OFFICIAL

Railway Sustainability Design Guide

Urban and Brownfield Design and Management Guidance Note

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Issue record

Issue	Date	Comments
0.1	June 2021	First release in advance of online edition

Reference documentation

NR/L2/ENV/122	Managing Biodiversity
NR/L2/ENV/122/01	Biodiversity
NR/L2/ENV/122/02	Habitat Management Plan
NR/L2/OTK/5201/01	Lineside vegetation inspection and risk assessment
NR/L2/OTK/5201/02	Lineside Vegetation Management Requirements
NR/L2/OTK/5201/03	Route Vegetation Management Plans
NR/L3/OTK/6202	Protecting railway assets during vegetation work
	Habitat Design and Management Guidance Note

Contents

1 Purpose

The lineside in urban areas includes a range of habitat types. Careful consideration of habitat design and effective management will contribute to safe and efficient rail operation and an increase in the natural-capital value of the lineside. This note provides guidance on:

a) Best practice habitat design and management for Central, Regional, and Route management teams showcasing what good urban habitat and biodiversity management looks like;

b) Why habitat management decisions are made in certain urban situations, including important considerations and implications;

c) Risks reduced by the application of this guidance note including, delays and unplanned costs from unforeseen/inadequately considered management and lineside constraints;

d) Benefits of the application of this guidance note including, enhanced biodiversity of the lineside, increased stakeholder confidence and improved performance relating to national biodiversity goals and the resilience of lineside habitat; and

e) Associated legislation and control documents that this document helps to achieve compliance with.

2 Scope

This guidance note applies to Network Rail, their supply chain and third parties working on Network Rail owned land. It shows how urban habitats within the lineside can be created and managed, supported by templates; habitat specifications; identification aids; toolbox talks; and case studies. It is also applicable to novel habitats outside of urban areas, for example brownfield, open-mosaic habitats that might develop on vacant land or within the lineside.

The guidance note complies with and supports the following documents:

a) Protecting railway assets during vegetation work (NR/L3/OTK/6202);

b) Biodiversity Standards (NR/L2/ENV/122);

c) Lineside Vegetation Management Standards (NR/L2/OTK/5201); and

d) Habitat Design and Management Guidance Note.

This guidance note informs:

a) The production of habitat management plans; and

b) The production of route vegetation management plans and sectional asset plans.

NOTE: *Habitat management plans are described in NR/L2/ENV/122 Module 02*

NOTE: *Route vegetation management plans and sectional asset plans are described in NR/L2/OTK/5201 Module 03.*

3 Definitions

Table 1 – Terms and definitions

Term	Definition
BAP Species	Biodiversity Action Plan (BAP) Priority species, is the former name given to species listed under Section 41 of the Natural Environment and Rural Communities Act (2006).
Bing	A heap, especially of metallic ore or of waste from a mine.
Biodiversity	Biodiversity is the variety and variability among all forms of life, including terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part.
Biodiversity Metric 2.0	A biodiversity metric devised by Natural England which assists with assessing measurable net gains in biodiversity by accounting for biodiversity losses and gains resulting from development or land management change.
Biodiversity Net Gain	An approach to development that leaves biodiversity in a better state than before, abbreviated in this document to BNG.
Bioremediation	Introducing plants, fungi or bacteria known to degrade target pollutants to an area of contaminated land.
Biosecurity	Procedures or measures designed to protect habitats and their populations of fungi, plants and animals against invasive non-native species, pests, disease or biochemical substances, which damage the health and condition of biodiversity and the environment.
Colonisation	Natural establishment of plant communities which start to form a habitat. Colonisation can occur from plants self-seeding by a variety of mechanisms e.g. wind or animal dispersed.
Circular economy	An economic system aimed at eliminating waste and promotes reusing, recycling to create a closed-loop system. In regard to the designing brownfield habitat across the lineside estate, this may mean using waste aggregate materials to create brownfield habitat.

Term	Definition
Edge habitats	The spaces between two different types of habitat. For example, the transition zone between a woodland and grassland habitat is an edge habitat.
Garden escapees	A plant(s), typically non-native, found growing outside a garden or other area where it was originally cultivated.
Green Infrastructure	A network of multi-functional green space, urban and rural, which is capable of delivering a wide range of environmental and quality of life benefits for local communities.
Habitat condition	The ecological condition of a particular habitat parcel. Condition relates to the value to biodiversity a particular habitat parcel provides relative to other parcels of the same habitat type. Habitat condition relates to Natural England's Biodiversity Metric's habitat condition scores which range from 'Poor' to 'Good' (Natural England 2019a and 2019b). Urban habitats will vary in their ecological condition. Factors that affect the condition of a habitat include human disturbance and presence of invasive non-native species (INNS).
Habitat value	A habitat's value is its relative importance in sustaining socially or ecologically significant wildlife populations and biodiversity.
Habitat mosaics	An area comprised of multiple habitat types.
Higher successional vegetation community	A community of plants comprising woody species such as shrubs and trees.
INNS	Invasive non-native species (INNS). Species which have been introduced into areas outside their natural range through human actions and are posing a threat to native wildlife.
Lineside	The extensive area of land that falls within the Network Rail ownership boundary.
Natural capital	The world's stocks of natural assets. These include geology, soil, air, water and all living things. From this natural capital, people derive a wide range of services, (ecosystem services), such as food production.

Term	Definition
Nature-based Solutions	The sustainable management and use of nature for tackling socio-environmental challenges whilst providing human well-being and biodiversity benefits.
Preferred Habitat Objective	The broad process which will enable an existing habitat to be modified into the preferred habitat type. Habitat Objectives related to one of the following processes: Transform, Conserve, Restore and Enhance. This is in relation to the Habitat Management Plans (NR/L2/ENV/122 Module 2) only.
Red Data Book	Document which states rare and endangered species. Red Data Books on invertebrates are of particular relevance to brownfield habitat.
Resilience	The ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change.
Semi-natural	Habitats that have been modified by human activities. Most of the UK's naturally occurring habitats are regarded as semi-natural.
Statutory Nature Conservation Organisation (SNCO)	The SNCO for England, Wales and Scotland are as follows: England: Natural England Scotland: NatureScot Wales: Natural Resources Wales
SINC / SNCI	Site of Importance for Nature Conservation / Site of Nature Conservation Interest; non-statutory, local habitat designations, defined by local planning authorities.
UK Habitat Classification	A system for classify habitats within the UK, devised by the UK Habitat Working Group. UK Habitat Classification is the classification system used within Natural England's Biodiversity Metric 2.0.
Whole ballast	Railway ballast which has not been broken down into finer pieces.

4 Introduction

This document provides guidance on habitats which are associated with urban areas and habitats on previously developed or industrial land in urban and rural areas. This document is split into two parts:

- **Urban habitats:** Sections 1 and 2 focus on illustrating what habitats in the urban context could look like on the lineside and provide guidance on how biodiversity can be enhanced; and
- **Brownfield habitats:** Sections 3 to 7 focus on brownfield classification, habitat and design, brownfield establishment, long-term management and restoration.

4.1 Urban (UK Habitat classification code – U)

In accordance with the UK Habitat Classification, urban habitats are defined as constructed, industrial and other artificial habitat.

This broad habitat type includes brownfield habitat but does not include urban variations of habitats such as grassland, woodland, heathland and shrub, and wetland. Definitions of these habitats and associated best practice are provided within the respective Design and Management Guidance Notes for each broad habitat type.

4.2 Document structure

This document provides guidance on the following:

1. Urban habitat classification – how to identify and classify habitats in the urban context to help apply best practice establishment and management guidance;
2. Urban habitat considerations – guidance and key considerations for the design and management of lineside habitats (e.g. grassland, heathland and shrub, wetland or woodland) in the urban context; this includes site functions, planting specification and protection;
3. Brownfield habitat classification - how to identify and classify brownfield habitats to help apply best practice establishment and management guidance. Brownfield habitats are also classified into priority and non-priority habitat;
4. Brownfield habitat and design – guidance and key considerations for the design of brownfield habitat within the lineside; this includes site selection, use of aggregate substrates and plant specification;
5. Brownfield habitat creation and establishment – guidance and key considerations on how to successfully create and establish new brownfield habitat in the lineside to maximise its biodiversity and the ecosystem services it supports;
6. Long-term management of brownfield habitat – guidance, key considerations and best practice management techniques to enhance established brownfield habitat; and
7. Brownfield habitat restoration – guidance on restoring brownfield habitat which has transitioned to a higher successional vegetation community (e.g. to dense shrub).

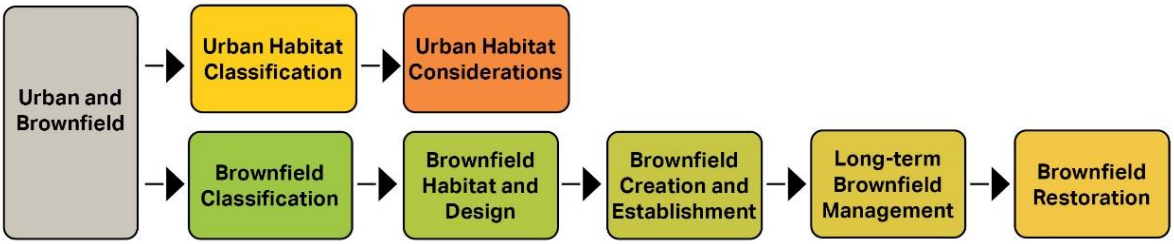


Figure 1 – Urban and brownfield design and management guidance process

NOTE: *Case studies are included in section 7 to illustrate examples of best practice in the delivery of preferred habitat objectives.*

4.3 Document hierarchy

Figure 2 shows the relationship hierarchy of the Urban and Brownfield Design and Management Guidance Note and other Level 2 standards and Level 3 Network Rail guidance notes, manuals and modules.

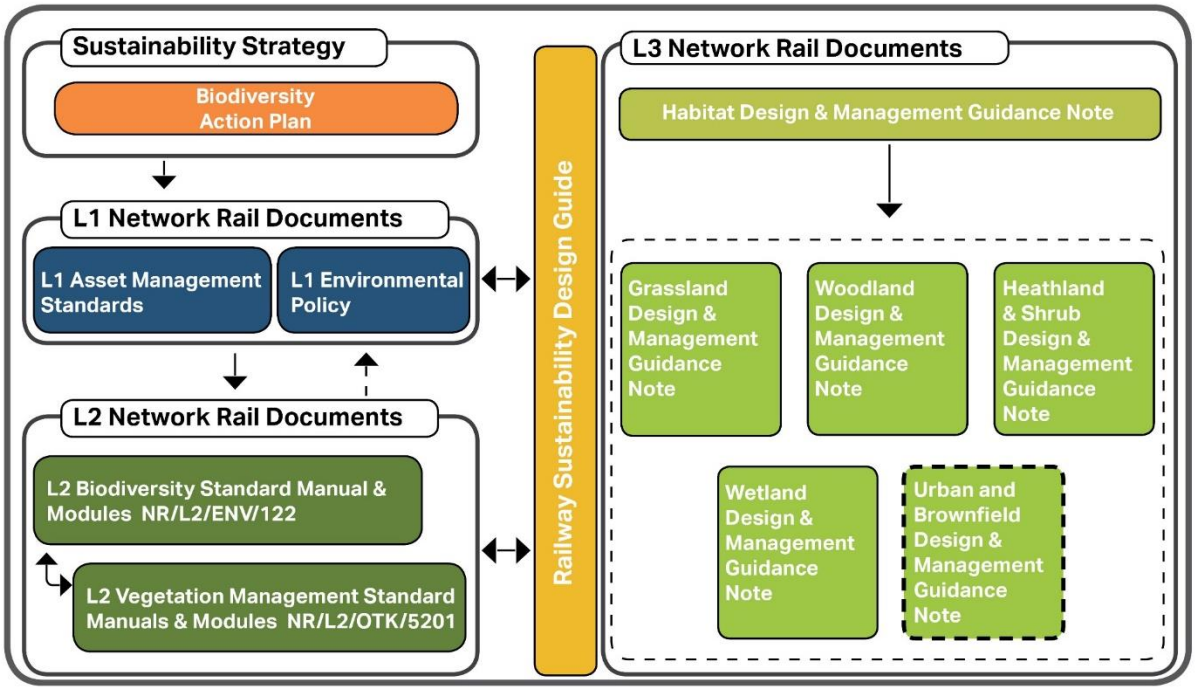


Figure 2 – Document hierarchy

5 Urban habitat classification

Urban Habitat Classification | **Urban Habitat Considerations**

5.1 Introduction

Network Rail has adopted the UK Habitat Classification to describe the habitats within the lineside. These are set out and described in the Habitat Design and Management Guidance Note, which defines five primary habitat types (UK Habitat Classification Level 2) according to which all land within the lineside should be classified:

- Grassland;
- Woodland;
- Heathland and Shrub;
- Wetland; and
- Urban.

***NOTE**: UK Habitat Classification documents are available at:*
https://ecountability.co.uk/ukhabworkinggroup-ukhab/

5.1.1 Definition

Urban habitats are defined in the UK Habitat Classification as constructed, industrial and other artificial habitat. Whilst this is relevant to brownfield (see Sections 7, 8 and 9) this guidance note also covers urban variations of semi-natural habitats (see Section 6), such as woodland.

Figure 3 – Typical urban lineside woodland habitat

5.1.2 Attributes

- Typically found along railway corridors in towns and cities, although spoil heaps, edges of the cess and vacant land in rural settings, if colonised by vegetation can provide urban habitat;
- Includes vegetation, e.g. ruderals or shrub, established on ballast and hard surfaces or growing on disturbed, modified or manufactured soil;
- On disturbed sites, where substrate structure varies, Open Mosaic Habitats can form, which can be of high value to invertebrates, birds, amphibians, reptiles and small mammals;
- Existing structures in urban areas can provide opportunities for wildlife habitats e.g. culverts, tunnels and arches of viaducts; and
- Artificial structures in urban areas can mimic habitats for wildlife e.g. living walls or artificially created open mosaic habitats.

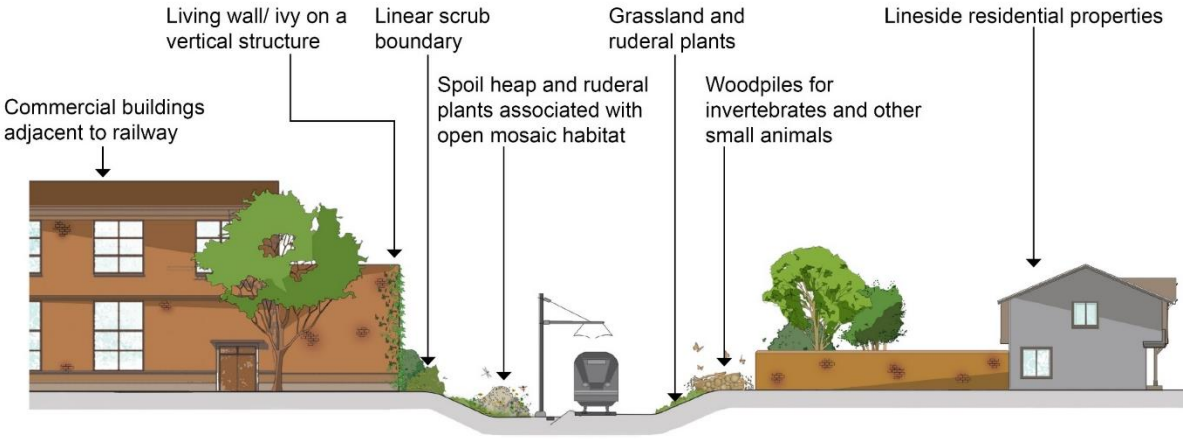


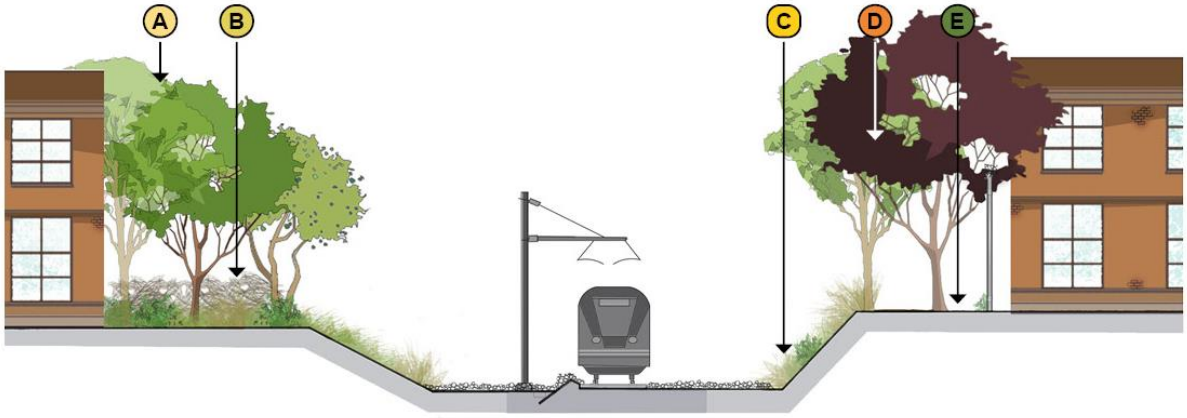
Figure 4 – Examples of typical urban lineside habitats

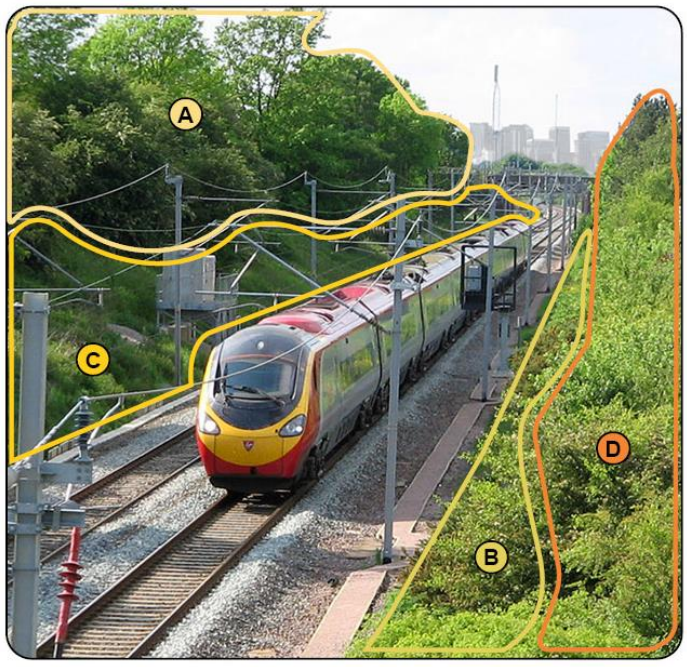
The following information should be used to further classify habitats in the urban context into sub-types (UK Habitat Classification, 2018):

5.1.3 W1: Woodland

Urban woodlands may have less ground flora and understorey vegetation, or may be more likely to be dominated by undesirable species, compared with woodlands in the rural context. Non-native trees, shrubs and ornamental plants can be common.

Figure 5 provides examples of lineside woodland within an urban context.





A Urban woodland canopy

Mix of native and non-native trees of benefit to biodiversity.

B Dense understorey

Understorey growth of urban woodlands is typically not well defined and dominated by species adapted to disturbance e.g. bramble or common nettle.

C Woodland edge

Tree growth within the first 7m of the lineside should be avoided for operational reasons. Scrub and grassland are likely to develop creating woodland edge habitat.

D Narrow woodland

Urban lineside can be extremely narrow. Many woodlands may be at most a few trees wide.

E Absent understorey

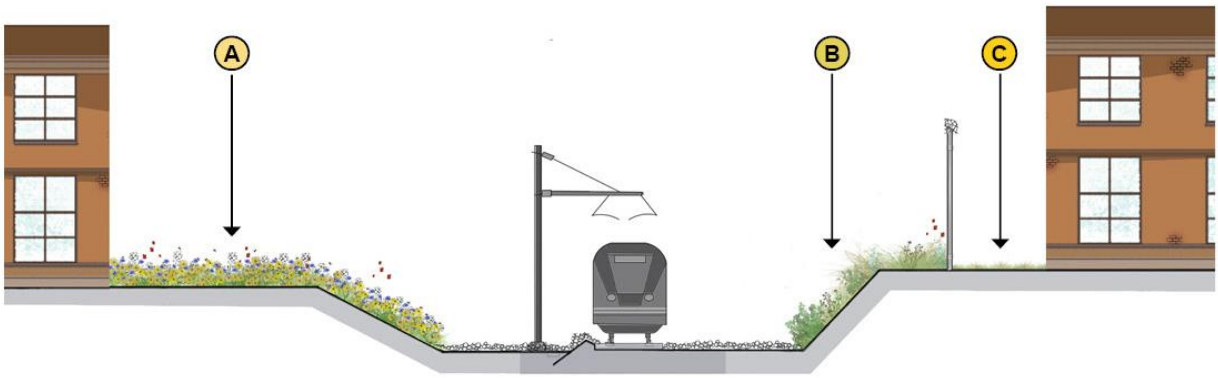
Excessive disturbance can lead to little ground flora or shrub establishing.

