A Framework for Conceptualizing Human Effects on Landscapes and Its Relevance to Management and Research Models

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Abstract: *The concept of habitat fragmentation is limited in its ability to describe the range of possible landscape configurations created by a variety of disturbances. This limitation is especially problematic in landscapes where human use of the habitat matrix occurs at multiple levels and where habitat modification may be a more important consideration than a simple binary classification of habitat versus nonhabitat. We propose a synthesizing scheme that places intact, variegated, fragmented, and relictual landscape states on a continuum, depending on the degree of habitat destruction. At a second level, the scheme considers the patterns of habitat modification that are imposed on remaining habitats. Management for conservation involves halting and sometimes reversing the trends of habitat destruction and modification. Conservation strategies will differ according to the state of alteration of the landscape, but all strategies include some consideration of the degree of modification of the matrix in determining habitat viability. It is convenient for biologists to assess landscape alteration state in terms of the persistence of large structural elements such as trees. Because animal species use habitats differently, however, they also experience the landscape differently. A landscape considered structurally fragmented by humans may be functionally variegated to other species. Therefore, it is necessary to consider the extent to which the entire landscape, including the matrix, is accessible and utilized by organisms with different spatial scales of resource use.*

Marco para la Conceptualización de los Efectos Humanos en Paisajes y su Relevancia en Modelos de Manejo y Investigación

Resumen: *El concepto de fragmentación el hábitat es limitado en su capacidad para describir el rango de configuraciones de paisaje creados por una variedad de perturbaciones. Esta limitación es especialmente problemática en paisajes donde el uso humano de la matriz de hábitats ocurre a múltiples niveles y donde las modificaciones al hábitat pueden ser una consideración mas importante que una simple clasificación binaria de "hábitat" y "no-hábitat." Proponemos un esquema sintetizador que coloca estados del paisaje como: lugares intactos, viables, fragmentados y paisajes relicto en un formato continuo, dependiendo del grado de destrucción del hábitat. A un segundo nivel, el esquema considera los patrones de modificación de hábitat impuestos a los hábitats remanentes. El manejo para la conservación involucra el detener y algunas vecer revertir las tendencias de destrucción y modificación del hábitat. Las estrategias de conservación diferirán de acuerdo al estado de alteración del paisaje, pero todas las estrategias incluyen alguna consideración del grado de modficación de la matriz en la determinación del hábitat viable. Para los biólogos es conveniente evaluar la alteración del estado del paisaje en términos de la persistencia de elementos estructurales grandes, como son los árboles. Debido a que las especies de animales utilizan el hábitat de diferente manera, también experimentan el paisaje de forma diferente. Un paisaje que puede ser considerado por humanos como estruc-*

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turalmente fragmentado, puede ser funcionalmente apto para otras especies. por lo tanto, es necesario considerar la extención a la cual el paisaje en su conjunto, incluyendo la matriz, es accesible y utilizado por organismos con diferentes escalas espaciales de uso del recurso.

Introduction

The theory of island biogeography (MacArthur & Wilson 1967) remains an important influence on conservation biology in the form of concepts of habitat fragmentation. Fragmentation caused by humans has been represented as a simple typology of landscape classification into (1) habitat that is reduced to fragments or patches and (2) nonhabitat, which is extensive enough to form the landscape matrix. The pervasive notion is that the matrix is hostile to the organisms within the relatively small fragments. These fragments function as islands from which the movement of organisms is restricted. This concept has been refined to describe landscapes generically in terms of patch, corridor, and matrix (Forman 1995).

Images of landscapes subjected to severe tree clearing (Fig. 1c & 1d) powerfully reinforce our concept of a dichotomy between persistence and destruction that, in current usage, is described as fragmentation. Not all human-altered landscapes, however, have a matrix of destroyed habitat, so the fragmentation model may be too simplistic for some landscapes (McIntyre & Barrett 1992; Wiens 1994; Pearson et al. 1996). An alternative image is the occurrence of scattered or irregular stands of trees that make the mapping of boundaries between woods and clearing arbitrary (Figs. 1b & 2a). Landscape "variegation" (McIntyre & Barrett 1992) was proposed to highlight the fact that in cases such as this, landscapes are dominated by original habitats that have been variously modified rather than extensively destroyed. This lack of discernible, nonarbitrary patches in landscapes showing continuous variation is not unique to Australia (e.g., Kotliar & Wiens 1990; Musick & Grover 1990).

We do not see fragmentation and variegation competing as concepts but rather both as representing segments along a continuum of landscape alteration. There is need in conservation biology for a simple framework that can accommodate the widest range of possible landscape states. Discriminating where a particular landscape lies on the continuum of human alteration is more than a taxonomic or aesthetic consideration; it is pivotal to the task of assessing landscape condition (Aronson & Le Floc'h 1996).

