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The value of abandoned mined sites for wildlife – the triumph of nature over our industrial past

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[Based on a talk to the Royal Geological Society of Cornwall 2010]

Introduction

Abandoned metalliferous mining sites occur throughout Cornwall, covering over 3,000ha (Spalding & Dinsdale 2000) and making an important contribution to Cornwall's nature-conservation resource (Spalding 1996; 2005). In the 18th and 19th centuries, technical advances in hard rock mining resulted in a transformed landscape (Earl 1968) and Cornwall became world famous for mining for copper, tin, arsenic and lead. This distinctive mining legacy persists within the landscape and is recognised in the World Heritage Site status for the Cornish Mining Landscape. Active mining, however, has now gone from Cornwall. The last working mine was South Crofty, worked for tin until 1998, although there are ongoing attempts to reopen it. Mine sites are thus a finite resource and there are unlikely to be further exposures of metal-rich substrates. When South Crofty is reopened, waste will be stored underground, rather than spread out on the surface as in previous centuries.

The development of wildlife communities in Cornwall over several centuries was at least partly characterized by the loss of woodland (as trees were felled for charcoal furnaces and later for timber props for the mines) and by the increase of heathland on thin acid soils (Bere 1982). Photographs from the 19th century show the mining landscape dominated by engine houses, well-used pathways, open areas of bare eroded ground and small fragments of gorse scrub and heathland. These habitats and their associated wildlife form part of the history of each site, and we can see how wildlife species and habitats survived and were influenced by the industrial process. The presence or absence of a species gives us clues as to how a habitat has developed and changed over the years and even what the surrounding areas were like. The presence of these historical indicator species in the wildlife sites of Cornwall gives them a cultural importance, contributing to our `sense of place', a sense of continuity with those who have gone before. Awareness of the development of the wildlife of a place as it has changed over centuries and been modified by man's activity constructs our `moral geography' of the countryside and emphasises our part within it. Too often, we see wildlife, particularly animals, as there despite us, when in most cases it is there because of us, the numbers and distribution of species being directly influenced by our activities, both past and present.

The Derelict Land Advisory Panel

The case for the conservation of abandoned metalliferous mines in Cornwall was put by the Derelict Land Advisory Panel, based at the world-famous Camborne School of Mines. This panel oversaw the publication of a report and accompanying leaflet highlighting the value of these sites for their archaeology, geology and mineralogy, nature conservation, scientific research, heritage and tourism (Johnson Payton & Spalding 1996). Following this, these sites were listed as a key habitat by English Nature (now Natural England) and as prime biodiversity areas (English Nature 1997). Metalliferous mine sites were included as a priority habitat in the first edition of the Cornwall Biodiversity Initiative 1998, although they have since been dropped as part of a rationalisation programme to ensure that Cornwall uses the same habitat criteria as the national biodiversity programme (CBI 2004). In addition, seven sites were included as part of the West Cornwall Bryophyte Site of Special

Scientific Interest, covering nearly 54ha of mine-site land. Most importantly, abandoned mine sites were no longer seen as derelict places to be restored, but as a key part of the Cornish heritage. As Box (1992) pointed out, naturally revegetated derelict-land sites are important parts of the ecological framework of the British landscape.

Contamination by metals

The nature of the land when mining ceased has greatly influenced vegetation development and colonisation by wildlife (Bradshaw & Chadwick 1980). Nitrogen and phosphorus availability is low and pH values are generally within the range of 4-5 (Whitbread-Abrutat 1995), and in places soils and associated micro-organisms are absent (Witter Giller & McGrath 1994). Many of the sites are contaminated by metals. Work by researchers at the Camborne School of Mines has shown that contamination is patchy, with `hot spots' of metals often associated with bare ground. Contamination is in the form of primary waste (residual unworked minerals on waste dumps) or processing waste (arsenic and other metal sulphides, found near the dressing floors, and concentrations of arsenic, cadmium and other minerals in the calciner flues, where ores were roasted to remove impurities). Analysis of sandy soil from 4 adjacent sites at Binner Downs near Leedstown showed low pH values and high metal contamination from arsenic, lead, copper and zinc, with lower levels of a suite of other metals (Table 1) (Spalding, Collins & Haes 2008).

