The Conservation of the Moorland Invertebrate Fauna on Exmoor

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1. Introduction

The Exmoor Moorland Invertebrate Survey (EMIS) has demonstrated that moorland in the National Park hosts a diverse invertebrate fauna that includes a number of nationally important species. In all, 80 key invertebrate species have been identified. Using both information on their observed ecology and distribution on Exmoor accrued during the EMIS, and information in the scientific literature, these key species have all been assigned to one or more of six key habitats; lowland heath, upland heath and blanket mire, valley mire, acid grassland, scrub and Bracken. These are listed in Table 1 below, along with the key species that they support. Notes on microhabitat preferences of the key species, and their national conservation status, where applicable, are also indicated in this table.

Of the six key habitats, much the most important for invertebrates is lowland heathland, with 37 of the key invertebrate species being associated with this on Exmoor. Upland heath and blanket mire supports populations of 20 key species, with 19 on valley mires, ten associated with scrub, seven with acid grassland and two with Bracken.

In terms of their national conservation status, the Heath and High Brown Fritillary butterflies stand out as being the highest priority. These are the only Red Data Book invertebrates currently known from moorland habitats on Exmoor, and the only ones that justify specific conservation action. There are a further 41 nationally scarce key invertebrates, which though still very uncommon in Britain, are nonetheless somewhat more widely distributed (species believed to occur in between 15-100 ten km squares of the National Grid).

The absence of national rarities on Exmoor is not surprising, as much of the moorland area supports invertebrate communities that are transitional between lowland types of southern England and communities generally associated with upland regions of Wales, northern England and Scotland. Many of the more uncommon invertebrates of heath, mire and other moorland habitats in Britain are either warmth-demanding (thermophilous) species, largely confined to the lowland heaths and mires of Dorset, Hampshire and Surrey, or upland species requiring a cool, wet climate, and having their British headquarters in the mountains of Wales, northern England and Scotland. Climatically, Exmoor is intermediate between these two types, with this being a consequence of both its geographical position - in southern England, but in the oceanic climate of the Atlantic seaboard, and its moderate altitude - with the highest point on Dunkey Beacon being just 519 metres. A further factor of importance is the topography of Exmoor, which rises steeply from the Bristol Channel. In consequence many of the areas of coastal moors that comprise the main lowland heath resource in the National Park have generally northerly aspects, which strongly mitigates against the presence of thermophilous species.

This is not to say that the invertebrate fauna of Exmoor is of low conservation interest. On the contrary, the mixture of lowland and upland elements present is quite

unique. The notification of many of the Exmoor heaths as a candidate Special Area of Conservation (cSAC) recognizes that the heathland vegetation of the National Park shows similar transitions between upland and lowland communites. Even within a southwestern context, Exmoor's invertebrate communites are quite distinctive, with Dartmoor and Bodmin Moor lacking a number of the northern species recorded on Exmoor.

In sections 2 to 7 below the invertebrate assemblages of the six key habitats are discussed in more detail. In particular, the management factors influencing the composition of these assemblages are considered, and management recommendations that aim to preserve and enhance this interest are provided.

