Invertebrates of Exposed Riverine Sediments

Entomological Monitoring Services (EMS)

R&D Technical Report W11

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Statement of Use
This document will assist the Environment Agency, statutory conservation organisations and others connected with river management to further the assessment and conservation of invertebrates associated with habitats provided by exposed riverine sediments (ERS).

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EXECUTIVE SUMMARY

The invertebrates of exposed riverine sediments (ERS) are known to be a potentially important conservation resource but the information concerning the distribution of both ERS and ERS invertebrate species and assemblages was limited and localised. The distribution of ERS was investigated using a questionnaire and by reference to the River Habitat Survey (RHS). Invertebrate data were collated from nature conservation bodies and from individuals with an interest in the field.

ERS are a product of river flow, geology and drift and the distribution and extent depends on topography and the effects of river management and land use. The rougher, coarse sediment ERS are found in the more upland areas with faster flowing rivers whilst silt and other small particle ERS are limited to lowland rivers with slow flow. Channel straightening and bank regrading are likely to reduce the abundance of ERS; other procedures can alter the nature of ERS. Adjacent land use and developments within catchments can also have important effects. The results of river corridor surveys and aerial photographs are of limited use in identifying ERS whilst the RHS data was good at giving an initial idea of ERS in a catchment. However, there were discrepancies between RHS data and known ERS distributions.

Rare and notable invertebrate records were abstracted from the Invertebrate Site Register but this data was not comprehensive. More useful species assemblage data was forthcoming from Wales, Northumbria and the Soar catchment in Leicestershire. Sufficient information was collated to produce two classifications of ERS habitats. A Britain and Ireland ground beetle classification and one using ground and rove beetles from the River Soar generated structures which could be used to investigate environmental change and conservation potential. These classifications gave an insight into the effects of river management procedures on invertebrate assemblages. The effects of bank regrading take about five years to stabilise, into relatively poor habitats, but if the sediment features are not totally removed recovery to a more natural state is possible.

A system based on species rarity proved viable in assessing the conservation value of sediments. Quantifications of rarity enabled sediments to be ranked in the habitat groups of the classifications. Some account of the number of the rarer species was shown to be possible.

It was concluded that ERS are likely to be one of the few relatively natural habitats present in highly managed landscapes. The knowledge of both ERS and invertebrates is not comprehensive but even so it is obvious that they are especially important in invertebrate conservation. It is possible to define conservation quality based on invertebrate recording. It is recommended that a systematic, structured survey throughout England and Wales is required to fully understand the distribution of ERS, of ERS invertebrates, their contribution to conservation and the effects of river management.

KEY WORDS

Exposed Riverine Sediments; Invertebrates; Conservation; River Management

1. INTRODUCTION

Rivers and streams are amongst the most valued elements of our landscape. In many lowland areas they represent an isolated strand of semi-natural habitat in a sea of intensive agriculture and urban development. The wealth of their aquatic life is widely recognised and in recent years there has been a welcome growth in the number of initiatives designed to conserve aquatic plants, invertebrates, fish and their environment.

Rivers also support rich and varied wildlife communities well away from the aquatic environment. Ecologists are increasingly turning their attention to the riparian zone and beyond to the floodplain. Much of the interest has centred on the important role of riparian areas in supplying nutrients and organic matter to the aquatic ecosystem. However, it is now apparent that these areas contain communities of plants, birds and mammals which are important in their own right. The conservation value of the riparian zone has recently been highlighted in studies of two threatened and declining mammal species, the otter and the water vole. Furthermore, it is now known that terrestrial invertebrates are a rich source of riparian biodiversity. There are far more species by rivers and streams than in them. Several hundred species of terrestrial invertebrate specialise in living in semi-aquatic habitats such as river margins and floodplain wetlands.

The wealth of insects and spiders living along riverbanks has long been known to specialist entomologists. This research note makes information on these neglected animals available for use in planning the management of river systems. It deals with one of the most important riverbank features for terrestrial invertebrates, exposed riverine sediments (ERS). ERS are shoals of sediment deposited by rivers and streams in times of spate and flood and become exposed during lower, more normal flow. ERS do not only occur by fast-flowing rivers draining hilly areas, where they are readily seen, but also occur by slow-flowing, lowland rivers where they are not so obvious and of a different composition.

This note examines the types of sediment found by British and Irish rivers and the factors affecting sediment composition. Invertebrate habitat requirements are explained and the use of various conservation evaluation criteria discussed. Advice on survey techniques is included. The natural and human influences on sediment and invertebrate distributions are considered and a number of positive approaches to management are suggested.

Current knowledge of ERS invertebrates is based on only a few studies in localised areas, sometimes in climates somewhat different from Britain such as central and northern Norway. Further research is urgently required, especially on the effects of different river management practices. However, the information contained in this note is based on our present knowledge and is a good basis for taking much-needed action to preserve an important but neglected element of our native wildlife.

2. EXPOSED RIVERINE SEDIMENTS

2.1 Definition

In this report, Exposed Riverine Sediments (ERS) are taken to be mounds of sediment which have recently been deposited in any channel of flowing water and then subsequently exposed by reduced water levels. A variety of terms are used for them including shoals, bars, berms, spits, sandbanks and shingle-banks. ERS are found under the main riverbank although large ERS may grade into the adjacent floodplain. There is often an easily observable boundary between an ERS and the adjacent floodplain. Normally the adjacent land use does not extend onto the ERS, although grazing stock may move onto ERS from surrounding pasture, either for feeding or access to water.

ERS are subject to repeated scourings by floods followed by fresh sedimentary deposition. Consequently, ERS vegetation undergoes a cycle regulated by frequency of flooding. During floods, plant material above ground is either removed or covered with fresh deposits to leave areas of bare ground. The vegetation then grows up again until it is removed by the next flood. At the top of large ERS flooding may be relatively infrequent and here vegetational succession may become quite advanced, leading to the presence of trees such as sallows and willow.

ERS also occur along secondary channels. These channels may only become filled during high floods and then ERS become difficult to distinguish from floodplain habitats. Vegetational succession may be advanced on ERS in secondary channels and in headwaters which suffer from relatively infrequent and mild flooding.

Limestone and chalk streams, winterbournes and headwaters, may dry up on the surface in the summer. Technically, the entire riverbed then becomes ERS.

2.2 ERS formation

The faster the flow of a river, the more sediment it carries. Sediment is deposited when the flow slows down. ERS are therefore found in those parts of the stream where water is relatively slow flowing. A typical place for an ERS is just downstream of a bend. On the outside of a bend the water flows relatively quickly and the bank is usually steep-sided and actively eroding. On the inside of the bend the water flows more slowly, allowing deposition of a point-bar. Changes in gradient also lead to ERS formation. As the gradient flattens, the flow rate is reduced leading to sedimentary deposition which can result in the formation of a fan. In the resulting braided stream, ERS can form as mid-channel bars.

Braided streams and meanders which contain ERS are associated with flatter gradients and slower flows. There is less ERS in ravines and on steep inclines and where it does occur, it tends to be comprised of large particles such as boulders. ERS can also be found at river confluences where sediment is deposited as water from a tributary enters a slower main channel. Point bars on meander systems tend to be more stable with regard to position than mid-channel bars which can migrate down the river channel and become attached to the riverbank as lateral bars.

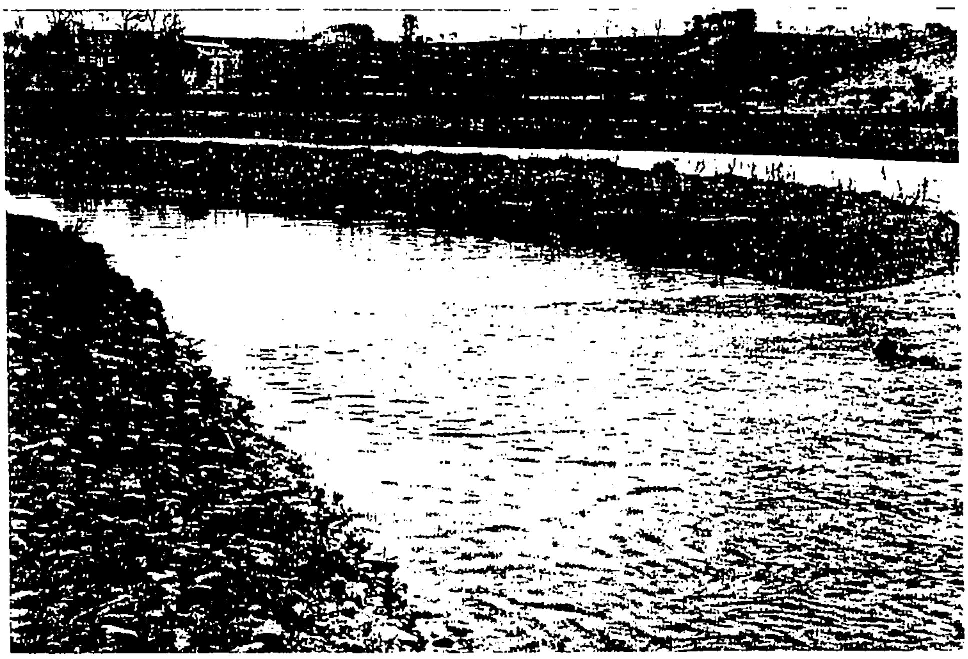

Figure 2.1 Photographs of a typical river flowing off hills (top, River Coquet) giving rise to large sediment ERS and bars on bends (bottom)

Large amounts of sediment are carried by rivers during floods. Fresh deposits are laid down on ERS during the period when the flood is subsiding. The particle size of the material deposited is related to the rate of flow of the water at the time of deposition. Cobbles and boulders are removed and laid down only by fast-flowing water, whereas silt is deposited by slow-flowing water.

Where water flows faster, usually in the upstream section of a river, the typical ERS is of coarse material which grades into finer material downstream as the flow rate becomes slower. However, reworking of ERS material leads to local discontinuities in substrate type, with areas of fine sediment interspersed with coarser sediment. Changes in flow pattern can lead to a net local erosion on part of an ERS. Large ERS can contain several secondary channels or chutes, leading to topographic complexity. Large continental rivers such as the Loire in France are bordered by ERS which can be several hundred metres wide and contain a bewildering array of sandhills, old channels and remnant pools.

Successive floods tend to be of unequal intensity and this may lead to silt, a finer sediment, being deposited over the top of sand, a coarser sediment. Conversely, pebbles are often found overlying a finer sediment such as sand. In secondary channels and oxbow lakes, where water stands in remnant pools during the summer, layers of undecayed organic litter deposited in stagnant water can be found interspersed with layers of silt brought in by winter floods.

The material laid down on ERS can originate from anywhere in the catchment upstream of the ERS. The composition of the ERS is therefore related to solid and drift geology over a wide area of the catchment. .Some features which look like ERS have a different origin. Steep eroding banks may slump into the channel either because they contain a spring or because they are poached by cattle. Even several years after cattle have been removed from a riverbank the results of their presence can still be evident in collapsed banks.

Abandoned channels, such as oxbows, can retain stagnant water for most of the year. These are subject to a vegetational succession proceeding through the build up of peat to fen and carr, or to bog in parts of western Britain. Flooding is important in retarding this succession. Scouring removes organic matter and deposition of sediment leads to the maintenance of marsh on mineral substrates.

2.3 ERS and River Hydrology

Due to seasonal changes in rainfall, most rivers in Britain tend to have higher flows in the winter than in the summer. The actual months of highest and lowest average discharge vary geographically, being slightly earlier in the west than in the east. The main exceptions to this pattern are found in some Scottish rivers which have a secondary peak in the spring due to snow-melt. Consequently, in most British rivers ERS becomes available for exploitation by terrestrial invertebrates in spring and is at its maximum extent in late summer or early autumn.

Superimposed on this seasonal variation in water levels are small-period fluctuations caused by individual cyclonic weather systems. It is these small-period fluctuations which give rise to the 'spatiness' of a river and create a natural disturbance factor to which ERS invertebrate communities are adapted. Spatiness varies from catchment to catchment and is related to rainfall, geology and land use and cover. Hard rock catchments with limited tree cover in the west of Britain tend to have a higher level of spatiness, as do urbanised catchments. Well-wooded chalk catchments, if they still existed, would regulate run-off to give a much lower level of spatiness.

Abandoned channels are usually subjected to much lower levels of spatiness. Their invertebrate communities tend to be less tolerant of disturbance than those by the main channel. Spatiness of rivers is markedly affected by regulation. It is reduced in rivers regulated by impoundment and increased in the main channel of regraded and engineered rivers but decreased in the secondary channels outside embankments. Different ERS types have different responses to spatiness. It is generally considered that the high flow events which have the greatest effect on channel morphology occur on average once every two or three years. However, ERS composed of sandy material are particularly vulnerable to scouring and their morphology will change on a more frequent basis. Conversely, ERS composed of boulders are more resistant to scouring and will be much more stable.

2.4 Impacts of River Management on ERS

River management practices affecting the number, size and composition of ERS are summarised below in Table 2.1.

Table 2.1. Impacts of River Management Practices on ERS

Management practice	*Effect*
Sediment removal	Loss of ERS
Bank resectioning	Loss of ERS
Channel straightening	Loss of ERS; coarser sediment due to faster flow
Impoundment (weirs, mills, fishing, navigation)	Finer sediment deposition due to slower flow, more permanent vegetation
Reservoir construction	Change of sediment type and extent of ERS downstream due to more regular flow
Navigation	Erosion of ERS and vegetation by wave action
Water abstraction	Increase in ERS area and transition to terrestrial habitat because of controlled flow
Sewage discharge	Organic deposition, change in type of vegetation and increase in cover
Flood alleviation	Transition of secondary channel ERS to terrestrial habitat

2.5 Impacts of Catchment-wide Processes

Events occurring in the catchment away from river channels undoubtedly have had considerable effects on rivers and their ERS. In the English midland rivers during the late bronze age, gravel depositions became superseded by depositions of red clay derived from Keuper Marl. This is believed to be due to deforestation followed by ploughing which released large amounts of fine sediments into the river systems. The introduction of silt and clay into lowland rivers continues to this day as a result of agriculture, mineral extraction and other developments such as road building which disturb large volumes of soil.

The present day domination of many lowland ERS by soft sediments may be a product of disturbance stretching back to prehistory. In their natural state, lowland ERS would probably contain coarser sediments. Afforestation of upland areas is also increasing sediment load of rivers but the long term effects are not known. The impacts of increased sediment load and the other results of catchment-wide land use operations are summarised below in Table 2.2.

Table 2.2. Impacts of Catchment-wide Processes on ERS

Impact	*Cause*	*Effect*
Siltation (increase in sediment load)	Deforestation, agriculture, mineral extraction, large engineering projects	Replacement of coarse sediments by fine sediments, larger area of ERS
Eutrophication	Fertiliser run-off from agricultural land and STW discharges.	Change in vegetation type and increase in cover
Increased run-off	Urbanisation, land drainage	Increased flooding leading to greater scouring of ERS
Loss of floodplain wetland to agriculture	Drainage, infilling and tipping	Loss of ERS in secondary channels and oxbow lakes
Pond creation	Conversion of floodplain wetland to amenity ponds	Loss of ERS in secondary channels and oxbow lakes
Access by grazing stock	Adjacent unfenced pasture poaching	Removal of vegetation,

2.6 ERS Distribution in England and Wales

2.6.1 ERS identification

Information on the types and distribution of exposed riverine sediments (ERS) in England and Wales was generated using a number of methods.

a) Questionnaire

A questionnaire was sent to National Rivers Authority (now the Environment Agency) biologists and others requesting information on the type and extent of ERS in their Region. There were four frequency categories (1=absent/rare; 2=occasional; 3=frequent; 4=common/widespread) of four types of ERS (silt=<0..2mm; sand=0.2-2mm; shingle/gravel/pebbles=2mm-5cm; cobbles/boulders=>5cm) to be estimated in the hydrometric areas in their Region. Other information requested on the questionnaire were data relating to the type and amount of river and water management practices, the major land uses in the Region and the extent of coverage of rivers by river corridor surveys and aerial photographs.

Maps showing the distribution of cobble/boulder and shingle/gravel/pebble ERS types in England and Wales, based on the questionnaire, are shown in Figure 2.2 whilst the distribution of sand and silt ERS are shown in Figure 2.3.

The cobble/boulder ERS were most abundant in the Yorkshire, North West and Welsh Regions and were also frequent in Northumbria, and the South West. There were some in Severn-Trent but few in the other central and Southern Regions. The distribution and abundance of shingle/gravel/pebble ERS was similar to the cobble/boulder ERS but there was more of this type of ERS in the Severn-Trent, Anglian, Thames and Southern Regions. Sand ERS were most frequent in parts of South West Region and were occasionally recorded from the other regions. Silt ERS were most abundant in Anglian Region and were frequently recorded from parts of Severn-Trent, Thames and South West Regions.

b) River habitat survey

Data from the River Habitat Survey (RHS), co-ordinated by Peter Fox in the National Rivers Authority (NRA) North West Region, was received. The RHS provided an estimate of the frequency of ERS by recording point bars, side bar and mid-channel bar totals for each site sampled in similar categories to those in the questionnaire (boulders; cobbles; gravel/pebbles; sand; silt; clay). The relative amounts of ERS in four categories (boulders/cobbles; pebbles/gravel; sand; silt/clay) were calculated as percentages of the total number of bars recorded. The sites were chosen as the nearest river to the centre of 10km national grid squares and were a sample of sites and not a comprehensive survey.

RHS data relates to a 500m section of river surveyed during May or June when river flows are at their lowest. It provides a random, unbiased estimate of the distribution of ERS features rather than a comprehensive picture. This survey represents the first set of absolute records, subject to quality assurance, that has been collected on such a large scale (over 5,000 sites by the end of 1996). In contrast the data collected by Entomologists or from comprehensive surveys of individual catchments tends to be skewed towards the best locations.

A new suite of data will be available for 1995 and 1996 including coverage in Scotland and Ireland.

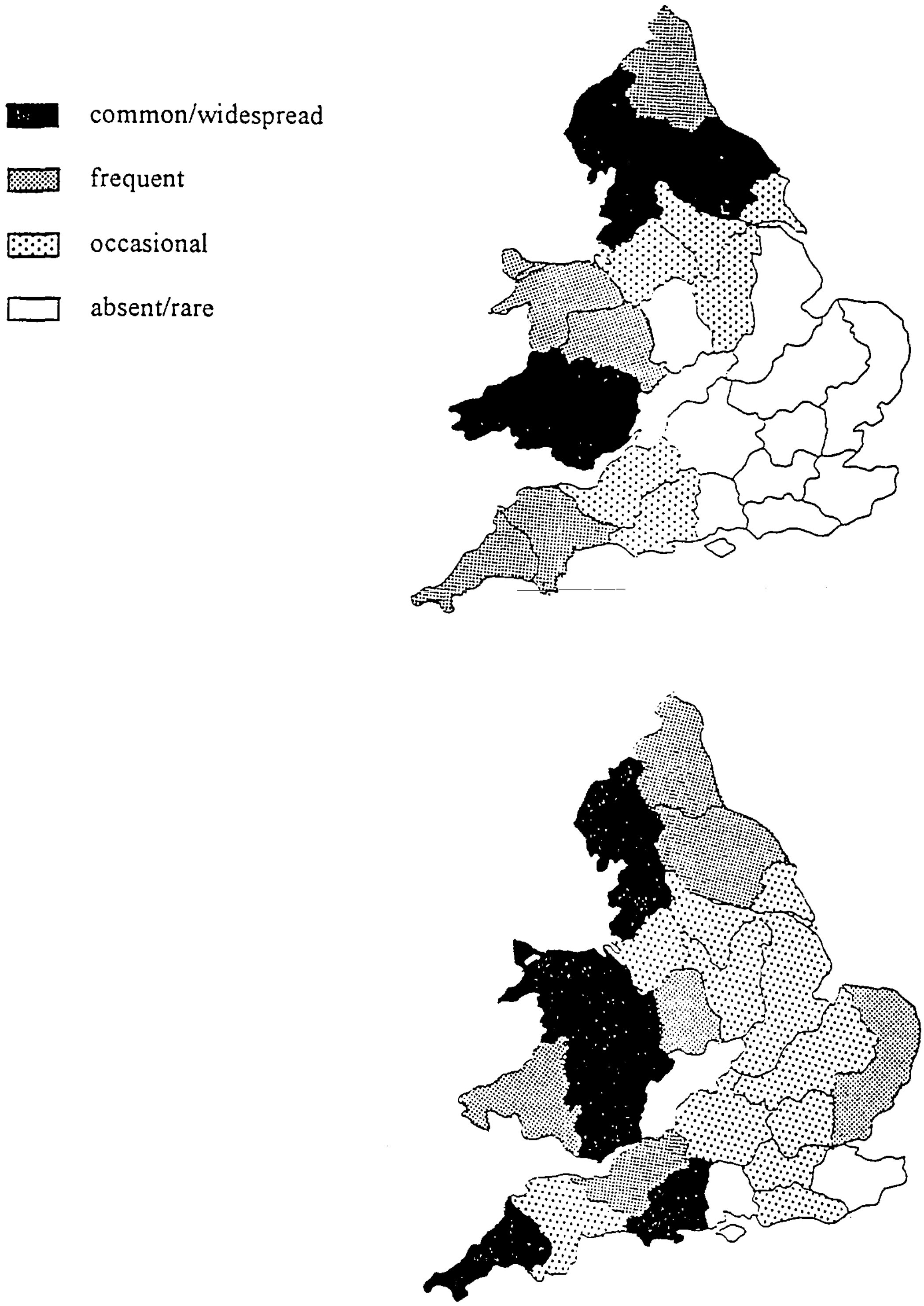

Figure 2.2 The distribution of cobble/boulder (top) and shingle/gravel/pebble (bottom) ERS in England and Wales based on the questionnaire

Figure 2.3 The distribution of sand (top) and silt (bottom) ERS in England and Wales based on the questionnaire

Maps showing the distribution of cobble/boulder and gravel/pebble ERS types in England and Wales, in percentage bands, are shown in Figure 3.3 whilst the distribution of sand and silt/clay ERS are shown in Figure 3.4.

The cobble/boulder ERS made up most of the ERS recorded by the RHS in North West and Northumbria Regions and in parts of Yorkshire and Welsh Regions. Gravel/pebble ERS were also abundant in Northumbria and made up most of the ERS in South West Region. They were also the most abundant ERS in parts of Severn-Trent, Anglian and Southern Regions and were found in the Thames Region. In no Region did sand ERS make up more than 25% of the ERS recorded and there are few catchments in England and Wales where sand ERS are abundant. Silt/clay ERS were recorded mainly in Severn-Trent, Anglian South West and Southern Regions but not as a high proportion of the total ERS recorded in the RHS.

c) River corridor surveys

River corridor surveys have been carried out to various degrees in the different NRA Regions. Coverage is best in Northumbria and Anglian and more than half of the rivers have been surveyed in Thames, Severn-Trent and Welsh Regions. Few river corridors have been surveyed in Yorkshire, Wessex and South West whilst the coverage is not accurately known for North West and Southern.

Vegetation types appear to be very important in recording features of river corridors in these surveys, although large areas of sediment and bare ground also tend to be recorded. However, in surveys of the River Soar (Lott 1992) some sediments present in the system were not recorded on survey maps. There were also areas of obvious vegetation types, e.g. *Phragmites* beds, not recorded. There is obviously a problem that this kind of survey only takes one visit and that since water levels fluctuate apparently obvious features may not be apparent on the survey day. There may be also a problem if the surveyor is on the opposite bank of the river, which may restrict observation. There is some evidence that different surveyors record river corridor features in different ways to different levels of accuracy.

One obvious flaw in the recording of most river corridors that may affect the distribution and quality of ERS is the lack of information on the land use next to the river. This is particularly important on lowland systems where stock, especially cattle, can have access to the river and to sediments. Cattle poaching can have a profound effect on ERS structure and quality (Lott 1992) and not only is it necessary to know the land use but also if stock are fenced off from the river. This sort of information tends to be absent from surveys.

