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Landscape Institute Technical Information Note

Connectivity and Ecological Networks

Technical Information Note 01/2016

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Contents

This Information Note introduces connectivity and ecological networks within the context of landscape planning, design and management and should assist discussions members typically hold with professional ecologists.

1. Introduction

1.1 For a variety of reasons, people and organisms need to be able to move through the landscape and to do so at different scales. Many landscapes are patchy, with areas that are favoured by organisms or people separated by less favoured ones. Connectivity describes the extent to which favoured areas are linked up.

1.2 For many species, this linking is often provided by linear features such as hedgerows or river corridors, which then enhance movement across the landscape. The combination of favoured areas and linking features is called an ecological network.

1.3 This Technical Information Note introduces connectivity and ecological networks within the context of landscape planning, design and management.

1.4 The Note examines the evidence for benefits resulting from increasing landscape connectivity, and considers some of the possible risks that increasing connectivity may bring. It also highlights how connectivity can be modified as part of the landscape design process.

1.5 Although much of the material contained within this Note is suitable to be widely adopted as guidance, the Note is at this stage for information only and should not be considered as a substitute for obtaining advice from a professional ecologist during the design process.

2. Why consider connectivity?

2.1 The impact of fragmentation and severance on biodiversity

2.1.1 The decline in biodiversity in the UK has been caused largely by habitat loss driven by changing land use [2]. Habitat loss not only reduces the total habitat area, but also usually fragments the remaining habitat. What remains are often small and scattered **habitat patches**, such as remnants of woodland or heathland, sitting within a wider landscape of less suitable habitat, termed the **matrix**, such as intensive agricultural land or urban areas.

2.1.2 Barriers such as fences and motorways can also deny some species freedom to move between patches. Such disconnection of habitats is termed **severance**.

2.1.3 Species vary in their ability to use and successfully cross the matrix between their favoured habitat patches [3] and to cross barriers.

2.1.4 Populations of species can become isolated in small gene pools due to fragmentation. These small isolated populations are less likely to survive and isolated habitat patches are less likely to be recolonised.

2.1.5 This situation is often exacerbated by climate change, which is altering the geographical range in which species can survive and putting pressure on some species to move [4].

2.2 The impact of fragmentation and severance on ecosystem services

2.2.1 As a society, our health, wellbeing and economy depend upon sustaining the ecosystem services we obtain from biodiversity within ecosystems.

2.2.2 Fragmentation can affect the supply and flow of different ecosystem services to people, such as the ability to go for a healthy walk in green surroundings. Linear infrastructure such as railways, motorways and rivers can sometimes limit physical access to areas offering some ecosystem services. However, in other situations, for example in relation to recreational services, they may help to increase access.

2.2.3 The function of linear habitats such as river corridors and railway lines in terms of connectivity or severance therefore depends on their position in the landscape relative to other habitat patches and linear elements, and the species concerned.

2.3 Connectivity and the Ecosystem Approach

2.3.1 Recognition of the impact of fragmentation, severance, the challenge of climate change and the need to manage often conflicting societal needs has led to a more integrated landscape-scale approach to conservation and land management [5-7] and interest in nature-based solutions to societal and environmental problems.

2.3.2 The Ecosystem Approach is an approach to landscape management that recognises the interdependence of the goals of economic development, social development and environmental protection. This approach aims to involve the whole of society in decisions about the management and use of natural resources.

2.3.3 Because of their areas of expertise and the opportunities presented on sites of all sizes, landscape professionals are in a key position to enhance habitat management, networks and connectivity for both ecological and wider societal benefit.

2.3.4 For further information about the Ecosystem Approach and Ecosystem Services see the Landscape Institute Technical Information Note on the subject.

3. Ecological networks

3.1 Green infrastructure as an ecological network

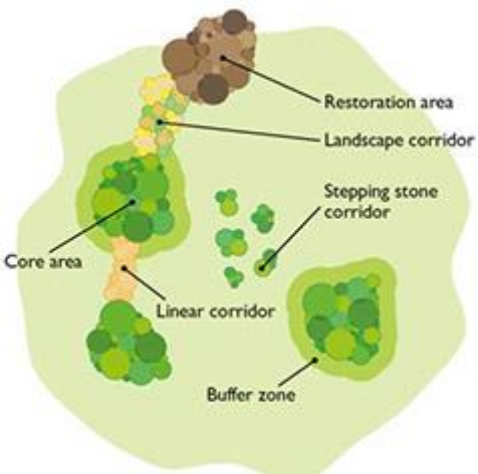
3.1.1 Green infrastructure is the **network** of our natural, semi-natural and man-made green spaces, such as parks, gardens, allotments, river banks, cycle paths, woodlands, tree belts, green roofs, green walls, green bridges and urban street trees, that support natural and ecological processes [8], as well as providing benefits for human health and wellbeing.

