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Communicating clearly about conservation corridors

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Abstract

Conflicting definitions lead to confusion when people communicate about 'corridors', particularly when they come from different disciplinary backgrounds. Usage of 'corridor' in game management, island biogeography, and metapopulation literature focused on function, namely, the movement of flora and fauna from one area to another. A structural usage of the term arose in the field of landscape ecology as it developed in North America with the matrix–patch–corridor paradigm of landscape structure. 'Corridor' is now used to describe both the structural and functional aspects of linear landscape features, often implicitly, in a wide range of disciplinary literature.

Lack of a clear and consistent terminology leads to confusion about the goals or implied functions of corridors. Consequently, the manner in which corridors should be designed, managed, and evaluated is also unclear. Proper design and management of a corridor depends critically on a clear and explicit statement of its intended functions. If corridors are not designed to perform well-defined functions, the outcome may be disappointing, or even deleterious. The roles corridors play derive from six ecological functions: habitat, conduit, filter, barrier, source, and sink. These ecological functions have been recognized widely and adopted by a number of disciplines, including conservation biology, wildlife management, landscape ecology, and landscape planning.

We review briefly the history of the term 'corridor' in the context of conservation, catalog some of its definitions and uses, review the functions of corridors, and differentiate between the structural and functional aspects of corridors. We reject the notion of defining 'corridor' succinctly, because of the complex and multiple functions a corridor may serve. Instead, we suggest that conservationists and planners consider and document *explicitly* all of the possible functions of corridors when designing them. Addressing explicitly these functions when designing a corridor should eliminate much of the confusion surrounding their roles, and focus attention on establishing design criteria for corridors that function as intended.

Keywords: Conservation corridors; Habitat fragmentation; Metapopulation literature

"Landscape linkages, land bridges, wildlife corridors, greenways, shelterbelts, turkey trots — call them what you will." Chadwick (1991: xxi): "Perhaps the generation of overarching principles for the evaluation and design of corridors could be assisted by the development of more rigorous definitions that reflect the range of potential values of retained areas for nature conservation." Lindenmayer and Nix (1993: 629)

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1. Introduction

Habitat loss and fragmentation have been cited widely as the major contemporary threats to biological diversity as people transform the landscape to accommodate their needs (e.g. Harris, 1984; Wilson, 1988; Saunders et al., 1991; Alverson et al., 1994; McCullough, 1996; Pickett et al., 1997; Fielder and Kareiva, 1998). Corridors have become popular tools in efforts to mitigate fragmentation and conserve biodiversity, but the term is used in ways that can be contradictory and confusing.

Numerous researchers working with corridors have noted that lack of a clear and consistent terminology leads to confusion about the goals of corridors (Saunders and Hobbs, 1991a; Loney and Hobbs, 1991; Simberloff et al., 1992; Lindenmayer and Nix, 1993; Rosenberg et al., 1995, 1997; Hobbs and Wilson, 1998; Bennett, 1999). Consequently, the manner in which corridors should be designed, managed, and evaluated is also unclear. If corridors are not designed to perform a well-defined function, the outcome may be disappointing, or even deleterious. The situation is further confounded when one considers definitions across the several disciplines that use the term: conservation biology, landscape ecology, landscape and urban planning, and landscape architecture.

Some conservation biologists have attempted to define the term 'corridor' succinctly and precisely, often by focusing on a specific function (e.g. Loney and Hobbs, 1991; Beier and Loe, 1992; Simberloff et al., 1992; Rosenberg et al., 1995, 1997). However, because corridors serve a variety of functions at many scales, the concepts and terms associated with them defy simple definition. Many definitions have exceptions and caveats, and corridors designed for one specific function *will* serve other functions, perhaps unintentionally. Further, confusion arises because terms included in the definitions of corridor are often themselves loosely defined or the subject of misunderstanding and debate (e.g. dispersal, habitat).