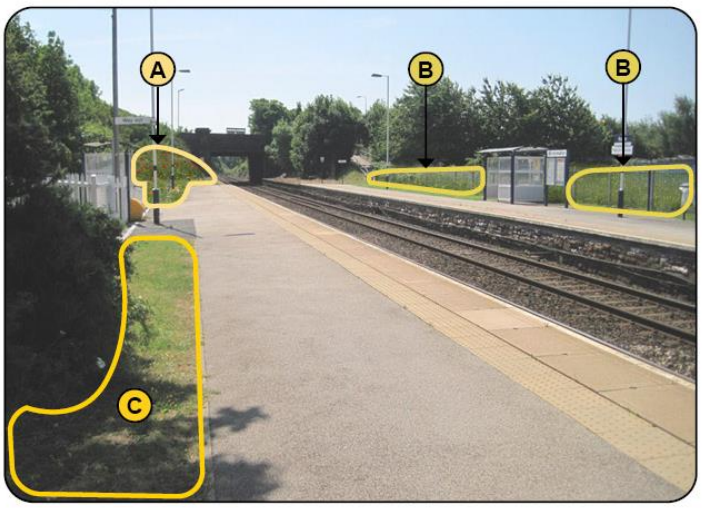
Figure 5 – Example of typical lineside urban woodland

5.1.4 G1: Grassland

The plant communities of urban grasslands tend to be unique, due to the environmental conditions provided by urban areas. In urban areas, grasslands can comprise a mix of native and non-native species. Non-native species may naturally colonise from adjacent parks and gardens. Some offer biodiversity value by providing nectar and pollen for urban invertebrates.

Figure 6 illustrates different types of grassland typically found within urban areas.





A Urban wildflower meadow

Whilst resembling semi-natural grasslands, urban wildflower meadows comprise colourful native and non-native annual and perennial flowering herbs and provide visually appealing habitat whilst benefitting urban wildlife.

B Semi-natural grassland

Typically not as species rich as the best rural grasslands. May comprise some garden escapees.

C Amenity grassland

Typically found in public facing areas and around stations. Short, frequently cut grassland used for recreation and amenity purposes.

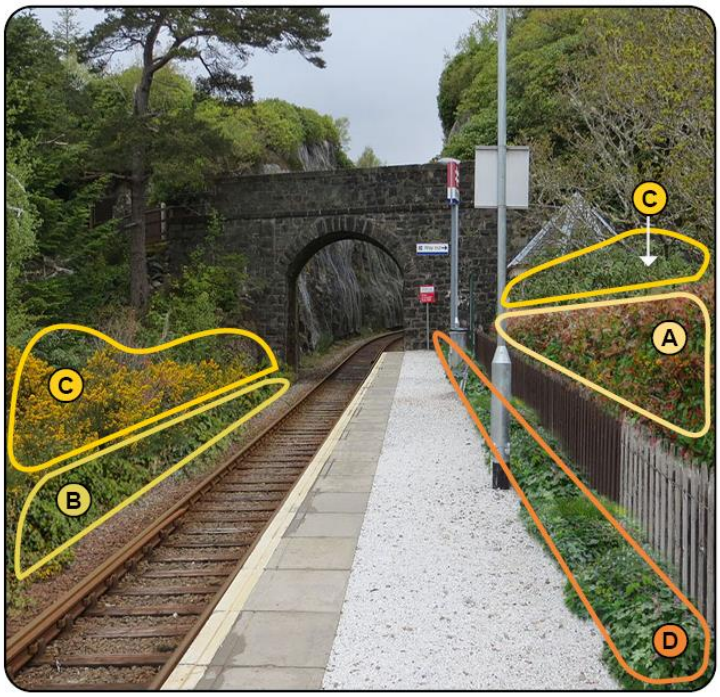
Figure 6 – Example of typical lineside urban grassland

5.1.5 H1: Heathland and shrub

Heathlands are extremely rare in urban settings, but pockets can remain.

Shrub and hedgerows occur frequently in urban areas, forming boundaries or for screening purposes. They typically comprise a mix of native and non-native species.

Figure 7 provides examples of urban shrubs and hedgerows.



A Ornamental hedgerow

A boundary feature comprising few ornamental species with little biodiversity value. Can be enhanced by introducing multiple shrub species of benefit to pollinators.

B Low growing shrub

Low growing shrub can dominate disturbed areas. Managing such habitat frequently will enable other species to establish.

C Tall shrub

May comprise native and non-native species and provides useful screening.

D Shrub structure

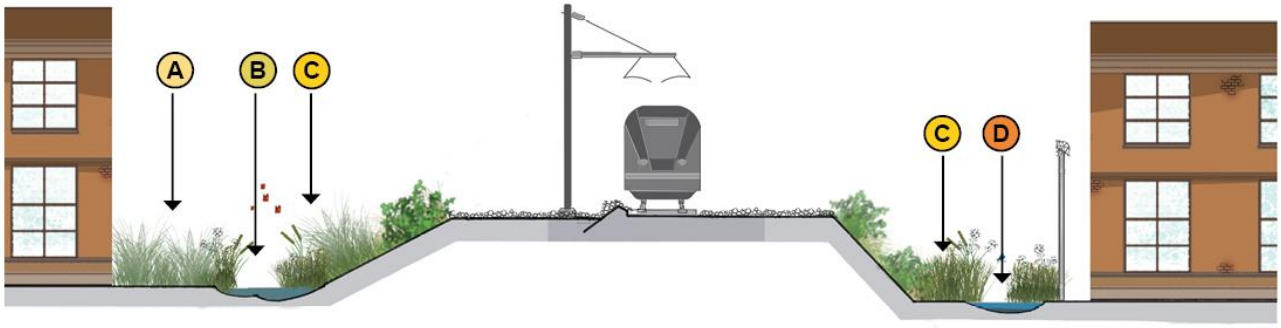
Landscaped areas, such as those near stations, are typically designed to mimic the structure of natural shrub habitats, with shrubs lines adjacent to herbaceous perennials and grasses.

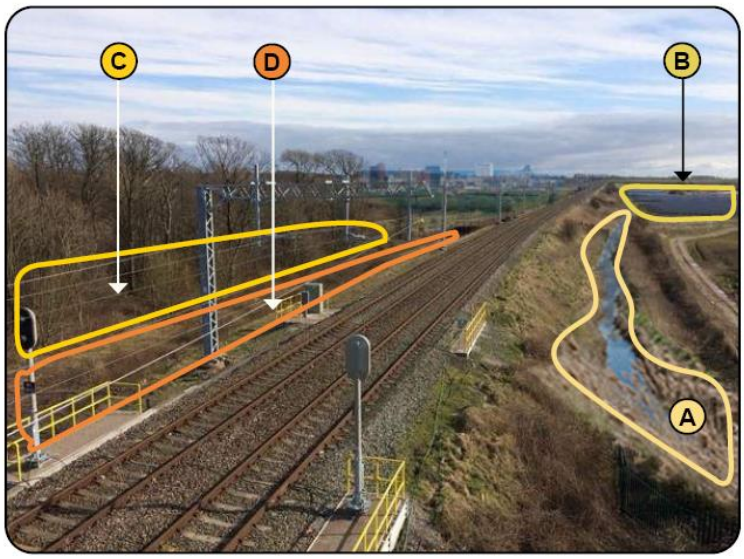
Figure 7 – Example of typical lineside urban shrub

5.1.6 F1: Wetland

The lineside can include or intersect wetland including artificial waterbodies such as balancing ponds, reservoirs and canals. The majority of urban wetlands comprise ditches, sparse reed beds and willow thickets on damp ground. Waterbodies may be present but may be seasonally dry and difficult to identify. Plant species such as common reed (*Phragmites australis*) and white willow (*Salix alba)* may indicate the presence or appropriateness for wetland in the absence of water.

Figure 8 provides examples of urban wetlands.





A Sparse reed bed

Reed beds may be less well defined and form a mosaic with scrub or grassland.

B Urban water bodies

May be artificial or form part of a sustainable drainage system.

C Wetland scrub

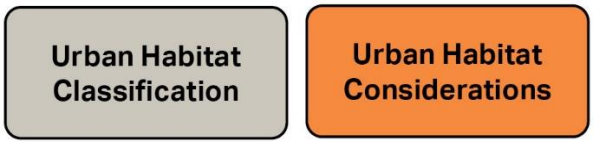
Patches of willow or alder are likely to fringe waterbodies or be present on damper soils.

D Seasonally wet ditch

Due to drier conditions, ditches may stay dry. Damp soils allow for wetland vegetation e.g. reed and willow, to establish.

Figure 8 – Example of typical lineside urban wetland

6 Urban Habitat Considerations



6.1 Introduction

Urban landscapes differ from rural landscapes for several reasons e.g. climate, habitat connectivity and the proximity of the lineside estate to housing and public spaces.

This section provides guidance on:

- General considerations related to the design and management of woodland, grassland, shrub and hedgerows and wetland habitats within an urban context;
- The design of new habitats in the urban context;
- Maintenance required to establish new habitats in the urban context; and
- Opportunities to enhance biodiversity within the urban lineside estate.

This section provides variations to best practice guidance on design, establishment and management. The respective Habitat Design and Management Guidance notes should be referred to for best practice guidance of woodland, grassland, shrub and hedgerow, and wetland habitats.

6.2 Function

When deciding which are the most appropriate habitats for the urban context, biodiversity may not be the sole focus. The different functions and ecosystem services that urban habitats provide should therefore be balanced according to local requirements on a case-by-case basis. For example, woodland or shrub may need to be structurally designed to screen the railway from lineside residents whilst also maximising biodiversity. Figure 9 illustrates the different functions that can influence the overall site function.

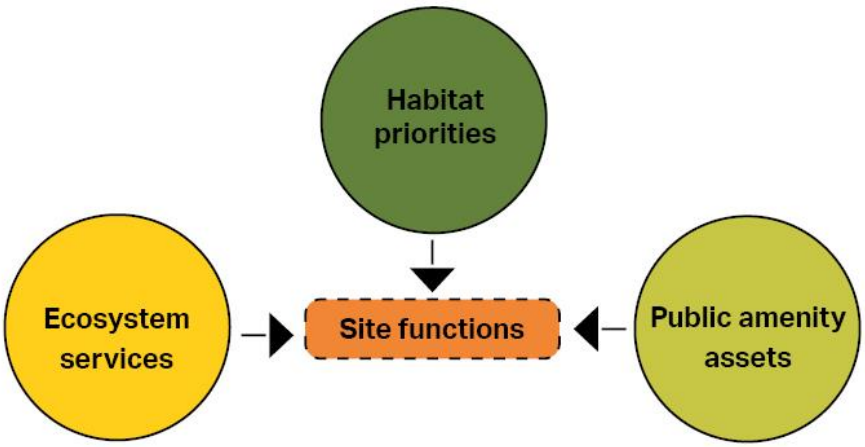


Figure 9 – Key site functions

6.2.1 Establish habitat priorities

Habitat surveys should identify habitats present on site, their condition and any species requiring protection. The protection of these species should be prioritised when considering management interventions.

***NOTE**: Refer to the habitat specific Design and Management Guidance Notes for detailed guidance on habitat surveys.*

6.2.2 Ecosystem services

Habitats in the urban context provide a wide range of ecosystem services which are likely to directly benefit a greater number of people.

Key ecosystem services which may influence the design and management of urban habitats include urban cooling, reducing air pollution, health and wellbeing, screening (noise / visual), recreation, aesthetics and pollination.

6.2.3 Local community benefits and stakeholder engagement

Community engagement in urban areas is important due to the typically large number of people living in close proximity to the lineside or using public spaces adjacent to the railway. The local community should be engaged from an early stage in the objectives of habitat management interventions. Involving the local community, where possible, with urban habitat design can result in a greater appreciation of long-term habitat management. This will help maximise the benefits that a habitat can deliver to the community and encourage, where appropriate, community stewardship of non-rail green spaces. For example, giving people responsibility of green spaces typically leads to them being looked after better.

6.2.4 Prioritisation

Relative to rural habitats, poorer habitat quality in an urban environment may be considered important due its rarity and valuable contribution to local biodiversity. Often urban habitats are considered within the planning process, meaning any land use changes must be considered carefully e.g. non-statutory designated sites, such as Sites of Importance for Nature Conservation (SINCs). These designations can influence how the habitats are managed.

Connecting disparate patches of habitat can increase biodiversity value as part of a wider network of habitats.

***NOTE**: Refer to the Preliminary Ecological Appraisal Report (PEAR) or contact the Local Ecological Record Centre (LERC) to establish whether the site has SINC status and restrictions on habitat management. LERC's typically undertake background data searches which highlight the locations of any designated sites. This task should be undertaken by a suitably qualified ecologist.*

6.3 Design considerations

Designing habitats in urban areas may have to consider different site issues in comparison with rural habitats, most notably in relation to access, security and local community benefits. Figure 10 illustrates some typical issues encountered in the urban lineside context.

A **Hazardous/contaminated materials**

If assessed and not deemed to be a saftey constraint, leftover spoil or spare aggregate may present an opportunity to create brownfield habitat.

B **Fly tipping**

Lineside spaces are sometimes seen as waste grounds which encourage fly tipping and littering.

C **Trespass**

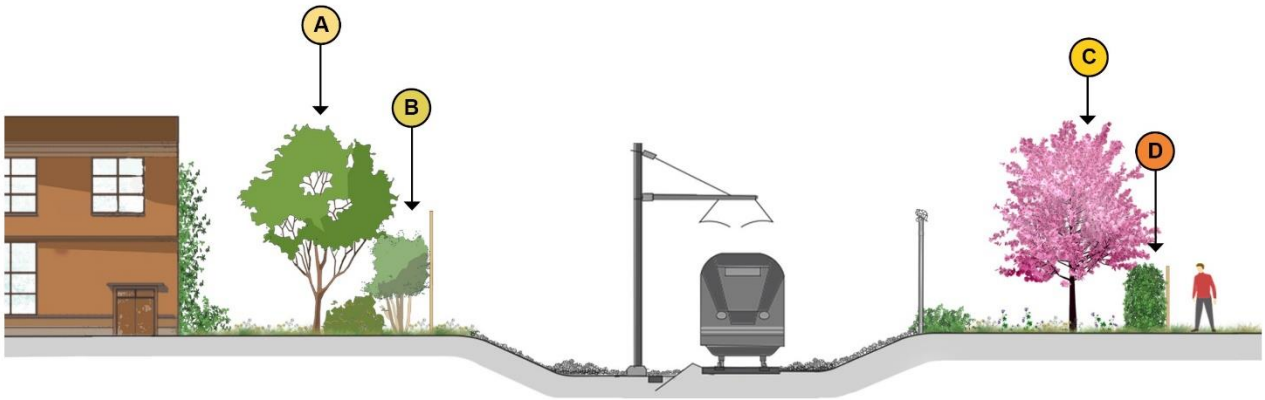
Trespassing can lead to operational delays and safety issues.

D **Abandoned vehicles**

Abandoned and burnt out cars can lead to operational delays and safety issues.

Figure 10 –Example of typical urban lineside issues

Figure 11 illustrates a series of best practice examples of how, well considered design features, can address some site issues that occur due to the urban context of the habitat.



A **Tree planting as screening**

Planting appropriate tree/tall shrub species can help screen detracting elements of the railway and reduce the perception of noise and pollution.

B **Thorny shrubs as deterrent**

Thorny shrubs such as hawthorn or gorse can create barriers to access.

C **Visual amenity**

Vibrant flowering and fruiting trees, shrubs and grasslands contribute to visual amenity. Visually appealing areas are more likely to be respected.

D **Vegetation restricting access**

Hedgerows and lower growing shrub can be used as barriers in locations where antisocial behaviour is less of a problem.

Figure 11 –Example of best practice lineside design solution

6.4 Management considerations

Management of urban habitats may differ to rural habitats due to the multiple functions they perform. Table 2 provides considerations which may be pertinent to habitat management in urban areas.

Table 2 - Alternative habitat management considerations within urban areas

Issues	Alternative habitat management considerations
Tree coppicing removes screening	• Where coppicing, pollarding or tree felling would normally remove a vegetation screen between a residential area or public space with the railway, the chevron cutting technique should be used.
Management undertaken at night or in close proximity to residents	• Use hand tools or battery powered machinery instead of large, noisy machinery. • Work at reduced hours to limit noise especially at anti-social times (early morning and evening).
Potential for hazards such as discarded needles	• Undertake appropriate risk assessment prior to site works and carryout management tasks with required Personal Protective Equipment (PPE).

6.5 Planting specification

Planting specifications in an urban context may vary in the following ways:

1. **Planting non-native species**: whilst native species are preferred, there are occasions where non-native species can be considered.
    - Non-native plant species can be found frequently growing wild within urban habitats, often as garden escapees which are adapted to grow under the stressful conditions present within urban areas.
    - Providing the species is not considered invasive, many non-native plants contribute to the biodiversity and ecosystem services in urban areas.
    - In some circumstances, planting non-native species may be preferable, especially if the species is resilient to drought, climate change and / or biodiversity, Figure 12 provides some examples.
    - Non-native species can be used in the design of planting specification to provide nectar and pollen sources all year round.

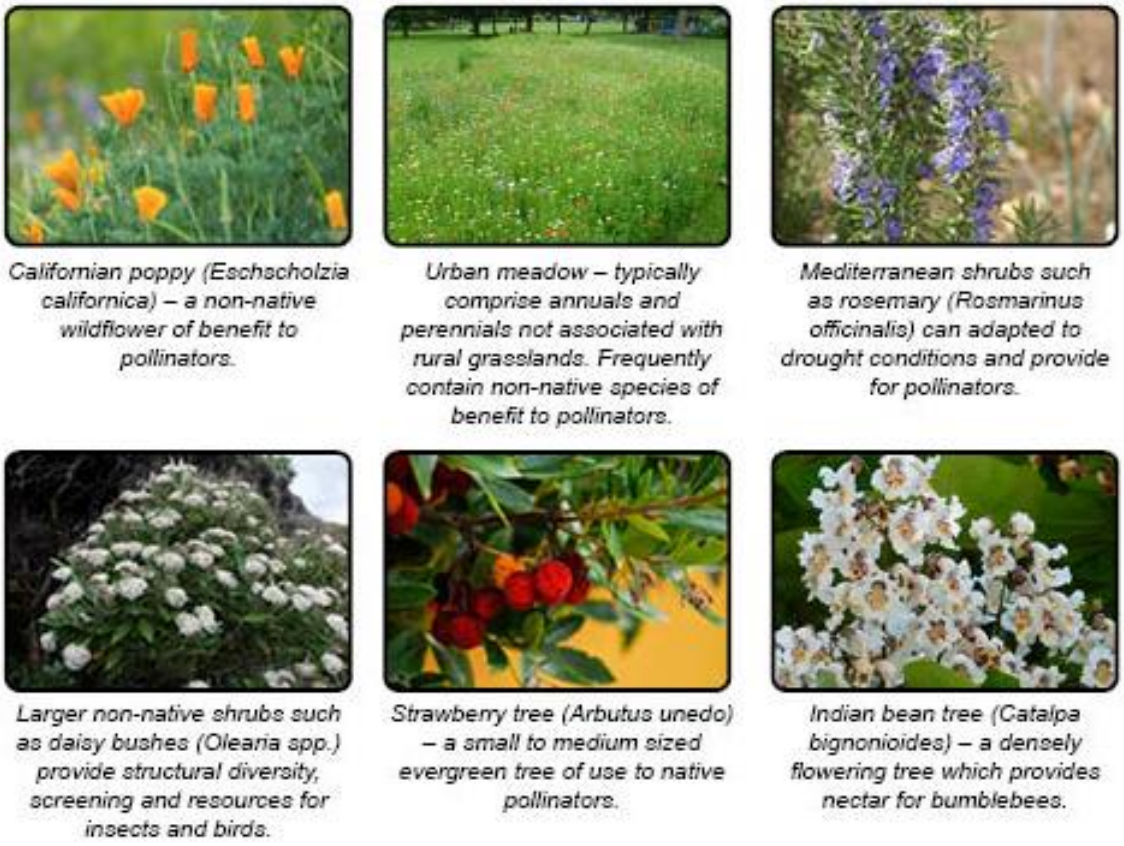


Figure 12 – Examples of non-native species of benefit to biodiversity which can be used within urban habitat

NOTE: *When sourcing seed, consider including species of benefit to pollinating insects. Royal Horticultural Society lists appropriate 'Plants for Pollinators' including native and non-native species: https://www.rhs.org.uk/science/conservation-biodiversity/wildlife/plants-for-pollinators*

NOTE: *Species listed under Schedule 9 of the Wildlife and Countryside Act 1981, by the GB Non-Native Species Secretariat and London Invasive Species Initiative (LISI) should not be considered.*

2. **Establishment:** establishment of plants within urban areas can be difficult due to the increased level of stress i.e. hotter and drier.
    - Considering using pre-established or more mature forms of plants, to avoid the need for frequent monitoring during the establishment period.
    - Grasslands could be plug planted or hydroseeded instead of hand sowing.
    - Avoid planting immature whips when planting shrub, hedgerow and tree species.
    - Avoid using plastic tree and shrub guards. Instead opt for a biodegradable alternative, which break down naturally over time.
3. **Size and density:** consider the potential impact of the size and density of shrub and trees specified on the railway and neighbouring land. Whilst this could lead to positive outcomes, there are also potential negative consequences:
    - Positive outcomes: tall, dense trees, such as cypresses can provide dense screening of the railway from public areas, and private land and gardens.

