently operate on this esker system. Considerable reserves of sand and gravel are found in the county. Some are adjacent to the eskers which they are exploiting (Fig. 16). These deglacial features includes fans, deltas, kames, sandar and gravelly hummocky moraine (see Appendix 1 for description). They cover an estimated 5 times as much land area as the eskers around Clonmacnoise-Clara alone. While these gravels may not be as 'clean' as those in the eskers, they are more extensive.

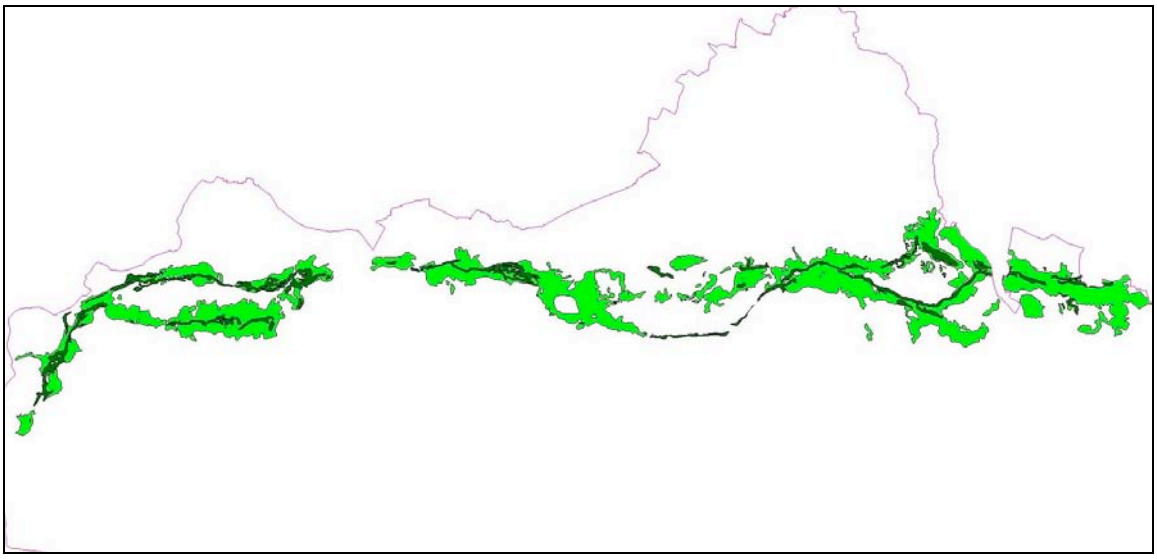


Figure 5.1. Glaciofluvial sands and gravels in the Clonmacnoise esker area of County Offaly. Dark green shows eskers, light green other sands and gravels. Mapped photogrammetrically as part of EPA Soil and Subsoil mapping project (formerly FIPS-IFS, Teagasc, Kinsealy, 1998-2005.

Registration of current pits should provide for expansion off the esker, the protection of habitats of biodiversity value in parts of the old pits or cuttings and landscaping which will maximise the biodiversity value of the land once operations cease.

There is considerable potential for habitat recreation when pits are closed or sections abandoned. Developers and owners of derelict pits should be encouraged to reprofile them to generate more structural diversity and in particular to create small wetlands. Old spoil where it exists might be used to level the old pits if necessary. Landscaping should be discouraged unless it is necessary to improve amenity values i.e. near houses. Even in these areas species planted should be similar to those already present on site.

There may be pressure to infill pits with waste including demolition waste. This pressure should be resisted as the introduction of such material will remove the biodiversity value of these pits and reduce their geomorphological interest. The deposits will be obscured and landscaping or reclamation is unlikely to provide habitats of equal biodiversity value to that which is currently present. Using esker pits for general dumping is also problematic due to the highly porous nature of the sediments, leading to a high risk of groundwater contamination.

5.1.5 Development of the special interest tourism potential of eskers

Consideration should be given to the establishment of a GEOPARK or World Heritage site in the Irish Midlands to highlight its heritage of eskers and bogs and ensure that it is safeguarded, sustainably managed and promoted.

The GEOPARK initiative has been proposed by UNESCO with the dual objective of enhancing the value of sites which act as key witnesses to the Earth's history whilst creating employment and promoting regional economic development. This label is awarded each year to some twenty territories which merit this distinction all over the world.

Geoparks must comprise a certain number of geological sites of particular importance in terms of their scientific quality, rarity, aesthetic appeal or educational value. The majority of sites present on the territory of a Geopark must be of geological heritage, but their interest may also be archaeological, ecological, historical or cultural. There are currently thirty-three recognised Geoparks worldwide. Twelve are in China and twenty-one in Europe, with two in Ireland. These are the Copper Coast Geopark in Waterford and the Marble Arch Geopark in Fermanagh.

Geopark nominations need to come from local communities and local authorities with a strong commitment to develop and implement a management plan which meets the economic needs of the local population whilst protecting the landscape in which they live. Application forms are available on the UNESCO web site. This initiative has proven an excellent means of gaining international recognition for important geological sites. Previous UNESCO initiatives, such as the World Heritage List (of which the Giants Causeway is the best known example in Ireland), have now become synonymous with the conservation, protection and promotion of important sites.