In this paper, we review briefly the history of the term 'corridor' in the context of conservation, catalog some of its definitions and uses, review the functions of corridors, and differentiate between the structural and functional aspects of corridors. We reject the notion of defining the term 'corridor' succinctly, because of its widespread and varied use by people from many disciplines. Instead, we propose that conservationists and planners consider and document explicitly all of the possible functions of corridors when designing them.

2. Brief history and definitions

Corridors for faunal movement have a relatively long history in game management (Harris, 1984, 1988; Harris and Scheck, 1991). They have been used as a conservation technique since early in the 20th century, particularly for birds (see extensive list of examples in Harris and Scheck, 1991). Indeed, a system of stepping-stone wildlife refuges is central to the migratory corridor planning critical to the restoration of waterfowl populations in North America. Other game species, including tree squirrels and ungulates, also have been the subject of corridor management (Harris, 1988; Harris and Scheck, 1991).

More recently, corridors have been associated with the theories of island biogeography (MacArthur and Wilson, 1967) and metapopulations (e.g. Levins, 1969; McCullough, 1996; Hanksi and Gilpin, 1997). These two theories form the basis for many current approaches to conservation biology, including the use of corridors to enhance the movement of flora and fauna. In island biogeography, the number of species on an island is a function of island size and the rates at which species immigrate to and become extinct on the island (MacArthur and Wilson, 1967). This concept has been extended by analogy to 'islands' of habitat embedded in a hostile landscape. By enhancing the ability of species to move among these islands, corridors increase the rate of species immigration and, thereby, the number of species occupying the island (Willis, 1974; Wilson and Willis, 1975).

In metapopulation theory, individuals of a single species are distributed among multiple patches of habitat — perhaps as a result of habitat fragmentation. The dynamics of a metapopulation are a function of within-population dynamics and among-population movement. Corridors enhance the ability of individuals to move among habitat patches, lowering the expected time to recolonization of a patch that has suffered extinction. Emigrants from well-populated patches may also 'rescue' patches with depleted populations (Brown and Kodric-Brown, 1977). In combination, these phenomenon are believed to reduce the probability of species extinction.

Use of 'corridor' in game management, island biogeography, and metapopulation literature focused on *function*, namely, the movement of flora and fauna. A *structural* use of the term arose in the field of landscape ecology as it developed in North America. Forman and Godron (1981, 1986) introduced the matrix–patch–corridor paradigm of landscape structure, in part because of its utility in describing and analyzing the structure of landscapes as seen in aerial photographs and satellite images (Forman, 1991). In this terminology, a matrix is the most extensive and most connected landscape type, a patch is a non-linear surface area differing in appearance from the matrix, and a corridor is a linear surface area that differs from the matrix on either side. A substantial vocabulary describes the structure, origins, goals, and functions of corridors within this paradigm (Table 1; Forman and Godron, 1981, 1986; Forman, 1995). Many of the corridor definitions we found in the recent landscape ecology, conservation biology, and landscape planning literature are rooted in this terminology and vocabulary.

3. Corridor functions

We found the term 'corridor' used in many ways in the literature, often without explicit definition (Table 2). Explicit definitions focused on different aspects of corridors. Hobbs (1992, p. 389) noted that "... almost any strip of vegetation could be viewed as a corridor in some contexts". In a literature review, Simberloff et al. (1992) identified six ways in which the term 'corridor' was used (Table 3). Andrews (1993) described five functions of wildlife corridors, and Forman (1995) identified six societal goals corridors contribute to corridors (Table 3).

The roles corridors play in addressing societal goals derive from a number of ecological functions: habitat, conduit, filter, barrier, source, and sink (Fig. 1; Forman and Godron, 1986; Forman, 1995; Smith and Hellmund, 1993; Dramstad et al., 1996). Forman and Godron (1981, 1986) introduced discussion of these six ecological functions, along with their structural definition of corridors. These functional roles are presented in a wide range of conservation literature, from wildlife conservation to greenways and hiking trails. They have been widely adopted, including use in a recent corridor planning manual produced by the USDA Natural Resources Conservation Service (USDA-NRCS, 1999). The greenway literature, in particular, also is explicit about the social functions of corridors, including recreation, aesthetics, and community cohesion (Smith and Hellmund, 1993; Forman, 1995). Addressing explicitly these intended functions when designing a corridor can eliminate much of the confusion surrounding their roles.