- Negative consequences: large or dense woody species can create excessive shade, leaf and fruit litter which could be negatively perceived by lineside neighbours.

4. **Bulb planting:** bulbs can be included to provide a source of nectar during early spring.
    - Native and naturalised species to consider include winter aconite (*Eranthis hyemalis*), Snowdrops (*Galanthus nivalis*) and Crocuses (*Crocus spp*.)
    - Bulbs should be planted according to the species' habitat requirements. For example, Snake's head fritillary (*Fritillaria meleagris*) is a bulb species which requires damp soils to successfully establish.
5. **Restricting access:** in lineside areas where trespassing is an issue, planting thorny or dense woody species may be desirable (See Figure 11)
6. **Visual amenity:** in public facing areas visual amenity may be an important consideration. Wildflower meadows, vibrant flowering and fruiting species should be considered for planting.

7 Brownfield Habitat Classification

7.1 Introduction

Derelict and vacant land can support brownfield habitat. For example, where previously developed land is left derelict, construction materials and substrates break down over time, allowing plants to establish and wildlife to colonise.

Whilst brownfield land may look untidy it can be of high value for biodiversity.

For example, Canvey Wick, see Figure 13, is a former industrial dredging site in Essex. It became the first brownfield site to be classified as a SSSI, as it has become one of the most important sites in the UK for invertebrates (Buglife, 2020). In the 1970's several metres of silt, sand and gravel, dredged from the Thames was left across the site, creating nutrient poor habitat for diverse plant communities and invertebrates to establish.

Canvey Wick, Canvey Island, Essex

Canvey Wick is a SSSI and nature reserve situated adjacent to the sea wall of Canvey Island in Essex. Open mosaic habitat, comprised of hardstanding areas, dense scrub, woodland, ruderal plants, and small wetland features, cover the disused oil refinery site that was once used to dump dredged waste on. The dredged waste, containing sand, gravel, chalk, and shells allows for varied topography, which supports diverse plant communities of different development phases which are of significance for invertebrate species.

Figure 13 – Canvey Wick as an example of a brownfield site with high biodiversity value

NOTE: *For more detail refer to the accompanying Canvey Wick case study*

Three types of brownfield habitats are outlined below which represent either different stages of brownfield succession, or a form of brownfield priority habitat. Throughout this document, 'brownfield' is used as an umbrella term for the habitats outlined within this section.

NOTE: *Identification of brownfield habitats (e.g. Open Mosaic Habitat on Previously Developed Land) is not a simple process. Expertise should be sought from a professional Ecologist or Botanist to classify the habitat.*

7.1.1 Classifying brownfield habitat

Brownfield is defined as previously developed land that is currently not in use. Such land can develop to support novel or unique assemblages of plant species, that have adapted to thrive in such conditions.

Brownfield habitats commonly form mosaics and may include grassland, scrubland and ruderal communities. Whilst these habitats are more commonly found in urban areas, they can also be found in rural locations. For example, where vacant land and disused spoil heaps are found adjacent to the lineside, such as old sidings or stabling yards.

A large proportion of the lineside is comprised of aggregates, such as ballast. Where such materials have accumulated beyond the operational area, these areas offer opportunities to enhance biodiversity with appropriate management.

The following definitions are drawn from the UK Habitat Classification. One of these represents a secondary code, normally used in conjunction with a UK Habitat Classification habitat category and are not typically used to solely define a habitat. However, this has been included for the purpose of defining a range of brownfield habitats which differ in size and plant communities.

U1a: Open Mosaic Habitats on previously developed land – Priority (Level 4)

Definition

Open Mosaic Habitat on previously developed land (OMH) has UK BAP priority habitat status as it can support a large diversity of invertebrates, including Red Data Book and BAP species.

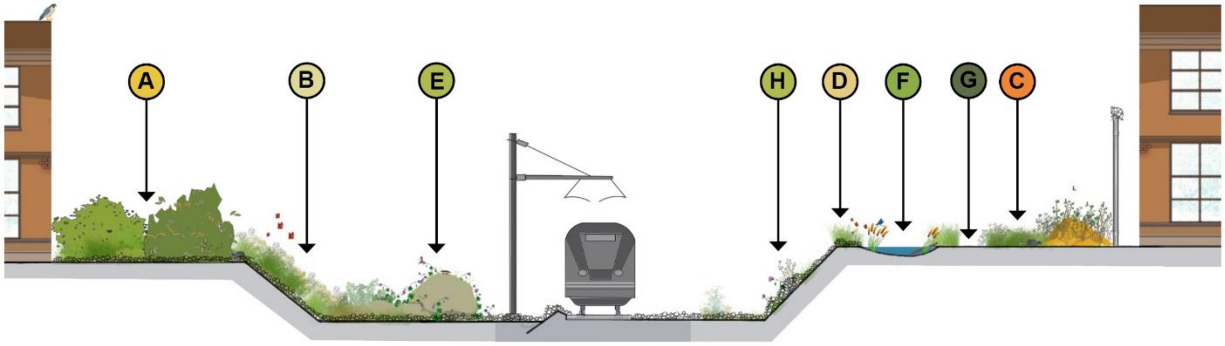
For a habitat to be classified as Open Mosaic on previously developed land (OMH), all of the following five criteria must be met:

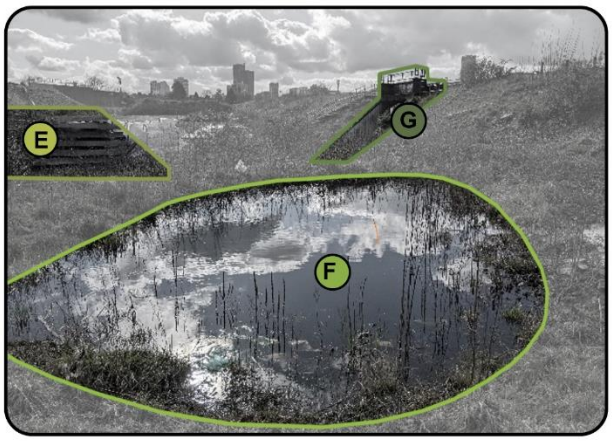
1. Open mosaic habitat at least 0.25 ha in size.
2. Known history of disturbance or evidence that soil has been removed or severely modified by previous use(s). Extraneous materials/substrates such as industrial spoil may have been added.
3. Site contains some vegetation. This will comprise early successional communities consisting mainly of stress-tolerant species (e.g. indicative of low nutrient status or drought). Early successional communities are composed of (a) annuals, or (b) mosses/liverworts, or (c) lichens, or (d) ruderals, or (e) inundation species, or (f) open grassland, or (g) flower-rich grassland, or (h) heathland.
4. Contains unvegetated, loose bare substrate and pools may be present.
5. The site shows spatial variation, forming a mosaic of one or more of early successional communities (a)–(h) above (criterion 3) plus bare substrate, within 0.25 ha.

7.1.2 Attributes

- Distinct from other brownfield habitats due to its consideration as a UK BAP Priority Habitat;
- Open Mosaic Habitat (OMH) is typically found in urban and former industrial areas across a diverse range of sites where historic human disturbance is evident. This includes railway sidings, quarries, former industrial works and houses, slag heaps, bings (a heap of mine waste or metallic ore) and brick pits;
- Open Mosaic sites are characterised by a patchwork of habitats shaped by the past land uses. They can comprise a mix of ruderal, shrub, grassland, hardstanding, bare ground, wet depressions and other habitats. Mosaics of habitats provide fine-scale changes in hydrology, pH and topography, allowing a diverse range of habitats to develop alongside each other;
- Bare ground and broken aggregates are important features of OMH, as they provide breeding space for many invertebrates e.g. solitary bees and bumble bees; and
- OHM can support diverse invertebrate communities. For example, Whittlesey Brick Pits near Peterborough, a site of historic clay extraction, which has given rise to a mosaic of terrestrial and wetland habitats, is considered one of the most important sites in the UK for invertebrates (Buglife, 2020b).

NOTE: *The ArcGIS Open Dataset for OMH indicates sites which have already been classified as OMH Priority Habitat. See https://data.gov.uk/dataset/8509c11a-de20-42e8-9ce4-b47e0ba47481/open-mosaic-habitat-draft*





A Shrub

Dense foliage formed by bushes and seedling trees, plants tend to be 1-4m high.

B Ruderal

Plants which colonise disturbed land after pioneer species, e.g. Wild carrot (*Daucus carota*) or Common toadflax (*Linaria vulgaris*).

C Ephemeral/grassland

Short patchy plant associations typical of unmanaged areas. The vegetation can include mixture of low growing species (>25cm tall), such as Greater plantain (*Plantago major*) or Oxeye daisy (*Leucanthemum vulgare*), taller species such as Hedge mustard (*Sisymbrium officinale*) and a low abundance of Common nettle (*Urtica dioica*), Creeping thistle (*Cirsium arvense*) and Hogweed (*Heracleum sphondylium*).

D Pioneer plants on hardstanding

The first plants which colonise artificial surfaces e.g mosses and lichens.

E Unused building material

Left over industrial materials which provide a substrate for plants to grow in or on.

F Seasonal ephemeral pond

Water can collect in low lying areas and form water bodies which are a valuable habitat.

G Bare ground

Artificial surfaces, e.g. rubble or hardstanding, which are not colonised by plant species. Bare ground is important for invertebrates.

H Disused ballast colonised by scrub

Undisturbed railway ballast can provide a substrate for scrub species e.g. Brambles (*Rubus* spp.).

Figure 14 – Example of typical lineside OMH (priority habitat)

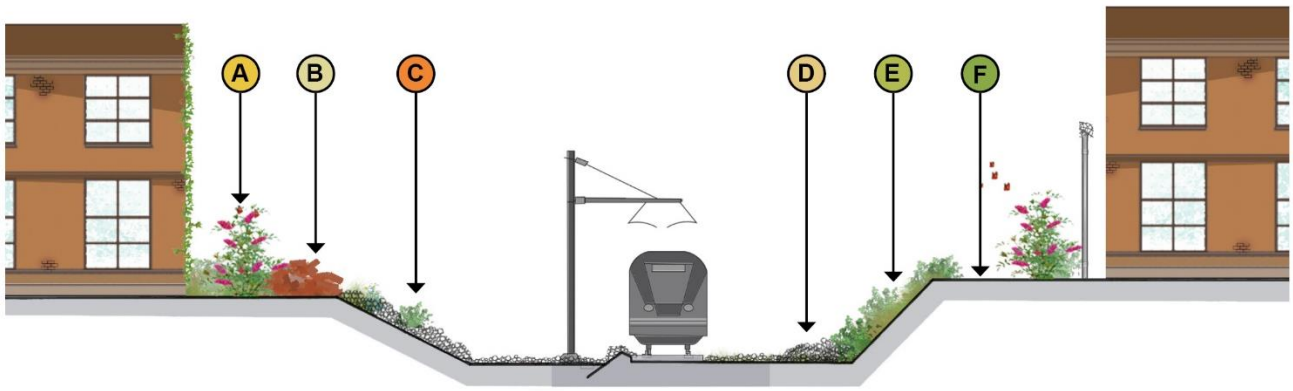
U - 350: Abandoned ruderal and derelict areas ('Brownfield Mosaic') (Secondary code)

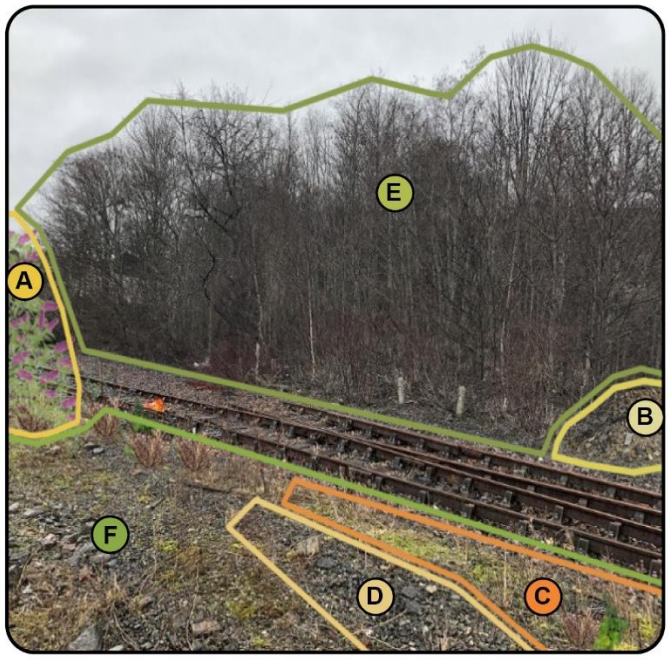
Definition

Previously developed land not currently in use which has been colonised by a variety of vegetation.

7.1.3 Attributes

- Brownfield mosaic, like OMH, is land which has a history of human activity. However, it does not meet all five of the OMH criteria;
- Typically defined as brownfield habitat, which is within the Establishing, Established or Mature Phase (see Sections 8.5 and 8.6);
- Brownfield mosaics may not have undergone significant disturbance and have less variety of habitats compared to OMH; and
- A brownfield site may still contain species important for biodiversity, despite not being recognised as an OMH.





A Presence of undesirable species

Species such as Butterfly-bush (*Buddleja davidii*) can suppress the growth of other plant species, reducing biodiversity.

B Exposed rubble mostly uncolonised

Rubble substrate has a few pioneer species growing on them.

C Pioneer plants establishing on ballast spill

Mosses, ruderal and ephemeral plants species are just starting to grow in the ballast.

D Ballast mostly uncolonised

Bare ballast more common than colonised ballast.

E Scrubland

Vegetation dominated by more or less closed canopy shrubs up to 5m in height.

F Little variation in topography

The site is predominantly flat.

Figure 15 – Example of typical lineside brownfield mosaic habitat (non-priority habitat)

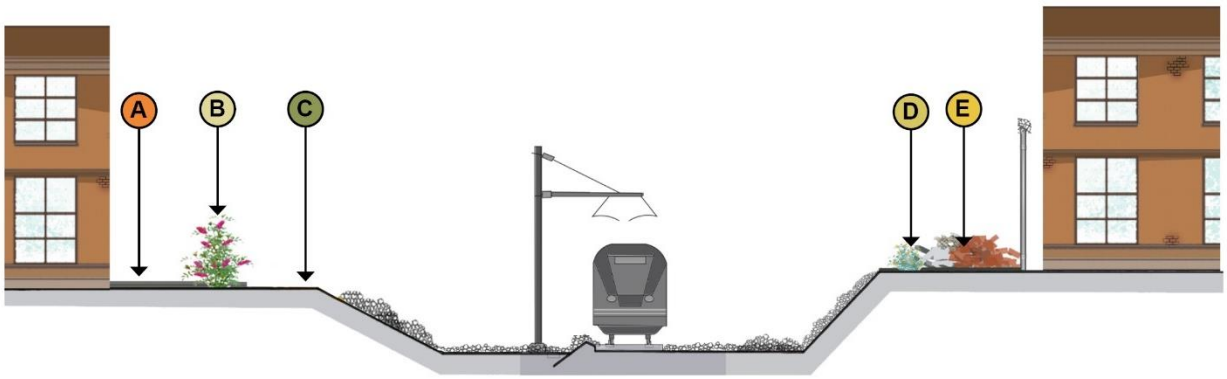
U - 351: Vacant/derelict land (Secondary code)

Definition

Land which has been disturbed by previous development or use but has no current land use.

7.1.4 Attributes

- Typically, brownfield habitat which is within the Pioneer Phase (see Section 8.5);
- Areas are made up of hard impervious material such as unbroken tarmac which prevents vegetation from growing. This means fewer niches for invertebrates are possible; and
- The habitat has very low biodiversity as few plants have successfully colonised it.



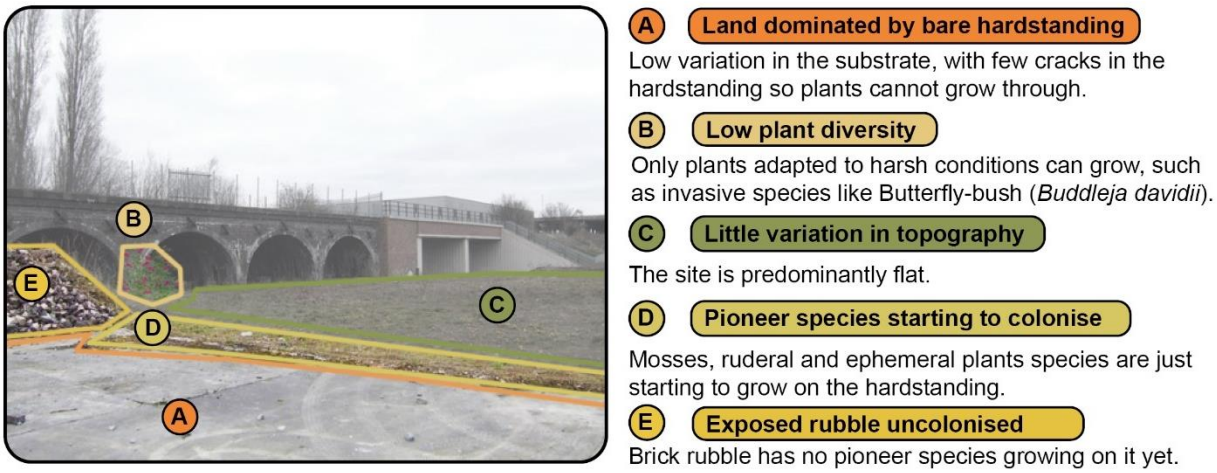


Figure 16 – Example of typical lineside vacant / derelict land

***NOTE**: Distinguishing the difference between Open Mosaic Habitat on Previously Developed Land and other brownfield habitats can be difficult. Seek advice from a suitably qualified Ecologist to confirm the correct classification.*

***NOTE**: It is important to check whether an urban habitat identified is a priority habitat, either nationally or locally, and whether it is present within a designated site or supports protected species, as this is likely to influence the Preferred Habitat Objective. This should be recorded as part of the habitat study.*

NOTE: *Refer to Habitat Design and Management Guidance Note for guidance on existing habitat surveys and site data information. This information should indicate whether a habitat is considered a priority habitat.*

NOTE: *Protected species licences may be required from the relevant Statutory Nature Conservation Organisation (SNCO). Refer the Habitat Design and Management Guidance Note for more information.*

Figure 17 illustrates the key differences between urban and brownfield habitats and can be used to aid identification of each brownfield habitat type. This highlights the differences between the brownfield priority habitat 'Open Mosaic Habitat on Previously Developed Land' (U1a), brownfield mosaic (U - 350) and vacant/derelict land (U – 351). Brownfield mosaic and vacant/derelict habitats can also be thought of as different transitional development phases of brownfield habitat (see Figure 17).