We seek to present a unified framework that integrates the concepts of both fragmentation and variegation in a form that permits readers to identify which part of the continuum might be relevant to the specific regions or ecosystems in which they work. We also discuss the classification of individual landscapes and the fact that any one location can be classified in several ways, depending on whether one is taking into account structural or functional attributes of the ecosystems or, alternatively, a human- versus organism-oriented perspective of landscape state. Although we recognize that a considerable body of work is underway to develop detailed metrics and landscape descriptors, we believe that this work needs to be placed in an overall context that will be useful to both managers and researchers from different disciplines. Our framework recognizes four alteration states, which are identified according to the extent to which habitats have been destroyed. A second level of detail, which is described qualitatively, is the degree of modification of the remaining habitat. Both these factors have a bearing on the type of conservation management that might be suitable for particular locations.

Framework Describing Landscape Alteration

Background

The range of human effects on landscapes has been described by Hobbs and Hopkins (1990) and McIntyre et al. (1996) who each recognized four levels of landscape alteration. Hobbs and Hopkins (1990) expressed these in terms of the prevalent land use: (1) conservation of a more or less unmodified system; (2) utilization of components of the system (e.g., forestry); (3) replacement of the system with another type (e.g., agriculture, plantation forestry); and (4) complete destruction (e.g., urban development, mining). McIntyre et al. (1996) used a more generic descriptor of a similar range of landscapes (intact, variegated, fragmented, and relict) to describe the continuum of human effects in terms of exogenous disturbances. We merged both approaches to more explicitly define intact, variegated, fragmented, and relictual states in terms of extent of habitat destruction and associated land uses.

Exogenous Disturbances and Landscape Alteration

Disturbance is an important agent shaping ecosystem structure and function, controlling species diversity, and promoting system renewal (Holling 1986; Petraitis et al. 1989; Pickett et al. 1989; Hobbs & Huenneke 1992; Perry & Amaranthus 1997). A distinction must be made, however, between disturbances to which the system has been exposed repeatedly through evolutionary time (endogenous disturbances) and novel disturbances that are

Figure 1. Patterns of landscape alteration in southwestern Western Australia seen as gross effects of human activities on tree distribution: (a) intact Eucalyptus marginata *forest; (b)* E. marginata *forest partially cleared for grazing, representing a variegated landscape; (c) fragmented woodland of mixed eucalypt species, mostly cleared for cropping and grazing; (d) relictual mixed eucalypt woodland heavily cleared for cropping and grazing. Photos by R. Hobbs.*

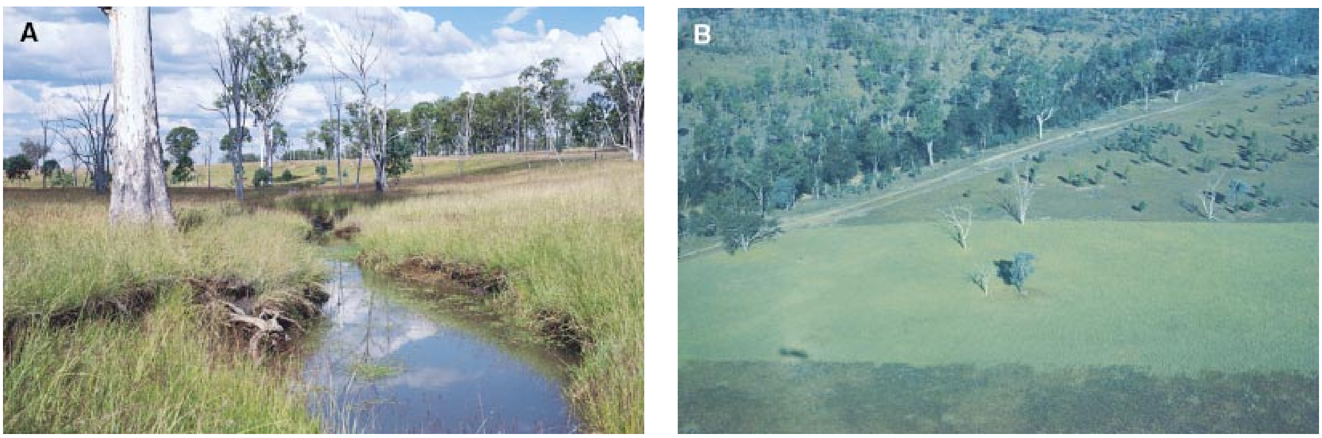

Figure 2. Variegated landscapes of grassy woodland of mixed Eucalyptus *species in southeastern Queensland, Australia: (a) native grassland forms the habitat matrix but is modified by livestock grazing, and trees are variously cleared or thinned (presence of scattered trees makes the delineation of woodland cover arbitrary); (b) five habitat modification states, representing different combinations of exogenous disturbance, (from front) native grassland cleared of trees, bright green fertilized pasture sown to the exotic grass* Cenchrus ciliaris*, native grassland cleared but recolonized with young eucalypts, uncleared riparian vegetation with mature tree and shrub layers present, and native grassland with a woodland of adult eucalypts that has been thinned. Photos by S. McIntyre.*