Table 1: Metal content (ppm) and pH values at 4 sample sites, Binner Downs, 2007

Analysis	Area 1 - bank top with heather	Area 2 - bank slope with no vegetation	Area 3 - with thick gorse scrub	Area 4 - with abundant moss
Arsenic	1300	1500	2000	1800
Cadmium	1.5	2.0	2.0	1.9
Chromium	22	24	23	30
Lead	460	1300	1300	1100
Mercury	<1.0	<1.0	<1.0	<1.0
Selenium	<1.2	<1.2	<1.2	<1.2
Copper	450	890	780	540
Nickel	28	45	45	44
Zinc	120	330	150	140
pH	6.1	5.4	5.6	5.6

Factors influencing habitats and species

Some significant influencing factors specific to mining sites that have helped to shape vegetation development and their use by key species include:

- hummock/hollow mosaics, with hot south-facing and cool north-facing slopes
- unstable substrates, especially spoil heaps, often with abundant clitter, sometimes recently reworked for minerals
- compacted and contaminated soils leading to long-term bare ground, prone to erosion and extremes of temperature
- lack of topsoil, soil structure, nutrients and micro-organisms
- steep slopes prone to water erosion
- toxicity due to a variety of metals (e.g. copper, lead, zinc, arsenic), leading to the development of specialised plant and animal communities
- derelict buildings and rubble
- abandoned settlement tanks and similar structures which provide aquatic environments
- shaft adits and open-cast pits.

(Details taken from Spalding *et al.* 1996)

The vegetation developed on the abandoned sites is generally typical of the vegetation of the geographical area in which the site lies (i.e. heath in heathland areas) and may give an indication of the habitat types that used to be present before agricultural or industrial use. Habitats are therefore representative of Cornwall as a whole, with gorse scrub dominating large areas of mine sites, grading into willow scrub where the soils are deeper and moister. In the more urban areas, mine sites are often used as dumping grounds for garden waste, with the result that garden escapes are common and Japanese Knotweed is a major problem. Wetland areas occur where the drainage has been impeded as part of the industrial process, e.g. in the settling tanks, and there are occasional pools of open water where invertebrate and plant diversity is severely reduced by ochre deposition, contamination of silt by arsenic and low pH values. However, the key habitats which distinguish mine sites from other wildlife areas are heathland, contaminated ground, disused buildings, adits and shafts. The heterogeneity of these habitats provides a broad spectrum of environmental conditions in which wildlife can survive.

