

West Lothian Local Biodiversity Action Plan
Oil Shale Bings



STUDY COMMISSIONED BY WEST LOTHIAN COUNCIL
- OIL SHALE BINGS -

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Summary of Report

This report establishes the importance of the West Lothian oil-shale bings at both a national (UK) and local (West Lothian) scale, for their contribution to local biodiversity, their historical importance; their education value, their social significance and their recreational function.

The bings are post-industrial spoil heaps, the result of retorting mineral oil from deep-mined carboniferous shale beds at a time when Scotland was the major oil producing nation in the world. They tower above the naturally low-lying landscape of West Lothian.

Their physical and chemical structure is unlike coal spoil or any other type of industrial waste. As a consequence they are a unique habitat, not found anywhere else in Britain or Western Europe. The bings are home to several nationally (UK) rare and protected plant and animal species, including badgers. In addition, on a local scale, the bings play a major role in the success of 15 of the 45 West Lothian habitat indicator species (1 mammal, 10 birds, 1 butterfly and 3 flowering plants). They form refugia for many other locally rare fauna and flora and are shown to contribute greatly to the overall biodiversity of West Lothian. More than 350 plant species have been recorded on the shale bings and Addiewell north bing is a Scottish Wildlife Trust nature reserve because of its many and varied habitats.

The bings are also of considerable social and historic importance; Five Sisters and Greendykes are scheduled as historic industrial monuments. They are a focus of community identity in a population whose common culture of mining is slowly being eradicated by families of non-West Lothian origin taking up residence in the many new housing developments in the county. As a consequence the bings have potential as an education resource at all levels because of the historical importance of the industries that created them (from paraffin to detergent), the ecological importance of their extensive flora and fauna (nature reserves and primary succession) and the geological importance of the sedimentary rocks that they were mined from (Carboniferous limestone series). In addition they provide much used public open spaces for various recreational pursuits in an increasingly urban area of the county.

The bings do not require intensive management to maintain their unique qualities but they should have more uniform protected status. The main threat to the bings is their financial value as hard core for road building and several sites are in the process of being removed for this purpose. Paradoxically, this monetary value has also protected them from demolition and landscaping at the end of the twentieth century when reclamation and restoration of mine waste was fashionable.

The West Lothian oil-shale bings must be recognised more widely as the unique structures they are and should be allocated sufficient protected status that they are no longer under threat.

Description of the bings from pre-history to post-industry

The oil shale bings of West Lothian are unique in Britain and north-west Europe. They play a significant role in the heritage and culture of the county. These spoil heaps, the by-products of an industrial process to extract mineral oil from underground seams of shale, have created landscapes with their own distinctive flora and fauna, and provide refuges for locally rare and threatened plants and animals. One bing at Addiewell is a Scottish Wildlife Trust nature reserve and three others are Scottish Industrial Heritage Sites. The bings of West Lothian also have high economic and social value. The spoil (blaes) is a valuable material for bottoming roads and preparing ground for building, resulting in the gradual removal of some bings, yet many of the remaining ones are also now important as local recreational sites. This combination of properties differentiates the bings from other industrial spoils that have largely been reclaimed and restored. As there are conflicts of interest between the various users it is necessary to examine the historical, ecological, social and economic reasons for their significance.

Pre-history: the geology of bings

Central Scotland lies in a large rift valley formed between the Highland Boundary and Southern Upland faults. The Pentland Hills, to the south-east, were formed during a major period of volcanic activity in the Old Red Sandstone Period (410-360 million years ago). Throughout the Carboniferous Period (360 – 285 million years ago) when Scotland lay on the Equator and experienced a tropical climate, there were further plutonic episodes producing the intrusions that resulted in Binnie Crag, Dechmont Law and other volcanoes and sills in West Lothian. Between the two periods of volcanic activity, warm seawater flooded across the central Scotland valley in a vast tropical lagoon. The land at the edge of this expanse of water was a swamp of primitive plants, which over time turned into coal under great thicknesses of sandstone. Limestone developed from the coral reefs. In the centre of the lagoon, layers of fine silt and organic debris were deposited by the tides to form oil-shale. This oil-shale field is the parent rock from which crude oil and paraffin was extracted.

In West Lothian, oil-shale is found in a broad band from the Firth of Forth, between Blackness and South Queensferry in the north to West Calder and Addiewell in the south, an area of approximately 200 km² (figure 1). Geologically, West Lothian has inherited (from west to east) bands of coal, fireclay, cement limestone, sandstone, limestone, oil-shale, limestone and sandstone. The reverse pattern continues through Mid, to East Lothian, culminating with the coalfields at Bilston, the swamp on the eastern shore of the tropical lagoon.

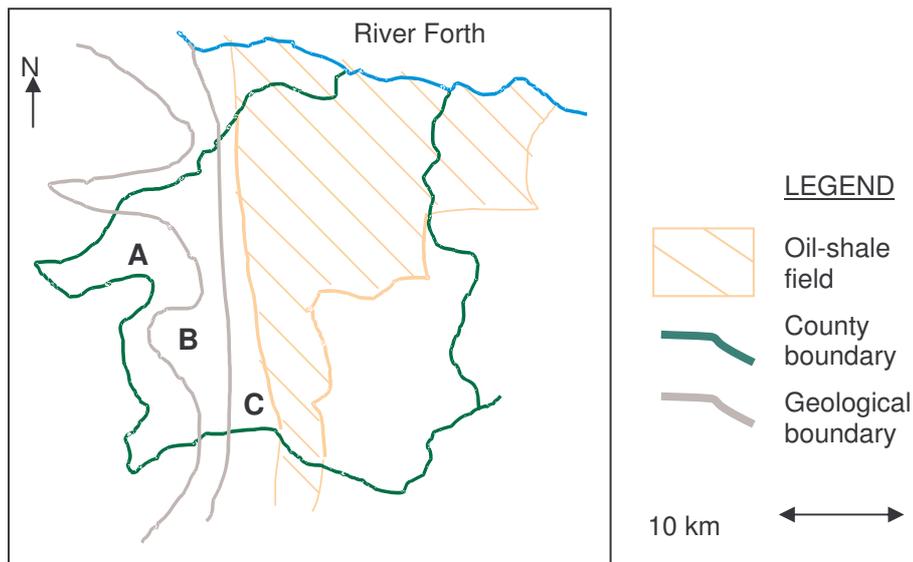


Figure 1 Geological map of West Lothian

Simplified geological map of West Lothian (adapted from Institute of Geological Sciences, 1979).

A: Westphalian coal measures; these extend west through Lanarkshire

B: Millstone grit series; the source of fireclay

C: Carboniferous limestone series; formed of narrow bands of limestone and sandstone

The birth of the oil industry

In 1851, James Young opened Britain's first commercial mineral oil refinery in Bathgate using cannel (parrot) coal. "Paraffin Oil" was a brand name and initially more than 4,000 litres a week of lubricants and naphtha were manufactured for the paint and rubber industries. As the retorting process improved, lighting oil was produced and the Bathgate works provided 25% of the lamp oil used in London.

The establishment of the oil industry in 1851 led to extensive development in many West Lothian villages. When the cannel coal seam ran out in 1858 Young discovered that oil was also extractable from oil-shale found near Broxburn and West Calder. Crude oil was retorted from shale mined at Westwood and Winchburgh then refined at Pumpherston into paraffin oil. The patent for the retorting process ran out in 1864 leading to a massive increase in industrial workings that changed the face of West Lothian.

The impact of oil on society

Broxburn's population of 660, in 1861, rose to 5,898 by 1891. West Calder grew from 2,120 inhabitants in 1851 to 8,454 by 1884. Eighty percent of the working population in these villages was employed in the oil industry. Complete new villages where between 80% and 90% of the housing was built and owned by the oil companies grew up around the mines at Addiewell, Niddrie, Oakbank, Pumpherston, Philpstoun, Seafield, Westfield, and Winchburgh. By 1865 there were 120 oil works in operation in the county, run by at least 20

different companies, with their associated shale pits and mines, producing more than 100 million litres of crude oil every year and employing 30-40,000 people. In 1866, Young's Paraffin Light and Mineral Oil Company Limited set up Addiewell works, the biggest oil works in the world. The oil-shale was supplied from seven shale mines. These works produced about 3.5 million litres of oil a year, occupied 28.3 ha of land and employed an additional 1500 workers.

To put this into perspective, the current population of West Lothian is only 160,000 including Livingston which is the fourth of Scotland's New Towns; established in 1962 after the demise of the oil industry and now the second largest population centre in the Lothians, after Edinburgh, with approaching 50,000 inhabitants.

One hundred years of industrialisation in the eastern parts of West Lothian are thus directly attributable to one man, James "Paraffin" Young, his development of an industrial process to extract crude oil from deep mined oil-bearing shale and the coincidence of a series of geological events.

The industry evolves

By-products of the oil extraction process included ammonium sulphate fertiliser, combustible gas for lighting, sulphuric acid, mothballs, paints, rubber goods, candles, petroleum jelly, wax for beekeepers, fluid for powering lighthouse lamps and detergent.

The Scottish Oil Industry moved rapidly with the times. The arrival of motor cars led to the production of motor spirit (petrol) from shale-oil that was sold throughout the UK. The development of the diesel engine in 1938 led to further refinement processes and the first diesel ship built on the Clyde ran its trials powered by "Oakbank Oil".

The maximum output from the industry in Scotland was in 1913 when 27.5 million barrels of crude oil were produced. However, production declined due to competition, initially from the Persian oilfields and ceased in 1963 when the Westwood mine closed. The Pumpherston refinery was all that remained of the original shale oil industry. Ironically when it finally closed in 1993 it was producing the detergent used to disperse oil spillages from the North Sea oilfields.

It is estimated that 300 million tonnes of oil-shale remain commercially extractable from the Scottish oilfield although the environmental consequences of their extraction make their exploitation unlikely. Commercially viable deposits are also found in Estonia (extending into Russia), Manchuria, Brazil, Canada and the United States of America although only Estonia and Manchuria are producing crude oil from deep mined oil-shale today.

Bings – a lasting by-product

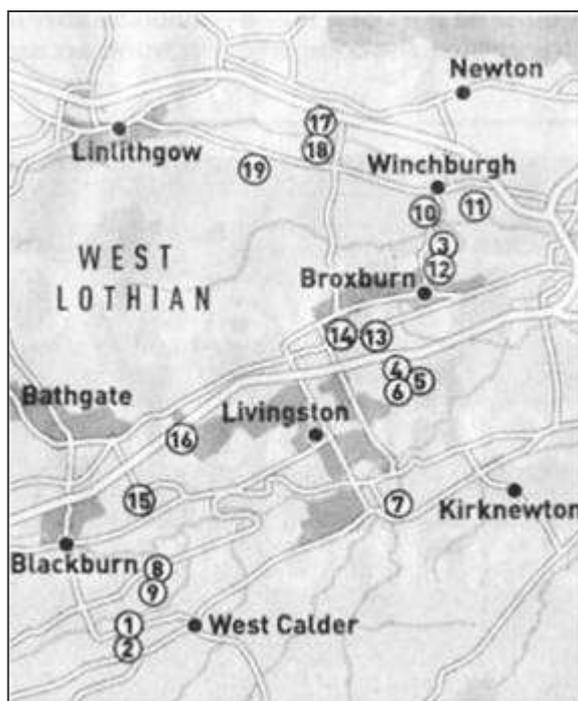
The process of retorting crude oil from oil-bearing shale resulted in a vast amount of waste. On average, the production of 10 barrels of oil left 7 tonnes of burnt shale waste. This was
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left lying around West Lothian in large heaps, the county's unique red shale bings. Bing, a Scots word meaning pile or heap, is derived from Old Norse 'bingr': a heap. The word has been in use from the 16th century and is still common in the every-day language of central Scotland.

Economic potential – destruction and deliverance

When oil production ceased in 1963 there were 27 bings containing over 200 million tonnes of burnt shale, the material remaining after the oil was extracted. Nineteen of these remain in West Lothian (figure 2). The use of the waste shale as a low-grade fill material for the construction industry resulted in the levelling of several bing sites. The burnt shale or blaes, referring to the blue colour of the shale when it first comes out of the retorts, has been used as hard core for roads, footpaths, infill for building sites and as foundation material for houses. The M8 and M9 motorways were founded on burnt shale.

The main reason that so many of the oil-shale bings have survived is that the waste shale is a valuable resource and many of the sites are on privately owned land and estates. It is this potential financial value that has saved so many of the bings from being 'reclaimed' in the same way that coal and other spoil heaps were during the 1970's and 80's.



Key to bings

- 1 Addiewell north
- 2 Addiewell south
- 3 Greendykes
- 4 Drumshoreland north
- 5 Clapperton
- 6 Drumshoreland south
- 7 Oakbank
- 8 Mid Breich
- 9 Five Sisters
- 10 Faucheldean
- 11 Niddry
- 12 Albyn
- 13 Green Bing

Figure 2 The nineteen West Lothian bings

The positions of the remaining bings, represented by numbers, in relation to some of the main towns of West Lothian.