The Clonmacnoise esker system in County Offaly provides a wonderful and unique scientific example of an esker which is of exceptional aesthetic, recreational and educational value. It is important geologically, for biodiversity and for its historical value. The Clonmacnoise esker system, as well as many of its adjacent esker systems in Offaly, has the potential to host a portion of a Geopark spanning the Westmeath-Offaly region. The development of a GEOPARK in the region would require co-operation between counties in the region to research and carry out management works to improve their amenity and heritage values.

5.1.6 Research needs

Surveys should take place on the other esker systems in Offaly to support a county wide strategy to inform and manage all esker systems.

A GIS based exercise should be carried out to examine the relationship between the known location of eskers, road and certain monuments.

The NPWS should be encouraged to develop management plans for other designated sites on eskers as their preparation would provide more detailed information on their biodiversity interest.

A brief study should be carried out on systems to identify priority grassland on eskers by comparing these results with those of the NPWS survey.

Consideration should be given to supporting a study which would compare grassland biodiversity in the Clonmacnoise region in the 1980's and present day based on fieldwork at sites which were surveyed by Dr Micheline Sheehy Skeffington of UCG.

5.4 Management guidelines

5.4.1 Partnership approach

The aspiration of maintaining esker heritage as a source of enjoyment and inspiration for successive generations requires co-ordinated actions. The Heritage Forum is the obvious forum to catalyse these actions.

The initiatives suggested belowcould either be promoted immediately by the Heritage Forum, developed as part of the County Biodiversity Plan or implemented independently by particular members of the Heritage Forum such as the local authority.

The immediate priority for the Forum is to highlight the value of this esker system to the public within the county.

5.4.2 Formal recognition of esker heritage nationally and locally

The following initiatives are suggested;

The Heritage Forum should write formally to the NPWS of the DOEHLG requesting that the designation of the Clonmacnoise esker as a pNHA should proceed as a matter of urgency, citing the current level of protection offered by the County Development Plan. The local authority should list the Clonmacnoise esker system as a County Geological Site, thus recognising the recommendation of the IGHP and the results of this study.

The results and conclusions in this report should be publicised locally. Copies of the survey report (or summary) and habitat maps should be available to the public, developers, landowners and planners through the county library section, local web sites or local authority intranet.

The County Development Plan and other relevant local development plans should include a map of this esker system.

5.4.3 Managing change

Applications for developments and waste permits should be informed by 1) the location of the esker segments and 2) the location and nature of habitats affected by the development. Applicants, the local authority or other agencies with responsibility for managing change should have access to this information. Assessment of planning applications for housing, waste permits should consider their impact on esker conservation (particularly landscape, biodiversity and water quality impacts). Housing should be discouraged if it will cause significant impact to esker deposits, result in the removal of semi-natural habitats or reduction of biodiversity values.

Major developments should be discouraged near the Clonmacnoise esker to protect its geodiversity, biodiversity, landscape value and water quality.

The operation of pits on the Clonmacnoise esker should not expand on the esker, and excavation does not occur below the water table. Pit closure plans should be agreed with all owners as part of the registration process which would allow for the retention of semi natural areas in their environs and the development as new areas of high biodiversity interest after operations cease. Applicants for licenses should be encourage to consult with experts on geodiversity or environmental impacts. No new pits should be permitted.

As local authorities or the Heritage Forum do not have close links with the farming/land use sector and their operations have potential to influence esker values, it is recommended that a meeting should be convened with representatives of the farming and forestry sectors, Teagasc, interested REPS planners and other stakeholders to discuss initiatives focused on esker farming. This meeting could be organized in co-operation with the Westmeath and Laois Heritage Fora. Initiatives for discussion include

- Management of forestry on eskers. To protect esker biodiversity coniferous forestry should not occur on eskers or on areas with semi-natural habitats (listed on Table 3).New planting should only take place under the auspices of the Native Woodland Scheme.

- The production of guidelines on scrub removal.

- The promotion of the Native Woodland Scheme to farmers who own small areas of woodland.

A field based course should be organised for REPS planners on the identification of eskers, their semi-natural habitats, particularly species rich grasslands and discussion of appropriate measures to improve biodiversity. These discussion

would cover: appropriate management practises (light grazing, retention of scrub and hedgerows, controlling grazing and closing off of woods to cattle) biodiversity measures which would be particularly appropriate for esker land such as restoring hay meadows, maintaining species rich grasslands, planting small woodlands or scrub areas particularly adjacent to species rich hedgerows and describing how pits should be treated.

5.2.4 Improving awareness

Improving awareness should be an on-going objective of a campaign to support sustainable development of eskers.

This programme should initially involve publicity and promotion of the results of this study and the commissioning of similar studies on other esker systems in the county. In the short/medium term an educational programme should be agreed with other partners who have particular expertise or resources. The target group for an educational programme should include schoolchildren and interested members of the public. Partners should include the NPWS and local teachers. Initiatives could include:

- Production of an information leaflet summarising the important features of eskers illustrated with aerial images and typical species.
- Production of a poster featuring an aerial of a dramatic esker sytem
- Producing a documentary on Dan Edwards, Clonfinlough who is a local authority on local history and landscape in the Clonmacnoise area.
- Guided esker walks as part of Heritage Week events in Offaly.
- Revewing access and interpretative facilities along the section of the esker at Clara with a view to either removing the interpretative panel or restoring facilities.
- Compilation of a comprehensive inventory of scientific papers relating to the esker geology, ecology, geomorphology and geodiversity of the county should be compiled and stored within the county library (local studies section or Offaly Historical Society).