3.1.2 The Landscape Institute has published a Position Statement on Green Infrastructure which explains this concept more fully. Green infrastructure can provide a means for enabling wildlife and human movement through less suitable matrix and across barriers.

3.1.3 The components of an ecological network can include many different component of green infrastructure:

- **Core nature areas** are areas of high quality habitat that are managed primarily for biodiversity conservation, whether or not they are protected. These form the 'nodes' in the ecological network.
- **Stepping stones** or **stepping stone corridors** are smaller areas of quality habitat that are intended to aid movement of individuals by serving as islands of favourable habitat in between larger core nature areas. These are also 'nodes' in the ecological network.
- **Landscape corridors** are linear elements of quality habitat, containing elements of the favoured habitat, that connect the core nature areas and stepping stones. These corridors form the 'edges' in the network that link the nodes.
- **Linear corridors** are linear elements of connecting habitat, normally narrower or less varied than landscape corridors, and therefore often suited to movement alone. These also form 'edges' in the network.
- **Restoration areas** are degraded areas where management is focused on restoring habitat that might become core nature areas or corridors.
- **Buffer zones** are transitional areas situated between habitat and the matrix, with a land use that is intended to reduce the impact that the matrix has on the habitat area.

Figure 1. An ecological network. Reproduced from Lawton (2010).



3.2 Ecological networks and connectivity

3.2.1 The 2010 "Lawton" report to Government proposed that England's wildlife areas need to be 'more, bigger, better and more joined' if they are to form a coherent and resilient ecological network [6]. The 'joined' aspect of ecological networks (its connectivity) promotes the ability of individuals to move across landscapes.

3.2.2 The Government's response to the Lawton report was set out in the Natural Environment White Paper [9] and included Nature Improvement Areas (NIAs), with 12 pilot projects funded April 2012 - March 2015. NIAs aimed to create more joined up and resilient ecological networks, with multiple benefits resulting for wildlife, society and the economy.

3.2.3 Creating more resilient landscapes by increasing connectivity is a widespread aspiration in national and international planning and conservation guidance [10, 11]. Increasing connectivity is the most frequently recommended conservation action for adaptation to climate change [7]. However, it is important to be clear about objectives to ensure that promoting connectivity will have the desired impact [12, 13].

4. Different aspects of connectivity

4.1 Structural connectivity

4.1.1 Given the description of an ecological network, it might appear that connectivity is simply the extent to which habitat patches in the landscape are linked physically. This **structural concept** of connectivity views the landscape from a human perspective at human spatial scales. It is relatively straightforward to understand, measure and communicate. However, it does not consider how people and organisms actually move through and use the landscape, or the consequences of these movements for ecosystem functions and services.

4.2 Functional connectivity

4.2.1 Ecologists usually define connectivity as "the degree to which the landscape facilitates or impedes movement among resource patches" [14]. This **functional concept** of connectivity (also known as behavioural or habitat connectivity) includes the combined effects of both the physical configuration of elements in the landscape and the behaviour of a particular species in that landscape [15, 16]. Behaviour includes the species use of, responses to and movements within different landscape elements and also their reactions to boundaries between habitat and non-habitat [15].

4.2.2 Different species vary in their ability to move successfully through the matrix and corridors between their habitat patches. Some species will not move at all through the matrix, while others may move relatively freely, but may be unable to cross hard barriers such as fences or roads. This means that the same landscape will have different levels of functional connectivity for different organisms [15].

- Structural connectivity can exist without functional connectivity, such as when a particular species does not move through the corridors between habitat patches. This may be the case for some plant species, such as ancient woodland flora with poor dispersal abilities.

- Functional connectivity can exist without structural connectivity if a species is able to use and move successfully through the matrix between habitat patches. This can be the case for species with relatively generalist habitat requirements such as badgers or highly mobile ones such as many bird species. However, the habitat patches must be relatively close together in relation to the species' movement abilities.
- Structural and functional connectivity are synonymous if a species tends to move only within habitat patches and along physically connected habitat corridors. This is the case for species with very specific habitat requirements and relatively limited mobility such as dormice and water voles.