TABLE 1: SUMMARY OF KEY MOORLAND HABITATS AND SPECIES

HABITAT	KEY SPECIES		
	NAME:	STATUS:	MICROHABITAT:
Lowland heath	Velvet Ant	Nb	Mature heath
	Tapinoma erraticum	Nb	Pioneer heath with bare ground
	Tetramorium caespitum		Heath with bare ground
	Myrmica lobicornis		Young heath with bare ground
	Lasius umbratus		Young heath
	Ammophila sabulosa		Heath with bare ground
	Amara consularis	Nb	Pioneer heath with bare ground
	Pterostichus angustatus	Nb	Pioneer heath with burnt ground
	Platydracus fulvipes	Nb	Grazed damp heath, with red ants
	Ocypus nitens	Na	Young heath with bare ground
	Tachyporus transversalis		*Molinia* litter, damp heathland
	Lomechusa emarginata	N	Heath with bare ground and ants
	Zyras limbatus		Heath with Yellow Meadow Ant
	Aleochara ruficornis	N	Mature heath with ants
	Mycetoporus punctus	N	Mature heath
	Lamprinodes saginatus	Na	Heath with red ants
	Claviger testaceus	Nb	Heath with Yellow Meadow Ant
	Sphaeriestes reyi		Burnt gorse twigs
	Scymnus schmidti	Nb	Mature heath
	Calomicrus circumfusus	Na	On gorse and Broom
	Polydrusus confluens	Nb	On gorse and Broom
	Caenopsis fissirostris	Nb	Heath with bare ground
	Caenopsis waltoni		Heath with bare ground
	Trachyphloeus angustisetulus		Heath with bare ground
	Trachyphloeus asperatus		Heath with bare ground
	Smicronyx jungermanniae	Nb	On Dodder
	Paracrocera orbiculus	Nb	Heathland with *Pardosa* spiders
	Smoky Wave		Mature heath with heathers
	Horse Chestnut	Nb	Mature heath with heathers
	Grass Wave		Mature heath with dwarf shrubs
	Wood Tiger		Mature heath with heathers
	Heath Rustic		Mature heath with Heather
	Neglected Rustic		Mature heath with heathers
	Dipoena inornata	Nb	Old-growth heath
	Walckenaeria incisa	Nb	Heather litter
	Drassyllus praeficus	Nb	Pioneer heath with bare ground
	Evansia merens		Heath with ant nests
Upland heath & blanket mire	*Myrmica lobicornis*		Young heath with bare ground
	Myrmica sulcinodis		Pioneer heath with bare ground
	Miscodera arctica	Nb	Bare peat
	Hydroglyphus geminus	Nb	Temporary pool
	Coelambus confluens		Temporary pools
	Rhantus suturellus		*Sphagnum* bog pool
	Helochares punctatus	Nb	*Sphagnum* bog pools
	Stenus geniculatus		Amongst heather litter
	Microdon myrmicae	N	Heath with black ants
	Microdon mutabilis	N	Wet heath with red ants
	Smoky Wave		Mature heath with heathers
	Grass Wave		Mature heath with heathers
	Grey Mountain Carpet		Mature heath with dwarf shrubs
	Wood Tiger		Mature heath with heathers
	Heath Rustic		Mature heath with heathers
	Neglected Rustic		Mature heath with Heather
	Glaucous Shears		Mature heath with heathers
	Haworth's Minor		Blanket mire with cottongrasses
	Pelecopsis mengei		Blanket mire with heathers
	Drepanotylus uncatus		Blanket mire

	NAME:	STATUS:	MICROHABITAT:
Valley mire	*Agabus affinis*		*Sphagnum* flushes
	Hydroporus discretus		Neutral seepage
	Hydroporus ferrugineus	Nb	Neutral springs
	Hydroporus longicornis	Nb	Acidic seepages
	Hydroporus longulus	Nb	Neutral seepages
	Hydroporus obsoletus	Nb	Acid spring
	Laccobius atratus	Nb	Acid-neutral seepages
	Paracymus scutellaris	Nb	Neutral seepage
	Helochares punctatus	Nb	*Sphagnum* flushes
	Hydraena britteni		Neutral seepage
	Platydracus fulvipes	Nb	Grazed mire, with red ants
	Trachys troglodytes		Well-grazed mire with *Succisa*
	Microdon mutabilis	N	*Sphagnum* bog with red ants
	Marsh Fritillary	Nb	Well grazed mire with *Succisa*
	Haworth's Minor		Upland mires with cottongrasses
	Walckenaeria incisa	Nb	*Molinia* litter
	Vertigo substriata		*Molinia* litter
	Pelecopsis mengei		Acid mire with heathers
	Drepanotylus uncatus		Litter in acid mires
Acid grassland	*Carabus monilis*	Nb	Amongst litter & tussocks
	Geotrupes vernalis	Nb	Sheep dung on warm slopes
	Aphodius conspurcatus	Nb	Pony dung on well-grazed lawns
	Ctenicera pectinicornis	Na	Well-grazed slopes
	Meloe violaceus	Nb	Warm slopes with bare ground and solitary bees
	Mantura chrysanthemi	Na	Warm slopes with Sheep's Sorrel
	Larinus planus	Nb	On Creeping Thistle
Scrub	Great Green Bush-cricket		Scrubby grassland
	Woodland Grasshopper	Nb	Scrubby heathland
	Sehirus biguttatus	N	Scrubby heathland
	Lasius mixtus		Scrubby grassland
	Cryptocephalus parvulus	Nb	Birch saplings on lowland heath
	Rhynchites cupreus	Nb	Rowan on moorland fringes
	Therevа nobilitata		Scrubby lowland heath
	Heath Fritillary	RDB2/BAP	Scrubby heathland
	Welsh Wave		Rowan on moorland fringes
	Pelecopsis mengei		Scrub on acid mires
Bracken	*Carabus monilis*	Nb	Amongst Bracken litter
	High Brown Fritillary	RDB2/BAP	Violets amongst Bracken litter