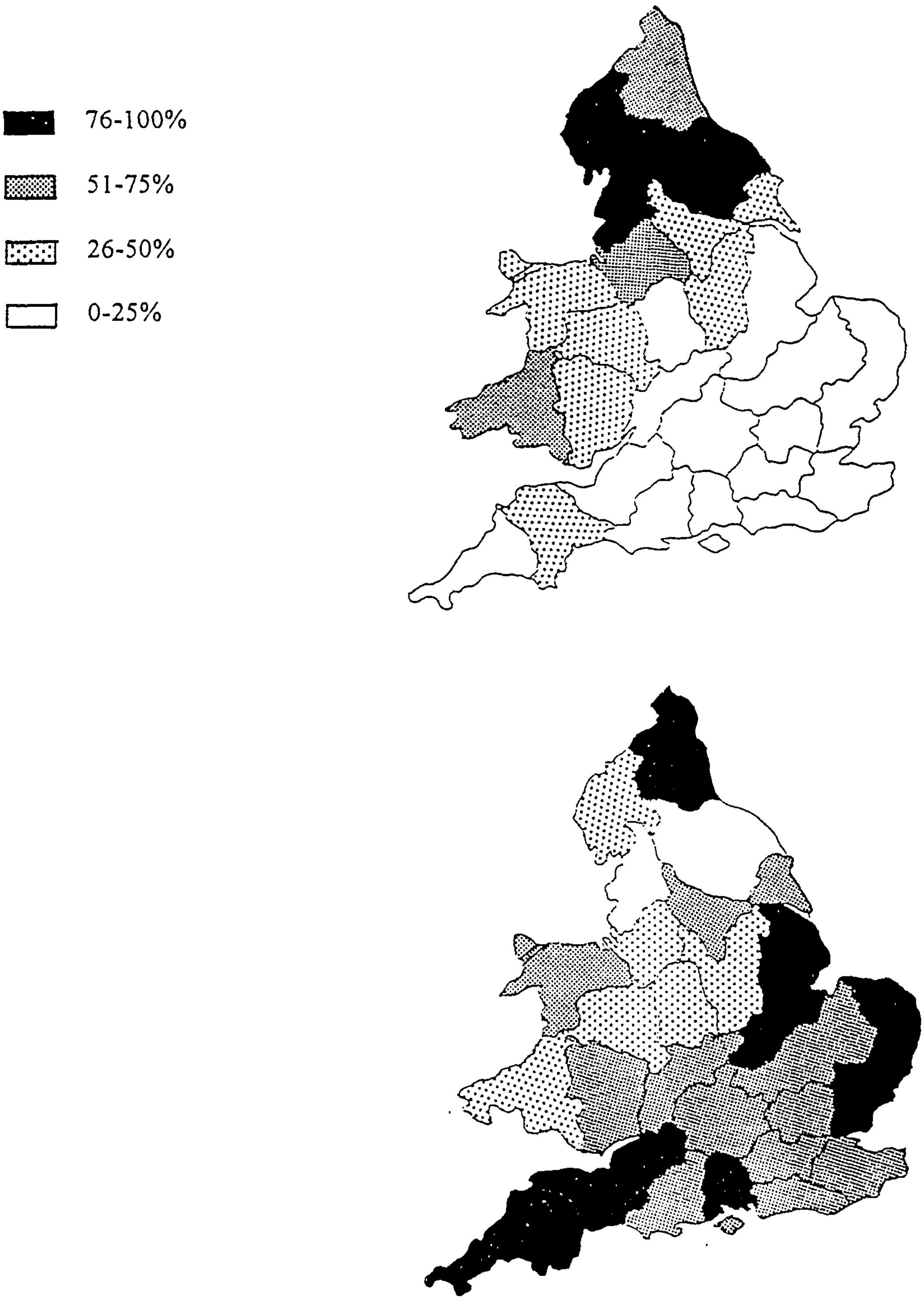

Figure 2.4 The proportion of cobble/boulder (top) and gravel/pebble (bottom) ERS in the totals recorded in the River Habitat Survey of England and Wales

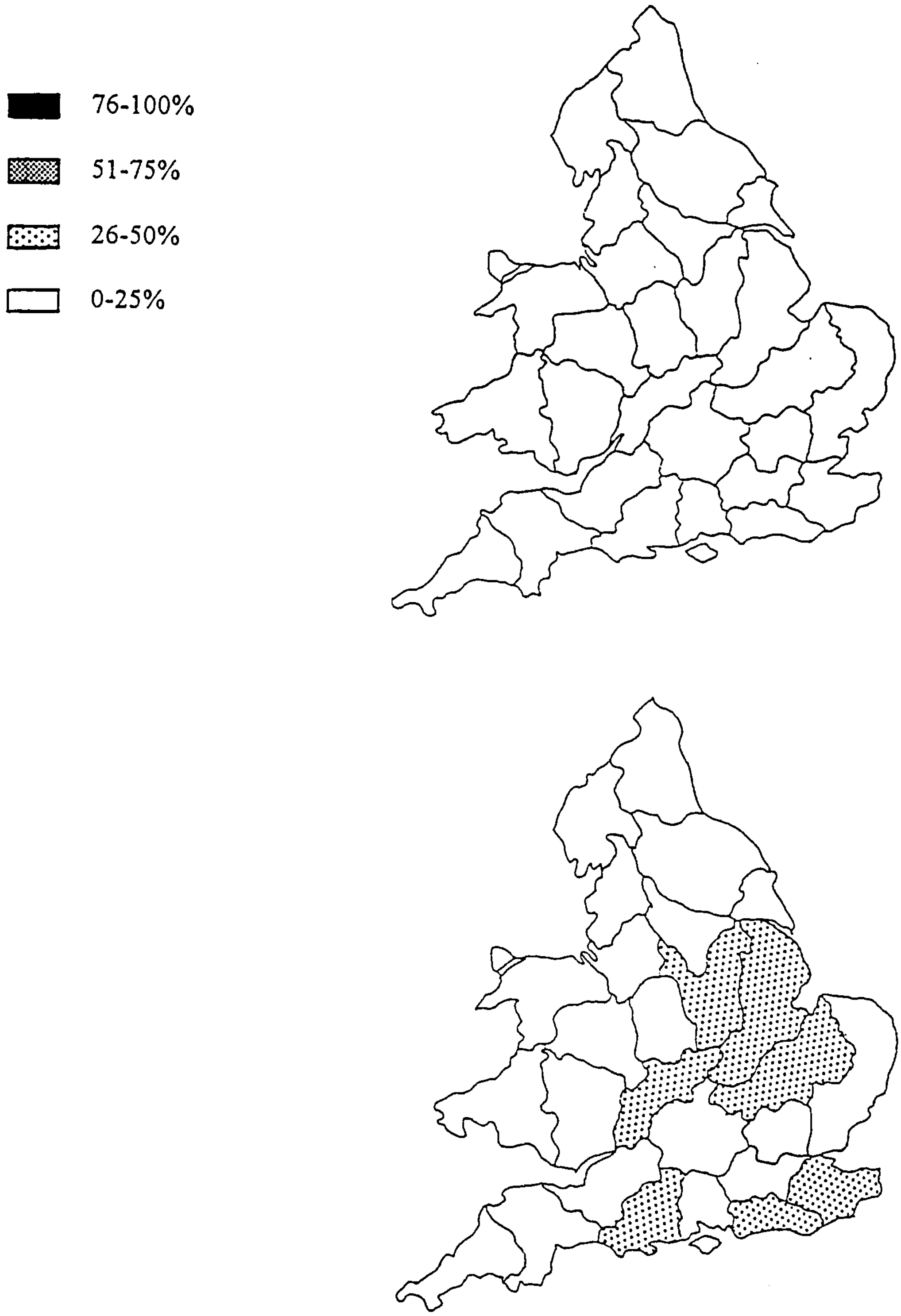

Figure 2.5 The proportion of sand (top) and silt/clay (bottom) ERS in the totals recorded in the River Habitat Survey of England and Wales

d) Aerial photographs

As with river corridor surveys, the coverage of rivers by aerial photographs held by the NRA varies between NRA Regions. Rivers in Wessex and South West has been totally covered and more than half have been photographed in Severn-Trent and Thames. There are only very limited photographs for rivers in Yorkshire, Anglian, Welsh and Southern Regions and none in Northumbria. There are other sources of aerial photographs, such as CCW in Wales and the Ordnance Survey, so there is scope for finding appropriate coverage if required.

Monochrome photographs of some river systems may show sediments, if they are large enough in the more upland regions but there are problems with lowland, slow-flowing systems. It is difficult to differentiate between vegetation under water and that on land and between vegetated and open areas, especially in canalized or impounded systems. Good colour photographs are better and are particularly good in the more upland systems where, for instance, sediments show up as white patches by the channel in the catchments of the Mawddach and Wnion in Wales. However, other features such as embankments and tracks also show up white and care is needed. One other feature that shows up the same colour as sediments is bedrock. These outcrops tend to be in straighter stretches of the river and should be identified by using maps in conjunction with the photographs. The other problem is that shading by trees can limit the identification of sediments, especially the smaller sites in the more upland areas.

The use of good colour photographs of a catchment should enable the identification of the general distribution of sediments. However, not all sediments will be able to be identified and photographs do not give any information about sediment structure. One major problem is that aerial photographs are a point sample in time. If, for instance, the photographs are taken after rainfall, sediments could be under water. This sort of limitation will also be a problem with satellite-derived remotely sensed imagery. Whilst the pixel signature of sediments is distinct from other land covers, it will not differentiate between sediments and bedrock and if wet will give a similar image to such features as wet roads and tracks. However, both aerial photographs and remotely-sensed imagery could be of considerable use in identifying the distribution of ERS.

e) Maps and walking

Recent ERS mapping work in the Mawddach, Gain and Wnion catchments in west Wales in September 1994 has indicated that the use of large scale maps and walking by the river are as good a method as any of identifying the distribution of sediments and their structure. Surveys of this sort should be restricted to times when the water levels are as low as possible. Obviously this takes more time than the study of river corridor maps or photographs but the increased knowledge and the limitation of mistakes are considerable positive attributes.

Large scale maps are the basis of a methodology for auditing the sediments in river channels by Sear and Newson (1994). This is an approach could be especially valuable because it not only takes into account the contemporary position but also the long term view of river morphology and may be used for quantifying changes in sediment distribution and sensitivity of ERS to environmental change.

3. INVERTEBRATES OF ERS

3.1 Invertebrate Groups on ERS

At present 441 species of beetle, 7 bug species, 43 fly species and 57 spider species have been identified as being inhabitants of ERS, showing that a diverse invertebrate fauna occurs on these sediments. Appendix A list the species found on ERS with their conservation status, fidelity to ERS, sediment preferences and life stage on ERS. Just under a half of these species (48%) are only found on ERS or similar habitats. The conservation of these habitats should be a component of any national strategy to preserve biodiversity in the UK (Department of Environment 1995). Details of the different types of invertebrates on ERS are given below.

3.1.1. Beetles (Coleoptera)

Species in two families of beetle, ground and rove beetles (Carabidae and Staphylinidae) dominate the invertebrate assemblages on ERS. Two strategies are used by these beetles on ERS. Most are surface-active animals (epigeic) but some burrow into the sediment and live below the surface (fossorial). The major difference in activity in these two types of strategy is that the surface-active beetles leave the sediments in times of flood whilst the burrowers stay in the sediment and can withstand flooding episodes.

Few ground beetle species are burrowers and are mainly highly active animals with a considerable number in the genus *Bembidion*. Examples of species in the ground beetles genera *Elaphrus* and *Bembidion* are often very conspicuous, running around bare sediment in sunshine. Figure 3.1 shows *Bembidion bruxellense*, a ground beetle found on ERS and on other disturbed substrates.

Rove beetles (Staphylinidae) contain the largest number of species associated with ERS of any group. They can easily be recognised by their short wing cases, which leave most of the abdomen exposed. This body form is highly suited to a way of life spent predominantly on or under the ground, either under stones, in soil or in tangled vegetation. Many rove beetles on sediments live in the interstices between the particles, e.g. *Thinobius newberyi* (Figure 3.2) and others in this genus. The genus *Bledius* contains several species with powerful front legs for burrowing into softer sediments such as sand and clay. Species in the genus *Carpelimus* and in the subgenus *Philhygra* contain many small species which live in cracks in sediment. On the other hand, the genera *Stenus* and *Paederidius* contain large-eyed, long-legged, species which hunt by day over bare substrates in the manner of species in the ground beetle genera *Bembidion* and *Elaphrus*.

Water beetle species generally use ERS in a different manner to ground and rove beetles. A number will inhabit pools on large, complex sediments as adults (e.g. *Bidessus minutissimus*), and different species prefer open and vegetated sediments, but species in the families Haliplidae and Dytiscidae mainly use the sediments as pupation sites. The larvae of many Helophoridae and Hydrophilidae tend to be terrestrial, in damp sites, and utilise ERS. Elmid species (riffle beetles) tend to be found on wetter ERS, usually under the larger sediment particles whilst the adults of Hydraenidae are mainly found at the junction of the sediment and the water and a number are particularly fond of small, fine particles.

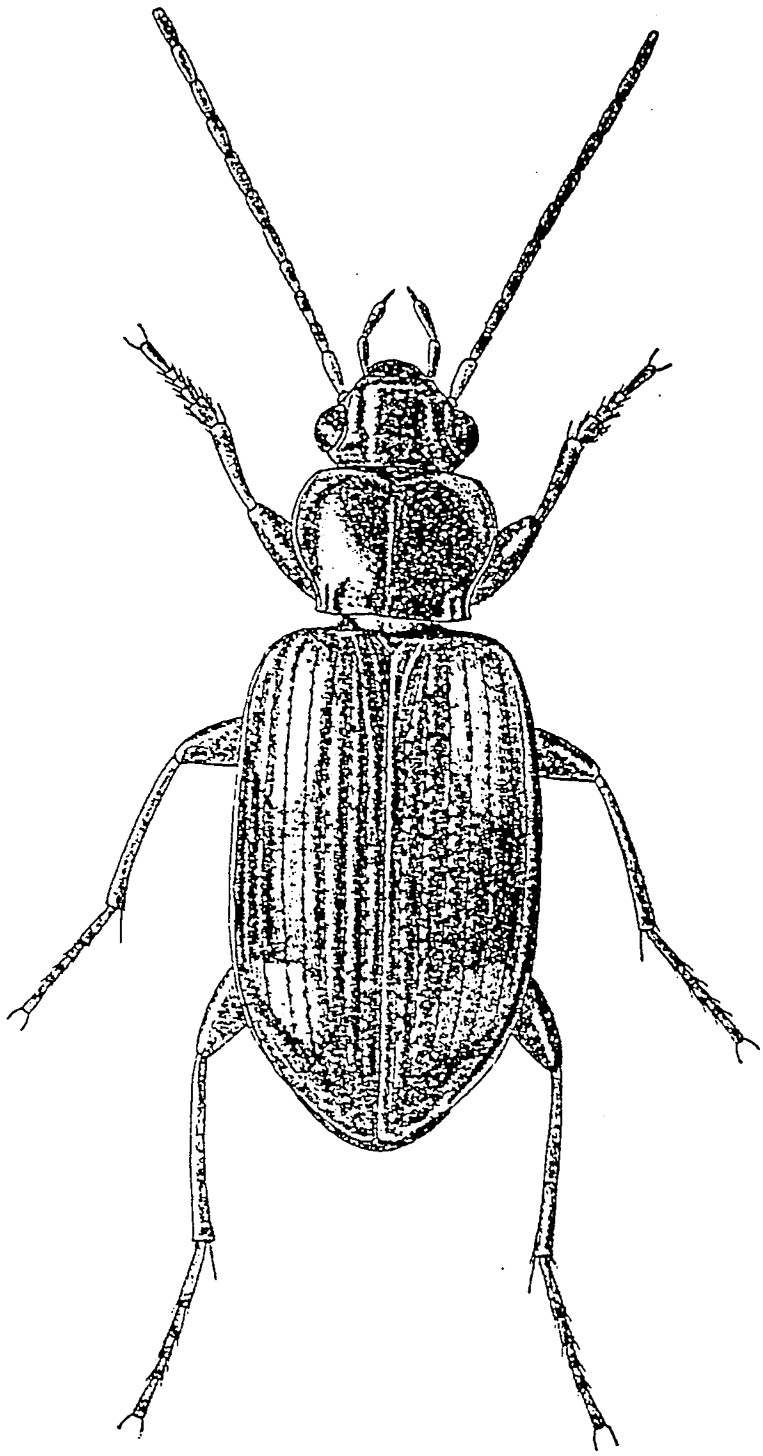

Figure 3.1 *Bembidion bruxellense*, a ground beetle species in a genus with many species occurring on ERS of all types

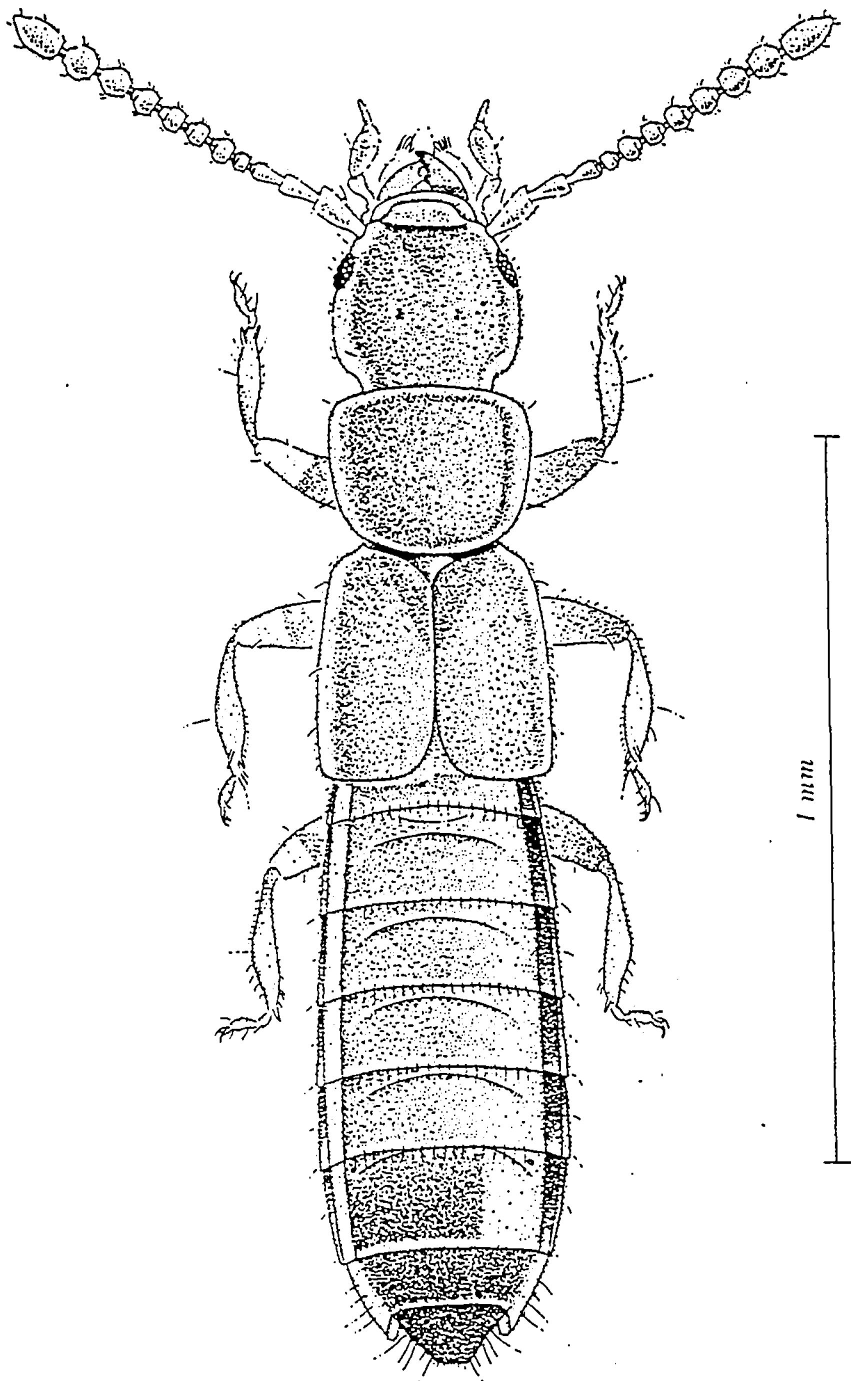

Figure 3.2 *Thinobius newberyi*, a rove beetle found in shingle ERS. This species has not been found outside the British Isles

Beetle species in several other families are associated with ERS. The Heteroceridae species burrow into soft sediments and are often found in association with rove beetle species of the genus *Carpelimus*. A number of click beetle (Elateridae) species are confined to ERS preferring the drier areas. Only one ladybird species, *Coccinella quinquepunctata*, is a specific ERS species. Plant feeding beetle species on ERS include species of leaf beetle (Chrysomelidae) and species of weevil (Apionidae and Curculionidae) but only a few species have a high fidelity for ERS.

3.1.2 Bugs (Hemiptera)

The main family of bugs associated with ERS is the Saldidae or shore-bugs. Several species in the genera *Salda* and *Saldula* occur on a number of sediment types and are especially active in sunshine. A dipsocorid bug, *Cryptostemma alienum*, is a shingle specialist living in the interstices between stones. Several species normally considered to be water bugs such as the water-measurer, *Hydrometra stagnorum*, and the water-scorpion, *Nepa cinerea*, are regularly caught in pitfall traps and probably use ERS at night.

3.1.3 Flies (Diptera)

The Tipulidae, or crane-flies, is a large family whose larvae can be found in a variety of soils ranging from damp grassland to aquatic substrates. Species with aquatic larvae which live in streams include *Dolichopeza albipes*, *Tipula coeruleiventris* and *Dicranota* species. Many genera contain species with larva that develop in ERS, as do two species in the closely related family Ptychopteridae.

The larva habits of the owl midges (Psychodidae) are largely unknown but several species of the genus *Pericoma* live in streamside moss, whilst *Sycorax silacea* lives in moss on boulders by fast-flowing streams. The larvae of blackflies (Simuliidae) develop in flowing water. *Metacnephia amphora* is a species which specialises in chalk winterbournes which dry up in the summer. Species of the genus *Atherix* (Athericidae) have aquatic larvae which pupate under moss on ERS. Horsefly larvae of the genus *Chrysops* (Tabanidae) develop in wet silt or sand by rivers and streams. Adults and larvae of the soldier fly *Rhadiurgus variabilis* are associated with sand and shingle on ERS.

Species in the family Therevidae lay their eggs in soil where the larva develop as predators on beetle larvae, especially of click beetles. *Thereva lunulata*, and probably other riverside *Thereva* species, lay their eggs in dry sand high up on ERS, an area favoured by the click beetle species *Zorochros minimus* and its relatives. The Empididae includes several species of the genera *Chersodroma* and *Tachydromia* whose larvae develop in sandy ERS. Larvae of species in the subfamilies Hemerodromiinae and Clinocerinae are aquatic and live in streams and rivers. Some species live in wet moss growing on boulders in fast-flowing streams and by waterfalls. Adults of the related family Dolichopodidae are often conspicuous on the surface of wet mud by rivers and ponds.

A number of other poorly studied families contain species which live in wet mud by rivers and streams, especially when the sediments are organically enriched. These include species in the families Ceratopogonidae, Ephydridae, Muscidae, Sepsidae and Sphaeroceridae.

3.1.4 Spiders (Araneae)

There are only a few species of spiders which are limited to ERS. The normal method of spider dispersion, ballooning, means that most species have a limited ability to determine where they go to. One species of large wolf-spider, *Arctosa cinerea*, is found on large-particle ERS and is found on the more bouldery ERS in Wales, northern England and Scotland. *Caviphantes saxetorum* is a money-spider (Linyphiidae) is small and found under large, embedded boulders on exposed, rough ERS. The other spider species of ERS are those usually found on either open grassland in the case of bare sediments or those preferring damp, marshy sites on silty sediments.

3.1.5 Other invertebrates

Springtails (Collembola) are often conspicuous on ERS because of their relative abundance. Very little is known about the species which inhabit ERS but they almost certainly play an important role in the food chain. Some species of soil-nesting aculeate bees and wasps (Hymenoptera) are associated with riverbanks but they tend to nest in steep banks rather than on ERS proper.

3.2 ERS Invertebrate Life Histories

The seasonality of the life history of an insect species is often fairly plastic and can vary in different parts of its range. However, some generalisations about ERS species in Britain can be made.

Most ERS ground beetles (Carabidae) breed in the spring, which means that they overwinter as adults either on the highest parts of large ERS or on the riverbank above ERS. Some species fly a considerable distance to hibernation sites in woods and hedgerows. In spring, late April and May, they come down to the ERS to breed. By early July a large proportion of the adults have died off. The larvae develop and pupate on and in the ERS during the summer. On the emergence, the adults leave their pupation sites and seek hibernation sites. This means that peak ground beetle numbers appear in ERS samples between April and June in most years. Many of the species in the genera *Bembidion* and *Agonum*, which are diagnostic ERS species, can be difficult to find after June. Few ground beetle species can be found on ERS in the autumn and winter as larvae. Species in phytophagous families such as the leaf beetles (Chrysomelidae) tend to follow a similar pattern to ground beetles.

Some ground beetle species, notably *Trechus discus* and *Bembidion lunatum*, are summer breeders which overwinter as larvae. The adults usually only emerge in late June or July, after the main peak of spring breeding adults has passed. In Norway the larvae overwinter on the riverbank. The click beetles (Elateridae) also overwinter as larvae, although in several species the adults emerge in the spring. Many flies (Diptera) overwinter in their immature stages although adult emergence times can vary widely between species.

Little is known about the seasonality of the life histories of rove beetles (Staphylinidae). Unlike most ground beetles, many species continue to be represented as adults in samples taken throughout the summer and into the autumn. In Europe several ERS species appear to be spring breeders, although in Britain species in the genus Lesteva, which is active in spring, breeds in the autumn and overwinters as larvae. Some rove beetle species overwinter in tussocks and rotten wood on the bank above the ERS like spring breeding ground beetles.

Most of the above groups use ERS for breeding. However, water beetles belonging to the families Haliplidae, Dytiscidae, Gyrinidae, Helophoridae, Hydrophilidae, Hydraenidae and Elmidae normally use ERS for pupation. Their larval and adult stages are generally spent in the water. Consequently, they only use ERS for a relatively short time in the summer, although this period is a crucial stage in their development. Exceptions to this are species such as *Bidessus minutissimus, Hydroglyphus geminus* and some Hydrophilidae which breed in remnant pools on shingle sediments. Other species of Helophoridae and Hydrophilidae, especially in the genera *Helophorus* and *Cercyo*n, live right at the edge of the water. Larvae of the Dryopidae are aquatic but the adult habitats vary from species to species. *Helichus substriatus* is mainly aquatic whilst *Dryops ernesti* can be found in large numbers on alluvial meadows far from the water edge. The hairy whirligig, *Orectochilus villosus*, is nocturnal and often spends the day under particles on ERS.

3.3 Conservation Value of ERS Invertebrates

The number of rare and notable species in each of the relevant families are shown in Table 3.1. The conservation status is as given by the various publications of the Joint Nature Conservation Committee. Red Data Book 1 (RDB1) species are rated as Endangered. They are those species thought to be in danger of extinction with only one population known, live in especially vulnerable habitats or in rapid decline in five or less 10km squares. Red Data Book 2 (RDB2) species are rated as Vulnerable. These include species which may are likely to move into the Endangered category in the near future, species which are declining throughout their range and species in vulnerable habitats. Red Data Book 3 (RDB3) species are Rare. These are species with small populations at risk of getting rarer, are restricted to limited geographical areas or habitats or are estimated to occur in less than 15 post-1970 10km squares. In addition, there are Red Data Book Indeterminate (RDBI) species which are considered to be Endangered, Vulnerable or Rare but there is not enough information to say which RDB1 to RDB3 category is applicable. Red Data Book K is a category for species which cannot be categorised because of lack of information. These can be species belonging to groups that are poorly recorded, which in the case of ERS means beetle families such as Ptiliidae and some Staphylinidae, or species in infrequently sampled habitats.