Recent changes to local conservation policy have now ensured that many of the remaining bings are safe from demolition, reshaping, reclamation and restoration, although a few have been sold with a pre-designation allowing them to be removed for construction work and application can be made to excavate some others (table 1).

Table 1 Bing designations

Designation	Bing
a] Bings where extraction is encouraged with planning permission – all currently worked	Drumshoreland north and south, Clapperton and Niddry
b] Bings where extraction may be encouraged but requiring planning permission	Albyn, Philpstoun north and south
c] Intact bings where extraction is resisted - * now scheduled monuments	*Five Sisters (Westwood), *Greendykes (north part), *Faucheldean and Oakbank
d] Restored bings where extraction is resisted and with no potential for further extraction	Addiewell north (SWT reserve), Deans bing, Green Bing and Stankards
e] Restored bings where extraction is resisted but with potential once other sources are completely worked	Addiewell south(now to be developed for new prison), Seafield (rehabilitated as open space)
f] Abandoned bings, or where resources are exhausted.	Bridgend and Mid Breich

Post-industry: the legacy

The 19 bings still extant in West Lothian cover 186 ha and are significant landmarks in the low lying and undulating landscape with peaks reaching up to 240 m above sea level (figure 3). Other than the Pentlands to the south, the local hills rarely rise to more than 180 m and the highest natural feature in the county is the Knock in the Bathgate Hills, at 315 m above sea level.

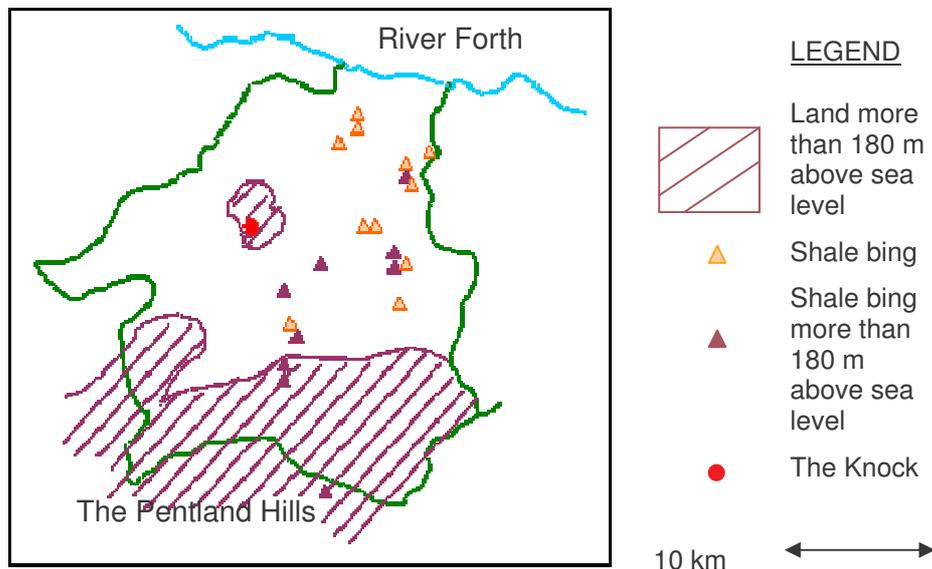


Figure 3 Topography of West Lothian

Simplified map of West Lothian displaying all physical features rising more than 180 m above sea level; naturally occurring land as shaded areas and the bings as dark triangles.

It is impossible to live in, work in, or travel through West Lothian today without feeling the impact of these massive monuments to industry in the area, and their overpowering effect on the landscape. The plateau of Greendykes Bing (figure 4a) rises to 195 m above sea level and towers over the town of Broxburn. The multiple peaks of Five Sisters Bing (figure 4b) at Westwood resemble the knuckles of a defiantly clenched fist raised above the surrounding agricultural area. This unique landmark provided the inspiration for a sculpture on Newpark roundabout, Livingston (figure 4c) and is incorporated into the West Lothian County logo alongside the Union Canal and the 39-arch railway viaduct (figure 4d).

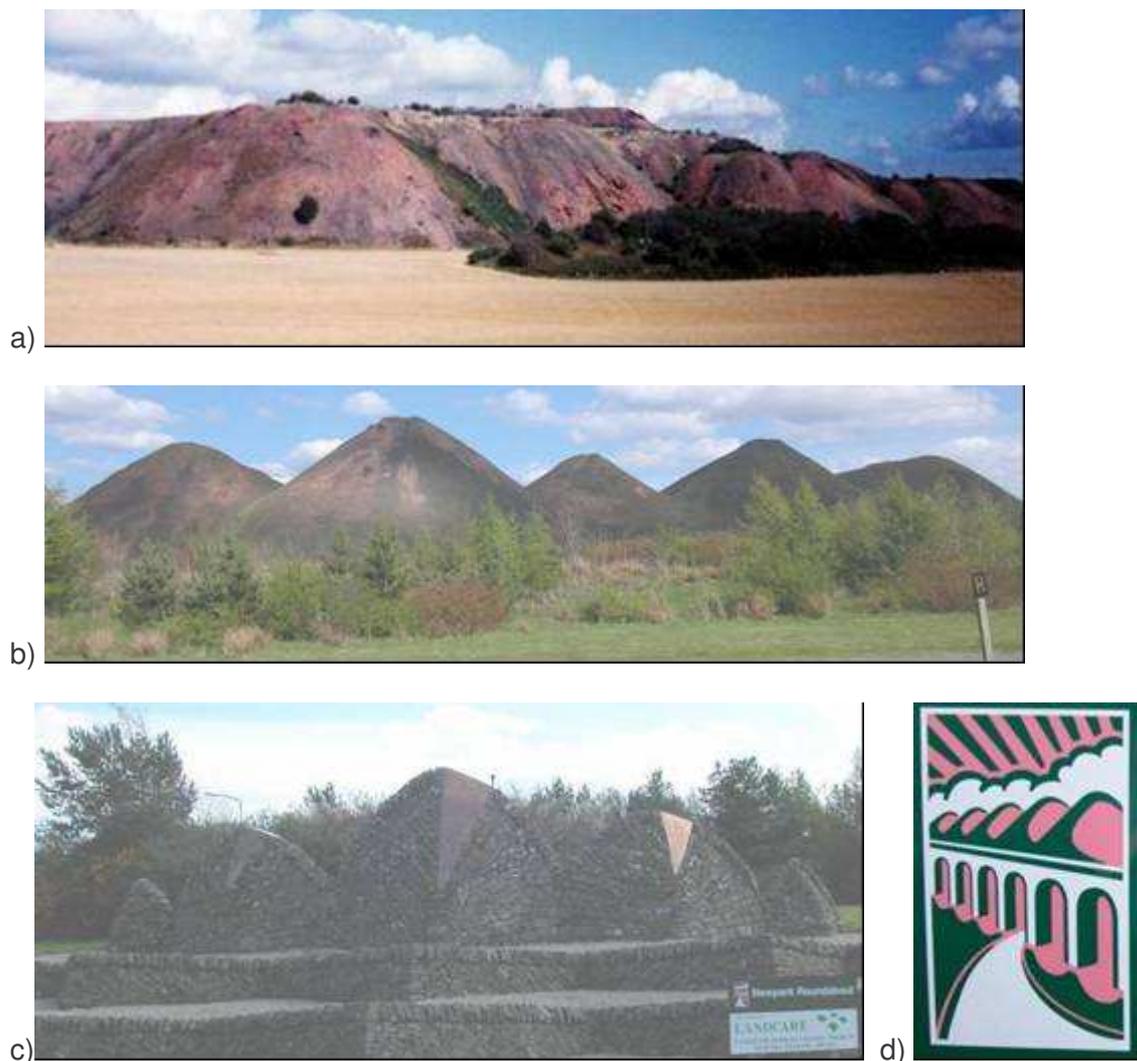


Figure 4 Visual and social impact of the Bings

- a) *Greendykes, the largest of the bings, towers over the surrounding farmland*
- b) *The unique five peaked summit of Five Sisters*
- c) *Stone and copper “Five Sisters” at Newpark roundabout*
- d) *Stylised Five Sisters on the West Lothian County logo*

Physical and chemical structure of the bings

Oil-shale spoil is physically and chemically different from other spoil types. The structure of bings make them more similar to volcanoes than industrial waste tips. Oil-shale waste has been heated to several hundred degrees centigrade before dumping. The substrate is non toxic, containing none of the heavy metals or other toxins associated with industrial and mine waste. Oil-shale is alkaline, not acidic like coal spoil. The steep sides of the bings are stable and not liable to slippage.

Variation in size and shape

Variation in bing size and shape is considerable reflecting the duration and different methods of dumping the blaes (Table 2).

Table 2 Bing locations and size

Bing height above surrounding landscape and summit altitude above sea level are adjusted to the nearest metre. Asterisks () denote bings where the height and altitude measurements are from pre-management records.*

	Site name	Grid reference	Closure date	Bing height	Summit altitude
1	Addiewell north	NT ⁽³⁾ 002 ⁽⁶⁾ 631	1932	9m	180m
2	Addiewell south	NT ⁽³⁾ 005 ⁽⁶⁾ 627	1932	30m	210m
3	Greendykes	NT ⁽³⁾ 087 ⁽⁶⁾ 736	1925	95m	185m
4	Drumshoreland north*	NT ⁽³⁾ 075 ⁽⁶⁾ 700	1925	61m	180m
5	Clapperton*	NT ⁽³⁾ 079 ⁽⁶⁾ 697	1925	38m	160m
6	Drumshoreland south*	NT ⁽³⁾ 078 ⁽⁶⁾ 695	1925	61m	180m
7	Oakbank	NT ⁽³⁾ 076 ⁽⁶⁾ 664	1932	46m	175m
8	Mid Breich	NT ⁽³⁾ 009 ⁽⁶⁾ 646	1915	12m	145m
9	Five Sisters	NT ⁽³⁾ 009 ⁽⁶⁾ 641	1962	91m	240m
10	Faucheldean	NT ⁽³⁾ 085 ⁽⁶⁾ 742	1925	31m	120m
11	Niddry*	NT ⁽³⁾ 097 ⁽⁶⁾ 746	1961	61m	150m
12	Albyn	NT ⁽³⁾ 085 ⁽⁶⁾ 729	1925	46m	135m
13	Green Bing*	NT ⁽³⁾ 070 ⁽⁶⁾ 710	1920	61m	160m
14	Stankards*	NT ⁽³⁾ 063 ⁽⁶⁾ 711	1920	61m	160m
15	Seafield	NT ⁽³⁾ 005 ⁽⁶⁾ 667	1932	53m	200m
16	Deans	NT ⁽³⁾ 015 ⁽⁶⁾ 685	1946	76m	175m
17	Philpstoun north	NT ⁽³⁾ 057 ⁽⁶⁾ 769	1932	30m	100m
18	Philpstoun south	NT ⁽³⁾ 056 ⁽⁶⁾ 765	1932	53m	125m
19	Bridgend	NT ⁽³⁾ 037 ⁽⁶⁾ 758	1932	24m	125m

Height above surrounding landscape ranges from 9 m at Addiewell north to 95 m at Greendykes and summit altitude above sea level varies from 100 m at Philpstoun north to

240 m at Five Sisters. The resulting mounds of spoil can be low lying over a large area or steep sided; single or multiple peaked; with or without a plateaued summit (figures 4a and 4b). The combined basal area of the bings is 186 ha.

Steepness of slope also varies both within and between sites, from flat to near vertical in parts. Managed and reclaimed bings tend to have more gentle slopes (median 10°) than the bings that have not been reshaped like Greendykes and Mid Breich (median 30°). Despite the steep slopes and great height of many of the bings they are very stable and there is little evidence of slippage largely due to the structure of the shale substrate.

Soil structure and water holding capacity

When the burnt blaes is dumped after retorting it rapidly weathers into smaller pieces as a result of wind and rain breaking down the laminar structure of the shale. Oxidation of the shale causes the colour of the shale to change from its initial blue-grey to the characteristic red associated with the bings (figures 5a and 5b).