3.1. Conduit and habitat

The ability of animals to move through a corridor from one place to another is central to most corridor definitions we found (Table 2). This is the conduit function of corridors. However, the issue of conduit versus habitat when defining the function of a corridor was raised frequently. A habitat is an area with the appropriate combination of resources (food, cover, water) and environmental conditions for the survival and reproduction of a species. Some research focuses on the habitat function, assuming that if a corridor provides suitable habitat it will also facilitate dispersal (Bennett et al., 1994; Downes et al., 1997). Other

Table 1
Terms describing corridors developed in Forman and Godron (1986) and Forman (1995)

Definition	A corridor is a narrow strip of land that differs from the matrix on either side (note that this is a structural definition)
Origins	Disturbance, remnant, environmental resource, planted/introduced, regenerated
Types	Line, strip, stream
Structural attributes	Curvilinearity, breaks, gaps, narrows, nodes, connectivity, width, central portion, length, edge, interior
Functional roles	Habitat, conduit, barrier, filter, source, sink

Table 2
Uses of the term 'corridor' and variants[a]

Term	Functional role(s)	Structure specified	Citation(s)
Corridor	Barrier, conduit, filter, habitat, sink, source	Yes	Forman and Godron (1986), Forman (1995)
	Barrier	Yes	Rich et al. (1994)
	Conduit	Yes	Wegner and Merriam (1979), Harris (1985), Henderson et al. (1985), Mansergh and Scotts (1989), Johnsingh et al. (1990), Date et al. (1991), Loney and Hobbs (1991), Saunders and de Rebeira (1991), Saunders and Hobbs (1991a), Hobbs (1992), Simberloff et al. (1992), Merriam and Saunders (1993), Dawson (1994), Vermeulen (1994), Heuer (1995), Ruefenacht and Knight (1995), Sutcliffe and Thomas (1996), Rosenberg et al. (1998), Danielson and Hubbard (1999), Gilliam and Fraser (2001)
		No	Willis (1974), Harrison (1992), Noss and Cooperrider (1994), Shkedy and Saltz (1999), Bowne et al. (1999), Haddad and Baum (1999), Haddad (1999a,b), Wiens (1996)
	Conduit, barrier (wildlife)	Yes	Ahern (1991)
	Conduit, barrier, habitat	No	Maelfait and de Keer (1990)
	Conduit, habitat	Yes	MacClintock et al. (1977), Merriam and Lanoue (1990), Nichols and Margules (1991), Bennett (1990), Spellberg and Gaywood (1993), Bennett et al. (1994), Rosenberg et al. (1995), Downes et al. (1997), Beier and Noss (1998), Fraser et al. (1999)
		No	Inglis and Underwood (1992), Lindenmayer (1994), Lindenmayer et al. (1994)
	Conduit, not habitat	Yes	Mock et al. (1992), Andreasen et al. (1996), Rosenberg et al. (1997)
		No	Lidicker and Koenig (1996)
	Conduit, filter (water quality), habitat	Yes	Kricher (1988), Machtans et al. (1996)
	Habitat	Yes	Bentley and Catterall (1997)
Corridor reserve	Conduit, habitat	Yes	Watson (1991)
Conservation corridor	Conduit	Yes	Soulé (1991)
	Barrier, conduit, filter, habitat, sink, source	Yes	USDA-NRCS (1999)
Dispersal corridor	Conduit, habitat	No	Haas (1995), Roberts (1995)
Ecological corridor	Conduit, habitat	Yes	Melman et al. (1988), Dmowski and Kozakiewicz (1990)
Faunal dispersal corridor	Conduit	Yes	Harris and Atkins (1991), Harris and Scheck (1991)
Greenway corridor	Conduit, filter (water quality)	No	Ndubisi et al. (1995)
Greenway	Conduit (primarily for wildlife), habitat	Yes	Burley (1989)
	Conduit (primarily for wildlife)	No	Linehan et al. (1995)
	Conduit (primarily for people)	Yes	Little (1990), Hay (1991)
	Barrier (to urban sprawl), conduit (people and wildlife), filter, habitat, source	Yes	Smith (1993)