Most rare and notable species in the total of 225 are ground and rove beetles (34 and 84 species respectively). Water beetle species in the families Dytiscidae, Hydrophilidae and Hydraenidae have several of these species but crane flies (Tipulidae) have the most other species in a family.

Table 3.1 The number of ERS invertebrate species, by family, in the various national conservation categories (RDB1, 2, 3, I , K; Notable A (Na), Notable B (Nb), Notable).

Order and Family	Number of Species							
	RDB1	RDB2	RDB3	RDBI	RDBK	Na	Nb	Notable
Coleoptera (beetles)								
Carabidae (ground beetles)	1	1	3	-	-	8	21	-
Haliplidae (water beetles)	-	-	-	-	-	-	1	-
Dytiscidae (water beetles)	-	1	1	-	-	-	10	-
Gyrinidae (water beetles)	-	-	-	-	-	-	2	-
Georissidae (water beetles)	-	-	-	-	-	1	-	-
Hydrochidae (water beetles)	-	-	1	-	-	-	-	-
Helophoridae (water beetles)	-	-	-	-	-	-	3	-
Hydrophilidae (water beetles)	-	-	-	-	1	1	6	-
Hydraenidae (water beetles)	-	-	2	-	-	-	8	-
Ptiliidae	-	-	-	-	1	-	-	1
Staphylinidae (rove beetles)	1	-	2	6	21	4	10	40
Pselaphidae	-	-	-	-	2	-	-	-
Scarabaeidae	-	-	-	-	-	-	1	-
Scirtidae	-	-	-	-	-	-	1	-
Limnichidae	-	-	-	-	-	1	-	-
Dryopidae	-	-	1	-	-	-	-	-
Elmidae (Riffle beetles)	-	2	-	-	-	2	3	-
Elateridae (Click beetles)	-	2	-	-	-	1	-	-
Rhizophagidae	-	-	-	-	-	2	-	-
Coccinellidae (ladybirds)	-	-	1	-	-	-	-	-
Curculionidae (weevils)	-	-	-	-	-	1	2	-
Total Beetles	2	6	11	6	25	21	68	41
Hemiptera (bugs)								
Saldidae	-	-	-	-	-	-	-	1
Total Bugs	-	-	-	-	-	-	-	1

Diptera (flies)								
Asilidae	-	-	1	-	-	-	-	-
Empididae	1	2	2	-	-	-	2	-
Dolichopodidae	-	-	-	-	-	-	5	-
Lauxaniidae	-	1	-	-	-	-	-	-
Micropezidae	-	-	1	-	-	-	-	-
Therevidae	-	-	5	-	-	-	-	-
Tipulidae (crane flies)	1	8	4	1	1	-	-	6
Total Flies	2	11	13	1	1	-	7	6
Araneae (spiders)								
Lycosidae	-	-	-	-	-	-	1	-
Linyphiidae	-	1	-	-	1	-	1	-
Total Spiders	-	1	-	-	1	-	2	-
Total Invertebrates	4	18	24	7	27	21	77	47

3.4 ERS Invertebrate Fidelity

Table 3.2. shows the percentage of rare and notable species in each of the families in each of the ERS fidelity groups. The fidelity classes are, Total=only found on ERS by rivers, High=also found on lake and pond margins, gravel pits, trickles on cliffs, all habitats similar to those found by rivers, Moderate=strongly associated with rivers at least in parts of the UK but often also found in other habitat types. e.g. fen, wet grassland, disturbed ground, Low=eutrytopic species whose association with ERS may be adventitious. Where the fidelity is not known a ? was used. There is a distinct bias such that most of these rare species have either a high or total fidelity to ERS (48 and 23% respectively), emphasising the importance of these sediments.

3.5 Geographical Distribution of ERS Invertebrates

The geographical distributions of many ERS invertebrate species are not well known but, apart from widespread species, the two main types of distribution appears to be related to altitude, highland and lowland. In many cases these distributions are probably less linked to altitude and climate than to preferences for sediment type. Several species of Welsh shingle sediments, for example, are not uncommon in the Iberian peninsula.

Table 3.2. The number of species in each family in each of the four fidelity groups (Low, Moderate, High, Total) or where the fidelity is not known (?).

Order and Family	Fidelity				
	Low	Moderate	High	Total	?
Coleoptera (beetles)					
Carabidae (ground beetles)	2	9	15	8	-
Haliplidae (water beetles)	-	1	-	-	-
Dytiscidae (water beetles)	2	3	4	3	-
Gyrinidae (water beetles)	1	-	1	-	-
Georissidae (water beetles)	-	-	1	-	-
Hydrochidae (water beetles)	-	-	1	-	-
Helophoridae (water beetles)	1	1	-	1	-
Hydrophilidae (water beetles)	-	4	4	-	-
Hydraenidae (water beetles)	1	2	3	4	-
Ptiliidae	-	-	-	2	-
Staphylinidae (rove beetles)	-	1	41	24	18
Pselaphidae	-	-	-	2	-
Scarabaeidae	-	1	-	-	-
Scirtidae	-	-	1	-	-
Psephenidae	-	-	-	1	-
Limnichidae	-	-	1	-	-
Dryopidae	-	1	-	-	-
Elmidae (Riffle beetles)	-	-	4	3	-
Elateridae (Click beetles)	-	-	3	-	-
Rhizophagidae	-	1	1	-	-
Coccinellidae (ladybirds)	-	-	-	1	-
Curculionidae (weevils)	-	2	1	-	-
Total beetles	7	26	80	49	18
Hemiptera (bugs)					
Saldidae	-	-	1	-	-
Total Bugs	-	-	1	-	-

Diptera (flies)					
Asilidae	-	-	1	-	-
Empididae	-	-	-	-	7
Dolichopodidae	-	-	-	-	5
Lauxaniidae	-	-	-	-	1
Micropezidae	-	-	-	-	1
Therevidae	-	1	4	-	-
Tipulidae (crane flies)	-	-	20	-	1
Total Flies	-	1	25	-	15
Araneae (spiders)					
Lycosidae	-	-	1	-	-
Linyphiidae	-	1	-	2	-
Total Spiders	-	1	1	2	-
Total	7	28	107	51	33

There are some odd British distributions. The ground beetle *Bembidion schueppeli* is found in a band across northern England and southern Scotland but nowhere else in Britain or Ireland (Reid and Eyre 1985). *Bembidion semipunctatum*, a common ERS species in France, is more or less confined in Britain to an area of the west Midlands centred on the Teme and the Severn. *Thinobius newberyi*, a rove beetle, is a species not recorded outside Britain, where it is very rare. A further rove beetle, *Meotica anglica*, is also unknown outside Britain although it belongs to a genus which is relatively understudied. It is obvious that this is one aspect of work on the invertebrates of ERS that requires considerably more attention.

3.6 Habitat Preferences

The habitat requirements of ERS invertebrates are still largely unknown. The particle size of the sediment is undoubtedly an important factor for the majority of species and this is linked to the flow rate of the river and to geology. Table 3.3 shows the substrate preferences for species in the invertebrate families found on ERS. The categories are limited to silt, sand and shingle, where shingle includes all the particle sizes above sand. Where species are found on all types of ERS, 'All' is used as a category and if the preference is not known, this is also indicated. Some beetle species have specialised habitats (e.g. subterranean, pools, moss) and the number of these is given under 'Other' in Table 3.3. Other factors thought to be important include vegetation cover and architecture, organic content of the substrate, the size or discharge of the river and the frequency and severity of disturbance by flooding.

Most ERS ground beetle species (77) are found on silt sediments but there are also a fair number found on sand (47) and shingle (39). This pattern is similar with most beetle families, especially

Table 3.3 The substrate preferences for ERS invertebrate species in each family. The categories are silt, sand, shingle (anything larger than sand), all (occur on all ERS), other (specialised habitats) and ? (preference not known). A species can have more than one preference.

Order and Family	Substrate					
	Silt	Sand	Shingle	All	Other	?
Coleoptera (beetles)						
Carabidae (ground beetles)	55	25	17	22	-	-
Haliplidae (water beetles)	8	5	2	-	-	-
Dytiscidae (water beetles)	28	5	9	-	3	-
Gyrinidae (water beetles)	1	-	1	1	2	-
Georissidae (water beetles)	1	1	-	-	-	-
Hydrochidae (water beetles)	1	-	1	-	-	-
Helophoridae (water beetles)	9	1	1	-	1	-
Hydrophilidae (water beetles)	14	1	1	-	-	-
Hydraenidae (water beetles)	12	-	3	1	1	-
Ptiliidae	3	2	2	-	-	-
Staphylinidae (rove beetles)	100	29	32	25	7	26
Scarabaeidae	-	1	1	-	-	-
Scirtidae	-	-	1	-	-	-
Psephenidae	1	-	1	-	-	-
Heteroceridae	2	-	-	-	-	-
Limnichidae	1	-	-	-	-	-
Dryopidae	2	1	2	-	-	-
Elmidae (Riffle beetles)	6	6	5	-	-	-
Elateridae (Click beetles)	1	1	4	-	-	-
Rhizophagidae	-	-	-	-	2	-
Cryptophagidae		-	-	-	1	-
Coccinellidae (ladybirds)	3	-	1	-	-	-
Chrysomelidae (leaf beetles)	8	-	-	1	-	1
Curculionidae (weevils)	6	-	-	-	-	-
Total beetles	261	78	84	49	16	27
Hemiptera (bugs)						
Dipsocoridae	-	-	1	-	-	-
Saldidae	2	3	-	-	-	-
Hydrometridae	1	1	-	-	-	-
Total Bugs	3	4	1	-	-	-

Diptera (flies)						
Asilidae	-	-	1	-	-	-
Empididae	-	-	-	-	-	7
Dolichopodidae	-	-	-	-	-	5
Lauxaniidae	-	-	-	-	-	1
Micropezidae	-	-	-	-	-	1
Therevidae	-	2	2	3	-	-
Tipulidae (crane flies)	1	15	5	2	-	3
Total flies	1	17	8	5	-	17
Araneae (spiders)						
Gnaphosidae	-	-	-	3	-	-
Clubionidae	1	-	-	-	-	-
Thomisidae	1	-	-	-	-	-
Lycosidae	1	1	1	6	-	-
Argyronetidae	1	-	-	-	-	-
Hahnidae	1	-	-	-	-	-
Tetragnathidae	-	-	-	2	-	-
Linyphiidae	14	-	4	20	-	1
Total spiders	19	1	5	31	-	1
Total Invertebrates	284	100	98	85	16	45

with rove beetles (Staphylinidae) where by far the greatest preference is for silt sediments. In all, 309 beetle species have been identified as being found on silt, whilst 126 occur on sand and 132 species on shingle. Most of the bug (Heteroptera) species are found on silt and sand, as are most of the spider species with some wolf (Lycosidae) and money spider (Linyphiidae) species being specific to shingle sediments.

The total number of invertebrates identified as being found on silt sediments is 369, with 185 species on sand and 182 species on shingle. Shingle and sand sediments are likely to have species with higher fidelity to ERS than silt sediments and these species are likely to be of considerable conservation importance. The shingle and sand sediments are habitats that have few parallels in the wider landscape whilst silt sediments can be similar to other wetland habitat types such as marshes. However, silt sediments are likely to be of high relevance in the calculation of biodiversity in a river system and greater consideration should be given to these habitats.

In fast-flowing upland streams deposits of ERS are rather small, subject to frequent flooding and composed of large sediment particles, but they can support a specialist fauna. However, large boulders in these situations can become stable and provide a substrate for luxuriant growth of mosses. These also attract a specialist invertebrate species assemblage containing rove beetles (e.g. *Lesteva* spp., *Thinodromus arcuatus, Dianous coerulescens, Quedius auricomus, Quedius riparius*) and fly species.

In lowland systems there is a concentration of conservation value in the ERS assemblages of undisturbed secondary channels and oxbow lakes. These assemblages are associated with silt sediments containing large amounts of undecayed organic matter. They share several species with assemblages found on the margins of temporary woodland pools. They can also be found around the undisturbed margins of reservoirs where water level fluctuations due to draw-down mimic the conditions found in large river cut-offs.

For species which hibernate high up on the riverbank the presence of hibernation sites on adjacent areas of the floodplain is important (Andersen 1968). These hibernation sites may consist of grass tussocks, rotten wood or areas of boulders and cobbles. Large ERS such as the famous shingle bank on the River Wye at Glasbury are probably important partly because they contain a number of hibernation sites suitable for surviving winter floods (A P Fowles pers. comm.).

3.7 Impact of River Management on ERS Invertebrates

Very little work has been done on the impact of river management on ERS invertebrates. Lott (1993) studied the effects on ERS beetle species of resectioning the banks of the lowland River Soar in Leicestershire as part of a flood alleviation scheme. For the first few years after resectioning the banks were dominated by a pioneer fauna adapted to highly disturbed systems. After five years this had been replaced by species assemblages with affinities to adjacent grassland. Specialist ERS species tended to be confined to ERS undisturbed by engineering or to areas where natural deposition had been allowed to continue.

Unpublished data (D A Lott) from the same river system also shows how impoundment favours species assemblages associated with low levels of natural disturbance. These assemblages shared several species with damp grassland assemblages. Small scale clearance of vegetation by anglers for fishing platforms ('pegs') was found to diversify the ERS fauna. The likely impacts of river management practices on ERS invertebrates are summarised in Table 3.4.

3.8 Impact of Catchment-wide Processes on ERS Invertebrates

Table 3.5. shows the likely impact of catchment-wide processes on ERS invertebrate assemblages. Undoubtedly, the historical changes in the sediment load has had a significant effect on the lowland ERS fauna. It is likely that species associated with coarse sediments have become rarer in lowland systems. Nationally, rare riffle beetles (Elmidae) such as *Stenelmis canaliculata* and *Normandia nitens* which are associated with large gravel-bedded lowland rivers are well represented in sub-fossil deposits (Coope 1995).

Management impacts on land adjacent to an ERS can have additional impacts. Lott (1992) found that on soft sediments by the River Soar the access of grazing cattle to an ERS produced a species assemblage of beetles associated with a higher level of natural disturbance. However, these assemblages tended to have less value for conservation than those produced by natural disturbance. A moderate grazing regime may, however, be beneficial for flies (C M Drake pers. comm.)

Table 3.4. Likely impacts of river management practices on ERS invertebrates

Management practice	*Effects*
Sediment removal	Loss of sites
Bank resectioning	Loss of hibernation sites
Channel straightening	Loss of sites; change in assemblage type due to change of sediment type
Channel dredging	Possible loss of habitat for aquatic larvae
Impoundment (weirs, mills, fishing & navigation)	Change in assemblage type due to change in sediment type
Reservoir construction	Unknown
Navigation	Unknown
Angling	Increase in habitat diversity due to creation of small patches of bare ground
Water abstraction	Unknown
Sewage discharge	Probably an increase in biomass rather than diversity and possibly a change in assemblage
Flood alleviation	Replacement of secondary channel ERS by terrestrial assemblages

The importance of the presence of hibernation sites such as grass tussocks and rotten wood has been highlighted. These resources are rare in urban areas and intensively grazed or cultivated land due to the use of piling and concrete in banks and the removal of buffer zones between riverbanks and fields. Unpublished data (D A Lott) from the River Soar indicates that sites of high conservation value are often adjacent to high quality terrestrial sites. This may be linked to the availability of hibernation sites.

Table 3.5 Likely impacts of catchment-wide processes on ERS invertebrates

Impact	*Cause*	*Effect*
Siltation (increase in sediment load)	Deforestation, agriculture, mineral extraction, large engineering projects	Change in assemblage type due to change of sediment type
Eutrophication	Fertiliser run-off from agricultural land	Change in assemblage type due to change in vegetation cover
Increased run-off	Urbanisation, land drainage	Change in assemblage type due to change of sediment type
Loss of floodplain wetland to agriculture	Drainage, infilling and tipping	Change from ERS assemblages to terrestrial assemblages
Pond creation	Conversion of floodplain wetland to amenity ponds	Loss of secondary channel sites and assemblages
Access by grazing stock	Adjacent unfenced pasture	Change in assemblage type due to vegetation cover change and extra disturbance; loss of hibernation sites
Change in adjacent land use	Urbanisation, intensive agriculture	Loss of hibernation sites

4. ERS INVERTEBRATES AND ENVIRONMENTAL EVALUATION

4.1 Sampling ERS Invertebrates

Most of the records in the species lists of ERS invertebrates already generated were derived by entomologists using a variety of hand collecting techniques. This activity has established the diverse and distinct nature of ERS invertebrate assemblages but variations in sampling methods, efficiency and effort make it difficult to compare sites.

Andersen (1969) developed a method of repeatable timed hand-collecting for beetles on ERS which was adapted by Plachter (1986), Fowles (1989) and Lott (1992, 1993). However, hand-collecting techniques require good weather and a high level of skill from the individual fieldworker. It is not suitable for inexperienced workers and cannot be considered to be generally applicable as a standard sampling method.

Pitfall trapping is a technique widely used for the sampling of beetles, especially ground and rove beetles, in a variety of habitats. Species in other families, especially leaf beetles and weevils, are also sampled well by pitfall trapping. A beaker with preservative is set into the ground so that invertebrates fall into the trap, producing a sample which can be retrieved later. This method requires less skill than hand-collecting and is less dependent on weather because it operates over a period. Pitfall trap samples are also likely to be skewed against nocturnal species. A standardised sampling methodology for sampling invertebrates, especially ground beetles and spiders, in grassland and woodland has been developed at the University of Newcastle upon Tyne and has been used in a considerable number of investigations (e.g. Rushton and Eyre 1992; Luff, Eyre and Rushton 1992; Eyre and Luff 1994).

The disadvantages of pitfall trapping are mainly connected with disturbance. They are especially vulnerable to floods and this limits the length of time that can be safely left between collections. They cannot be used on soft sediments which are trampled by cattle because they quickly become displaced and there are problems in regions frequented by the public because of an apparently great desire to interfere with the traps. In well vegetated sites, traps tend to be less visible than in areas of bare ground and some kind of camouflage may be required, a process that may skew the sample.

Pitfall trapping has been used successfully used to sample ERS in Wales, Northumberland and Leicestershire. D A Lott (unpublished results) compared samples from hand-collecting and pitfall traps operated from one week on the same ERS and found that they gave similar results. Specialist species of spiders and bugs were also caught in the pitfall traps. The number of flies caught in the pitfall traps was comparable to the number of beetles but it is not known how the representativeness of pitfall trap fly samples compares with other sampling methods.

Standard repeatable sampling techniques for ERS flies have not been used in Britain, although their use is being developed in Belgium (Pollet and Grootaert 1994). The most widely used trapping methods in other habitats have been Malaise traps and water traps. Malaise traps consist of a tent with one side open and designed so that flying insects which enter the trap are funnelled into a collecting bottle in one corner. The exposed nature of many ERS makes the use of Malaise traps impractical. A water trap consists of a coloured bowl filled with water treated to reduce the surface tension. It can be placed on the ground or up a pole. A further method becoming more widely used is the window trap. This consists of a perspex sheet to intercept flying insects with a collecting tray underneath.

Water traps and window traps have similar advantages to pitfall traps in that they can be operated over a period of time, although they need to be serviced at shorter intervals. They are much more vulnerable to disturbance than are pitfall traps because of their grater visibility and the fact that they are above ground and more easily physically damaged. The effects on weather, especially wind, on the sampling of flying insects above ground does not appear to have been addressed. 'Tourist' species from a considerable distance and other habitats are likely to be sampled by window and water traps given certain conditions. Pitfall traps also contain some 'tourist' species not associated with the sampled habitat but they are likely to be a relatively small proportion of the catch.

On present evidence pitfall trapping is the best candidate for standardised sampling of invertebrates on ERS, although its suitability for sampling flies needs to be assessed. The attributes of hand-collecting, pitfall trapping and water traps are compared in Table 4.1.

Table 4.1 A comparison of the attrributes of hand-collecting, pitfall trapping and water traps

	Hand-collecting	*Pitfall trapping*	*Water traps*
Skill level required	Advanced	Moderate	Moderate
Comparability of samples	Low	Moderate	Moderate?
Suitability for nocturnal species	Low	High	Unknown
Sensitivity to weather problems	High	Low	Moderate
Vulnerability to flooding	None	High	Very high
Vulnerability to disturbance by cattle or other animals	None	High on soft sediments	Very high
Vulnerability to human disturbance	None	High on soft sediments	Very high
Expense	Low	Moderate	High

4.2 Sorting

The sorting of samples may be thought of as being of little interest or importance. With hand-collecting only the invertebrates tend to be sampled and there is usually little detritus in water traps. However, the ability to differentiate invertebrate species from the detritus encountered in pitfall traps is a highly skilled operation. Considerable experience is required to sort all the specimens from a pitfall sample and this should not be forgotten when this method is being used.

4.3 Identification

Correct identification to species level is of the utmost importance in ecological, biogeographical and conservation studies with invertebrates. This is especially true when rarity is used a criterion for conservation evaluation since the presence of a single spurious rare species in a sample list can significantly alter the ranking of a site.

The identification process requires three resources; expertise, a reference collection and relevant, accurate literature. Inexperienced workers often rely too much on identification keys, not all of which are totally accurate or up to date. When using keys to an unfamiliar group, identifications should always be checked against name reference specimens. Identifications using keys alone are unreliable. Voucher specimens of species which are rarely recorded or which are in difficult species groups should always be retained and submitted to a specialist in that group.

It should be recognised that even when workers are experienced in the identification of invertebrates, the time taken to deal with an unfamiliar group will be several orders of magnitude greater than someone who has a specialist knowledge of that group. Tackling large amounts of material from ERS samples is totally unfeasible for someone inexperienced in invertebrate identification. In order to evaluate someone's ability to carry out identifications it is necessary to scrutinise their published work.

4.4 Conservation and Environmental Criteria

4.4.1 Rarity

Rarity is a highly 'political' criterion which is readily understood by the general public. Several invertebrate groups have been used to produce rarity values for sites based on distribution records. When the rarity value of a site can be quantified, the site can then be ranked along side other similar sites.

Comparison of sites using lists of rare species is common bad practice in many fields of site evaluation. The number of rare invertebrate species recorded tends to depend on the amount of sampling effort and any rarity value should take into account the total number of species recorded. If possible, comparisons should be made using species lists derived from a single, standardised sampling method.

The national rarity designations for invertebrate species (RDB1, Notable A etc.) produced by

JNCC reviews of various groups has also been used as a basis for generating site scores. However, the designations of ERS species are in need of review and further investigation. It is hoped to have more reliable designations after more survey work.

4.4.2 Diversity

Another criterion becoming increasingly more 'political' is diversity ('biodiversity'). The simplest, and most easily understood, of the ways of quantifying diversity is as straightforward species number. This creates problems with invertebrate sampling because of the number of species there are and the fact that the more sampling the longer the species list. Comparisons can only be made where the sampling effort is the same at each site and where the sampling has been standardised.

A number of ERS sites in Northumberland have been pitfall trapped, whilst samples have been taken along the River Soar in Leicestershire by timed hand-collecting. On the River Till in north Northumberland, pitfall trapping over three months in six sites gave a mean of 26 ground beetle species (range 19-32). In 1991, eighteen sites along the River Soar were sampled by hand-collecting and the mean number of ground and rove beetle species recorded was 44 (range 23-62). These data were for only one and two families of beetle but they indicate the potential of ERS as areas of considerable invertebrate biodiversity.

The use of a standardised sampling method such as pitfall trapping should enable comparisons of biodiversity on ERS to be made. Any quantification should be limited to those groups which are sampled well by pitfall traps and should avoid the more 'accidental' records.

4.4.3 Naturalness

Naturalness is a difficult criterion to quantify but if ways could be found they could be of use in assessing the impacts of river management practices on the invertebrates of ERS. There are a number of sites in north-east England with records of invertebrates, especially beetles, recorded in the 1840's and 1850's. These provide an idea of the fauna before land use changes brought about by intensive agriculture and urbanisation but there is little in the way of historical data for ERS.

ERS are naturally highly disturbed sites that are sensitive to changes in the river system and land use. However, in highly managed landscapes, ERS are likely to be one of the most natural invertebrate habitats present. It would be of value to identify stretches of rivers which have not radically affected by land or river management and to identify within those stretches ERS which reflect near natural conditions. One product of a large-scale survey of ERS invertebrates will be the definition of invertebrate assemblages indicative of more natural ERS. Methods based on ordination or using more subjective techniques should then provide naturalness baselines with which to compare the effects of environmental change.

4.5 Site Classification

Classifications are required because it is not sensible to compare sites which are dissimilar. It is obvious that there are big differences in the structure and invertebrates of ERS throughout England and Wales, ranging from the rough, open sediments in upland areas to the vegetated, silt sediments in lowland areas and taking in all variations between. Ranking of sites using any of the conservation and environmental criteria above needs to be carried out within defined groups of similar sites so that the ranking means something. British rivers have been classified using plant community data (Holmes 1983) and with aquatic invertebrates (Wright et al. 1984) but it is not known how far these would match any classification based on ERS invertebrates.

A preliminary classification of 194 ground beetle species lists from ERS throughout Britain and Ireland and species lists of ground and rove beetles from the River Soar in Leicestershire have also been classified.

4.5.1 Methods

A total of 198 ground beetle (Carabidae) species lists, with four species or more, were assembled from England, Wales, Scotland and Ireland. Four sites from Wales were from the tidal reaches of mid-Welsh rivers and were omitted from the data set. The 194 remaining presence/absence site data were ordinated using DECORANA (Hill 1979a). The first three axes of the ordination were used a basis for fuzzy-set classification (Bezdek 1981). This has proved to be a better method of classifying species list data than TWINSPAN (Hill 1979b), with the one advantage that no sites are chained off as outliers (Gardner 1991; Eyre 1994). The classification was used as a structure within which to use rarity assessments.

