

Recent applications of airborne videography to management of forest fauna

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ABSTRACT

The spatial distribution of suitable habitat for animal taxa has been a major topic of ecological research. Information on the spatial distribution of habitat and its temporal variability provides a basis, both theoretically and practically, for habitat management. As a result, the use of geographic information system (GIS) algorithms and approaches for assessing fauna habitat has become a vital tool in wildlife management. The advent of high spatial resolution remotely sensed imagery (as obtained, for example, from airborne camera, videography or satellite based sensors) provides the possibility of providing base layer spatial information on habitat distributions and quality as well as an efficient means of updating this information based on natural and anthropogenic change.

Key words: remote sensing, forest structure, habitat, fauna.

Introduction

The natural environment of south-eastern Australia contains a variety of woodland and forest ecosystems containing a mosaic of understorey environments ranging from heathland elements on the most infertile sites to grasses on the more fertile sites or ferns in the wetter, taller forests (Newsome and Catling 1979). Collection of forest structure information in the field over this mosaic is both an extremely expensive and a logistically difficult task, due to the significant size of the resource and because forest structure is spatially very variable resulting in significant change within a few metres. Additionally, a mosaic is created by temporal changes in forest structure as the forest or woodland undergoes the progression from regrowth to senescence, such as from the effects of fire or timber harvesting. Many animal species display associations with forest structure. Consequently, for management purposes, forest structure needs to be identified and quantified across the landscape, but also needs to be regularly monitored (Gill and Nicholls 1989). For example, changes in tree, shrub, ground and litter cover are significant for many ground-dwelling mammals, rather than the nutrient richness of a site (Catling *et al.* 1998; 2000). Habitat structure is also important for birds (Briggs *et al.* 2001; Freudenberger 1999; Reid 2000). Catling and Burt (1995) found the composition of the ground-dwelling mammal fauna in forests in south-eastern New South Wales is determined by the complexity of the understorey, which is influenced by burning (Catling 1991), grazing (Tasker *et al.* 1999) or logging (Lunney and Ashby 1987; Kavanagh and Webb 1998).

A similar pattern exists for the arboreal fauna in the same forests. The highest abundance of arboreal marsupials is found where site fertility is highest (Braithwaite 1983; Braithwaite *et al.* 1983). However,

there is a nutrient-threshold effect. Below the threshold, the significant explanatory variables are all related to food quality and abundance. Above the threshold, the variables explaining occurrence are exclusively related to structural variables (Pausas *et al.* 1995). Davey (1989) found that structural attributes are as important as nutrient levels in determining the habitat of arboreal marsupials, particularly at the finer scale of an actual forest. Also, stand age and the age and density of old trees was important in providing suitable hollows for a range of arboreal species (Davey 1989; Lindenmayer 1989; Lindenmayer *et al.* 1990; Kavanagh *et al.* 1995).

Remotely sensed data at high spatial resolution has significant potential in modelling a variety of forest attributes including habitat condition, individual tree delineation, forest typing and fragmentation (Coops *et al.* 1998). Digital camera, videography and high spatial resolution imagery from satellites all have a number of advantages over conventional aerial photography for forestry applications including almost immediate availability of imagery for visual assessment and digital processing, digital recording format, in most cases reduced cost structure over large areas, and the ability to collect data in a number of spectral wave bands. Applications of high spatial resolution imagery range from shoreline oil spill surveys (Owens and Robilliard 1980) to imaging of soil (Vlcek 1983) and assessing rangeland conditions (Pickup *et al.* 1995). Forestry applications of high spatial resolution data include the quantification of plant leaf radiation (Gausman *et al.* 1983), prediction of size, density and spatial distribution of leaves, branches and trunks (Wu 1988) and deriving the pattern of forest destruction related to arsenic

concentrations (Airola 1989). Additional research includes the prediction of soil colour and organic matter content (Mausel *et al.* 1990), detecting weed infestations on rangelands (Everitt *et al.* 1990), using middle infrared data to detect differences in forest species (Everitt *et al.* 1986) and detecting the presence of wildfires (Everitt *et al.* 1989).

The need for accurate, timely, and cost-effective forest information has never been more critical because of Australia's commitments to sustainable forest management and conservation of biodiversity. Generally, Australia is far from achieving sustainability and there is a need to know much more about how the environment functions, how and why it is changing and to avoid further loss of biodiversity (State of the Environment, Australia 2001). While modelling of biophysical variables such as climate, geology and landform might be useful for broad-scale spatial prediction of faunal distributions, such models are unlikely to provide descriptions of habitat requirements for animals (Cork and Catling 1996). The ability of forest managers to develop policies to protect and/or manage habitat structure and quality in native forests depends on the availability of accurate forest structure maps that indicate the diversity and extent of different habitats over the landscape. This paper discusses recent developments in the use of imagery of high spatial resolution and its application to conserving Australia's forest fauna.