recent in origin (exogenous disturbances). Exogenous disturbances are frequently the result of changing human activities, and, because they tend to result in modification of the ecosystem and irreversible loss of species, they are the major factor in landscape alteration. Exogenous disturbances can take the form of novel types of disturbance, changes to the endogenous disturbance regime, or removal of endogenous disturbances. This terminology follows that of Fox and Fox (1986).

We assumed that a baseline "unaltered" habitat can be recognized and that exogenous disturbances operate to alter, or in some circumstances destroy, this habitat (Fig. 3). We recognize (but have not illustrated) a continuum of degrees of modification. It is theoretically possible to quantify the state of alteration of any landscape by describing the degree and extent of habitat modification and destruction. The conservation literature demonstrates that baselines are widely recognized through the identification of conservation "problems" (i.e., the baseline is generally defined as the point from which losses of species or ecosystem function occurs). Our framework accepts this user-defined concept of unaltered habitat.

Habitat Destruction and Landscape States

Habitat destruction is the loss of all structural features of the original vegetation and loss of the majority of species. There are four landscape states: intact, variegated, fragmented, and relictual (Figs. 1–4). They represent segments along a continuum of destruction of a previously continuous habitat matrix. The term *matrix* is used in the biological sense of a medium in which things are embedded—a class of habitat state (destroyed, modified, unmodified) that forms the majority of the landscape. In intact and variegated landscapes, habitat still forms the matrix, whereas in fragmented landscapes the matrix comprises "destroyed habitat" (Table 1).

Although to some extent the definitions are arbitrary, most of the habitat states relate to hypothesized thresholds in geometric characteristics of the landscape and to effects on biota (e.g., Fry & Main 1993; Green 1994; Pearson et al. 1996; Wiens 1997). A functional distinction between variegated and fragmented landscapes is supported by theoretical landscape models that indicate organisms are operationally unfragmented when there is >60% habitat retention (Pearson et al. 1996; Wiens 1997). Between 10% and 60% retention (fragmented landscapes), the degree of fragmentation is highly dependent on the mobility of the organism and the arrangement of the habitat. For example, 30% retention appears adequate for birds and mammals, but organisms of low mobility may be affected by fragmentation (Andrén 1994; Pearson et al. 1996). Below 10% retention (relictual) there appears to be a dramatic difference in bird composition on landscapes (Bennett & Ford 1997), and fragmentation effects are severe (Andrén 1994).

Modification of Remaining Habitat

Exogenous disturbances not only destroy habitats but can have lesser effects that modify the remaining habitat. Modifications are changes to the structure, biotic composition, or ecosystem functioning of habitats. Livestock grazing, tree harvesting, pollutant deposition, and changed fire regimes are examples of such disturbances that lead to modification.

If a modifying influence is intense or protracted, it will eventually lead to habitat destruction or cause sudden