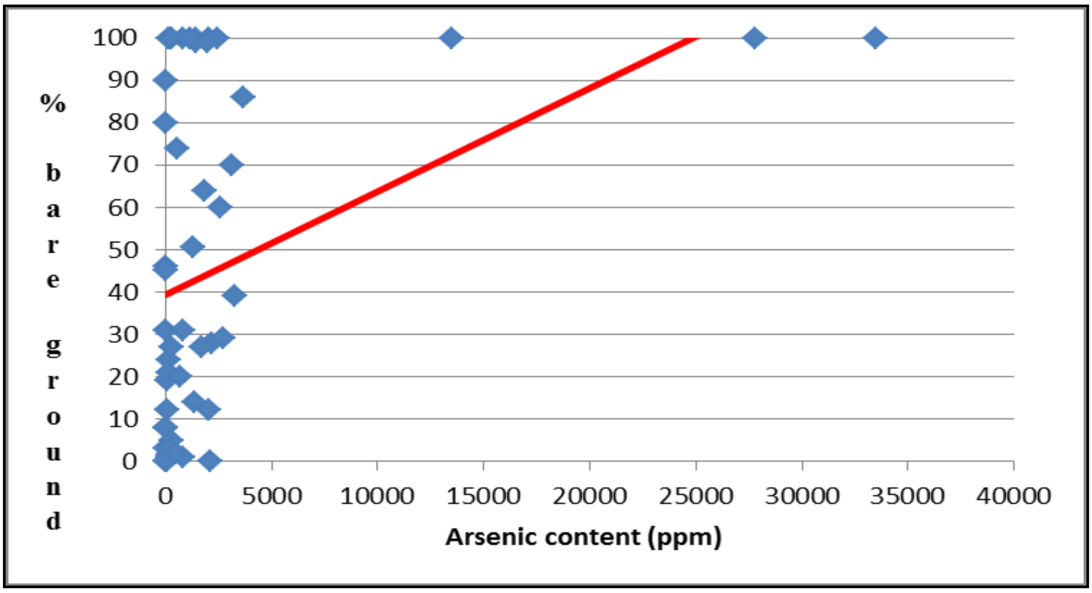
Heathland

Heathland is often the dominant habitat on nutrient-poor soils. Ling *Calluna vulgaris* is the commonest heather, forming a climax self-regulating community on toxic ground which inhibits the growth of competing plants. The tolerance of heavy-metal contamination (e.g. arsenic) by Ling may be due to the presence of mycorrhizal fungi, which reduces exposure of the host plant to metals; at Binner Downs Ling grows in Area 1 despite heavy concentrations of arsenic (Table 1). On most sites, the heathland is of even age, with sparse plants growing over bare ground. Ling is important as a larval foodplant for a range of invertebrates and provides structure for concealment and nesting places, but perhaps it is most important as a nectar source in autumn, when the mine sites are alive with flying insects.

Metals and bare ground

There are large areas of bare ground present on the mine dumps, forming a habitat in its own right (Kirby 1992). Some of these areas are heavily compacted and devoid of wildlife interest. Others are covered with clitter, with sporadic vegetation where occasional predatory and foraging insects move amongst the stones. More interesting are the occasional places where the soil is toxic, plants are stunted or absent, and colonisation by heathers and gorse is slow. There are statistically significant weak correlation between metal contamination and bare ground in Cornwall for arsenic ($r = 0.38$; $n = 52$; $p<0.01$) (Fig 1) and zinc ($r = 0.26$; $n = 52$; $p<0.05$) and non-significant correlations between bare ground and copper ($r = 0.2$; $n = 52$; $p<0.1$), lead ($r = 0.15$; $n = 52$; $p<0.1$) and tin ($r = 0.13$; $n = 52$; $p<0.1$). High levels of zinc, copper, lead and arsenic at Binner Downs in Area 2 (Table 1) contribute to the absence of vegetation here. The processes that continually inhibit plant succession but maintain firm bare ground over relatively long periods provide valuable wildlife habitat (Key 2000).

Fig 1: Significant weak correlation between arsenic and bare ground in 12 mine sites in west Cornwall (1998) (data collected by Sheena Cotton, Camborne School of Mines) ($r = 0.38$)



Metallophytes

The presence of copper, zinc, lead and arsenic has led particularly to the formation of communities where plants are found in unusual associations. These plants can be classified variously as absolute metallophytes (found on metal-rich soils only), local metallophytes (found on metal-rich soil only within a given region) or pseudometallophytes (widespread species occurring on both metal-rich and more normal soils as distinct races or ecotypes) (DoE 1994). They possess biological mechanisms which enable them to tolerate high levels of metals which are ordinarily toxic to plants. Some metallophytes have mechanisms to limit metal uptake, whilst others (hyperaccumulating plants) can amass high concentrations of metals in their tissues without symptoms of toxicity (Whiting Reeves & Baker 2002). Metallophytes can be used as bio-indicators (indicating where metalliferous substrates occur), for ecological restoration (e.g. using metal-tolerant grasses for reseeding areas) or for metal recovery (harvesting toxic metals from polluted sites with hyperaccumulating plants) (Whiting Reeves & Baker 2002). Hyperaccumulation may be a defence strategy to deter insects. The evolution of tolerance of metal contamination can be extremely rapid in some cases (Macnair 1987a).
In Cornwall, Thrift is a local metallophyte, associated particularly with copper mine wastes. It occurs at many copper-mining sites in Cornwall and also on mine waste in the Pennines and Wales (Baker & Proctor 1990). Thrift is more typically a coastal plant, but some of the most extensive colonies in Cornwall are associated with saltmarsh vegetation in estuaries contaminated by mine run-off (Jenkin *et al*. 1996). Common Bent grass is a pseudometallophyte common on some of these sites, where it appears to have become tolerant of metal contamination; in some areas it is the commonest grass. On mine sites in Devon, Macnair (1987b) found that Common Bent collected at Wheal Exmouth was tolerant of lead and copper and samples collected at Devon Great Consols were tolerant of arsenic and copper (but not lead or zinc), whereas specimens collected on uncontaminated grass pasture showed no tolerance of any metal.