A second data set of sites in Leicestershire, 56 sites by the River Soar sampled in 1991 and 1992, was used to assess whether an input derived from the number of beetles recorded by standardised sampling into the rarity values improved the comparison of site quality. This data set contained both ground beetle and rove beetle (Staphylinidae) species. Each site was hand-sampled for the same time and the number of beetles of each species was recorded. The proportion of each species in the total was calculated and this value was used in the DECORANA ordination. The first two axes of the ordination were used in the classification.

4.5.2 Results

a) Britain and Ireland ground beetle classification

The classification resulted in a set of assemblage types which can be readily associated with recognisable habitats. The most appropriate classification gave five groups of sites. Group 1 was 38 mainly Welsh river sediment sites (35) with others from north Yorkshire and Northumberland and one from Ireland. These sites were by small rivers with fast-flowing water and were composed of a good mixture of sediment particle sizes with little or no vegetation. There were 28 sites in group 2, mostly from north-east England (19) and some Welsh and Irish. These sites were from by larger rivers than those in group 1 with slower flow. The mixture of sediment types was again comprehensive ranging from boulders to sand and there was some vegetation. Group 3 had 32 sites, a mixture from the English Midlands (19), north-east England (8), Wales (4) and including one site from the Sussex Rother. These sites were from slow-flowing rivers and were mainly sand with some silt and some larger sediment particles. The 27 sites in group 4 were mainly from north-east England (19) with four Welsh sites, two Scottish and one from Ireland. These were similar to the group 2 sites but had more boulders, less sand and little vegetation. They occurred on rivers intermediate in size between group 1 and group 2 sites. Group 5 was a large group of 69 silty sediments with considerable vegetation, all from lowland, midland England except one Irish site.

b) River Soar ground and rove beetles classification

The most appropriate classification gave three groups of sites. Group 1 had 22 sites, which were more open and silty with less vegetation than those in group 3 and some of these sediments had been subject to river engineering more recently than sites in group 3. Group 2 sites were the most open, least silty sites, some with shingle and all with less vegetation than sites in the other two groups. These were the most natural sediments in the data set. The 18 sites in group 3 had the most vegetation, the fewest open areas and no recent management.

4.6 Conservation Assessments using ERS Invertebrates

4.6.1 Methods

Within a classification, sites can be compared using a number of conservation criteria. The most important of these, and most 'politically' useful, is rarity. However, a considerable knowledge of the distribution of species in any particular group is required in order to generate species quality values. This is especially relevant with invertebrates because few groups have been surveyed to the required level. Ground and water beetles are two groups where the distribution knowledge on a UK scale is sufficient (Foster 1991, Foster and Eyre 1992; Luff 1996). The national data is based on 10km national grid squares but local distribution data based on tetrad (2 x 2km) data has also been used. For instance, north-east England has been comprehensively surveyed for ground and water beetles (Eyre Ball and Foster 1985; Eyre, Luff and Ball 1986) and the data used to generate local species rarity values (Eyre and Rushton 1989). There are also local species rarity values for all beetle species in Leicestershire, which means that other beetle species than ground beetles can be used in assessing site quality.

With the Britain and Ireland data set, species rarity values based on data in the Britain and Ireland ground beetle distribution scheme (Luff 1996) were used to compare and rank sites on conservation quality. Species rarity values were generated depending on the number of 10km squares a species had been recorded from (post 1960). The values were a geometric scale from 1-256 (1=256 and more squares; 2=128-255; 4=64-127; 8=32-63; 16=16-31; 32=8-15; 64=4-7; 128=2-3; 256=1 square). The species values were summed for all the species in a site list and divided by the number of species. This gives a Species Quality Factor (SQF). To get an idea of rarity association, a Rarity Quality Factor (RQF) was calculated by adding all the values of 2 and above, with a reduction of the highest score if this is the only one of this value (see Eyre and Rushton 1989), and adding these to the first total. This new total is divided by the number of species and a large difference between the SQF and RQF indicates good rarity association. The larger the RQF and the better the rarity association, the better the site conservation quality.

As an example, if a list contained species rarity values of 1, 1, 2, 2, 2, 4, 8, 16, 16 and 64 these values would be summed (116) and then divided by the number of species (10) to give a Species Quality Factor (SQF) of 11.60. The additional element for rarity association would be the sum of 2, 2, 2, 4, 8, 16 and 16 plus 16 for the 64 value because there was only one 64. This is an additional 66 to be added to the 116, giving 182. This is then divided by the number of species to give a Rarity Quality Factor (RQF) of 18.20. The difference between the SQF and RQF (in this case 6.60) gives an idea of how many rare species occur in the list by comparison with other lists.

The basis for the species rarity values in Leicestershire was the same as for the Britain and Ireland ground beetle data set but only scores up to 64 were used (1=64 and more tetrads; 2=32-63; 4=16-31; 8=8-15; 16=4-7; 32=2-3; 64=1) because there are less tetrads in Leicestershire than 10km squares in Britain.

4.6.2 Results

a) Britain and Ireland site ranking

The mean Species Quality Factors (SQF) and Rarity Quality Factors (RQF), and ranges, for each of the sites in the five groups of the classification are given in Table 4.2.

Table 4.2 The mean Species Quality Factors (SQF) and Rarity Quality Factors (RQF) values, with ranges, of sites in the groups derived from the classification of the Britain and Ireland data set.

Group	Mean SQF and range	Mean RQF and range
1	8.08 (2.20 - 35.00)	12.04 (3.80 - 52.00)
2	2.62 (1.00 - 11.50)	3.76 (1.00 - 17.00)
3	2.64 (1.00 - 7.55)	3.67 (1.00 - 11.05)
4	4.31 (1.60 - 16.33)	6.87 (1.60 - 29.00)
5	1.94 (1.20 - 4.82)	3.04 (1.20 - 6.93)

Group 1, with mainly Welsh sites, had the highest mean rarity values, with the greatest range, and, on average these sites had considerably more conservation value than sites in the other four groups. The sites in groups 2 and 3 had similar rarity values, with those for sites in group 4 slightly higher and those for the silt sites in group 5 the lowest. The results here show that there are likely to be geographical differences in site type, in composition of ground beetle assemblages and in conservation value even with data from a more standardised survey.

b) River Soar site ranking

The mean Species Quality Factors (SQF) and Rarity Quality Factors (RQF), and the range, for the sites in the three groups of the classification are given in Table 4.3.

Table 4.3 The mean Species Quality Factors (SQF) and Rarity Quality Factors (RQF), with ranges, of sites in the groups derived from the classification of the River Soar data set.

Group	Mean SQF and range		Mean RQF and range	
1	3.02	1.29-5.75	5.14	1.86-8.95
2	3.06	1.13-7.07	4.87	1.13-11.47
3	2.68	1.52-4.74	4.60	2.33-8.52

The mean values for the two indices were similar for sites in groups 1 and 2 whilst the more vegetated sites of group 3 had slightly lower values.

4.6.3 Discussion

a) Classification

Given the disparate nature of the ground beetle data from Britain and Ireland, there was a good classification of river sediment types generated. However, it should be seen as preliminary. The species lists used in this analysis represent an uneven coverage of rivers both geographically and ecologically. A more rigorous classification can only be achieved through the analysis of standard samples covering all the variation in river systems. Useful classifications have been seen before with this sort of non-standardised data (e.g. Eyre, Ball and Foster 1986; Luff, Eyre and Rushton 1989) but better classifications with ground beetle data was possible with standardised pitfall trap ground beetle data (Luff, Eyre and Rushton 1992). TWINSPAN (Hill 1979b) was used in these classifications but the use of fuzzy-set classification has improved the placing of sites within groups (Gardner 1991; Eyre 1994).

The classification of the River Soar ground and rove beetle data was more difficult because there was less variation in the area surveyed and in the beetle data. However a structure based on the naturalness of the sediments and on the amount of recent river management was possible. The classification did provide a structure within which to test the potential for using rarity values for ranking sites.

b) Site ranking

There has been regular use of species rarity values derived from national recording schemes, especially in the assessment of the conservation quality with water beetles (e.g. Foster et al. 1990, 1992; Foster and Eyre 1992). Ground beetle data has also been used on a regional basis (Eyre and Rushton 1989) and this group is now used systematically for conservation quality assessments of terrestrial sites in north-east England and Leicestershire. The potential for using this sort of system with invertebrate data from ERS can be seen with both of the data sets above. Good differences between sites was seen and the ability to rank sites on conservation quality values could be very useful in assessing site quality.

There are some sediments, for example on the River Till and River Wye, which are of great value for ERS species other than ground beetles. An examination of the ranking of sites according to the rarity of its ground beetles shows that in some cases (e.g. River Wye) they score well. However, several sites of major importance cannot be identified from the ground beetle fauna alone. In order to use rarity scores more effectively, it will be necessary to establish an ERS database covering a wider range of groups. One potential approach, given standardised sampling, may be to use ground beetles for a main ranking system and then use the national conservation status to flag high quality sites. This requires a better knowledge of national rarity status, another potential product of a standardised survey.

The comparison of species rarity values for sediments may give an indication of changes brought about by river management or by land use factors. Lott (1992) found that heavy trampling by cattle reduced the conservation value of sediments in the Soar catchment. Some light grazing, may however, be beneficial for flies (C M Drake pers. comm.), but the highest scoring sites tend to be adjacent to relatively undisturbed land. In general, the more naturally disturbed and the most open sites in the River Soar classification presented here had the highest conservation values, indicating a potential input into management plans.

5. POSITIVE MANAGEMENT PRACTICES

5.1 Identification of Valuable Sites

The first conservation priority of any management strategy should always be to evaluate the existing interest of the river. Sites or features of major interest can then be retained and a management programme adopted to protect and add to these features.

The only satisfactory way to evaluate the conservation interest of ERS is to survey the invertebrates, as described in chapter 4. However, in the absence of survey resources or as a preliminary stage in the evaluation, some general principles can be used to gauge the potential of a stretch of river. In our present state of knowledge, these general principles should be regarded as provisional, especially with regard to the conservation of flies and they may need to be modified in the light of further research.

5.1.1 Recognition of habitat types

A stretch of river will have ERS resources which will be used by a number of different invertebrate assemblages. The main differences in the resources required by each community are related to levels of disturbance. The easiest way to recognise the level of disturbance at a site is to examine the substrate particle size. Table 5.1 shows the categories that will tend to support different invertebrate assemblages.

Table 5.1 The relationship between ERS substrate and type of disturbance

Substrate	*Type of disturbance*
Moss-covered boulders	High water flow on small rivers and large streams
Boulder and cobbles	Very high water flow
Pebbles and shingle	High water flow
Shingle and sand	Moderate water flow
Sand and silt	Slow water flow
Trampled sand and silt	Slow water flow with high levels of unnatural disturbance
Silt and undecayed organic matter	Intermittent water flow in abandoned channels and backwaters

On ERS composed of coarse sediments, the presence of dry sandy areas at the back of the site will provide a resource for an additional assemblage which includes click beetles and therevid flies. Indeed, large ERS sites may contain a mosaic of different sediment types, each with a separate invertebrate assemblage. Additional specialist communities can be found in remnant pools on shingle, in winterbournes, in beached dead wood and in old flood refuse but further research is required to identify which factors affect their value for conservation

The conservation value of a river segment needs to be considered separately for each of the different assemblages by assessing the quality of each of the relevant habitat types.

5.1.2 Habitat quality

Factors which increase the potential quality of an ERS site for any particular community include large size, topographic complexity and the availability of hibernation sites in the form of grass tussocks and dead wood either high up on the ERS or on an adjacent bank.

The quality of a river stretch for a particular assemblage is increased by a large number of individual suitable sites. The presence of secondary channels and remnant pools on ERS can provide a resource for additional specialist assemblages.

Intensive trampling or poaching of soft sediments on ERS by grazing stock, especially cattle, and human pressure changes the assemblage type to one that is adapted to higher disturbance levels but which is of lower conservation value. This is especially true of abandoned channels, which are sensitive to any kind of disturbance. However, small scale clearance of vegetation by anglers on main channel sites can result in an interesting increase in habitat and species diversity.

The quality of ERS composed of coarse sediments is adversely affected by organic discharges into the river and by increases in suspended silt in the river. Sewage outfalls, run-off from agricultural land, forestry operations and mineral workings can have significant effects on the composition of ERS and thus on the invertebrate assemblages.

5.1.3 Avoidance of damaging engineering practices

Having identified which assemblages are of conservation interest in a stretch of river, a list of key sites containing high quality resources for these assemblages should be compiled. These sites should then be protected from the following operations:

1. complete sediment (shoal) removal
2. bank resectioning
3. channel straightening
4. channel deepening (damage to secondary channel sites)
5. clearance of hibernation sites (grass tussocks and dead wood) from the sediment or bank
6. river impoundment, either upstream and downstream

The impact of partial sediment (shoal) removal is difficult to predict. The introduction of steep marginal slopes should probably be avoided. Important ERS characters which should be retained include the height and topographic complexity. However, it may be beneficial to scrape some parts of a site in order to compensate for removal of low-lying damp sediment.

The timing of engineering works is likely to be important. Spring-breeding invertebrates are active on ERS between April and July. Water beetles use ERS for pupation in the summer.

Avoidance of operation in spring and summer would lessen the impact on those groups of invertebrates active then but it is probably impossible to avoid impact on some fossorial species and summer breeders, which may spend the whole year on the site. As a corollary, disturbance on the bank would be most damaging in autumn and winter when the spring breeders are in hibernation.

5.2 Creative Engineering

Creative engineering can be used to protect existing conservation interest, to enhance existing interest or to add to existing interest. This section assesses the engineering works discussed in the New Rivers and Wildlife Handbook (RSPB, NRA and RSNC 1994) for their potential for increasing habitat quality for ERS invertebrates. These works and the assemblages that they may benefit are shown below in Table 5.2.

Table 5.2 The potential beneficial effects of river engineering work on invertebrate assemblages

Engineering work	*Assemblages benefited (characterised by sediment type)*
Artificial sediments	Unknown
Restoration of meanders	All
Introduction of changes in gradient	All
Backwaters and bays	Silt and sand
Multi-stage channels	Silt and undecayed organic matter
By-pass channels	Silt and undecayed organic matter
Flood storage lakes	Silt and undecayed organic matter
Deflectors (groynes)	All
Weirs	Moss-covered boulders
Buffer zones	All

5.2.1 Artificial sediments

There is little information on the colonisation of artificial sediments by ERS invertebrates. Some ERS ground beetles are capable of colonising gravel pits and probably of resectioned banks if they are of suitable material. It is likely that the construction of artificial sediments will be a valuable conservation measure. However, many natural sediments have a complex laminar structure with alternating sediment particle types which would be difficult to replicate.

Further work is required to establish the suitability of artificial sediments for the full range of ERS invertebrates.

5.2.2 Encouraging natural deposition

An elegant method of creating new sediments (shoals) is to manage the river flow in a way which encourages their formation by natural deposition. Restoration of meanders, changes in gradient and groyne construction are engineering operations which will achieve this end.

For both artificial sediments and new naturally formed sediments the management of land above the adjacent bank is critical. A buffer zone containing grass tussocks and/or rotten wood for hibernation sites should be established and grazing stock, especially cattle, should be excluded from soft sediments.

5.2.3 Backwaters and bays

The creation of backwaters and bays will provide additional habitat for communities adapted to soft sediments associated with low natural disturbance. A buffer zone containing grass tussocks and/or rotten wood for hibernation sites should be established on the adjacent bank and fencing should be used to exclude grazing stock where necessary.

5.2.4 Multi-stage channels and by-passes.

Multi-stage channels which incorporate secondary channels and remnant pools into their design and new by-pass channels to divert excess water from the main channel during flooding have long-term potential for assemblages associated with secondary river channels, but only if they are protected from unsuitable disturbance such as intensive grazing. If areas are allowed to succeed to carr woodland or are managed by cutting, they could in time attract a valuable fauna., though these habitats would not be classified as ERS.

The construction of flood storage and balancing lakes leads to similar opportunities if the margins are protected from disturbance. If the water level is allowed to fluctuate, an interesting abandoned channel assemblage may develop over time. Constant water levels in these areas will eventually attract a fen community.

5.2.5 Deflectors

The construction of groynes leads to the deposition of sediments downstream of the new structures. In large rivers in Europe this results in extensive ERS formation, with a complexity of habitats and assemblages.

5.2.6 Weirs and sluices

The impoundment of a stretch of river using a weir results in the disappearance of ERS containing coarse-grained sediments for some distance upstream and their replacement by silt. In severe cases, the ERS becomes permanently vegetated, resulting in the transition of the invertebrate assemblage to one resembling a wet grassland fauna. However, on the weir itself a flora of mosses and other plants may flourish and support an invertebrate assemblage associated with moss-covered boulders. In lowland rivers with no nearby source of immigration this community is often impoverished, although weirs may also provide the only suitable habitat for some predominantly upland species.

5.2.7 Buffer zones

The establishment of semi-natural vegetation on the bank in a buffer zone lead to the availability of hibernation sites. These could be of especial importance in urban and intensive agricultural systems where the lack of hibernation sites may be a limiting factor for the development of ERS communities.

6. CONCLUSIONS

6.1 Exposed Riverine Sediments

ERS are the product of the effects of river flow on the geology and drift in an area, with the major factors affecting the extent and type of ERS channel slope and the flow rate of the water. The nature of the bedrock does not appear to be especially important but drift, especially clay, is important in the formation of lowland ERS. The type and structure of ERS are related to altitude, topography and water flow. The rougher, larger particle ERS, with little or no vegetation, are generally found on the upper reaches of rivers with the steepest slope and the fastest flow in zones prone to spates. As the gradient flattens out flow rates reduce with the deposition of smaller particle ERS with more vegetation. In areas with little drift these ERS tend to be sandy, with sparse vegetation, whilst where rivers flow through clay, silt ERS with considerable vegetation are deposited.

The most knowledge of the distribution and extent of ERS has been derived from invertebrate survey work. The knowledge of ERS in the NRA regions is generally poor, probably because there has been little or no interest in these features by either engineers or biologists. There is an obvious need for accurate and systematic data on the extent, structure and distribution of ERS throughout England and Wales. The River Habitat Survey (RHS) will give a idea of the potential distribution of ERS in catchments since it will provide a random, unbiased estimate of the distribution of ERS features. This information represents the first set of absolute records, subject to quality assurance and collected on such a large scale (over 5,000 sites by end of 1996). In contrast, the information gathered by entomologists tends to be skewed towards the best sites. However, RHS data will not provide a comprehensive account of ERS distribution or produce the precision in estimates of ERS structure that are desirable. The use of data from river corridor surveys and aerial photograph coverage for the determination of ERS distribution and structure is likely to be limited to indications of potential. There is too much inconsistency in corridor surveys and photographs both within and between NRA Regions for these to be relied upon.

The use of RHS, river corridor surveys, aerial photographs and remote-sensed data in estimating the distribution and structure of ERS is limited because these methods are point samples taken at only one time. Any method limited to this approach will only give an estimate of the potential distribution of features such as ERS, which are prone to change and to being hidden by such factors are high river water levels. Experienced geographers working with the requisite large-scale and geological maps are as likely to be able to predict the presence, and to some extent the structure, of ERS to a more accurate extent than estimations from any of the NRA and other data sets.

One obvious lack of knowledge is the effect of river management and land use on ERS distribution and structure. The only way sufficiently accurate data will be generated is by survey work by experienced personnel with access to the history of management and river engineering.

6.2 ERS Invertebrates

The information about the invertebrates of ERS in England and Wales is a mixture of data generated by recorders especially interested in the distribution and biogeography of beetles, flies and spiders and the work carried out by A P Fowles in Wales and by D A Lott on the River Soar in Leicestershire on the distribution of beetles and other invertebrates by heavy-metal polluted and lowland rivers respectively, with some work on the effects of river management by D A Lott. The work on the Soar is the most systematic work carried out on ERS invertebrates in Britain and the most comprehensive recording of all beetle species by rivers in Europe. There has been some work on specific groups of invertebrates, especially ground beetles, in Norway, Sweden, Finland, Germany, Italy and Belgium but it appears that the most information about the distribution of most ERS invertebrate species is British.

Although the British data is probably the best in Europe, it is very patchy in terms of both the invertebrate groups and areas covered. By far the most information, especially on distribution, ecology and biogeography, is concerned with ground beetles (Carabidae) with other beetle groups, especially rove beetles (Staphylinidae), also relatively well researched. There are 230 species of beetle with high or total fidelity to ERS, including 44 and 123 species of ground and rove beetle respectively. However, it can be seen from Figures 4.1 and 4.2 that the coverage in England and Wales is concentrated on certain catchments and that ground beetle species assemblage data is restricted to only a few catchments. Only 25 fly and 5 spider species are known to have either high or total fidelity to ERS, a situation that is probably due to the relatively small effort put into investigations of these groups on ERS in England and Wales.

Appendix A lists a total of 369 invertebrate species which are known to occur on silt ERS. This is of interest as this indicates that there is likely to be most species on the ERS where knowledge of distribution and extent is least. These silt sediments are found in where rivers flow through highly managed landscapes and these ERS may constitute one of the most 'natural' habitats in that landscape. It is also likely that these ERS will contribute substantially to the biodiversity of any highly managed landscape area.

6.3 ERS and Conservation

The only data available from the national conservation bodies was a list of rare and notable species with localities received from the Joint Nature Conservation Committee (JNCC). This list contained 92 species which are supposed to be associated with 'shingle', the nearest category on the Invertebrate Site Register (ISR) for ERS. Not only was this number of species very inadequate as a list of rare and notable species found on ERS, it also contains species which are not found on 'shingle' or by rivers. The other major problem with ISR data is that it has been taken on trust from recorders, some of who may not be sufficiently competent. Species determinations have not been checked where this would be appropriate and, consequently, information from the ISR has to be treated with some suspicion.

In the list of ERS species (Appendix A) there are a total of 226 rare and notable species found on ERS. Most are beetle species (180) with the list of ground and rove beetles containing 36 and 84 rare and notable species respectively. 41 fly species are also rare or notable but it should be understood that the designation of conservation status to invertebrate species by JNCC is subject to considerable argument and change due to the generation of more distribution data. The conservation statuses of a number of ERS invertebrate species were probably out of date when the lists were published and a systematic survey of ERS invertebrates in England and Wales will help to rationalise the list of rare and notable species. A survey is also likely to increase the number of rare species found on ERS and it is undoubtedly true that as well as being important for biodiversity, ERS will be the habitats of a considerable number of rare invertebrate species.

The work on the ability to assess site quality using invertebrate records has been pioneered in Britain, mainly using two groups of invertebrates found commonly on ERS, ground and water beetles. Although the generation of ground beetle species assemblage has not been systematic, a sensible ERS habitat classification was produced for sites in Britain and Ireland. A more sophisticated classification was possible with the River Soar ground and rove beetle data, which had been generated in a standardised manner. These classification provided structures within which sites of similar type could be ranked using rarity indices based on distribution records. These classifications and site rankings are preliminary attempts designed to show the potential for using invertebrates for assessing ERS quality. Only classifications with more sites and incorporating more of the variation in data from the full range of ERS in England and Wales should be used for comparison purposes.

The use of ERS habitat classifications and rankings based on invertebrate species assemblage data is likely to be the way to assess not only individual ERS site quality but also the effects on ERS by the various river management and land use procedures. It has been shown by the work on the River Soar that ERS invertebrate species assemblages change with activities such as bank regrading and then with time. The conservation value of these ERS are also likely to change and the effects can be quantified using the ranking methods based on rarity indices. These indices would probably be based on regional distribution data to give the necessary fine tuning required to assess local ERS changes and temporal trends.

7. RECOMMENDATIONS

There is an obvious need for a structured, standardised field survey of ERS and ERS invertebrates so that the full potential for these habitats for biodiversity and conservation can be explored. There would be little point in carrying out a less than comprehensive survey as the problems of lack of basic knowledge, patchy coverage and ignorance of the effects of river management outlined in this report would not be addressed.

7.1 Survey Work

A comprehensive survey would require

(a) Sampling by pitfall trapping of ERS in the all NRA regions such that the variation in the sediments of each region is covered. More sample sites will be needed in some regions than others.

(b) The recording of a number of environmental variables from each ERS site sampled such that associations between invertebrate species and assemblage data and the size, structure and history of the sediment can be ascertained as well as the effects of river management and land use.

(c) Sorting should be carried out by an entomologist with sufficient experience. Catches should be sorted into major groups, usually insect orders and spiders, and preserved in tubes with 70% alcohol.

(d) Identification needs to be carried out by specialists, to species level, known to have the required ability in the relevant invertebrate groups and with a proven pedigree. This is not a job for inexperienced personnel and requires considerable expertise.

(e) The invertebrate and environmental data needs to be collated such that it can easily be converted into data sets for statistical analyses. These multivariate (e.g. DECORANA, TWINSPAN, fuzzy classification) methods and such techniques as logistic regression should initially identify the environmental variables affecting the distribution of ERS invertebrates.

(f) The data should be used to quantify some conservation criteria, with an approach similar to that shown in this report. Sediments should be ranked within habitat classifications and ranking should be on both a national and regional basis.

(g) Assessments of the effects of river management and engineering and of land use should be carried out using a mixture of multivariate analyses and site ranking procedures.

7.2 Other Objectives

There needs to be a concerted effort to emphasise and publicise the potential of ERS for wildlife conservation, in both river corridor and landscape contexts. A comprehensive survey of ERS for invertebrates would provide some publicity and more information should be made available to people further up the managerial hierarchy of relevant bodies who are in positions to make policy and decisions. Obviously, this NRA initiated project could be used as a tool for improving the knowledge and importance of ERS invertebrates. The use of NRA biologists in a standardised survey will also improve the knowledge base.

The carrying out of a survey of ERS invertebrates provides an opportunity for collaborative work with conservation bodies, especially English Nature and the Countryside Council for Wales. The product of any survey will be of considerable interest to these bodies as sites with conservation interest are bound to be identified.

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APPENDIX A

A.1 Invertebrate Species Found on ERS.