In the medium to long term the possibility of establishing a Geopark /World Heritage Site within the area straddling the Offaly-Westmeath-Laois boundary should be examined. This initiative could start with the establishment of a group Friends of the Clonmacnoise Esker with representatives from the local authority, residents, landowners, community groups, business owners and other stakeholders which could discuss:

Research on the significance of cultural resources, encompassing buildings, structures, sites, and objects on and around the esker system.

Agreed measures and monitoring to ensure the preservation, restoration, or protection of significant cultural resources.

Design of services which would allow for appreciation and enjoyment of the esker without causing damage to their valuable resources.

Appropriate re-use of structures which have associations with esker management such as old pits, or buildings made of esker material.

6 Conclusions

While eskers cover only a small part of Offaly they provide the area with an extremely rich and valuable heritage.

The esker system examined by this survey, the Clonmacnoise Esker, which has which has been recommended for designation as a geological Natural Heritage Area and is listed for protection in the County Development Plan is of international importance for geodiveristy. This esker contains examplies of habitats of international biodiversity interest outside designated areas.

Consultations during fieldwork confirmed the local association between the esker system in certain areas and old roads.

The study provided an assessment of local development and its impacts on esker heritage. It confirmed the need for policies to restrict exploitation on eskers and suggested a further focus on pit restoration. A suggestion is made to identify this esker system within a GEOPARK/World Heritage Site which would highlight the quaternary landscape features in the Midlands .

Sustainable development requires easy access to information on the location and value of esker systems and increased awareness among developers and local agencies on the actions required to protect and manage esker heritage.

Farmers who own esker land and old pits, the communities who live in asssociation with eskers, developers, and all authorities who manage development on eskers share this responsibility.

The Heritage Forum is the obvious forum to co-ordinate initiatives which will ensure the maintenance and improvement of esker values.

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Appendix 1 Characteristics of other types of sand and gravel deposits

Eskers are defined by the fact that they are steep-sided, sinuous ridges that have been formed in ice walled channels, either beneath glacier ice or beneath open sky between bodies of glacier ice, during deglaciation (ice melting). From this, there are many other landforms which may appear in some sense to be eskers, but which are not. Generally these other landforms are also hummocky and ridge-like, and are regularly composed of sands and gravels or gravelly tills, but have been deposited by completely different deglacial processes. Many of such landforms occur in Offaly. A brief summary of these landforms, which in some senses looks like eskers but are ***not***, follows.

Linear moraines.

Mostly, moraines are composed of debris transported to the glacier front and accumulated there, and may consist of debris that was pushed by the ice, flowed off it, was dumped by the ice at its' edge, or was deposited at the edge of the ice by water, either under air or into water. Offaly possesses linear ridges comprised of sands and gravels which were deposited at the edge of the glacier ice under air and into water. Their form may suggest that they are eskers, but they were not formed in tunnels and are therefore not.

Hummocky moraine.

Hummocky moraine is a non-genetic term describing landforms characterised by an irregular landscape of large or small hummocks, ridges and collapse features. The material within these hummocks may be any type of sediment that had collected on the ice surface, including till, glaciofluvial sands and gravels or even glaciolacustrine silts and clays. If the material is till, the area is broadly labelled a 'moraine'. If it is glaciofluvial, the term kame is preferred.

Outwash Fans.

Outwash fans are deposited in front of a stationary ice margin, with the apex of each fan centred at a point at which meltwater emerges. The coarse material is deposited relatively close to the meltwater's exit from the ice by the water, with the finer fraction transported far from the glacier. The fans often have steep sides, especially if they were once supported by an ice wall, but usually have gradual slopes on other flanks. These fans are common in the Midlands, with some fine examples around Athlone. Again, they are not 'eskers', despite the fact that they may have steep sides and appear to be so.

Kames and kettle holes.

Kames are a product of sedimentation in traps along meltwater drainage routes through glaciers. They may form in lakes and pools within the glacier or in uphill sections of englacial or supraglacial tunnels, or in debris rich bands within the ice which are crossed by a stream. When the ice melts these deposits are lowered onto the ground surface and become mounds of glaciofluvial sediment, which are the 'kames'. They are somewhat like rounded or haphazard 'blobs' of esker segments.

The kame features may be conical, flat topped, elongated or irregular and can occur singly or in small or large groups. They are commonly interspersed with kettle holes, which are rounded depressions left after buried blocks of dead ice melt during or shortly after deglaciation. When the ice melts in these 'kettle holes' the gravel caves in around it. Topography with many features such as this, and hummocky moraine topography, is often termed 'kame and kettle', or 'dead ice' topography.

Kames are often associated with eskers and may make up hummocks around and close to the linear esker features. Kettle holes within these areas generally assumed lacustrine (lake) conditions during and after ice melt, and silt and clay has often been deposited in their floors. Therefore the 'hollows' close to and around eskers may be poorly drained owing to this, or may even have lakes and/or fens occupying their bases where the water table now breaks their surface. In particular cases the lakes may act almost as turloughs, where the water occupies the base in winter, but the base then becomes dry as the water table lowers in summer.

In kettle holes/hollows that have thick sequences of clay at their base, peat may have formed since deglacial times.