NOTE: *For detailed information on UK Habitat Classification habitats, use the UKHab Reference Guide (UKHab App)* *https://ukhab.org/*

NOTE: *Ellipse/GeoRINM utilises the Natural England's 'Open Mosaic Habitat' database. See* *https://data.gov.uk/dataset/8509c11a-de20-42e8-9ce4-b47e0ba47481/open-mosaic-habitat-draft*

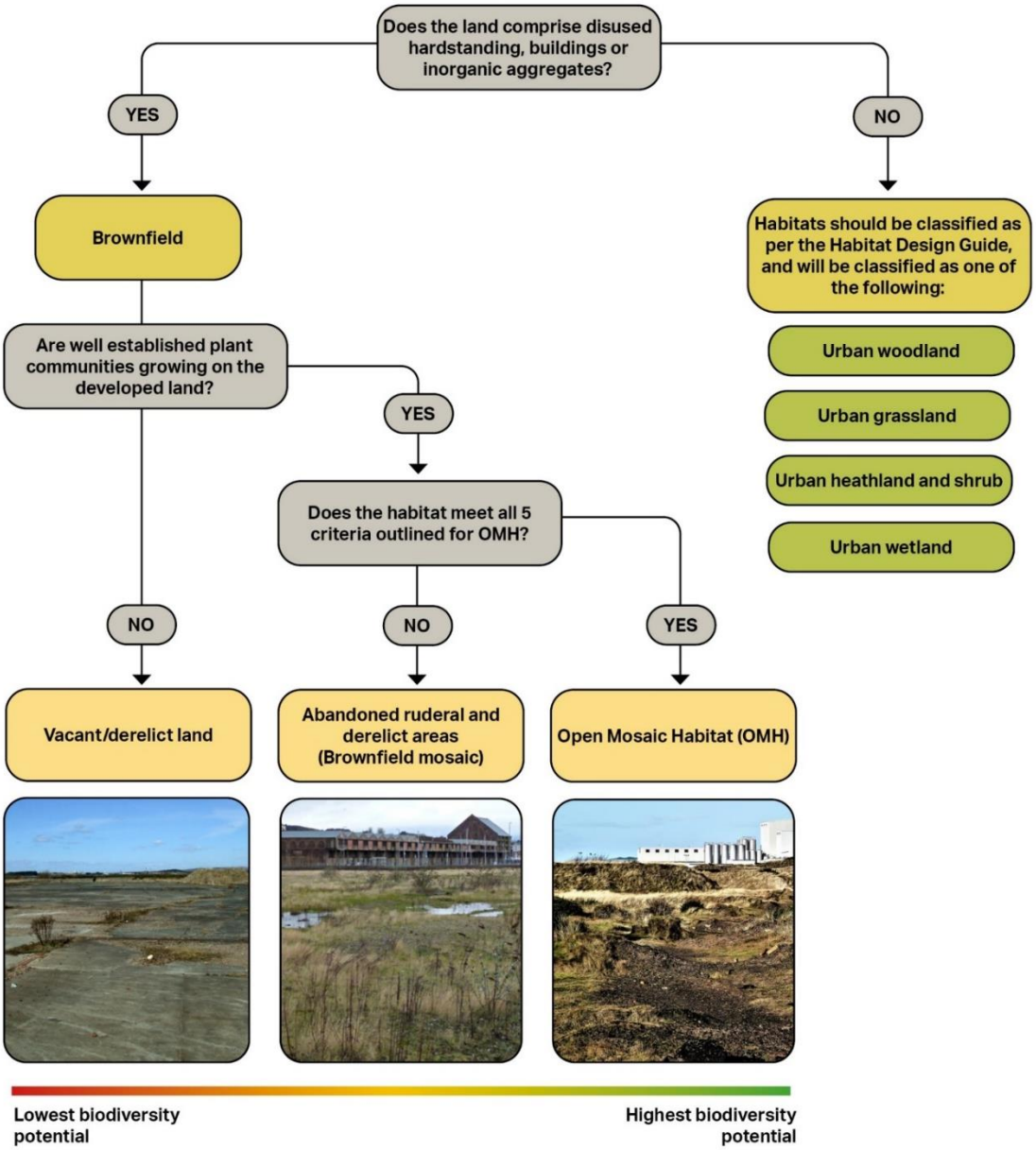


Figure 17 – Visual aid to assist in determining urban habitat types

7.2 Brownfield habitat development cycle

Figure 18 illustrates the development cycle of brownfield and OMH, which typically transitions over time.

A brownfield site which has a large variety of plant communities in different phases is likely to result in greatest biodiversity. It is important to note that natural succession of brownfield habitat is influenced by environmental conditions; e.g. certain aggregates or chemicals in the soil may prevent complete succession to the next successional phase.

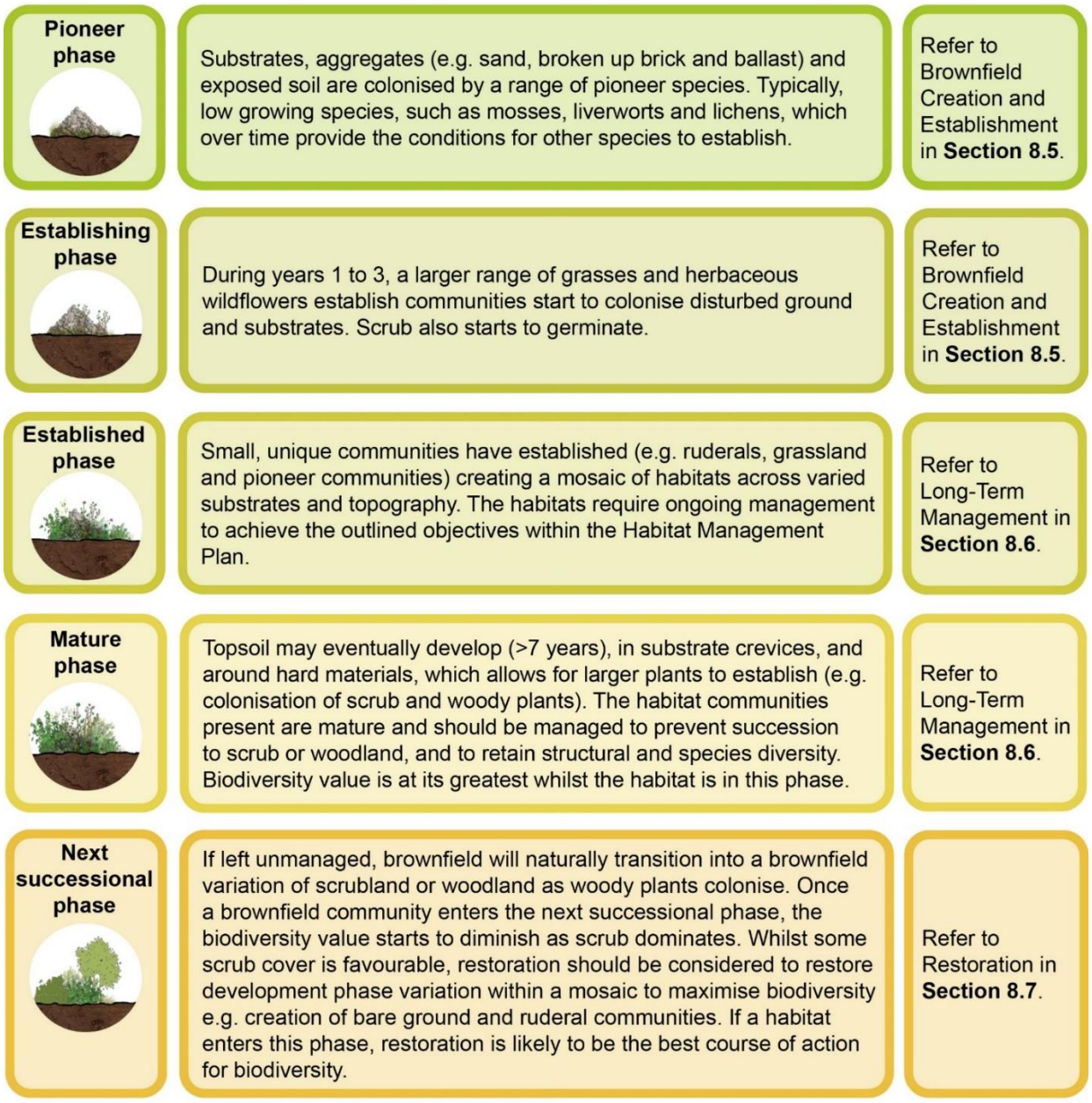


Figure 18 – Phases of brownfield habitat development cycle

NOTE: *Anticipated costs of different stages in brownfield habitat management are addressed in the cost summary folder.*

7.3 License requirements

This section details the legal requirements and need for licences if designated sites, protected species, or priority habitats are encountered within a site.

7.3.1 Statutory Designated sites

Sites of Special Scientific Interest (SSSI) are statutory designated sites protected under the Wildlife and Countryside Act (1981). Certain habitat management, such as tree felling within a SSSI will require consent from the relevant SNCO e.g. Natural England, NatureScot or Natural Resources Wales.

Brownfield habitat situated within Special Protection Areas (SPA), Special Areas of Conservation (SAC) and designated Ramsar Sites may also need assessment under UK habitat regulations before proceeding with works.

7.3.2 Protected species

Many species are protected under UK and European law. Protected animals under Schedule 5 of the Wildlife and Countryside Act most associated with brownfield sites include bats, reptiles (slow worm, common lizard, adder, grass snake), amphibians (great crested newt, common frog and toad), badgers, hazel dormouse and birds (black redstart).

Examples of UK BAP priority invertebrate species most associated with brownfield include dingy skipper, grayling butterfly, shrill carder bee, distinguished jumping spider, four-banded weevil wasp, streaked bombardier beetle, phoenix fly and horehound longhorn moth.

Protected plants under Schedule 8 of the Wildlife and Countryside Act most associated with brownfield habitat include Meadow clary (*Salvia pratensis*), Deptford Pink (*Dianthus armeria*), Stinking goosefoot (*Chenopodium vulvaria*), Field wormwood (*Artemisia campestris*), Petalwort (*Petallophyllum ralfsi*) and Slender green feather-moss (*Drepanocladius vernicosus*).

7.3.3 Protected species licences

Where protected species may be at risk protected species licences may be required. A professional ecologist can advise on licence requirements and appropriate mitigation. This may include consulting the following relevant government bodies prior to the implementation of brownfield habitat creation or management activities:

- Natural England: https://www.gov.uk/guidance/wildlife-licences
- NatureScot: https://www.nature.scot/professional-advice/safeguarding-protected-areas-and-species/licensing
- Natural Resources Wales: https://naturalresources.wales/permits-and-permissions/species-licensing/?lang=en

7.3.4 Other consents

OMH on previously developed land is recognised as UK Priority BAP Habitat which is statutorily protected under the NERC Act 2006. Where present within the lineside, management of this habitat must be prioritised. This is to ensure that management effectively prevents complete succession to scrubland and ensures structural

diversity and diversity of botanical communities as per the UK BAP Priority Habitat Description.

NOTE: *Budget costs of works to specific areas or management interventions requiring statutory consent are outlined in the cost summary folder.*

NOTE: *For a full list of protected animals refer to Schedule 5 of the Wildlife and Countryside Act 1981: https://www.legislation.gov.uk/ukpga/1981/69/schedule/5.*

NOTE: *For a full list of protected plant species refer to Schedule 8 of the Wildlife and Countryside Act 1981: https://www.legislation.gov.uk/ukpga/1981/69/schedule/8*

7.4 Biosecurity

7.4.1 Invasive non-native species

Several INNS listed under Schedule 9 of the Wildlife and Countryside Act (1981) can colonise brownfield sites and urban areas. Plant species include Japanese knotweed (*Reynoutria japonica*), Himalayan balsam (*Impatiens glandulifera),* Giant hogweed (*Heracleum mantegazzianum*), Contoneaster (*Cotoneaster horizontalis*), Three-corned garlic (*Allium triquetrum*), Monbretia (*Crocosmia x crocosmiiflora*), Variegated yellow archangel (*Lamiastrum galeobdolon subsp. argentatum*). Under this Act it is illegal to plant or otherwise cause to grow in the wild any plant species listed. Presence of these species may cause delay or change to the Preferred Habitat Objective.

If non-native species, listed in Schedule 9, or otherwise known to be invasive are found within a site, a suitably qualified Ecologist should be contacted, in order to devise a plan in which the plants can be removed and safely disposed of without causing spread, with the overall aim to eradicate the species from site. In this instance, the landowner is duty bound to take action to prevent spread of the species.

Invasive non-native animal species may also be found on brownfield sites, for example parakeet, common wall lizard, muntjac deer, edible dormouse, alpine newt and grey squirrel.

Japanese knotweed
(Reynoutria japonica)

Giant hogweed
(Heracleum mantegazzianum)

Monbretia
(Crocosmis x crocosmiiflora)

Himalayan balsam
(Impatiens glandulifera)

Three cornered garlic
(Allium triquetrum)

Variegated yellow archangel
(Lamiastrum galeobdolon subsp. Argentatum)

Figure 19 – Example of INNS associated with brownfield sites

NOTE: *Refer to Schedule 9 of the Wildlife and Countryside Act (1981) and gov.uk guidance for a full list of invasive non-native species: https://www.legislation.gov.uk/ukpga/1981/69/schedule/9 and https://www.gov.uk/guidance/invasive-non-native-alien-plant-species-rules-in-england-and-wales#list-of-invasive-plant-species*

NOTE: *Refer to https://www.gov.uk/guidance/prevent-the-spread-of-harmful-invasive-and-non-native-plants for information on removing INNS.*

7.4.2 Highly competitive species

Many species, whether native or non-native, can colonise and dominate brownfield habitat, outcompeting other species. Whilst small populations of most of these species can be beneficial to biodiversity, dominance can lead to the habitat becoming less valuable for biodiversity. Butterfly-bush (*Buddleja davidii*) is an example of a non-native species not listed on Schedule 9, but which is sometimes considered problematic. For example, Butterfly-bush is listed as an invasive species in London under the London Invasive Species Initiative.

NOTE: *Refer to London Invasive Species Initiative (LISI) for a list of species of concern specific to the London area: http://www.londonisi.org.uk/*

7.4.3 Pests and disease

Whilst pests and diseases impact all habitat types, brownfield sites are typically resilient due to the variety of habitats and species present. Pests and diseases

associated with grassland and woodland habitats are most likely to affect a brownfield site.

Examples include:

- **Aphids:** such as the greenfly or blackfly are one of the most common pests that attack plants by feeding on their sap which in severe cases can kill annual and perennial herbs. Aphids and other pests can also carry diseases.
- **Oak Processionary Moth (OPM):** is an increasingly common pest in urban areas. Large populations of OPM caterpillar can strip whole oak trees bare, leaving them vulnerable to factors such as drought stress (Forest Research, 2021). Brown tail moth is also common in urban areas and lay their eggs on hosts such as hawthorn, blackthorn and cherry. Dense webs attached to branch ends are a tell-tail sign. Once hatched, the caterpillars can cause rapid defoliation. The hairs of both species' of caterpillars can cause skin irritation and anaphylaxis.

NOTE: *For more information on health effects of OPM, refer to* https://www.gov.uk/government/publications/oak-processionary-moth-opm-health-effects-of-exposure

- **Ash dieback:** Ash trees (*Fraxinus excelsior*) often colonise brownfield sites. However, they are at risk of chalara ash dieback (*Hymenoscyphus fraxineus*), now one of the most common tree diseases in the UK. Affected ash trees will exhibit symptoms such as wilting leaves and dark patches on leaves and stems indicating dieback.
- **Xylella**: *Xylella fastidiosa* is a bacterium which causes leaf scorch, wilt, dieback and plant death and is known to infect 560 different plant species, most of which are associated with horticulture. As brownfields are typically found in urban areas, garden escapees and plug plants could potentially introduce Xylella into a site.

Aphids

Oak Processionary Moth

Ash dieback disease

Figure 20 – Example of pests and deseases associated with brownfield sites

By implementing proactive biosecurity measures, the risk of introducing or spreading pests and diseases within an urban area can be reduced.

This can be achieved by:

- Referring to government guidance on the requirements for plant passports, quarantining affected planting stock, removing diseased vegetation and reporting suspected pest and disease attacks (Defra, 2020);

- Planning, monitoring and reporting of concerns to identify issues through the UK Plant Health Information Portal: https://planthealthportal.defra.gov.uk/ and Forest Research;
- The use of locally prevalent species and where possible, seed harvested locally. If seed cannot be sourced locally, it should be sourced from plants grown within the UK (Natural England, 2007); and
- Establishing biosecurity protocols on site, for example regular cleaning of equipment with disinfectant.

NOTE: *For more guidance on species selection see Section 8.*4.6.

NOTE: *Anticipated costs of INNS management are addressed in the cost summary folder.*

NOTE: *Anticipated costs of disease management are addressed in the cost summary folder.*

8 Brownfield Design and Management

8.1 Introduction

This section provides guidance on:

- General considerations related to the design and management of brownfield habitats;
- The design of new brownfield habitats;
- Maintenance required to establish new brownfield habitats; and
- Restoration of brownfield habitat.

Each section includes practical guidance and makes reference to tables in the cost summary folder to understand the budget costs of carrying out work.

NOTE: *Professional expertise should be sought throughout the design and management process. For example, an experience Ecologist should be consulted to determine the Preferred Habitat Objective and objectives set out in the site Habitat Management Plan. In addition, landscape advice should be sought where design, implementation and management advice are needed.*

8.2 Habitat management plans

In addition, Network Rail's requirements for Habitat Management Plans are set out in NR/L2/ENV/122 Module 02.

According to the Habitat Design and Management Guidance Note, Habitat Management Plans should incorporate Short to Long-term objectives. Periods for brownfield differ to other habitats, due to a differing development cycle (see Section 7.3). Objective periods for brownfield habitat are likely to be as follows.

- *Short-term* (year 0 to 3);
- *Medium-term* (year 3 to 10); and
- *Long-term* (year 10+).

NOTE: *Refer to NR/L2/ENV/122 Module 02 for information on the requirements for Habitat Management Plans.*

NOTE: *Management objectives should be reviewed against data collected via monitoring (see Section 8.6.2.).*

8.3 Ecosystem services and design considerations

As outlined in the Habitat Design and Management Guidance Note, an initial site appraisal can help identify ecosystem services present and the potential to expand the range provided by the lineside. This will help inform decisions on whether brownfield is the preferred habitat for the site and how brownfield is designed or managed.

Brownfield habitats within the lineside can provide a range of ecosystem services. The greatest ecosystem service benefits associated with brownfield habitat are likely to include:

- **Pollination**: supports a wide range of pollinating insects, offering refuge, breeding habitat and food resources that can help boost the population of native pollinator species which are essential for wild plant pollination and arable crop pollination;

- **Biodiversity**: supports a wide range of species which provide further ecosystem services such as pollination;
- **Habitat connectivity:** networks of habitat enhance permeability of the landscape for species, greater genetic viability and increased resilience;

Whilst brownfield habitat also provides the following ecosystem services, the value of the service provided is typically less than that of semi-natural habitats:

- **Water regulation**: can reduce the rate at which water meets waterbodies and watercourses; reducing the occurrence of flash flooding downstream;
- **Carbon sequestration:** carbon sequestration of urban habitats provides benefits including improved health and protection against climate change;
- **Health and wellbeing:** access to semi-natural habitats provides physical and mental health/wellbeing benefits to people;
- **Landscape integration**: can improve lineside aesthetics and integrate the landscape with the wider setting; and

NOTE: *Ecosystem services of the land should be identified when fieldwork is undertaken. This should be determined by an environmental specialist, using professional judgement. Refer to the Habitat Design and Management Guidance Note for more information on ecosystem services.*

8.3.1 Lineside design considerations

In addition to ecosystem services, there are other lineside specific design risks and benefits which will help to inform whether brownfield habitat is an appropriate habitat within a specific location (Table 3 and Table 4). In some cases, there may be conflict between different objectives, for example introducing varied topography for biodiversity may cause health and safety concerns.

Table 3 – Key considerations for brownfield habitat in a railway setting: lineside risks

Consideration	Associated risk	Potential solution
Contouring substrate to create varied topography.	Could create unstable structures which pose a risk to rail operations or lineside operators.	Ensure substrate mounds are built on stable, flat ground and / or structures. Contouring of substrate should not be undertaken on embankments and areas which require routine access. Ensure there is a safe, visible and easily navigable route through the extent of the site.
Introducing competitive species into the wild.	Risk that newly introduced non-native plant species could act invasively and pose-risks to semi natural habitats.	Monitor planting and species dispersal. Specify plant species with no known associated risk of them acting invasively.

Consideration	Associated risk	Potential solution
Contamination from previous land use.	Could disturb existing contamination and cause leaching into the wider environment.	Carry out appropriate surveys prior to site alterations.

Table 4 – Key considerations for brownfield in a railway setting: lineside benefits

Consideration	Associated benefit	Potential solution
Using surplus substrate.	Surplus or unused substrate within Network Rail land can be used to create brownfield habitat, removing wastage. Will be viewed by members of the public from trains but without high footfall. Substrate can be moved from one site to another where appropriate.	Planting should be aesthetically appealing. Substrate should be placed on suitable sites and designed as detailed in Section 8.4.2 and 8.4.3.
Creation and maintenance of brownfield habitat on steep slopes and derelict sites.	Providing not allocated for development, previously developed sites or sites with disused waste and construction materials can be easily enhanced for biodiversity. Plants could help to stabilise slopes and reduce the chance of landslides Where access and management of semi-natural habitats is difficult, creation of brownfield habitat could be considered due to its low maintenance requirement.	Ensure proper assessment of lineside gradients to determine where it is appropriate to create brownfield sites.
Contamination	Many contaminated sites are left undeveloped due to associated risks, presenting an opportunity to create habitat. For example, certain plant species will be tolerant of contaminants and as such may provide biodiversity value where the site may otherwise have been left derelict. Creating a brownfield	Appropriate surveys to identify contaminated areas and assessments to suggest next actions Where contaminated soils can be left undisturbed, creation of brownfield may be beneficial to extract value from the site.