2. Lowland heath

Many of the key species of lowland heath require very warm, dry conditions (xerothermic species) and a number are restricted to sparsely vegetated habitats with an abundance of bare ground. For some, such as the ant *Tapinoma erraticum* the ground beetle *Pterostichus angustatus* and the Horse Chestnut moth, Exmoor is at the extreme limits of their British range. For this reason, diverse lowland heathland invertebrate communities on Exmoor are most often found on heathlands along the Exmoor coast, where the climate is warmer and drier. Key sites include Trentishoe Down and Foreland on the Devon section of the coast, and the North Hill/Selworthy Beacon block on the Somerset side. The latter area has a particularly important lowland heathland fauna, including the only Exmoor populations of extremely xerothermic species such as *T erraticum* and *P angustatus*. There is a generally northerly aspect on most of the coastal heaths, and areas of lowland heath with more southerly aspects are of especially high value in providing a suitable micro-climate for xerothermic invertebrates. Such south-facing slopes are very localised, with some of the most important areas being at North Hill, Alcombe Common, Bossington Hill, Cosgate Hill, Ashton Cleeve, Foreland and the Valley of Rocks. Recognizable lowland heath invertebrate assemblages also occur in a few inland areas, such as the low-lying, sheltered fringes of Dunkery Beacon, and on Haddon Hill, but most of the more exacting thermophiles are missing from these sites.

A striking feature of Exmoor's lowland heathland invertebrate assemblage is the importance of ants. Ants reach their peak diversity and abundance on Exmoor in lowland heathland habitats, with common species such as *Myrmica ruginodis*, *M scabrinodis*, *Leptothorax acervorum, Lasius flavus*, *L niger, Formica lemani* and *F fusca* which are common in a range of habitats on Exmoor, being joined here by a suite of xerothermic species such as *Tapinoma erraticum*, *Tetramorium caespitum*, *Myrmica sabuleti* and *M sulcinodis*. As well as being important in their own right, ants are keystone species in heathlands, with a vital role in the maintenance of ecosystem functioning and diversity. As an example of this, seven of the key invertebrate species of lowland heaths; *Lomechusa emarginata*, *Zyras limbatus, Lamprinodes saginatus*, *Claviger testaceus*, *Microdon myrmicae* and *Evansia merens* are myrmecophilous, spending some or all of their life cycle within ant nests. They are thus utterly reliant for their survival upon the presence of particular ant species. In addition, the spider *Dipoena inornata* is thought to be a specialist ant predator.

The key management requirement for the majority of these species is patchy heathland vegetation, with an abundance of bare ground, which is most often created by a combination of grazing, burning and scrub/Bracken control. Burning of lowland heathland on a 10-15 year rotation is a valuable management tool for many lowland heath invertebrates. Xerothermic species such as *T erraticum*, *Amara consularis* and *Drasyllus praeficus* are restricted to pioneer heathland with abundant bare ground, with this habitat most often occurring on lowland heathland areas burnt within the last five years. Additonally, two of the key species, *P angustatus* and *Sphaeriestes reyi* have an obligate association with freshly burnt areas of heathland. We should therefore aim to have a very significant proportion of lowland heathland sites (20-30% of total heathland area) supporting pioneer heathland communities. It is important that we are not afraid to use burning as a management tool on lowland

heathland sites, provided that this is controlled and allows for the development of a full range of heather age-classes on individual sites.

On many of Exmoor's lowland heaths, including important sites such as North Hill and Alcombe Common, grazing was lost for many years in the post-war period (though it has been reintroduced to North Hill recently), and this has led to the loss of much former heathland to Bracken, European Gorse and scrub. Scrub encroachment has been greatest on the lower, more sheltered slopes, which would have provided the best habitat for xerothermic invertebrates of lowland heathland. On North Hill for example, there are extensive areas of south-facing slopes, which supported heathland vegetation in the past, but which are now mantled by dense Bracken, scrub and secondary woodland. Unfortunately it is these low-lying stands of warm, sheltered heathland, especially those on south-facing slopes, which would have provided the best habitat for the lowland heathland assemblage. One example is provided by *T erraticum*, restricted on North Hill to three tiny patches of recently burnt heath, on south-facing slopes, amounting to no more than half a hectare in extent. The danger of extinction with such small and fragmented habitat patches is very high and it is vital that we safeguard existing areas of lowland heath habitat, but also look to substantially increase it by further burning and cutting of scrub, and through the reintroduction of grazing to control re-encroaching scrub. A fuller discussion of the value and management of scrub can be found in sub-section 6 of this report.