A list of the invertebrates found on exposed riverine sediments (ERS) is given below. The conservation status (RDB1,2,3,I,K, Na, Nb) fidelity to ERS (low, moderate, high, total, ?) and the substrate preference for each species (silt, sand, shingle indicated by +, ?, other) are indicated (see section 4.1.) and the life stage (A=adult, L=larva, P=pupa) of each species on ERS shown. The species with high or total fidelity to ERS are enboldened.

	Conservation Status	Fidelity	Substrate Preference Silt	Sand	Shingle	Other	Life Stage
Coleoptera							
Carabidae							
Carabus granulatus Linnaeus	None	Moderate	+				A
Carabus violaceus Linnaeus	None	Low	+	+			A
Pelophila borealis (Paykull)	RDB3	Moderate	+	+			A
Nebria brevicollis (Fabricius)	None	Low	+	+	+		AL
Nebria gyllenhali (Schoenherr)	None	Moderate			+		AL
Nebria salina Fairmaire & Laboulbene	None	Low		+			AL
Notiophilus biguttatus (Fabricius)	None	Low	+	+	+		A
***Elaphrus cupreus* Duftschmid**	**None**	**High**	+				**AL**
***Elaphrus riparius* (Linnaeus)**	**None**	**High**	+	+			**AL**
Loricera pilicornis (Fabricius)	None	Low	+	+			AL
***Dyschirius aeneus* (Dejean)**	**None**	**High**	+				**AL**
***Dyschirius luedersi* Wagner**	**None**	**High**	+				**AL**
Dyschirius politus (Dejean)	None	Moderate	+	+			AL
***Clivina collaris* (Herbst)**	**None**	**High**	+	+	+		**AL**
Clivina fossor (Linnaeus)	None	Low	+				A
Patrobus atrorufus (Stroem)	None	Low	+				A
***Perileptus areolatus* (Creutzer)**	**Na**	**Total**			+		**AL**
***Thalassophilus longicornis* (Sturm)**	**Na**	**Total**			+		**AL**
Trechus discus (Fabricius)	Nb	Moderate	+	+	+		AL
Trechus micros (Herbst)	None	Low	+	+	+		A
Trechus obtusus Erichson	None	Low	+	+	+		A
Trechus quadristriatus (Schrank)	None	Low	+	+	+		A
Trechus rubens (Fabricius)	Nb	Low	+	+	+		A
***Asaphidion flavipes* (Linnaeus)**	**None**	**High**	+	+			**AL**
***Asaphidion pallipes* (Duftschmid)**	**Nb**	**High**	+	+			**AL**
Bembidion aeneum Germar	None	Moderate	+	+	+		A
***Bembidion andreae* (Fabricius)**	**None**	**Total**	+	+			**AL**
***Bembidion articulatum* (Panzer)**	**None**	**High**	+	+			**AL**
***Bembidion atrocoeruleum* Stephens**	**None**	**Total**			+		**AL**
Bembidion biguttatum (Fabricius)	None	Moderate	+				A
***Bembidion bipunctatum* (Linnaeus)**	**Nb**	**High**			+		**AL**
Bembidion bruxellense Wesmael	None	Moderate	+	+	+		A
***Bembidion clarki* (Dawson)**	**Nb**	**High**	+				**AL**
***Bembidion decorum* (Zenker)**	**None**	**Total**			+		**AL**
***Bembidion dentellum* (Thunberg)**	**None**	**High**	+				**AL**

Bembidion femoratum Sturm	None	Moderate			+	AL
***Bembidion fluviatile* Dejean**	**Nb**	**High**	+	+		**AL**
***Bembidion genei* Kuster**	**None**	**High**	+	+	+	**A**
***Bembidion geniculatum* Heer**	**None**	**Total**			+	**AL**
Bembidion gilvipes Sturm	Nb	Moderate	+			AL
Bembidion guttula (Fabricius)	None	Moderate	+	+		A·
Bembidion lampros (Herbst)	None	Low	+	+	+	A
***Bembidion litorale* (Olivier)**	**Nb**	**Total**	+	+		**AL**
***Bembidion lunatum* (Duftschmid)**	**Nb**	**Total**		+		**AL**
Bembidion lunulatum (Fourcroy)	None	Moderate	+	+	+	AL
***Bembidion monticola* Sturm**	**Nb**	**High**			+	**AL**
Bembidion nitidulum (Marsham)	None	Moderate	+			A
Bembidion obtusum Serville	None	Moderate	+			A
Bembidion properans (Stephens)	None	Moderate	+	+		A
***Bembidion prasinum* (Duftschmid)**	**None**	**Total**			+	**AL**
***Bembidion punctulatum* Drapiez**	**None**	**High**			+	**AL**
Bembidion quadrimaculatum (Linnaeus)	None	Low	+	+	+	A
***Bembidion schueppeli* Dejean**	**Na**	**Total**	+	+		**AL**
***Bembidion semipunctatum* Donovan**	**Na**	**Total**	+	+	+	**AL**
***Bembidion stomoides* Dejean**	**Nb**	**Total**			+	**AL**
***Bembidion testaceum* (Duftschmid)**	**Nb**	**Total**		+	+	**AL**
***Bembidion tetracolum* Say**	**None**	**High**	+	+	+	**AL**
***Bembidion tibiale* (Duftschmid)**	**None**	**Total**			+	**AL**
Bembidion varium (Olivier)	None	Moderate	+			A
***Bembidion virens* Gyllenhal**	**RDB3**	**High**			+	**AL**
***Tachys bistriatus* (Duftschmid)**	**Nb**	**High**	+	+		**AL**
Tachys parvulus (Dejean)	Nb	Moderate	+	+	+	A
Pterostichus cupreus (Linnaeus)	None	Low	+			A
***Pterostichus gracilis* (Dejean)**	**Nb**	**High**	+			**AL**
Pterostichus minor (Gyllenhal)	None	Moderate	+			A
Pterostichus niger (Schaller)	None	Low	+	+	+	A
Pterostichus nigrita (Paykull)	None	Moderate	+			AL
Pterostichus rhaeticus Heer	None	Low	+			AL
Pterostichus strenuus (Panzer)	None	Moderate	+			AL
Pterostichus vernalis (Panzer)	None	Moderate	+			A
Pterostichus versicolor (Sturm)	None	Low	+			A
***Agonum albipes* (Fabricius)**	**None**	**High**	+	+	+	**AL**
Agonum assimile (Paykull)	None	Moderate	+	+	+	AL
Agonum dorsale (Pontoppidan)	None	Low	+	+		A
Agonum fuliginosum (Panzer)	None	Moderate	+			A
***Agonum livens* (Gyllenhal)**	**Na**	**High**	+			**AL**
Agonum marginatum (Linnaeus)	None	Moderate	+			A
***Agonum micans* Nicolai**	**None**	**High**	+			**AL**
Agonum muelleri (Herbst)	None	Low	+	+	+	A
Agonum obscurum (Herbst)	None	Moderate	+			A
***Agonum scitulum* Dejean**	**Na**	**High**	+			**AL**
Agonum thoreyi Dejean	None	Moderate	+			A
***Amara fulva* (Mueller)**	**Nb**	**High**		+		**AL**
Amara quenseli (Schoenherr)	Na	Moderate		+		A
Amara similata (Gyllenhal)	None	Low	+	+	+	A
Trichocellus placidus (Gyllenhal)	None	Moderate	+			A
***Stenolophus mixtus* (Herbst)**	**None**	**High**	+			**A**

Acupalpus flavicollis (Sturm)	Na	Moderate	+	+			A
Badister anomalus (Perris)	RDB1	Moderate	+				A
Badister dilatatus Chaudoir	Nb	Moderate	+				A
Badister unipustulatus Bonelli	Nb	Moderate	+				A
***Chlaenius nigricornis* (Fabricius)**	**Nb**	**High**	**+**				**A**
***Chlaenius vestitus* (Paykull)**	**None**	**High**	**+**	**+**			**A**
Demetrias atricapillus (Linnaeus)	None	Low	+				A
***Lionychus quadrillum* (Duftschmid)**	**RDB3**	**High**			**+**		**AL**
Polistichus connexus (Fourcroy)	RDB2	Low	+	+			A
Haliplidae							
***Brychius elevatus* (Panzer)**	**None**	**Total**	**+**	**+**	**+**		**P**
Haliplus flavicollis Sturm	None	Moderate	+	+			P
***Haliplus fluviatilis* Aube**	**None**	**High**	**+**	**+**			**P**
Haliplus fulvus (Fabricius)	None	Moderate			+		P
Haliplus immaculatus Gerhardt	None	Moderate	+	+			P
***Haliplus laminatus* (Schaller)**	**Nb**	**High**	**+**	**+**			**P**
Haliplus lineatocollis (Marsham)	None	Moderate	+	+			P
Haliplus ruficollis (DeGeer)	None	Low	+				P
Haliplus wehnckei Gerhardt	None	Low	+				P
Dytiscidae							
***Laccophilus hyalinus* (DeGeer)**	**None**	**High**	**+**				**P**
Laccophilus minutus (Linnaeus)	None	Low	+				P
Hydroglyphus geminus (Fabricius)	Nb	Low	+	+			P
***Bidessus minutissima* (Germar)**	**RDB3**	**High**	**+**	**+**			**P**
Hygrotus inaequalis (Fabricius)	None	Low	+				P
Hygrotus versicolor (Schaller)	None	Low	+				P
Hydroporus discretus Fairmaire	None	Moderate	+				P
Hydroporus erythrocephalus (Linnaeus)	None	Low	+				P
***Hydroporus ferrugineus* Stephens**	**Nb**	**High**				**Subterranean**	**P**
Hydroporus longulus Mulsant	Nb	Low	+				P
Hydroporus marginatus (Duftschmid)	Nb	Moderate				Chalk	P
Hydroporus memnonius Nicolai	None	Low	+				P
Hydroporus nigrita (Fabricius)	None	Low	+				P
Hydroporus obscurus Sturm	None	Low	+				P
Hydroporus obsoletus Aube	Nb	Moderate				Subterranean	P
Hydroporus palustris (Linnaeus)	None	Low	+	+			P
Hydroporus planus (Fabricius)	None	Low	+				P
Hydroporus pubescens (Gyllenhal)	None	Low	+				P
Hydroporus tessellatus Drapiez	None	Moderate	+				P
Stictonectes lepidus (Olivier)	Nb	Moderate	+				P
Graptodytes pictus (Fabricius)	None	Moderate	+				P
***Deronectes latus* (Stephens)**	**Nb**	**Total**			**+**		**P**
***Nebrioporus depressus elegans* (Panzer)**	**None**	**High**		**+**	**+**		**P**
***Oreodytes davisii* (Curtis)**	**Nb**	**Total**			**+**		**P**
***Oreodytes sanmarkii* (Sahlberg)**	**None**	**High**			**+**		**P**
***Oreodytes septentrionalis* (Sahlberg)**	**None**	**High**		**+**	**+**		**P**
Scarodytes halensis (Fabricius)	Nb	Moderate	+				P
***Platambus maculatus* (Linnaeus)**	**None**	**High**			**+**		**P**
Agabus bipustulatus (Linnaeus)	None	Low	+				P
***Agabus biguttatus* (Olivier)**	**Nb**	**High**			**+**		**P**

***Agabus brunneus* (Fabricius)**	**RDB2**	**Total**			**+**		**P**
***Agabus didymus* (Olivier)**	**None**	**Total**	**+**				**P**
***Agabus guttatus* (Paykull)**	**None**	**Total**	**+**		**+**		**P**
Agabus nebulosus (Forster)	None	Low	+				P
***Agabus paludosus* (Fabricius)**	**None**	**High**	**+**				**P**
Agabus sturmii (Gyllenhal)	None	Low	+				P
Ilybius fuliginosus (Fabricius)	None	Moderate	+				P
Colymbetes fuscus (Linnaeus)	None	Low	+				P
Dytiscus marginalis Linnaeus	None	Low	+				P
Dytiscus semisulcatus Mueller	None	Moderate	+				P
Gyrinidae							
Gyrinus aeratus Stephens	Nb	Low				Pools	AL
Gyrinus substriatus Stephens	None	Low	+				P
***Gyrinus urinator* Illiger**	**Nb**	**High**				**Shade**	**AL**
***Orectochilus villosus* (Mueller)**	**None**	**High**			**+**		**P**
Georissidae							
***Georissus crenulatus* (Rossi)**	**Na**	**High**	**+**	**+**			**ALP**
Hydrochidae							
***Hydrochus nitidicollis* Mulsant**	**RDB3**	**High**	**+**		**+**		**ALP**
Helophoridae							
Helophorus aequalis Thomson	None	Low	+				ALP
***Helophorus arvernicus* Mulsant**	**Nb**	**Total**	**+**	**+**			**ALP**
Helophorus brevipalpis Bedel	None	Low	+				ALP
Helophorus flavipes Fabricius	None	Low	+				ALP
Helophorus grandis Illiger	None	Low	+				ALP
Helophorus griseus Herbst	Nb	Low	+				ALP
Helophorus minutus Fabricius	None	Low	+				ALP
Helophorus obscurus Mulsant	None	Low	+				ALP
Helophorus strigifrons Thomson	Nb	Moderate	+				ALP
Hydrophilidae							
Hydrobius fuscipes (Linnaeus)	None	Low	+				ALP
***Anacaena bipustulata* (Marsham)**	**Nb**	**High**	**+**				**ALP**
Anacaena globulus (Paykull)	None	Moderate	+				ALP
Anacaena limbata (Fabricius)	None	Moderate	+				ALP
Anacaena lutescens Stephens	None	Low	+				ALP
***Laccobius atrocephalus* Reitter**	**Nb**	**High**	**+**				**ALP**
Laccobius bipunctatus (Fabricius)	None	Low	+				ALP
Laccobius sinuatus Motschulsky	Nb	Moderate	+				ALP
***Laccobius striatulus* (Fabricius)**	**None**	**High**	**+**				**ALP**
***Cercyon bifenestratus* Kuster**	**Na**	**High**		**+**			**ALP**
Cercyon convexiusculus Stephens	Nb	Moderate	+				ALP
Cercyon marinus Thomson	None	Moderate	+				ALP
Cercyon tristis (Illiger)	Nb	Moderate	+				ALP
Cercyon ustulatus (Preyssler)	Nb	Moderate	+				ALP
***Chaetarthria similis* Wollaston**	**RDBK**	**High**	**+**		**+**		**A**

Hydraenidae							
Ochthebius bicolon Germar	Nb	High	+				ALP
Ochthebius dilatatus Stephens	None	Low	+				ALP
Ochthebius exsculptus Germar	Nb	Total	+		+		ALP
Ochthebius minimus (Fabricius)	None	Low	+				ALP
Hydraena gracilis Germar	None	Total			+		ALP
Hydraena minutissimus Stephens	Nb	High				Moss	ALP
Hydraena nigrita Germar	Nb	Total	+				ALP
Hydraena pulchella Germar	RDB3	Total	+				ALP
Hydraena pygmaea Waterhouse	RDB3	Total	+		+		ALP
Hydraena riparia Kugelann	None	High	+				ALP
Hydraena rufipes Curtis	Nb	High	+		+		ALP
Hydraena testacea Curtis	Nb	Moderate	+				ALP
Limnebius nitidus (Marsham)	Nb	Moderate	+				ALP
Limnebius papposus Mulsant	Nb	Low	+				ALP
Limnebius truncatellus (Thunberg)	None	Low	+	+	+		ALP
Ptiliidae							
Acrotrichis henrici (Matthews)	None	Moderate	+				A
Acrotrichis sitkaensis (Motschulsky)	None	Moderate	+				A
Actidium aterrimum (Motschulsky)	RDBK	Total		+	+		A
Ptenidium brenskei Flach	Notable	Total			+		A
Ptenidium longicorne Fuss	None	Total?	+	+			A
Staphylinidae							
Lesteva hanseni Lohse	Notable	High				Moss	A
Lesteva heeri Fauvel	None	Moderate	+			Moss	A
Lesteva longoelytra (Goeze)	None	High	+	+	+		A
Lesteva monticola Kiesenwetter	None	Moderate				Moss	A
Lesteva pubescens Mannerheim	None	High	+				A
Lesteva punctata Erichson	None	High				Moss	A
Geodromicus nigrita (Mueller)	None	Total?			+		A
Deleaster dichrous (Gravenhorst)	Nb	High	+	+	+		A
Bledius annae Sharp	None	Total?		+			A
Bledius arcticus Sahlberg	RDBI	Total?	?	?	?		A
Bledius defensus Fauvel	RDBK	High		+			A
Bledius erraticus Erichson	RDBK	High	+	+			A
Bledius filipes Sharp	RDB1	High?		+			A
Bledius gallicus (Gravenhorst)	None	High	+	+			A
Bledius longulus Erichson	None	Moderate		+			A
Bledius pallipes (Gravenhorst)	None	High	+	+			A
Bledius subterraneus Erichson	None	Total?		+			A
Bledius terebrans (Schiodte)	RDBK	High		+			A
Ochthephilus andaluciacus (Fagel)	Notable	Total?	?	?	?		A
Ochthephilus aureus (Fauvel)	None	Total?			+		A
Ochthephilus omalinus (Erichson)	None	Total?			+		A
Ochthephilus venustulus (Rosenhauer)	Notable	Total?			+		A
Thinodromus arcuatus (Stephens)	None	Total	+	+	+		A
Carpelimus bilineatus Stephens	None	High	+				A
Carpelimus corticinus (Gravenhorst)	None	Moderate	+				A
Carpelimus fuliginosus (Gravenhorst)	Notable	?	?	?	?		A
Carpelimus gracilis (Mannerheim)	None	High	+	+	+		A

Capelimus impressus (Bois. & Lac.)	None	High	+				A
Carpelimus lindrothi Palm	Notable	High	+				A
Carpelimus obesus (Kiesenwetter)	Notable	Total?	+				A
Carpelimus rivularis (Motsculsky)	None	High	+	+			A
Carpelimus similis (Smetana)	Notable	High	+	+			A
Carpelimus subtilicornis (Roubal)	None	Total?	+	+			A
Carpelimus subtilis (Erichson)	Notable	High	+	+	+		A
Carpelimus zealandicus (Sharp)	None	High	+	+			A
Thinobius bicolor Joy	Na	Total			+		A
Thinobius brevipennis Kiesenwetter	RDBK	?	+	+			A
Thinobius crinifer Smetana	Notable	Total			+		A
Thinobius longipennis (Heer)	None	Total			+		A
Thinobius major Kraatz	RDBK	Total			+		A
Thinobius newberyi Scheerpeltz	RDBI	Total			+		A
Thinobius praetor Smetana	Notable	Total			+		A
Platystethus alutaceus Thomson	None	Moderate	+				A
Platystethus cornutus (Gravenhorst)	None	High	+				A
Platystethus degener Mulsant & Rey	None	High	+				A
Platystethus nitens (Sahlberg)	None	High	+				A
Platystethus nodifrons (Mannerheim)	Notable	High	+				A
Anotylus rugosus (Fabricius)	None	Moderate	+	+	+		A
Oxytelus fulvipes Erichson	Na	High	+				A
Stenus argus Gravenhorst	Nb	High	+				A
Stenus bifoveolatus Gyllenhal	None	Moderate	+				A
Stenus biguttatus (Linnaeus)	None	?	+				A
Stenus bimaculatus Gyllenhal	None	Moderate	+				A
Stenus boops Ljungh	None	Moderate	+				A
Stenus calcaratus Scriba	RDBK	High	+				A
Stenus canaliculatus Gyllenhal	None	High	+				A
Stenus carbonarius Gyllenhal	Nb	High	+				A
Stenus cicindeloides (Schaller)	None	Moderate	+				A
Stenus comma LeConte	None	High		+	+		A
Stenus guttula Mueller	None	High			+		A
Stenus guyemeri Jacquelin du Val	None	High			+	Moss	A
Stenus incanus Erichson	RDBK	High	+				A
Stenus juno (Paykull)	None	Moderate	+				A
Stenus latifrons Erichson	None	Moderate	+				A
Stenus melanopus (Marsham)	None	Moderate	+				A
Stenus pallitarsis Stephens	None	Moderate	+				A
Stenus pubescens Stephens	None	Moderate	+				A
Stenus pusillus Stephens	None	Moderate	+				A
Stenus solutus Erichson	None	Moderate	+				A
Stenus tarsalis Ljungh	None	High	+				A
Dianous coerulescens (Gyllenhal)	None	High			+	Moss	A
Paederus littoralis Gravenhorst	None	Moderate	+	+	+		A
Lathrobium angustatum Bois. & Lac.	Nb	High			+		A
Lathrobium angusticolle Bois. & Lac.	Nb	High			+		A
Lathrobium brunnipes (Fabricius)	None	Low	+				A
Lathrobium dilutum Erichson	RDB3	High			+		A
Lathrobium elongatum (Linnaeus)	None	Moderate	+				A
Lathrobium fulvipenne (Gravenhorst)	None	Moderate	+				A
Lathrobium geminum Kraatz	None	Moderate	+				A

Lathrobium multipunctum Gravenhorst	None	Moderate	+				A
***Lathrobium pallidum* von Nordmann**	**RDBK**	**Total?**		+	+		**A**
Lathrobium quadratum (Paykull)	None	Moderate	+				A
Lathrobium ripicola Czwalina	Notable	Moderate	+				A
Achenium depressum (Gravenhorst)	None	?	?	?	?		A
Achenium humile (Nicolai)	Nb	?	?	?	?		A
***Medon ripicola* (Kraatz)**	**Notable**	**High**		+			**A**
Sunius bicolor (Olivier)	RDBK	?	?	?	?		A
***Scopaeus gracilis* (Sperk)**	**RDBK**	**Total?**			+		**A**
Scopaeus sulcicollis (Stephens)	None	Moderate	+	+	+		A
Rugilus fragilis (Gravenhorst)	Notable	?	?	?	?		A
Xantholinus linearis (Olivier)	None	Low	+	+	+		A
Xantholinus longiventris Heer	None	Moderate	+				A
Neobisnius procerulus (Gravenhorst)	RDBK	?	?	?	?		A
***Neobisnius prolixus* (Erichson)**	**RDBK**	**Total?**			+		**A**
***Neobisnius villosulus* (Stephens)**	**None**	**Total?**	+	+			**A**
***Erichsonius signaticornis* (Mulsant & Rey)**	**Nb**	**Total?**		+	+		**A**
***Philonthus atratus* (Gravenhorst)**	**Na**	**Total?**		+			**A**
***Philonthus micantoides* Benick & Lohse**	**None**	**High**	+				**A**
Philonthus pullus von Nordmann	RDBI	?	?	?	?		A
***Philonthus punctus* (Gravenhorst)**	**RDB3**	**High**	+				**A**
***Philonthus quisquiliarius* (Gyllenhal)**	**None**	**High**	+	+	+		**A**
***Philonthus rotundicollis* (Menetries)**	**None**	**High**	+				**A**
***Philonthus rubripennis* Stephens**	**None**	**Total?**			+		**A**
Philonthus umbratilis (Gravenhorst)	None	Low	+				A
***Gabrius astutoides* (Strand)**	**RDBI**	**High**	?	?	?		**A**
***Gabrius bishopi* Sharp**	**Nb**	**High**	+	+			**A**
***Gabrius nigritulus* (Gravenhorst)**	**None**	**High**		+			**A**
***Gabrius pennatus* Sharp**	**None**	**High**	+				**A**
Gabrius subnigritulus (Reitter)	None	?	+				A
***Gabrius velox* Sharp**	**Nb**	**High**	+				**A**
***Quedius auricomus* Kiesenwetter**	**Nb**	**High**				**Moss**	**A**
Quedius maurorufus (Gravenhorst)	None	Low	+				A
***Quedius plancus* Erichson**	**Na**	**Total?**	+				**A**
***Quedius riparius* Kellner**	**RDBK**	**High**				**Moss**	**A**
Tachyporus chrysomelinus (Linnaeus)	None	Low	+	+	+		A
Tachyporus dispar (Paykull)	None	Low	+	+	+		A
Tachyporus hypnorum (Fabricius)	None	Low	+	+	+		A
Tachyporus nitidulus (Fabricius)	None	Low	+	+	+		A
Tachyporus obtusus (Linnaeus)	None	Moderate	+	+	+		A
Tachyporus pallidus Sharp	None	Moderate	+				A
Tachyporus solutus Erichson	None	Low	+				A
Tachinus signatus Gravenhorst	None	Low	+				A
***Deinopsis erosa* (Stephens)**	**None**	**High**	+				**A**
***Myllaena elongata* (Matthews)**	**Notable**	**High**	+	+	+		**A**
Hygronoma dimidiata (Gravenhorst)	None	Moderate	+				A
Falagria sulcatula (Gravenhorst)	Notable	?	+				A
***Tachyusa atra* (Gravenhorst)**	**None**	**High**	+				**A**
***Tachyusa coarctata* Erichson**	**Notable**	**High**	+				**A**
***Tachyusa constricta* Erichson**	**None**	**High**	+	+			**A**
***Tachyusa leucopus* (Marsham)**	**None**	**High**	+	+			**A**
***Tachyusa scitula* Erichson**	**RDBK**	**Total?**	?	?	?		**A**