Consideration	Associated benefit	Potential solution
	habitat using such species may therefore be an option. In addition, certain plants can provide bioremediation of particular contaminants e.g. horsetails (*Equisetum* spp.) can remove lead and heavy metals (Refer to Section 8.4.4 for more information on bioremediation).	

NOTE: *Refer to Network Rail's Guidance Note on Contaminated Land (XXXX) for information on working with contamination.*

8.4 Brownfield Habitat and Design

This section provides advice on the design of new brownfield habitats within the lineside and key considerations for implementation.

Good brownfield habitat design should seek to achieve the following:

- Support resilient and diverse plant and invertebrate communities which enhance the biodiversity value of the habitat;
- Appropriate preparation and management to ensure establishment of brownfield plant communities;
- Cost effective management where works are planned and combined to minimise costs associated with site access and operational restrictions;
- Utilise unused sites and aggregates, taking the circular economy approach to creating habitat, minimising cost and increasing sustainability;
- Connections to adjacent habitats to create urban habitat corridors, stepping-stones or wider habitat mosaics;
- Where brownfield is proposed for creation, create a site brownfield plan to indicate the areas which different substrates, contours and depressions will be located, listing seed mixes and plug plants to be introduced across each substrate type as detailed in 8.4.3; and
- Maintain the safety and performance of the lineside.

NOTE: *The value of brownfield habitat is greatly increased if connected and managed as part of a network.*

NOTE: *Anticipated costs of urban habitat creation are addressed in the cost summary folder.*

NOTE: *Seek advice from an experienced specialist (e.g. Ecologist) where designated sites, protected habitats or species are known to be present on site. Refer to Section 7 to classify open mosaic and brownfield habitats.*

8.4.1 Operational considerations for brownfield habitats

Creating or enhancing brownfield habitats in close proximity to the railway requires consideration of the key site-specific constraints to operational rail use.

Typical operational considerations for brownfield appraisal may include:

- Flooding;
- Steepness or stability of embankments and cuttings;
- Accessibility;
- Lineside width and the proximity to the line;
- Protected species or protected habitats and sites;
- Abundance of invasive shrub (e.g. bramble) on adjacent land; and

- Security, e.g. discouraging public access.

NOTE: *Refer to NR/L3/OTK/6202 Protecting Railway Assets During Vegetation Work for guidance on protecting railway assets.*

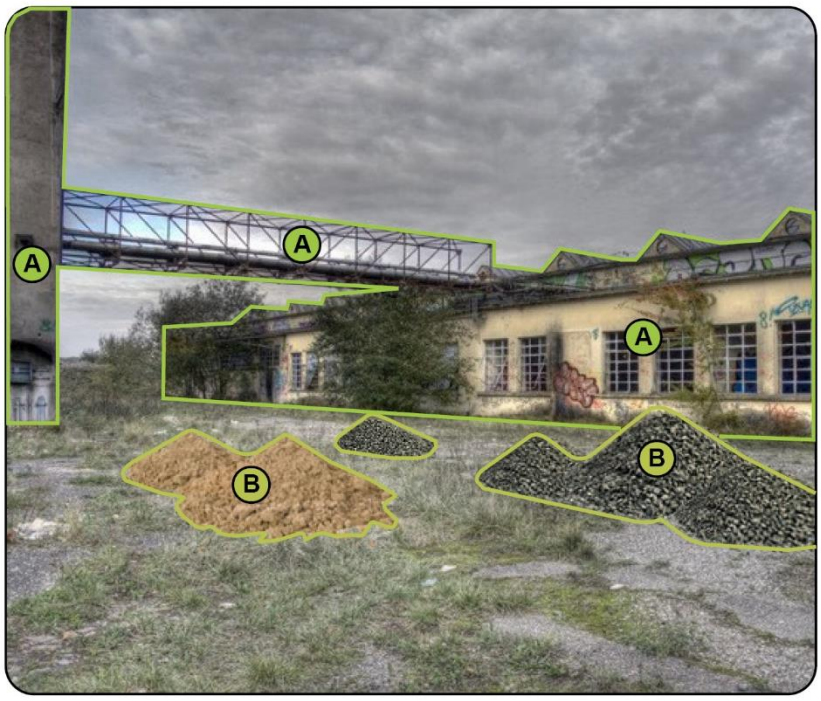
8.4.2 Site selection

The suitability of a site for brownfield habitat creation should be assessed through the habitat study and site appraisal and should align with the Preferred Habitat Objective. This includes consideration of safety aspects of railway operations, habitat opportunities and constraints. Guidance on the process of recording and analysing this data is found in the Habitat Design and Management Guidance Note.

In relation to the Preferred Habitat Objective, the following should be noted:

- **Enhance:** the guiding principles in this section should be used to enhance brownfield habitat to create diverse plant and invertebrate communities.
- **Restore:** the habitat was once a brownfield community which has transitioned to a shrub dominated habitat growing on previously developed land (e.g. hardstanding or inorganic substrates).
- **Transform**: it is likely that the habitat has grown on soils as opposed to previously developed land. Inorganic substrates may need to be introduced onto site to help create a brownfield habitat.

Observations made on site are likely to indicate opportunities for creating brownfield habitat but may also indicate that the site is unsuitable. Some indicators of brownfield habitat creation opportunities are illustrated in Figure 21. The visual cues depicted in Figure 22 relate to considerations which may make brownfield habitat creation difficult.



A Inactive sites

Previously developed sites which are inactive could be prime targets for brownfield habitat creation, especially where aggregates have been left in piles, unused. However, consider whether the site could become active again in the future. Sites which are likely to become active again are unlikely to be suitable for brownfield habitat creation

B Unused aggregates

Piles of undisturbed sand and aggregates on site offers the basis for creating brownfield habitat

C Cost effectiveness

Unused, previously developed land offers opportunity to create biodiverse habitat at a small cost. For example, unused aggregates can be used reducing habitat creation costs. The long-term management of brownfield habitat is also less extensive than most semi-natural habitats

Figure 21 - Site indicators of brownfield habitat creation opportunities

Inactive sites may exist because they sit within non-operational land (see Figure 21). Whilst the land may be non-operational, it may be considered a risk to create or allow

brownfield habitat to form on site, due to the level of protection afforded to certain brownfield habitat, such as OMH, or species which it may support (e.g. reptiles). As these would limit future use of the land, it is important that an agreement is made with Network Rail stakeholders to secure the site for creation or enhancement of brownfield habitat.

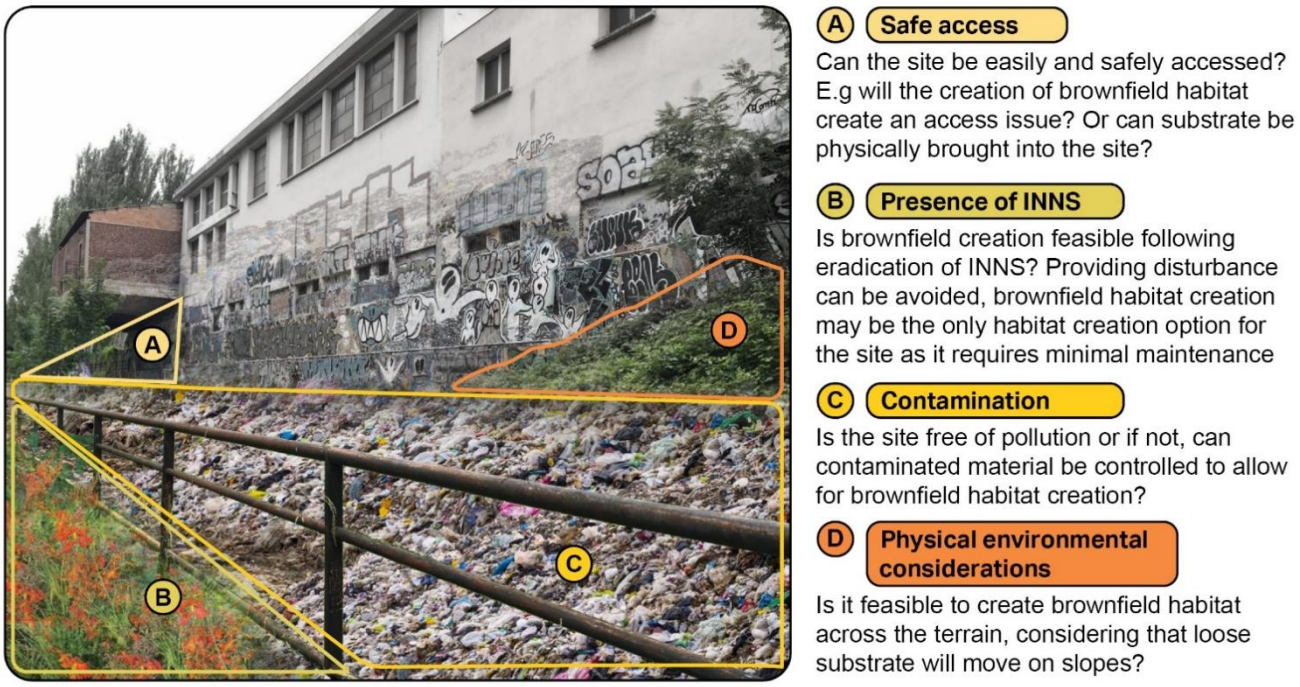


Figure 22 - Indicators that a site may be unsuitable for brownfield creation

NOTE: *Refer to NR_L2_OTK_5201 MOD1 Lineside Vegetation Inspection and Risk before undertaking any fieldwork.*

NOTE: *Refer to NR/LN/ENV/122 MOD 01 Biodiversity section 3.3 regarding field surveys.*

NOTE: *Refer to NR/L2/ENV/122 MOD 01 and MOD 02 regarding data gathering, the identification of existing habitats and species (e.g. SSSI) or protected species recorded on site.*

8.4.3 Structural and substrate variation

Substrates and aggregates are an important component of brownfield habitat, and the key character that differentiates brownfield from most other semi natural habitats. The most biodiverse brownfield habitats comprise diverse plant communities growing upon a variety of different substrates.

Brownfield biodiversity is influenced by two main factors which are indicated in Figure 23:

- the type of substrate;
- and topography.

A Substrate diversity

Using a variety of different substrates introduces different environmental conditions e.g. pH, water drainage, compaction. As different plants are adapted to different conditions, this allows for diverse plant communities to establish. Unused aggregates on site or on the network can be recycled to create brownfield mosaics.

B Structural diversity

Creating a variety of different shaped mounds and depressions using different substrates adds to the complexity of environmental conditions (e.g. amount of shade and moisture) which can encourage establishment of diverse plant communities and nesting of invertebrates.

Figure 23 - Example of a biodiverse brownfield habitat

The following sections outline how to identify substrate which can be used to create brownfield habitat, what to do with contaminated substrate or land, and best practice guidance principles in relation to creating substrate and structural diversity for plants and invertebrates.

8.4.4 Identifying and selecting substrate

Where possible, surplus substrates present within a site or located elsewhere within the Network Rail land should be used. It provides a cost-effective solution to creating species-rich habitat and recycles materials which may otherwise be discarded. This important first step will directly influence the types of plant communities that will grow.

The process illustrated in Figure 24 can be used to determine how to proceed with using the substrate.

- **Contamination:** substrate or waste materials which are deemed hazardous due to the presence of chemicals, asbestos or other toxins may impede what can be created on the site. Most contaminated sites within Network Rail land have been identified and should be highlighted during the desk study undertaken for the site. However, where contamination has not been previously identified but is suspected, the Network Rail team should be contacted to determine if contamination is present and to what extent. Creation of brownfield habitat may present an opportunity to bring value to a site which cannot otherwise be used providing there are guarantees the contaminated waste is not disturbed. Alternatively, there may be an opportunity to bioremediate the site using plants;
- **Inorganic aggregate:** most inorganic aggregates can be used, including broken up concrete or ceramics. However, understanding the type of material will help determine appropriate seed mixes (see Sections 8.4.6 and 8.4.7); and
- **Soil:** if present, habitat creation should follow the guidance outlined within the Grassland Design and Management Guidance Note. However, introducing topsoil should be avoided as it is likely to be nutrient rich and not allow for species rich habitats to form.

NOTE: *There may be legal barriers to moving or using contaminated land for habitat creation. Refer to the Environment Agency's Principles for Land Contamination guidance for more information - https://webarchive.nationalarchives.gov.uk/20140328173027/http://cdn.environment-agency.gov.uk/geho1109brgy-e-e.pdf*

NOTE: *Some plant species could help remediate certain contaminated soils. The possibility of utilising bioremediation should be raised with a contamination specialist and if possible, should be considered the focus of brownfield habitat design.*

NOTE: *Refer to the Habitat Design and Management Guidance Note for information on how to undertake a desk study which can help determine presence of contaminated substrates on site.*

NOTE: *Discuss site contamination with Network Rail to understand whether brownfield habitat creation is feasible for the site and under what precautions.*

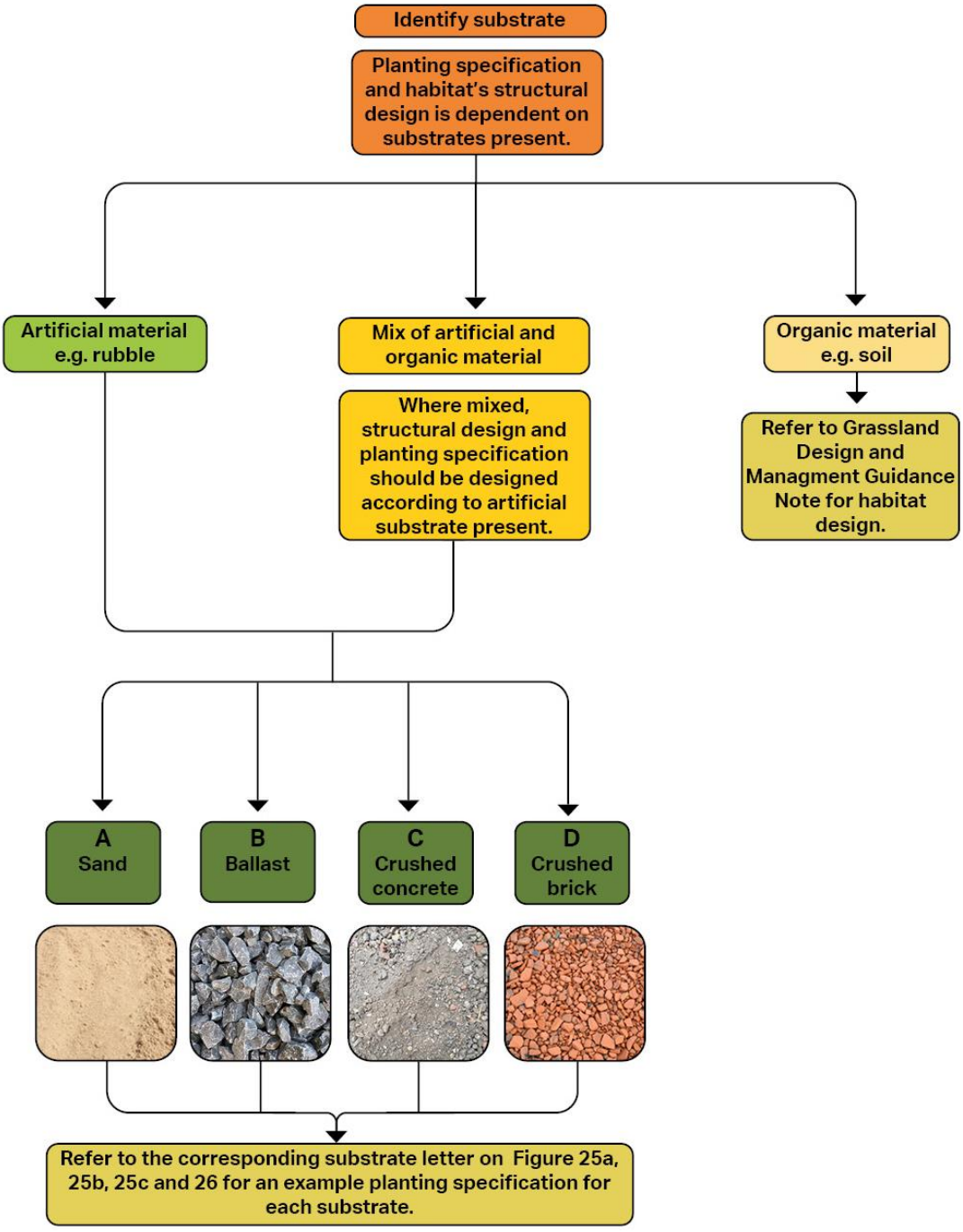


Figure 24 - Process to identify substrate

8.4.5 Design for diverse plant communities and invertebrates

The placement of substrate should be varied to create as many micro-habitats as possible, for different species of plants and invertebrates to colonise. The following principles should be considered to maximise the potential for diverse communities to establish:

- **Substrate condition:** Substrate should have a minimum depth of 75mm above soil, ideally 150mm-200mm. This enables weed suppression and creates an optimum layer for seed germination (Hitchmough, 2017);
- **Creating mounds:** varying the topography of the habitat by creating substrate mounds, provides variation in light and moisture, which different plants are adapted to. Existing or additional substrate should be shaped to create mounds up to 0.9m high with a footprint of up to 2m² and varying topography. It is important to use different substrates, varying in particle size and composition. If using whole ballast, sharp sand should be used to aid seedling establishment in the gaps; and
- **Creating depressions:** depressions in substrate collect water and are suitable for plant species which can tolerate very damp conditions.

Figures 25a, 25b and 25c illustrate how substrates, depressions and mounds could be located across a lineside site and provides examples of benefits to wildlife. Whilst aggregates are the preferred substrate, retaining or creating areas of existing bare soil, shrubs and wetland, can add to the habitat mosaic, increasing biodiversity.