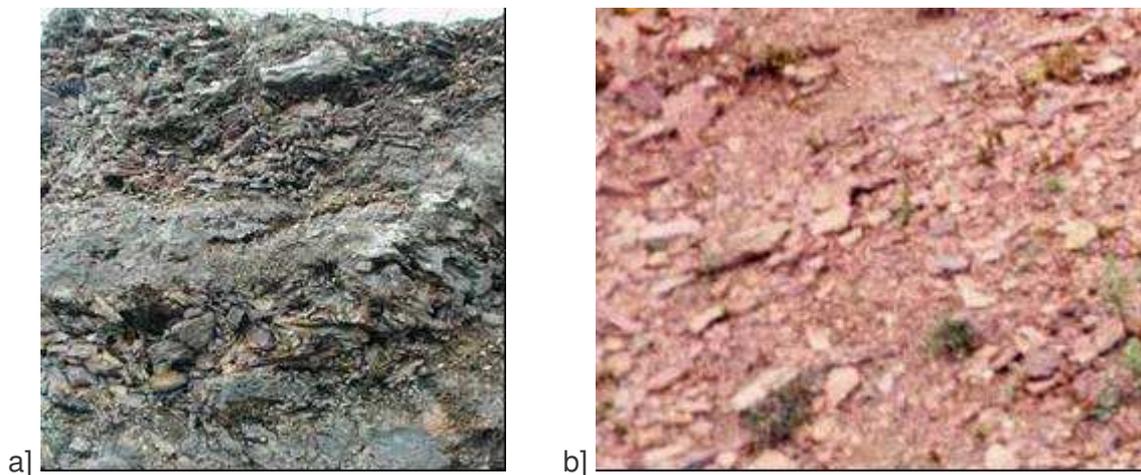


Figure 5 Unweathered and weathered blaes

The initial grey-blue coloured burnt shale a] that gives blaes its name (Scots for blues) rapidly oxidises in contact with the elements and changes to the red colour b] uniquely associated with oil-shale bings

The weathered substrate has a large particle size compared with the fine dust of eroded coal and soil structure can vary over small distances. Large clumps of fused clinker were also dumped occasionally when the retorting process went wrong. The bing substrate has a lower water holding capacity than coal spoil, making it free-draining, and the shale particles are more cohesive than coal. These factors combine to increase the stability of the bing surface and the slopes are less likely to be eroded by rainfall and runoff causing gullies and landslips. The physical structure of the substrate is suitable for seed germination and seedling development, offering a good rooting medium, but lack of existing vegetation results in rapid, short-term, surface desiccation from both sun and wind, making conditions difficult for early colonisers and continuing seedling establishment.

Nutrients and pH

Despite being formed from the waste of the same industrial process the bings are not homogeneous in their chemical structure. There is considerable variation in soil nutrients and pH both within and between bing sites. Soil samples were tested for pH, sodium and the five main nutrients: magnesium, potassium, phosphorus, calcium and nitrogen. The results were compared with the optimum levels of nutrients required for normal growth in wild plants (table 3). In most instances the lowest measurements recorded in the shale were significantly lower and the highest were significantly higher than the optimum levels (Bradshaw and Chadwick, 1980). Magnesium and calcium in particular were measured both at extremely high levels and at one tenth (or less) of the amounts considered necessary for normal growth in wild plants.

Table 3 Comparison of nutrients in bing soil with required levels of nutrients

The minimum and maximum measured ranges of pH, sodium and the five main nutrients, in parts per million, are compared with the minimum and maximum requirements for normal growth in wild plants (Bradshaw and Chadwick, 1980). Na = sodium; Mg = magnesium; K = potassium; P = phosphorus; Ca = calcium; NH₄⁺ and NO₃⁻ = nitrate and ammonia - the main forms of nitrogen found in soil. Measurements in blue (bold) are significantly lower and in red (italics) are significantly higher than those required.

	pH	Na	Mg	K	P	Ca	NH ₄ ⁺	NO ₃ ⁻
Minimum in shale	5.72	1	16	5	5	50	0.05	0.03
Maximum in shale	<i>8.17</i>	<i>275</i>	<i>1289</i>	<i>371</i>	<i>180</i>	<i>20300</i>	0.47	4.67
Minimum required	5.00	0	50	100	5	500	2.00	2.00
Maximum required	7.50	120	300	300	20	2000	20.00	20.00

The variations in nutrients do not relate directly to bing size and management or to elevations within the sites (plateau, top, middle and base). The lack of any measurable trends in the chemical data in relation to sites does not lessen the importance of the extremes of variation recorded from the bing substrate. Sodium, magnesium, potassium, phosphorus, calcium and available nitrogen are all measured below and/or above the required levels for plant growth.

References from literature continually stress the importance of availability of nutrients, particularly nitrogen, to the successful establishment of vegetation. The exceptionally low levels of available nitrogen measured in the substrate of all bing sites does not seem to deter successful invasion and production of biomass by plant species.

The range of soil nutrients, both high and low, is not evidence of contaminated land or the unsuitability of bings as a habitat. These extremes of nutrients are also recorded in the naturally occurring cinder cones formed by volcanic eruptions like those on Ascension Island.

Ecology and biodiversity value

The West Lothian shale bings are of great ecological and scientific importance. They are examples of a distinctive and rare type of post-industrial waste that is unique within Britain; only Estonia and Manchuria have similar sites. They are also examples of sites of primary succession. The invasion of a novel substrate is an ideal subject for studies of colonisation processes, the ecology of individual species (both plant and animal) and communities that are adapted to low competition conditions. Primary sites are only found naturally on sand dunes, glaciers and volcanoes; all of which are very uncommon in Britain

The bing habitat

Variations in the substrate of the bings (demonstrated in the previous section) create unique conditions and produce a wide range of fresh habitats and new niches for plants and animals. The bings are island refugia for wildlife in a primarily agricultural and urban/industrial landscape.

Some of the bings have remained unmanaged since shale extraction ceased, and are slowly being colonised by plants and animals. Others have been reshaped, seeded and planted in various ways during the 1970's and 80's when land reclamation was a national, political priority. Blaes is currently being (or has recently been) extracted from the remainder. The resulting vegetation, in all instances, is so unusual within the region that the oil-shale bings constitute one of the eight main habitats in West Lothian's Biodiversity Action Plan

Habitats within the bings vary from almost bare substrate to semi-natural grassland, heather scrub and pioneering birch woodland. Differences in the age and size of the bings, how they have been managed, available seed sources, substrate type and soil chemistry all contribute to the habitats and their vegetation. They provide refuges for a wide range of animals and plants that are under increasing pressure in the surrounding area from farming and urban development. Due to their lowland location the bings are primarily enclosed by arable land producing wheat, barley, oilseed rape and until recently peas and potatoes. Species diversity on this surrounding land is relatively low due to the intensification of farming and a shift from spring to winter cereals. By comparison, the diversity of plant species on the bings is considerable and the sites are home to more than 350 plant species (Appendix 1).

Plant communities

The bings are a major habitat for new and developing plant communities. The structure of naturally developing vegetation is determined primarily by the availability and suitability of local seed sources and to a lesser degree by the invasion of suitable seeds that can disperse over great distances. The arrival of seeds and subsequent successful colonization by individuals are random processes so the resulting vegetation can not be predetermined or assumed from existing adjoining vegetation.

The National Vegetation Classification (NVC) system is the conventional method of describing vegetation in the United Kingdom and forms the basis of Phase 1 Surveys and Environmental Impact Assessments. Within the bing vegetation there are matches for each of the named vegetation types from swamp (S) to sand-dune (SD).

Although the bing vegetation can be described in terms of general matches to phase one habitats and NVC types (table 4) it cannot easily be classified into recognized communities. There are several possible reasons for this. The most likely is that the bing plant communities are still developing and therefore represent incomplete species lists for comparison with NVC communities. It is also possible that the vegetation on the oil-shale bings is as unique as the bings themselves and does not comply with the abstract classifications of standardised communities.

Table 4 NVC types

The phase one habitat definitions and NVC vegetation types identified on the bings.

Phase 1 habitat definition	NVC type
Calcareous (alkaline) grassland	CG
Heathland	H
Mire (flushes, springs and fens)	M
Maritime cliff	MC
Neutral grassland	MG
Other vegetation	OV
Swamp	S
Sand dune	SD
Acid grassland	U
Woodland and scrub	W

There are many unusual, but recurring, species associations on the bings that cannot be categorised. Large areas are covered with ox-eye daisies and wild strawberries on several sites. Sticky groundsel and weld are the dominant species in highly disturbed areas and on steep slopes on most of the bing sites. Neither of these combinations of species is representative of any recognised plant community type.

There is a danger that emphasis on classifying as a way of describing the vegetation on the bings will result in the loss of awareness of the dynamics of the successional processes by "putting concrete vegetation into abstract boxes" (Legg, 1992).

Variation between and within sites

The numbers of plant species recorded between sites differ enormously (table 5) and each bing has a particular cohort of "unique" species (Appendix 2). On some bings these species are known to be planted, on others they are the result of the vagaries of dispersal.

Table 5 Numbers of species recorded on each bing

The total number of plant species recorded on eight of the bing sites and the number of these species that are "unique" to the bing. These species are listed in Appendix 2

Bing	Number of plant species recorded	Number of unique species recorded
Addiewell north	99	20
Addiewell south	101	8
Clapperton	92	13
Drumshoreland north	60	2
Drumshoreland south	49	2
Greendykes	86	4
Mid Breich	92	13
Oakbank	84	11

Species with shared characteristics are recorded in different habitats within the bings. The vegetation at the tops of all of the bings has a higher proportion of wind and bird dispersed species than their bases but calcareous grassland species, trees and shrubs are found on the plateaux while the peaked summits are more sparsely covered with species associated with disturbed ground and sand dunes. Some groups of species found on the bings are strongly associated with bare ground and others with dense vegetation. Distribution of a few species is also constrained by gradients in substrate nutrients, particularly pH and potassium. A significant group of species are only recorded on bing sites where there has been no management.

The bing species

Of the more than 350 plant species recorded only five are recorded as present on every bing site in the combined data from all available surveys: yorkshire fog, goat willow, white clover, colt's foot and stinging nettle. Not a very impressive list but what is perhaps more interesting is that many very common and abundant weed species like dandelion, creeping buttercup and rosebay willowherb are not formally recorded on all of the bing sites. Omission from lists, however, is not conclusive evidence that a species does not occur at a site. Biting stonecrop grows in great profusion on one slope of Greendykes bing (figure 6) but does not appear on any recording lists.



Figure 6 Biting stonecrop (*Sedum acre*)

Photograph taken on Greendykes bing July 2000

Diversity of species

Biodiversity is not only about rare and exotic species but also about the variety of common species and communities that are contributing to the quality of the landscape.

The importance of the bings as refuge sites for a range of plant species is acknowledged in the recent publication “Plant Life of Edinburgh and the Lothians”. Around 800 plant species have been recorded in West Lothian. Three hundred of these are either very rare (recorded on 1 or 2 sites) or rare (recorded on 3-5 sites). Only 150 species are considered common or very common. There are more than 350 plant species recorded on the oil-shale bings whose 186 hectares cover 4% of the county.

The oil-shale bings form island refugia for wildlife in the primarily agricultural and urban landscape of West Lothian. The extent of floral biodiversity has been documented in various studies of the bings. There are formal records from the Scottish Wildlife Trust’s North Addiewell Nature Reserve and the bing at Faucheldean, which are both protected from development and which support several plant species not found elsewhere in the county. Five Sisters and Greendykes bings, which are scheduled national monuments, also provide habitats for a wide range of locally threatened flora and fauna. These and the other bings provide habitats for a variety of locally threatened flora and fauna and are a primary site for West Lothian’s newly adopted County Flower, common spotted orchid.

All of the bings are home to many common plants and animals that are becoming increasingly marginalised by demands for more land for new housing and changes in farming methods.

Priority species and habitats

Eight species with Nationally Scarce status in Great Britain are found on the oil shale bing habitat. All of them are lichens or mosses and they are recorded nowhere else in West Lothian.

Some locally rare species are found only on a single bing: Alpine clubmoss on Faucheldean and tall melilot on Drumshoreland south. Greendykes is one of only two sites in the county where wormwood is recorded. The bings are also home to badgers (protected nationally under the badger act) and many species considered to be local habitat indicators: brown hare, sky lark, red grouse, yellow rattle, bird's-foot trefoil, and wild hyacinth (bluebell).

Addiewell north is host to species like common twayblade and common wintergreen, which despite their "common" sobriquet are rare inhabitants of the county. This bing also supports a diverse range of habitats from established woodland, both natural and planted, to almost bare scree slopes (figure 7). On the plateaued summit of Greendykes, above the bare steep sides of the bing, a species poor calcareous grassland has established naturally from self seeding species, despite the altitude (figure 8).

A genetically distinct birch woodland has established naturally at the base of the tiny bing at Mid Breich, complete with many of the associated ground flora and bryophyte species of long established native woodlands.



Figure 7 Addiewell north

Mature woodland, tall herb grassland and scree slopes photographed at Addiewell north



Figure 8 Greendykes plateau

Species poor calcareous grassland photographed on Greendykes plateau

Locally Rare Flora

There are many other records of locally and nationally rare flora on the bings. As a habitat they are consistently recorded as sole or main habitats for species in local floras.

Sixteen of West Lothian’s rarest plants are also recorded on bing sites (table 6). Yellow rattle, bird’s-foot trefoil and wild hyacinth (bluebell) have already been noted as habitat indicator species that grow on the bings.