Habitat complexity scores

Under Australian forest conditions, Newsome and Catling (1979) developed the "habitat complexity score". This score is an index of the structural complexity and biomass of forested vegetation irrespective of the plant species. The score is based on the vertical distribution of tree canopy, shrub canopy and ground herbage coverage, the cover of rocks, logs and litter and general soil-moisture condition in the forest stand. The habitat complexity score provides a key input into the development and application of Habitat Suitability Indices (HSI) as it provides a description of the local habitat from which relationships are derived between habitat and its suitability for a specific organism. HSI attempt to quantify habitat quality using attributes considered important to wildlife species and they are commonly based on the underlying assumption that either individuals or groups of species select areas that best satisfy their life requisites (Schamberger and O'Neil 1986). By making these types of models spatially explicit, wildlife are considered along with other resource activities for watersheds, landscapes and regions.

Habitat complexity scores, derived from forest structure information, provide descriptions of habitat and facilitate the prediction of faunal distribution and abundance (Catling and Burt 1995). For example, Catling and Burt (1995) demonstrated relationships between forest structure and the relative abundances of different mammalian fauna using habitat complexity scores. Some species such as the Bush Rat *Rattus fuscipes*

are positively related and others such as the Eastern Grey Kangaroo *Macropus giganteus* are negatively related to the habitat complexity score. Freudenberger (1999) found similar relationships between woodland birds, remnant size and habitat complexity scores. Similarly, Monamy and Fox (2000) found a direct association between small mammal abundance and vegetation structure following wildfire.

Prediction of forest structure from habitat complexity scores in eucalypt forests using aerial videography

In the 1990s, new techniques were developed which utilised the high spatial resolution airborne, or space-borne, remote sensing imagery. These techniques consider the local variance around each pixel in the image at a variety of scales. One technique provides an index of local pixel variability, which provides an indication of habitat complexity (Coops and Catling 1997a). To do this, the local variance surrounding individual pixels is computed with increasingly large windows of pixels

(i.e. 3×3 , 5×5 ... 49×49). This produces an individual local variance response function for each pixel on the image, which provides an indication of the spatial elements within the scene. Theoretically, if the spatial resolution of a forested image is considerably smaller than the crown size, the neighbouring pixels are highly correlated and thus the variation will be small. If the canopies in the scene approximate the size of the pixel then the likelihood of the neighbourhood resembling the central pixel decreases and the local variance increases. As the window size of pixels increases, and many crowns are found, the local variation stabilises.

To demonstrate this effect, aerial videography imagery of the *Eucalyptus* dominated Currowan State Forest in south-eastern Australia ($35^{\circ} 35'S$, $150^{\circ} 07'E$) was obtained (Coops and Catling 1997a,b). Twenty nine sites were established of 0.25 hectares using local field and 1:25,000 scale maps. Each site was located within a homogeneous forest type and was chosen using a "gradsect" approach allowing altitude, lithology and vegetation types to be represented (Austin and Heyligers 1991). At each site, a habitat complexity score was given for the structure of fauna habitat (Newsome and Catling 1979) on the basis of five features: (1) canopy cover; (2) shrub cover; (3) ground vegetation cover; (4) the amount of litter, fallen logs and rocks and (5) a moisture rating. Each feature was rated on a scale of 0-3 and the scores of the five features tallied. For the five features and their scores see Table 1 of Coops and Catling (1997b). Figure 1 diagrammatically represents the different habitat complexity scores derived from forest structure. Generally, a score of 9 or 10 is a forest with a thick understorey, and good ground and litter cover (Figure 1a), whereas a score of 4 or 5 denotes a forest with poor structure with few understorey shrubs and little ground cover (Figure 1c). A score of 7 denotes a forest with a moderate structure (Figure 1b).



Figure 1. Diagrammatic representation of a forest with habitat complexity scores of (a) 10, (b) 7 and (c) 5. (Adapted from Coops and Catling 1997b).

Three videography transects were flown over the forest on 2nd April 1996. The field sites were located on the imagery, and the local variance of the videography within each site was computed on the assumption that changes in local variance provided an indication of forest structure, and thus the habitat complexity of the site. The Near InfraRed (NIR) channel demonstrated the most variation, as that channel provided an indication of photosynthetic activity and, as a result, the variation between canopy, understorey, ground cover, soil and shadow provided a highly variable response in the video imagery. The relationship between the NIR variance at a site and the field habitat complexity scores was highly significant ($p < 0.001$) ($R^2 = 0.75$; $n = 29$) (Coops and Catling 1997b). From this relationship, maps of the habitat complexity scores were predicted from the videography at 2 m spatial resolution. Field verification has shown that the predicted habitat complexity scores varied across the landscape in a similar way to the recorded scores with 80% correctly predicted by the videography using the model. In all remaining cases, the recorded and predicted scores were within a single habitat score. Figure 2 demonstrates the different levels of variance obtained from videography over sites with different habitat complexity scores. High

habitat complexity exhibited the highest variance and low complexity the lowest variance. Also, note the manner in which the local variation stabilises as the window size of pixels increases and many objects have been found. The site with high structural complexity is a highly complex moist forest with an extensive cover of overstorey, understorey shrubs, ground cover and litter (e.g. Figure 1a). Medium habitat complexity (e.g. Figure 1b) is a dry forest of lower complexity than the above site and the site with low complexity (e.g. Figure 1c) is a dry exposed site with a sparse understorey of shrubs and ground cover.

