Focal Species: A Multi-Species Umbrella for Nature Conservation

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Abstract: *To prevent the further loss of species from landscapes used for productive enterprises such as agriculture, forestry, and grazing, it is necessary to determine the composition, quantity, and configuration of landscape elements required to meet the needs of the species present. I present a multi-species approach for defining the attributes required to meet the needs of the biota in a landscape and the management regimes that should be applied. The approach builds on the concept of umbrella species, whose requirements are believed to encapsulate the needs of other species. It identifies a suite of "focal species," each of which is used to define different spatial and compositional attributes that must be present in a landscape and their appropriate management regimes. All species considered at risk are grouped according to the processes that threaten their persistence. These threats may include habitat loss, habitat fragmentation, weed invasion, and fire. Within each group, the species most sensitive to the threat is used to define the minimum acceptable level at which that threat can occur. For example, the area requirements of the species most limited by the availability of particular habitats will define the minimum suitable area of those habitat types; the requirements of the most dispersal-limited species will define the attributes of connecting vegetation; species reliant on critical resources will define essential compositional attributes; and species whose populations are limited by processes such as fire, predation, or weed invasion will define the levels at which these processes must be managed. For each relevant landscape parameter, the species with the most demanding requirements for that parameter is used to define its minimum acceptable value. Because the most demanding species are selected, a landscape designed and managed to meet their needs will encompass the requirements of all other species.*

Especies Focales: Una Sombrilla Multiespecífica para Conservar la Naturaleza

Resumen: *Para evitar mayores pérdidas de especies en paisajes utilizados para actividades productivas como la agricultura, la ganadería y el pastoreo, es necesario determinar la composición, cantidad y configuración de elementos del paisaje que se requieren para satisfacer las necesidades de las especies presentes. Propongo un enfoque multiespecífico para definir los atributos requeridos para satisfacer las necesidades de la biota en un paisaje y los regímenes de manejo que deben ser aplicados. El enfoque se basa en el concepto de las especies sombrilla, de las que se piensa que sus requerimientos engloban a las necesidades de otras especies. El concepto identifica una serie de "especies focales", cada una de las cuales se utiliza para definir distintos atributos espaciales y de composición que deben estar presentes en un paisaje, así como sus requerimientos adecuados de manejo. Todas las especies consideradas en riesgo se agrupan de acuerdo con los procesos que amenazan su persistencia. Estas amenazas pueden incluir pérdida de hábitat, fragmentación de hábitat, invasión de hierbas y fuego. Dentro de cada grupo, se utiliza a la especie más sensible a la amenaza para definir el nivel mínimo aceptable en que la amenaza ocurre. Por ejemplo, los requerimientos espaciales de especies limitadas por la disponibilidad de hábitats particulares definirán el área mínima adecuada de esos tipos de hábitat; los requerimientos de la especie más limitada en su dispersión definirán los atributos de la vegetación conectante, las especies dependientes de recursos críticos definirán los atributos de composición esenciales; y especies cuyas poblaciones están limitadas por procesos como el fuego, la depredación o invasión de hierbas definirán los niveles en que deberán manejarse estos procesos. Para cada parámetro relevante del*

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paisaje, se utiliza a la especies con los mayores requerimientos para ese parámetro para definir su valor aceptable mínimo. Debido a que se seleccionan las especies más demandantes, un paisaje diseñado y manejado para satisfacer sus necesidades abarcará los requerimientos de todas las demás especies.

Introduction

Throughout the world, changing patterns of land use have resulted in the loss of natural habitat and the increasing fragmentation of that which remains. Not only have these changes altered habitat composition and configuration, but they have modified the rates and intensities of many ecological processes essential for ecosystems to retain their integrity. As a consequence, many landscapes that are being used for productive purposes such as agriculture, grazing, and forestry, are suffering species declines and losses (Saunders 1989; Saunders et al. 1991; Hobbs et al. 1993). Attempts to prevent further loss of biological diversity from such landscapes requires a capacity to define the spatial, compositional, and functional attributes that must be present if the needs of the plants and animals are to be met.