Though of somewhat lower value for key invertebrates on Exmoor than the pioneer communities, more mature heathland does host a number of key species, such as the leaf beetle *Calomicrus circumfusus*, the spider *Dipoena inornata* and the six macromoths included in Table 1. For this reason, it is important that the burning rotation is long enough to ensure that a significant proportion of the site (not less than 30%) supports more mature heathland communities. In reality, most of the lowland heaths of Exmoor (barring Trentishoe Down, which has been subject to repeated uncontrolled burning) have a preponderance of more mature heathland age-classes, and the invertebrate fauna associated with this type of vegetation is not threatened.

3. Upland heath and blanket mires

In this section I include all of the "higher quality" vegetation found on the upland plateau. On drier soils, typical upland heath with dwarf shrubs such as Heather and Whortleberry. However, the very wet climate means that in many areas, the mineral soil is overlain by peat. This results in impeded drainage, and favours the development of wet heath vegetation in which dwarf shrubs are mixed with more moisture-loving species such as Purple Moor-grass, Deer-grass *Trichophorum cespitosum* and the bog-mosses *Sphagnum capillifolium* and *S compactum*. On some of the wettest, least disturbed areas, a sufficient depth of peat has accumulated to support vegetation communities transitional to blanket mire types in which Hare's-tail Cottongrass *Eriophorum vaginatum* and the bog-moss *Sphagnum papillosum* also occur. Blanket mires on Exmoor are of very local occurence, amounting to approximately 480 hectares in extent (ENPA, 2001). The invertebrate fauna of Exmoor's blanket mires and wet heaths is limited, with most of the acid mire associated species being widespread in Britain across a range of mire types. Examples of such species include the ground beetles *Pterostichus diligens* and *Pterostichus rhaeticus* and the rove beetles *Oxypoda procerula* and *Ochthephilum fracticorne*. All of these species are moisture-loving (hygrophilous), with the

maintenance of very damp conditions throughout the year being of key importance for their conservation.

On some of the higher quality areas of blanket mire and wet heath, sufficient variation in the micro-topography of the mire surface has developed to allow for the occurrence of small bog pools dominated by the bog-mosses *Sphagnum cuspidatum* and *Sphagnum recurvum* and the Common Cotton-grass *Eriophorum angustifolium*. The bog-pool water beetle community is relatively species-poor, but includes a number of acid water specialists such as *Helochares punctatus*, *Hydroporus gyllenhalii*, *Hydroporus melanarius*, *Hydroporus tristis*, *Ilybius montanus* and *Rhantus suturellus*, the first and last being sufficiently scarce to be considered key species in this report. Permanently saturated lawns of bog-moss around the fringes of bog pools provide suitable habitat for extremely hygrophilous species such as the ground beetle *Agonum gracile* and the rove beetles *Gymnusa brevicollis*, *Lathrobium terminatum* and *Philonthus nigrita*. These species are usually common amongst *Sphagnum* on British blanket mires, but the lack of micro-topography and relatively low *Sphagnum* cover of Exmoor's blanket mires means that they are of much more restricted occurrence here.