Appendix 2 Soils associated with eskers

Soil types on eskers may be quite variable. Generally, soils are mineral-derived and shallow, but other soils types do occur.

Rendzina soils

Rendzinas are one of the most common soil types found on eskers in Offaly These soils are considered shallow as they are less than 50cm deep. They are derived from parent material that contains over 40% carbonates. The surface horizon is dark coloured with a well developed structure and a neutral or alkaline reaction. A calcareous 'B' horizon may be present but generally the 'A' horizon directly overlies the calcareous parent material.

Rendzina soils generals occur on the esker summits, shoulder and upper backslopes. A humic, gravely, loamy sand texture is commom with moderately developed granular structure at the surface. The subsurface horizon has a gravely coarse sand texture, single grain structure and uncompact consistence. The profiles are generally very calcareous throughout. The soils are prone to drought, even after short dry periods, due to rapid permeability and poor water-holding capacity. Land-use is also restricted owing to the morphology of the esker crests. The soil generally supports vegetation of poor pasture grasses, mixed herbs and scrub.

Brown earths of hi-base status soils

These are well drained soils with generally uniform profiles and little differentiation into horizons. They may be deep or shallow, but on eskers they are generally shallow (less than 50cm deep), and often occupy the mid- to lower backslopes of the eskers.

Brown earths have not been extensively leached or degraded with the result that there are no obvious signs in the profile of removal and depositon of materials such as iron oxides, humus or clay. On eskers the soils are freely drained and have a moderately wide use range, being limited only by shallowness, drought risk and, in places, by slope. The soils can be grazed early and late without serious risk of poaching, and they are suited also to malting barley as well as pasture.

Grey-brown podzolic soils

Grey brown podzolic soils have a significant increase in clay in the 'B' horizon relative to the 'A'. They have relatively deep profile development and are up to 1m deep. They occur rarely on the eskers, but may be present in clayey 'pods' within the features. From this, it is rare that these soils will occupy extensive portions of the esker features.

Gleys, peaty gleys and peats.

Gleys are poorly drained, saturated soils. Classically that are not associated with esker features, but they may occur in the footslopes and toeslopes of the features, especially if the water table breaks the surface there for all or part of the year (groundwater gleys). They have a grey, reduced colour, and are susceptible to poaching owing to their saturated condition.

Peaty gley soils are gleys with an organic horizon over 30cm thick. In areas where basin peats have developed in hollows between eskers, the peat may have overgrown much of the esker morphology itself, so peat soils may even occur high on esker backslopes, as well as on the footslopes and toeslopes.

Appendix 3 Description of the Clara esker system (from Appendix 6 in Tubridy and Meehan, 2005)

Esker 11 Clara Esker

Map foldout 5

Mapped from fieldwork

Esker 9 km long from Cartron Cross Roads to Grange and Kiltober.It includes a pNHA Derrygolan Esker No 000896 on segment 11e.It is also bisected by the Kilbeggan branch of the Grand Canal (pNHA 0002104). As part of the esker (2.5km) is within Co Offaly, this was not examined.

There are BSBI (date?) records at 11e for *Orchis morio, Anthyllus vulneraria, Carex caryophyllea, Helictotrichon pubescens.*

The Derrygolan section of the esker was designated because of the presence of good semi-natural grassland with *Orchis morio* etc. A survey in 1991 showed presence of large population of *Orchis morio (NPWS Site File).* As location details are ambiguous the rare plant survey may have taken place on the adjacent section of esker (outside the designated area). Designated area is now principally covered in improved grassland and a poorly maintained hedgerow. The field adjacent to it is covered in unimproved grassland and scrub. It is a potential GS1* site but is heavily grazed.

Part of the esker in Offaly is within the Durrow Demesne and its presense and vegetation are referred to in a Conservation Plan prepared in 2005 for Offaly County Council (Howley Hayes, 2005). According to the ecology section of this report (prepared by Dr Christopher Moriarty) the esker is covered in woodland (High Wood) which dates from 18th century. This woodland was established as part of the landscaping to provide a view from the house. Current woodland refects this character. The ecological study was a walk over study. It stated that deer are present in Durrow and there is possibly very old oak in the parkland adjacent to the esker. Elsewhere in Offaly the esker is covered in mature semi-natural woodland adjacent to unimproved grassland. This area should be looked at and results incorporated in Westmeath study.

Esker features some areas of GS1* and scrub. Valuable habitat in small pocket.However there are numerous townland hedgerows. Some extensively managed land to east. Area near Grand Canal of potential interest.
Not all GS1 areas looked at as access was not possible.

The grasslands bounding the hedgerow on the minor road adjacent to the designated area are particularly species rich and deserve further study. These should probably be designated for protection together with adjacent unimproved field. Other features of interest include seasonally wet grasslands and wetlands adjacent to 11e and 11g.These wetlands are surrounded by scrub and are particularly good for birds in winter. Much interest in rearing pheasants for game shooting. They are obviously released into woodlands. A pheasant coop was found in woodland (11a). Many signs of badgers. Badger sett in 11b.

Residents living near 11d,e and f very aware of the historic value of the esker (part of the Sli Mhor).

A conifer plantation has recently been established (c. 8 years ago) on the esker at Ballycahan, near Cartron Cross Roads on the Offaly border. Almost all of section 11d has been removed through small scale quarrying. A change in ownership may threaten the survival of scrub on 11g. Some hedgerows very species rich. It is noteworthy that the townland boundary hedgerow near 11f exactly follows the line of the esker.