There has been considerable debate in the ecological literature about whether the requirements of single species should serve as the basis for defining conservation requirements or whether the analysis of landscape pattern and process should underpin conservation planning (Franklin 1993; Hansen et al. 1993; Orians 1993; Franklin 1994; Hobbs 1994; Tracy & Brussard 1994). Species-based approaches have taken the form of either single-species studies, often targeted at rare or vulnerable species, or the study of groups of species considered to represent components of biodiversity (Soulé & Wilcox 1980; Simberloff 1988; Wilson & Peter 1988; Pimm & Gilpin 1989; Brussard 1991; Kohm 1991). Species-based approaches have been criticized on the grounds that they do not provide whole-landscape solutions to conservation problems, that they cannot be conducted at a rate sufficient to deal with the urgency of the threats, and that they consume a disproportionate amount of conservation funding (Franklin 1993; Hobbs 1994; Walker 1995). Consequently, critics of single-species studies are calling for approaches that consider higher levels of organization such as ecosystems and landscapes (Noss 1983; Noss & Harris 1986; Noss 1987; Gosselink et al. 1990; Dyer & Holland 1991; Salwasser 1991; Franklin 1993; Hobbs 1994). These alternative approaches place a greater emphasis on the relationship between landscape pattern and processes and community measures such as species diversity or species richness (Janzen 1983; Newmark 1985; Saunders et al. 1991; Anglestam 1992; Hobbs 1993, 1994).

Although approaches that consider pattern and processes at a landscape scale help to identify the elements that need to be present in a landscape, they are unable to define the appropriate quantity and distribution of those elements. Such approaches have tended, by and large, to be descriptive. They can identify relationships between landscape patterns and measures such as species richness, but they are unable to define the composition, configuration, and quantity of landscape features required for a landscape to retain its biota.

Ultimately, questions such as what type of pattern is required in a landscape, or at what rate a given process should proceed, cannot be answered without reference to the needs of the species in that landscape. Therefore, we cannot ignore the requirements of species if we wish to define the characteristics of a landscape that will ensure their retention. The challenge then is to find an efficient means of meeting the needs of all species without studying each one individually. In order to overcome this dilemma, proponents of single-species studies have developed the concept of umbrella species (Murphy & Wilcox 1986; Noss 1990; Cutler 1991; Ryti 1992; Hanley 1993; Launer & Murphy 1994; Williams & Gaston 1994). These are species whose requirements for persistence are believed to encapsulate those of an array of additional species.

The attractiveness of umbrella species to land managers is obvious. If it is indeed possible to manage a whole community or ecosystem by focusing on the needs of one or a few species, then the seemingly intractable problem of considering the needs of all species is resolved. Species as diverse as Spotted Owls (Franklin 1994), desert tortoises (Tracy & Brussard 1994), black-tailed deer (Hanley 1993) and butterflies (Launer & Murphy 1994) have been proposed to serve an umbrella function for the ecosystems in which they occur. But given that the majority of species within an ecosystem have widely differing habitat requirements, it seems unlikely that any single species could serve as an umbrella for all others. As Franklin (1994) points out, landscapes designed and managed around the needs of single species may fail to capture other critical elements of the ecosystems in which they occur. It would therefore appear that if the concept of umbrella species is to be useful, it will be necessary to search for multi-species approaches that identify a set of species whose spatial, compositional, and functional requirements encompass those of all other species in the region.

I present a method for selecting, from the total pool of species in a landscape, a subset of "focal species" whose requirements for persistence define the attributes that must be present if that landscape is to meet the requirements of the species that occur there. The approach, while consistent with the concept of umbrella species, differs in that it identifies a suite of species, each of which is used to define the characteristics of different landscape attributes that must be represented in the landscape. The needs of these focal species can be used to develop explicit guidelines regarding the composition, quantity, and configuration of habitat patches and the management regimes that must be applied to the resulting design.

Definition of what constitutes a habitat patch depends on the system being managed. Habitat patchiness can be defined at a variety of spatial scales (O'Neill et al. 1986), and the resolution selected for a management exercise will invariably represent a compromise between the biological complexity of the landscape under consideration and the practical requirements of land managers. In the agricultural regions of Western Australia, for example, patchiness can usefully be defined at the resolution of the dominant vegetation communities that form a distinct mosaic that reflects underlying edaphic and topographic attributes.

Grouping Species According to Threats

To select the focal species it is necessary first to identify the processes that contribute to the decline in abundance and subsequent loss of species. Species considered susceptible to similar threatening processes are then grouped and, for each threat, the species that requires the most comprehensive response is identified. The types of threatening processes depend on the landscape being managed. In the agricultural landscapes of Western Australia the major threats have been identified as the loss and fragmentation of habitat, the loss of critical resources, and inappropriate rates and intensities of ecosystem processes such as fire, nutrient cycling, and predation (Hobbs et al. 1993).