The main reason for the relatively impoverished invertebrate fauna of plateau mires on Exmoor, and the localisation of more hygrophilous elements of the invertebrate fauna is the long history of frequent, uncontrolled burning to which these areas have been subjected. Burning is very damaging to blanket mire and wet heath vegetation, particularly the various bog-moss species that help to maintain permanently high water tables across the mire surface. Burning results in widespread die-back of *Sphagnum* and a reduction in the water table within the peat column. It also encourages the spread of Purple Moor-grass, which thrives in the drier, better oxygenated peat. Where repeated burning has taken place over many years, as on the Exmoor Forest, blanket mire and wet heath communities are now restricted to small pockets where there is the greatest peat depth. Elsewhere the plateau is covered by monotonous tracts of dense Purple Moor-grass tussocks. Sampling of species-poor Purple Moor-grass stands has revealed most of the invertebrates to be habitat generalists (eurytopic species) with a high dispersive ability. Only one invertebrate, the wolf spider *Pirata uliginosus* appears to show a particular preference for species-poor Purple Moor-grass swards on Exmoor, but this is a common species of low conservation importance. Burning is also extremely damaging to bog pool communities, as the lowering of the water table increases the likelihood that the pools will dry up during dry periods. This was well seen on the blanket mire at Burcombe, which suffered a large uncontrolled burn in 2000, and in which most of the smaller bog pools have subsequently dried up over the summer months, resulting in the loss of much of their typical fauna. It is imperative that burning be prevented on plateau wet heaths and blanket mires in the future. Non-burning areas should also include degraded mire areas where there is still enough diversity of vegetation to suggest that recovery of the community is achievable. Grazing pressure on blanket mires and wet heaths should be light enough to allow a good vegetation structure to develop, with mature stands of ericaceous dwarf shrubs being particularly important for the important upland macromoth community, most of whose larvae feed on these plants.

Management of species-poor *Molinia* grasslands should aim to revert these areas to more species-rich wet heath and blanket mire communities. In order to control Purple

Moor-grass, relatively heavy grazing by cattle and ponies is required initially, as this is very effective in suppressing *Molinia* growth.

As has already been explained in sub-section 1, Exmoor's equable climate and relatively low altitude means that its upland invertebrate fauna is quite poorly developed. However, "relict" populations of upland species do still occur on the plateau heaths and blanket mires, and constitute a regionally important invertebrate assemblage of considerable biogeographical interest. Also of unique interest is the presence in these invertebrate assemblages of species with both "upland" and "lowland" distributions in Britain. Seven of the key species are true upland species in Britain, with the major part of their British range being in the mountains of Scotland, northern England and Wales. These seven are the ground beetle *Miscodera arctica*, the Smoky Wave, Grey Mountain Carpet, Glaucous Shears and Haworth's Minor moths, and the money spiders *Pelecopsis mengei* and *Drepanotylus uncatus*.

All of these, except the Glaucous Shears, have their main southwest English populations on Exmoor. That Exmoor should have a better developed upland fauna than Dartmoor is surprising given the higher altitudes and much larger extent of upland habitat present in the latter area. In part, this may result from the more intense grazing pressure to which the Dartmoor commons have been subjected. This has resulted in the loss of dwarf shrubs (the foodplants of the Smoky Wave and Grey Mountain Carpet) over large areas of the moor. It is also probably true that the geographical position of Exmoor, within sight of the Brecon Beacons across the Bristol Channel, has facilitated periodic colonisation of Exmoor by upland invertebrate species from the south Welsh mountains.

These upland species are essentially "relicts", which would have been of much wider occurrence in southwest England at the end of the last Ice Age, when the climate was considerably cooler than now. Most upland species are of very local occurrence on Exmoor, and in the case of *M arctica* and the Grey Mountain Carpet, records are so sparse, that there is speculation that they may be no more than vagrants from established populations in south Wales (Robbins, 1990). Global warming may result in the continuing impoverishment of this upland fauna. Clearly, this is one of the most threatened invertebrate assemblages of moorland habitats on Exmoor, and it is important that we elucidate the distribution of these species, both because of their importance as extreme outlying relicts of a community that finds its fullest expression in the mountains of northern Britain, and as potentially hyper-sensitive indicators of the ongoing process of climate change. By the same token, it seems certain that some of the scarce lowland heathland species discussed in sub-section 3.2 will increase in abundance, and we should expect that further species of this faunistic element will colonise the area.

As has been mentioned above, most of the macromoths found on upland heath are reliant upon mature stands of ericaceous dwarf shrubs, upon which the larvae feed. It is therefore important that a high proportion of upland heath sites support more mature age-classes of heather moorland (at least 50% of the area of upland heath), and a somewhat longer burning rotation of 25-30 years is appropriate. Where "layering" of heather is taking place it may be possible to retain "old growth" stands that are burnt or cut on a much longer rotation. Mature and "old growth" heather stands have a more complexed vegetation architecture and a well-developed litter layer. This

provides excellent habitat for a number of important invertebrates, especially amongst the spiders, which include a number of species that are confined to mature and "old growth" heathland. These species are very sensitive to over-frequent burning, and it is necessary to allow for a longer burning rotation that provides a constant supply of mature heather age-classes for them to colonise. Burning is generally a much more equivocal management tool for conserving the upland heath invertebrate fauna than is the case in lowland situations. However, one of the key species, the ant *Myrmica sulcinodis* has only been found on recently burnt pioneer heathland, and it is important that at least some areas of recently burnt heath (at least 10% of the area of upland heath) are created by regular rotational burning.

