Mapping koala habitat quality

Tools to help save an Australian icon

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Loved the world over, the koala is an icon of Australia's natural and cultural heritage. Unfortunately, its iconic status hasn't protected it from numerous threats including habitat loss and fragmentation, predation, vehicle collision, disease, and changing drought and fire regimes (*Decision Point #50*, p6). The koala's continued survival in many parts of Australia is uncertain.

Such is the concern over the declines in koala populations in recent years that the Australian Government set up a Senate inquiry to investigate the issue and possible solutions. That inquiry ran for most of 2011 and released a report in September titled 'The koala—saving our national icon'. While the report proposes a number of actions to address the problem of declining koala numbers, a fundamental question remains regarding the distribution of koalas across eastern Australia.

Koalas everywhere face numerous threats to their survival. Despite this, koala populations are highly variable across the animal's range. Some regions have historically low numbers or have experienced substantial and alarming declines in populations over the past decade. Other areas have an over-abundance of koalas. Landscape managers at these locations have employed koala population control measure such as sterilization to reduce over browsing, which would otherwise result in mass starvation. The reasons for these large differences in koala populations are unclear, but variations in forage quality may play a role.

Measuring habitat quality

Managing landscapes for conservation requires a capacity to measure habitat quality. Although multiple factors are often responsible for the distribution and abundance of herbivores, spatial variations in the quality and quantity of plant forage are known to be important for many species. Similarly, plant productivity has been used to predict productivity at higher trophic levels; for example, animal reproductive success, body mass and biodiversity.

Koala populations are highly variable across the animal's range. The reasons for these large differences in koala populations are unclear, but variations in forage quality may play a role. (Photo by Karen Marsh)

Although a landscape might look homogenous in terms of plant species composition and density of cover, the quality of the forage for leaf-eating animals can be very patchy. This variability in foliar chemistry is determined by a combination of plant genetics and environmental factors such as soil and climate. While we cannot see the chemical complexity of landscapes with our naked-eye, advances in laboratory, airborne, and satellite spectrophotometry are making it possible to assess the quality of forage on a landscape-scale.

The foraging behaviour of the koala, and several other arboreal marsupial leaf-eaters (folivores), have been extensively researched. A few, key foliar chemicals are thought to explain a large amount of

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How does imaging spectroscopy work?

When sunlight hits an object, like plant leaves, some of it is absorbed, but some of it also bounces off the surface and back into the atmosphere. Imaging spectrometers measure the amount of light, or electromagnetic radiation, that is reflected and absorbed across a range of wavelengths. These sensors can tell us about the chemical composition of an object because specific wavelengths correspond to specific molecular interactions. Molecular vibrations resulting from the rotation, bending and stretching of chemical bonds, absorb electromagnetic radiation at frequencies that correspond to their energy state. These vibrations also create harmonics and overtones in the near-infrared (NIR) and shortwave infrared (SWIR) regions of the electromagnetic spectrum.

This data can be used to measure and map variations in a wide-range of foliar chemicals across landscapes. Many plant species also have distinctive spectral signatures and spectral data can also help us to identify and map some plant taxa.

Sensors that capture many wavelengths (over 100) are called 'hyperspectral'. In addition to being used in the laboratory and in hand-held field instruments, hyperspectral sensors can be attached to a platform on an airplane or a satellite. Of these two remote sensing platforms, only airborne hyperspectral data has sufficiently high spectral and spatial resolution to analyse the chemical composition of leaves in individual tree canopies. Hyperspectral satellite data is still too coarse.

Airborne hyperspectral sensors were first developed to map minerals in soils for mining companies. The application of this technology is rapidly expanding into agricultural science, forestry, and landscape management for wildlife. Australia currently has two hyperspectral sensors that include both NIR and SWIR wavelengths. Demand for these instruments is high.

New sensors recently developed by NASA and purchased in the USA and Canada specifically for environmental science research incorporate light detection and ranging (LiDAR) and the highest spectral and spatial resolution hyperspectral data available. These next-generation instruments are capable of providing both structural and chemical information about landscapes (for more information visit, http://spectranomics.stanford.edu and http://www.neoninc.org/news/nasaspectrometer). As this technology continues to progress and data acquisition becomes more accessible, our knowledge about the composition, structure, and function of landscapes will increase enormously. This, in turn, will improve our ability to measure habitat quality and make informed landscape management decisions for threatened species like the koala.

tree selection and landscape use by these animals. The chemical quality of forage within a landscape would therefore have an influence on habitat quality for koalas.

Building on this research, scientists at the University of Queensland, the Australian National University and CSIRO are developing techniques to map foliar nutrients and plant secondary metabolites that are known to be important factors in the foraging decisions of the koala and several other folivorous marsupials. High-resolution imaging spectroscopy data allows researchers to create these maps at an individual tree canopy-level and across large areas from a few hectares to thousands of hectares.

In addition, they also have developed techniques to map the spatial distribution of eucalypt subgenera. This is important for mapping koala habitat because koalas preferentially feed on eucalypt leaves from the *Symphyomyrtus* subgenera. Landscape-scale information on forage quality and eucalypt subgenera distributions could provide an important management tool for identifying and selecting landscapes for the conservation of koalas and other arboreal folivores. Landscape-scale measurements of plant biochemistry also can provide important information about ecosystem processes and functioning.

A new mapping project

The Australian Government's Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) is providing funding for a ground-breaking project to assess foliar chemistry across the range of the koala using a combination of field-based leaf sampling and the collection of airborne hyperspectral data. Researchers will sample leaves from a range of sites across Queensland, NSW, Victoria and SA with variable koala populations to look at relationships between foliar chemistry and animal densities.