Boundary hedgerows should be protected if housing developed.
Housing is resulting in the removal of some sections of esker at 11a.
There is potential for a passive amenity area at the western end of 11c.

Two small inactive quarries and two small active quarries.

Target notes

WD 4

TN1 GS1 (11Gi)

Meadow vetchling
Red fescue
Blackthorn
Hawthorn
Red clover
White clover
Ragwort
Bramble
Poa compressa
Hogweed
Veronica chamaedrys
Vicia cracca
Bush vetch
Cerastium glomeratum

Birds foot trefoil
Cowslip
Cock's foot
Narrow leaved plantain
Glaucous sedge
Rumex acetosa
Helictotrichon pubescens
Silverweed
Carex nigra
Burnet saxifrage
Sweet vernal grass
Cirsium arvense
Crested dog's tail
Yorkshire fog
Sweet vernal grass
Luzula campestris
Quaking grass
Red fescue
Wild carrot
Flax
Bird's foot trefoil

Bryophytes dominant

TN2 GA1 11-gi

Reclaimed esker. Bushes cleared 40 years ago.
Reseeded then and more recently in certain places.

Cirsium arvense
Trifolium repens
Lolium perene
Poa annua
Bellis perennis
Cynosurus cristatus
Ranunculus repens
Poa compressa
Geranium dissectum
Leontodon taraxacoides
Festuca rubra
Cirsium vulgaris
Cerastium conglomeratum
Ranunculus bulbosus
Annacamptis pyrammidalis
Brachypodium sylvaticum
Phleum bertolonia
Pimpinella saxifraga
Luzula campestris

Pilosella officinalis

TN3 GS1* (11 d, e, f) TN 1

Festuca rubra
Helictotrichon pubescens
Crataegus monogne
Pimpinella saxifraga
Linum catharticum
Carex caryophyllea
Leontodon hispidus
Ulex europaeus
Filipendula ulmaria

TN 4 GS 3 (roadside verge/bank)

Dactyllus glomerata
Lolium perene
Holcus lanatus
Geranium dissectum
Ranunculus bulbosus
Festuca rubra
Achillea millefolium
Trifolium pratense
Cynosurus cristatus
Anthoxanthum odoratum
Veronica chamaedrys
Carex caryophyllea
Fragaria vesca
Galium verum
Listera cordata
Potentialla erecta
Dactyllorhiza maculata ssp ericetorum
Lotus corniculatus
Briza media
Origanum vulgare
Leontodon hispidus
Hedera helix
Carex pulicaris
Polygala vulgaris
Bromopsis erectus

WD5 (Durrow demesne)

Oak *Quercus robur*
Ash *Fraxinum excelsior*
Lime *Tilia sp*
Horse chestnut *Aesculus hippocastanum*

TN5 WS1

Cleared thirty years ago. Not managed and scrub returned.

Prunus spinosa (dominant)
Crataegus monogyna F
Coryllus avellana
Rubus fruticosus agg
Moehringia
Galium aparine
Fraxinus excelsior (seedling)
Heracleum sphonsyllium
Fragaria vesca
Rumex sanguineum
Brachypodium sylvaticum
Hedera helix
Viola riviniana
Arum maculatum
Geranium robertianum

TN 6 (best example in 11g1. TN4)
Remnant of scrub woodland which covered esker c. 40 years ago.

Fraxinus excelsior
Quercus robur
Ilex aquilifolium
Malus sylvestris ssp sylvestris
Sambuccus nigra
Rosa canina
Fagus sylvatica
Coryllus avellana
Crataegus monogyna
Salix caprea
Acer pseudoplatanus
Tilia sp

Appendix 4 Identification of the priority type "orchid rich grassland"

The methodology was informed by an examination of the EU manual (EU 2003) and literature on grassland ecology.

According to the Interpretation Manual (EU 2003) the priority type calcareous grassland fulfils one of the following three criteria:
(a) the site hosts a rich suite of orchid species
(b) the site hosts an important population of at least one orchid species considered not very common on the national territory
(c) the site hosts one or several orchid species considered to be rare, very rare or exceptional on the national territory

The habitat is also expected to contain some of the following plant species *Anthyllis vulneraria, Arabis hirsuta, Brachypodium pinnatum, Carex caryophyllea, Carlina vulgaris, Centaurea scabiosa,Leontodon hispidus, Ophrys apifera, O. insectifera, Orchis mascula, O. morio, O. mascula,, Primula veris, Sanguisorba minor and Bromus erectus.*

No formal phytosociological analysis has been undertaken on calcareous grassland communities in Ireland (Cross 2004). A brief description is provided in Fossit (2000). There are several references in the literature on the ecology of this type of habitat in the context of broader work on Irish vegetation. According to Fossitt (2000) the more calcareous grasslands which might approximate to the priority habitat type are characterised by the presence of *Knautia arvensis, Anthyllis vulneraria, Antennaria dioica, Blackstonia perfoliata, Sanguisorba mino, Carlina vulgaris.*as well as orchid species, including *Ophrys* and *Orchis* sp.

Some guidance on the nature of the flora associated with eskers is provided by several papers in Irish Vegetation Studies (O' Sullivan, 1982) and to a lesser extent in a follow up paper (White and Doyle, 1982).