As is the case with the lowland heathland invertebrate assemblage, discussed in section 1 above, Exmoor lacks many of the more restricted upland specialists, as its climate is too warm for them. However, the mix of upland and lowland elements to the invertebrate fauna that we find on the heaths of Exmoor is unique, and makes the area a fascinating natural laboratory for studying ongoing change in the British invertebrate fauna in response to climate change.

4. Valley Mire

Compared to other moorland areas in southwest England, such as Dartmoor and Bodmin Moor, Exmoor's valley mires are relatively poorly developed, and they lack a number of the more exacting species associated with mire habitats elsewhere in the region. The free-draining, steep-sided periglacial valleys of Exmoor, mean that valley mires tend to occur as very narrow, somewhat fragmented strips along the valley floor of streams draining the moorland plateau.

Despite the relatively limited extent of valley mires on Exmoor, they still support an important invertebrate assemblage that includes 19 of the key species listed in section 2. The definition of valley mire used is a loose one, and encompasses the range of semi-natural wetland vegetation found in moorland valley bottoms. Though Exmoor does have areas of mire in the strict sense, much of the valley bottom vegetation is relatively mesotrophic poor-fen in which Soft Rush *Juncus effusus* and Sharp-flowered Rush *Juncus acutiflorus* predominate. The mire fringes and valley sides are frequently dotted with springs, which support similar vegetation communities, and are also discussed here.

Two of the key species associated with valley mire habitats, the Marsh Fritillary butterfly and the jewel beetle *T troglodytes*, are phytophagous specialists that feed exclusively on Devil's-bit Scabious *Succisa pratensis*. Both are more characteristic of enclosed wet grassland, but also occur on Exmoor on the lower moorland fringes of sites such as Codsend Moors. The key management requirement for both of these species is adequate grazing levels by cattle or ponies. This produces the heterogeneous sward height across they require. The two myrmecophilous species, *Microdon mutabilis* and *Platydracus fulvipes* are also most often encountered in well-grazed valley mire. Both of these species are associated with red ants *Myrmica* spp, with *M mutabilis* being specifically associated with *Myrmica scabrinodis*. Where it occurs in valley mires, *M scabrinodis* nests in *Sphagnum* hummocks growing in open "lawns" within the mire. To conserve populations of these myrmecophiles, sufficient grazing is essential to maintain the open mire habitat required by their ant host. Without adequate grazing, rank tussocks of Purple Moor-grass and rushes will tend to

become excessively dominant. Burning is generally to be discouraged in valley mire habitats, as it is extremely damaging to populations of many of the specialist invertebrates. It should only be considered where Purple Moor-grass has become very rank and tussocky and where there is an adequate level of cattle and pony grazing to control subsequent *Molinia* regrowth.

The Exmoor Forest is generally considered to be an extremely degraded area of moorland. Excessive burning has largely eliminated plateau blanket mire and wet heath communities, with these being replaced with large tracts of species-poor Purple Moor-grass. It is however clear from this survey, that the valley mires of the Exmoor Forest still support an invertebrate community of great interest. For example, valley mire habitats at Larkbarrow host a diverse invertebrate community that includes five key species, *Hydroporus discretus*, *Hydroporus ferrugineus*, *Platydracus fulvipes*, *Walckenaeria incisa* and *Vertigo substriata*. The latter is a small whorl snail that is generally found in undisturbed neutral wetlands. Its presence on the Forest's valley mires is surprising, and indicates that the springs arising around the fringes of these habitats must be at least moderately nutrient rich.

Aquatic moorland habitats on Exmoor are not as well developed as in many other upland areas, being largely restricted to areas of running water in the main valleys. The fast-flowing streams of the moorland valleys have a macro-invertebrate fauna typical of upland areas throughout Britain dominated by stonefly, mayfly and caddis nymphs. In many of the streams, they are joined by large populations of the freshwater shrimp *Gammarus pulex*, which indicates that the moorland streams here must be at least moderately base-rich. The commonest water beetles are *Oreodytes sanmarkii*, *Elmis aenea* and *Limnius volckmari* all of which are common across western Britain. No key invertebrates have been recorded, though more detailed study of the Plecoptera, Ephemeroptera and Trichoptera is needed before we can fully evaluate the importance of the invertebrate fauna of this habitat.