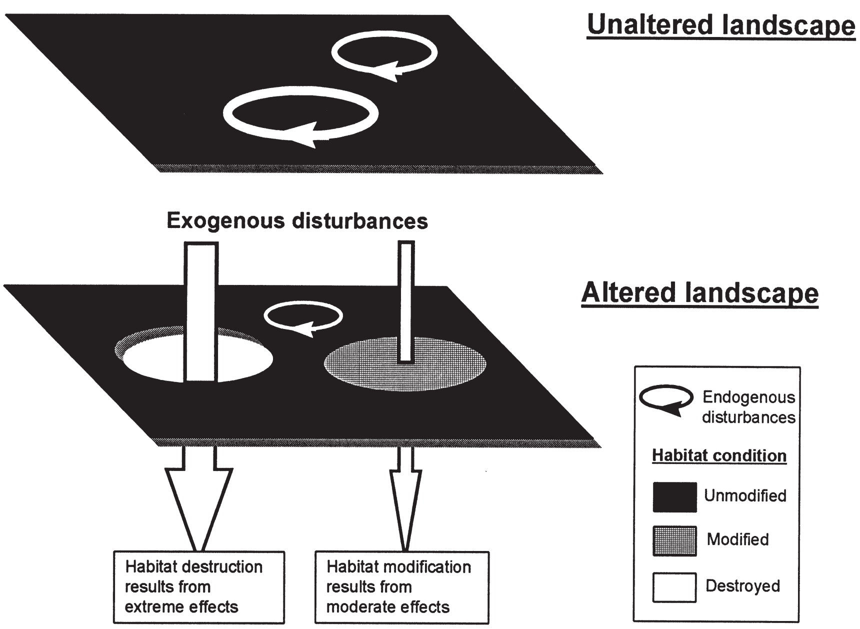

Figure 3. Processes of landscape alteration that can result in various levels of habitat modification or, at the extreme, habitat destruction. In the unaltered landscape, endogenous disturbances are operating to maintain ecosystem function. In the altered landscape, endogenous disturbances may or may not be operating alongside exogenous disturbances.

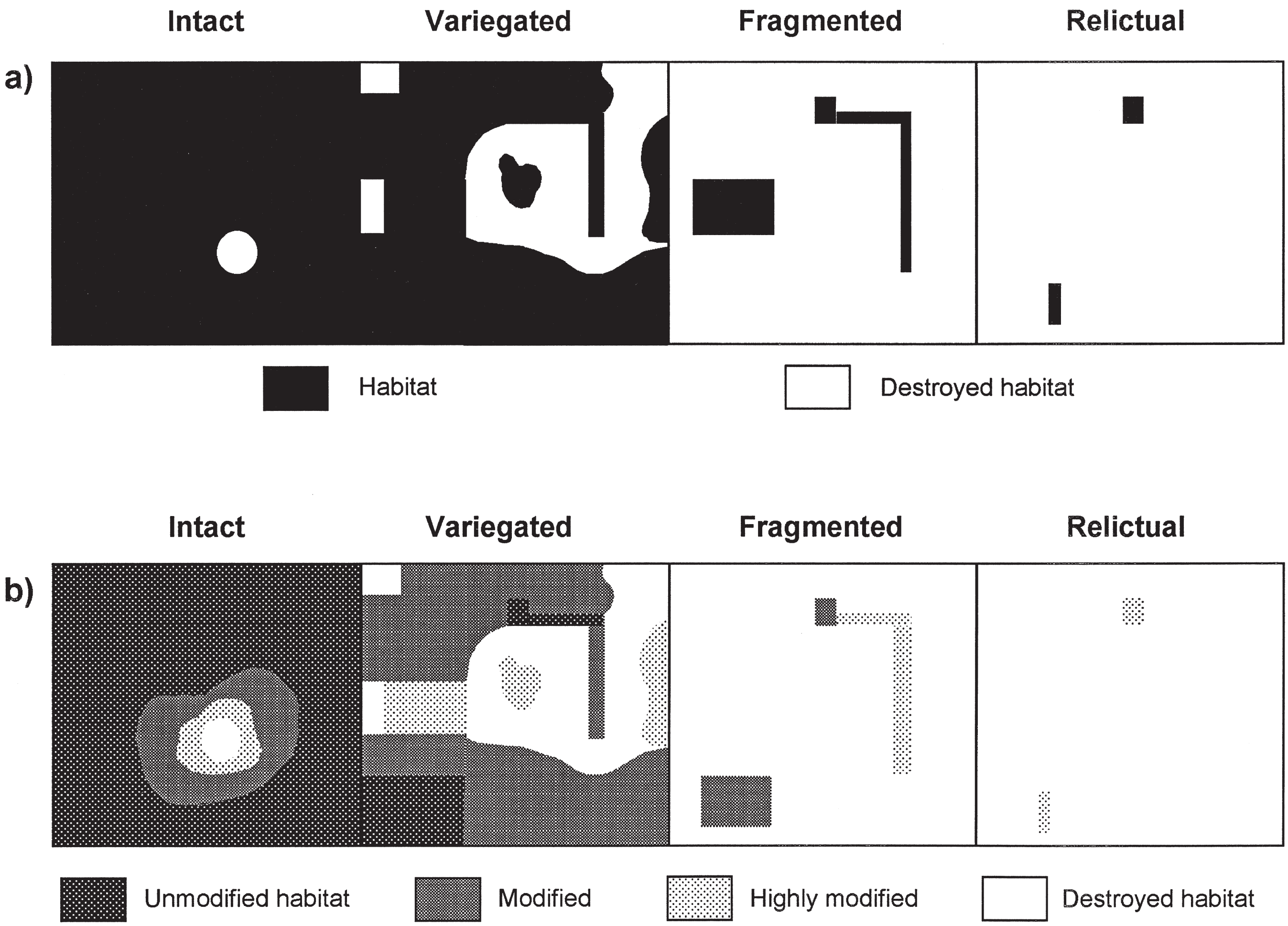

Figure 4. Four landscape alteration states (intact, variegated, fragmented, relictual) showing (a) habitat destruction (the degree of destruction defines the four landscape alteration states) and (b) overlying modification of remaining habitat that might be typically associated with increasing levels of destruction. Table 1 further elucidates these four states.