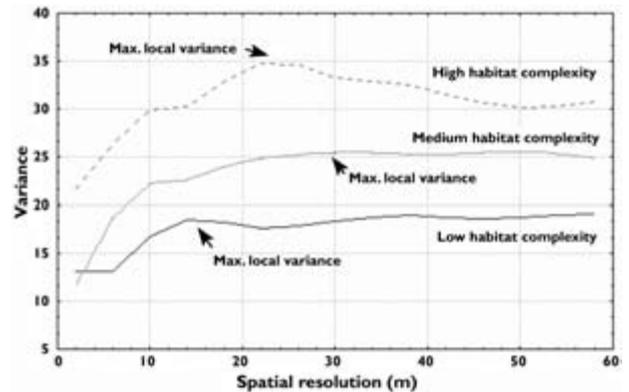


Figure 2. Graphs of the local variance for three sites with different habitat complexity scores. The X axis indicates the spatial resolution with the Y axis showing the level of variance at increasing window sizes of pixels in the NIR channel (from Coops et al. 1998).

Some applications of the method

1. Identification of areas of high habitat value for small ground-dwelling mammals

The spatial distribution of suitable habitat for animal taxa has been a major topic of ecological research with the size, spatial arrangement and quality of habitat being a significant variable on the probability of persistence of some taxa. Catling and Burt (1995) established relationships between habitat complexity scores and the distribution and abundance of a variety of species of fauna in the southern forests of Australia. Using the local variance prediction method, existing models of species abundance (Figure 3a) can be applied to spatial estimates of habitat complexity (Figure 3c) and to produce predictions of the distribution and abundance of small mammals found in the eucalypt forests of southern Australia (Figure 3d) (Coops and Catling 1997a, b). The accuracy of the abundance predictions have been verified using trapping grids for small mammals across a range of abundances (Catling and Coops 1999). There is close agreement between the predicted abundance of small mammal species (number per 100 trap nights) predicted from the imagery and the recorded abundance for the species in the field, which demonstrates that airborne videography predicts the distribution and abundance of small mammals from habitat complexity scores derived from forest structure (Catling and Coops 1999). The close similarity between the predicted and observed abundance is an extremely good result considering that habitat variables are significant, but not the only variables, in models of the distribution and abundance of small mammals (Catling et al. 1998, 2000).