Figure 1 outlines the sequence of decisions that are made to identify groups of species whose vulnerability is attributable to common causes. Subsequent analysis of each group identifies those species whose requirements for mitigating the threat are nested within those of other species. The outcome of this selection process is a suite of focal species whose requirements for management or habitat reconstruction encapsulate the needs of all other species.

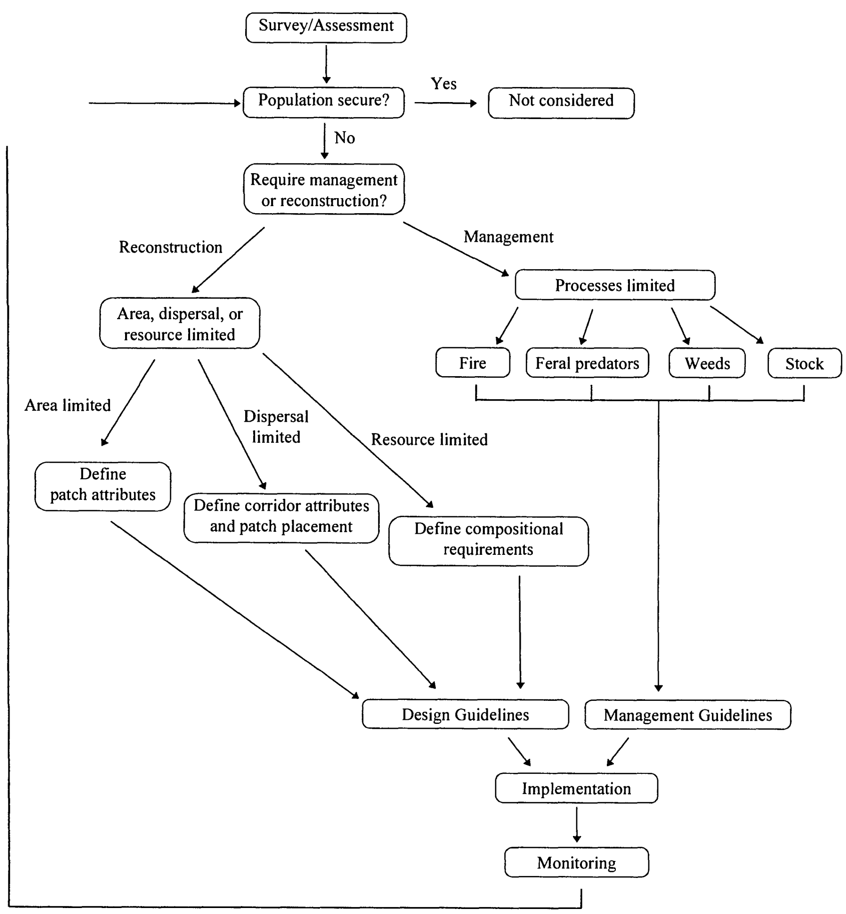

Figure 1. Schematic representation of the procedure used to identify focal species. The requirements of these species are used to define the spatial, compositional, and management guidelines for the area under consideration. The actual causes of vulnerability may vary from place to place. In this example, taken from the wheatbelt of Western Australia, fragmentation, habitat loss, and resource depletion were identified as the limiting factors that require landscape reconstruction. Fire, exotic predators, and weeds represent examples of the types of processes that need to be managed.

Identifying Vulnerable Species

The first dichotomy in Fig. 1 differentiates between those species considered secure in the current landscape and those expected to be lost in the absence of action. Species considered secure are removed from the selection process. If the status of a species is in doubt, it should remain in the analysis. Secure species may re-enter the analysis subsequently if their presence is identified as being the cause of vulnerability of some other species. The subsequent decisions outlined in Fig. 1 have to be made only for species considered at risk.

Assessment of the status of the biota should ideally be based on surveys that are designed to identify species whose populations display downward trajectories. Often, however, such information is difficult to acquire; it may be necessary to rely on anecdotal observations and expert opinion. The reliability of the assessment will obviously vary with the quality of the data available. More-detailed ecological data must be acquired for the species considered at risk to enable subsequent assessment of the cause of their vulnerability. The decision process outlined will help to identify the information required for these species.