Mosses, liverworts and lichens

Although there appear to be no absolute metallophytes amongst the vascular plants in Cornwall, several lichens and bryophytes are in this category. Detailed surveys on the bryophytes, carried out by David Holyoak (Holyoak 2000) on 107 areas of former metal-mining in Cornwall, highlighted the importance of these sites for mosses and liverworts; 13 nationally rare taxa were recorded, including the Cornish Path Moss *Ditrichum cornubicum*, which is unique to Cornwall and found on only two former mine sites. The key areas for bryophytes include the unshaded, highly calcareous old mortar on old mine walls, but the rarest species are found on the unshaded, poorly vegetated copper-contaminated soils; the liverworts *Cephaloziella nicholsonü* and *C. massalongi* and the mosses *Scopelophila cataractae* and Cornish Path Moss are restricted to these copper-contaminated substrates. The designation of the West Cornwall Bryophytes SSSI was a direct result of these surveys.

Mine sites are also recognised as being nationally important for lichens (Purvis 1993). In Cornwall, in detailed surveys carried out on 56 former mine sites, Giavarini recorded 338 taxa, including ten nationally rare and 39 nationally scarce taxa, and he considers that Cornish mine sites support about 40% of all British metallophyte lichens (Giavarini 2002). The key habitats for lichens include:

- unshaded, sparsely vegetated mine wastes, especially where copper contamination is present: habitat for the nationally scarce metallophytes *Cladonia cariosa, Lecanora handelii, L. subaurea, Stereocaulon leucophaeopsis* and *S. nanodes*.
- vertical shaded walls constructed from mine waste: habitat for the metallophytes *Acarospora impressula, Lecanora epanora* and *Rhizocarpon furfurosum*.

Mine buildings, shafts and adits

Many mine sites contain derelict buildings (engine houses, arsenic calciners and chimneys), structures such as tramways, settling tanks, wheel pits and dressing floors, and underground workings and access features such as shafts and adits (Johnson 1996). Some of these structures may be used by birds such as Barn Owl, Kestrel, Raven and Stock Dove, which nest on the ledges and in the cracks of the crumbling masonry. Badgers often build setts beneath structures (e.g. at Geevor) and bats use mine openings and engine houses (e.g. Chapel Porth). A number of bryophytes grow on the lime mortar used to point the stone walls (e.g. at Botallack).

Shafts and adits on mine sites provide safe, undisturbed environments in which bats can hibernate, with little variation in temperature and humidity throughout the year (McAney 1999). Some bats may also use these underground areas in the summer as night roosts and feeding areas. Some air flow through the shaft or adit is preferred by bats, although they will use single shafts with little air movement for temporary roosts. The structure of the shaft or adit is important, creating pockets of cooler or warmer air. Several species of bat in Cornwall hibernate underground, mainly in mine sites or caves, including Brandt's, Brown Long-eared, Daubenton's, Greater Horseshoe, Lesser Horseshoe, Natterer's and Whiskered (Tompsett 1997). Other species, such as Pipistrelle and Serotine, may roost in summer in the derelict ivy-covered buildings. The greatest threat to bats hibernating in these sites is from human activity, either through blocking mine entrances or through direct disturbance. Many shafts have been capped with solid concrete plugs in the past for safety reasons, preventing access by people or wildlife. The Cornwall Underground Access Advisory Group (CUAAG) was formed in 1992 with the aim of securing safe and future access to underground sites of scientific and heritage importance (Hocking 2000). The option of erecting fences or walls around shaft openings and/or grills across entrances facilitates controlled access by people but allows unhindered access by bats.