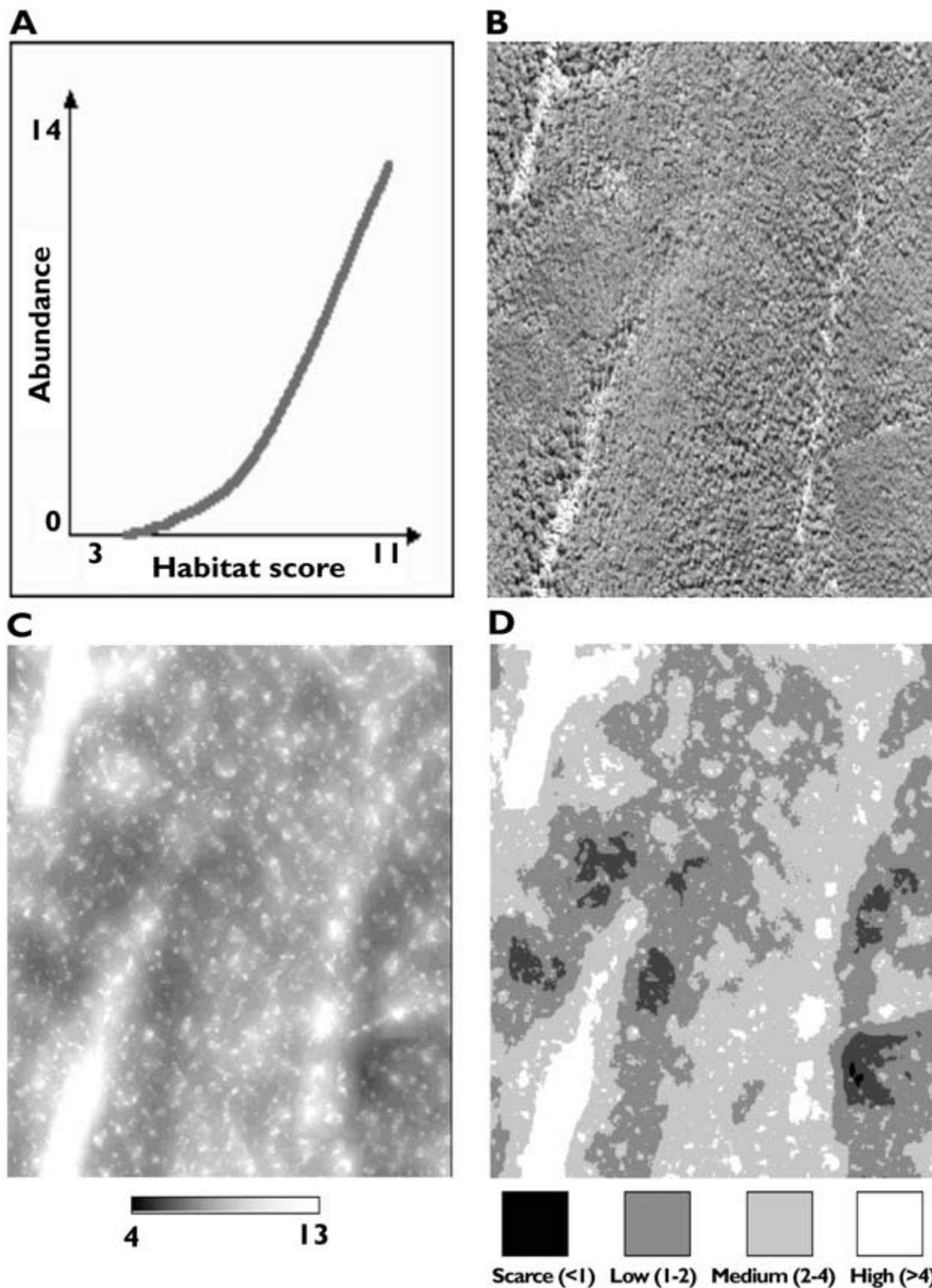


Figure 3. (a) shows a schematic representation of the model developed by Catling and Burt (1995) to predict the abundance of Agile Antechinus *Antechinus agilis* using forest habitat data. Figure 3(b) shows airborne videographic data of 1 km² of Currawan State Forest, N.S.W. Figure 3(c) shows the predicted habitat scores of the same region of Currawan State Forest from the videography (dark = low complexity; light = high complexity) and Figure 3(d) shows the predicted distribution of *Antechinus agilis* for the same area (dark = low abundance; light = high abundance).

2. Predicting historical spatial heterogeneity of habitat and mammal abundance

Based on the success of the results at Currawan State Forest, a new method was developed based on habitat prediction and simulation models (Coops and Catling 2000, 2001). The approach combined generalized linear regression modelling of species abundance with respect to habitat quality and time since disturbance with the spatial distribution of habitat quality as predicted and simulated from remote sensing imagery. The strength of this approach is that the input data can be derived as part of a mapping program of standard forest inventory with the addition of remote sensing imagery of high spatial resolution. Furthermore, the approach operates at the scale used for wildlife management in Australia, which makes it widely applicable. Compared to current management practice, the model improves the assessment of abundances by allowing calculation of both habitat change and its effect on the abundance of selected mammal species.

The approach was examined in Nadgee Nature Reserve, which is a 20 000 ha reserve located in the south-eastern corner of New South Wales. In April 1972, study sites ($n = 120$) were established in the Reserve as part of the study of the ecology of the Dingo *Canis lupus dingo* (Newsome *et al.* 1983). These sites were used later to study the responses of ground-dwelling mammals to wildfires, which swept the Reserve in 1972 and again in 1980 (Newsome *et al.* 1975; Catling and Newsome 1981; Catling *et al.* 2001). Twenty one sites are on beaches and the rest are in heathland and forest ($n = 99$). At the heathland and forest sites, a habitat complexity score (Newsome and Catling 1979) was estimated for the structure of habitat and were recorded in December 1980 (one month post fire), 1986 and every two years since 1986 to 1998. In 1982 only a subset of the sites ($n = 25$) was recorded for habitat complexity.

Soil plots, placed at each of the 120 study sites, were used to record the tracks of medium-sized and large mammals to provide an index of their abundance (Catling and Burt 1994). Soil plots are 1m wide bands of raked soil and sand aligned across vehicle tracks. They were read for animal tracks, then re-raked each morning for three consecutive days. Samples were taken at least twice per year.

Step 1: Predicting HCS from local variance of aerial videography (cf. the first three boxes in Figure 4).