Table 6 Rare plants of West Lothian recorded on shale bings

Sixteen of West Lothian’s rarest plants are recorded on the bings. The list does not include the many rare mosses and liverworts that have been mentioned in the text.

Wormwood	Knotted pearlwort
Pillwort	Tall mellilot
Greater knapweed	Common wintergreen
Corn marigold	Deadly nightshade
Chicory	Grey field speedwell
Alpine clubmoss	Crowberry
Early purple orchid	Salad burnet
Hoary plantain	Melancholy thistle

Sticky groundsel and kidney vetch are usually associated with coastal dunes and bitter stonecrop with dry stane dykes neither of which are common habitats in West Lothian. Grey
 Dr Barbra Harvie 16 02/09/2005

field-speedwell and small toadflax are both recorded on bings but are recognised as very rare in West Lothian. Faucheldean bing is noted for colonies of stag's-horn clubmoss and alpine clubmoss. Both species are very rare in West Lothian and are more usually associated with montane habitats. This bing is also renowned for a diverse orchid population including broad helleborine, great butterfly orchid and early purple orchid.

Many of the rarest species recorded on the bings, however, are bryophytes and lichens. A small population of the montane lichen *Stereocaulon saxatile* is found on Addiewell bing and extensive colonies of three species (*S. leucophaeopsis*, *S. nanodes* and *S. pileatum*) on Philpstoun bing that are otherwise exceedingly rare locally (B.J. Cobbins in Smith *et al.*, 2002). Almost half of all the bryophytes that are recorded in Britain are present in the Lothians and shale bing habits are identified as important to the bryophyte flora by D.F Chamberlain (Smith *et al.*, 2002). *Buxbaumia aphylla* Hedw. is a rare moss in Britain that has been recorded in sizeable populations only on bing debris in central Scotland. Its persistence at Addiewell bing for more than 35 years is remarkable for a species that is usually considered to be ephemeral in natural habitats. The destruction and landscaping of shale bings is a severe threat to this species nationally.

Locally Rare Fauna

Although this report concentrates primarily on the succession of vegetation on the bings locally rare animals are often seen, especially on early morning field visits. These include hares on Greendykes and Clapperton, red grouse on Greendykes, badgers on Oakbank, sky larks on Greendykes and common blue butterflies on Oakbank. The bings are also home to foxes, often seen in family groups, suggesting that many unobserved smaller fauna are also inhabiting the sites.

Insect records from Addiewell bing tend to be of showy species, mainly butterflies (table 7). They include ringlet butterfly, very rare in central Scotland, and a first recording of ten-spot ladybird in the county. Additional butterfly species recorded at Faucheldean include green-veined white, meadow brown, small heath and common blue. More formal insect recordings have been carried out in West Lothian but are not specific to the bings.

Table 7 Insects recorded at Addiewell nature reserve

The notable species recorded in 1997 on Addiewell nature reserve adapted from Collinson and McLean (1997). The common blue damselfly and orange-tip butterfly are local habitat indicator species.

Butterflies	Butterflies	Other insects
Small tortoiseshell	Small white	Elephant hawkmoth
Orange tip	Large white	Common blue damselfly
Red admiral	Meadow brown	Ten-spot ladybird
Small copper	Ringlet	Sexton beetle

Formal recording of birds has been carried out at Addiewell north bing by the Scottish Wildlife Trust. Forty seven species were recorded during 1997, including 30 species with permanent breeding territories. Less formal observations on Faucheldean in 1995 recorded 39 species, including 9 local habitat indicator species (table 8).

Table 8 Bird species recorded on Faucheldean

*Bird species recorded on Faucheldean (Maka, 1995). *(asterisk) denotes local habitat indicator species.*

Grey heron	Song thrush*	Blackbird
Wren	Grasshopper warbler	Whitethroat
Garden warbler	Blackcap	Starling
Sand martin	Bullfinch*	Duncock
Oyster catcher	Magpie	Willow warbler
Chiffchaff	Pheasant	Grey partridge*
Great tit	Blue tit	Spotted flycatcher*
Grey wagtail	Swallow*	Chaffinch
Kestrel*	Robin	Yellowhammer*
House martin	Carrion crow	Woodpigeon
Stock dove	Goldfinch	Linnet*
Swift	Meadow pipit	Mallard
Skylark*	Sedge warbler	Black-headed gull

The biodiversity of the bings has been measured mainly by their extensive flora. Vascular plants are considered to be the most useful indicator species for identification of habitat quality: mammals and birds are too mobile and lower plants are often too difficult to identify in the field.

Social value

The bings are an integral part of the identity of West Lothian. They are currently utilised by a wide range of people for an equally wide range of purposes from recreation to business.

Community identity

From a social perspective the bings form a focus of individuality particularly in the eastern part of the county. Shale miners always considered themselves to be better than their fellow coal miners. They were provided with affordable housing and their jobs were relatively clean, safe and well paid. A large proportion of the population of the ex-mining towns of the county is descended from the miners who moved into West Lothian 150 years ago from all over the British Isles. Many of them have parents and grandparents, still living, who worked in the shale oil and related industries. Their only common culture is mining and they have always been fiercely proud both of their recent cultural background and the physical landmarks that their forefathers (and mothers) toiled to produce. They are the focal point of community identity in a population whose common culture of mining is slowly being eradicated by incomers to the many new housing developments in the county.

They formed part of the West Lothian Tourist Board's 'Shale Trail' (no longer operational) that ran from Grangemouth Refinery via the original refinery at Whiteside, Bathgate, to Pumpherston oil works and Greendykes bing. Grangemouth, the only crude oil refinery in Scotland, is situated less than 15 kilometres from 'Paraffin' Young's original refinery in Boghall and was set up using the expertise of a key workers recruited from the shale industry. Up to 1 million barrels of oil a day are currently refined at Grangemouth, one of the largest and most integrated oil and gas complexes in the world, and stored in tanks buried deep under the remains of Dalmeny bing before being shipped from the oil terminal at Hound Point.

Without the shale industry the eastern half of West Lothian would now be a mix of intensive agriculture, modest scale industrial developments and housing, supporting a smaller, less structured, population. Until 1750 most of the land was low intensity farmland with continuity of tenure often from one generation to the next. Land reforms and rapid rent increases over the next hundred years resulted in a two-class system of tenant farmers and their labourers by 1850. These landless workers became a seasonally shifting population who moved around Scotland: as recently as 1939 a quarter of the school roll in rural areas of West Lothian left for other places, usually in November, to be replaced by another set of pupils. These villages would now probably be dormitories for commuters to Edinburgh, as is happening in similar rural areas of Mid and East Lothian

Public open space

Today the bings are important in West Lothian as public open space. The most common general use of bings is as recreation sites, especially on bings that are situated near residential areas. Many of the bings are used every day by dog walkers and joggers. This is particularly true of Oakbank and Greendykes bings, by East Calder and Broxburn respectively, the Philpstoun bings and to a lesser extent of Faucheldean and the Addiewell bings. At weekends and during school holidays, especially when the weather is good, numbers of users increase.

Public use of individual sites seems to be habitual. Five Sisters and Mid Breich are not visited to the same degree, possibly because they are further from towns. Green and Stankards bings are rarely visited by the public. They are close to new housing estates but the residents do not have a history of utilising the bings as green space. These two sites have recently been restored/renovated and are perceived as less attractive than some of the unmanaged sites or older managed sites. In addition pedestrian access requires crossing the busy A8.

Other recreational uses

Botanists, bikers and bing baggers. The bings are also a favourite haunt of individuals in pursuit of various hobbies.

Amateur and professional naturalists, botanists, lichenologists and bryologists, individually and in groups like LWIC (Lothian Wildlife Information Centre), record and monitor the flora and fauna of various bings. The favourites are Addiewell north and Faucheldean, as these two bings are known to be hotspots of biodiversity with many unusual and rare species.

The ownership of off-road motor bikes and quad bikes has become more prevalent in recent years and the bings offer ideal terrain for this sport. Mountain bikers also use the bings as unofficial trials courses. These vehicles are both good and bad for the bings and local communities. Physical disturbance to the surface of the bings maintains diversity by preventing vegetation from becoming too close and competitive however too much disturbance can damage fragile ecosystems and cause major erosion on unstable slopes. Off-road vehicles are currently concentrated on bings that are also popular with pedestrian users or could be promoted as attractions because of the views from their summits. Unfortunately bikes and pedestrians do not mix well and the present situation is potentially dangerous to both parties. In addition the noise pollution from motor vehicles is a source of extreme annoyance to residents of nearby towns. This conflict of interest is unlikely to be resolved if the bikers are banned from the bings as they will use cycle paths, canal tow-paths and other less suitable areas.

Another new sport is bing bagging. This sport first came to light in an article in The Angry Corrie, Scotland's Hillwalking Fanzine (v 63: Dec 2004-Feb 2005) as part of "an occasional series on hills which might not really be hills at all". Serious climbers apparently like the bings because of their steep sides and unpredictability, their contours are not drawn on Ordnance Survey maps so you can not tell in advance what you are going to climb, or how you are going to climb it. The bing climbs range from a tiny 9 metres to a slightly higher 95 metres so have the advantage that several peaks can be "bagged" in a single day. This story was taken up by the national press and carried in The Herald on 27th May 2005 and Sunday Times on 21st August 2005 but there is no evidence so far of West Lothian being inundated by climbers. Perhaps the sport should be promoted by a "joint bing owners association".

Education and interpretation

The historical importance of West Lothian in the development of the oil industry in Scotland, and the world, is in danger of being forgotten. The bings have great potential as an education resource but are underused for this purpose, probably because of lack of readily available, readable information. The bings are visited annually during an MSc course run by the University of Edinburgh to demonstrate both primary succession and ecological management and they are the subject of occasional research in MSc dissertations and PhD theses.

Schools, libraries, colleges, community centres and universities could include the bings and/or the oil-shale industry in educational courses at all levels from primary to tertiary.

- History – the history of the oil industry and its impact on the county of West Lothian, Scotland and the world can be taught using the bings and the many buildings associated with the industry. These include the miners' rows on Greendykes road and elsewhere and Young's original paraffin works at Pumpherston. A range of oil-based products from diesel to detergent were manufactured from oil extracted from the West Lothian shale.
- Social geography – the demographics of the population of West Lothian were altered radically by the development of the oil and associated industries between 1850 to 1993. The repercussions are still noticeable today.
- Science - the extensive flora and fauna on the bings make them ideal for introductory nature study at the SWT nature reserve on open days and ranger led walks. The ecology of primary succession and vegetation dynamics can be studied in wide range of habitats. The bings are also important to geology due to the significance of the sedimentary rocks that they were mined from (Carboniferous limestone series).

Management issues

The best management of oil shale bings is no management. The *status quo* should be maintained allowing free access to the public (including off-road vehicles), as this is a major factor in determining the disturbed and diverse habitat conditions that maintain the complexity of vegetation. Bings should not immediately be fenced off to minimise disturbance. Maximum species levels occur when there is a small amount of disturbance. The best way to manage for rare species and biodiversity is not to enclose a site to keep everything out. The bings high species diversity can only be maintained if there is low productivity of biomass. All of the situations that restoration managers try to prevent, low nutrient availability, grazing, trampling, off-road biking, tend to increase diversity and have resulted in the particular flora that has arisen on the bings. Of course if there is too much of any kind of disturbance you will lose both diversity and habitat. Management plans have to strike a balance.

“No management” is often not recognised as an option because natural establishment of vegetation is considered to be too slow and the outcome can not be guaranteed.

The bings are good for plants that prefer dry conditions and like alkaline soils but don't require much other nutrition. This eliminates many weeds, which have high nutrient requirements, but semi-Mediterranean plants do well. Bing substrate is ideal for creating wildflower meadows without the addition of expensive topsoil and fertilisers. The species that do best on the bings are not the most common, nor are they all rarities but they are many and diverse. A major benefit of standing back and allowing nature to run its course is that there are no monetary costs involved.

Exotics

Several garden escapes have been recorded on the bings and are well established on many sites. Opium poppies grow in profusion on more than one bing and can also be found on other man made sites, including the many roundabouts in Livingston. Fox-and-cubs are rare garden escapes that add to the biodiversity of the bings. These and other exotics can pose a major dilemma to ecologists, botanists and land managers, especially when they are establishing on post-industrial waste land that has to be managed. Should they be encouraged as an integral part of a novel vegetation type or treated as undesirables, alien species that should be removed for fear that they spread uncontrollably throughout the surrounding landscape?