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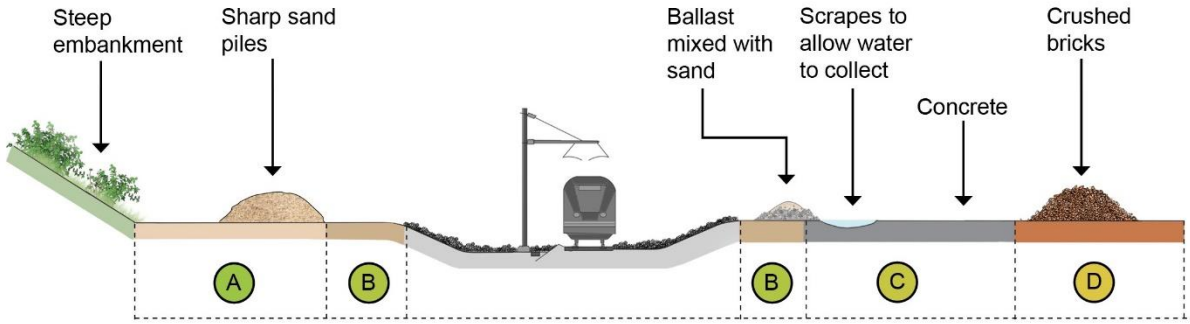

Figure 25a Example of brownfield habitat substrate design – section view

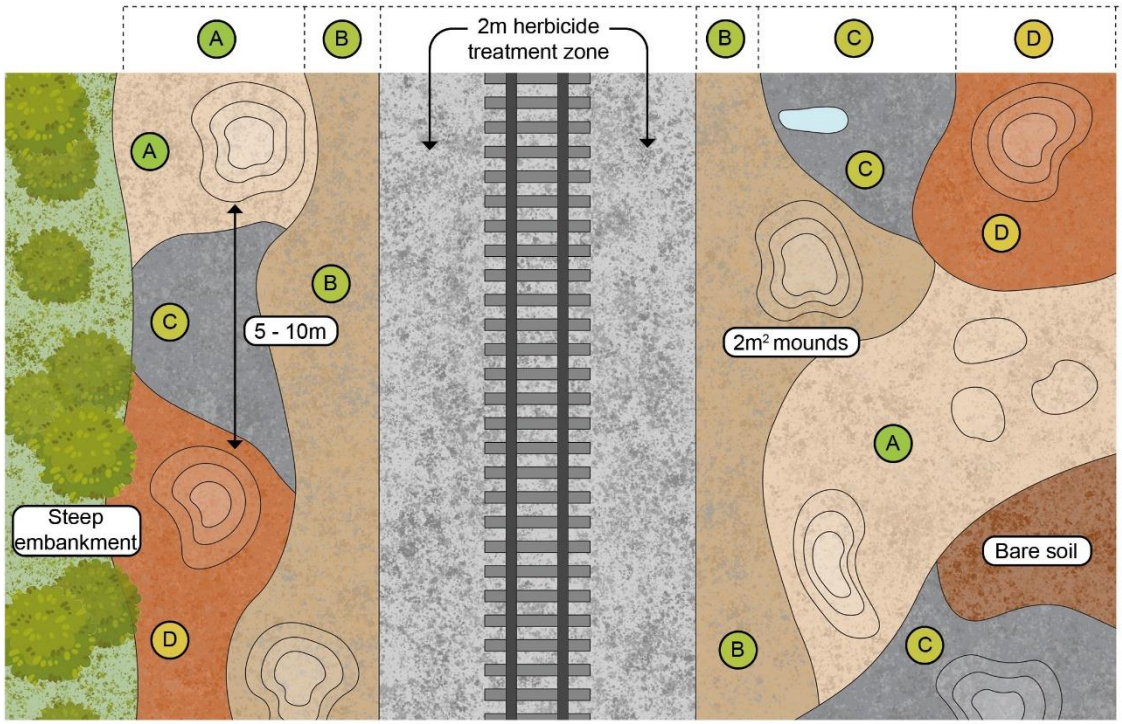

Figure 25b - Example brownfield habitat substrate design – plan view

Creating mounds and depressions using different substrates also influences the diversity of invertebrates which are likely to use the site. Different invertebrate groups (e.g. butterflies, beetles, flies and bees) have different requirements throughout their life stages. For example, solitary bees require warm surfaces which they can burrow into to nest, whilst bumblebees prefer large crevices to nest within. The following brownfield habitats features should be considered for invertebrates:

- **Variation in mound height:** when creating mounds, varying the height will add to the complexity of the habitat and provide refuge for different invertebrates;
- **South-facing slopes:** make the longest vertical slope of each mound south facing. South facing slopes will generally receive the most sunlight, warming the ground and providing optimum conditions for many invertebrates to nest in. South facing slopes of sand and rubble will quickly be colonised by solitary bees.
- **Bare ground**: approximately 5 -10% of bare ground should be created and maintained free of vegetation as these areas warm up more quickly and are ideal for invertebrates to bask or nest. Areas of bare ground should not be seeded.
- **Scrapes:** creating depressions or 'scrapes' in the substrate will allow for water to collect, forming seasonal or permanent pools, which provides habitat for many invertebrates. Varying scrape depth allows mud to develop alongside these ponds, which allows larvae development.

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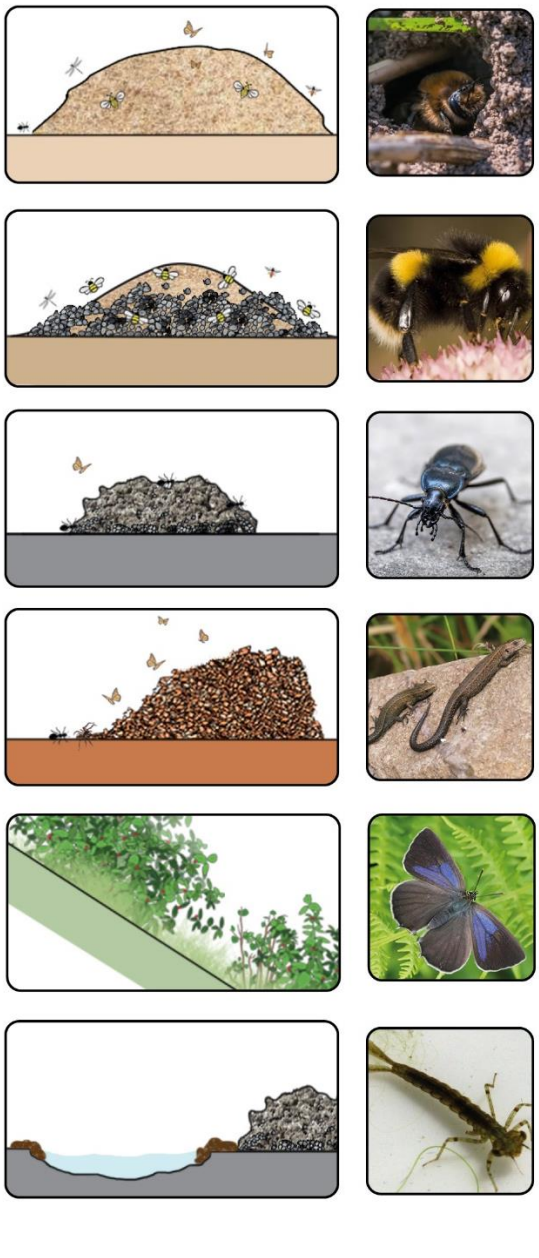


A Sharp sand

As a fine material, sand is used by nesting invertebrates, such as solitary bees, which burrow into the sand. The fine material also allows for fast establishment for herbaceous plants adapted to the neutral pH.

B Ballast and sand mix

The gaps present between ballast also provide nesting opportunities for bumblebees. Due to size, ballast is difficult for many plants to establish on; by using sand, it filters through the large gaps providing a substrate for more plants to root in.

C Crushed concrete

Mixing concrete with other finer substrates such as sand should be considered to prevent concrete clumping. Bits of concrete will vary in size, but provide useful nesting and refuge for invertebrates such as beetles.

D Crushed brick

Crushed brick has similar properties to concrete and warms quickly in the sun, providing locations for invertebrates and reptiles to bask and warm up.

Steep embankment

Line side spaces are frequently fringed with cuttings and embankments. Semi-natural habitats like scrub can be planted on steep slopes unsuitable for brownfield creation to add to the habitat mosaic. Scrub can provide valuable habitat for species such as butterflies.

Shallow scrapes

By creating scrapes in substrates, water can collect and form ephemeral or permanent pools which provide additional habitat for aquatic inverterbrates and plants which prefer damper conditons. Varying scrape depth allows mud to develop alongside these ponds, which is an essential habitat for larvae development. Scrapes should be greater than 2m x 2m to reduce the impact of encroaching vegetation. Consider creating multiple scrapes across an area rather than one large scrape.

Figure 25c – Key features for wildlife as labelled in Figure 25a and 25b

8.4.6 Planting specification

The success of establishing plant communities on substrate is influenced by the type of substrate. This is due to the differences in particle size and the substrate's ability to retain water. To enable successful establishment and long-term viability of brownfield habitat it is important to consider the following:

- **Substrate**: assess the pH and environmental conditions provided by the substrates on site and select plant species adapted to those conditions (see Figure 26);

- **Native vs non-native:** in urban areas, non-native species should be considered, providing they are not invasive and the plant species are known to benefit urban wildlife and / or provides resilience to climate change;
- **Extending the flowering period:** specify a palette of plant species which combined flower throughout the year to increase nectar and pollen sources; and
- **Planting for pollinators:** specifying plant species used by different life stages of pollinating insects can enhance the chance of those species nesting and using the site. Where possible, specifications should be designed to benefit local or regional urban BAP invertebrates. For example, kidney vetch (*Anthyllis vulneraria*) is an important foodplant for butterfly larvae, whereas bird's-foot trefoil (*Lotus corniculatus*) is a key nectar source for adult butterflies.

NOTE: *Refer to the RHS Plants for Pollinators lists to understand which non-native species are suitable for planting in brownfield habitat: https://www.rhs.org.uk/science/conservation-biodiversity/wildlife/plants-for-pollinators*

NOTE: *Species listed under Schedule 9 of the Wildlife and Countryside Act 1981, by the GB Non-Native Species Secretariat and London Invasive Species Initiative (LISI) should not be specified.*

Figure 26 indicates the different environmental properties presented by each of four commonly used brownfield substrates and provides examples of species which are adapted to each substrate's properties.

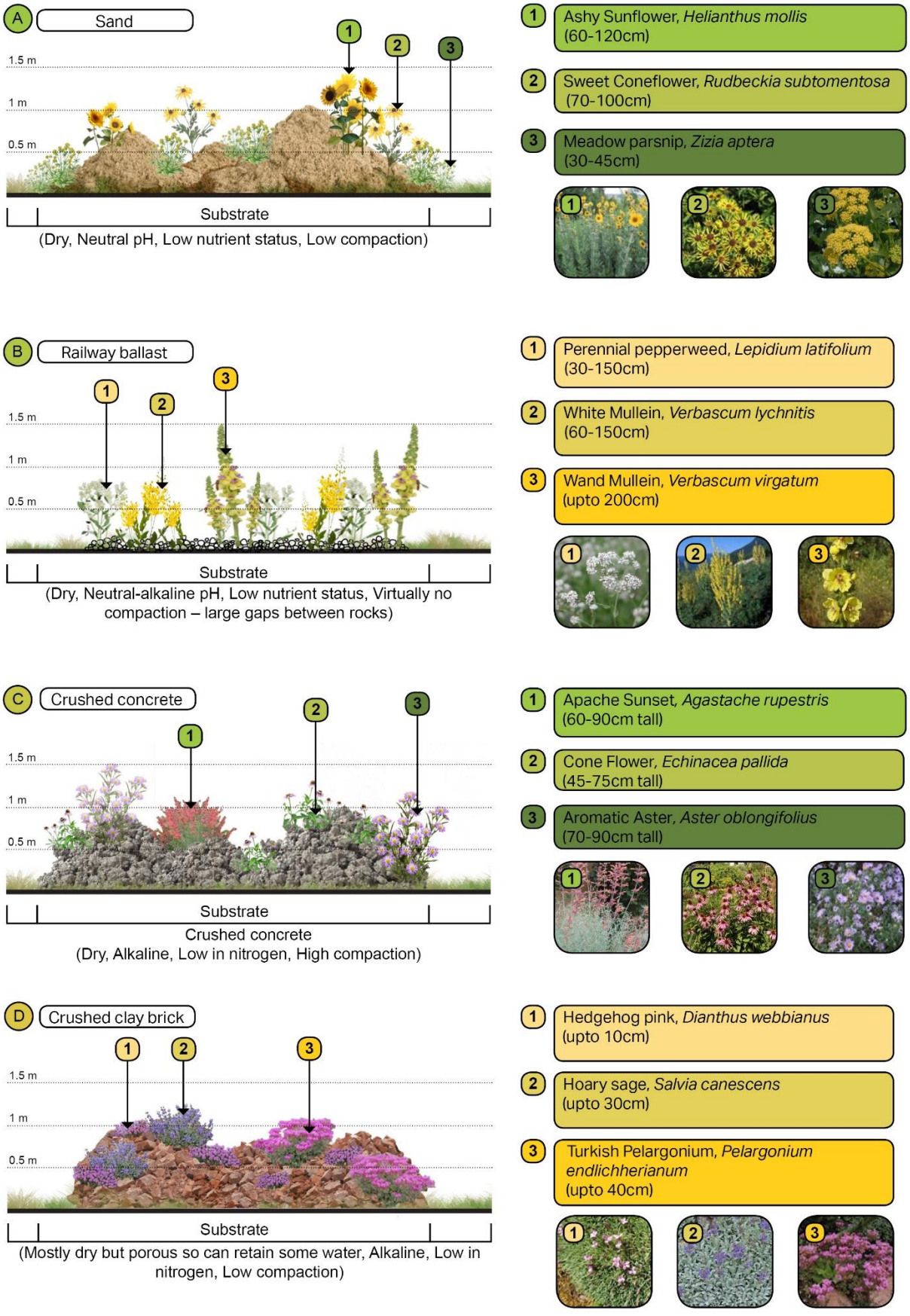


Figure 26- Example species that can grow in different substrates

8.4.7 Approaches to establishing diverse plant communities

There are two main approaches to encouraging plant communities to grow on brownfield. These are:

- **Sowing seed:** scattering a seed mix suitable for the site's substrates as detailed in Section 8.4.6. Crushed rock or artificial aggregates and substrates typically used for brownfield habitat have no existing seed bank. Sown seed is more likely to establish if the species are adapted to the pH, substrate size and nutrient status of the substrate used. Seeding methods for different substrates are outlined below.
- **Plug planting:** plug planting immature plants is useful where quick establishment of a particular species is required within an existing sward or to ensure establishment of certain species within a newly created brownfield habitat. Success of establishment is high providing plug plants are selected according to the substrate as detailed in Section 8.4.6 and they are irrigated if planted during spring and summer.
- **Natural regeneration**: is the 'do nothing approach', whereby plants naturally colonise substrate from surrounding areas. Whilst cheaper, habitats which establish are unlikely to be as diverse as those created by sowing and will take longer to reach the established or mature phase. Whilst natural regeneration can be less labour intensive and initially cheaper than other options, the likelihood of a species-rich sward developing is unpredictable (Buglife, 2020). Undesirable species are more likely to establish meaning greater time and cost to manage.

When seeding brownfield substrate, the following densities should be considered:

- **Higher densities (100 to 200 seedlings / m2):** slow growing, small, long flowering, highly attractive or less shade tolerant species. Should also be considered for brownfield habitats which will receive limited maintenance
- **Lower densities (60-70 seedlings per m²):** Plant species which are fast growing, have large flowers for a shorter period.

***NOTE**: For detailed information on seeding densities and sowing targets, refer to Hitchmough (2017).*

8.4.8 Sourcing seed

Where seed is used, success of brownfield establishment is influenced by the quality and viability of seed and requires robust procurement processes. Refer to the Grassland Design and Management Guidance Note for information on sourcing seed.

***NOTE:** Refer to the RHS Plants for Pollinators lists to understand which non-native species are suitable for planting in brownfield habitat: https://www.rhs.org.uk/science/conservation-biodiversity/wildlife/plants-for-pollinators*

8.4.9 Devising a brownfield creation plan

Where brownfield is proposed for creation, a site plan (Example provided in Section 8.4.5) should be created using GIS which indicates the following:

- Proposed location and area of coverage of each substrate;
- Proposed locations of contours and depressions;
- Species lists associated with each substrate type (see Figure 26); and

- Areas to be retained as bare ground and thus not seeded.

Once created, the brownfield plan should be used to indicate which vegetation will be managed to ensure no one development phase or vegetation community dominates the site (see Section 8.6).

8.4.10 Resilience and adaptability

Botanical communities which tend to establish in brownfield habitats are generally more resilient to climate change, due to the environmental, drought like conditions provided by the inorganic substrates that are typically present. Including a diverse range of species can help increase resilience to warmer climates and limit the damage caused by pest and disease outbreaks. This can include non-native species adapted to dryer and warmer climates.

***NOTE*:** *The Action Zone is defined NR/L2/OTK/5201/02 Lineside Vegetation Management Requirements.*

8.4.11 Protection

Brownfield creation or management can present safety and operational risks, whilst also being at risk of physical damage which is difficult to reverse. Table 5 highlights these risks and associated protection measures. In addition to these risks, typical lineside issues encountered in urban areas and potential solutions to these, which may be relevant to brownfield, are discussed in Section 6.3.

Table 5 – Protection measures required for brownfield habitats

Risk	How	Protection measures
Safety or operational issues arising from substrate mounds or depressions.	Whilst modifying brownfield topography using substrates can enhance biodiversity, it may pose safety issues where staff need to access areas of the lineside.	Create depressions and mounds away from walkways and ensure enough level ground is present to allow ease of access across lineside spaces for. Where hazardous features are created in publicly accessible areas, fencing should be considered.
Lack of understanding or appreciation for the biodiversity value of brownfield habitats.	The general public are unlikely to have any knowledge of brownfield habitat and may perceive it to be waste ground that has been unmanaged.	Include signage to educate the general public about the benefits of brownfield habitat. Vibrant flowering species could be sown in public facing brownfield habitat to create an attractive outlook.

8.4.12 Opportunities within new railway developments

New urban railway developments present an opportunity to create visually engaging, biodiverse brownfield habitats. As aggregates and substrates are typically needed in

the construction of new developments, left-over materials can be used to increase the sustainability of the development whilst benefiting biodiversity.

Figure 27 illustrates how brownfield habitats can be incorporated into new development. In public facing spaces, the planting specification can be designed to be vibrant and visually appealing and benefit biodiversity. Due to the low maintenance requirements of brownfield habitat, such habitats can be easily designed into roof spaces (e.g. brown roofs for buildings, cycle storage etc) to further increase the biodiversity value of the development. In addition, instead of traditional retaining walls and barriers, gabion baskets can be filled with different aggregates.

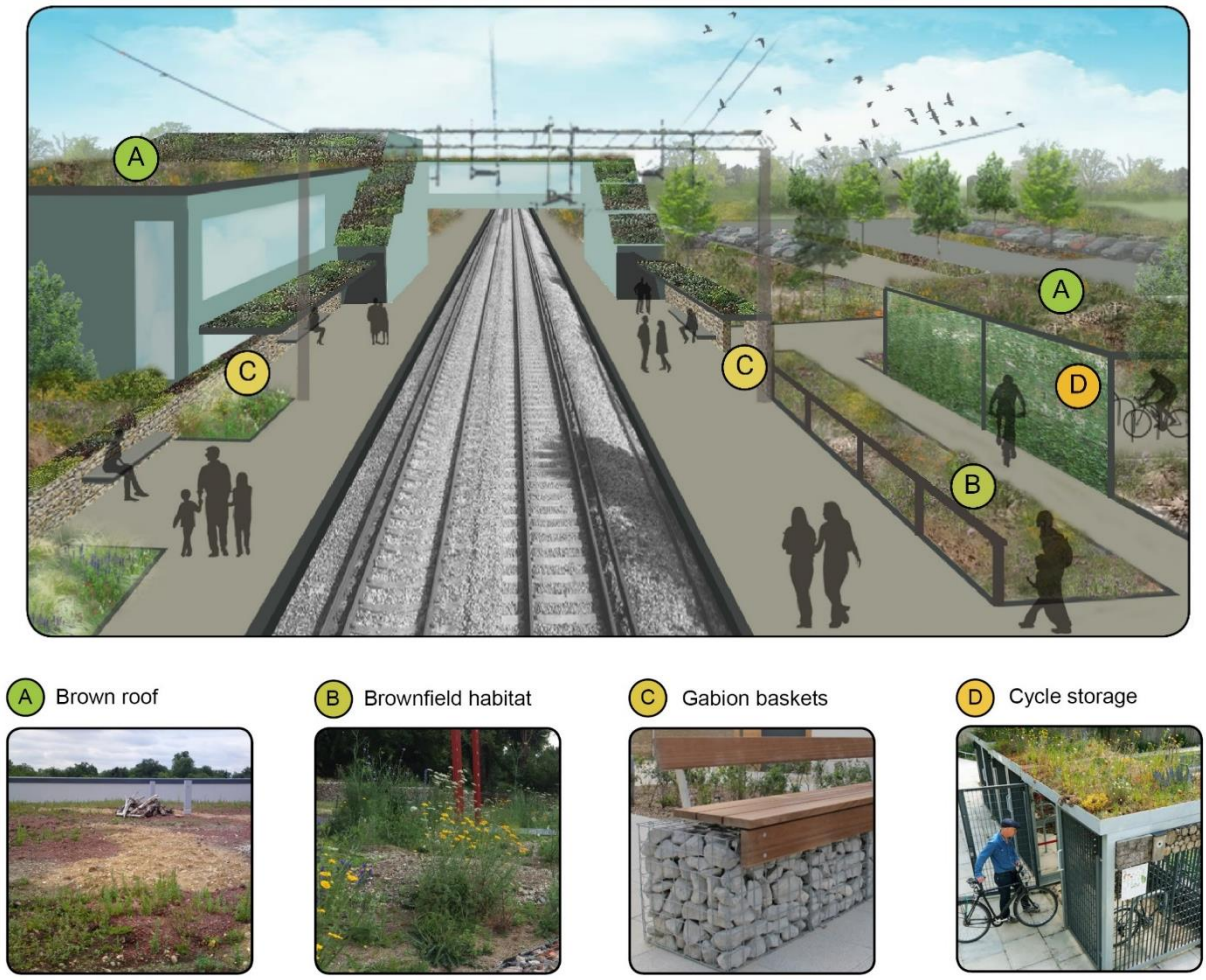
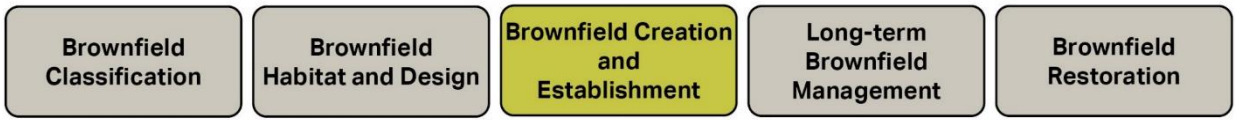


Figure 27 – Artist's impression of brownfield habitats integrated into a new station development

8.5 Brownfield Creation and Establishment



This section provides guidance on how to successfully create and establish brownfield habitat in the lineside to maximise its biodiversity value and ecosystem service provision. This guidance refers to the pioneer and establishing phases of the brownfield habitat development cycle.