Bare ground, particle size and temperature

Perhaps the most valuable habitats on metalliferous mining sites for invertebrates are the heathland and bare-ground areas. Many invertebrates use heather as an architectural feature and an important nectar source (Kirby 1992). Many insects take special advantage of the lack of vegetation and the compacted, toxic dark-coloured soil which warms up quickly in the sun, using such areas for nesting, thermo-regulation and catching prey (Fry & Lonsdale 1991). Temperatures on a metal-contaminated bank at Binner Downs went as high as 40.1°C in late summer 2007 (mean 17.4 °C) (Fig. 2), compared to cooler ground temperatures (high 19.6°C; mean 13.5°C) on ground of similar aspect in adjacent areas where European Gorse and Heather shaded the ground. The difference was especially marked in the higher temperatures ranges; for example, on 25

August 2003 temperatures on the bank reached 40.1°C at 15.00h, whereas the ground temperature under the gorse at this time was 19.3°C.

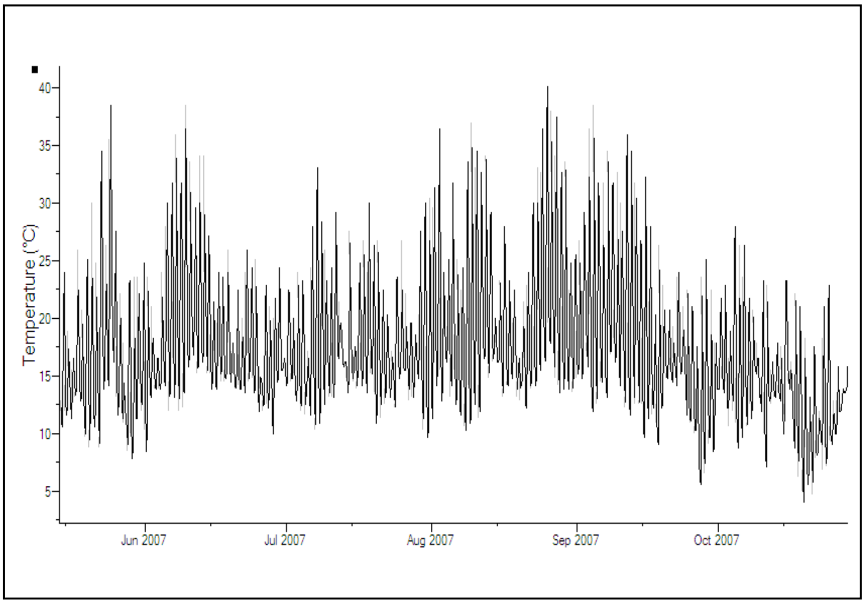
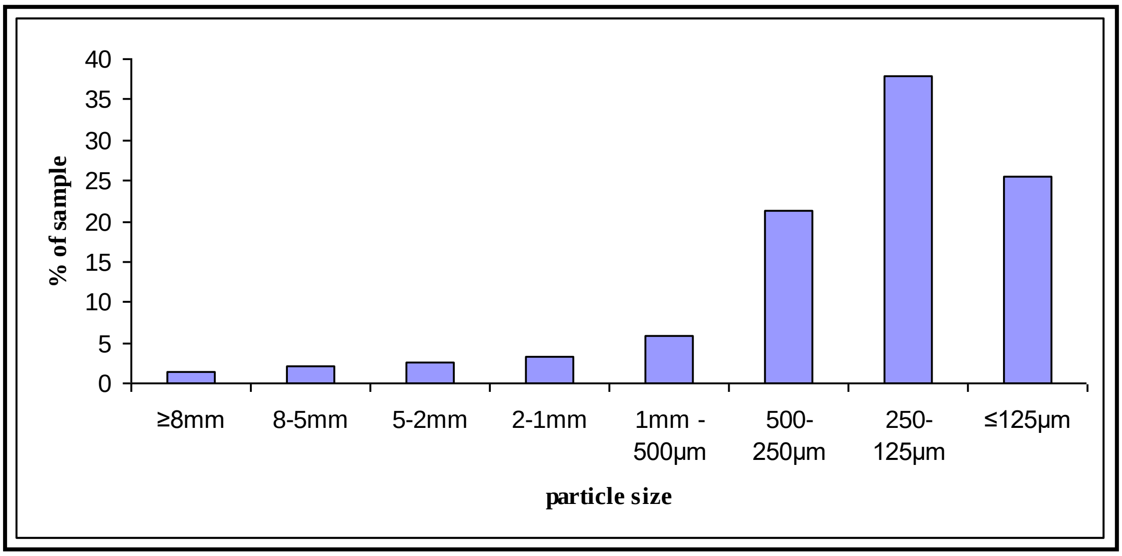