The major steps in the simulation strategy are shown in Figure 4. Initially, the aerial videography imagery was processed following methods similar to Pickup *et al.* (1995) to correct and normalise for geometric and brightness differences in individual scenes. Due to a lack of recent topographic mapping of the region at a sufficiently fine scale (1:10,000 or better), a precision corrected SPOT panchromatic scene was acquired with a spatial positional accuracy of 5 m. This image was used as the mapping base upon which to register the imagery. The local variance method was applied to the imagery to predict the habitat complexity scores and, as with previous studies (Coops and Catling 1997a, Coops *et al.* 1998), the relationship was highly significant ($P < 0.01$) ($R^2 = 0.78$, $n = 96$).

Step 2: Predicting historical change in HCS (cf. the fourth and fifth boxes of Figure 4).

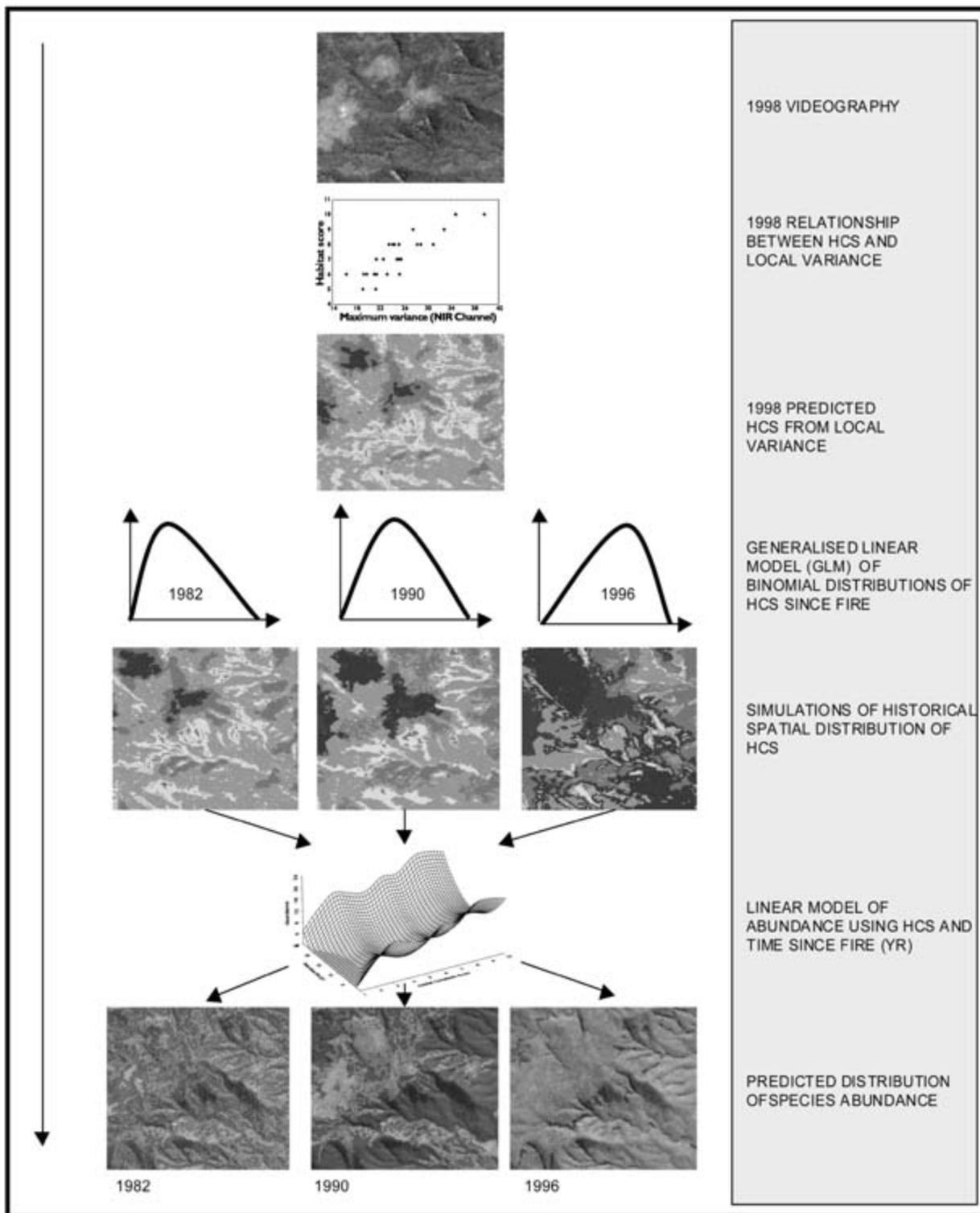
When forest structure (measured as habitat complexity scores) is assessed at sites over a number of measurement periods, a model of the frequency distributions of habitat complexity scores can be developed. These frequency distributions have two important implications. Firstly, the distributions can describe the characteristics of the variation of habitat complexity over an area, and secondly, the distributions can be used to estimate parameters relating to the spatial pattern, such as the mean and spatial heterogeneity of habitat over the entire forest at the given site size at a given time. A number of previous studies characterized the frequency distributions of a number of agricultural and forest based biomass variables and found that most are well described by distribution models (Thomas, 1988; Shiyomi, 1991; Shiyomi and Okobu, 1996).