4.2.3 Movement of organisms includes:

- Relatively restricted movements of individuals during their day-to-day activities (e.g. foraging, seeking shelter, seeking mates and flight from threats).
- More wide-ranging one-directional movements by individuals (e.g. the dispersal of individuals, seeds and spores).
- Wide-ranging return movements of individuals and populations (e.g. seasonal migration).
- Slower, long-term shifts in population range over multiple generations due to external factors such as human pressures and changing environmental conditions.

4.2.4 Different species have different habitat requirements and will perceive and respond to a landscape at different spatial scales. Consider for example the different habitat needs and movement ranges of lowland juniper, white-clawed crayfish and peregrine falcons. Different types of habitat patches within an ecological network will be specific to different groups of species. Indeed, what may be the matrix or barrier for some species could be habitat for others. So, both the components and connectivity of an ecological network may be experienced very differently by different species.

4.2.5 Functional connectivity is therefore species- and context-specific [1, 15]. This can make it challenging to measure functional connectivity and to meet the connectivity needs of all people, species and processes within any one landscape.

5. Benefits and risks to biodiversity

5.1 Benefits to biodiversity

5.1.1 Most of the research into the benefits and potential risks to biodiversity of increasing connectivity has examined the effects of corridors. Existing corridors generally promote species movement in fragmented landscapes [17]. This has been shown for butterflies and birds [18, 19].

5.1.2 Corridors have been shown to increase plant biodiversity both in main habitat patches [20] and also in neighbouring habitats, a process termed a ‘spillover effect’ [21].

5.1.3 Corridors also promote pollination across habitat patches by promoting the movement of pollinating insects [22].

5.2 Risks to biodiversity

5.2.1 Despite the overall conservation benefits of increasing connectivity, there are some potential risks that it is important to consider in planning and design.

5.2.2 The main potential risks to biodiversity within the UK are edge effects causing increased mortality within corridors, increased predation and the spread of invasive species and disease.

5.3 Edge effects

5.3.2 Fragmentation increases the amount of edge between habitat and the amount of matrix habitat that species experience. Environmental conditions and species interactions differ at the edge compared with the core of a habitat and this can have a negative impact on populations of species. Corridors have high edge to area ratios, so there is concern that corridors might act as sinks (traps) for some species, whereby species moving along corridors are exposed to higher rates of mortality. There is limited empirical evidence to support this, although sink effects have been recorded for bees and wasps on continental Europe [23].

5.3.2 A review of studies that considered edge effects of corridors found eight studies where corridors had some negative effects on target species due to edge effects, six with positive effects, and eight with no effect [24]. The effect of edges is the only negative effect of corridors that has been shown to reduce the population size or persistence of target species.

5.4 Predation

5.4.1 There have been concerns that increased predation on a particular species of conservation concern might occur because of edge effects or through increased connectivity for predators.

5.4.2 In studies that considered the impact of predation, ten found neutral or positive effects of corridors, while seven found that corridors increased predation rates on the target species or the abundance of predators of the target species [24]. Most of the studies where there was a negative effect involved plant seed predators or parasites. However, bird nesting success can also be adversely affected in edge habitats, especially for certain habitats such as wetlands and deciduous woodlands [25].

5.5 Invasions by exotic species and disease

5.5.1 Just as corridors can enhance movement of species of conservation concern, they can also increase routes of access to invasive species, pests and disease.

5.5.2 Haddad and colleagues [24] argue that introducing corridors seems unlikely to worsen existing invasions by exotic species in most circumstances, since invasive species in terrestrial systems are usually good dispersers. There was no evidence from six studies that corridors increase exotic invasions [24].

5.5.3 The spread of infectious disease is related to the distribution of hosts and the structure of habitat that the hosts occupy. In certain situations, the spread of disease has been linked closely to habitat structure. For example, the early spread of myxomatosis among rabbits in Australia was through river corridors [26]. However, in many cases, host density seems to be more important than habitat structure in determining the spread of disease [26], and the relative importance of different factors will depend on the transmission characteristics of the disease of concern.

5.5.4 In aquatic systems, promoting connectivity, such as by removing dams, does have the potential to increase the dispersal of invasive species [27]. Intentionally reducing connectivity to halt the dispersal of invasive species can therefore be an effective conservation strategy in aquatic systems [27]. This has been used to protect native brown trout populations in parts of the Rocky Mountains and to prevent invasive carp in Australia reaching spawning grounds.