Habitat corridor	Conduit	Yes	Beier (1995)
	Conduit, habitat	Yes	Bennett (1990, 1999), Dunning et al. (1995)
Landscape corridor	Barrier, conduit, habitat, sink (for pollutants), source (for some animals)	Yes	Barrett and Bohlen (1991)
Landscape connection	Conduit	No	Forman and Hersperger (1996)
Line corridor	Habitat	Yes	Forman and Godron (1986)
Landscape linkage	Conduit	No	Bennett (1999)
	Conduit, habitat	No	Csuti (1991)
	Conduit, habitat	Yes	Harris (1988), Noss (1991)
Riparian corridor	Habitat, source (sediment, woody debris)	Yes	Naiman et al. (1993)
River corridor	Conduit, filter, habitat, source (for nutrients entering water)	Yes	Schaefer and Brown (1992)
Steam corridor	Conduit, filter, habitat	Yes	Forman and Godron (1986)
	All	Yes	Forman (1995)
	Conduit, habitat	Yes	Spackman and Hughes (1995)
Strip corridor	Habitat	Yes	Forman and Godron (1986)
Wildlife corridor	Conduit	Yes	Harris and Scheck (1991), Norton and Nix (1991), Soulé and Gilpin (1991), Grishaver et al. (1992)
		No	Andrews (1993), Johnson and Beck (1989)
	Conduit, habitat	Yes	Wilson and Lindenmayer (1995), Wheeler (1996)
		No	Lindenmayer (1994), Newmark (1993), Claridge and Lindenmayer (1994)
	Barrier, conduit, habitat, sink	Yes	Wilson and Lindenmayer (1996)
	Habitat, not conduit	Yes	Lindenmayer et al. (1993)
Wildlife movement corridor	Conduit, habitat	Yes	Beier and Loe (1992)

[a] We classified each use according to functional roles, and whether or not a structure was specified. We considered structure to be specified, if the discussion contained phrases such as ‘‘linear landscape elements’’ or ‘‘narrow strips of land’’. Citations are listed chronologically, then alphabetically.

Table 3
Many uses have been described for corridors

Simberloff et al. (1992) identified six ways in which the term was used
1. Distinct habitat, whether or not it aids movement
2. Greenbelts and buffers in urban areas
3. Biogeographic land bridges
4. Series of discrete 'stepping stone' refuges for migratory waterfowl
5. Highway underpasses and tunnels designed for wildlife passage
6. Strips of land that facilitate movement between large habitats
Andrews (1993) described five functions of wildlife corridors
1. Permit colonization of new sites as they become suitable
2. Allow wildlife to move out of sites as they become unsuitable
3. Permit recolonization of sites locally extinct
4. Allow species to move between separate areas needed for different stages of their life cycles
5. Increase overall extend of habitat, especially for species with large range requirements
Forman (1995) identified six societal goals corridors
1. Biodiversity protection
2. Enhancing water resources management and water quality protection
3. Enhancing agroforestry productivity
4. Recreation
5. Community and cultural cohesion
6. Dispersal routes for species isolated in nature reserves

research focuses on the conduit function, and excludes corridors that functioned as habitat, but did not connect reserves (Loney and Hobbs, 1991; Soulé, 1991; Beier and Noss, 1998). Some of this discord may result from confusion about the meaning of the term 'habitat' and the inconsistent use of habitat terminology (Hall et al., 1997).