Austin O'Sullivan's paper places grasslands on limestone eskers and moraines in the midlands in the Festuco-Brometea class(Br.-Bl. et Tx. 1943 em. Tx.1961) and within this in the order Brometalia erecti Br.-Bl. 1936. Important character species of both the class and order are – *Anthyllis vulneraria, Helictrichon pubescens, Blackstonia perfoliata, Centaurea scabiosa, Bromopsis erecta, Leontodon hispidus, Carlina vulgaris, Filipendula vulgaris, Koeleria macrantha, Gentianella amarella, Sanguisorba minor, Sesleria coerulea.* Significantly, O'Sullivan comments that only a limited number of stands belonging to this order had been described by the author and that on midland eskers and moraines these communities on the tops of these limestones gravel deposits pass over to communities of the Centaurea-Cynosuretum sub assoc.galietosum around their base. The extent of more general soil cover appears to be the major influencing factor in this transition.

In pps 135/136 of the same paper O'Sullivan places "moderate-quality pastures, rich in weeds and poor-yielding grasses" which occur widely in midland counties in the class Centaureo-Cynosuretum Br.-Bl. et Tx.1952. Differential species from the Lolio-Cynosuretum would be *Hypochoeris radicata, Carex flacca, Lotus corniculatus, Centaurea nigra, and Luzula campestris*. Because of variations in soil depth and drainage O'Sullivan recognises several sub-associations of which sub assoc. Galietosum which is mainly confined to shallow, well-drained soils derived from Carboniferous Limestone is the one most appropriate in the context of the esker study. Important differential species of this sub-association are- *Ranunculus bulbosus, Primula veris, Agrimonia eupatoria, Trisetum flavescens, Galium verum, Pimpinella saxifrage, Daucus carota. Medicago lupulina, Briza media and Helictotrichon pubescens.* Even within the Lolio-Cynosuretum class found on highly fertile soils O'Sullivan(p136) includes some of these latter species in a sub association Brometorum which can occur locally on shallow well drained soils of varied origin.

Within the Festuco-Brometea class O'Sullivan also includes a sub-alliance EU Mesobromenion to include the Antennarietum hibernicae Br,-Bl.et Tx 1952 in which the character species are *Antennaria dioica* and *Polygala vulgaris.* O'Sullivan notes that the distinctive features of this sub association are "the high constancy and abundance of the herb *Antennaria dioica*, the frequency of *Polygala vulgaris* and the presence of a large diversity of herbs characteristic of lime-rich soils. He also comments that on the sides of the steeply sloping eskers where they occur these *Antennaria* communities often have a terraced appearance due partly to centuries of use as permanent grazings.

In the absence of an appropriate classification system for grasslands a pragmatic approach can be taken which identifies species rich calcareous grasslands if it contains species which are known to be associated with this type of habitat or orchids.

The identification of fields with species rich grassland (wet and dry) to inform actions under the Countryside Management Scheme in Northern Ireland (www.dardni.gov.uk) is based on the presence of more than five species from a list of thirty nine in six out of ten random 1 sqm in a field.

Appendix 5 Identification of eskers using FIPS/EPA

Mapping was completed in three stages:

- Initial compilation of existing data;
- Mapping using photogrammetry;
- Field work for verification of mapping.

Initial compilation of subsoil data.
The mapping of subsoils involves the integration of a number of suites of data. Initially, all available Quaternary (*i.e.* glacial) information for the county being mapped is compiled and any relevant information on sediments is portrayed on a paper 1:50,000 map. The most important of these sources were the National esker map of the Geological Survey of Ireland (Glanville and Warren, 1995), and Quaternary sediment maps of County Offaly, mapped by the Geological Survey of Ireland, where available.

Photogrammetric mapping of subsoils.
Following this initial compilation of these data, boundaries between sediment types are interpreted and mapped using photo-interpretation in a soft copy photogrammetric station with digital stereo-pairs of black and white photography (acquired in 1995 at a scale of 1:40,000) using ATLAS software. Boundary polygons are therefore accurately located in the Irish National Grid in three dimensions. In areas where previous mapping has taken place and data have been compiled in the initial stages of work on that county the boundaries are re-digitised within the ATLAS domain. This ensures the accuracy of the boundaries on the finished map and ensures they pertain to the landforms and deposits that they are supposed to.

While mapping the minimum unit depicted is about 30m x 30m for some esker segments *i.e.* 900 square metres (although some units are smaller). This is at quite a detailed scale. Over the remainder of the subsoil map, units are generally no more than 100m x 100m across, equating to a mapping scale of around 1:50,000. The ATLAS coverage consists of lines, that constitute polygons, and text labels. The completed ATLAS file for each county is exported as a **DXF** file. This is imported into ERDAS Imagine software where the linework is cleaned and built into a full GIS polygonal coverage. While the file is exported from ATLAS an algorithm converts the 3D subsoil coverage into 2D to be used as a map theme for subsequent display and analysis in ArcView GIS software.