An essential component of this project involves testing the potential of hyperspectral remote sensing to provide fast and accurate estimates of plant nutrients and secondary metabolites across landscapes. Researchers will use this technology to assess habitat quality for koalas across a few sites in Queensland.

This research directly addresses action items 6.1, 6.2, and 6.3 in the National Koala Conservation and Management Strategy. The work will further develop and implement techniques to estimate the nutritional quality of forage with remote sensing data, improve our understanding of the habitat requirements of koalas, and provide baseline data on foliar chemistry in tree species across eastern Australia that can be used for future studies on climate-change impacts on forage quality for herbivorous species. As elevated carbon dioxide is known to increase the production of some secondary metabolites that deter herbivores, the ability to monitor foliar chemistry and forage quality over time will be particularly important for the future management and survival of species such as the koala.

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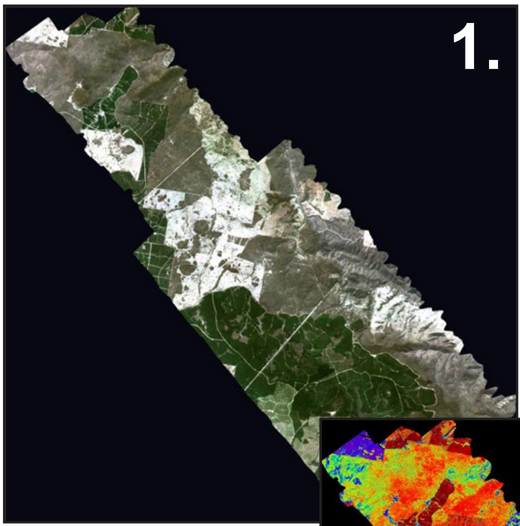
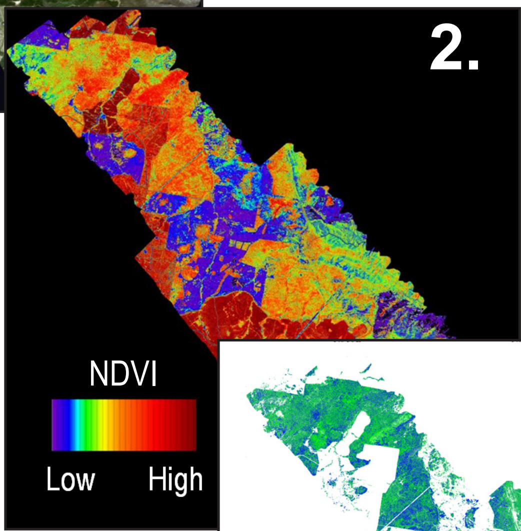
Light on landscape

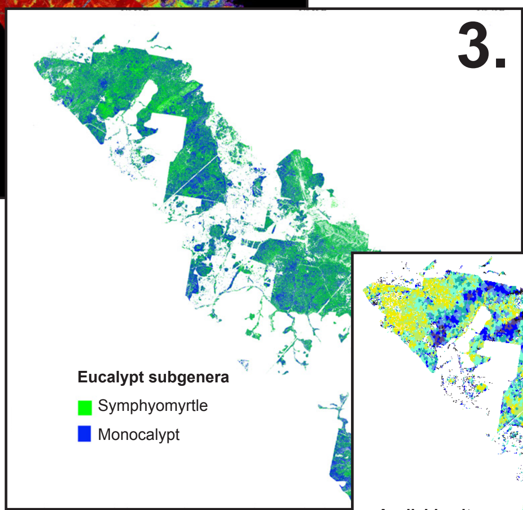
An example of how imaging spectroscopy can deliver valuable information on habitat quality at a landscape scale. The area shown in figures 1-4 includes part of Bungongo and Buccleuch State Forests, NSW (the thick end of the strip is approximately eight kilometres wide). The data was collected with an airborne hyperspectral imaging spectrometer (HyMap, HyVista pty ltd) for a separate study (decribed in *Decision Point #35*).



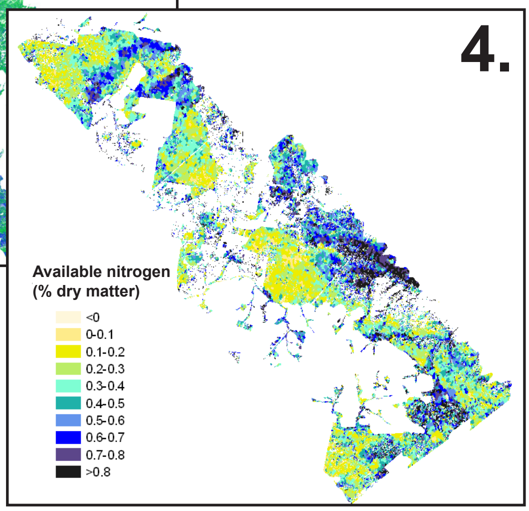
1. An aerial image of the study area captured by HyMap hyperspectral sensor. Pine plantations are dark green. Eucalypt forests are light green. Paddocks, roads, and powerlines appear white.



2. Normalized Difference Vegetation Index (NDVI) applied to the imagery data. NDVI is the ratio of reflectance in two spectral bands located in the red and near infrared wavelengths. This index can be used to provide an indication of greenness and net primary productivity based on the fraction of absorbed photosynthetically active radiation.



3. A map of eucalypt subgenera, *Eucalyptus* (common name 'monocalypt') and *Symphyomyrtus* ('symphyomyrtle'). All non-eucalypt forest areas in the image have been masked.



4. A map of available nitrogen. Available nitrogen is a measure of forage quality that integrates the effects of fibre and tannins on the amount of nitrogen that is available for digestion by herbivores. Non-eucalypt areas in the image have been masked.