Tachyusa umbratica Erichson	None	Total?	+	+		A
Gnypeta caerulea (Sahlberg)	Notable	Total?	+			A
Gnypeta carbonaria (Mannerheim)	None	High	+			A
Gnypeta ripicola (Kiesenwetter)	Notable	High	+			A
Gnypeta rubrior Tottenham	None	High	+			A
Gnypeta velata (Erichson)	Notable	High	+	+		A
Brachyusa concolor (Erichson)	Notable	High	+			A
Hydrosmecta delicatula (Sharp)	RDBK	Total?			+	A
Hydrosmecta eximia (Sharp)	None	Total?			+	A
Hydrosmecta fragilis (Kraatz)	Notable	Total?			+	A
Hydrosmecta thinibiodes (Kraatz)	Notable	High			+	A
Hydrosmectina septentrionum Benick	Notable	Total?		+	+	A
Aloconota cambrica (Wollaston)	None	Total?			+	A
Aloconota currax (Kraatz)	None	Total?			+	A
Aloconota eichoffi (Scriba)	Notable	Total?			+	A
Aloconota gregaria (Erichson)	None	Moderate	+	+	+	A
Aloconota insecta (Thomson)	None	High	+	+	+	A
Aloconota mihoki Bernhauer	RDBI	?	?	?	?	A
Aloconota planifrons (Waterhouse)	RDBK	High			+	A
Aloconota subgrandis (Brundin)	RDBK	?	?	?	?	A
Aloconota sulcifrons (Stephens)	None	High	+	+	+	A
Amischa analis (Gravenhorst)	None	Low	+			A
Dochmonota clancula (Erichson)	Notable	High	+			A
Liogluta nitidula (Kraatz)	None	Moderate	+			A
Atheta autumnalis (Erichson)	RDBK	Total?	+			A
Atheta basicornis (Mulsant & Rey)	Notable	High	+			A
Atheta debilis (Erichson)	None	?	?	?	?	A
Atheta deformis (Kraatz)	Notable	?	?	?	?	A
Atheta elongatula (Gravenhorst)	None	High	+	+		A
Atheta fungi (Gravenhorst)	None	Low	+			A
Atheta graminicola (Gravenhorst)	None	Moderate	+	+		A
Atheta gyllenhali (Thomson)	None	High	+			A
Atheta hygrobia (Thomson)	Notable	High	+			A
Atheta hygrotopora (Kraatz)	None	High	+	+	+	A
Atheta laticollis (Stephens)	None	Low	+			A
Atheta luridipennis (Mannerheim)	None	High	+			A
Atheta luteipes (Erichson)	None	High	+			A
Atheta malleus Joy	None	High	+			A
Atheta melanocera (Thomson)	None	High	+			A
Atheta nannion Joy	RDBK	?	?	?	?	A
Atheta obfuscata (Gravenhorst)	Notable	High	+			A
Atheta scotica (Elliman)	Notable	Total?			+	A
Atheta vilis (Erichson)	None	High	+			A
Atheta volans (Scriba)	None	High	+			A
Alianta incana (Erichson)	None	Moderate	+			A
Pachnida nigella (Erichson)	None	Moderate	+			A
Ilyobates propinquus (Aube)	Notable	?	+			A
Ilyobates subopacus Palm	Notable	?	+			A
Calodera aethiops (Gravenhorst)	None	High	+			A
Calodera nigrita Mannerheim	Notable	High	+			A
Calodera riparia Erichson	Notable	High	+			A
Calodera uliginosa Erichson	RDBK	High	+			A

Chiloporata longitarsis (Erichson)	None	High	+	+	+	A
Chiloporata rubicunda (Erichson)	Notable	Total?	+	+	+	A
Ocalea latipennis Sharp	None	?	?	?	?	A
Ocalea rivularis Miller	None	?	+			A
Meotica anglica Benick	Notable	High	+	+	+	A
Oxypoda brachyptera (Stephens)	None	Low	+	+	+	A
Oxypoda elongatula Aube	None	Moderate	+			A
Oxypoda exoleta Erichson	Notable	High	+	+	+	A
Oxypoda lentula Erichson	None	High	+			A
Oxypoda nigrocincta Mulsant & Rey	RDBI	High	+			A
Oxypoda riparia Fairmaire	RDBK	?	?	?	?	A
Oxypoda soror Thomson	Notable	?	?	?	?	A
Aleochara brevipennis (Gravenhorst)	Notable	High	?	?	?	A
Pselaphidae						
Bibloplectus minutissimus Aube	RDBK	Total?			+	A
Brachygluta pandellei (Saulcy)	RDBK	Total?			+	A
Scarabaeidae						
Aegialia sabuleti (Panzer)	Nb	Moderate		+	+	A
Scirtidae						
Hydrocyphon deflexicollis (Mueller)	Nb	High			+	A
Heteroceridae						
Heterocerus fenestratus (Thunberg)	None	High	+			A
Heterocerus marginatus (Fabricius)	None	High	+			A
Limnichidae						
Limnichus pygmaeus (Sturm)	Na	High	+			A
Dryopidae						
Dryops ernesti des Gozis	None	Moderate	+			A
Dryops luridus (Erichson)	None	Low	+		+	A
Dryops nitidulus (Heer)	RDB3	Moderate		+	+	A
Elmidae						
Elmis aenea (Mueller)	None	Total		+	+	P
Esolus parallelepipedus (Mueller)	None	Total		+	+	P
Limnius volckmari (Panzer)	None	Total			+	P
Normandia nitens (Mueller)	RDB2	Total			+	P
Oulimnius major (Rey)	Na	High	+			P
Oulimnius rivularis (Rosenhauer)	Na	Total	+			P
Oulimnius troglodytes (Gyllenhal)	Nb	High	+	+		P
Oulimnius tuberculatus (Mueller)	None	High	+	+		P
Riolus cupreus (Mueller)	Nb	High	+	+		P
Riolus subviolaceus (Mueller)	Nb	Total	+	+		P
Stenelmis canaliculata (Gyllenhal)	RDB2	High			+	P

Elateridae							
***Fleutiauxellus maritimus* (Curtis)**	**Na**	**High**		**+**	**+**		**A**
Hypnoides riparius (Fabricius)	None	Moderate	+				A
***Negastrius pulchellus* (Linnaeus)**	**RDB2**	**High**		**+**	**+**		**A**
***Negastrius sabulicola* (Boheman)**	**RDB2**	**High**		**+**	**+**		**A**
***Zorochros minimus* (Bois. & Lac.)**	**None**	**High**		**+**	**+**		**A**
Rhizophagidae							
***Cyanostolus aeneus* (Richter)**	**Na**	**High**				**Bark**	**A**
Rhizophagus picipes (Olivier)	Na	Moderate				Bark	A
Cryptophagidae							
***Paramecosoma melanocephalum* (Herbst)**	**None**	**High**				**Refuse**	**A**
Coccinellidae							
Anisostricta novemdecimpunctata (Linn.)	None	Moderate	+				A
***Coccinella quinquepunctata* Linnaeus**	**RDB3**	**Total**			**+**		**A**
Coccidula rufa (Herbst)	None	Moderate	+				A
Coccidula scutellata (Herbst)	None	Moderate	+				A
Chrysomelidae							
Altica lythri Aube	None	Low	+				A
Donacia simplex Fabricius	None	Moderate	+				A
Galerucella calmariensis (Linnaeus)	None	?	?	?	?		A
Galerucella sagittariae (Gyllenhal)	None	Moderate	+				A
Gastrophysa viridula (DeGeer)	None	Low	+				A
Oulema melanopa (Linnaeus)	None	Low	+	+	+		A
Phaedon armoraciae (Linnaeus)	None	Moderate	+				A
Phaedon cochleariae (Fabricius)	None	Moderate	+				A
Prasocuris junci (Brahm)	None	Moderate	+				A
Psylliodes affinis (Paykull)	None	Low	+				A
Curculionidae							
***Baris lepidii* Germar**	**Na**	**High**	**+**				**A**
Notaris acridulus (Linnaeus)	None	Moderate	+				A
Notaris bimaculatus (Fabricius)	Nb	Moderate	+				A
Notaris scirpi (Fabricius)	Nb	Moderate	+				A
Poophagus sisymbrii (Fabricius)	None	Moderate	+				A
Thryogenes festucae (Herbst)	None	Moderate	+				A
Hemiptera							
Dipsocoridae							
***Cryptostemma alienum* Herrich-Schaeffer**	**None**	**Total?**			**+**		**A**
Saldidae							
***Saldula c-album* (Fieber)**	**None**	**Total?**			**+**		**AL**
Salda littoralis (Linnaeus)	None	Moderate	+				AL
***Saldula fucicola* (Sahlberg)**	**Notable**	**High**			**+**		**AL**
Saldula saltatoria (Linnaeus)	None	Moderate	+				AL
***Saldula scotica* (Curtis)**	**None**	**Total?**			**+**		**AL**

Hydrometridae						
Hydrometra stagnorum **(Linnaeus)**	**None**	**High**	+	+		**A**
Diptera						
Asilidae						
Rhadiurgus variabilis **(Zetterstedt)**	**RDB3**	**High**			+	**A**
Empididae						
Chersodromia cursitans (Zetterstedt)	Nb	?	?	?	?	A
Heleodromia irwini	pRDB1	?	?	?	?	A
Hemerodromia laudatoria Collin	Nb	?	?	?	?	A
Tachydromia acklandi Chvala	pRDB2	?	?	?	?	A
Tachydromia halidayi (Collin)	pRDB3	?	?	?	?	A
Tachydromia woodi (Collin)	pRDB2	?	?	?	?	A
Wiedemannia phantasma Mik	pRDB3	?	?	?	?	A
Dolichopodidae						
Rhaphium fractum Loew	Nb	?	?	?	?	A
Rhaphium gravipes Haliday	Nb	?	?	?	?	A
Rhaphium nasutum Fallen)	Nb	?	?	?	?	A
Rhaphium patulum (Raddatz)	Nb	?	?	?	?	A
Rhaphium rivale (Loew)	Nb	?	?	?	?	A
Lauxaniidae						
Homoneura limnea (Becker)	RDB2	?	?	?	?	A
Micropezidae						
Calobata stylifera Loew	pRDB3	?	?	?	?	A
Therevidae						
Psilocephala rustica **(Panzer)**	**RDB3**	**High**		+	+	**A**
Thereva handlirschi **Krober**	**RDB3**	**High**	+	+	+	**A**
Thereva inornata **Verrall**	**RDB3**	**High**	+	+	+	**A**
Thereva lunulata **Zetterstedt**	**RDB3**	**High**		+	+	**A**
Thereva valida Loew	RDB3	Moderate	+	+	+	A
Tipulidae						
Arctoconopa melampodia **(Loew)**	**RDB2**	**High**		+		**A**
Dicranota robusta **Lundstroem**	**Notable**	**High**		+	+	**A**
Dicranota simulans **Lackschewitz**	**RDB3**	**High**			+	**A**
Erioptera edwardsii **(Lackschewitz)**	**RDBI**	**High**			+	**A**
Erioptera limbata **Loew**	**RDB2**	**High**		+		**A**
Erioptera meigeni **(Zetterstedt)**	**RDB3**	**High**		+	+	**A**
Erioptera nigripalpis **Goetghebuer**	**RDB3**	**High**	+			**A**
Erioptera pusilla **(Schiner)**	**RDB1**	**High**		+	+	**A**
Gonomyia edwardsi	pRDBK	?	?	?	?	A
Gonomyia punctata **Edwards**	**RDB2**	**High**		+		**A**
Limnophila apicata **(Loew)**	**Notable**	**High**	+	+	+	**A**
Limnophila mundata **(Loew)**	**Notable**	**High**	+	+	+	**A**
Limonia omissinervis **(de Meijere)**	**RDB2**	**High**		+		**A**
Molophilus propinquus **(Egger)**	**Notable**	**High**		+		**A**

***Nephrotoma aculeata* (Loew)**	**RDB2**	**High**		**+**		**A**
***Nephrotoma dorsalis* (Fabricius)**	**Notable**	**High**		**+**		**A**
***Nephrotoma lunulicornis* (Schummel)**	**Notable**	**High**		**+**		**A**
Nephrotoma submaculosa Edwards	None	?	?	?	?	A
Rhabdomastix edwardsi Tjeder	None	?	?	?	?	A
***Rhabdomastix hilaris* Edwards**	**RDB3**	**High**		**+**		**A**
***Rhabdomastix inclinata* Edwards**	**RDB2**	**High**		**+**		**A**
***Tipula bistilata* Lundstroem**	**RDB2**	**High**		**+**		**A**
***Tipula dilatata* Schummel**	**RDB2**	**High**		**+**		**A**
Araneae						
Gnaphosidae						
Drassodes cupreus (Blackwall)	None	Low	+	+	+	A
Zelotes latreille (Simon)	None	Low	+	+	+	A
Micaria pulicaria (Sundevall)	None	Low	+	+	+	A
Clubionidae						
Clubiona phragmitis Koch	None	Low	+			A
Thomisidae						
Xysticus ulmi (Hahn)	None	Low	+			A
Lycosidae						
***Pardosa agricola* (Thorell)**	**None**	**High**	+	+	+	**A**
Pardosa amentata (Clerck)	None	Low	+	+	+	A
Pardosa nigriceps (Thorell)	None	Low	+	+	+	A
Pardosa palustris (Linnaeus)	None	Low	+	+	+	A
Trochosa ruricola (DeGeer)	None	Low	+	+	+	A
Trochosa terricola Thorell	None	Low	+	+	+	A
***Arctosa cinerea* (Fabricius)**	**Nb**	**High**			+	**A**
Arctosa perita (Latreille)	None	Low		+		A
Pirata piraticus (Clerck)	None	Low	+			A
Argyronetidae						
Argyroneta aquatica (Clerck)	None	Low	+			A
Hahniidae						
Antistea elegans (Blackwall)	None	Low	+			A
Tetragnathidae						
Pachygnatha clercki Sundevall	None	Low	+	+	+	A
Pachygnatha degeeri Sundevall	None	Low	+	+	+	A

Linyphiidae

Walckenaeria acuminata Blackwall	None	Low	+	+	+	A
Walckenaeria alticeps (Denis)	None	Low	+			A
Walckenaeria cuspidata (Blackwall)	None	Low	+	+	+	A
Walckenaeria nudipalpis (Westring)	None	Low	+	+	+	A
Walckenaeria unicornis Cambridge	None	Low	+	+	+	A
Pocadicnemis pumila (Blackwall)	None	Low	+	+	+	A
Gnathonarium dentatum (Wider)	None	Moderate	+			A
Hypomma bituberculatum (Wider)	None	Moderate	+			A
Baryphyma pratense (Blackwall)	None	Low	+			A
Baryphyma trifrons (Cambridge)	None	Low	+			A
Oedothorax agrestis (Blackwall)	None	Low	+			A
Oedothorax apicatus (Blackwall)	None	Moderate			+	A
Oedothorax fuscus (Blackwall)	None	Low	+	+	+	A
Oedothorax gibbosus (Blackwall)	None	Low	+			A
Oedothorax retusus (Westring)	None	Low	+	+	+	A
Lophomma punctatum (Blackwall)	None	Moderate	+			A
Savignya frontata (Blackwall)	None	Low	+	+	+	A
***Diplocephalus connatus* Bertkau**	**RDB2**	**Total**			**+**	**A**
Diplocephalus cristatus (Blackwall)	None	Low	+	+	+	A
Diplocephalus picinus (Blackwall)	None	Low	+	+	+	A
***Diplocephalus protuberans* (Cambridge)**	**None**	**High**	**?**	**?**	**?**	**A**
Erigone atra (Blackwall)	None	Low	+	+	+	A
Erigone dentipalpis (Wider)	None	Low	+	+	+	A
Donacochara speciosa (Thorell)	None	Moderate	+			A
Leptorhoptrum robustum (Westring)	None	Moderate	+			A
Halorates distinctus (Simon)	None	Moderate	+			A
***Caviphantes saxetorum* (Hull)**	**Nb**	**Total**			**+**	**A**
Centromerus persimilis (Cambridge)	RDBK	Moderate			+	A
Centromerita bicolor (Blackwall)	None	Low	+	+	+	A
Tallusia experta (Cambridge)	None	Low	+			A
Bathyphantes approximatus (Cambridge)	None	Low	+	+	+	A
Bathyphantes gracilis (Blackwall)	None	Low	+	+	+	A
Kaestneria pullata (Cambridge)	None	Low	+			A
Lepthyphantes mengei Kulczynski	None	Low	+	+	+	A
Lepthyphantes pallidus (Cambridge)	None	Low	+	+	+	A
Lepthyphantes tenuis (Blackwall)	None	Low	+	+	+	A
Lepthyphantes zimmermanni Bertkau	None	Low	+	+	+	A
Allomengea scopigera (Grube)	None	Low	+			A
Allomengea vidua (Koch)	None	Low	+			A

APPENDIX B

DRAFT ERS INVERTEBRATE HANDBOOK

1. INTRODUCTION

Rivers and streams are amongst the most valued elements of our landscape. In many lowland areas they represent an isolated strand of semi-natural habitat in a sea of intensive agriculture and urban development. The wealth of their aquatic life is widely recognised and in recent years there has been a welcome growth in the number of initiatives designed to conserve aquatic plants, invertebrates, fish and their environment.

Rivers also support rich and varied wildlife communities well away from the aquatic environment. Ecologists are increasingly turning their attention to the riparian zone and beyond to the floodplain. Much of the interest has centred on the important role of riparian areas in supplying nutrients and organic matter to the aquatic ecosystem. However, it is now apparent that these areas contain communities of plants, birds and mammals which are important in their own right. The conservation value of the riparian zone has recently been highlighted in studies of two threatened and declining mammal species, the otter and the water vole. Furthermore, it is now known that terrestrial invertebrates are a rich source of riparian biodiversity. There are far more species by rivers and streams than in them. Several hundred species of terrestrial invertebrate specialise in living in semi-aquatic habitats such as river margins and floodplain wetlands.

The wealth of insects and spiders living along riverbanks has long been known to specialist entomologists. This handbook breaks new ground in making information on these neglected animals available for use in planning the management of river systems. It deals with one of the most important riverbank features for terrestrial invertebrates, exposed riverine sediments (ERS). ERS are shoals of sediment deposited by rivers and streams in times of spate and flood and become exposed during lower, more normal flow. ERS do not only occur by fast-flowing rivers draining hilly areas, where they are readily seen, but also occur by slow-flowing, lowland rivers where they are not so obvious and of a different composition.

This handbook examines the types of sediment found by British and Irish rivers and the factors affecting sediment composition. Invertebrate habitat requirements are explained and the use of various conservation evaluation criteria discussed. Advice on survey techniques is included. The natural and human influences on sediment and invertebrate distributions are considered and a number of positive approaches to management are suggested.

Current knowledge of ERS invertebrates is based on only a few studies in localised areas, sometimes in climates somewhat different from Britain such as central and northern Norway. Further research is urgently required, especially on the effects of different river management practices. However, the information contained in this handbook is based on our present knowledge and is a good basis for taking much-needed action to preserve an important but neglected element of our native wildlife.

2. ERS PHYSICAL CHARACTERISTICS

2.1 Definition

In this handbook, ERS are taken to be mounds of sediment which have recently been deposited in any channel of flowing water and then subsequently exposed by reduced water levels. A variety of terms are used for them including shoals, bars, berms, spits, sandbanks and shingle-banks. ERS are found under the main riverbank although large ERS may grade into the adjacent floodplain. There is often an easily observable boundary between an ERS and the adjacent floodplain. Normally the adjacent land use does not extend onto the ERS, although grazing stock may move onto ERS from surrounding pasture, either for feeding or access to water.

ERS are subject to repeated scourings by floods followed by fresh sedimentary deposition. Consequently, ERS vegetation undergoes a cycle regulated by frequency of flooding. During floods, plant material above ground is either removed or covered with fresh deposits to leave areas of bare ground. The vegetation then grows up again until it is removed by the next flood. At the top of large ERS flooding may be relatively infrequent and here vegetational succession may become quite advanced, leading to the presence of trees such as sallows and willow.

ERS also occur along secondary channels. These channels may only become filled during high floods and then ERS become difficult to distinguish from floodplain habitats. Vegetational succession may be advanced on ERS in secondary channels and in headwaters which suffer from relatively infrequent and mild flooding.

Limestone and chalk streams, winterbournes and headwaters, may dry up on the surface in the summer. Technically, the entire riverbed then becomes ERS.

2.2 ERS Formation

The faster the flow of a river, the more sediment it carries. Sediment is deposited when the flow slows down. ERS are therefore found in those parts of the stream where water is relatively slow flowing. A typical place for an ERS is just downstream of a bend. On the outside of a bend the water flows relatively quickly and the bank is usually steep-sided and actively eroding. On the inside of the bend the water flows more slowly, allowing deposition of a point-bar. Changes in gradient also lead to ERS formation. As the gradient flattens, the flow rate is reduced leading to sedimentary deposition which can result in the formation of a fan. In the resulting braided stream, ERS can form as mid-channel bars.

Braided streams and meanders which contain ERS are associated with flatter gradients and slower flows. There is less ERS in ravines and on steep inclines and where it does occur, it tends to be comprised of large particles such as boulders. ERS can also be found at river confluences where sediment is deposited as water from a tributary enters a slower main channel. Point bars on meander systems tend to be more stable with regard to position than mid-channel bars which can migrate down the river channel and become attached to the riverbank as lateral bars.

Large amounts of sediment are carried by rivers during floods. Fresh deposits are laid down on ERS during the period when the flood is subsiding. The particle size of the material deposited is related to the rate of flow of the water at the time of deposition. Cobbles and boulders are removed and laid down only by fast-flowing water, whereas silt is deposited by slow-flowing water.

Where water flows faster, usually in the upstream section of a river, the typical ERS is of coarse material which grades into finer material downstream as the flow rate becomes slower. However, reworking of ERS material leads to local discontinuities in substrate type, with areas of fine sediment interspersed with coarser sediment. Changes in flow pattern can lead to a net local erosion on part of an ERS. Large ERS can contain several secondary channels or chutes, leading to topographic complexity. Large continental rivers such as the Loire in France are bordered by ERS which can be several hundred metres wide and contain a bewildering array of sandhills, old channels and remnant pools.

Successive floods tend to be of unequal intensity and this may lead to silt, a finer sediment, being deposited over the top of sand, a coarser sediment. Conversely, pebbles are often found overlying a finer sediment such as sand. In secondary channels and oxbow lakes, where water stands in remnant pools during the summer, layers of undecayed organic litter deposited in stagnant water can be found interspersed with layers of silt brought in by winter floods.

The material laid down on ERS can originate from anywhere in the catchment upstream of the ERS. The composition of the ERS is therefore related to solid and drift geology over a wide area of the catchment. .Some features which look like ERS have a different origin. Steep eroding banks may slump into the channel either because they contain a spring or because they are poached by cattle. Even several years after cattle have been removed from a riverbank the results of their presence can still be evident in collapsed banks.

Abandoned channels, such as oxbows, can retain stagnant water for most of the year. These are subject to a vegetational succession proceeding through the build up of peat to fen and carr, or to bog in parts of western Britain. Flooding is important in retarding this succession. Scouring removes organic matter and deposition of sediment leads to the maintenance of marsh on mineral substrates.

2.3 ERS and River Hydrology

Due to seasonal changes in rainfall, most rivers in Britain tend to have higher flows in the winter than in the summer. The actual months of highest and lowest average discharge vary geographically, being slightly earlier in the west than in the east. The main exceptions to this pattern are found in some Scottish rivers which have a secondary peak in the spring due to snow-melt. Consequently, in most British rivers ERS becomes available for exploitation by terrestrial invertebrates in spring and is at its maximum extent in late summer or early autumn.

Superimposed on this seasonal variation in water levels are small-period fluctuations caused by individual cyclonic weather systems. It is these small-period fluctuations which give rise to the 'spatiness' of a river and create a natural disturbance factor to which ERS invertebrate communities are adapted. Spatiness varies from catchment to catchment and is related to rainfall, geology and land use and cover. Hard rock catchments with limited tree cover in the west of Britain tend to have a higher level of spatiness. Well-wooded chalk catchments, if they still existed, would regulate run-off to give a much lower level of spatiness.

Abandoned channels are usually subjected to much lower levels of spatiness. Their invertebrate communities tend to be less tolerant of disturbance than those by the main channel.

Spatiness of rivers is markedly affected by regulation. It is reduced in rivers regulated by impoundment and increased in the main channel of regraded and engineered rivers but decreased in the secondary channels outside embankments.

Different ERS types have different responses to spatiness. It is generally considered that the high flow events which have the greatest effect on channel morphology occur on average once every two or three years. However, ERS composed of sandy material are particularly vulnerable to scouring and their morphology will change on a more frequent basis. Conversely, ERS composed of boulders are more resistant to scouring and will be much more stable.

2.4 Impacts of River Management on ERS

River management practices affecting the number, size and composition of ERS are summarised below.

Management practice	*Effect*
Sediment removal	Loss of ERS
Bank resectioning	Loss of ERS
Channel straightening	Loss of ERS; coarser sediment due to faster flow
Impoundment (weirs, mills, fishing & navigation)	Finer sediment deposition due to slower flow, more permanent vegetation
Reservoir construction	Change of sediment type and extent of ERS downstream due to more regular flow
Navigation	Erosion of ERS and vegetation by wave action and mooring
Water abstraction	Increase in ERS area and transition to terrestrial habitat because of controlled flow
Sewage discharge	Organic deposition, change in type of vegetation and increase in cover
Flood alleviation	Transition of secondary channel ERS to terrestrial habitat

2.5 Impacts of Catchment-wide Processes

Events occurring in the catchment away from river channels undoubtedly have had considerable effects on rivers and their ERS. In the English midland rivers during the late bronze age, gravel depositions became superseded by depositions of red clay derived from Keuper Marl. This is believed to be due to deforestation followed by ploughing which released large amounts of fine sediments into the river systems. The *introduction* of silt and clay into lowland rivers continues to this day as a result of agriculture, mineral extraction and other developments such as road building which disturb large volumes of soil.

The present day domination of many lowland ERS by soft sediments may be a product of disturbance stretching back to prehistory. In their natural state, lowland ERS would probably contain coarser sediments. Afforestation of upland areas is also increasing sediment load of rivers but the long term effects are not known. The impacts of increased sediment load and the other results of catchment-wide land use operations are summarised below:

Impact	*Cause*	*Effect*
Siltation (increase in sediment load)	Deforestation, agriculture, mineral extraction, large engineering projects	Replacement of coarse sediments by fine sediments, larger area of ERS
Eutrophication	Fertiliser run-off from agricultural land	Change in vegetation type and increase in cover
Increased run-off	Urbanisation, land drainage	Increased flooding leading to greater scouring of ERS
Loss of floodplain wetland to agriculture	Drainage, infilling and tipping	Loss of ERS in secondary channels and oxbow lakes
Pond creation	Conversion of floodplain wetland to amenity ponds	Loss of ERS in secondary channels and oxbow lakes
Access by grazing stock	Adjacent unfenced pasture	Removal of vegetation, poaching

3. INVERTEBRATES OF ERS

3.1 Invertebrate Groups on ERS

At present 441 species of beetle, 7 bug species, 43 fly species and 57 spider species have been identified as being inhabitants of ERS, showing that a diverse invertebrate fauna occurs on these sediments. Just under a half of these species (48%) are only found on ERS or similar habitats. The conservation of these habitats should be a component of any national strategy to preserve biodiversity in the UK. Details of the different types of invertebrates on ERS are given below.