Reconstruction or Management

Having identified the vulnerable species, it is necessary to distinguish between those that require habitat reconstruction and those that would be able to persist in the current landscape, provided that biophysical processes were managed in a different way. This dichotomy reflects a distinction between the relative importance of pattern and process. Generally, species that could persist in the landscape if it were managed differently are those sensitive to the rates of particular processes or to changes in the intensity and frequency of those processes. In Australian agricultural landscapes these processes include altered fire regimes, predation by introduced foxes and cats, grazing of native vegetation by stock, and competition between native plants and exotic weeds. Species whose populations are constrained by processes such as these are considered process-limited. The remaining vulnerable species are those whose populations are limited by the pattern of landscape attributes, such as habitat area or connectivity, that limit the amount of or access to essential resources.

Species Requiring Reconstruction

Species will require landscape reconstruction if they are limited by (1) a shortage of critical resources, (2) an inability to move between suitable habitat patches, or (3) insufficient habitat to meet their resource needs.

For resource-limited species, the number of individuals that a region can support is determined by the carrying capacity at the time of lowest resource availability. Species limited by a resource bottleneck may exhibit a significant population response to the enhancement of resources at the time of greatest shortage. For example, many nectarivorous birds utilize a sequence of nectar sources throughout the year; depletion of these resources at any stage in this sequence constrains their population size (Lambeck 1995). A rehabilitation response targeted at alleviating the bottleneck should increase the local carrying capacity for nectarivorous species. In such circumstances, a strategic restoration action may produce a greater population response than would a major landscape reconstruction that failed to explicitly address the resource shortage.

Dispersal-limited species are those for which there are suitable habitat patches to support small populations, but the patches are beyond the distance over which individuals can move or are separated by a matrix that is too hostile to permit movement. If individual populations are too small to be viable in their own right, the combination of stochastic and anthropogenic impacts can result in rates of local extinction that exceed rates of recolonization. Such species will require increased connectivity between habitat patches either by the provision of corridors or by a reduction in the resistance of the intervening matrix (Knaapen et al. 1992).

Area-limited species are those for which the patches of appropriate habitat are simply too small to support a breeding pair, or, in the case of colonial species, a functional social group. Area-limited species are also resource-limited, but they should be considered in this category if the limiting resource is not obvious or quantifiable. Habitat patches are therefore used as a surrogate for resources (Hansen et al. 1993), and it is assumed that there is a minimum patch size of a given quality that will provide sufficient resources to support a pair or group.

Species Requiring Management of Ecosystem Processes

The types of threatening processes and their relative importance will vary depending on the region being investigated, so they are not considered individually here. But the procedure for selecting focal species for each of the relevant processes will be the same regardless of location. Species at risk as a result of inappropriate rates or intensities of these ecosystem processes are grouped according to the processes that present the most immediate threat.

Selecting the Focal Species

After the decision-making process is complete, all species considered at risk will be allocated to at least one of four major categories: area-limited, resource-limited, dispersal-limited, or process-limited. The area-limited group can be further subdivided according to the number of major habitat types in the area being managed. Similarly, the process-limited group should be subdivided according to the number of processes that require management. Some species may occur in more than one category. The species in each threat category are then ranked in order of their sensitivity to that threat.

For each patch type, those species considered area-limited are ranked according to the smallest patch in which they are observed to occur. The species with the greatest area requirements for a particular patch type is identified as the focal species whose spatial requirements define the minimum size for that patch type. Any patch large enough to support a breeding pair or social group of the focal species is assumed to be large enough to support individuals of all other species that utilize that patch type. For any given region there will be as many focal species that define minimum patch area as there are patch types.

For the majority of species, dispersal is one of the least understood aspects of their ecology. The approach taken to define the characteristics necessary for connecting vegetation would ideally follow that used to define area requirements. Species should be ranked according to the minimum width, length, and structural requirements of the connecting vegetation through which they are known to move. The species with the greatest need for wide corridors or with the least inclination to move along corridors become the focal species for defining corridor width and length, respectively. Similarly, species with the most demanding structural requirements are used to define the structural attributes of the connecting vegetation. If dispersal data are not available, presence/absence data can be used to determine the inter-patch distance beyond which seemingly suitable habitat is not occupied. For example, P. Cale (unpublished data) found, for a range of bird species, that seemingly suitable patches remained unoccupied if they were too isolated (see Fig. 2 for an example). For each patch type in a landscape, the minimum acceptable distance between patches would be defined by the species with the shortest distance beyond which an otherwise suitable patch is not occupied.