Many authors acknowledged that corridor function could range from providing only passage to providing habitat and passage (Melman et al., 1988; Loney and Hobbs, 1991; Merriam, 1991; Lindenmayer and Nix, 1993; Petit et al., 1995). Noss (1993) listed the two major functions of wildlife corridors as dwelling habitat for plants and animals, and conduits for movement. Rosenberg et al. (1995) clearly separated the habitat and conduit functions of corridors and provided a quantitative approach to distinguishing the two roles. A corridor that provides for movement between habitat patches, but not necessarily reproduction, is performing a conduit function. If a corridor provides resources needed for survivorship, reproduction, and movement, it is performing a habitat function.

Some conservation biologists limited the definition of a corridor to conduits that allow passage of only native species (e.g. Harris and Scheck, 1991; Noss, 1991; Harris and Atkins, 1991). Corridors also have been differentiated according to the manner and time scale in which they are used by animals (Harris and Scheck, 1991; Beier and Loe, 1992; Noss, 1993; Bennett et al., 1994). 'Passage species' may use a corridor as a conduit to move from one place to another in short, discrete time periods (Beier and Loe, 1992). This kind of movement includes natal dispersal, seasonal migration, daily foraging, exploration, and searching for a mate (Noss, 1991, 1993; Bennett et al., 1994). If a corridor is wide and long relative to the scale of an animal's movement, it may take several generations for a species to move through it. Beier and Loe (1992) called such species 'corridor dwellers' and noted that the corridor must perform a habitat function, if it can support reproduction for multiple generations.

Harris and Scheck (1991) linked corridor width to type and duration of use. Individuals move through narrow corridors on a time scale of hours to months. Wider corridors support the movement of entire species on an annual time scale, and assemblages of species can move through still wider corridors for decades or centuries. All, but the narrowest corridors must fulfill a habitat function, because the movement occurs over multiple years. Extremely wide corridors may support the complete range of community and

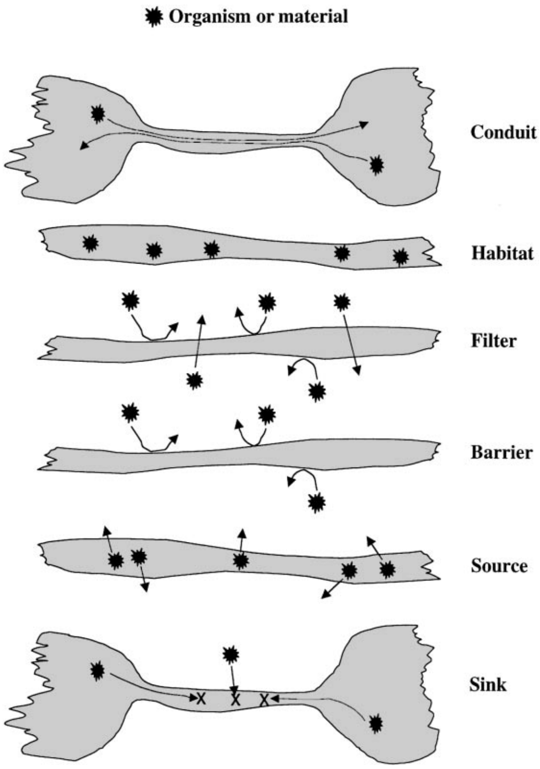

Fig. 1. Corridor functions. Conduit: organisms pass from one place to another, but do not reside within the corridor. Habitat: organisms can survive and reproduce in the corridor. Filter: some organisms or material can pass through the corridor; others cannot. Barrier: organisms or material cannot cross the corridor. Source: organisms or material emanate from the corridor. Sink: organisms or material enter the corridor and are destroyed.

ecosystem processes, enabling plants and smaller animals to move between larger reserves over a period of generations. These have been called landscape linkages and are intended to provide regional connectivity (Noss, 1991; Harris and Scheck, 1991; Csuti, 1991; Harris, 1988). Bennett (1999) prefers the terms 'link' or 'linkage' to 'corridor', to make clear his focus on the conduit function and landscape connectivity.