By contrast, the small spring-fed seepages that occur on the sides and at the heads of the moorland combes have a rich invertebrate fauna that includes a number of key species. Springheads at such sites on Exmoor are frequently characterised by the presence of a "lens" of bog-moss, though the frequent occurrence of other plant species such as Blinks *Montia fontana* and Opposite-leaved Golden-saxifrage *Chrysosplenium oppositifolium* again indicates that the groundwater must be at least modestly mesotrophic. Nine specialists of spring and seepage habitats as defined by Boyce (2002) have been recorded during the current study, these being the planarian flatworm *Crenobia alpina*, and the water beetles *Agabus guttatus*, *Hydroporus discretus, H ferrugineus*, *H obsoletus*, *H longicornis*, *H longulus*, *Paracymus scutellaris* and *Laccobius atratus*. The latter four *Hydroporus* species are classified as being nationally, as well as regionally scarce species (Foster, in press). Generally *H obsoletus* is a species of rather acid springs, whilst *H ferrugineus* is thought to occur in more base- and nutrient-rich spring waters. It is interesting that it is the latter species that appears to be the more widespread on Exmoor, an indication that springwater on Exmoor is generally of relatively high base status. Both of these species are confined to the immediate springhead, and are known to be at least partially subterranean, retreating underground in the summer when there may be no surface water flow from the spring.

H longicornis is a predominantly northern species of acid flushes, with a "relict" distribution at scattered sites in southern England, where it tends to be confined to springheads, where the water is much cooler. This appears to be a genuinely scarce species on Exmoor, only being found during the EMIS in two acid flushes near Sherdon Hutch on Withypool Common. As with *H obsoletus*, this perhaps reflects the relative scarcity of acidic flushes, with most seepages investigated during the EMIS having vegetation consistent with more neutral water pH values.

H longulus has only been found twice during the EMIS, these records being from somewhat mesotrophic spring-fed seepages on Winsford Hill and Dunkery. *H discretus* is also a species of somewhat richer waters, and as with *H longulus*, it tends to occur more widely in seepages, some way from springheads. The water beetle fauna of Exmoor's springhead mires is of considerable interest, and the presence of a number of species with requirements for subtly different hydrological conditions indicates that a range of water chemistry conditions are found here.

5. Acid grassland

As defined here, acid grassland comprises vegetation dominated by Common Bent *Agrostis capillaris*, Sheep's Fescue *Festuca ovina* and Mat Grass *Nardus stricta*. Such vegetation requires relatively free-draining conditions, and is thus generally found on valley sides, where the slope is sufficiently steep to preclude peat formation.

Upland acid grassland is often considered to be of relatively low interest by those involved with nature conservation. On Exmoor at least, this does not appear to be the case, with seven key species largely restricted to this habitat. Generally speaking, the most diverse invertebrate assemblages are found on south-facing acid grassland banks, with known populations of *C monilis*, *G vernalis* and *M chrysanthemi* being confined to such situations on Exmoor.

Because the fine-leaved grasses that dominate the vegetation of these areas are highly palatable to stock, acid grassland is usually quite heavily grazed. This results in large accumulations of dung being present, and it is therefore not surprising that the two key dung beetle species recorded during this study, *Aphodius conspurcatus* and *Geotrupes vernalis* have both been found in association with this habitat. The moorland dung invertebrate fauna of Exmoor was the subject of a separate study undertaken by Peter Skidmore. He found this fauna to be somewhat disappointing, with the great majority of the species recorded being widespread and common across Britain. The most likely reason for this disappointing lack of diversity is the use of veterinary chemicals, such as avermectins, that are slow to break down, and persist in the dung for a number of weeks. These chemicals are highly toxic, and have been shown to greatly reduce the diversity and abundance of dung invertebrates. It is important that the use of persistent veterinary chemicals is avoided wherever possible, or if they are to be used, then their application is timed to minimise the impact of the dung invertebrate fauna.

6. Scrub

On the lower fringes of Exmoor, moorland habitats frequently have a significant element of scrub, with the most frequent scrub species being Hawthorn *Crataegus monogyna*, Downy Birch *Betula pubescens* and Rowan *Sorbus aucuparia*, with Grey Willow *Salix cinerea* and Eared Willow *Sailx aurita* being common in boggy areas.