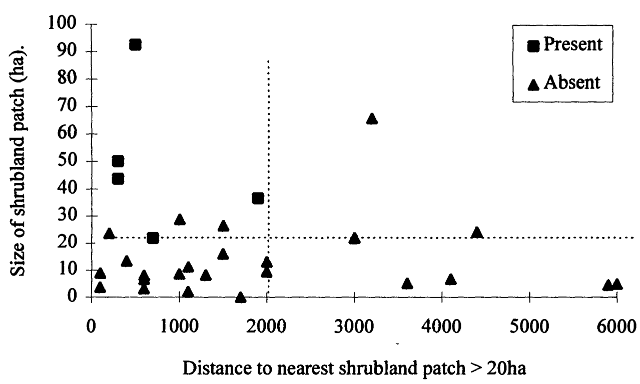

*Figure 2. Pattern of shrubland patch occupancy for the Western Yellow Robin (*Eopsaltria griseogularis*) in the central wheatbelt of Western Australia (P. Cale, unpublished data). This species does not occur in patches less than 20 ha in size or more than 2 km from the nearest suitable shrubland patch. Similar analyses of all vulnerable species in each patch type enable identification of those species that have the greatest minimum area and distance requirements. These species then become the focal species for defining the minimum patch size and inter-patch distance for each patch type.*

Resource-limited species are those for which critical resources can be identified and shown to limit the carrying capacity of a region. Where there are a number of species utilizing the same resource base, the resource must be increased to a level at which it is able to meet the needs of the least abundant consumer (Lambeck 1995). This species becomes the focal species for that resource.

When species have been categorized according to their needs for management of threatening processes they are then ranked in terms of their vulnerability to those threats. Those species most vulnerable to or most dependent upon a given process become the focal species for defining the intensity, rate, or frequency at which that process should be managed. For example, the species most deleteriously affected by weed invasion would define the level of weed control required. Similarly, the species most vulnerable to feral predators will define the appropriate level of predator control.

Implementation

The outcome of the procedure described above is a list of species that can be used to define different attributes that must be present if a landscape is to meet the needs of its constituent flora and fauna. The list would include focal species to define the minimum area of each patch type; species to define the minimum width, length, and structure of connecting vegetation; species to define appropriate levels of critical limiting resources; and species to define the minimum rate or intensity of each potentially threatening process. The needs of these focal species define the minimum requirements, or thresholds, that must be exceeded if the needs of the biota are to be met.

These minimum requirements can be expressed as spatially explicit guidelines for management. In landscapes requiring habitat reconstruction, for example, a management guideline would require that the size of a reconstructed habitat patch exceed the minimum identified by the focal species for that patch type. Maps of abiotic attributes, such as soils, landforms, or environmental domains (Austin et al. 1990; Busby 1991), that correlate with the identified patch type could be used to identify positions in a landscape that meet those area requirements and hence should be preferentially reconstructed. Vegetation types can be mapped by remote sensing technologies or by ground survey. The maps can be incorporated into geographic information systems and interrogated to identify those patches that meet the specified spatial requirements or, alternatively, those that do not and that could be enhanced in order to meet the minimum requirement.

Consequences of Implementation

Although the focal species identified by the above process can be used to determine the minimum spatial characteristics required in a landscape, it must be remembered that the initial assessment of risk considered only proximal threats. It is possible that a species currently limited by landscape configuration may, when the configuration is altered, change in numbers only to a level whereby a new limit is imposed by another factor. In addition, changes in landscape pattern may alter species' responses to the new landscape configuration. For example, as the number of patches in a landscape increases, it may be possible for individuals of a species to occupy smaller patches than they could when fewer patches were available. This could result in the conservative error of allocating more area to habitat reconstruction than is actually required. Conversely, if the number of patches is to be reduced, those that currently support individuals of a species may no longer be able to do so. For this reason, extreme caution must be used if this approach is to be applied in situations where habitat is being cleared.

Similarly, changes in the quality of corridors may alter the minimum inter-patch distance over which individuals of some species can move. Not only will interactions between species and their habitat change as a result of changing configurations, but interactions between species may also change as a result of different species responding in different ways to altered configurations.

These unpredictable interactions, together with imperfect knowledge about the species to be managed, make the establishment of a monitoring process critically important. The monitoring program must be designed to test the underlying assumptions and must have a capacity to detect deviations from predicted responses at the earliest possible time. The monitoring program must focus primarily on the focal species but must also consider the responses of a suite of additional nonfocal taxa. These additional species should be selected to represent a range of life-history characteristics in a variety of taxonomic groups. With this approach, a strategic monitoring program based on a limited set of species would provide an indication of the changes occurring in a system in response to management actions. The failure of any species to respond to these actions as predicted may indicate that the purported focal species are not the most sensitive to the processes being managed or that some other threatening process has been overlooked.