Fig 2: Ground temperatures on an un-vegetated bank at Binner Downs (summer 2007)

The taxonomic composition of the invertebrate assemblages on old mine workings at Newlyn Downs was shown during surveys in 1997 to be heavily weighted towards these habitats, with 71 species associated with bare ground and 91 with heathland, out of 175 species recorded (Spalding & Haes 2000). The presence of species of limited mobility, such as Lesser Cockroach, Mottled Grasshopper and the Tiger-beetle Wasp, indicates that these habitats have been available on or adjacent to these sites for some considerable time (Spalding & Haes 1995). Even small, isolated sites can be important for insects, such as the 0.7ha Wheal Johnny, which is an ecological island in an agricultural landscape (Haes & Spalding 1996), especially where there are vegetation-free south-facing banks where the soil is deep and soft enough for nesting and firm enough for nests to survive heavy rain. Particle size analysis at Binner Downs indicated that the soils where bees and wasps nest were very fine, with 84% of the particles less than 250µm (Fig 3). The Green Tiger Beetle (both adults and larvae) was also common here.

Fig 3. Particle size analysis of soil adjacent to bee and wasp nesting holes at Binner Downs, 2006



Wheal Busy

Great Wheal Busy is a good example of a mine that is now rich in wildlife. It was worked periodically from about 1700 until the early 1900s, producing first 100,000 tons of copper ore, then tin and more recently 27,000 tons of arsenic. Soil samples taken here in 1998 by Sheena Cotton indicate high levels of copper, arsenic, tin and zinc, with lower levels of lead. It was the first Cornish mine with a James Watt pumping engine (erected in 1778). Extant buildings include an ivycovered engine house and chimney, a boiler house, workshops for carpenters and smiths, and a nearby arsenic calciner. The mine dumps themselves are covered by extensive heathland, with clumps of European Gorse and Grey Willow. Common Bent is widespread at the edges of pathways. There have been several proposals for developing this site, but it is of considerable importance for its lichens, bryophytes and invertebrates.

In a brief study by the author and ECM Haes, 77 invertebrate species were discovered here, including Beautiful Yellow Underwing, Mottled Grasshopper, Heather Leafhopper, Sand Wasp, Heath Bumblebee, Common Colletes, Green Tiger Beetle and Heather Beetle. The Scarce Blue-tailed Damselfly has been recorded mating by the shallow unvegetated pool. Of special interest is the tiny colony of Silver-studded Blue. Normally feeding on heathers, in Cornwall this butterfly has large populations on the sand dunes, where the foodplant is Common Bird's Foot Trefoil. Despite being surrounded by extensive tracts of Ling and Bell Heather, it lays its eggs solely on Trefoil, which occurs in mats in places surrounded by scrub. This colony is almost certainly the result of an accidental introduction following the import to the site of sand (along with Trefoil with butterfly eggs or caterpillars) collected from the dunes for loading onto carriages at the nearby railway siding for spreading onto farmland.

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