The use of imagery of high spatial resolution and frequency distribution models based on historical habitat complexity data can provide detailed information on the spatial and temporal variation of habitat, respectively. The approach was to use the prediction of habitat complexity scores derived from the imagery as a base to derive retrospective predictions of the spatial extent and pattern of habitat quality over the landscape. A binomial distribution is fitted to the frequency distributions of the HCS recorded at each recording period (Figure 5). The parameters of the binomial distribution are modelled using generalized linear modelling to provide a relationship between the frequency of different HCS across the landscape to the time since fire. In most cases, the binomial distributions fit the observed data significantly allowing the frequency of different HCSs to be predicted solely as a function of time since fire (Coops and Catling 2000). This provides a model to make both retrospective and future predictions of the distribution of habitats. This is achieved by projecting the spatial distribution of habitat complexity scores derived from the videography backward in time using a combination of simple Boolean logic, estimated binomial distributions, and the use of random fluctuations to mimic natural forest dynamics that are likely to occur over the modelling period (Coops and Catling 2001).

Step 3: Habitat models and prediction for forest mammals (cf. the sixth and seventh boxes of Figure 4).

Finally, multiple regression was then used to determine the relationship between the observed abundance of each mammal species (percentage of soil plot nights with tracks) and (a) the observed habitat complexity score and (b) the time (in years) since the fire. An optimum model is selected based on the highest coefficient of determination (r^2) and significance of the model. A stepwise regression approach is used to examine the response of fauna to time since fire and to changes in vegetation structure, utilizing (a) simple linear representations of time since fire and (b) a quadratic (polynomial) transformation of time since fire (Catling *et al.* 2001).

The modelling approach is a compromise between ecological realism and limited available input data. It



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Figure 4. Schematic diagram of the modelling approach (from Coops and Catling 2001). An explanation of each step is provided on the right hand side of the figure.

provides an estimate of species abundances which allows model predictions to be compared over a range of sites in the landscape. The approach is spatially explicit, and thus produces a better understanding of dispersal and habitat selection by mammals, as well as it makes the linking of population models spatially explicit (Byron, 1981; Thor, 1990; Bideau *et al.* 1993; Holt *et al.* 1995). The approach encompasses the major aspects of current scientific understanding of mammal habitat requirements.

3. Identification of areas of high habitat value for arboreal marsupials

The potential for imagery of high spatial resolution to predict the distribution and abundance of other fauna, such as arboreal marsupials, also exists. Coops *et al.* (1998) and Culvenor (2002) have demonstrated the development of software for individual tree recognition from videography or digital camera imagery. This may be a significant