3.2. Filter and barrier

The filter and barrier functions separate and differentiate areas on the opposite sides of a corridor (Forman, 1995). The term 'filter' implies some level of permeability and is most commonly associated with riparian zones and water quality issues. A 'filter strip' or 'buffer strip' is riparian vegetation adjacent to streams, lakes, or other aquatic systems designed to remove nutrients, sediment, and other pollutants from surface runoff before it reaches the water (e.g. Schaefer and Brown, 1992; Schueler, 1995). Although riparian buffer strips are often said to have conservation value for wildlife, these claims should be viewed with some suspicion unless the actual needs of wildlife are accounted for in the design. Corridors may also filter out certain species moving across or along them (Forman and Godron, 1986; Thorne, 1993). This function is usually associated with continental scale, long-term connections, such as land bridges (Simpson, 1940), and may be a consideration when designing landscape linkages for continental connectivity.

The term 'barrier' implies nearly complete blockage. Roads, which are conduits for people, are often viewed as barriers to wildlife (Forman and Hersperger, 1996). There are many efforts underway to mitigate this effect using tunnels, underpasses, and bridges to serve as conduits across the barriers (e.g. Harris and Scheck, 1991; Bennett et al., 1994; Beier, 1995; Evink et al., 1996). On the other hand, some researchers are excited about the conservation value for flora of road verges (several papers in Saunders and Hobbs, 1991b; Vermeulen, 1994), highlighting again the multiple and complex functions a corridor can perform. Windbreaks are barriers that block wind and filter wind-borne soil and snow, but also serve as wildlife habitat (Forman and Godron, 1986; Johnson and Beck, 1989).

3.3. Source and sink

Source and sink are usually used in a demographic sense. 'Source' describes a habitat in which local reproduction exceeds mortality; 'sink' describes a habitat in which mortality exceeds reproduction (Shmida and Ellner, 1984; Pulliam, 1988). These functions of corridors are described far less frequently than the other four functions.

Poorly designed corridors may act as population sinks, because the large amount of edge exposes animals to predation from matrix dwellers and competition from generalist species (e.g. Henein and Merriam, 1990; Soulé, 1991). Greenways may serve as a source of plant species for colonizing adjacent areas (Thorne, 1993), although these species are likely to be aggressive exotics (Noss, 1987). Harris and

Scheck (1991) described windbreaks as a source of species that were not Great Plains natives (e.g. fox squirrels (*Sciurus niger*), Mississippi kites (*Ictinia mississippiensis*), yellow-shafted flickers (*Colaptes auratus*), and Knopf (1986) discussed the role of riparian corridors as sources for change in the avifauna of eastern Colorado.

The pollutant filtering function of corridors is sometimes described as a sink function, when filter strips retain nutrients and sediments moving toward streams (Thorne, 1993). Riparian vegetation along streams may also be a source of nutrients to the stream when leaves and branches fall into the water (Schaefer and Brown, 1992). Forman (1995) described several instances, in which corridors may be a source of abiotic contaminants, including road corridors acting as a source of noise, dust, and pollutants.

4. Distinguishing structure and function

Used carefully, the vocabulary developed by Forman and Godron (1981, 1986) and Forman (1995) can describe any linear landscape element (Table 1). In that vocabulary, the basic definition of corridor is from a structural perspective: a narrow strip of land that differs from the matrix on either side. The structural attributes of a corridor can be described using many of the terms presented by Forman (1995), including length, width, narrows, and curvilinearity.