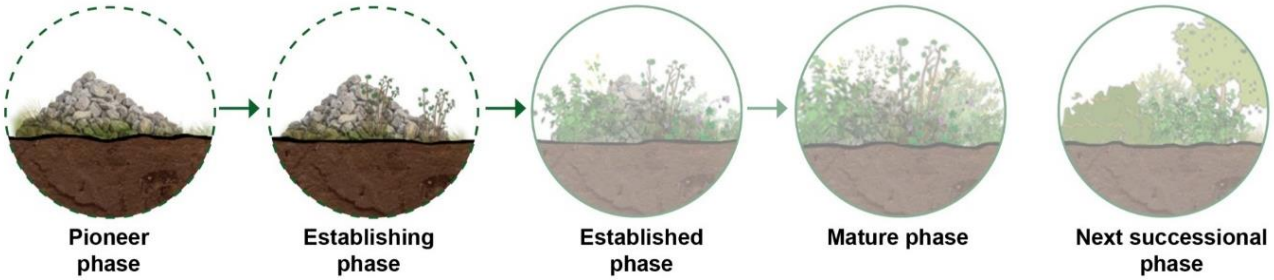


Figure 28 – Phases of brownfield development cycle: applicable brownfield creation and establishment

Best practice suggests the following general brownfield creation and establishment principles should be applied:

- Ensure the correct seed mix is directly sown onto the correct substrate;
- Mix sharp sand or a finer substrate with larger, less compacted substrates (e.g. ballast), where possible, and rake once seeded where finer substrates are used;
- Implement appropriate establishment maintenance;
- If possible, remove all vegetation arisings once brownfield habitat is cut to prevent fertile soils and a detritus layers from forming;
- Removing dead or diseased vegetation material from site to a licensed green waste recycling facility (with the exception of dead wood which should be retained); and
- Consider risks to brownfield habitats, for example security.

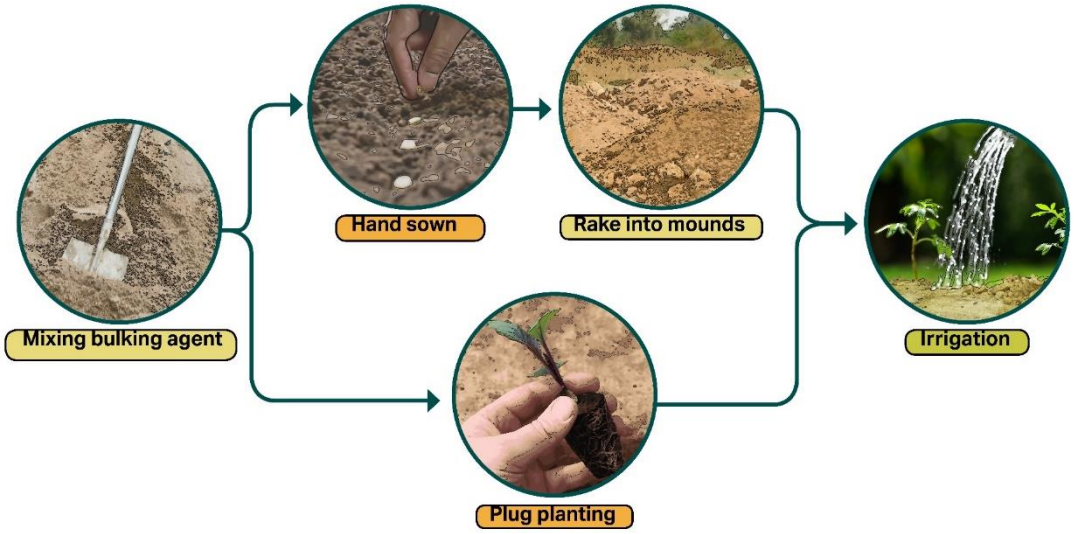


Figure 29 – Brownfield creation and establishment process

Figure 29 outlines the process that should be followed when creating brownfield habitat and the subsequent actions recommended for successful establishment. This process will differ depending on the size of the substrate used. These matters are discussed in Section 8.5.1.

Methods and considerations relating to ground preparation, implementation and immediate aftercare are outlined within the following subsections. Management interventions and long-term management are discussed in Section 8.6.

NOTE: *Seek advice from an experienced Ecologist where brownfield creation or management advice is required or where individual botanical species advice is required.*

NOTE: *The routine maintenance schedule for brownfield including when to undertake inspections is set out in the schedule folder.*

8.5.1 Implementing brownfield habitat creation

Brownfield habitat creation should follow these five steps:

1. **Place aggregate in desired locations:** using appropriate machinery to move all aggregates to the locations outlined within the site brownfield creation plan (see Section 8.4.9), ensuring mounds and depressions are created.
2. **Create a bulking agent:** mix sand with damp sawdust for 5 minutes to form a bulking agent. This should then be incorporated with the seed mix.
3. **Sowing technique:** seed should be sown in two passes, each at 90 degrees, at 1m intervals.
4. **Raking:** where dealing with fine substrates that can be raked (e.g. sand), rake seeds in with 900mm wide rakes.
5. **Irrigation:** irrigate every 1-3 days (weather dependent) to increase the rate of seed emergence from April to the beginning of June (dependent on sowing time), where possible.

As illustrated in Figure 30, to enable plants to root in larger aggregates, such as ballast, it is recommended that a finer substrate, such as sharp sand, is either mixed or placed on top of the larger aggregate. The ideal depth of finer substrate is 100mm

but shallower depths may still assist plant to roots as the sand will filter down between the gaps in the ballast.

Where this concerns lineside ballast, sand should be introduced across the area of ballast spill, starting 2m away from the track and ending where the ballast spill stops, up to 5m in width.

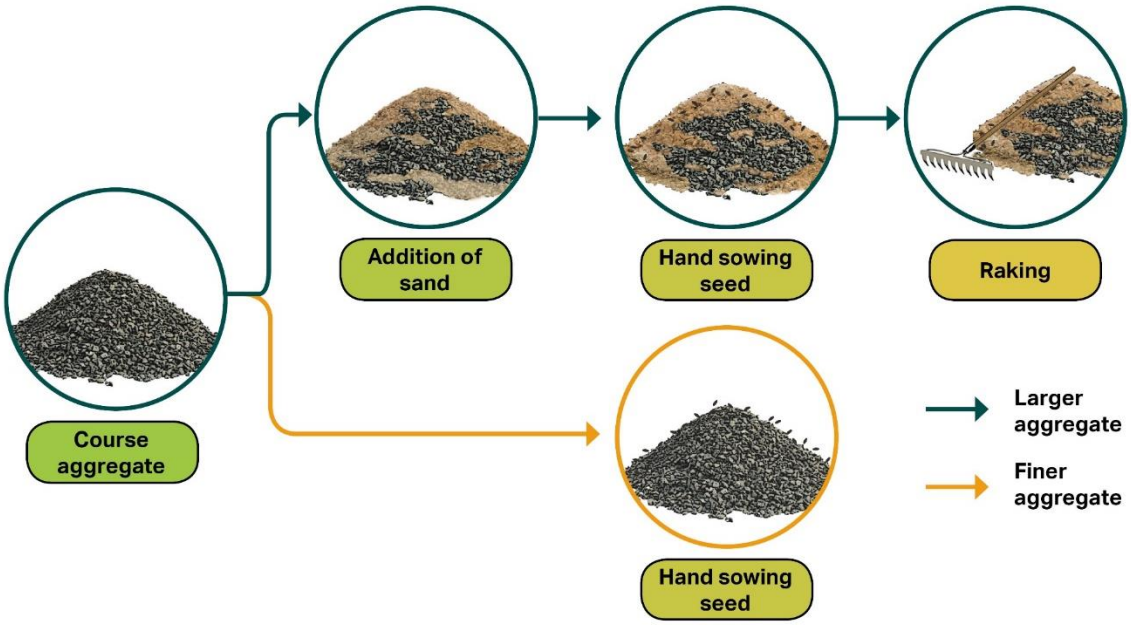


Figure 30 – Mixing substrate diagram

NOTE: *Refer to Section 6.5 of the Grassland Design and Management Guidance Note to determine appropriate times of year for seeding annual and perennial herbaceous brownfield plants. Refer to the Heathland and Shrub Design and Management Guidance Note, for guidance on creating and establishing shrub communities.*

8.5.2 Establishment

Maintenance is important to ensure successful establishment. It may be beneficial to irrigate brownfield habitat during hot and dry spells while it is establishing.

For information relating to ongoing management and pernicious weed removal, refer to the Establishment Section of the Grassland Design and Management Guidance Note.

NOTE: *The routine maintenance schedule for brownfield habitat, including when to undertake inspections is set out in the schedule folder.*

8.5.3 Lineside management considerations

In most instances, where aggregates are being brought onto or moved around a site to create mounds and depressions, machinery will be required.

Physical and operational constraints (see Section 8.4.1) should be considered before undertaking brownfield creation. Use of machinery appropriate to the site's conditions is key in ensuring successful habitat creation and lineside safety.

8.6 Long-term brownfield management

This section outlines the key considerations for the management of established and mature brownfield habitat. It should be read alongside NR/L3/OTK/6202 Protecting railway assets during vegetation work.

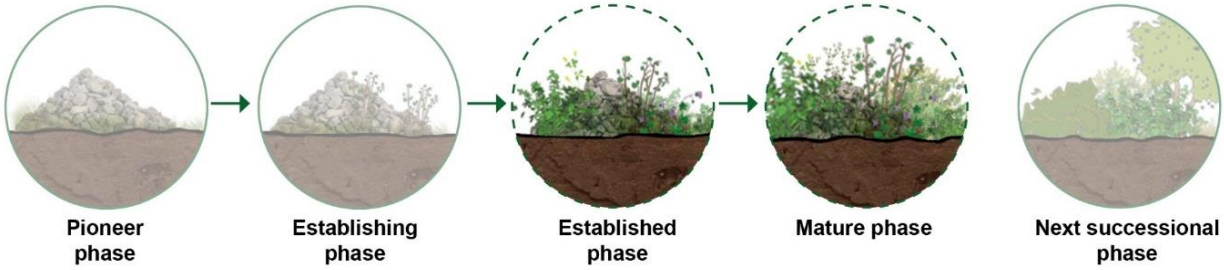


Figure 31 – Phases of brownfield development cycle: applicable to brownfield established and mature phases

Best practice suggests the following general principles should be applied:

- Implementing a long-term management regime suitable for the site, substrates present and brownfield habitat communities that have formed e.g. shrub, mosses and liverworts, annuals and perennial herbs;
- Monitoring brownfield habitat to assess changes in habitat composition and structure to inform future management; and
- Organising toolbox talks for site staff on maintenance protocols, including recording and reporting on suspected cases of pests and diseases.

Once a brownfield habitat is established, good brownfield management seeks to:

- Maintain a variety of development phases and structural diversity to ensure a varied habitat mosaic develops and is maintained;
- Conserve, create or enhance micro-habitat features e.g. scattered shrub, hibernacula, areas of bare ground in sunny locations etc; and
- Enhance biodiversity of each vegetation community or development phase.

The management interventions used for brownfield habitat will largely depend on the types of vegetation that have established and are likely to be targeted to particular areas as opposed to the whole brownfield habitat. Refer to the brownfield site creation plan to understand the proposed habitats and manage accordingly (see Section 8.4.9). Details of each management approach are outlined in the sections below.

8.6.1 Managing brownfield habitat mosaics

Retaining a balanced variety of development phases is key to ensuring biodiversity enhances over time or is maintained at its peak. Of the five development phases outlined within this report, an ideal brownfield habitat should have an even split of each i.e. the brownfield habitat should comprise 20% of each development phase.

Understanding the following will enable the correct management intervention and frequency of management to be determined for each brownfield development phase:

- **Natural succession:** in most instances, a mosaic will naturally transition from the pioneer phase through the different phases until it reaches the next successional phase (e.g. dense shrub and tree community), over time;
- **Larger substrates:** depending on the substrates present on site, succession to the next successional phase could naturally take a long time (e.g. 30+ years) or may fail to transition beyond a certain phase; and
- **Finer substrates:** succession to the next successional phase may be quicker, akin to the timeframe which occurs in grassland establishment.

Figure 32 illustrates how a brownfield mosaic may transition from the pioneer phase to the mature phase. Once management ceases, most mosaics will transition to the next successional phase (e.g. dense shrub). Whilst the mature brownfield communities are typically the most diverse for plant life, once a brownfield enters the next successional phase, dense scrub starts to dominate, diminishing the diversity of plant species, lowering the potential of the habitat for invertebrates.

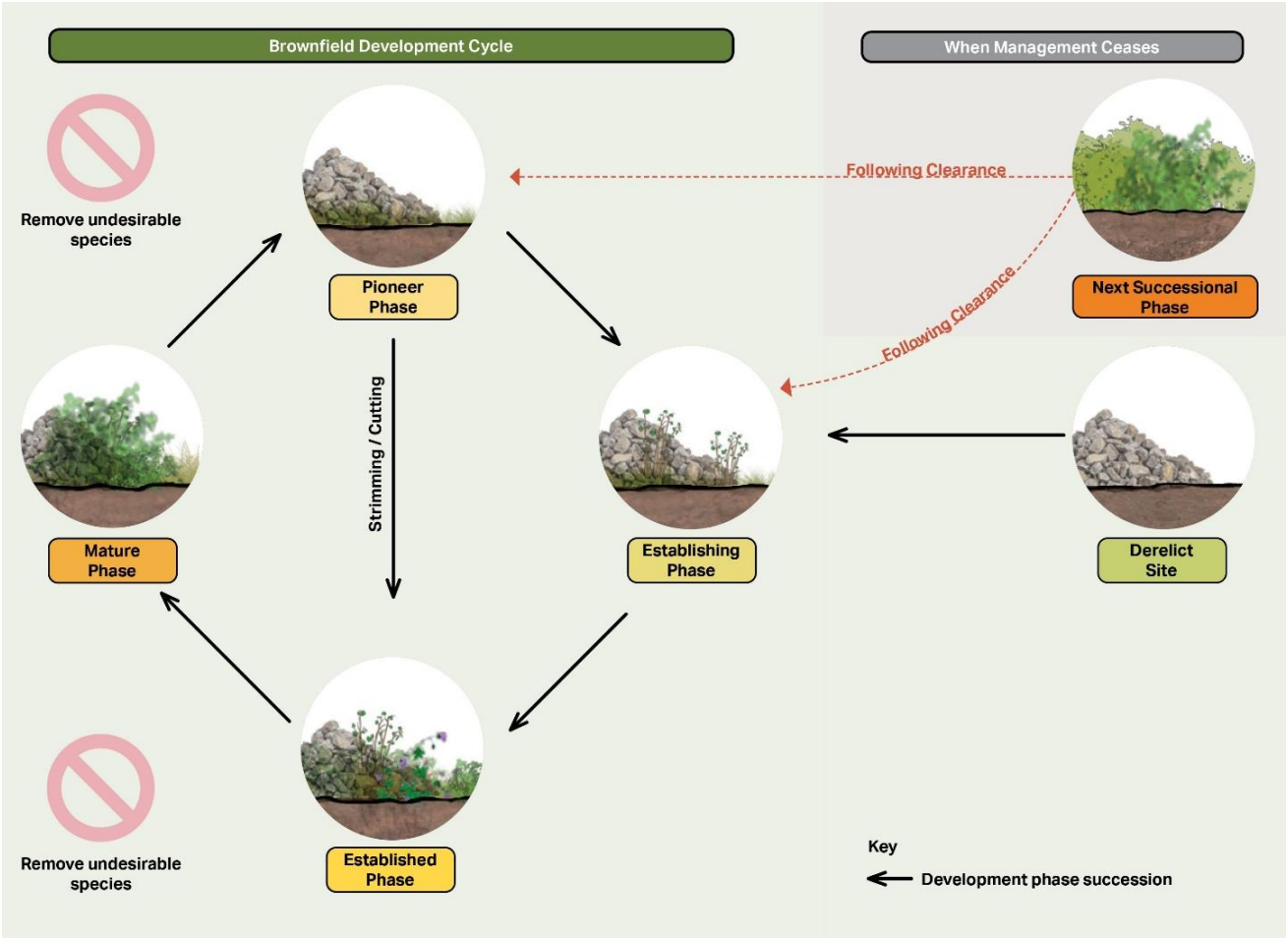


Figure 32 – Phases of the brownfield development cycle and management process

The following management interventions should be carried out where certain phases start to dominate across the site:

Table 6 - Management techniques for brownfield habitat

Technique	Method	Timing
Shrub clearance	Where shrubs surpass 20% cover of the entire site, clearance should be undertaken (e.g. mature phase or next successional phase). Refer to the Heathland and Shrub Design and Management Guidance Note for guidance on clearing shrub. Where shrub has established on mounds or in depressions, it should be removed using hand tools.	September to end of March
Strimming / cutting	Where annual and perennial herbs and grasses cover more than 20% of the entire site (e.g. established or establishing phases), a proportion of this habitat should be cut back to retain a balance of development phases. This should be undertaken on an ad-hoc basis, when certain plant communities start to dominate across the site. Refer to the Grassland Design and Management Guidance Note for guidance on cutting. However, strimming or hand tools may need to be used on brownfield habitats, where larger substrates don't allow for machine use.	July to September
Exposing substrate	Where bare ground or pioneer communities covers less than 20% of the entire brownfield habitat, the vegetation of dominant development phases should be cleared, and substrate exposed. Vegetation should be cleared using the methods outlined above. Substrate should then be scarified where possible. Scarifying can be undertaken using a scarify disc or a chain harrow.	Where possible, scarifying should be undertaken in autumn.

NOTE: *Effects on protected species should be considered before undertaking brownfield habitat management. A suitably qualified Ecologist should be consulted on the ongoing management works to ensure they are carried out sensitively. For example, loose rubble on a site may act as hibernacula for common reptiles.*

Figure 33a illustrates how development phases may occur across the lineside.

Creating and maintaining a mosaic of development phases across the site is integral to enhancing biodiversity over time. Figure 33b illustrates how each mosaic transitions to a new development phase over time. In this example, the next successional phase becomes dominant, covering approximately 40% of the site. In line with the site management plan, clearance of all vegetation and exposing of the substrate would be recommended to re-establish a pioneer community within the site's brownfield habitat as illustrated in Figure 33c.