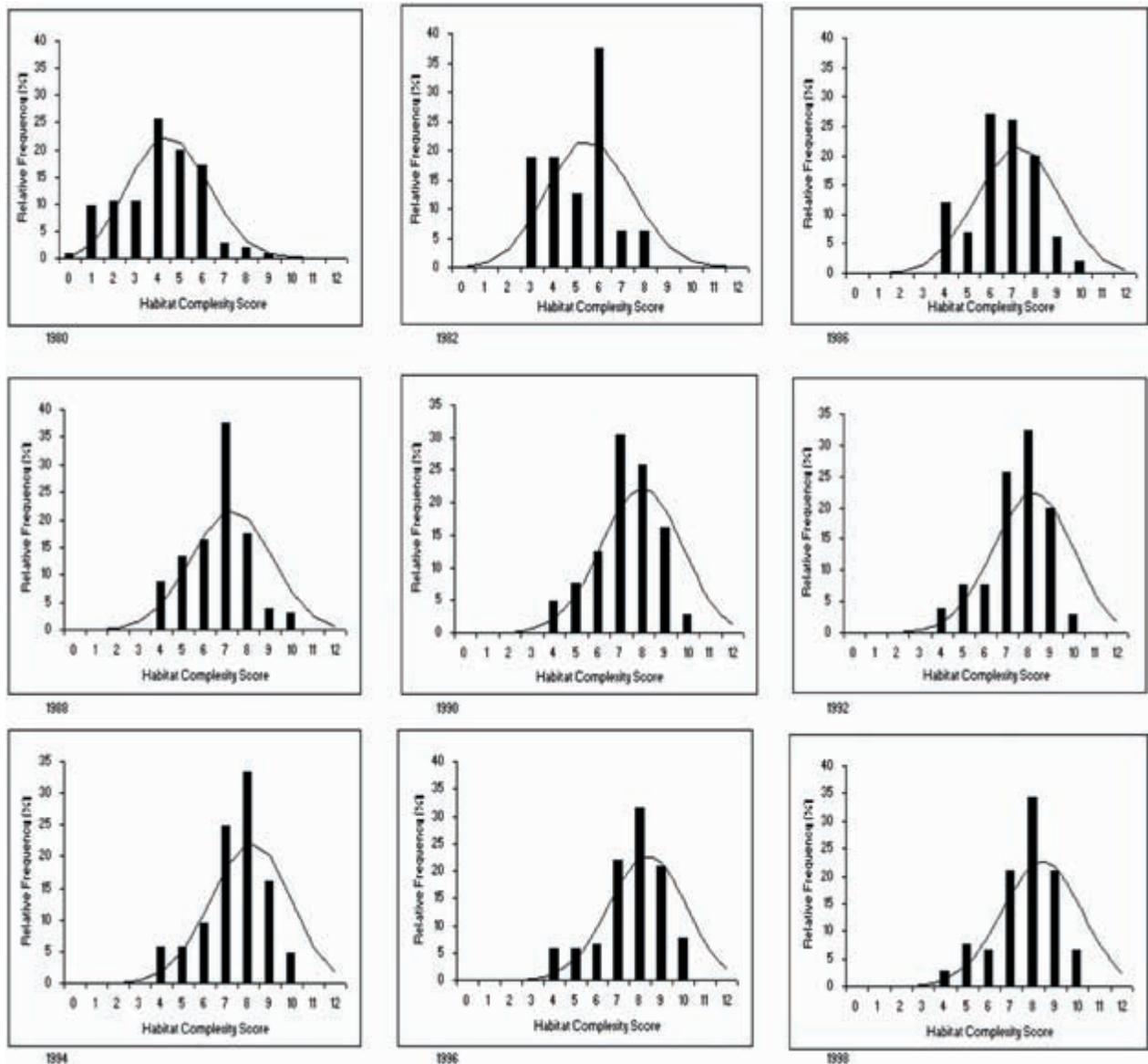


Figure 5. Frequency distributions of the measured habitat complexity scores from 1980 to 1998 with fitted binomial distribution superimposed (from Coops and Catling 2000).

development for the prediction of habitat for arboreal marsupials, because the size class of the forest is a critical factor in habitat suitability (Smith and Lindenmayer 1988, 1992; Pausas *et al.* 1995). Lindenmayer *et al.* (1996) showed that the trees most used for den sites by Mountain Brushtail Possums *Trichosurus caninus* are large old trees with several cavities and are not surrounded by dense vegetation. Thus the recognition of individual trees (Culvenor 2002) used in combination with forest structure identification as outlined above (Coops and Catling 1997a,b) could predict habitat for *Trichosurus caninus*.

Davey (1984) surveyed arboreal fauna in one State Forest (Kioloa) in southeastern NSW and related distribution and abundance to a range of habitat variables, including structural and shelter attributes, environmental and floristic data. Repeated measures were made at permanent plots and details were collected about the height at which the species foraged in the canopy. It was concluded that the biomass of foliage at different heights in the canopy was an important indicator of habitat quality for different arboreal marsupial

species; e.g. a high biomass of leaf in the upper canopy appears to be important for the Greater Glider *Petaroides volans* (a 1-2 kg leaf-eater) and structural complexity in the understorey appears important for the Common Ringtail Possum *Pseudocheinus peregrinus* (a 0.7-1.0 kg leaf-eater), and *Trichosurus caninus* (a 2-4 kg leaf-eater/generalist). Methods are becoming available in remote sensing such as the use of LIDAR to separate the component layers of a forest which would aid the prediction of the distribution of these species (Lovell *et al.* in press).

Braithwaite (1983) and Braithwaite *et al.* (1988) examined the distribution of the arboreal marsupial fauna of the Eden Woodchip Agreement Area and found major disparities in the distribution and density of animals with no animals found in over half of the forest area studied. Most of the arboreal marsupial fauna observed (63%) came from 9% of the area sampled. The group of eucalypts known as “Peppermints” was the major correlate of the density and species richness of arboreal marsupials (Braithwaite 1983). Airborne videography can be used to predict forest species composition (Preston 1997a, b) to aid in the prediction of the

distribution of these arboreal marsupials. Also, Lindenmayer and colleagues (see references cited below) have pioneered the use of GLM's for modelling habitat requirements of arboreal fauna in temperate Australian forests. Lindenmayer *et al.* (1991) concluded that the probability of occurrence of Leadbeater's Possum *Gymnobelideus leadbeateri* a 120–130 g exudivore/ insectivore, in the montane ash forests of southeastern Australia primarily is a function of the basal area of *Acacia* species (an exudate source) and the number of trees with hollows. The diversity and abundance of all arboreal marsupials at these sites are functions of the number of trees with holes, the basal area of *Acacia* species, the degree of bark shedding, and aspect (Lindenmayer *et al.* 1991). Remote sensing methods are becoming available to predict these habitat features.