5.5.5 The relative merits of introducing or removing movement barriers will usually need to be evaluated on a case-by-case basis [27], by considering the characteristics of the matrix, the proposed changes and the particular invasive species of concern.

5.6 Relative importance of benefits and risks

5.6.1 A review of 33 studies concluded that the conservation benefits of corridors outweigh their potential costs [24], and that there are no consistent negative effects.

5.6.2 There is still a lack of studies at larger spatial scales that evaluate the effect of corridors on population persistence, rather than just species presence or movement in corridors [24].

6. Connectivity and ecosystem services

6.0 The movement and distribution of people, organisms and materials (such as nutrients, water, soil and pollutants) will have varying impacts on ecosystem service provision [28].

6.1 Supply of ecosystem services

6.1.1 Increased connectivity can directly increase the supply of ecosystem services [28]. For example, adding non-crop habitat margins to fields can support the movement of natural predators of pest species into the crops and therefore increase pest regulation [29].

6.1.2 Increased connectivity can also indirectly increase ecosystem services through effects on biodiversity and ecosystem function [28]. For example, the regulation of insect pests of crops depends on the variety and quantity of predators and parasites of these pests, which in turn are affected by the connectivity of non-crop habitats [29].

6.1.3 Generally, the effect of habitat fragmentation in reducing connectivity will have a negative effect on the supply of ecosystem services, for example through decreasing populations of pollinator species [30].

6.1.4 Sometimes, reduced connectivity increases the supply of certain ecosystem services from the matrix [31]. For example, severance of a woodland by a road could improve public access to the woodland and result in an increase in cultural ecosystem services, with more people enjoying recreation in the woodland. However, for designated sites, this effect may in itself have a detrimental impact on biodiversity and conservation objectives.

6.1.5 Ecosystem Services are discussed further in TIN 02/2016

7 Connectivity as a unifying concept

7.1 Connectivity and conservation

7.1.1 Some ecologists caution that the current enthusiasm for connectivity and ecological networks within policy and practice is not supported by evidence [1, 32-34]. Arguments include:

- There is a lack of precise definitions and practical evidence regarding the implementation of ecological networks [1].
- Actions to improve connectivity may be relatively less effective than alternative investments for biodiversity conservation [32].
- Evidence of the benefits of connectivity is limited, and there is more evidence to support the beneficial effects of increasing the area of high quality habitat, prioritising areas of high heterogeneity, and controlling threats to habitat, in supporting the viability of populations [32].
- Connectivity could be increased co-incidentally while increasing habitat area and improving habitat quality [32].

7.2 Differing approaches by landscape professionals and ecologists

7.2.1 Some of the mismatch between the perception of ecological networks in practice and research has been attributed towards a difference in approach and attitude taken by landscape professionals and ecologists (Table 1) [33].

7.2.2 The training which landscape planners and designers have received may make them more likely to focus on the structural features of landscapes and to interpret ecological networks as a design to be achieved [33]. In contrast, ecologists tend to focus on the functional aspects of connectivity for particular species and processes. They are more likely to approach ecological networks as a way of thinking to inform decision making [33].

Table 1. Different goals, emphases and units between ecologists and environmental planners in Ecological Network strategies. Adapted from Battisti [33].

	Ecologists	Landscape planners
Main goal is…	Conservation actions towards biodiversity targets affected adversely by habitat fragmentation.	Design of an ecologically based plan with areas characterized by specific rules and planning measures.
Emphasis on…	Complexity and dynamics of ecological systems; long-term analyses; ecosystems as 'open' systems.	Synthesis aimed to design a pattern of Ecological Network units; short-term analyses; ecosystems as 'closed' systems.
Ecological Network units correspond to…	Ecological and functional units referred to specific targets (e.g. species).	'Closed' units on the map with a specific regime of conservation or planning legislation.
An Ecological Network is mainly…	A way of thinking.	A design.

7.3 A unifying concept enabling collaboration

7.3.1 Corridors, connectivity and ecological networks are examples of 'boundary objects' that have different specific meanings in scientific and non-scientific domains [35-37], but can be useful in bringing together people with different backgrounds in policy and practice [36].

7.3.2 When appropriate, depending on the objectives of a particular scheme, spatially explicit social and economic data such as public values and preferences can be combined with ecological data to inform connectivity planning [38]. Rather than focusing on biophysical, social and economic systems separately, it is also possible to use network science as a unifying concept to bring different evidence and viewpoints together [39].