changes from one habitat state to a more degraded one (Hobbs & Norton 1996; Yates & Hobbs 1997). Lord and Norton (1990) argue that the term *habitat modification* is made redundant by the concept of a continuum of spatial scales of destruction, with modification representing the finest scales. Nonetheless, we continue to differentiate between modification (as a continuous variable) and destruction (as the most severe outcome of modification) as a useful way of describing patterns of landscape alteration. There are meaningful examples in which the spatial scales of destruction are quite divergent due to the nature of human management. For example, an initial act of habitat destruction (e.g., broad-scale clearing of vegetation for housing development) is often quite distinct from subsequent fine-scale disturbances that modify the remaining habitat (e.g., effects of domestic pets on wildlife, urban run-off, and rubbish dumping).

Modification acts to create a layer of variation in the landscape beyond the straightforward spatial patterning caused by vegetation destruction. Although the extent of destruction defines the landscape state in this framework, modification describes the condition of the remaining habitat. All combinations of the habitat destruction and modification gradients are theoretically possible, but habitats tend to become more highly modified with increasing levels of destruction (Table 1; Fig. 4b; Saunders et al. 1991), and particular states may have distinctive patterns of disturbance and land use.

States of Landscape Alteration and Associated Land Uses

Intact Landscapes

The degree of human intervention associated with intact landscapes varies but can be extremely low (Table 1), particularly in reserves managed for conservation. In intact and variegated landscapes, modification gradients can be a significant feature because remaining habitat is relatively

Table 1. Four states of landscape alteration defined by degree of habitat destruction.

Type of alteration	*Degree of destruction of habitat (% remaining)*	*Connectivity of remaining habitat**	*Degree of modification of remaining habitat*	*Pattern of modification of remaining habitat*
Intact	little or none (>90)	high	generally low	mosaic with gradients
Variegated	moderate (60–90)	generally high, but lower for species sensitive to habitat modification	low to high	mosaic that may have both gradients and abrupt boundaries
Fragmented	high (10–60)	generally low, but varies with mobility of species and arrangement on landscape	low to high	gradients with fragments less evident
Relictual	extreme (<10)	none	generally highly modified	generally uniform

**Pearson et al. (1996).*

extensive. A widespread example of intact landscape is rangeland in marginal regions, where domestic livestock graze the landscape and modify it to varying degrees. Because pasture improvement and cultivation are not economical in these situations, habitat destruction is limited, but managing the effects of grazing around water points can be a key conservation issue (Landsberg et al. 1999).

Intact landscapes can be associated with land uses ranging from the most extensive (e.g., Antarctica) to the most intensive. In Europe, traditional agricultural systems with hedgerows, managed woodlands, and so on, represent systems where human activities create endogenous disturbances upon which elements of the biological diversity depend. The problem now facing many of these cultural landscapes is that the traditional management is either giving way to modern technological agriculture or being abandoned (e.g., Goudie 1990; Burel & Baudry 1995). They are therefore highly susceptible to destruction or modification and conversion to another alteration state. Rangelands are also cultural landscapes, having been inhabited by indigenous aboriginal people for long periods.

Variegated Landscapes

Variegated landscapes are widespread in parts of eastern Australia where domestic livestock grazing of eucalypt woodlands has been primarily dependent on native pastures (Fig. 2). Habitat destruction in these landscapes (Table 1) is limited in extent and results mainly from human settlement and conversion to exotic pastures. Nonetheless, natural grasslands with varying densities of eucalypts still form the landscape matrix in many regions. Habitat modification takes the form of species replacements, loss of native species, and loss of structural complexity of the habitat. (McIntyre & Lavorel 1994*a*, 1994*b*). Modifications are generally present as both abrupt boundaries (e.g., roads, fencelines) and gradients (grazing patterns).

Barrett et al. (1994) identified three functional groups of birds in variegated woodlands: (1) woodland species sensitive to structural modifications; (2) tolerant woodland birds that use both modified and unmodified woodlands; and (3) open-country species that replace woodland birds when tree densities are low. Understory plants of the woodlands are more directly affected than birds by disturbances such as grazing, fertilizer use, and soil disturbance (McIntyre & Lavorel 1994*a*, 1994*b*). Unlike birds, native herbaceous plant communities are not disrupted by the removal of trees alone.