Species like these may become a permanent component of plant assemblages on the bings and could form part of an established novel community type. Many environmentalists and ecological managers may consider that they are not natural and should therefore be discouraged, but having originated in a human-created habitat they can scarcely be

considered as alien or introduced. Smith (2003) highlights the example of rosebay willowherb, a species that is recognised as native throughout Britain by the New Atlas of the British and Irish Flora and other floras but was regarded as a garden escape by the county flora writers of Worcestershire and Derbyshire at the beginning of last century. Several other native species recorded on the bings are also be of dubious origin:

Pineapple weed - First recorded in Britain in 1871 and only becoming widespread after the invention of the patterned tread of motor tyres

Large field speedwell – first recorded @ 1820 and extending throughout Britain within 50 years despite its large seed size

Sticky groundsel – possibly only native as far north as Belgium on the European continent and first recorded in Britain in 1660

Sycamore – a naturalised introduction that is considered to be displacing native woodland species in Scotland (along with Beech)

Transitory species

Transitory species are species that form an integral part of one or more of the early stages of succession. They reproduce and are well adapted to the initial conditions of the new environment. However as the ecosystem develops they are less able to compete with new invaders, or are unable to adapt to changes in the physics and chemistry of the developing substrate. On the unmanaged bings these are represented by species like sticky groundsel and weld that are limited to areas of the bing where continuous disturbance or steep slopes maintain the conditions similar to those found in early successional stages with low vegetation cover and little competition from more competitive species. These are species of 'no fixed abode' that survive by 'island hopping' from one disturbed site to the next.

Natural colonisation

The characteristically poor flora associated with some of the bings is more likely to be due to their isolation from similar habitats than to any deficiencies of the substrate. Seeds of species that would otherwise be unsuited to local soil conditions find refuge in these sites and add to the local biodiversity. The species involved in the colonisation of a newly formed bing (or any other primary site) can not all be retained permanently, even in areas of continuous disturbance. Conservationists and managers however have to be prepared to accept loss of species as well as gains if successional habitats like the bings are to be maintained. Succession is a dynamic process that cannot be preserved.

Management and communities

Michael Usher (1993) has promoted the creation of complete communities as an alternative to planting trees and hoping that all other organisms will arrive naturally. This is an exciting and innovative approach to assisted succession and land reclamation but unwittingly supports the current trend for constructing vegetation types using Rodwell's NVC volumes (1991a, 1991b, 1992, 1995, 2000) as a series of recipe books: certainly not the use that was

intended for the National Vegetation Classification. The modern ideal that species will march in serried ranks to fulfil the criteria for NVC type CG5, for example, if the “correct” habitat conditions are provided is a dangerous and totally unrealistic concept.

Restoration

Restoration and management of spoil waste is not a new concept but on the shale bings it is unnecessary. A great deal of restoration work currently being carried out continues to adhere to fifty-year old policies. Restoration policy in the 1950’s followed a standard recipe of reducing the height and gradient of the heap, rounding peaks and ridges, covering with topsoil, applying fertilizers (liberally) and sowing with commercial grass mix. On low lying heaps trees, usually birch and alder, were planted directly into the spoil at the bottom of the heap without any amelioration. The sole purpose was “to obtain a satisfactory visual effect” (Oxenham, 1966). Examples can be seen in some of the privately owned shale bings near Broxburn: Stankards and Green Bing. The end product is species poor and visually boring. Conversely Oakbank bing has been seeded and planted with an interesting variety of semi-natural habitats and some of its steep slopes have been retained. The restoration has resulted in a visually appealing, well-used site that links to Almondell Country Park.

Management decisions on the restoration of the bings and similar sites are often considered to be constrained by available sources of funding but frequently the real constraints on restoration managers are imposed by an unrealistic public perception of what post industrial and other waste sites should be restored to, and how quickly they should be restored. In Britain it is not the quantity of spoil that causes public concern but that it is situated in or near centres of population where it is seen as an immediate problem.

Restoration management in Central Europe

In Central Europe natural succession is relied upon in restoration projects except in the case of especially toxic substrates. It is considered to be especially advantageous where the disturbed site is small and surrounded by natural vegetation; like shale bings. These observations support the findings of this report that there is no indication that lack of available seed sources, nutrients or nitrogen has any significant effect on invasion and establishment. The climatic conditions in Central Europe are more conducive to rapid invasion than those in Central Scotland however with a time scale of only ten years for successful colonisations of spoil sites. An indication of the possible, positive effects of climate change on future bing management.

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Appendix 1 Species list for the bing habitat

Plant species recorded on the oil-shale bing habitat are listed by scientific name, family and common name

Species name	Family	Common name
Acer platanoides L.	ACERACEAE	Norway maple
Acer pseudoplatanus L.	ACERACEAE	Sycamore
Achillea millefolium L.	ASTERACEAE	Yarrow
Achillea ptarmica L.	ASTERACEAE	Sneezewort
Aegopodium podagraria L.	APIACEAE	Ground elder
Agropyron caninum (L.) Beauv.	POACEAE	Bearded couch grass
Agropyron repens (L.) Beauv.	POACEAE	Couch grass
Agrostis gigantea Roth.	POACEAE	Black bent
Agrostis stolonifera L.	POACEAE	Brown bent
Agrostis tenuis Sibth.	POACEAE	Common bent
Aira praecox L.	POACEAE	Early hair-grass
Alchemilla filicalis Buser	ROSACEAE	Lady's mantle
Alisma plantago-aquatica L.	ALSMATACEAE	Water plantain
Alliaria petiolata (Bieb.) Cavara & Grande	BRASSICACEAE	Garlic mustard
Allium ursinum L.	LILIACEAE	Ramsons
Alnus glutinosa (L.) Gaertn.	BETULACEAE	Alder
Alnus rubra Bong.	BETULACEAE	Red alder
Aloina brevirostris (Hook & Grev.) Kindb.		a moss
Aneura pinguis (L.) Dum.	ANEURACEAE	a liverwort
Angelica sylvestris L.	APIACEAE	Wild angelica
Anthoxanthum odoratum L.	POACEAE	Sweet vernal grass
Anthriscus sylvestris (L.) Hoffm.	APIACEAE	Cow parsley
Anthyllis vulneraria L.	FABACEAE	Kidney vetch
Arabidopsis thaliana (L.) Heynh.	BRASSICACEAE	Thale cress
Arctium minus (Hill) Bernh.	ASTERACEAE	Lesser burdock
Arenaria serpyllifolia L.	CARYOPHYLLACEAE	Thyme-leaved sandwort
Armoracia rusticana P.Gaertn., B.Mey & Schreb.	BRASSICACEAE	Horse radish
Arrhenatherum elatius (L.) Beauv. ex J. & C.Presl.	POACEAE	False oat grass
Artemisia vulgaris L.	ASTERACEAE	Mugwort
Artemisia absinthium L.	ASTERACEAE	Wormwood
Aster sp L.	ASTERACEAE	Michaelmas daisy
Athyrium filix-femina (L.) Roth	ATHYRIACEAE	Lady fern
Atropa belladonna L.	SOLANACEAE	Deadly nightshade
Avena fatua L.	POACEAE	Common wild oat
Bacidia viridescens		a lichen
Barbula recurvirostra (Hedw.) Dix.	POTTIACEAE	a moss
Bellis perennis L.	ASTERACEAE	Daisy
Betula pendula Roth.	BETULACEAE	Silver birch
Betula pubescens Ehrh.	BETULACEAE	Downy birch
Blechnum spicant (L.) Roth	BLECHNACEAE	Hard fern
Botrychium lunaria (L.) Sw.	OPHIOGLOSSACEAE	Moonwort
Brassica napus L.	BRASSICACEAE	Rape
Brassica nigra (L.) W.D.J.Koch	BRASSICACEAE	Blak mustard
Briza media L.	POACEAE	Quaking grass
Bromus ramosus Huds.	POACEAE	Hairy brome
Bryum caespiticium Hedw.	BRYACEAE	a moss
Bryum capillare Hedw.	BRYACEAE	a moss
Bryum pallens Sw.	BRYACEAE	a moss
Buxbaumia aphylla Hedw.	BUXBAUMIACEAE	a moss
Calluna vulgaris (L.) Hull	ERICACEAE	Heather (ling)

Species name	Family	Common name
<i>Caloplaca cerinella</i>		a lichen
<i>Caltha palustris</i> L.	RANUNCULACEAE	Marsh marigold
<i>Calystegia sepium</i> (L.) R. Br.	CONVOLVULACEAE	Hedge bindweed
<i>Calystegia sylvatica</i> (Kit.) Griseb.	CONVOLVULACEAE	Large bindweed
<i>Campanula latifolia</i> L.	CAMPANULACEAE	Giant bellflower
<i>Campanula rotundifolia</i> L.	CAMPANULACEAE	Harebell
<i>Campylopus atrovirens</i> De Not.	DICRANACEAE	a moss
<i>Campylopus introflexus</i> (Hedw.) Brid.	DICRANACEAE	a moss
<i>Capsella bursa-pastoris</i> (L.) Medik.	BRASSICACEAE	Shepherd's purse
<i>Cardamine hirsuta</i> L.	BRASSICACEAE	Hairy bittercress
<i>Carduus crispus</i> L.	ASTERACEAE	Wetted thistle
<i>Carex flacca</i> Schreber	CYPERACEAE	Carnation grass
<i>Carex hirta</i> L.	CYPERACEAE	Hairy sedge
<i>Carex nigra</i> (L.) Reichard	CYPERACEAE	Common sedge
<i>Carex rostrata</i> Stokes	CYPERACEAE	Bottle sedge
<i>Carex viridula</i> Michx.	CYPERACEAE	Yellow sedge
<i>Centaurea montana</i> L.	ASTERACEAE	Perennial cornflower
<i>Centaurea nigra</i> L.	ASTERACEAE	Black knapweed
<i>Centaurea scabiosa</i> L.	ASTERACEAE	Greater knapweed
<i>Cerastium fontanum</i> Baumg.	CARYOPHYLLACEAE	Common mouse-ear
<i>Cerastium glomeratum</i> Thuill.	CARYOPHYLLACEAE	Sticky mouse-ear
<i>Chaenorhinum minus</i> (L.) Lange	SCROPHULARIACEAE	Small toadflax
<i>Chamerion angustifolium</i> (L.) Holub	ONAGRACEAE	Rosebay willowherb
<i>Chenopodium album</i> L.	CHENOPODIACEAE	Fat hen
<i>Chrysanthemum segetum</i> L.	ASTERACEAE	Corn marigold
<i>Cicerbita macrophylla</i> (Willd.) Wallr.	ASTERACEAE	Blue sow thistle
<i>Cichorium intybus</i> L.	ASTERACEAE	Chicory
<i>Cirriphyllum crassinervium</i> (Tayl.) Loeske	BRACHYTHECIACEAE	a moss
<i>Cirsium arvense</i> (L.) Scop.	ASTERACEAE	Creeping thistle
<i>Cirsium heterophyllum</i> (L.) Hill	ASTERACEAE	Melancholy thistle
<i>Cirsium palustre</i> (L.) Scop.	ASTERACEAE	Marsh thistle
<i>Cirsium vulgare</i> (Sari) Ten.	ASTERACEAE	Spear thistle
<i>Cladonia fimbriata</i> (L.) Fr.	CLADONIACEAE	a lichen
<i>Cladonia squamosa</i> (Scop.) Hoffm.	CLADONIACEAE	a lichen
<i>Claytonia sibirica</i> L.	AIZOACEAE	Pink purslane
<i>Conium maculatum</i> L.	APIACEAE	Hemlock
<i>Conopodium majus</i> (Gouan) Loret	APIACEAE	Pignut
<i>Corylus avellana</i> L.	CORYLACEAE	Hazel
<i>Cotoneaster integrifolius</i> (Roxb.) G.Klotz	ROSACEAE	Entire-leaved cotoneaster
<i>Crataegus monogyna</i> Jacq.	ROSACEAE	Hawthorn
<i>Crepis capillaris</i> (L.) Wallr.	ASTERACEAE	Smooth hawksbeard
<i>Crepis paludosa</i> (L.) Moench	ASTERACEAE	Marsh hawksbeard
<i>Cruciata laevipes</i> Opiz	RUBIACEAE	Crosswort
<i>Cymbalaria muralis</i> P.Gaertner, B.Meyer & Scherb.	SCROPHULARIACEAE	Ivy-leaved toadflax
<i>Cynosurus cristatus</i> L.	POACEAE	Crested dog's tail
<i>Cytisus scoparius</i> (L.) Link.	FABACEAE	Broom
<i>Dactylis glomerata</i> L.	POACEAE	Cocksfoot
<i>Dactylorhiza fuchsii</i> Druce	ORCHIDACEAE	Common spotted orchid
<i>Dactylorhiza maculata</i> L.	ORCHIDACEAE	Heath orchid
<i>Dactylorhiza purpurella</i> T. & T.A. Stephenson	ORCHIDACEAE	Northern marsh orchid