Some confusion results, because the term 'corridor' is now used for both the structural and functional aspects (Rosenberg et al., 1995). At the heart of this confusion is a clash between common and historical uses of the word 'corridor' that imply a conduit function, and attempts to assign structural and other meanings to the word. Several researchers cited standard dictionary definitions in their efforts to clarify the role of corridors (e.g. Panetta and Hopkins, 1991; Saunders and Hobbs, 1991a; Dawson, 1994; Rosenberg et al., 1995). They noted that all dictionary definitions of 'corridor' have connotations of movement and that many imply some protection for the body passing along them. Dawson (1994) insisted that those who use the word 'corridor' to describe elongated patches of habitat that are not intended for movement must qualify their use of the word to indicate a departure from the dictionary meaning.

Forman (1995) also used the reciprocal terms 'connectivity' and 'gaps' in both a structural and functional sense. Connectivity in a structural sense is built on the foundation of transportation theory and geography, in which connectivity is a function of the number of gaps per unit length (Forman, 1995). Functional connectivity derives from island biogeography (MacArthur and Wilson, 1967) and metapopulation theory (e.g. Levins, 1970; Hanksi and Gilpin, 1997; McCullough, 1996), in which connectivity is a function of how easily plants and animals can move among islands or habitat patches. Bennett (1999) distinguishes between structural and behavioral components of connectivity, where the behavioral component is essentially the functional connectivity just discussed.

Baudrey and Merriam (1988) distinguished between structural 'connectedness' and functional 'connectivity', noting that linear landscape elements that appear from a human perspective to connect patches do not necessarily enhance connectivity for other species. This is an important point, but the difference between these terms is subtle and we suspect that they will be used interchangeably by most people. Further, structural connectedness is as much a matter of scale and perspective as functional connectivity.

Wheeler (1996) noted that defining a wildlife corridor, its boundaries, and gaps is "fraught with difficulties" because of differences in the life histories and habitat needs of animals using them. The distinction between structural and functional connectivity is important, because apparent physical connectedness does not guarantee functional connectivity. For example, in designing a wildlife corridor, how large must a structural gap be before we say that the corridor is not functionally connected? The answer depends upon the intended function of the corridor. For example, continental migration corridors for North American waterfowl consist of widely separated stepping-stone reserves (Harris and Scheck, 1991). In contrast, Willis (1974, p. 166) noted that tropical antbirds do not cross water gaps of even a few hundred meters. Similarly for filters, a well-vegetated riparian filter strip is not functioning properly as a filter, if it is crossed by channel flow from concentrated runoff or point sources of pollution, such as discharge pipes.

When designing corridors, discussion of gaps and connectivity without a functional context is meaningless (Bennett, 1999). Once a functional context has been established for a corridor, these terms have meaning and can be measured and evaluated with respect to the corridor's intended function. If a corridor has multiple functions, multiple measures of connectivity may be needed.

5. Communicating clearly about corridors

Most corridors probably perform more than one function, even if they have been designed with only one function in mind. Much of the discord in the literature is caused by attempts to cram too much meaning into the single word, 'corridor'. Because of the complex and multiple functions a corridor may serve, it is extremely difficult to describe a corridor's function succinctly. For example, a conduit to one species may be habitat to another and barrier to a third. Although general principles can be found, wildlife corridor design is site and species specific (Soulé and Gilpin, 1991; Merriam and Saunders, 1993; Bennett, 1999). Riparian corridors must be designed carefully, if they are to serve effectively as buffer strips or wildlife corridors (Binford and Buchenau, 1993; Schueler, 1995). Newmark (1993) noted that a corridor's effectiveness can only be judged in relation to its objectives, and Loney and Hobbs (1991) made an impassioned plea for clear management objectives when corridors are created.

Greenways provide an example of the wide range of functions that people may want a corridor to serve. Forman (1995) wrote that human recreation and aesthetics are the main functions of greenways. Greenways provide community and cultural cohesion by inhibiting sprawling development, functioning as regional barriers, and providing recreational areas by serving as conduits for hiking (Smith, 1993). Because, they are often designed for riparian zones along streams, a water quality function is frequently stated or implied. However, Schueler (1995) noted that urban and suburban buffer strips must be designed carefully if they are to function properly.