Further examples of variegated landscapes can be found in tropical areas, where land mosaics consist of unmodified forest and a range of modified or transformed systems (Greenberg 1996; Nepstad et al. 1996). For instance, Nepstad et al. (1996) recognized primary forest, logged forest, secondary forest, managed pasture, and degraded pasture in the landscape mosaic in the eastern Amazon. Although the primary forest remnants were undoubtedly the most important habitat for many species, data obtained by Nepstad et al. (1996) indicate that the modified areas still acted as a habitat component for many forest species.

We suggest that variegated landscapes are often associated with land uses that impose a range of exogenous disturbances and where the disturbances are not always tightly correlated. For example, in the variegated eucalypt woodlands, the following combinations of disturbances form common management practices: (1) grazing alone; (2) grazing and fertilizer application; (3) grazing, fertilizer application, and presence of exotic species; (4) grazing, fertilizer application, presence of exotic species, and cultivation; (5) none of these uses. There are more potential combinations because clearing trees is another management option for most of these categories. Individual disturbance types tend to be applied in set combinations, but there sufficient uncoupling occurs to provide a wide range of states (Fig. 2b), while the variable nature of livestock grazing imposes additional spatial complexity. Pastoral land use consequently creates in the grassy woodlands a gradient of habitat modification states, forming a mosaic that is typical of a variegated landscape.

In the same way, forestry operations in native forests impose a series of disturbance regimes of different intensity on the landscape: for example, (1) no disturbance (in conservation or riparian zones), (2) selective logging, (3) clear felling, and (4) clearing for roads (destruction). In addition, a mosaic of modified habitats is created by the presence of forest patches at different stages of the harvesting cycle, representing shorter or longer periods after an exogenous disturbance event. A specific illustration of a variegated forestry landscape is given by Dunning et al. (1995), who described habitats in pine woodlands of South Carolina (U.S.A.). The major exogenous disturbance is clearcutting, and habitats included unlogged hardwood riparian corridors, mature pine woodland, and clearcut pine woodland regrowth of 0–80 years.

Fragmented Landscapes

The central Western Australian wheatbelt is a classic example of a fragmented landscape (Table 1). It contains mostly discrete patches of native vegetation in a matrix transformed for agriculture (Hobbs & Saunders 1993; Saunders et al. 1993). The remaining native vegetation is contained in many small fragments and roadside corridors. Although some of this native vegetation remains relatively unmodified, much has been severely modified by prolonged periods of grazing by livestock (Norton et al. 1995; Abensperg-Traun et al. 1996). Other external influences, such as nutrient inputs and feral predators, have also had significant influences on the biota in the fragments (Hobbs 1993; Hobbs et al. 1993). Studies indicate that the matrix provides virtually no habitat for native plants (Table 2) and extremely poor habitat for native invertebrates (Scougall 1991; Lobry de Bruyn 1993). Nevertheless, significant numbers of ant species are common to both fragment and matrix (Fig. 5), highlighting Wiens' (1997) point that the matrix cannot be assumed to be ecologically neutral, even in a distinctively fragmented environment.

We suggest that the fragmented landscape may often differ from a typical variegated landscape in its pattern of exogenous disturbances. In fragmented landscapes, the degree of destruction is greater and the disturbances tend to be more tightly coupled (i.e., highly correlated). As a result, the destruction and modification boundaries on the landscape are typically sharper and the modification gradients shorter. In the central wheatbelt in Western Australia, for example, vegetation clearing is always associated with cultivation and use of fertilizers, which destroys the native vegetation (Table 2). Another land use that commonly leads to fragmentation and sharp habitat boundaries is urbanization, in which initial vegetation clearing is tightly correlated with building construction, paved surfaces, and nutrient runoff. Remaining habitat is frequently allocated to reserves and can be comparatively undisturbed. Gradients of modification can certainly occur in the remaining habitat, but in fragmented landscapes it is generally overshadowed by the magnitude of habitat destruction.

Table 2. Average number of plant species recorded in two habitats (seven quadrats each) in the fragmented Western Australian wheatbelt.*

Plant life-form (quadrat dimensions, m)	*Woodland fragments*	*Cropland matrix*
Native trees (10 × 10)	1.6	0
Native shrubs (5 × 5)	0.4	0
Native herbs (1 × 1)	12	0
Exotic herbs (1 × 1)	2.2	2.8

**Landscape is similar to that depicted in Fig. 1c. Original vegetation (*Acacia acuminata *and* Eucalyptus loxophleba *woodland) has been fragmented through conversion to cropland (wheat and pasture rotation). Data are averages taken over seven transects running from fenced woodland into cropland. Woodland samples were 100 m from the edge (fence); cropland sites were 20 m from the edge. There were no exotic trees or shrubs. Data are from Scougall (1991).*

Relictual Landscapes

Relictual landscapes appear to be most often associated with regions where the effects of urban and intensive agricultural development are greatest (Table 1). These land uses destroy habitat, and the economic pressures to develop the entire landscape are great. In eastern Australia, habitats close to the coast (Catterall & Kingston 1993) and on the most fertile soils (e.g., grasslands, Fensham 1998) can be reduced to a relictual state. The remaining fragments are under immense pressure from the intensively used matrix, although with appropriate management even small remnants can persist (Kirkpatrick 1986), albeit with a loss of ecological function.