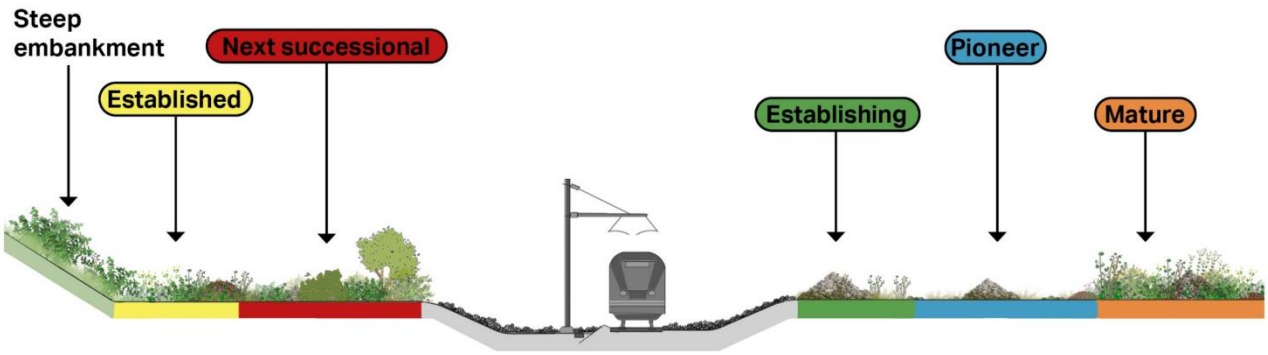


Figure 33a – Section illustrating ideal variation in development phases across a lineside site

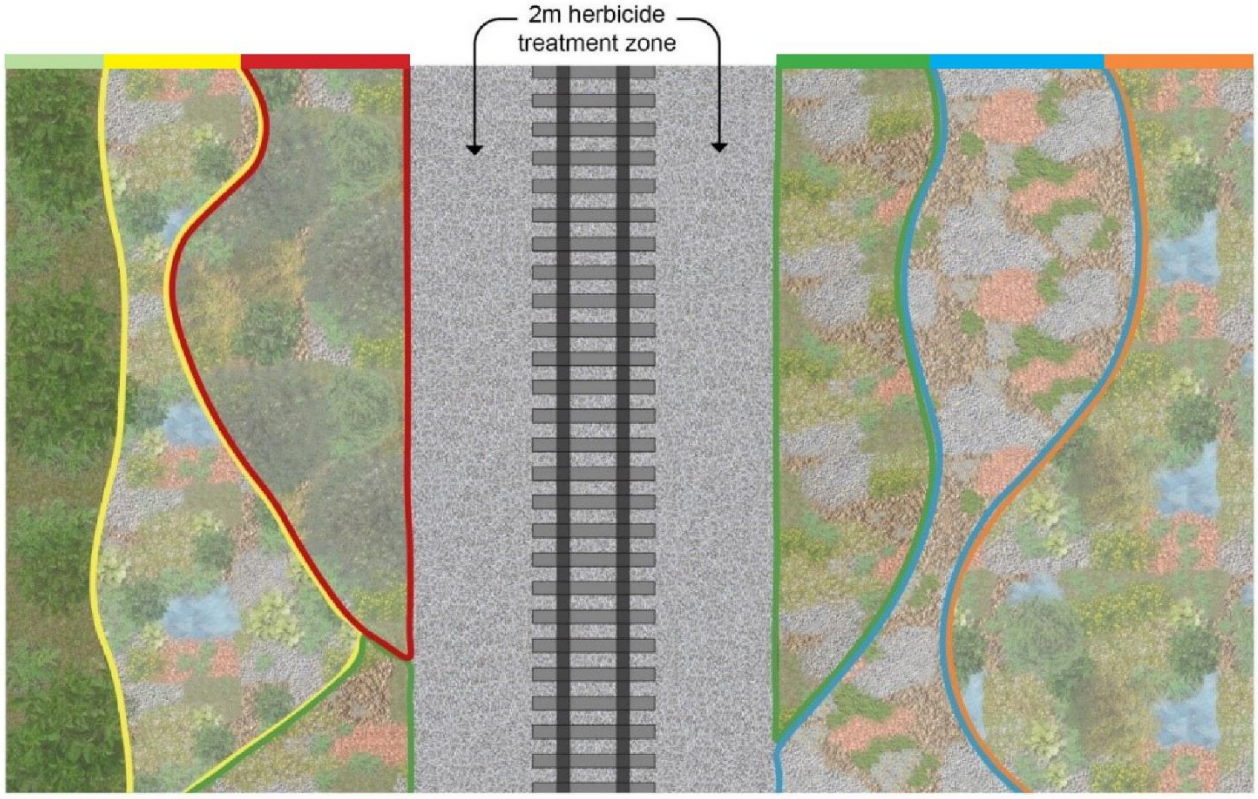


Figure 33b – Plan view illustrating ideal variation in development phases across a lineside site

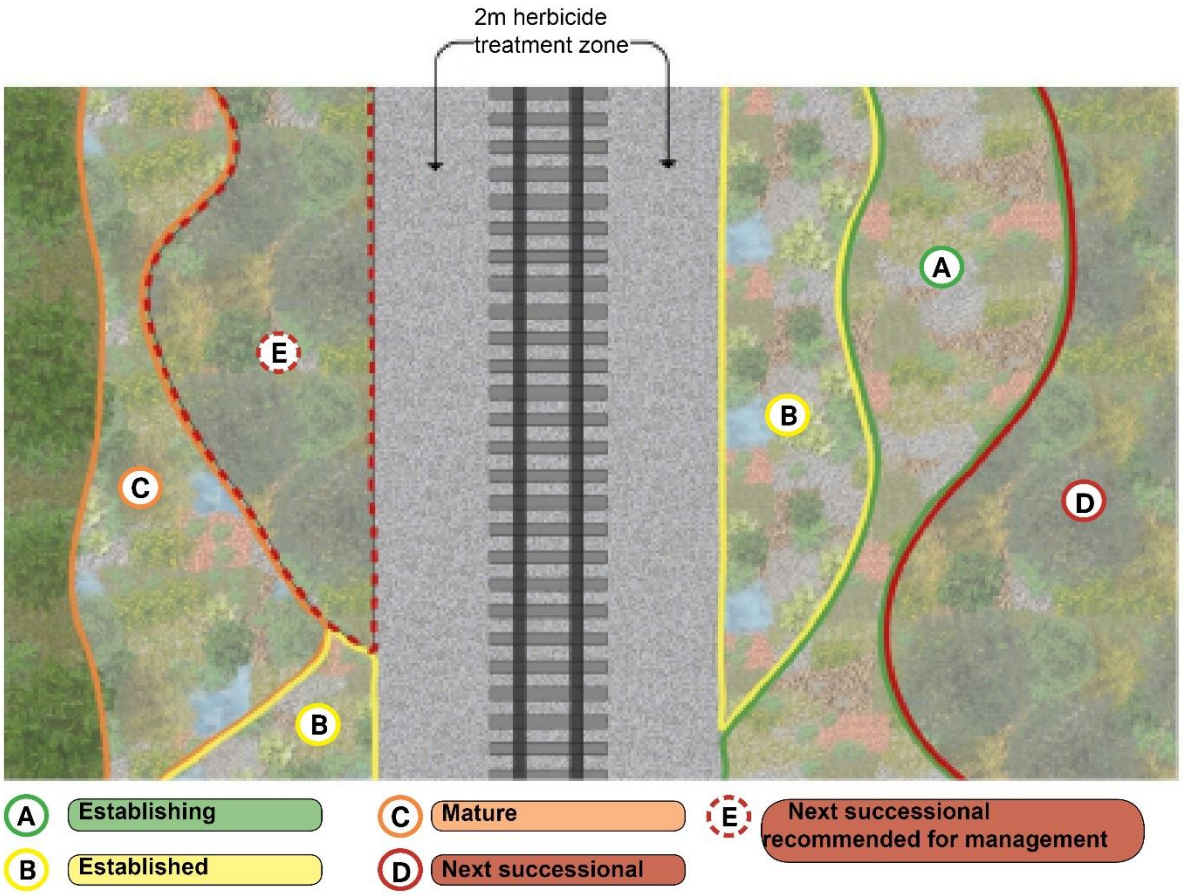


Figure 33c – Plan view illustrating ideal variation in development phases across a lineside site

8.6.2 Monitoring and inspections

Brownfield habitat should be inspected and monitored after the establishment period, at least once every three years by a suitably qualified professional. Table 7 outlines the different types of monitoring and inspections that should be undertaken for brownfield habitat.

Table 7 Monitoring and inspections for brownfield habitats

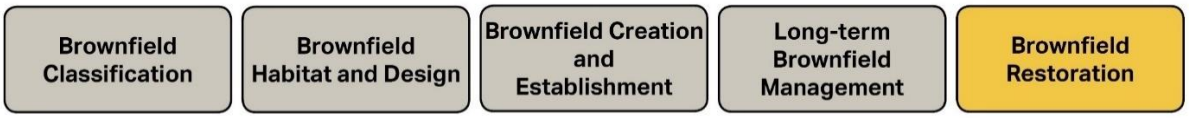
Inspection type	Approach	Frequency
Establishment monitoring	Determine whether the sub-habitats present within the brownfield habitat are developing in-line with the objectives outlined within the site's habitat management plan.	Once annually.
General inspections	Monitor the success of brownfield habitat establishment against the specification, inspect for signs of damage and disease.	Once annually.
Botanical surveying	Habitat and botanical surveys should be undertaken for each site, prior to flowering herbs being cut back. Using baseline data as a reference for comparison, monitoring	At least once every three years – April to September.

	would assess change in botanical communities as a proxy for biodiversity.	

As most of the vegetation communities of brownfield are likely to comprise annual and perennial herbs, the guidance on monitoring and inspections for grasslands in the Grassland Habitat and Design Guidance Note is relevant for most brownfield habitats.

NOTE: *For information relating to establishment and long-term management monitoring and inspections, refer to the Routine Maintenance Schedule in the schedule folder.*

8.7 Brownfield Restoration



This section provides guidance on how to successfully restore brownfield habitat in the lineside once shrub or woodland vegetation dominates the habitat (i.e. it has reached the next successional phase). If shrub or woodland vegetation covers more than 50% of a brownfield site, restoration should be considered to re-establish a variety of different plant communities and development phases.

Areas of shrub identified on previously developed land (i.e. land formed of hardstanding and inorganic substrates) should also be considered for restoration. Re-establishing brownfield mosaics through restoration will lead to diverse plant and invertebrate communities re-colonising.

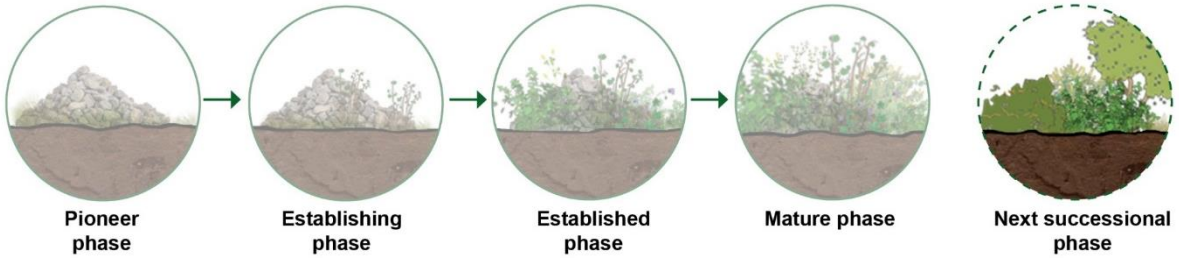


Figure 34 – Phases of brownfield development cycle: applicable to brownfield next successional phase

Best practice suggests the following general principles should be applied:

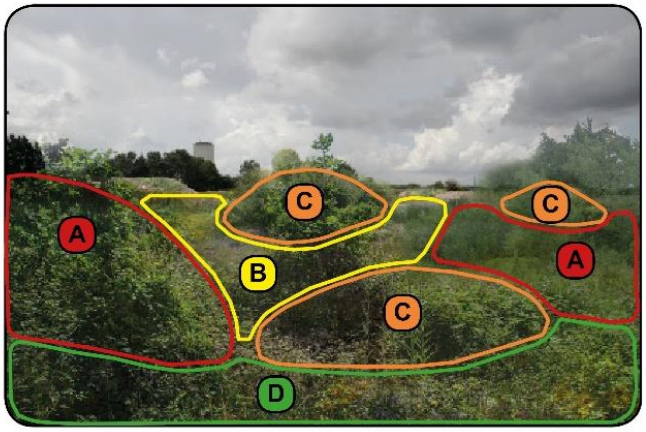
- Undertake removal of shrub and trees where appropriate to restore brownfield or open mosaic habitat;
- Move existing substrates and add finer aggregates, where structural diversity has diminished, as per Section 8.4.3.
- Consider seeding or plug planting to accelerate restoration, particularly if large areas of substrate have been exposed;
- Organising toolbox talks for site staff on maintenance protocols, including recording and reporting on suspected cases of pests and diseases;
- Remove all arisings once vegetation is cut to prevent the soil or substrate becoming more fertile; and,
- Updating the HMP to ensure the brownfield habitat will be maintained and enhanced as a brownfield habitat, providing emphasis on the management required for each sub-habitat component is of the mosaic.

8.7.1 Restoration approaches

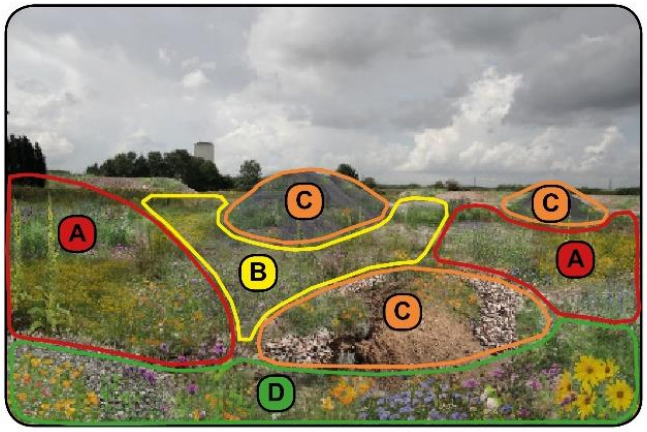
Restoration involves reversing the process of succession to ensure the range of development phases found within the brownfield habitat are equally balanced. This is intended to enhance the habitat's biodiversity. It is important that brownfield restoration is only undertaken if 'Restore' is the Preferred Habitat Management Objective (see Section 8.4.2).

The techniques outlined in Figure 35 should be followed to restore brownfield habitat.

Following shrub clearance, aim for a balance of development phases (i.e. no more than 20% of each phase):



Example of brownfield habitat requiring restoration.



Example of biodiverse brownfield habitat.

A Shrub clearance

The shrub clearance approach outlined in Section 8.6.1 should be undertaken for all areas, allowing for a small percentage of shrub to be retained.

B Scarify

Scarifying of substrate as per Section 8.6.1 should also be considered for a proportion of the site to encourage flowering herbs to re-establish.

C Create mounds and depressions

The shrub clearance approach outlined in Section 8.6.1 should be undertaken for all areas, allowing for a small percentage of shrub to be retained.

D Reseeding

On scarified areas, seed may need to be re-sown. Follow the method outlined in Section 8.4.6.

Figure 35 – Example of a brownfield habitat requiring before and after restoration

NOTE: *Effects on protected species should be considered before undertaking brownfield restoration. A suitably qualified Ecologist should be consulted on the ongoing management works to ensure they are carried out sensitively.*

8.7.2 Lineside management considerations

Restoration of brownfield is likely to result in significant amounts of green waste arisings from cleared shrub. Appropriate machinery should be used to remove the waste from site and dispose of it within a green waste disposal centre, where possible. It is essential that green waste is removed from site, to ensure that no decaying vegetation is present on site, which would ultimately lead to the substrates becoming more fertile encouraging growth of undesirable species.

9 Sources of further information

9.1 Urban and brownfield references

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McGill, J. (2018). *Management and creation of open mosaic habitat for invertebrate conservation.* London: University of East London.

9.2 Figure References

Figure 3 Typical urban woodland:

Otford Railway Station 2 © Ravenseft, 2008 (CC-BY-SA-2.0-UK)

https://commons.wikimedia.org/wiki/File:Otford_Railway_Station_2.jpg

Figure 12: Examples of non-native species of benefit to biodiversity which can be used within urban habitat:

Californian poppy © Couleur, Pixabay (Pixabay Licence)
https://pixabay.com/photos/search/eschscholzia%20californica/

Wildflower meadow in Manor Park © Marathon, 2013 (CC BY-SA 2.0)
https://www.geograph.org.uk/photo/3015138

Rosmarinus officinalis © Wikipedia Commons (CC BY-SA 4.0)
https://upload.wikimedia.org/wikipedia/commons/9/99/Rosmarinus_officinalis_10zz.jpg

Olearia avicenniifolia on Stewart Island © Wikipedia Commons (CC BY-SA 4.0)
https://en.wikipedia.org/wiki/Olearia_avicenniifolia#/media/File:Olearia_avicenniifolia.jpg

Strawberry tree © Pixabay (Pixabay Licence) https://pixabay.com/photos/strawberry-tree-fruit-tree-leaves-4586385/

Catalpa bignonioides inflorescence © Wikipedia Commons (CC BY-SA 4.0)
https://commons.wikimedia.org/wiki/File:Catalpa_bignonioides_inflorescence.jpg

Figure 19: Example of INNS associated with brownfield sites

Giant hogweed © Scottish Invasive Species Initiative, 2018 (CC BY 2.0).
https://www.flickr.com/photos/sisi-project/48917447233/in/photolist-2hwEGND-2hwJyqT-2hwHxcX-2hwEHtX-2jvx9wm-2hwJtN6-2hwHskx-2hwHrFX-AYACoK-286Aeg2-6oMjTF-6oMjux-6oRtWE-6wW7zH-fHZaXB-6wW2aZ-TmKNK7-RJAia6-fHZ8dt-2fv1wPg-qyXSHT-fJgFiu-6wW6bK-6x1aCu-6wW4Mp-24TrDjP-csDYH1-5qWcYo-5qWdpA-asB1pv-89ms73-2h6tjJ9-2e77v1e-fHZ9LH-fsMDPx-2ep3h61-

TmKGvy-24TrUpZ-fa6mtj-fa6kQw-daYB3Q-6wqJBX-2jf9jUn-2jh3dLS-5o7oQc-daYzQx-ft31FU-ft31g9-fa6m9S-6wuR1m

Japanese rose © Robin Webster, 2019 (CC BY-SA 2.0).
https://www.geograph.ie/photo/6253701

Himalayan balsam © Evelyn Simak, 2017 (CC BY-SA 2.0).

https://www.geograph.org.uk/photo/5454648

Monbretia © James Emmanus, 2015 (CC BY-SA 2.0).
https://www.geograph.ie/photo/4683534

Three cornered garlic © Anne Burgess, 2020 (CC BY-SA 2.0).
https://www.geograph.org.uk/photo/6495146

Variegated yellow archangel © Patrick Roper, 2017 (CC BY-SA 2.0).
https://www.geograph.org.uk/photo/5340899

Figure 20 Example of pests and disease:

Aphids © Wikipedia Commons (CC BY-SA 4.0).
https://commons.wikimedia.org/wiki/File:Aphids_May_2010-2.jpg

Oak processionary moth © Wikipedia Commons (CC BY-SA 4.0).
https://commons.wikimedia.org/wiki/File:(2022)_Oak_Processionary_(Thaumetopoea_processionea)_(36319090925).jpg

Ash dieback © Adrian Diack (CC BY-SA 2.0).
https://www.geograph.org.uk/photo/6495996

A.1 Indicative ballast-sand planting specification trialled on the Kent Pilot

Latin name	Common name
Achillea millefolium	Yarrow
Aster oblongifolius	Michaelmas daisy
Campanula persicifolia	Peach-leaved bellflower
Chrysanthemum leucanthemum	Ox-eye daisy
Chrysanthemum (Glebionis) segetum	Corn marigold
Cirsium vulgare	Spear thistle
Corydalis flexuosa, lutea	Blue corydalis, fumewort
Diplotaxis tenuifolia	Wall Rocket
Dipsacus fullonum	Teasel
Echium vulgare	Vipers bugloss
Galium verum	Lady's bedstraw
Hyssopus officinalis	Hyssop
Knautia arvensis	Field scabious
Linaria purpurea	Purple toadflax
Linaria vulgaris	Common toadflax
Malva aclea	Greater musk mallow
Malva moschata	Musk mallow
Malva sylvestris	Common mallow
Papaver atlanticum	Atlas poppy
Papaver rhoeas	Common poppy
Primula veris	Cowslip
Salvia pratensis	Meadow clary
Scabiosa columbaria, comosa	Scabious
Silene armeria, S. latifolia	Campion
Sonchus arvensis	Field sow thistle
Tanacetum vulgare	Tansy
Verbascum chaixii	White nettled leaved mullein
Verbascum lychnitis	White mullein
Verbascum phoeniceum	Purple mullein

A.2 Sowing densities and substrate depth of brownfield habitat (Hitchmough, 2017)

Information	Section in book	Summary
Substrate depth	Page 187, 'Seed mix design, implementation and initial establishment': *A sowing mulch is a layer of weed-seed-free mineral or organic debris material spread on top of the soil to inhibit the generally massive weed seed bank (up to 50,000 viable seeds/m² in the top 100mm of soil) from germinating and emerging among the sown seed. When the firmed sowing mulch layer is a minimum of 75mm deep, very few of these weed seeds are able to emerge and compete with sown species. Those that do are mainly large-seeded grasses like false oat grass, Arrhenatherum elatius, and generally numerically few.*	75mm minimum depth of substrate in order to suppress weeds. 50mm has very little effect on preventing weed growth. For optimum results 100mm is best.
Seedling densities	Page 175, 'Seed mix design, implementation and initial establishment': *For many small to medium herbaceous plants, a sown target of approximately 100 seedlings/m² is a reasonable starting point. Where maintenance will be limited, you might want to go to 200 seedlings/m2, but that will result in the loss of many of the slower growing species through increased competition. Where there is maintenance and the aim is to develop sown communities that have the much more varied surface topography associated with planted vegetation, you might want to go as low as 60-70 seedlings/m².*	If designing own seed mixes: Need 3 pieces of information: Seedling target per m² Number of seeds in a gram of seed Approximate field emergence (ie. How many seeds successfully germinate) For seedling target per m²: 100 seedlings/m² for small to medium herbaceous plants High density seeds: 200 seedlings/m² for plantings where maintenance is limited, species that grow slowly or are small, less shade tolerant, highly attractive or long flowering. 60-70 seedlings/m² for a varied surface topography

		with maintenance, species which are fast growing, less attractive, large or flower for a shorter time. Divide seedling density by number of species in plant mix to give the density of each species in the mix. e.g. 100 seedlings per m^2/ 20 species = 5 seedlings per species