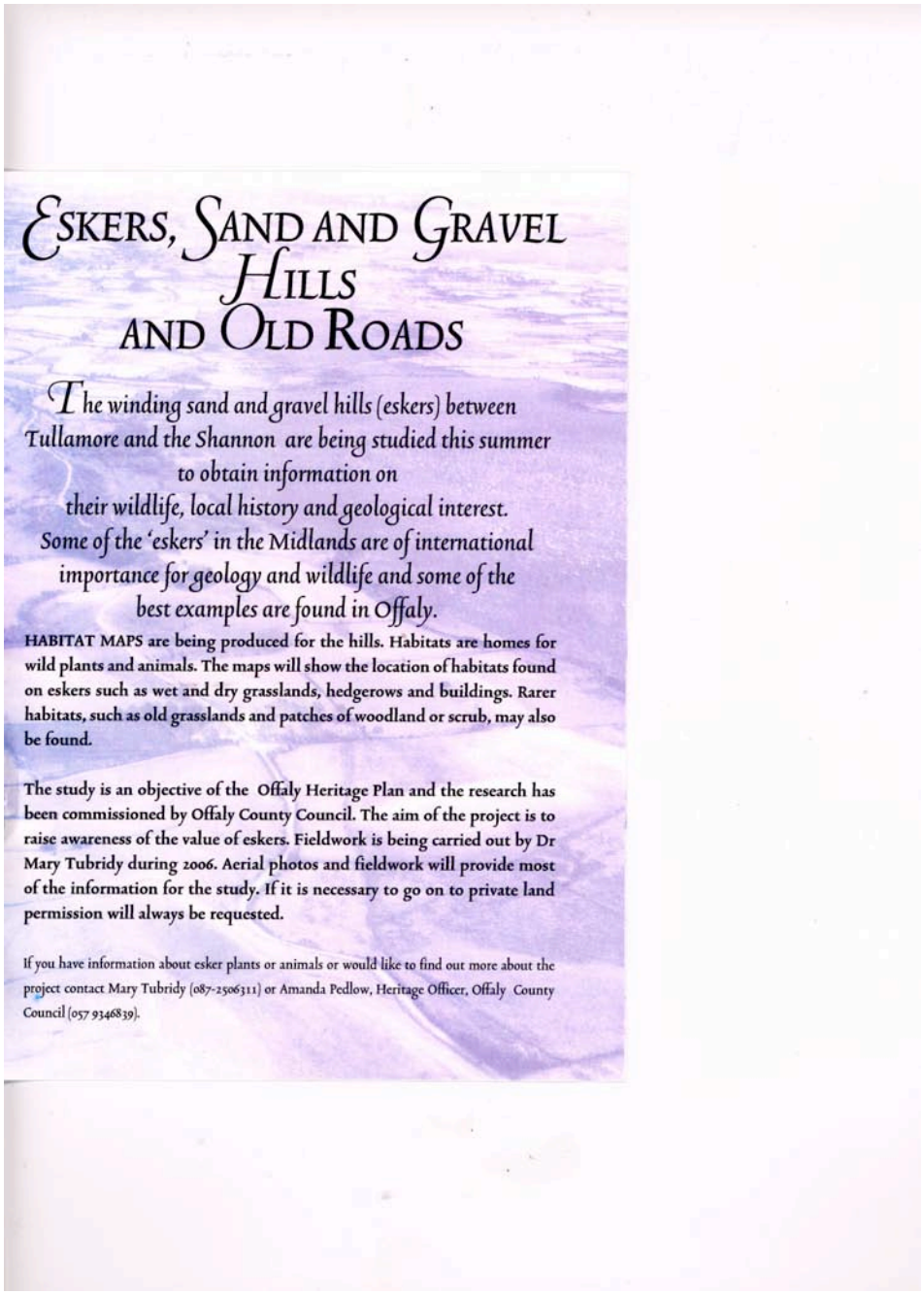
The classification of subsoils on the subsoils maps mimics the classification used by the Geological Survey of Ireland Quaternary Section in mapping Quaternary sediment types. This classification has been altered only to ensure further utility to the requirements of the EPA Soil and Subsoil Mapping Project. Eskers are mapped as part of this classification as 'eskers dominated by acidic sands and gravels' and 'eskers dominated by basic sands and gravels'. Only eskers

dominated by basic sands and gravels occur in County Offaly, as limestone dominates the gravel material there.

Field programme for verifying eskers as part of the current project.

The preliminary identification of subsoil boundaries within the photogrammetric medium means that problem areas, can be focused on during fieldwork. The field mapping also allows for the checking of the ground for areas mapped during the photogrammetric analysis, and is therefore crucial in increasing the accuracy and defensibility of the maps. Only reconnaissance field mapping of the eskers was carried out during the EPA project.

Appendix 6 Information leaflet



ESKERS, SAND AND GRAVEL HILLS AND OLD ROADS

The winding sand and gravel hills (eskers) between Tullamore and the Shannon are being studied this summer to obtain information on their wildlife, local history and geological interest. Some of the 'eskers' in the Midlands are of international importance for geology and wildlife and some of the best examples are found in Offaly.

HABITAT MAPS are being produced for the hills. Habitats are homes for wild plants and animals. The maps will show the location of habitats found on eskers such as wet and dry grasslands, hedgerows and buildings. Rarer habitats, such as old grasslands and patches of woodland or scrub, may also be found.

The study is an objective of the Offaly Heritage Plan and the research has been commissioned by Offaly County Council. The aim of the project is to raise awareness of the value of eskers. Fieldwork is being carried out by Dr Mary Tubridy during 2006. Aerial photos and fieldwork will provide most of the information for the study. If it is necessary to go on to private land permission will always be requested.