Using the Framework to Classify Individual Landscapes

Possible Classifications

The common typology of the landscape in terms of patch, corridor, and matrix (Forman 1995) reflects a highly anthropocentric view of the world. These elements are the same as those identified in human perceptual theory and describe a landscape at a scale experienced by humans (Bell 1993; Nassauer 1995). Hence the biologists' preoccupation with fragmentation is understandable. Fragments are tangible structural entities that are easily identified on the landscape. These human perceptions are not necessarily those of other organisms, however, and there can be large differences between a human-defined landscape state and that landscape as

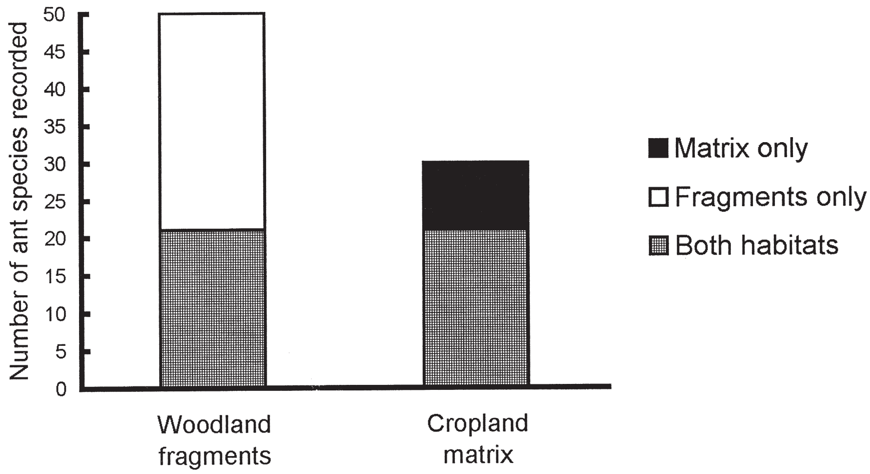

Figure 5. Ant species recorded in two habitats in the fragmented Western Australian wheatbelt at the study site described in Table 2. Data are averages taken over seven transects running from fenced woodland into cropland. Woodland samples were 100 m from the edge (fence); cropland sites were 20 m from the edge. Data are from Scougall (1991).

perceived by other biota. In the Pietermaritzberg Botanic Gardens in South Africa, Ingham and Samways (1996) perceived the landscape to contain fragments of indigenous forest and grassland embedded in a matrix of mown grass. Structurally and floristically the landscape could be classified as fragmented. Their study of the distribution of epigaeic invertebrates suggested otherwise, however. Only a few species had distributions mirroring that of the fragmented vegetation. Most taxa varied in their ability to exist in lawn and the variously modified forest fragments, but all orders had some species that occurred in all habitats and sites sampled.

Other examples include differential use of the matrix by invertebrates in apparently fragmented (Margules et al. 1994) and intact landscapes (Baudry & Asselin 1991). In Normandy, where pasture habitats were being modified by grazing abandonment, different taxa of spiders were sensitive to the physical, structural differences between modified and unmodified habitat (Baudry & Asselin 1991). In Australia King et al. (1985) compared Collembola in natural grasslands with those in sown exotic pasture. Sown pastures, which would commonly be regarded as destroyed natural habitat, supported 9 of the 21 species of native Collembola recorded. In a North American pine woodland managed for forestry, in terms of exogenous disturbances and structural attributes, the habitat is variegated (Dunning et al. 1995). In terms of one organism of study, a sparrow, breeding is restricted to areas with a dense groundlayer and an open shrub layer associated with pine stands >80 years old or 1–5 years old, and this type of habitat is fragmented (Dunning et al. 1995).

Biotic Experience

Because conservation biology is concerned with maintaining a particular species assemblage, the way different species experience altered landscapes is arguably more significant than the human perspective on that landscape. An individual species' response to landscape alteration will be determined by the scale at which it normally operates and at which it perceives the environment (Andrén 1994; Cale & Hobbs 1994; Pearson et al. 1996). In a human-defined, structurally fragmented landscape, there will be a large proportion of species that perceive the landscape as fragmented—plants with poor dispersal capabilities and animals with low mobility. A small proportion, however, will be able to move among fragments and/or use the matrix between fragments, and these will experience the landscape as variegated or even intact.