4. Prediction of forest fuels for fire management

Imagery of high spatial resolution is also being examined as a tool to predict forest fuel levels for fire management and control (Catling and Coops unpublished). A recent change in philosophy of assessing fuel factors affecting fire behaviour in Victorian forests and woodlands shifted the emphasis from simply considering surface fine fuels to considering the whole fuel complex, and particularly the bark and elevated fuels (McCarthy *et al.* 1998). Bark and elevated fuels are considered to be the fuel elements that are principally responsible for general suppression difficulty in Victorian vegetation. A number of the components of the habitat complexity score developed by Newsome and Catling (1979) mimic the components of the fuel hazard score developed for Victoria. For example, the scores for shrub and ground cover record the elevated fuels, and the score for litter essentially records the surface fine fuels. As habitat complexity scores can be predicted from imagery (Coops and Catling 1997a, b), the possibility exists for the direct prediction of fuel loads. However, for fuel factors to be used to assess fire behaviour the components of the habitat complexity score need to be separated. This is not possible at present, but it is being examined (Coops and Catling unpublished).

5. Biodiversity assessment

The approach requires an understanding of the habitat conditions favoured by individual wildlife species. Several studies associate changes in the complexity of forest structure with fluctuations in the abundance of small mammals (e.g. Braithwaite and Gullan 1978; Recher *et al.* 1980; Catling and Newsome 1981; Lunney *et al.* 1987), birds (e.g. Recher and Christensen 1980; Freudenberger 1999), and for medium and large mammals (e.g. Newsome *et al.* 1975; Catling and Newsome 1981; Catling and Burt 1995; Catling *et al.* 2001; Lunney and O'Connell 1988). In general, many ground-dwelling mammals are more abundant in forests with a dense understorey (Catling *et al.* 1982; Lunney *et al.* 1987) which is possible to predict by remote sensing. The identification of areas of significance for arboreal marsupials from environmental variables (Braithwaite *et al.* 1983, 1984; Pausas *et al.* 1995), habitat variables (Lindenmayer *et al.* 1996) or imagery (Preston 1997a, b) combined with the method to predict ground-dwelling mammals (Catling and Coops 1999) could be used in biodiversity assessments for mammalian fauna.

Discussion

Currently there is a demand for efficient and consistent methods for monitoring temporal and spatial variation in forest structure. This demand is likely to continue to increase in the future as this type of information is vital for operational wood production planning, biodiversity and habitat assessment, and regional and national reporting of forest sustainability indicators. A reliable method to monitor harvesting in native forests to provide information useful for management planning, and for regional and national reporting of indicators of ecological sustainability, is urgently needed. Existing mapping techniques based on aerial photo interpretation have provided baseline information on the floristic, structural, and wood resource attributes of important forest regions in Australia through the recently completed Comprehensive Regional Assessment process. Regional Forest Agreements require this information to be updated and reviewed. Accurate prediction of the distribution and abundance of fauna from imagery of high spatial resolution over large areas and/or inaccessible terrain has an array of possible ecological applications (Coops and Catling 1997b). For example, the position and quality of each patch of forest habitat in the landscape is often critical in determining the faunal composition of ground-dwelling mammals (Catling and Burt 1994; 1995; Braithwaite and Muller 1997).

The spatial prediction of habitat structure provides valuable information that is difficult to obtain by other methods. The overview presented here indicates that there is an excellent correspondence between habitat complexity scores measured in the field and local variance as calculated from imagery of high spatial resolution. Such imagery is typically very variable in terms of its spatial information content. As a result, the use of local variance algorithms allows the high spatial resolution nature of video imagery to be fully exploited; however, in situations where the land cover changes significantly within the forest, and when these are not represented within the habitat complexity score, prediction errors will occur. These errors will either cause an under or over estimation of habitat complexity. In the first case, if the local variance algorithm encounters abrupt changes in brightness, such as bright exposed soil or quarries, a large local variance will result, and the algorithm will subsequently predict a larger habitat complexity score than actually exists. In the converse case, some forests exhibit a very uniform cover of overstorey and understorey, such as young forest plantations or melaleuca swamp forest. In these forests, the local variance measure may be low, due to the canopy cover being uniform, however the site may have a higher habitat complexity score.

The benefit of having a spatial coverage of habitat complexity scores allows a variety of additional "spatial" habitat variables to be predicted. For example, within forested landscapes, open areas of lower quality habitat provide temporary, suitable habitats inside dense forest mosaics. A variety of spatial statistics can be computed from the spatial distribution of habitat complexity scores that may help quantify the habitat mosaic for some

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