For the purposes of this report, species associated with gorse are treated in the earlier sub-sections on lowland heath (sub-section 1) and upland heath (sub-section 3). As explained in section 1, excessive scrub invasion is detrimental to open moorland habitats, as it shades out important heath, mire and grassland communities. An element of scrub is however to be encouraged, as it significantly enhances the diversity of the invertebrate fauna at a site.

Of the 10 key species associated with scrub, only three, the leaf beetle *Cryptocephalus parvulus*, the weevil *Rhynchites cupreus* and the Welsh Wave moth, are directly associated with scrub vegetation. The first species feeds on birch leaves, whilst the latter two both feed on Rowan trees. For the remaining species it is the importance of scattered scrub in providing a warm, sheltered microclimate that is of key importance. The Heath Fritillary is a prime example of this. Though the larvae develop on Common Cow-wheat, a widespread hemi-parasite of Whortleberry on Exmoor, colonies of the butterfly are restricted to scrubby moorland fringes, where scrub and Bracken growing on the heathland provide the sheltered conditions that appear to be essential for this species.

Generally, Exmoor's moorlands are less intensively managed now than they were in the first half of the twentieth century, and this has led to a considerable increase in the amount of scrub found around the moorland fringes. Though some scrub is important for a range of scarce moorland invertebrates, lack of management input has allowed vegetational succession to dense species-poor Bracken stands or secondary woodland to take place, resulting in the loss of important scrub invertebrates. This is especially apparent on Exmoor's coastal heaths. Scrub control should be carried out on a rotation, with both cutting and burning being valuable management tools. The aim should be to keep the amount of scrub on moorland sites within acceptable limits of between 10% and 20% of the total moorland area.

7. Bracken

The importance of south-facing bracken slopes as a breeding habitat for the High Brown Fritillary butterfly is well documented. Bracken also forms a component of the breeding habitat used by the Heath Fritillary butterfly on Exmoor. A discussion of the status of that species is included in section 6 above. English Nature commissioned an invertebrate survey of bracken habitats in southwest England to see if there were other invertebrates of comparable interest to the fritillary butterflies that were also reliant upon this habitat (Skidmore, 1998). The conclusions of this report, backed up by the results of the EMIS are that there do not appear to be many other important invertebrate species associated with Bracken habitats on the moors of south west England, and it is the fritillary butterflies that are of key importance in determining the management of Bracken habitats in the region.

As with the scrub habitats discussed in section 5, Bracken is thought to have increased greatly on Exmoor, primarily as a result of the loss of Bracken cutting and grazing from a number of areas of moorland. This is resulting in the loss of heathland, mire and grassland communities to dense Bracken that is generally of much lower interest for moorland invertebrates than the open habitats discussed in sub-sections 1 to 4 above. Away from High Brown Fritillary breeding areas, the control of encroaching Bracken is one of the most important objectives of moorland management on Exmoor

if we wish to maintain and enhance the invertebrate interest of heathland, mire and grassland habitats.

Even on High Brown Fritillary sites, inadequate management is resulting in the development of very dense Bracken, Bramble and scrub. Dense Bracken litter chokes the patches of Common Dog-violet on which the larvae feed, and whilst violets may still grow under Bramble and scrub, conditions here are too cool and shaded for larval development. This is one of the most important species occurring on Exmoor, and it is the subject of both national and local BAPs. It is imperative that existing sites for the species are adequately grazed by cattle and/or ponies, and that on sites where scrub invasion has occurred, programmes of scrub control are initiated to maintain suitable Bracken habitat for the butterfly. When carrying out scrub control on High Brown Fritillary sites, areas with high densities of Common Dog Violet in the understorey should be prioritised for clearance. Some scrub on High Brown Fritillary sites is valuable in providing shelter and roosting sites for the adults. Generally, scrub cover should be maintained at between 10 and 20% of the total area of Bracken habitat. On sites where Bracken is becoming too dense, annual cutting should be considered, as this can be effective in reducing its vigour and in encouraging subsequent stock grazing. Cutting of "runnels" through the Bracken may also be valuable in providing warm, sheltered edges in which the foodplant can flourish, and also in encouraging stock access into the Bracken stands. Without significant additional management input onto High Brown Fritillary sites, it is likely that this species will be lost from Exmoor.