Similarly, in variegated landscapes the majority of species will experience the landscape as variegated and thus be able to move through the matrix, even while encountering variation in percolation characteristics. But the species that are most sensitive to exogenous disturbances, will find themselves confined to the fragments of least modified habitat. The assessment of habitat quality and hence the effect of exogenous disturbances on species is a complex question and the subject of considerable detailed research (e.g., Wiens 1989; Hansen et al. 1993).

Classifying landscapes based on how biota respond to them presents a wide range of options. If individual species are considered, there could be as many classifications as there are species on the landscape. Alternatively, emphasis could be placed on particular "focal" species whose requirements encompass those of the rest of the biota (Lambeck 1997). Another approach is to classify landscapes differentially for different groups of species. Taxonomic groups (e.g., birds, spiders) can be examined, but the heterogeneity of resource use within taxa will likely prevent a single classification being relevant to an entire taxon. A more useful refinement is to identify functional groups within taxa, based on tolerance of exogenous disturbances, such as disturbance tolerators, disturbance dependents, or sensitive species (Barrett et al. 1994; Lavorel et al. 1997). The landscape can then be classified as intact, variegated, and so forth, according to the response of different functional types.

Usefulness of Human Perceptions of Landscape

Human perceptions of a landscape can be different from those of other organisms, and we suggest that how an organism experiences landscape alteration, is of more significance in conservation biology than the human perspective. But human perceptions of altered landscapes are of some importance as well. The processes of habitat destruction and modification are generally the result of human activities, so the gross structural changes to ecosystems (e.g., patterns of destruction) are also at a human scale. Human land use is applied in particular spatial scales and patterns that may be mirrored in the subsequent biological effects on the landscape. In the case of fragmented landscapes, where different disturbance types tend to be tightly coupled, the loss of habitat provides both a strong visual and biological contrast to the remnant vegetation. The strong link between visual and biological effects makes fragmented landscapes attractive subjects for conservation research. In these circumstances, the human-based classification is in close alignment with the landscape state as it is experienced by the majority of other species. But this is not always the case.

Human-based classifications of landscape alteration will continue to be used, and the human perspective can be of value, particularly at a preliminary stage of investigation when little is understood about resource use in the biotic community. We do not object to human-based classifications per se, but we do see a problem when classifications are attributed without appropriate identification of the reference organism(s). It is commonplace among conservation biologists to assume, because certain structural elements of habitats are fragmented or a particular species finds a landscape operationally fragmented, that it is a fragmented landscape in all other respects.

Conclusion

Adequate description of a particular landscape or habitat must include (1) description of what makes up the baseline habitat(s) of conservation concern; (2) description of the human effects (differentiating between exogenous and endogenous disturbances) and other exogenous disturbances associated with this landscape, as well as their effects on habitats in structural, biotic, and functional terms; (3) general description of the state of alteration of the landscape from a human perspective, taking into account land-use effects relating to the degree of destruction and modification; and (4) additional landscape classification(s) that take into account the species or community of concern in terms of their patterns and scale of resource use.

Setting the landscape context using these steps is an important tool for more effective communication within the research sphere and between researchers and land managers. The framework we present provides a landscape classification that will account for the widest range of habitat alteration states and, it is hoped, assist this communication.

Conservation management in altered landscapes involves stopping and, if possible, reversing the processes of destruction and modification. Within this overall aim, priorities will vary according to the alteration state of the landscape. Hobbs and Hopkins (1990) and McIntyre et al. (1996) presented some discussion of management actions needed for intact, variegated, fragmented, and relictual landscapes, and these are developed further by McIntyre and Hobbs (2000). Because effective habitat restoration is extremely difficult, a first priority will always be to maintain the least modified habitat available. This may include some or most of the matrix in intact and variegated landscapes. There is likely to be little or no unmodified habitat remaining in fragmented and relictual landscapes. In these cases, improvement of degraded fragments is required. Relictual and fragmented landscapes also require that management priorities be given to buffering fragments from hostile land uses and restoring connectivity. A desirable aim for fragmented landscapes would be to return them to a state of variegation through restoration and modification of management in critical locations. In variegated landscapes, rehabilitation is less of a priority, but maintaining the condition of the matrix is important to halt trends toward fragmentation.

A much more proactive approach is needed so that landscape changes can occur with less impact on the native biota (Laurance & Gascon (1997). Using our framework to describe state of landscape alteration allows users to articulate the idea that landscapes do not have to be fragmented before conservation actions are justified.

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