Determining Landscape Viability

Although the procedure presented above identifies design and management criteria that must be applied to a landscape to meet the needs of the species that occur there, it does not indicate the area over which the solution must be implemented to ensure that the species present occur in sufficient numbers to persist in the face of natural or anthropogenic catastrophes or under conditions of demographic, environmental, stochastic, and genetic variability (Shaffer 1987). The approach provides an efficient and strategic means of enhancing the conservation value of a landscape, based on the needs of the species present, but it does not provide a method of achieving a viable landscape—that is, one that will retain its biota over time.

Attempts to determine viability have, in the past, focused on the viability of populations of single species. A logical extension of the focal-species approach is to examine whether a landscape that has the characteristics to support viable populations of the focal species will also deliver viability for nontarget species. The method provides criteria for identifying species that may be best suited for population viability analysis. Models of population viability could be developed by means of population parameters for the focal species and the landscape attributes required by these species. These models could then be tested against a number of nonfocal taxa that represent a range of life-history strategies and habitat requirements to determine whether the landscape and population parameters necessary for viability of the focal species will also result in population viability for these additional species.

Conclusions

The urgency of many conservation problems throughout the world requires that protective or restorative actions be implemented within a relatively short period of time. Whether landscapes are being dismantled or rebuilt, it will be necessary to identify the minimum landscape configurations, or thresholds in landscape quality, below which components of the biota are unlikely to be retained. These thresholds would represent a combination of landscape features that provide the habitat required for the persistence of the plants and animals in that landscape. For degraded landscapes, reconstruction actions must enhance the landscape until those thresholds are exceeded, whereas in situations where landscapes are being dismantled, it will be necessary to determine levels of habitat removal below which species will be lost. Neither single-species approaches nor investigations of landscape pattern and processes can, when considered alone, quantify the requirements necessary for the retention of the biota at a landscape scale. Attempts to rescue individual species only when they reach the brink of extinction are clearly inadequate in the face of widespread and ongoing biotic impoverishment, and there is as yet no theoretical basis for expecting that single-species recovery strategies will deliver adequate landscapes for the remainder of the biota. Similarly, descriptions of landscape patterns and processes cannot define landscape requirements for nature conservation without reference to the needs of the constituent flora and fauna.

The procedure I present provides a method for linking these two apparently divergent approaches. Although species are used to assess landscape adequacy and to guide management strategies, the choice of species is based on their capacity to encapsulate the needs of other species in the landscape. These focal species can be used to identify the appropriate spatial and functional parameters that must be present in a landscape. Area-limited species define the spatial attributes of each patch type, dispersal-limited species define patch configurations and connectivity characteristics, resource-limited species define compositional attributes, and process-limited species define the management regimes that have to be implemented.

The critical aspect of this approach is that it does not provide a template to apply uncritically across all landscapes but provides a procedure by which to determine the actions required in any given landscape. These actions are guided by the needs of a subset of the species present, with recognition that the composition of this set will differ from one place to another because of environmental differences and differences in the extent of anthropogenic disturbance. In relatively undisturbed landscapes where much of the original community composition remains intact, the focal taxa are more likely to be relatively sedentary resource specialists that prefer patch interiors rather than edges. In many cases these will be larger vertebrates with the greatest demands for habitat. In landscapes that have progressed further along the continuum of fragmentation and degradation, many of these species may have already been lost, and smaller vertebrates, plants, or even invertebrates will have an increasing probability of being identified as the most demanding species that remain in the landscape.

By applying my approach it is possible to specify what is required in a landscape, in what quantities, and in what configurations in order to meet the needs of the species present. The approach does not, however, identify the area over which the solution must be applied before the landscape becomes a viable one. The focal-species approach does have the potential to resolve this problem if further investigations reveal that landscapes that ensure population viability for the focal species also provide the requirements to support viable populations of all other species.

The effectiveness of any management strategy will obviously depend on the quality of the information available. The selection of the focal species would ideally be based on detailed surveys and complete knowledge of the requirements of all species in the area to be managed. In reality, this will never be the case. Consequently, a critical appraisal should be made of the quality of the data available on the location to be managed to determine whether this approach is warranted. It is also essential to implement a strategic monitoring program able to test the assumption that landscapes designed and managed according to the needs of what appear to be the most demanding species in the landscape do in fact protect nonfocal taxa.

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