Species name	Family	Common name
<i>Deschampsia cespitosa</i> (L.) Beauv.	POACEAE	Tufted hair-grass
<i>Deschampsia flexuosa</i> (L.) Trin.	POACEAE	Wavy hair-grass
<i>Dicranella heteromalla</i> (Hedw.) Schimp.	DICRANACEAE	a moss
<i>Dicranum scoparium</i> Hedw.	DICRANACEAE	a moss
<i>Digitalis purpurea</i> L.	SCROPHULARIACEAE	Foxglove
<i>Diphasiastrum alpinum</i> (L.) Holub	LYCOPODIACEAE	Alpine clubmoss
<i>Diploicia canescens</i> (Dickson) Massal.	PHYSICIACEAE	a lichen
<i>Dipsacus fullonum</i> L.	DIPSACEAE	Teasel
<i>Dryopteris dilatata</i> (Hoffm.) A.Gray	ASPIDACEAE	Common buckler fern
<i>Dryopteris filix-mas</i> (L.) Schott	ASPIDACEAE	Male fern
<i>Empetrum nigrum</i> L.	ERICACEAE	Crowberry
<i>Epilobium hirsutum</i> L.	ONAGRACEAE	Great willowherb
<i>Epilobium montanum</i> L.	ONAGRACEAE	Broad-leaved willowherb
<i>Epilobium palustre</i> L.	ONAGRACEAE	Marsh willowherb
<i>Epipactis helleborine</i> (L.) Crante	ORCHIDACEAE	Broad-leaved helliborine
<i>Equisetum arvense</i> L.	EQUISETACEAE	Field horsetail
<i>Equisetum fluviatile</i> L.	EQUISETACEAE	Water horsetail
<i>Equisetum palustre</i> L.	EQUISETACEAE	Marsh horsetail
<i>Equisetum sylvaticum</i> L.	EQUISETACEAE	Wood horsetail
<i>Erica cinerea</i> L.	ERICACEAE	Bell heather
<i>Erica tetralix</i> L.	ERICACEAE	Cross-leaved heath
<i>Eriophorum angustifolium</i> Honck	CYPERACEAE	Cotton grass
<i>Euphrasia nemorosa</i> (Pers.) Wallr.	SCROPHULARIACEAE	Eyebright
<i>Fagus sylvatica</i> L.	FAGACEAE	Beech
<i>Fallopia convolvulus</i> (L.) Á. Löve	POLYGONACEAE	Black bindweed
<i>Fallopia japonica</i> (Houtt.) Ronse	POLYGONACEAE	Japanese knotgrass
<i>Festuca ovina</i> L.	POACEAE	Sheep's fescue
<i>Festuca rubra</i> L.	POACEAE	Red fescue
<i>Festuca vivipara</i> (L.) Sm.	POACEAE	Viviparous fescue
<i>Filipendula ulmaria</i> (L.) Maxim.	ROSACEAE	Meadowsweet
<i>Fragaria vesca</i> L.	ROSACEAE	Wild strawberry
<i>Fraxinus excelsior</i> L.	OLEACEAE	Ash
<i>Galeopsis bifida</i> Boenn.	LAMIACEAE	Bifid hemp-nettle
<i>Galeopsis tetrahit</i> L.	LAMIACEAE	Common hemp-nettle
<i>Galium aparine</i> L.	RUBIACEAE	Sticky willie (cleavers, goosegrass)
<i>Galium palustre</i> L.	RUBIACEAE	Marsh bedstraw
<i>Galium saxatile</i> L.	RUBIACEAE	Heath bedstraw
<i>Galium uliginosum</i> L.	RUBIACEAE	Fen bedstraw
<i>Galium verum</i> L.	RUBIACEAE	Lady's bedstraw
<i>Geranium nodosum</i> L.	GERANIACEAE	Knotted crane's bill
<i>Geranium pratense</i> L.	GERANIACEAE	Meadow crane's bill
<i>Geranium robertianum</i> L.	GERANIACEAE	Herb robert
<i>Geranium sylvaticum</i> L.	GERANIACEAE	Wood crane's bill
<i>Geum rivale</i> L.	ROSACEAE	Water avens
<i>Geum urbanum</i> L.	ROSACEAE	Wood avens
<i>Glyceria maxima</i> (Hartm.) Holmb.	POACEAE	Reed sweet-grass
<i>Gnaphalium sylvaticum</i>		
<i>Grimmia pulvinata</i> (Hedw.) Sm.	GRIMMIACEAE	a moss
<i>Hedera helix</i> L.	ARALIACEAE	Ivy

Species name	Family	Common name
<i>Heracleum sphondylium</i> L.	APIACEAE	Hogweed
<i>Hesperis matronalis</i> L.	BRASSICACEAE	Dame's violet
<i>Hieracium maculatum</i> Sm.	ASTERACEAE	Spotted hawkweed
<i>Hieracium sabaudum</i> L.	ASTERACEAE	Many-leaved hawkweed
<i>Hieracium umbellatum</i> L.	ASTERACEAE	Hawkweed
<i>Hippophae rhamnoides</i> L.	ELAEAGNACEAE	Sea buckthorn
<i>Holcus lanatus</i> L.	POACEAE	Yorkshire fog
<i>Holcus mollis</i> L.	POACEAE	Creeping soft grass
<i>Hyacinthoides non-scriptus</i> (L.) Chouard ex Rothm.	LILIACEAE	Wild hyacinth (bluebell)
<i>Hylocomium splendens</i> (Hedw.) Br. Eur.	HYPNACEAE	a moss
<i>Hypericum perforatum</i> L.	HYPERACEAE	Perforate St John's wort
<i>Hypericum pulchrum</i> L.	HYPERACEAE	Slender St John's wort
<i>Hypnum cupressiforme</i> Hedw.	HYPNACEAE	a moss
<i>Hypnum jutlandicum</i> Holmen & Warncke	HYPNACEAE	a moss
<i>Hypnum mammillatum</i> (Brid.) Loeske	HYPNACEAE	a moss
<i>Hypochoeris radicata</i> L.	ASTERACEAE	Cat's ear
<i>Iberis amara</i> L.	BRASSICACEAE	Wild candytuft
<i>Impatiens glandulifera</i> Royle	SCROPHULARIACEAE	Indian balsam
<i>Iris pseudacorus</i> L.	IRIDACEAE	Yellow iris
<i>Juncus acutiflorus</i> Ehrh. Ex Hoffm.	JUNCACEAE	Sharp-flowered rush
<i>Juncus articulatus</i> L.	JUNCACEAE	Jointed rush
<i>Juncus conglomeratus</i> L.	JUNCACEAE	Conglomerate rush
<i>Juncus effusus</i> L.	JUNCACEAE	Soft rush
<i>Knautia arvensis</i> (L.) Coult.	DIPSACEAE	Field scabious
<i>Lamium album</i> L.	LAMIACEAE	White dead-nettle
<i>Lamium purpureum</i> L.	LAMIACEAE	Red dead-nettle
<i>Lapsana communis</i> L.	ASTERACEAE	Nipplewort
<i>Larix decidua</i> Mill.	PINACEAE	European larch
<i>Larix x eurolepis</i> Henry	PINACEAE	Dunkeld larch (hybrid larch)
<i>Lathyrus pratensis</i> L.	FABACEAE	Madow vetchling
<i>Leontodon autumnalis</i> L.	ASTERACEAE	Autumn hawkbit
<i>Leontodon hispidus</i> L.	ASTERACEAE	Rough hawkbit
<i>Leucanthemum vulgare</i> Lam.	ASTERACEAE	Oxeye daisy
<i>Leucojum vernum</i> L.	AMARYLLIDACEAE	Spring snowflake
<i>Ligustrum vulgare</i> L.	OLEACEAE	Wild privet
<i>Linaria vulgaris</i> Mill.	SCROPHULARIACEAE	Common toadflax
<i>Linum catharticum</i> L.	LINACEAE	Fairy flax
<i>Listera ovata</i> (L.) R.Br.	ORCHIDACEAE	Common twayblade
<i>Lolium perenne</i> L.	POACEAE	Perennial rye grass
<i>Lonicera periclymenum</i> L.	CAPRIFOLIACEAE	Honeysuckle
<i>Lophocolea bidentata</i> (L.) Dum.	LOPHOCOLEACEAE	a liverwort
<i>Lophocolea cuspidata</i> (Nees.) Limpr.	LOPHOCOLEACEAE	a liverwort
<i>Lotus corniculatus</i> L.	FABACEAE	Bird's-foot trefoil
<i>Lotus pedunculatus</i> Cav.	FABACEAE	Large bird's-foot trefoil
<i>Lupinus arboreus</i> Sims	FABACEAE	Tree lupin
<i>Lupinus nootkatensis</i> Donn ex Sims	FABACEAE	Nootka lupin
<i>Lupinus polyphyllus</i> Lindl.	FABACEAE	Garden lupin (Russell lupin)

Species name	Family	Common name
Luzula campestris (L.) DC.	JUNCACEAE	Field woodrush
Luzula multiflora (Retz.) Lej.	JUNCACEAE	Many-headed woodrush
Luzula sylvatica (Huds.) Gaudin	JUNCACEAE	Greater woodrush
Lycopodium clavatum L.	LYCOPODIACEAE	Stag's horn clubmoss
Lysimachia vulgaris L.	PRIMULACEAE	Yellow loosestrife
Malus domestica Borkh.	ROSACEAE	Apple
Malus sylvestris (L.) Mill.	ROSACEAE	Crab apple
Matricaria discoidea DC.	ASTERACEAE	Pineapple weed
Medicago lupulina L.	FABACEAE	Black medick
Melilotus altissimus Thuill.	FABACEAE	Tall melilot
Mentha spicata L.	LAMIACEAE	Spearmint
Micaria lithinella		a lichen
Mimulus guttatus DC.	SCROPHULARIACEAE	Monkey flower
Molinia caerulea (L.) Moench.	POACEAE	Purple moor grass
Myosotis arvensis (L.) Hill	BORAGINACEAE	Field forget-me-not
Myosotis scorpioides L.	BORAGINACEAE	Water forget-me-not
Myosotis sylvatica Hoffm.	BORAGINACEAE	Wood forget-me-not
Myrrhis odorata (L.) Scop.	APIACEAE	Sweet cicely
Nardus stricta L.	POACEAE	Mat grass
Odontites vernus (Bellardi) Dumort	SCROPHULARIACEAE	Red bartsia
Oligotrichum hercynicum (Hedw.) Lam. & Cand.	POLYTRICHACEAE	a moss
Orchis mascula (L.) L.	ORCHIDACEAE	Early purple orchid
Oreopteris limbosperma (Bellardi ex All.) Holub	THELYPTERIDACEAE	Sweet mountain fern
Papaver dubium L.	PAPAVERACEAE	Long headed poppy
Papaver rhoeus L.	PAPAVERACEAE	Common poppy
Papaver somniferum L.	PAPAVERACEAE	Opium poppy
Peltigera canina (L.) Willd.	PELTIGERACEAE	a lichen
Pentaglottis sempervirens (L.) Tausch ex L.H. Bailey	BORAGINACEAE	Green alkanet
Pertusaria corallina (L.) Arnold	PERTUSARIACEAE	a lichen
Petasites hybridus (L.) P.Gaertn., B.Mey & Scherb.	ASTERACEAE	Butterbur
Phalaris arundinacea L.	POACEAE	Reed canary-grass
Phleum pratense L.	POACEAE	Timothy
Phragmites communis Trin.	POACEAE	Common reed
Picea sitchensis (Bong.) Carrière	PINACEAE	Sitka spruce
Pilosella aurantiaca (L.) F.W.Schultz & Sch. Bip.	ASTERACEAE	Fox-and-cubs
Pilosella officinarum F.W.Schultz & Sch. Bip.	ASTERACEAE	Mouse-eared hawkweed
Pilularia globulifera L.	MARSILEACEAE	Pillwort
Pinus contorta Douglas ex Louden	PINACEAE	Lodgepole pine
Pinus sylvestris L.	PINACEAE	Scots pine
Pyrola minor L.	PYROLACEAE	Common wintergreen
Plantago lanceolata L.	PLANTAGINACEAE	Ribwort
Plantago major L.	PLANTAGINACEAE	Greater plantain
Plantago media L.	PLANTAGINACEAE	Hoary plantain
Platanthera chlorantha (Custer) Rchb.	ORCHIDACEAE	Great butterfly orchid
Pleurozium schreberi (Brid.) Mitt.	HYPNACEAE	a moss
Poa annua L.	POACEAE	Annual meadow grass