At the other end of the spectrum, Linehan et al. (1995) insisted that a wildlife corridor system should be at the forefront of greenway planning, with recreational opportunities as a byproduct. Similarly, Ndubisi et al. (1995) wrote that greenways serve primarily as a conduit for animals to move between larger habitats, and secondarily as areas for the protection of water quality.

Wildlife habitat and corridor functions are often listed among the functions served by greenways. However, although greenways may look like faunal corridors, they are often too thin and rich in exotic plant species to enhance the movement of native wildlife (Harris and Atkins, 1991; Smith, 1993). Simberloff et al. (1992) noted that the presence of people in greenways would probably impede their function as wildlife corridors for some animals.

Two things are clear from this brief discussion of potential greenway functions. First, it would be extremely difficult to encapsulate this range of functional capabilities in a few words. Second, unless a corridor is designed properly, it will not likely serve its intended functions. Proper design and management of a corridor depends critically on a clear and explicit statement of its intended functions.

The complexity of these issues led us to abandon the idea of succinctly defining the term 'corridor'. Instead, we recommend identifying explicitly during the design process all of the roles a corridor is expected to play. For example, the USDA's conservation planning at the landscape level, which focuses largely on the wildlife habitat and conduit functions of corridors, includes a checklist of conservation interests and goals (USDA-NRCS, 1999). Beier and Loe (1992) also created a checklist intended to ensure that wildlife movement corridors function as intended.

Another way to organize this kind of information is a corridor design table that details desired functions and primary uses (Hellmund, 1993), other uses, and potential problems (Table 4). The ecological functions shown in the table are derived from Forman and Godron (1986) and Forman (1995). The value of such an approach is that it requires explicit definition of the proposed corridor's functions, increases the visibility of important issues and questions, and makes potential use conflicts apparent. It would also provide a rich source of information for the design, management, and evaluation of a corridor. This approach fits nicely into various frameworks for the design of wildlife corridor and greenway systems, such as those proposed by Ahern (1991), Hellmund (1993), Ndubisi et al. (1995), Wilson and Lindenmayer (1996), and Fleury and Brown (1997).

Table 4
Corridor design table[a]

Function	Primary uses	Other uses	Potential problems
Societal goals			
Conduit			
Habitat			
Barrier			
Filter			
Source			
Sink			

[a] This approach to describing a corridor requires explicit recognition of intended functions and potential negative effects.

The corridor design table can be used at several levels of detail, and we imagine an iterative process of refinement as a project is designed, implemented, and managed. An initial version would provide general design goals and desired functions. As discussion proceeded, generically specified functions (e.g. wildlife corridor; filter strip) would be made increasingly specific (e.g. allow movement of bobcat (Felis Rufus); remove 75% of sediment from agricultural runoff). Biologists, planners, and managers could interact using available scientific information to design a corridor with the necessary structural properties to attain the goals and functions expressed in the design table. During this process, functional conflicts might be uncovered that require modification of the initial objectives. Once a design is completed and implemented, managers will be able to refer to the corridor design table and the resulting specifications when evaluating the corridor's effectiveness.

Of course, defining clearly a corridor's roles is only the beginning of the design process. Developing design criteria for each of a corridor's functions remains an unfinished and formidable task. For example, formulating design rules for the wildlife conduit function is extremely difficult, in part, because it is difficult to demonstrate empirically that corridors provide functional connectivity (Nichols and Margules, 1991; Inglis and Underwood, 1992; Beier and Noss, 1998; Haddad et al., 2000). The site- and species-specific nature of connectivity issues (Soulé and Gilpin, 1991; Merriam and Saunders, 1993) further complicates the challenge. Similarly, design standards that meet ecological functions as well as the nutrient and sediment filtering function of riparian corridors is the subject of ongoing debate (Fischer et al., 2000). Nevertheless, clear communication about the roles of corridors is an important step toward designing and managing corridors that function as intended.

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