3.1.1 Beetles (Coleoptera)

Species in two families of beetle, ground and rove beetles (Carabidae and Staphylinidae) dominate the invertebrate assemblages on ERS. Two strategies are used by these beetles on ERS. Most are surface-active animals (epigeic) but some burrow into the sediment and live below the surface (fossorial). The major difference in activity in these two types of strategy is that the surface-active beetles leave the sediments in times of flood whilst the burrowers stay in the sediment and can withstand flooding episodes.

Few ground beetle species are burrowers and are mainly highly active animals with a considerable number in the genus *Bembidion.* Examples of species in the ground beetles genera *Elaphrus* and *Bembidion* are often very conspicuous, running around bare sediment in sunshine. Figure 3.1 shows *Bembidion bruxellense*, a ground beetle found on ERS and on other disturbed substrates.

Rove beetles (Staphylinidae) contain the largest number of species associated with ERS of any group. They can easily be recognised by their short wing cases, which leave most of the abdomen exposed. This body form is highly suited to a way of life spent predominantly on or under the ground, either under stones, in soil or in tangled vegetation. Many rove beetles on sediments live in the interstices between the particles, e.g. *Thinobius newberyi* (Figure 3.2) and others in this genus. The genus *Bledius* contains several species with powerful front legs for burrowing into softer sediments such as sand and clay. Species in the genus *Carpelimus* and in the subgenus *Philhygra* contain many small species which live in cracks in sediment. On the other hand, the genera *Stenus* and *Paederidius* contain large-eyed, long-legged, species which hunt by day over bare substrates in the manner of species in the ground beetle genera *Bembidion* and *Elaphrus*.

Water beetle species generally use ERS in a different manner to ground and rove beetles. A number will inhabit pools on large, complex sediments as adults (e.g. *Bidessus minutissimus*), and different species prefer open and vegetated sediments, but species in the families Haliplidae and Dytiscidae mainly use the sediments as pupation sites. The larvae of many Helophoridae and Hydrophilidae tend to be terrestrial, in damp sites, and utilise ERS. Elmid species (riffle beetles) tend to be found on wetter ERS, usually under the larger sediment particles whilst the adults of Hydraenidae are mainly found at the junction of the sediment and the water and a number are particularly fond of small, fine particles.

Beetle species in several other families are associated with ERS. The Heteroceridae species burrow into soft sediments and are often found in association with rove beetle species of the genus *Carpelimus*. A number of click beetle (Elateridae) species are confined to ERS preferring the drier areas. Only one ladybird species, *Coccinella quinquepunctata*, is a specific ERS species. Plant feeding beetle species on ERS include species of leaf beetle (Chrysomelidae) and species of weevil (Apionidae and Curculionidae) but only a few species have a high fidelity for ERS.

3.1.2 Bugs (Hemiptera)

The main family of bugs associated with ERS is the Saldidae or shore-bugs. Several species in the genera *Salda* and *Saldula* occur on a number of sediment types and are especially active in sunshine. A dipsocorid bug, *Cryptostemma alienum*, is a shingle specialist living in the interstices between stones. Several species normally considered to be water bugs such as the water-measurer, *Hydrometra stagnorum*, and the water-scorpion, *Nepa cinerea*, are regularly caught in pitfall traps and probably use ERS at night.

3.1.3 Flies (Diptera)

The Tipulidae, or crane-flies, is a large family whose larvae can be found in a variety of soils ranging from damp grassland to aquatic substrates. Species with aquatic larvae which live in streams include *Dolichopeza albipes*, *Tipula coeruleiventris* and *Dicranota* species. Many genera contain species with larva that develop in ERS, as do two species in the closely related family Ptychopteridae.

The larval habits of the owl midges (Psychodidae) are largely unknown but several species of the genus *Pericoma* live in streamside moss, whilst *Sycorax silacea* lives in moss on boulders by fast-flowing streams. The larvae of blackflies (Simuliidae) develop in flowing water. *Metacnephia amphora* is a species which specialises in chalk winterbournes which dry up in the summer. Species of the genus *Atherix* (Athericidae) have aquatic larvae which pupate under moss on ERS. Horsefly larvae of the genus *Chrysops* (Tabanidae) develop in wet silt or sand by rivers and streams. Adults and larvae of the soldier fly *Rhadiurgus variabilis* are associated with sand and shingle on ERS.

Species in the family Therevidae lay their eggs in soil where the larva develop as predators on beetle larvae, especially of click beetles. *Thereva lunulata*, and probably other riverside *Thereva* species, lay their eggs in dry sand high up on ERS, an area favoured by the click beetle species *Zorochros minimus* and its relatives. The Empididae includes several species of the genera *Chersodroma* and *Tachydromia* whose larvae develop in sandy ERS. Larvae of species in the subfamilies Hemerodromiinae and Clinocerinae are aquatic and live in streams and rivers. Some species live in wet moss growing on boulders in fast-flowing streams and by waterfalls. Adults of the related family Dolichopodidae are often conspicuous on the surface of wet mud by rivers and ponds.

A number of other poorly studied families contain species which live in wet mud by rivers and streams, especially when the sediments are organically enriched. These include species in the families Ceratopogonidae, Ephydridae, Muscidae, Sepsidae and Sphaeroceridae.

3.1.4 Spiders (Araneae)

There are only a few species of spiders which are limited to ERS. The normal method of spider dispersion, ballooning, means that most species have a limited ability to determine where they go to. One species of large wolf-spider, *Arctosa cinerea*, is found on large-particle ERS and is found on the more bouldery ERS in Wales, northern England and Scotland. *Caviphantes saxetorum* is a money-spider (Linyphiidae) is small and found under large, embedded boulders on exposed, rough ERS. The other spider species of ERS are those usually found on either open grassland in the case of bare sediments or those preferring damp, marshy sites on silty sediments.

3.1.5 Other invertebrates

Springtails (Collembola) are often conspicuous on ERS because of their relative abundance. Very little is known about the species which inhabit ERS but they almost certainly play an important role in the food chain. Some species of soil-nesting aculeate bees and wasps (Hymenoptera) are associated with riverbanks but they tend to nest in steep banks rather than on ERS proper.

3.2 ERS Invertebrate Life Histories

The seasonality of the life history of an insect species is often fairly plastic and can vary in different parts of its range. However, some generalisations about ERS species in Britain can be made.

Most ERS ground beetles (Carabidae) breed in the spring, which means that they overwinter as adults either on the highest parts of large ERS or on the riverbank above ERS. Some species fly a considerable distance to hibernation sites in woods and hedgerows. In spring, late April and May, they come down to the ERS to breed. By early July a large proportion of the adults have died off. The larvae develop and pupate on and in the ERS during the summer. On the emergence, the adults leave their pupation sites and seek hibernation sites. This means that peak ground beetle numbers appear in ERS samples between April and June in most years. Many of the species in the genera *Bembidion* and *Agonum*, which are diagnostic ERS species, can be difficult to find after June. Few ground beetle species can be found on ERS in the autumn and winter as larvae. Species in phytophagous families such as the leaf beetles (Chrysomelidae) tend to follow a similar pattern to ground beetles.

Some ground beetle species, notably *Trechus discus* and *Bembidion lunatum*, are summer breeders which overwinter as larvae. The adults usually only emerge in late June or July, after the main peak of spring breeding adults has passed. In Norway the larvae overwinter on the riverbank. The click beetles (Elateridae) also overwinter as larvae, although in several species the adults emerge in the spring. Many flies (Diptera) overwinter in their immature stages although adult emergence times can vary widely between species.

Little is known about the seasonality of the life histories of rove beetles (Staphylinidae). Unlike most ground beetles, many species continue to be represented as adults in samples taken throughout the summer and into the autumn. In Europe several ERS species appear to be spring breeders, although in Britain species in the genus Lesteva, which is active in spring, breeds in the autumn and overwinters as larvae. Some rove beetle species overwinter in tussocks and rotten wood on the bank above the ERS like spring breeding ground beetles.

Most of the above groups use ERS for breeding. However, water beetles belonging to the families Haliplidae, Dytiscidae, Gyrinidae, Helophoridae, Hydrophilidae, Hydraenidae and Elmidae normally use ERS for pupation. Their larval and adult stages are generally spent in the water. Consequently, they only use ERS for a relatively short time in the summer, although this period is a crucial stage in their development. Exceptions to this are species such as *Bidessus minutissimus, Hydroglyphus geminus* and some Hydrophilidae which breed in remnant pools on shingle sediments. Other species of Helophoridae and Hydrophilidae, especially in the genera *Helophorus* and *Cercyo*n, live right at the edge of the water. Larvae of the Dryopidae are aquatic but the adult habitats vary from species to species. *Helichus substriatus* is mainly aquatic whilst *Dryops ernesti* can be found in large numbers on alluvial meadows far from the water edge. The hairy whirligig, *Orectochilus villosus*, is nocturnal and often spends the day under particles on ERS.

3.3 Conservation Value of ERS Invertebrates

The number of rare and notable species in each of the relevant families are shown in Table 3.1. The conservation status is as given by the various publications of the Joint Nature Conservation Committee. Red Data Book 1 (RDB1) species are rated as Endangered. They are those species thought to be in danger of extinction with only one population known, live in especially vulnerable habitats or in rapid decline in five or less 10km squares. Red Data Book 2 (RDB2) species are rated as Vulnerable. These include species which may are likely to move into the Endangered category in the near future, species which are declining throughout their range and species in vulnerable habitats. Red Data Book 3 (RDB3) species are Rare. These are species with small populations at risk of getting rarer, are restricted to limited geographical areas or habitats or are estimated to occur in less than 15 post-1970 10km squares. In addition, there are Red Data Book Indeterminate (RDBI) species which are considered to be Endangered, Vulnerable or Rare but there is not enough information to say which RDB1 to RDB3 category is applicable. Red Data Book K is a category for species which cannot be categorised because of lack of information. These can be species belonging to groups that are poorly recorded, which in the case of ERS means beetle families such as Ptiliidae and some Staphylinidae, or species in infrequently sampled habitats.

Most rare and notable species in the total of 225 are ground and rove beetles (34 and 84 species respectively). Water beetle species in the families Dytiscidae, Hydrophilidae and Hydraenidae have several of these species but crane flies (Tipulidae) have the most other species in a family. The fidelity of species to ERS habitats has been estimated; total fidelity=only found on ERS by rivers, high=also found on lake and pond margins, gravel pits, trickles on cliffs, all habitats similar to those found by rivers, moderate=strongly associated with rivers at least in parts of the UK but often also found in other habitat types, e.g. fen, wet grassland, disturbed ground and low=eutrytopic species whose association with ERS may be adventitious. There is a distinct bias such that most of these rare species have either a high or total fidelity to ERS (48 and 23% respectively), emphasising the importance of these sediments. The rare and notable species with high, total or unknown fidelity to ERS are given in Appendix A.

Table 3.1 The number of ERS invertebrate species, by family, in the various national conservation categories (RDB1, 2, 3, I , K; Notable A (Na), Notable B (Nb), Notable).

Order and Family	Number of Species							
	RDB1	RDB2	RDB3	RDBI	RDBK	Na	Nb	Notable
Coleoptera (beetles)								
Carabidae (ground beetles)	1	1	3	-	-	8	21	-
Haliplidae (water beetles)	-	-	-	-	-	-	1	-
Dytiscidae (water beetles)	-	1	1	-	-	-	10	-
Gyrinidae (water beetles)	-	-	-	-	-	-	2	-
Georissidae (water beetles)	-	-	-	-	-	1	-	-
Hydrochidae (water beetles)	-	-	1	-	-	-	-	-
Helophoridae (water beetles)	-	-	-	-	-	-	3	-
Hydrophilidae (water beetles)	-	-	-	-	1	1	6	-
Hydraenidae (water beetles)	-	-	2	-	-	-	8	-
Ptiliidae	-	-	-	-	1	-	-	1
Staphylinidae (rove beetles)	1	-	2	6	21	4	10	40
Pselaphidae	-	-	-	-	2	-	-	-
Scarabaeidae	-	-	-	-	-	-	1	-
Scirtidae	-	-	-	-	-	-	1	-
Limnichidae	-	-	-	-	-	1	-	-
Dryopidae	-	-	1	-	-	-	-	-
Elmidae (Riffle beetles)	-	2	-	-	-	2	3	-
Elateridae (Click beetles)	-	2	-	-	-	1	-	-
Rhizophagidae	-	-	-	-	-	2	-	-
Coccinellidae (ladybirds)	-	-	1	-	-	-	-	-
Curculionidae (weevils)	-	-	-	-	-	1	2	-
Total Beetles	2	6	11	6	25	21	68	41
Hemiptera (bugs)								
Saldidae	-	-	-	-	-	-	-	1
Total Bugs	-	-	-	-	-	-	-	1
Diptera (flies)								
Asilidae	-	-	1	-	-	-	-	-
Empididae	1	2	2	-	-	-	2	-
Dolichopodidae	-	-	-	-	-	-	5	-
Lauxaniidae	-	1	-	-	-	-	-	-
Micropezidae	-	-	1	-	-	-	-	-
Therevidae	-	-	5	-	-	-	-	-
Tipulidae (crane flies)	1	8	4	1	1	-	-	6
Total Flies	2	11	13	1	1	-	7	6

Order and Family	Number of Species							
	RDB1	RDB2	RDB3	RDBI	RDBK	Na	Nb	Notable
Araneae (spiders)								
Lycosidae	-	-	-	-	-	-	1	-
Linyphiidae	-	1	-	-	1	-	1	-
Total Spiders	-	1	-	-	1	-	2	-
Total Invertebrates	4	18	24	7	27	21	77	47

3.4 Geographical Distribution of ERS Invertebrates

The geographical distributions of many ERS invertebrate species are not well known but, apart from widespread species, the two main types of distribution appears to be related to altitude, highland and lowland. In many cases these distributions are probably less linked to altitude and climate than to preferences for sediment type. Several species of Welsh shingle sediments, for example, are not uncommon in the Iberian peninsula.

There are some odd British distributions. The ground beetle *Bembidion schueppeli* is found in a band across northern England and southern Scotland but nowhere else in Britain or Ireland (Reid and Eyre 1985). *Bembidion semipunctatum*, a common ERS species in France, is more or less confined in Britain to an area of the west Midlands centred on the Teme and the Severn. *Thinobius newberyi*, a rove beetle, is a species not recorded outside Britain, where it is very rare. A further rove beetle, *Meotica anglica*, is also unknown outside Britain although it belongs to a genus which is relatively understudied. It is obvious that this is one aspect of work on the invertebrates of ERS that requires considerably more attention.

3.5 Habitat Preferences

The habitat requirements of ERS invertebrates are still largely unknown. The particle size of the sediment is undoubtedly an important factor for the majority of species and this is linked to the flow rate of the river and to geology. Other factors thought to be important include vegetation cover and architecture, organic content of the substrate, the size or discharge of the river and the frequency and severity of disturbance by flooding.

Species assemblages associated with shingle and other coarse sediments contain the highest proportion of ERS specialists. There appear to be significant differences between these assemblages in different parts of the country but more work is required in order to establish how far these differences are related to geological or historical factors. Some species in this group are also found in similar habitats around upland lakes. Plachter (1986) found that some species of *Bembidion* associated with upland Bavarian rivers were able to colonise gravel pits lower down the valley.

In fast-flowing upland streams deposits of ERS are rather small, subject to frequent flooding and composed of large sediment particles, but they can support a specialist fauna. However, large boulders in these situations can become stable and provide a substrate for luxuriant growth of mosses. These also attract a specialist invertebrate species assemblage containing rove beetles (e.g. *Lesteva* spp., *Thinodromus arcuatus, Dianous coerulescens, Quedius auricomus, Quedius riparius*) and fly species.

In lowland systems there is a concentration of conservation value in the ERS assemblages of undisturbed secondary channels and oxbow lakes. These assemblages are associated with silt sediments containing large amounts of undecayed organic matter. They share several species with assemblages found on the margins of temporary woodland pools. They can also be found around the undisturbed margins of reservoirs where water level fluctuations due to draw-down mimic the conditions found in large river cut-offs.

For species which hibernate high up on the riverbank the presence of hibernation sites on adjacent areas of the floodplain is important (Andersen 1968). These hibernation sites may consist of grass tussocks, rotten wood or areas of boulders and cobbles. Large ERS such as the famous single bank on the River Wye at Glasbury are probably important partly because they contain a number of hibernation sites suitable for surviving winter floods (A P Fowles pers. comm.).

3.6 Impact of River Management on ERS Invertebrates

Very little work has been done on the impact of river management on ERS invertebrates. Lott (1993) studied the effects on ERS beetle species of resectioning the banks of the lowland River Soar in Leicestershire as part of a flood alleviation scheme. For the first few years after resectioning the banks were dominated by a pioneer fauna adapted to highly disturbed systems. After five years this had been replaced by species assemblages with affinities to adjacent grassland. Specialist ERS species tended to be confined to ERS undisturbed by engineering or to areas where natural deposition had been allowed to continue.

Unpublished data (D A Lott) from the same river system also shows how impoundment favours species assemblages associated with low levels of natural disturbance. These assemblages shared several species with damp grassland assemblages. Small scale clearance of vegetation by anglers for fishing platforms ('pegs') was found to diversify the ERS fauna. The likely impacts of river management practices are summarised below:

Management practice	*Effects*
Sediment removal	Loss of sites
Bank resectioning	Loss of hibernation sites
Channel straightening	Loss of sites; change in assemblage type due to change of sediment type
Channel dredging	Possible loss of habitat for aquatic larvae
Impoundment (weirs, mills, fishing & navigation)	Change in assemblage type due to change in sediment type
Reservoir construction	Unknown
Navigation	Unknown
Angling	Increase in habitat diversity due to creation of small patches of bare ground
Water abstraction	Unknown
Sewage discharge	Probably an increase in biomass rather than diversity and possibly a change in assemblage
Flood alleviation	Replacement of secondary channel ERS by terrestrial assemblages

3.7 Impact of Catchment-wide Processes on ERS Invertebrates

Table 3.4. shows the likely impact of catchment-wide processes on ERS invertebrate assemblages. Undoubtedly, the historical changes in the sediment load described in chapter 2 has had a significant effect on the lowland ERS fauna. It is likely that species associated with coarse sediments have become rarer in lowland systems. Nationally, rare riffle beetles (Elmidae) such as *Stenelmis canaliculata* and *Normandia nitens* which are associated with large gravel-bedded lowland rivers are well represented in sub-fossil deposits (Coope 1995).

Management impacts on land adjacent to an ERS can have additional impacts. Lott (1992) found that on soft sediments by the River Soar the access of grazing cattle to an ERS produced a species assemblage of beetles associated with a higher level of natural disturbance. However, these assemblages tended to have less value for conservation than those produced by natural disturbance. A moderate grazing regime may, however, be beneficial for flies (C M Drake pers. comm.)

The importance of the presence of hibernation sites such as grass tussocks and rotten wood has been highlighted in section 3.5. These resources are rare in urban areas and intensively grazed or cultivated land due to the use of piling and concrete in banks and the removal of buffer zones between riverbanks and fields. Unpublished data (D A Lott) from the River Soar indicates that sites of high conservation value are often adjacent to high quality terrestrial sites. This may be linked to the availability of hibernation sites.

The likely impact of catchment-wide processes on ERS invertebrate assemblages are summarised below:

Impact	*Cause*	*Effect*
Siltation (increase in sediment load)	Deforestation, agriculture, mineral extraction, large engineering projects	Change in assemblage type due to change of sediment type
Eutrophication	Fertiliser run-off from agricultural land	Change in assemblage type due to change in vegetation cover
Increased run-off	Urbanisation, land drainage	Change in assemblage type due to change of sediment type
Loss of floodplain wetland to agriculture	Drainage, infilling and tipping	Change from ERS assemblages to terrestrial assemblages
Pond creation	Conversion of floodplain wetland to amenity ponds	Loss of secondary channel sites and assemblages
Access by grazing stock	Adjacent unfenced pasture	Change in assemblage type due to change in vegetation cover and extra disturbance; loss of hibernation sites
Change in adjacent land use	Urbanisation, intensive agriculture	Loss of hibernation sites

4. ERS INVERTEBRATES AND ENVIRONMENTAL EVALUATION

4.1 Sampling ERS Invertebrates

Most of the records in the species lists of ERS invertebrates already generated were derived by entomologists using a variety of hand collecting techniques. This activity has established the diverse and distinct nature of ERS invertebrate assemblages but variations in sampling methods, efficiency and effort make it difficult to compare sites.

Andersen (1969) developed a method of repeatable timed hand-collecting for beetles on ERS which was adapted by Plachter (1986), Fowles (1989) and Lott (1992, 1993). However, hand-collecting techniques require good weather and a high level of skill from the individual fieldworker. It is not suitable for inexperienced workers and cannot be considered to be generally applicable as a standard sampling method.

Pitfall trapping is a technique widely used for the sampling of beetles, especially ground and rove beetles, in a variety of habitats. Species in other families, especially leaf beetles and weevils, are also sampled well by pitfall trapping. A beaker with preservative is set into the ground so that invertebrates fall into the trap, producing a sample which can be retrieved later. This method requires less skill than hand-collecting and is less dependent on weather because it operates over a period. Pitfall trap samples are also likely to be skewed against nocturnal species. A standardised sampling methodology for sampling invertebrates, especially ground beetles and spiders, in grassland and woodland has been developed at the University of Newcastle upon Tyne and has been used in a considerable number of investigations (e.g. Rushton and Eyre 1992; Luff, Eyre and Rushton 1992; Eyre and Luff 1994).

The disadvantages of pitfall trapping are mainly connected with disturbance. They are especially vulnerable to floods and this limits the length of time that can be safely left between collections. They cannot be used on soft sediments which are trampled by cattle because they quickly become displaced and there are problems in regions frequented by the public because of an apparently great desire to interfere with the traps. In well vegetated sites, traps tend to be less visible than in areas of bare ground and some kind of camouflage may be required, a process that may skew the sample.

Pitfall trapping has been used successfully used to sample ERS in Wales, Northumberland and Leicestershire. D A Lott (unpublished results) compared samples from hand-collecting and pitfall traps operated from one week on the same ERS and found that they gave similar results. Specialist species of spiders and bugs were also caught in the pitfall traps. The number of flies caught in the pitfall traps was comparable to the number of beetles but it is not known how the representativeness of pitfall trap fly samples compares with other sampling methods.

Standard repeatable sampling techniques for ERS flies have not been used in Britain, although their use is being developed in Belgium (Pollet and Grootaert 1994). The most widely used trapping methods in other habitats have been Malaise traps and water traps. Malaise traps consist of a tent with one side open and designed so that flying insects which enter the trap are funnelled into a collecting bottle in one corner. The exposed nature of many ERS makes the use of Malaise traps impractical. A water trap consists of a coloured bowl filled with water treated to reduce the surface tension. It can be placed on the ground or up a pole. A further method becoming more widely used is the window trap. This consists of a perspex sheet to intercept flying insects with a collecting tray underneath.

Water traps and window traps have similar advantages to pitfall traps in that they can be operated over a period of time, although they need to be serviced at shorter intervals. They are much more vulnerable to disturbance than are pitfall traps because of their grater visibility and the fact that they are above ground and more easily physically damaged. The effects on weather, especially wind, on the sampling of flying insects above ground does not appear to have been addressed. 'Tourist' species from a considerable distance and other habitats are likely to be sampled by window and water traps given certain conditions. Pitfall traps also contain some 'tourist' species not associated with the sampled habitat but they are likely to be a relatively small proportion of the catch.

On present evidence pitfall trapping is the best candidate for standardised sampling of invertebrates on ERS, although its suitability for sampling flies needs to be assessed. A comparison of hand-collecting, pitfall trapping and water traps is shown below:

	Hand-collecting	*Pitfall trapping*	*Water traps*
Skill level required	Advanced	Moderate	Moderate
Comparability of samples	Low	Moderate	Moderate?
Suitability for nocturnal species	Low	High	Unknown
Sensitivity to weather problems	High	Low	Moderate
Vulnerability to flooding	None	High	Very high
Vulnerability to disturbance by cattle or other animals	None	High on soft sediments	Very high
Vulnerability to human disturbance	None	High on soft sediments	Very high
Expense	Low	Moderate	High

4.2 Sorting

The sorting of samples may be thought of as being of little interest or importance. With hand-collecting only the invertebrates tend to be sampled and there is usually little detritus in water traps. However, the ability to differentiate invertebrate species from the detritus encountered in pitfall traps is a highly skilled operation. Considerable experience is required to sort all the specimens from a pitfall sample and this should not be forgotten when this method is being used.

4.3 Identification

Correct identification to species level is of the utmost importance in ecological, biogeographical and conservation studies with invertebrates. This is especially true when rarity is used a criterion for conservation evaluation since the presence of a single spurious rare species in a sample list can significantly alter the ranking of a site.

The identification process requires three resources; expertise, a reference collection and relevant, accurate literature. Inexperienced workers often rely too much on identification keys, not all of which are totally accurate or up to date. When using keys to an unfamiliar group, identifications should always be checked against name reference specimens. Identifications using keys alone are unreliable. Voucher specimens of species which are rarely recorded or which are in difficult species groups should always be retained and submitted to a specialist in that group.

It should be recognised that even when workers are experienced in the identification of invertebrates, the time taken to deal with an unfamiliar group will be several orders of magnitude greater than someone who has a specialist knowledge of that group. Tackling large amounts of material from ERS samples is totally unfeasible for someone inexperienced in invertebrate identification. In order to evaluate someone's ability to carry out identifications it is necessary to scrutinise their published work.