Species name	Family	Common name
<i>Poa nemoralis</i> L.	POACEAE	Wood meadow grass
<i>Poa pratensis</i> L.	POACEAE	Smooth-stalked meadow grass
<i>Poa trivialis</i> L.	POACEAE	Rough meadow grass
<i>Polemonium caeruleum</i> L.	POLEMONIACEAE	Jacob's ladder
<i>Polygonum aviculare</i> L.	POLYGONACEAE	Knotgrass
<i>Polygonum maculosa</i> Gray	POLYGONACEAE	Redshank
<i>Polytrichum commune</i> Hedw.	POLYTRICHACEAE	a moss
<i>Polytrichum juniperum</i> Hedw.	POLYTRICHACEAE	a moss
<i>Populus tremula</i> L.	SALICACEAE	Aspen
<i>Potamogeton polygonifolius</i> Pourr.	POTAMOGETONACEAE	Bog pondweed
<i>Potentilla anserina</i> L.	ROSACEAE	Silverweed
<i>Potentilla erecta</i> (L.) Raeusch.	ROSACEAE	Tormentil
<i>Potentilla palustris</i> (L.) Scop.	ROSACEAE	Marsh cinquefoil
<i>Potentilla reptans</i> L.	ROSACEAE	Creeping cinquefoil
<i>Pottia truncata</i> (Hedw.) Furnr.	POTTIACEAE	a moss
<i>Primula veris</i> L.	PRIMULACEAE	Cowslip
<i>Primula vulgaris</i> Huds.	PRIMULACEAE	Primrose
<i>Prunella vulgaris</i> L.	LAMIACEAE	Selfheal
<i>Prunus avium</i> (L.) L.	ROSACEAE	Gean (wild cherry)
<i>Prunus spinosa</i> L.	ROSACEAE	Blackthorn
<i>Pteridium aquilinum</i> (L.) Kuhn	HYPOLEPIDACEAE	Bracken
<i>Quercus petraea</i> (Matt.) Liebl	FAGACEAE	Sessile oak
<i>Quercus robur</i> L.	FAGACEAE	Pedunculate oak
<i>Racomitrium canescens</i> (Hedw.) Brid.	GRIMMIACEAE	a moss
<i>Ranunculus acris</i> L.	RANUNCULACEAE	Meadow buttercup
<i>Ranunculus ficaria</i> L.	RANUNCULACEAE	Lesser celandine
<i>Ranunculus repens</i> L.	RANUNCULACEAE	Creeping buttercup
<i>Raphanus raphanistrum</i> L.	BRASSICACEAE	Wild radish
<i>Reseda lutea</i> L.	RESEDACEAE	Wild mignonette
<i>Reseda luteola</i> L.	RESEDACEAE	Weld
<i>Rhinanthus minor</i> L.	SCROPHULARIACEAE	Yellow rattle
<i>Rhytidiadelphus squarrosus</i> (Hedw.) Warnst.	HYPNACEAE	a moss
<i>Rhytidiadelphus triquetrus</i> (Hedw.) Warnst.	HYPNACEAE	a moss
<i>Ribes uva-crispa</i> L.	GROSSULARIACEAE	Gooseberry
<i>Rorippa nasturtium-aquaticum</i> (L.) Hayek	BRASSICACEAE	Water cress
<i>Rosa canina</i> agg. L.	ROSACEAE	Dog rose
<i>Rubus fruticosus</i> agg. L.	ROSACEAE	Bramble (blackberry)
<i>Rubus idaeus</i> L.	ROSACEAE	Raspberry
<i>Rumex acetosa</i> L.	POLYGONACEAE	Common sorrel
<i>Rumex acetosella</i> L.	POLYGONACEAE	Sheep's sorrel
<i>Rumex crispus</i> L.	POLYGONACEAE	Curled dock
<i>Rumex obtusifolius</i> L.	POLYGONACEAE	Broad-leaved dock
<i>Rumex sanguineus</i> L.	POLYGONACEAE	Wood dock
<i>Sagina nodosa</i> (L.) Fenzl	CARYOPHYLLACEAE	Knotted pearlwort
<i>Sagina procumbens</i> L.	CARYOPHYLLACEAE	Procumbent pearlwort
<i>Salix alba</i> L.	SALICACEAE	White willow
<i>Salix aurita</i> L.	SALICACEAE	Eared willow
<i>Salix caprea</i> L.	SALICACEAE	Goat willow
<i>Salix fragilis</i> L.	SALICACEAE	Crack willow
<i>Salix viminalis</i> L.	SALICACEAE	Osier

Species name	Family	Common name
Salvia verticillata L.	LAMIACEAE	Whorled clary
Sambucus nigra L.	CAPRIFOLIACEAE	Elder
Sanguisorba minor Scop.	ROSACEAE	Salad burnet
Scrophularia nodosa L.	SCROPHULARIACEAE	Figwort
Sedum acre L.	CRASSULACEAE	Biting stonecrop
Sedum album L.	CRASSULACEAE	White stonecrop
Senecio aquaticus Hill	ASTERACEAE	Marsh ragwort
Senecio jacobaea L.	ASTERACEAE	Common ragwort
Senecio sylvaticus L.	ASTERACEAE	Wood groundsel
Senecio viscosus L.	ASTERACEAE	Sticky groundsel
Senecio vulgaris L.	ASTERACEAE	Groundsel
Silene dioica (L.) Clairv.	CARYOPHYLLACEAE	Red campion
Silene latifolia Poir.	CARYOPHYLLACEAE	White campion
Silene vulgaris Garcke	CARYOPHYLLACEAE	Bladder campion
Sinapis arvensis L.	BRASSICACEAE	Charlock
Sium latifolium L.	APIACEAE	Water parsnip
Solanum dulcamara L.	SOLANACEAE	Bittersweet
Solidago canadensis L.	ASTERACEAE	Tall goldenrod
Sonchus arvensis L.	ASTERACEAE	Perennial sow-thistle
Sonchus asper (L.) Hill	ASTERACEAE	Prickly sow-thistle
Sonchus oleraceus L.	ASTERACEAE	Sow-thistle
Sorbus aria (L.) Crantz	ROSACEAE	Whitebeam
Sorbus aucuparia L.	ROSACEAE	Rowan (mountain ash)
Sparganium emersum Rehmman	SPARGANIACEAE	Unbranched bur-reed
Sphagnum sp.	SPHAGNACEAE	Sphagnum sp.
Stachys palustris L.	LAMIACEAE	Marsh woundwort
Stachys sylvatica L.	LAMIACEAE	Hedge woundwort
Steinia geophana		a lichen
Stellaria graminea L.	CARYOPHYLLACEAE	Lesser stitchwort
Stellaria holostea L.	CARYOPHYLLACEAE	Greater stitchwort
Stellaria media (L.) Vill.	CARYOPHYLLACEAE	Chickweed
Stereocaulon nanodes		a lichen
Stereocaulon saxatile		a lichen
Stereocaulon leucophaeopsis		a lichen
Succisa pratensis Moench	DIPSACEAE	Devil's bit scabious
Symphoricarpos albus (L.) S.F.Blake	CAPRIFOLIACEAE	Snowberry
Symphytum officinale L.	BORAGINACEAE	Common comfrey
Symphytum x uplandicum Nyman	BORAGINACEAE	Russian comfrey
Tanacetum parthenium (L.) Sch. Bip.	ASTERACEAE	Feverfew
Tanacetum vulgare L.	ASTERACEAE	Tansy
Taraxacum officinale agg. Wigg.	ASTERACEAE	Dandelion
Teucrium scorodonia L.	LAMIACEAE	Wood sage
Thlaspi arvense L.	BRASSICACEAE	Field penny cress
Torilis japonica (Houtt.) DC.	APIACEAE	Upright hedge parsley
Tragopogon pratensis L.	ASTERACEAE	Goat's beard
Trifolium campestre Schreb.	FABACEAE	Hop trefoil
Trifolium dubium Sibth.	FABACEAE	Lesser trefoil
Trifolium hybridum L.	FABACEAE	Alsike clover
Trifolium medium L.	FABACEAE	Zig-zag clover
Trifolium pratense L.	FABACEAE	Red clover
Trifolium repens L.	FABACEAE	White clover
Trifolium striatum L.	FABACEAE	Knotted clover
Tripleurospermum inodorum (L.) Sch. Bip.	ASTERACEAE	Scentless mayweed

Species name	Family	Common name
Tussilago farfara L.	ASTERACEAE	Coltsfoot
Typha latifolia L.	TYPHACEAE	Bullrush
Ulex europaeus L.	FABACEAE	Gorse (whin, furze)
Ulmus glabra Huds.	ULMACEAE	Wych elm
Urtica dioica L.	URTICACEAE	Stinging nettle
Vaccinium myrtillus L.	ERICACEAE	Blaeberry
Valeriana officinalis L.	VALARIANACEAE	Common valarian
Verbascum thapsus L.	SCROPHULARIACEAE	Great mullein
Veronica arvensis L.	SCROPHULARIACEAE	Wall speedwell
Veronica chamaedrys L.	SCROPHULARIACEAE	Germander speedwell
Veronica officinalis L.	SCROPHULARIACEAE	Heath speedwell
Veronica persica Poiret	SCROPHULARIACEAE	Large field speedwell
Veronica polita Fries	SCROPHULARIACEAE	Grey speedwell
Veronica serpyllifolia L.	SCROPHULARIACEAE	Thyme-leaved speedwell
Viburnum opulus L.	SCROPHULARIACEAE	Guelder rose
Vicia cracca L.	FABACEAE	Tufted vetch
Vicia hirsuta (L.) Gray	FABACEAE	Tare
Vicia lutea L.	FABACEAE	Yellow vetch
Vicia sativa L.	FABACEAE	Common vetch
Vicia sepium L.	FABACEAE	Bush vetch
Viola arvensis Murray	VIOLACEAE	Field violet

Appendix 2 Species 'unique' to bing sites

Plant species from the main list (appendix 2) that have only been recorded on one of the bing sites listed table 5 (page 13)

Bing site	Species
Addiewell north	<i>Agrostis gigantea</i> , <i>Aneura pinguis</i> , <i>Calluna vulgaris</i> , <i>Campylopus atrovirens</i> , <i>Carex flacca</i> , <i>Carex nigra</i> , <i>Cirsium palustre</i> , <i>Dryopteris dilatata</i> , <i>Filipendula ulmaria</i> , <i>Hypericum pulchrum</i> , <i>Galium saxatile</i> , <i>Hieracium sabaudum</i> , <i>Juncus conglomeratus</i> , <i>Juncus effusus</i> , <i>Listera ovata</i> , <i>Lotus uliginosus</i> , <i>Lysimachia vulgaris</i> , <i>Potentilla anserina</i> , <i>Sonchus oleraceus</i> , <i>Succisa pratensis</i> , <i>Tanacetum parthenium</i> (20 species)
Addiewell south	<i>Bryum caespiticium</i> , <i>Dicranella heteromalla</i> , <i>Geranium robertianum</i> , <i>Racomitrium canescens</i> , <i>Symphocarpus albus</i> , <i>Tanacetum vulgare</i> , <i>Trifolium hybridum</i> , <i>Viburnum opulus</i> (8 species)
Clapperton	<i>Agrostis capillaris</i> , <i>Agrostis stolonifera</i> , <i>Brassica napus</i> , <i>Capsella bursa-pastoris</i> , <i>Cerastium glomeratum</i> , <i>Galeopsis tetrahit</i> , <i>Lamium purpureum</i> , <i>Matricaria discoides</i> , <i>Papavar somniferum</i> , <i>Pottia truncata</i> , <i>Raphanus raphanistrum</i> , <i>Thlaspi arvense</i> , <i>Viola arvensis</i> (13 species)
Drumshoreland north	<i>Chaenorhinum minus</i> , <i>Pleurozium schreberi</i> (2 species)
Drumshoreland south	<i>Artemesia vulgaris</i> , <i>Stellaria graminea</i> (2 species)
Greendykes	<i>Artemesia absinthium</i> , <i>Calystegia sepium</i> , <i>Equisetum sylvaticum</i> , <i>Oligotrichum hercynicum</i> , <i>Sinapsis arvensis</i> (5 species)
Mid Breich	<i>Anthyllis vulneraria</i> , <i>Bryum pallens</i> , <i>Campanula latifolia</i> , <i>Campylopus introflexus</i> , <i>Cymbalaria muralis</i> , <i>Digitalis purpurea</i> , <i>Diploica canescens</i> , <i>Erica cinerea</i> , <i>Hieracium aurantiacum</i> , <i>Hylocomium splendens</i> , <i>Phragmites australis</i> , <i>Polemonium caeruleum</i> , <i>Silene vulgaris</i> (13 species)
Oakbank	<i>Barbula recurvosa</i> , <i>Bromus ramosus</i> , <i>Cirriphyllum crassinervium</i> , <i>Corylus avellana</i> , <i>Hippophae rhamnoides</i> , <i>Lupinus arboreus</i> , <i>Lupinus nootkatensis</i> , <i>Poa trivialis</i> , <i>Silene dioica</i> , <i>Trifolium medium</i> , <i>Ulmus glabra</i> (11 species)

STATUS AND ECOLOGY

The oil shale bings of West Lothian are unique in Britain and north-west Europe. They play a significant role in the heritage and culture of the county. These spoil heaps, the by-products of an industrial process to extract mineral oil from underground seams of shale, have created landscapes with their own distinctive flora and fauna, and provide refuges for locally rare and threatened plants and animals. One bing is a Scottish Wildlife Trust nature reserve and three others are UK Industrial Heritage Sites. The bings of West Lothian also have high economic and social value. The spoil (blaes) is a valuable material for bottoming roads and preparing ground for building, resulting in the gradual removal of some bings, yet many of the remaining bings are also important local recreational sites. This combination of properties differentiates the bings from other industrial spoils that have largely been reclaimed and restored.