If you have information about esker plants or animals or would like to find out more about the project contact Mary Tubridy (087-2506311) or Amanda Pedlow, Heritage Officer, Offaly County Council (057 9346839).

Appendix 7 Checklist of esker plants

Acer pseudoplatanus
Achillea millefolium
Agrostis capillaris
Agrostis stolonifera
Ajuga reptans
Alchemilla filicaulis
Alchemilla xanthochlora
Alisma plantago aquatica
Anacamptis pyramidalis
Anagallis arvensis
Angelica sylvestris
Antennaria dioica
Anthoxanthum odoratum
Anthriscus sylvestris
Apium nodiflorum
Arctium minus
Arrhenatherum elatius
Arum maculatum
Atropa belladonnna
Avena fatua
Bellis perennis
Betula pubescens
Blackstonia perfoliata
Brachypodium sylvaticum
Briza media
Bromopsis erectus
Bromus hordaceus
Buxus sempivirens
Calluna vulgaris
Capsella bursa pastoris
Carex caryophyllea
Carex hirta
Carex spicata
Carex nigra
Carex sylvatica
Carlina vulgaris
Centaurea nigra
Centaurea scabiosa
Centaurium erythraea
Cerastium conglomeratum
Cerastium fontanum
Circea lutetiana
Cirsium arvense
Cirsium vulgare
Conium maculatum

Conopodium majus
Coryllus avellana
Cotoneaster integrifolius
Crataegus monogyna
Cynosusus cristatus
Dactyllorhiza fucshii
Dactyllorhiza maculata ssp ericetorum
Dacyllorhiza maculata
Dacyllis glomerata
Daucus carota
Dryopteria dilitata
Dryopteris felix mas
Elytrigia repens
Equisetum patustre
Euonymous europaeus
Fagus sylvatica
Fallopia japonica
Festuca pratensis
Festuca rubra
Filipendula ulmaria
Fragaria vesca
Fraxinus excelsior
Fumaria officinalis
Equisetum arvense
Galium aparine
Galium odoratum
Galiun verum
Geranium robertianum
Geum urbanum
Glechoma hederecea
Glyceria pedicillatus
Glyceria notata
Gymnadenia conopsea
Hedera helix
Helictotrichon pubescens
Heraclium sphondylium
Hieracium pilosella
Holcus lanatus
Hyacinthoides non scriptus
Hypercium androsaemum
Hypericum perforatum
Hypericum pulchrum
Hypericum tetrapterum
Hypochaeris radicata
Ilex aquilifolium
Iris foetidissima
Juncus effusus
Juniperus communis
Knautia arvensis

Koeleria macrantha
Larix europaeus
Lapsana communis
Lathyrus pratensis
Lemna minor
Leontodon hispidus
Leontodon taraxacoides
Leucanthemum vulgare
Ligustrum ovalifolium
Linum catharticum
Lolium multiflorum
Lolium perene
Lonicera periclymenum
Lotus corniculatus
Luzula campestris
Lysimachia nemorum
Malus sylvestris ssp sylvestris
Melica uniflora
Molinia caerulea
Mycelis muralis
Myosotis ramossima
Nasturtium sp
Odontites vernus
Ophrys apifera
Origanum vulgare
Oxalis acetosella
Papaver rhoes
Phalaris arundinacea
Phleum pratense
Phragmites australis
Phyllitis scolopendrium
Picea sitchensis
Pilosella officinarum
Pimpenella saxifraga
Plantago lanceolata
Plantago major
Poa annua
Poa pratensis
Poa trivialis
Polygala vulgaris
Polygonum aviculare
Polystichum setiferum
Potentilla anserina
Potentilla erecta
Potentilla sterilis
Polypodum sp
Primula veris
Primula vulgaris
Prunella vulgaris

Prunus domestica
Prunus lauracerasus
Prunus spinosa
Pteridium aquilinum
Phyllitis scolopendrium
Quercus robur
Ranunculus bulbosus
Ranunculus acris
Ranunculus ficaria
Ranunculus repens
Rhinanthus minor
Ribus uva crispa
Rosa arvensis
Rosa canina
Rosa uliginosus
Reseda luteola
Rubus fruticosus agg
Rumex acetosa
Rumex acetosella
Rumex crispus
Rumex sanguineus
Sagina procumbens
Salix aurita
Salix cinerea spp oleifolia
Salix fragilis
Sambuccus nigra
Sanguisorba minor
Sanicula europaea
Scrophularia nodosa
Senecio jacobea
Sieglingia decumbens
Silene dioica
Sisymbrium officniale
Solanum dulcamara
Sonchus oleraceus
Sorbus aria
Stachys sylvatica
Stellaria graminea
Stellaria holostea
Stellaria media
Succisa pratensis
Symphoricarpos albus
Taraxacum off
Taxus baccata
Thymus drucei
Tilia sp
Torilis japonica
Trifolium dubium
Trifolium pratense

Trifolium repens
Trisetum flavescens
Triticum aestivum
Tussilago farfara
Ulex europaeus
Ulmus sp
Urtica dioica
Veronica chamaedrys
Veronica serpyllifolia
Viburnum opulus
Vicia cracca
Vicia sepium
Viola rechenbachiana
Viola riviniana