4.4 Conservation and Environmental Criteria

4.4.1 Rarity

Rarity is a highly 'political' criterion which is readily understood by the general public. Several invertebrate groups have been used to produce rarity values for sites based on distribution records. When the rarity value of a site can be quantified, the site can then be ranked along side other similar sites.

Comparison of sites using lists of rare species is common bad practice in many fields of site evaluation. The number of rare invertebrate species recorded tends to depend on the amount of sampling effort and any rarity value should take into account the total number of species recorded. If possible, comparisons should be made using species lists derived from a single, standardised sampling method.

The national rarity designations for invertebrate species (RDB1, Notable A etc.) produced by JNCC reviews of various groups has also been used as a basis for generating site scores. However, the designations of ERS species are in need of review and further investigation. It is hoped to have more reliable designations after more survey work.

4.4.2 Diversity

Another criterion becoming increasingly more 'political' is diversity ('biodiversity'). The simplest, and most easily understood, of the ways of quantifying diversity is as straightforward species number. This creates problems with invertebrate sampling because of the number of species there are and the fact that the more sampling the longer the species list. Comparisons can only be made where the sampling effort is the same at each site and where the sampling has been standardised.

A number of ERS sites in Northumberland have been pitfall trapped, whilst samples have been taken along the River Soar in Leicestershire by timed hand-collecting. On the River Till in north Northumberland, pitfall trapping over three months in six sites gave a mean of 26 ground beetle species (range 19-32). In 1991, eighteen sites along the River Soar were sampled by hand-collecting and the mean number of ground and rove beetle species recorded was 44 (range 23-62). These data were for only one and two families of beetle but they indicate the potential of ERS as areas of considerable invertebrate biodiversity.

The use of a standardised sampling method such as pitfall trapping should enable comparisons of biodiversity on ERS to be made. Any quantification should be limited to those groups which are sampled well by pitfall traps and should avoid the more 'accidental' records.

4.4.3 Naturalness

Naturalness is a difficult criterion to quantify but if ways could be found they could be of use in assessing the impacts of river management practices on the invertebrates of ERS. There are a number of sites in north-east England with records of invertebrates, especially beetles, recorded in the 1840's and 1850's. These provide an idea of the fauna before land use changes brought about by intensive agriculture and urbanisation but there is little in the way of historical data for ERS.

ERS are naturally highly disturbed sites that are sensitive to changes in the river system and land use. However, in highly managed landscapes, ERS are likely to be one of the most natural invertebrate habitats present. It would be of value to identify stretches of rivers which have not radically affected by land or river management and to identify within those stretches ERS which reflect near natural conditions. One product of a large-scale survey of ERS invertebrates will be the definition of invertebrate assemblages indicative of more natural ERS. Methods based on ordination or using more subjective techniques should then provide naturalness baselines with which to compare the effects of environmental change.

4.5 Site Classification

Classifications are required because it is not sensible to compare sites which are dissimilar. It is obvious that there are big differences in the structure and invertebrates of ERS throughout England and Wales, ranging from the rough, open sediments in upland areas to the vegetated, silt sediments in lowland areas and taking in all variations between. Ranking of sites using any of the conservation and environmental criteria above needs to be carried out within defined groups of similar sites so that the ranking means something. British rivers have been classified using plant community data (Holmes 1983) and with aquatic invertebrates (Wright et al. 1984) but it is not known how far these would match any classification based on ERS invertebrates.

A preliminary classification of 194 ground beetle species lists from ERS throughout Britain and Ireland produced five groups of sites. These ranged from predominantly Welsh open ERS by fast-flowing rivers through sandy sites by larger slower flowing rivers to highly vegetated silt sediments in the English midlands. More subtle classifications have been produced from species lists of ground and rove beetles from the River Soar in Leicestershire and the groups produced reflect the influences of practices as channel resectioning and flood alleviation schemes on habitats (Lott 1992, 1993).

For standard comparisons of sites within habitat groups, a large amount of ERS invertebrate species data is required using standardised sampling. Fieldwork for the production of a national classification of ERS is being planned.

5. POSITIVE MANAGEMENT PRACTICES

5.1 Identification of Valuable Sites

The first conservation priority of any management strategy should always be to evaluate the existing interest of the river. Sites or features of major interest can then be retained and a management programme adopted to protect and add to these features.

The only satisfactory way to evaluate the conservation interest of ERS is to survey the invertebrates, as described in chapter 4. However, in the absence of survey resources or as a preliminary stage in the evaluation, some general principles can be used to gauge the potential of a stretch of river. In our present state of knowledge, these general principles should be regarded as provisional, especially with regard to the conservation of flies and they may need to be modified in the light of further research.

5.1.1 Recognition of habitat types

A stretch of river will have ERS resources which will be used by a number of different invertebrate assemblages. The main differences in the resources required by each community are related to levels of disturbance. The easiest way to recognise the level of disturbance at a site is to examine the substrate particle size. The following categories will tend to support different invertebrate assemblages:

Substrate	*Type of disturbance*
Moss-covered boulders	High water flow on small rivers and large streams
Boulder and cobbles	Very high water flow
Pebbles and shingle	High water flow
Shingle and sand	Moderate water flow
Sand and silt	Slow water flow
Trampled sand and silt	Slow water flow with high levels of unnatural disturbance
Silt and undecayed organic matter	Intermittent water flow in abandoned channels and backwaters

On ERS composed of coarse sediments, the presence of dry sandy areas at the back of the site will provide a resource for an additional assemblage which includes click beetles and therevid flies. Indeed, large ERS sites may contain a mosaic of different sediment types, each with a separate invertebrate assemblage. Additional specialist communities can be found in remnant pools on shingle, in winterbournes, in beached dead wood and in old flood refuse but further research is required to identify which factors affect their value for conservation

The conservation value of a river segment needs to be considered separately for each of the different assemblages by assessing the quality of each of the relevant habitat types.

5.1.2 Habitat quality

Factors which increase the potential quality of an ERS site for any particular community include large size, topographic complexity and the availability of hibernation sites in the form of grass tussocks and dead wood either high up on the ERS or on an adjacent bank.

The quality of a river stretch for a particular assemblage is increased by a large number of individual suitable sites. The presence of secondary channels and remnant pools on ERS can provide a resource for additional specialist assemblages.

Intensive trampling or poaching of soft sediments on ERS by grazing stock, especially cattle, and human pressure changes the assemblage type to one that is adapted to higher disturbance levels but which is of lower conservation value. This is especially true of abandoned channels, which are sensitive to any kind of disturbance. However, small scale clearance of vegetation by anglers on main channel sites can result in an interesting increase in habitat and species diversity.

The quality of ERS composed of coarse sediments is adversely affected by organic discharges into the river and by increases in suspended silt in the river. Sewage outfalls, run-off from agricultural land, forestry operations and mineral workings can have significant effects on the composition of ERS and thus on the invertebrate assemblages.

5.1.3 Avoidance of damaging engineering practices

Having identified which assemblages are of conservation interest in a stretch of river, a list of key sites containing high quality resources for these assemblages should be compiled. These sites should then be protected from the following operations:

1. complete sediment (shoal) removal
2. bank resectioning
3. channel straightening
4. channel deepening (damage to secondary channel sites)
5. clearance of hibernation sites (grass tussocks and dead wood) from the sediment or bank
6. river impoundment, either upstream and downstream

The impact of partial sediment (shoal) removal is difficult to predict. The introduction of steep marginal slopes should probably be avoided. Important ERS characters which should be retained include the height and topographic complexity. However, it may be beneficial to scrape some parts of a site in order to compensate for removal of low-lying damp sediment.

The timing of engineering works is likely to be important. Spring-breeding invertebrates are active on ERS between April and July. Water beetles use ERS for pupation in the summer. Avoidance of operation in spring and summer would lessen the impact on those groups of invertebrates active then but it is probably impossible to avoid impact on some fossorial species and summer breeders, which may spend the whole year on the site. As a corollary, disturbance on the bank would be most damaging in autumn and winter when the spring breeders are in hibernation.

5.2 Creative Engineering

Creative engineering can be used to protect existing conservation interest, to enhance existing interest or to add to existing interest. This section assesses the engineering works discussed in the New Rivers and Wildlife Handbook for their potential for increasing habitat quality for ERS invertebrates. These works and the assemblages that they benefit are summarised below:

Engineering work	*Assemblages benefited (characterised by sediment type)*
Artificial sediments	Unknown
Restoration of meanders	All
Introduction of changes in gradient	All
Backwaters and bays	Silt and sand
Multi-stage channels	Silt and undecayed organic matter
By-pass channels	Silt and undecayed organic matter
Flood storage lakes	Silt and undecayed organic matter
Deflectors (groynes)	All
Weirs	Moss-covered boulders
Buffer zones	All

5.2.1 Artificial sediments

There is little information on the colonisation of artificial sediments by ERS invertebrates. Some ERS ground beetles are capable of colonising gravel pits and probably of resectioned banks if they are of suitable material. It is likely that the construction of artificial sediments will be a valuable conservation measure. However, many natural sediments have a complex laminar structure with alternating sediment particle types which would be difficult to replicate. Further work is required to establish the suitability of artificial sediments for the full range of ERS invertebrates.

5.2.2 Encouraging natural deposition

An elegant method of creating new sediments (shoals) is to manage the river flow in a way which encourages their formation by natural deposition. Restoration of meanders, changes in gradient and groyne construction are engineering operations which will achieve this end.

For both artificial sediments and new naturally formed sediments the management of land above the adjacent bank is critical. A buffer zone containing grass tussocks and/or rotten wood for hibernation sites should be established and grazing stock, especially cattle, should be excluded from soft sediments.

5.2.3 Backwaters and bays

The creation of backwaters and bays will provide additional habitat for communities adapted to soft sediments associated with low natural disturbance. A buffer zone containing grass tussocks and/or rotten wood for hibernation sites should be established on the adjacent bank and fencing should be used to exclude grazing stock where necessary.

5.2.4 Multi-stage channels and by-passes.

Multi-stage channels which incorporate secondary channels and remnant pools into their design and new by-pass channels to divert excess water from the main channel during flooding have long-term potential for assemblages associated with secondary river channels, but only if they are protected from unsuitable disturbance such as intensive grazing. If areas are allowed to succeed to carr woodland or are managed by cutting, they could in time attract a valuable fauna.

The construction of flood storage and balancing lakes leads to similar opportunities if the margins are protected from disturbance. If the water level is allowed to fluctuate, an interesting abandoned channel assemblage may develop over time. Constant water levels in these areas will eventually attract a fen community.

5.2.5 Deflectors

The construction of groynes leads to the deposition of sediments downstream of the new structures. In large rivers in Europe this results in extensive ERS formation, with a complexity of habitats and assemblages.

5.2.6 Weirs and sluices

The impoundment of a stretch of river using a weir results in the disappearance of ERS containing coarse-grained sediments for some distance upstream and their replacement by silt. In severe cases, the ERS becomes permanently vegetated, resulting in the transition of the invertebrate assemblage to one resembling a wet grassland fauna. However, on the weir itself a flora of mosses and other plants may flourish and support an invertebrate assemblage associated with moss-covered boulders. In lowland rivers with no nearby source of immigration this community is often impoverished, although weirs may also provide the only suitable habitat for some predominantly upland species.

5.2.7 Buffer zones

The establishment of semi-natural vegetation on the bank in a buffer zone lead to the availability of hibernation sites. These could be of especial importance in urban and intensive agricultural systems where the lack of hibernation sites may be a limiting factor for the development of ERS communities.

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7. Draft ERS Invertebrate Handbook - Appendix A

Invertebrate species found on ERS with conservation status (RDB1,2,3,I,K, Na, Nb) and either total, high or unknown (?) fidelity to ERS with the substrate preference for each species (silt, sand, shingle indicated by +, ?, other) and the life stage (A=adult, L=larva, P=pupa) of each species on ERS.

	Conservation Status	Fidelity	Substrate Preference Silt	Sand	Shingle	Other	Life Stage
Coleoptera							
Carabidae							
Perileptus areolatus (Creutzer)	Na	Total			+		AL
Thalassophilus longicornis (Sturm)	Na	Total			+		AL
Asaphidion pallipes (Duftschmid)	Nb	High	+	+			AL
Bembidion bipunctatum (Linnaeus)	Nb	High			+		AL
Bembidion clarki (Dawson)	Nb	High	+				AL
Bembidion fluviatile Dejean	Nb	High	+	+			AL
Bembidion litorale (Olivier)	Nb	Total	+	+			AL
Bembidion lunatum (Duftschmid)	Nb	Total		+			AL
Bembidion monticola Sturm	Nb	High			+		AL
Bembidion schueppeli Dejean	Na	Total	+	+			AL
Bembidion semipunctatum Donovan Na	Total	+	+	+		AL	
Bembidion stomoides Dejean	Nb	Total			+		AL
Bembidion testaceum (Duftschmid)	Nb	Total		+	+		AL
Bembidion virens Gyllenhal	RDB3	High			+		AL
Tachys bistriatus (Duftschmid)	Nb	High	+	+			AL
Pterostichus gracilis (Dejean)	Nb	High	+				AL
Agonum livens (Gyllenhal)	Na	High	+				AL
Agonum scitulum Dejean	Na	High	+				AL
Amara fulva (Mueller)	Nb	High		+			AL
Chlaenius nigricornis (Fabricius)	Nb	High	+				A
Lionychus quadrillum (Duftschmid)	RDB3	High			+		AL
Haliplidae							
Haliplus laminatus (Schaller)	Nb	High	+	+			P
Dytiscidae							
Bidessus minutissima (Germar)	RDB3	High	+	+			P
Hydroporus ferrugineus Stephens	Nb	High				Subterranean	P
Deronectes latus (Stephens)	Nb	Total			+		P
Oreodytes davisii (Curtis)	Nb	Total			+		P
Agabus biguttatus (Olivier)	Nb	High			+		P
Agabus brunneus (Fabricius)	RDB2	Total			+		P
Gyrinidae							
Gyrinus urinator Illiger	Nb	High				Shade	AL

	Conservation Status	Fidelity	Substrate Preference Silt	Sand	Shingle	Other	Life Stage
Georissidae							
Georissus crenulatus (Rossi)	Na	High	+	+			ALP
Hydrochidae							
Hydrochus nitidicollis Mulsant	RDB3	High	+		+		ALP
Helophoridae							
Helophorus arvernicus Mulsant	Nb	Total	+	+			ALP
Hydrophilidae							
Anacaena bipustulata (Marsham)	Nb	High	+				ALP
Laccobius atrocephalus Reitter	Nb	High	+				ALP
Cercyon bifenestratus Kuster	Na	High		+			ALP
Chaetarthria similis Wollaston	RDBK	High	+		+		A
Hydraenidae							
Ochthebius bicolon Germar	Nb	High	+				ALP
Ochthebius exsculptus Germar	Nb	Total	+		+		ALP
Hydraena minutissimus Stephens	Nb	High				Moss	ALP
Hydraena nigrita Germar	Nb	Total	+				ALP
Hydraena pulchella Germar	RDB3	Total	+				ALP
Hydraena pygmaea Waterhouse	RDB3	Total	+		+		ALP
Hydraena rufipes Curtis	Nb	High	+		+		ALP
Ptiliidae							
Actidium aterrimum (Motschulsky)	RDBK	Total		+	+		A
Ptenidium brenskei Flach	Notable	Total			+		A
Staphylinidae							
Lesteva hanseni Lohse	Notable	High				Moss	A
Deleaster dichrous (Gravenhorst)	Nb	High	+	+	+		A
Bledius arcticus Sahlberg	RDBI	Total?	?	?	?		A
Bledius defensus Fauvel	RDBK	High		+			A
Bledius erraticus Erichson	RDBK	High	+	+			A
Bledius filipes Sharp	RDB1	High?		+			A
Bledius terebrans (Schiodte)	RDBK	High		+			A
Ochthephilus andaluciacus (Fagel)	Notable	Total?	?	?	?		A
Ochthephilus venustulus (Rosenhauer)	Notable	Total?			+		A
Carpelimus fuliginosus (Gravenhorst)	Notable	?	?	?	?		A
Carpelimus lindrothi Palm	Notable	High	+				A
Carpelimus obesus (Kiesenwetter)	Notable	Total?	+				A
Carpelimus similis (Smetana)	Notable	High	+	+			A
Carpelimus subtilis (Erichson)	Notable	High	+	+	+		A
Thinobius bicolor Joy	Na	Total			+		A
Thinobius brevipennis Kiesenwetter	RDBK	?	+	+			A
Thinobius crinifer Smetana	Notable	Total			+		A
Thinobius major Kraatz	RDBK	Total			+		A
Thinobius newberyi Scheerpeltz	RDBI	Total			+		A
Thinobius praetor Smetana	Notable	Total			+		A

	Conservation Status	Fidelity	Substrate Preference Silt	Sand	Shingle	Other	Life Stage
Platystethus nodifrons (Mannerheim)	Notable	High	+				A
Oxytelus fulvipes Erichson	Na	High	+				A
Stenus argus Gravenhorst	Nb	High	+				A
Stenus calcaratus Scriba	RDBK	High	+				A
Stenus carbonarius Gyllenhal	Nb	High	+				A
Stenus incanus Erichson	RDBK	High	+				A
Lathrobium angustatum Bois. & Lac.	Nb	High			+		A
Lathrobium angusticolle Bois. & Lac.	Nb	High			+		A
Lathrobium dilutum Erichson	RDB3	High			+		A
Lathrobium pallidum von Nordmann	RDBK	Total?		+	+		A
Achenium humile (Nicolai)	Nb	?	?	?	?		A
Medon ripicola (Kraatz)	Notable	High		+			A
Sunius bicolor (Olivier)	RDBK	?	?	?	?		A
Scopaeus gracilis (Sperk)	RDBK	Total?			+		A
Rugilus fragilis (Gravenhorst)	Notable	?	?	?	?		A
Neobisnius procerulus (Gravenhorst)	RDBK	?	?	?	?		A
Neobisnius prolixus (Erichson)	RDBK	Total?			+		A
Erichsonius signaticornis (Mulsant & Rey)	Nb	Total?		+	+		A
Philonthus atratus (Gravenhorst)	Na	Total?		+			A
Philonthus pullus von Nordmann	RDBI	?	?	?	?		A
Philonthus punctus (Gravenhorst)	RDB3	High	+				A
Gabrius astutoides (Strand)	RDBI	High	?	?	?		A
Gabrius bishopi Sharp	Nb	High	+	+			A
Gabrius velox Sharp	Nb	High	+				A
Quedius auricomus Kiesenwetter	Nb	High				Moss	A
Quedius plancus Erichson	Na	Total?	+				A
Quedius riparius Kellner	RDBK	High				Moss	A
Myllaena elongata (Matthews)	Notable	High	+	+	+		A
Falagria sulcatula (Gravenhorst)	Notable	?	+				A
Tachyusa coarctata Erichson	Notable	High	+				A
Tachyusa scitula Erichson	RDBK	Total?	?	?	?		A
Gnypeta caerulea (Sahlberg)	Notable	Total?	+				A
Gnypeta ripicola (Kiesenwetter)	Notable	High	+				A
Gnypeta velata (Erichson)	Notable	High	+	+			A
Brachyusa concolor (Erichson)	Notable	High	+				A
Hydrosmecta delicatula (Sharp)	RDBK	Total?			+		A
Hydrosmecta fragilis (Kraatz)	Notable	Total?			+		A
Hydrosmecta thinibiodes (Kraatz)	Notable	High			+		A
Hydrosmectina septentrionum Benick	Notable	Total?		+	+		A
Aloconota eichoffi (Scriba)	Notable	Total?			+		A
Aloconota mihoki Bernhauer	RDBI	?	?	?	?		A
Aloconota planifrons (Waterhouse)	RDBK	High			+		A
Aloconota subgrandis (Brundin)	RDBK	?	?	?	?		A
Dochmonota clancula (Erichson)	Notable	High	+				A
Atheta autumnalis (Erichson)	RDBK	Total?	+				A
Atheta basicornis (Mulsant & Rey)	Notable	High	+				A
Atheta deformis (Kraatz)	Notable	?	?	?	?		A
Atheta hygrobia (Thomson)	Notable	High	+				A

	Conservation Status	Fidelity	Substrate Preference Silt	Sand	Shingle	Other	Life Stage
Atheta nannion Joy	RDBK	?	?	?	?		A
Atheta obfuscata (Gravenhorst)	Notable	High	+				A
Atheta scotica (Elliman)	Notable	Total?			+		A
Ilyobates propinquus (Aube)	Notable	?	+				A
Ilyobates subopacus Palm	Notable	?	+				A
Calodera nigrita Mannerheim	Notable	High	+				A
Calodera riparia Erichson	Notable	High	+				A
Calodera uliginosa Erichson	RDBK	High	+				A
Chiloporata rubicunda (Erichson)	Notable	Total?	+	+	+		A
Meotica anglica Benick	Notable	High	+	+	+		A
Oxypoda exoleta Erichson	Notable	High	+	+	+		A
Oxypoda nigrocincta Mulsant & Rey	RDBI	High	+				A
Oxypoda riparia Fairmaire	RDBK	?	?	?	?		A
Oxypoda soror Thomson	Notable	?	?	?	?		A
Aleochara brevipennis (Gravenhorst)	Notable	High	?	?	?		A
Pselaphidae							
Bibloplectus minutissimus Aube	RDBK	Total?			+		A
Brachygluta pandellei (Saulcy)	RDBK	Total?			+		A
Scirtidae							
Hydrocyphon deflexicollis (Mueller) Nb	High			+		A	
Limnichidae							
Limnichus pygmaeus (Sturm)	Na	High	+				A
Elmidae							
Normandia nitens (Mueller)	RDB2	Total			+		P
Oulimnius major (Rey)	Na	High	+				P
Oulimnius rivularis (Rosenhauer)	Na	Total	+				P
Oulimnius troglodytes (Gyllenhal)	Nb	High	+	+			P
Riolus cupreus (Mueller)	Nb	High	+	+			P
Riolus subviolaceus (Mueller)	Nb	Total	+	+			P
Stenelmis canaliculata (Gyllenhal)	RDB2	High			+		P
Elateridae							
Fleutiauxellus matitimus (Curtis)	Na	High		+	+		A
Negastrius pulchellus (Linnaeus)	RDB2	High		+	+		A
Negastrius salbulicola (Boheman)	RDB2	High		+	+		A
Rhizophagidae							
Cyanostolus aeneus (Richter)	Na	High				Bark	A
Coccinellidae							
Coccinella quinquepunctata Linnaeus	RDB3	Total			+		A
Curculionidae							
Baris lepidii Germar	Na	High	+				A

	Conservation Status	Fidelity	Substrate Preference Silt	Sand	Shingle	Other	Life Stage
Hemiptera							
Saldidae							
Saldula fucicola (Sahlberg)	Notable	High			+		AL
Diptera							
Asilidae							
Rhadiurgus variabilis (Zetterstedt)	RDB3	High			+		A
Empididae							
Chersodromia cursitans (Zetterstedt)		Nb	?	?	?	?	A
Heleodromia irwini	pRDB1	?	?	?	?		A
Hemerodromia laudatoria Collin	Nb	?	?	?	?		A
Tachydromia acklandi Chvala	pRDB2	?	?	?	?		A
Tachydromia halidayi (Collin)	pRDB3	?	?	?	?		A
Tachydromia woodi (Collin)	pRDB2	?	?	?	?		A
Wiedemannia phantasma Mik	pRDB3	?	?	?	?		A
Dolichopodidae							
Rhaphium fractum Loew	Nb	?	?	?	?		A
Rhaphium gravipes Haliday	Nb	?	?	?	?		A
Rhaphium nasutum Fallen)	Nb	?	?	?	?		A
Rhaphium patulum (Raddatz)	Nb	?	?	?	?		A
Rhaphium rivale (Loew)	Nb	?	?	?	?		A
Lauxaniidae							
Homoneura limnea (Becker)	RDB2	?	?	?	?		A
Micropezidae							
Calobata stylifera Loew	pRDB3	?	?	?	?		A
Therevidae							
Psilocephala rustica (Panzer)	RDB3	High		+	+		A
Thereva handlirschi Krober	RDB3	High	+	+	+		A
Thereva inornata Verrall	RDB3	High	+	+	+		A
Thereva lunulata Zetterstedt	RDB3	High		+	+		A
Thereva valida Loew	RDB3	Moderate	+	+	+		A
Tipulidae							
Arctoconopa melampodia (Loew)	RDB2	High		+			A
Dicranota robusta Lundstroem	Notable	High		+	+		A
Dicranota simulans Lackschewitz	RDB3	High			+		A
Erioptera edwardsii (Lackschewitz)	RDBI	High			+		A
Erioptera limbata Loew	RDB2	High		+			A
Erioptera meigeni (Zetterstedt)	RDB3	High		+	+		A
Erioptera nigripalpis Goetghebuer	RDB3	High	+				A
Erioptera pusilla (Schiner)	RDB1	High		+	+		A
Gonomyia edwardsi	pRDBK	?	?	?	?		A

	Conservation Status	Fidelity	Substrate Preference				Life Stage
			Silt	Sand	Shingle	Other	
Gonomyia punctata Edwards	RDB2	High		+			A
Limnophila apicata (Loew)	Notable	High	+	+	+		A
Limnophila mundata (Loew)	Notable	High	+	+	+		A
Limonia omissinervis (de Meijere)	RDB2	High		+			A
Molophilus propinquus (Egger)	Notable	High		+			A
Nephrotoma aculeata (Loew)	RDB2	High		+			A
Nephrotoma dorsalis (Fabricius)	Notable	High		+			A
Nephrotoma lunulicornis (Schummel)	Notable	High		+			A
Rhabdomastix hilaris Edwards	RDB3	High		+			A
Rhabdomastix inclinata Edwards	RDB2	High		+			A
Tipula bistilata Lundstroem	RDB2	High		+			A
Tipula dilatata Schummel	RDB2	High		+			A
Araneae							
Lycosidae							
Arctosa cinerea (Fabricius)	Nb	High			+		A
Linyphiidae							
Diplocephalus connatus Bertkau	RDB2	Total			+		A
Caviphantes saxetorum (Hull)	Nb	Total			+		A