The West Lothian shale bings are of great ecological and scientific importance. They are examples of a distinctive and rare type of post-industrial waste that is unique within Britain; only Estonia and Manchuria have similar sites. They are also examples of sites of primary succession. The invasion of a novel substrate is an ideal subject for studies of colonisation processes, the ecology of individual species (both plant and animal) and communities that are adapted to low competition conditions. Primary sites are only found naturally on sand dunes, glaciers and volcanoes; all of which are very uncommon in Britain

Oil-shale spoil is physically and chemically different from other spoil types. The structure of bings make them more similar to volcanoes than industrial waste tips. Oil-shale waste has been heated to several hundred degrees centigrade before dumping. The substrate is non toxic, containing none of the heavy metals or other toxins associated with industrial and mine waste. Oil-shale is alkaline, not acidic like coal spoil. The steep sides of the bings are stable and not liable to slippage.

Variations in the substrate of the bings create unique conditions and produce a wide range of fresh habitats and new niches for plants and animals. The bings are island refugia for wildlife in a primarily agricultural and urban/industrial landscape. The resulting vegetation is so unusual within the region that the oil-shale bings constitute one of the eight main habitats in West Lothian's Biodiversity Action Plan

Habitats within the bings vary from almost bare substrate to semi-natural grassland, heather scrub and pioneering birch woodland. The diversity of plant species on the bings is considerable and the sites are home to more than 350 plant species.

Eight species with Nationally Scarce status in Great Britain are found on the oil shale bing habitat. Sixteen of West Lothian's rarest plants are also recorded on bing sites. Links with

other West Lothian LBAP species and habitats can be established through the major role played by the bings in the success of 15 of the 45 West Lothian habitat indicator species (brown hare, kestrel, skylark, bullfinch, song thrush, spotted flycatcher, linnet, grey partridge, yellowhammer, swallow, red grouse, orange tip butterfly, yellow rattle, bird's foot trefoil, wild hyacinth [bluebell]).

FACTORS CAUSING LOSS OR DECLINE

Physical removal. The value of blaes as hardcore for roads is a permanent threat to all of the bings. Contentibus now lies under the M8, some of Albyn disappeared under Greendykes Road when the Union Canal was reopened for the millennium and Drumshoreland is currently being demolished (at least some of this bing is under the new park and ride facility at Hermiston). Continued increase in pressure for development in urban areas is also a threat. Niddry bing is being removed to allow the building of several thousand new homes near Winchburgh and Addiewell south is the proposed site of a new prison.

Management. The invasive and unnecessary restoration of many bing sites after extraction of blaes has resulted in the loss of potential biodiversity and encourages weedy species. This is particularly noticeable at Stankards and the Green bing where topsoil has been added and/or fertiliser applied to the rounded off remains of the site. At Mid Breich there has been unnecessary "enrichment" planting of oak and ash (under a woodland grant scheme contract) adjoining the site of naturally occurring, and genetically unique, birch woodland. Part of the contract requires that the "Planted stock will be spot treated chemically to control weed competition and **to control competing birch regeneration** in the immediate vicinity" yet natural regeneration is expected.

Public attitude. The bings are seen as waste ground or spoil and this leads to abuse at several levels. Dumping of household building rubble and garden waste is common on some sites. Mid Breich in particular is under considerable threat from the owners of the adjoining property whose business spills over on to the lower slopes of this small bing. The bings are also wrongly perceived by some as a source of toxic waste and therefore dangerous. The inconsiderate use of bings by other members of the public, particularly those on motor vehicles, increases

Government policy (Scotland). National Planning Policy Guideline NPPG 4: LAND FOR MINERAL WORKING paragraphs 52 and 53 suggest that local planning policies should provide for the reworking of mineral waste deposits and the recycling of demolition and construction wastes (including oil-shale bings) where ever possible.

CURRENT ACTION

The bings collectively, as a habitat, have no formal protection. Of the nineteen bings extant in West Lothian only four have formal protected status. A further four have been restored

and are unlikely to be under threat. The remaining eleven bings are either being extracted, have already been extracted or could be in the future.

The finalised West Lothian local plan (April, 2005) defines the status of the bings in Chapter 11: Circumstances likely to support a grant of planning permission for removal, extraction and rehabilitation (policy NWR4) and Circumstances where extraction is unlikely to be acceptable (policies NWR5 & NWR6). Drumshoreland north and south, Clapperton and Niddry are all currently being extracted; Addiewell south is earmarked for extraction; Philpstoun north and south could be extracted if planning permission is granted; Bridgend, Mid Breich, Albyn and Seafield are abandoned, or exhausted as a source of blaes, but as 'brown field sites' could potentially be given planning permission for development; Deans bing, Green bing and Stankards have been restored (badly) after extraction; Oakbank has been restored intact and extraction is resisted; Addiewell north is listed as an SWT nature reserve (Appendix 3.1 "Designated sites of international and national importance"), Faucheldean as a local Wildlife site (Appendix 3.2) and Faucheldean, Five Sisters and Greendykes as scheduled monuments (Appendix 4.3).

The proposals in this habitat action plan will result in a bing habitat of nineteen diverse and well protected sites that are appreciated for their contribution to the biodiversity of West Lothian, the well-being of its inhabitants and their historical significance. The alternative is a habitat consisting of only the four designated sites, three badly restored sites and Oakbank.

ACTION PLAN OBJECTIVES AND TARGETS

** ORGANISATIONS AND INDIVIDUALS HAVE OCCASIONALLY BEEN IDENTIFIED AS POTENTIALLY RESPONSIBLE FOR THE PROPOSED ACTIONS BUT HAVE NOT BEEN CONSULTED.

Objectives:

1. As a priority increase public awareness and appreciation of the wildlife and recreational value of oil-shale bings. Promote these man-made habitats to the community as an asset with the same intrinsic worth as woodlands and other semi-natural habitats.
2. In doing so, protect and maintain the bings along with the communities of plants and animals that they support.
3. Identify the factors likely to cause deterioration and/or destruction to the bings themselves and to their unusual vegetation types and use this information to target actions that will effectively and efficiently protect and enhance the habitat.

Targets:

1. Liaise with current bing owners (SWT, Hopetoun Estates etc) on the development and application of the action plan.
2. Establish communications with community councils and schools to raise awareness of their ecological importance and to encourage involvement in protecting the bing habitat.

3. Improve accessibility to the bings and encourage their use as public open spaces and educational resources.
4. Secure formal protection for all of the remaining oil-shale bings through the local plan, as examples of primary succession processes and for their contribution to the biodiversity of West Lothian, and as industrial heritage sites because of their historical significance.

PROPOSED ACTION for the bing habitat

Discourage restoration programmes on all 19 bing sites even after extraction. To maintain and enhance the bing habitat management should be kept to a minimum. Sites only require minor regrading to remove overhangs and stabilise large blocks of clinker so that they are made safe. Retain old elder trees when ever possible as they are a unique source of epiphytic lichen and moss diversity

Raise awareness locally (priority) and nationally by encouraging visits from the general public, schools, universities, bing baggers. On most bings this will require minor work to improve access. Promote the bings in schools and libraries and preferably on–line as sites of interest historically and ecologically. The panorama from the top of Greendykes in particular is breathtaking and affords views across the River Forth, including both bridges, and Fife to the north; the city of Edinburgh and Arthur’s seat to the east; the Pentland hills to the south; the whole of West Lothian to Five Sisters, the Knock and beyond to the west. Reopen the “Shale Trail” with widespread publicity (BP Grangemouth should be approached to fund and promote this).

PROPOSED ACTION by bing site

Mid Breich (WLC) – Protect the birch woodland by avoiding further tree planting and, if possible, stop all chemical weed prevention. Enter into consultation with the adjoining bus company re keeping scrapped vehicles and other debris within their boundaries and maintaining the fences to the east of their premises. Monitor fly-tipping of household rubble and garden refuse (this latter should be less of a problem with new compost bins)

Addiewell north (SWT) – Arrange immediate removal of a patch of Japanese knotweed developing by the edge of Breich Water (to the left of the east path). Continue the gradual removal of non-native trees, particularly the pines. Removal of larch and broadleaved non-native tree species is probably unnecessary unless they become invasive or hybridise with native species. Monitor the patches of bracken that are developing in some areas and are in danger of becoming invasive. Continue the existing mowing programme but extend the mowing area in places to encourage wild strawberries. Be aware of wintergreen and twayblade sites and the importance of the very old elder trees.

Greendykes (WLC and Hopetoun Estate) – On the plateau retain trees and shrubs for stability. Make access easier by clearing a small area for parking (two or three vehicles only)

on the north side at the foot of the path that was the main winching track when the bing was in operation.

To increase diversity of the calcareous grassland meadow the plateau should be mowed annually. By hand with a scythe in the late Autumn after seeding would be ideal (volunteers such as the Edinburgh University "Dirty Weekenders" could be approached).

Direct off-road bikers and quad bikers to designated areas on the south section of the bing. Arrange clearly defined access. This should be possible from the south, via the industrial estate to the East of Broxburn, and will keep bikes away from residential areas but will have to be agreed after consultation. It is not feasible to ban off-road vehicle users as they will only go elsewhere or ignore the ban. There is likely to be considerable local opposition to any proposal despite the public generally agreeing to "designated parks/tracks which were needed to be built for the riders." (From minutes of Winchburgh community council meeting 14th Feb 2005). Off-road vehicles *per se* do not harm the bing or its diversity, indeed the disturbance from biking is needed to maintain stonecrop and some other species, but they are not compatible with walkers, particularly children. Designating off-road tracks also makes it easier for the police to monitor vehicles without road-tax etc but this could be counterproductive.

There is an additional (occasional) problem of stolen cars being driven to the top of this bing, set fire to and then pushed over the edge. Again this practice does not affect the bing or plant diversity but it does not enhance the bing's image.

Drumshoreland south – No management required. Monitor the tall melilot growing on the remains of the north facing side. Do not seed or plant on the banks beside the golf course

Drumshoreland north – Stop extraction before the bing is totally removed. Retain the slopes to the north and east, and their vegetation, if possible. When extraction is completed encourage minimal management to make safe then allow the remains to colonise without sowing or planting. The summit of this bing was the site of grey-field speedwell and small toadflax before extraction. Both of these are very rare species in West Lothian.

Clapperton – Leave this bing to develop with no more seeding or planting. Many of the trees are already dying and it is unlikely that the weedy species will predominate for long. There should be sufficient invasion from the surrounding strips of mature woodland and the vegetation at the base of the bing to allow natural revegetation of the site. The only authenticated Scottish record of *Aloina brevirostris*, a moss, was from this site in 1989.

Oakbank – Continue with the present management regime. Monitor the lupins on the summit to ensure that they do not become invasive and remove them if necessary.

Faucheldean – Encourage more visitors! Lack of disturbance is allowing the vegetation to close up and this site is in danger of losing club moss and orchid habitats.

Green and Stankards bing – These bings have both been badly restored in the recent past. There is some evidence that naturally invading species are becoming more successful but these sites would benefit from enrichment planting of native woody species to make them more attractive. Small scale parking areas would encourage their use as amenity sites but they also need to be positively promoted as public open space.

Philpstoun north and south – The situation on these sites is similar to that on Greendykes and the off-road vehicles/pedestrian mix is perceived to be a major problem. Again the best solution is to designate areas for motor vehicles, preferably on the south side of Philpstoun south bing with access from the minor road/track leading to Burnside.

Bridgend – Encourage public use as amenity site. No management.

Niddry – Retain partially if possible and develop into a major green site like Oakbank in conjunction with the Gala homes development. Ensure that any proposed planting is with native species that are suited to the alkaline environment (not standard central Scotland vegetation). Incorporate the development of access into the proposed new footpaths and roads in “New Winchburgh”. Promotion of the bings as amenity and educational sites should be very high priority in this area, perhaps as part of a “welcome pack” in every new home.

Albyn – Tidy up the remains to make them more welcoming. Allow the site to develop as an extension to the central forest area and also to promote pedestrian access to Greendykes plateau from the south west.

Seafield – From 1959 onwards there was tipping on various parts of the site, including domestic refuse. There have also been areas where sewage sludge was dumped (1989-90). Proposals for reclamation were made in June 1991 and the work completed in 1996. This included reshaping to form a crag and tail geomorphological feature and planting to produce an amenity area similar to Oakbank. Despite its previous use there is no evidence to suggest that the land is contaminated. The failure of tree planting is due to other factors.

Deans and Addiewell south – These bings have little real potential as amenity sites. Deans is already developed and home to the First Group bus depot and Addiewell south is earmarked for development as the site for a new prison.



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