8. Modifying connectivity in design plans

8.0 Landscape professionals have considerable opportunity to influence functional connectivity across a landscape. Actions taken with the intention of increasing connectivity as part of an ecological network (Fig. 1) include:

- Creating new **corridors** or improving the quality of existing corridors between habitat patches (section 8.1).
- Creating new **stepping stones** or improving existing stepping stones between habitat patches (section 8.2).
- Changing aspects of the **matrix** to improve permeability, use and to reduce mortality for particular species (section 8.3).
- Introducing **buffer zones** around core habitat patches (section 8.3).

8.1 Corridors

8.1.1 Corridors are usually defined as an area of habitat that is longer than it is wide connecting two or more habitat patches that would otherwise be isolated within a non-habitat matrix [17]. Occasionally, the term corridor is used to refer to anything in the landscape that facilitates movement [6].

8.1.2 Corridors are often equated with connectivity, although the existence of a corridor does not guarantee that it will function as a conduit for movement, and there are also other landscape elements that influence connectivity (sections 8.2 & 8.3) [15].

8.1.3 Corridors can exist naturally or be created by restoring habitat or constructed through hard barriers (such as wildlife bridges). The term corridor has been used to refer to:

- Greenbelt
- Buffers in urban areas
- Greenways
- Underpasses
- Green bridges
- Habitat alongside roads, waterways or railways
- Wind breaks (vegetative)
- Visual screens (vegetative)
- Hedgerows

8.1.4 Although corridors are usually thought of as movement conduits, they can actually function in six ways [12]. Corridors might function differently during the night compared with the day, because impacts of the surrounding matrix (such as light spill) might affect how well it functions as a conduit.

- Conduit – organisms or materials move along the corridor
- Habitat – organisms survive and reproduce in the corridor

- Filter – only some organisms or material can cross or move along the corridor
- Barrier – organisms or material cannot cross the corridor
- Source – organisms emanate from the corridor into the connected habitat or matrix because reproduction in the corridor exceeds mortality.
- Sink - organisms or materials enter the corridor and are destroyed.

8.1.5 When designing or modifying any landscape element, it is useful to consider the multiple intended aims and to consider how it is likely to function. For example, might a corridor intended to promote connectivity for people or a particular species actually function as a filter or a barrier for another species or process? In such instances, it may be helpful to choose a representative group of species and to follow the principles of the Ecosystem Approach [40] to consider different perspectives and viewpoints.

8.1.6 Completing a corridor design table (Table 1) or running through a checklist of possible aims with an ecologist can help to prioritise relevant species and bring to light any potential conflicts [12].

8.1.7 Greenways created with the primary intention of promoting the movement and recreation of people have the potential to conflict with the movement of some wildlife [12].

8.1.8 Brownfield sites are sometimes planted with grass or ornamental trees for aesthetic reasons [41]. Rather than providing corridor stepping stones, this might result in lower biodiversity value and reduced connectivity for invertebrates that need the open mosaic habitats that some of these sites provide [41].

8.1.9 Corridors only increase functional landscape connectivity if a species or group of species are actually using them to move between habitat patches. There is little evidence about the optimum width of corridors and other attributes needed by different species [42]. However, protecting existing landscape elements that function as corridors is likely to be more effective than creating new corridors [42].

8.1.10 The Landscape Institute has published a technical guidance note on the development of green bridges, which can be important as corridors linking habitats across roads and railways.

8.2 Stepping stones

8.2.1 Stepping stones are patches of habitat that are smaller than the core habitat patches. They are positioned between core habitat patches with the intention of improving functional connectivity by supporting movement through the matrix. Stepping stones may be pre-existing habitat remnants, or they may be created by restoration or improving the quality of existing habitat for particular species.

8.2.2 Stepping stones are likely to be most important for species in situations where the matrix reduces, but does not completely prevent, movement between core patches [43]. The loss of intermediate stepping stones can cause a sharp decline in the distance that can be travelled by species between core habitat patches [44]. Stepping stones can be particularly important in allowing rare long distance dispersal and dispersal across generations, where reproduction occurs between habitats.

Table 1. A corridor design table modified from Hess and Fischer [12], completed for an example for an urban meadow corridor created primarily for pollinator conservation purposes.

Function category	Primary purpose	Secondary purpose	Potential problems and conflicts
Conduit	*Movement of pollinators between flower rich habitat areas.*	*Movement of other grassland invertebrate species*	*N/A*
Habitat	*N/A*	*Cover & food resources for invertebrates and birds.*	*N/A*
Barrier	*N/A*	*N/A*	*Potentially a barrier for dog walkers and other recreational use in the park*
Filter	*N/A*	*N/A*	*N/A*
Source	*N/A*	*Potentially a source of pollinators in longer term*	*N/A*
Sink	*N/A*	*N/A*	*N/A*
Ecosystem services	*N/A*	*Enhancing important ecosystem services such as carbon sequestration, nutrient cycling and soil quality regulation*	*Perceived 'untidiness' of unmown or dead vegetation and wood.*

8.2.3 It cannot be assumed that creating stepping stones will result in functional connectivity for a particular species and compensate for the negative effect of habitat loss and fragmentation.

8.2.4 The size, type of habitat and the distance needed between stepping stones and core habitat patches to ensure functional connectivity will vary depending on the species. For example:

- Stag beetles need very small stepping stone nest sites (piles of logs) less than 1km apart in order for them to colonise new areas [45].
- Bat activity increases in farmland matrix when there is a variety of both linear and patchy habitat such as hedgerows and groups of trees close to larger habitat areas [46].
- Brownfield sites can be very important for invertebrates, as they contain a mosaic of different habitat patches within and between sites that act as an ecological network [41].

8.2.5 Stepping stones can also function as habitat in themselves and supply ecosystem services. For example, stepping-stone meadow patches in urban parks may provide habitat for insects and enhance aesthetics, in addition to promoting the movement of insects between larger habitat patches.

8.3 Softening the matrix and adding buffer zones

8.3.1 The effectiveness of corridors and stepping stones in enhancing movement of individuals can depend on the landscape elements and activities in the matrix [47]. For example, species may be affected by the following activities occurring within habitat patches, stepping stones and corridors:

- Disturbance.
- Pollution (including light).
- Increased predation.
- Changes to species behaviour near the edges of habitat.

8.3.2 ‘Softening’ the matrix involves trying to improve functional connectivity by making the matrix less hostile as an area to move in. In situations where most of the favourable habitat has been destroyed and what remains is already protected, actions to soften the matrix might have the most influence on biodiversity conservation [48].

8.3.3 There are a number of actions that can soften a matrix:

- Change in management to restore and improve the ecological and landscape value of existing habitats such as hedgerows, parkland, wetlands and field margins [46, 49].
- Addition of new areas of landscape elements with a similar structure to the habitat patches of interest [50, 51], such as providing a field corner copse adjacent to hedgerows

linking different woodlands, or providing small ponds to act as stepping stones in between larger ones.

- Reduction of pesticide and fertiliser inputs [49].
- Provision of resources in the matrix for the species of interest, such as providing additional food resource for birds [49], e.g. fruit trees within urban areas or buffer strips as part of agri-environment schemes.
- 'Buffer zones' between the matrix and habitat patches with a land use and management that is intended to reduce negative impacts of the matrix on habitat.

9. Summary

9.1 Actions taken by landscape professionals will influence connectivity. Landscape professionals are in a strong position to reduce the damaging impact of habitat loss, climate change, fragmentation and severance on biodiversity.

9.2 These actions can also have wider benefits, by influencing the provision of ecosystem services that the landscape provides.

9.3 Structural and functional connectivity are different. Functional connectivity relates to ecological processes and its effects will be different for different species.

9.4 Improvements to connectivity will be most effective if carried out in conjunction with other measures to improve habitat quantity and quality.

9.5 Connectivity is not just about the provision of corridors. Other factors to consider include:

- The site as part of the wider landscape, including how actions might affect the functional connectivity at different spatial scales for various species of interest.
- Impact of design or management actions in altering the permeability of the matrix between habitat patches for your species of interest.
- Effect of design or management actions in increasing or decreasing negative impacts of the matrix on existing habitat patches, corridors and stepping stones.
- Ways in which corridors are likely to function as movement conduits, habitats or barriers for different species and processes.
- Effects of design or management actions on supply and flow of ecosystem services to people.
- Trade-offs between the needs of different species and different groups of people.

9.6 Actions such as introducing corridors and stepping stones are not without risks and trade-offs, although in general the benefits to biodiversity usually outweigh the risks.

9.7 A professional ecologist can provide an evaluation of the ecological benefits and risks of improving connectivity in a particular landscape in order to maximise positive outcomes and avoid inadvertent harm.

10. Further resources

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