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Identification of refugia in western NSW

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Abstract

The Western Local Land Service (LLS) area of operation is large, covering 40% of NSW, with a range of Landsystems and vegetation community types. Under future climate change scenarios, western NSW is likely to experience longer periods of hot, dry weather. This may pose problems for terrestrial biota that are not well adapted to warmer conditions. Recent studies suggest that convergent environments, such as deep valleys and gorges, are potential refuge sites because their local climate is decoupled from the regional climate, making them environmentally stable. These environments may be characterised by higher soil moisture with denser, more persistent vegetation than the surrounding region on a similar land system. This is due to them being in water run-on areas where moisture and nutrients accumulate, and in areas of cold-air drainage, with lower daily insolation, and sheltered from hot, dry wind. Due to the large size and inaccessible nature of Western NSW, a remote sensing based approach may assist in identifying potential refuge sites. Several remotely-sensed datasets are being developed so they can be used within a decision-support tool environment, combining local, expert knowledge, in an innovative approach to identifying refugia locations across western NSW.

Introduction

Under future climate change scenarios, western NSW is likely to experience longer periods of hot, dry weather (Reside et al., 2013). This may pose problems for terrestrial biota that are not well adapted to warmer conditions. Assessing particular sites as possible refuge areas is complicated by the large area and inaccessible nature of Western NSW. A remote sensing based approach to identifying potential refuge sites is suited to the broad scale and variability of the western NSW environment.

Recent studies suggest that convergent environments, such as deep valleys and gorges, are potential refuge sites because their local climate is decoupled from the regional climate, making them environmentally stable (Davis et al., 2013, Dobrowski, 2011). These environments may be characterised by higher soil moisture with denser, more persistent vegetation than the surrounding region on a similar land system or land unit. This is due to them being in water run-on areas where moisture and nutrients accumulate, and in areas of cold-air drainage, with lower daily insolation, and sheltered from hot-dry winds (Dobrowski, 2011).

The gorges and valleys in Western NSW can be narrow – less than 100 m in places – so remotely-sensed data sources with relatively high spatial resolution that cover a large geographic area are required. Landsat, and other data, with a 30 m pixel size offers the best compromise between high spatial resolution and large geographic coverage for the aims of this project. The Shuttle RADAR Topography Mission (SRTM) Digital Elevation Model (DEM) is available at 1-second resolution (nominally 30 m) (Farr et al., 2007, Gallant and Read, 2009), and Landsat TM/ETM+ imagery with 30 m spatial resolution in the visible and short-wave infrared bands was suitable for identifying potential refugia.

Topographic index layers

Various topographic indices such as slope, aspect, topographic position were generated from the SRTM DEM 1 arc sec data. The topographic position index shows whether a particular location is at the crest of a hill, mid-slope or foot-slope. In addition, further indices such as topographic roughness and cold air drainage were calculated. SRTM elevation information also allowed the identification of deep valleys and gorges.

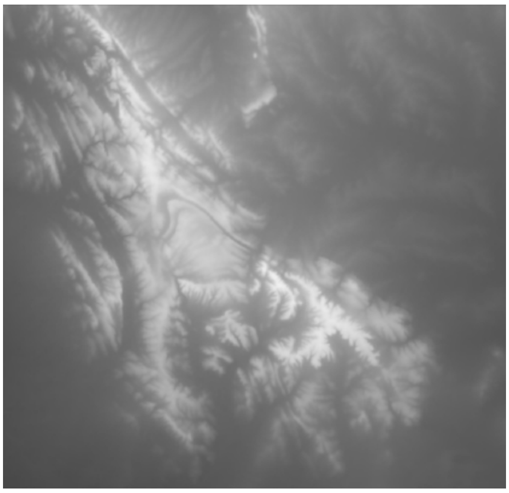

Fig 1a. SRTM digital elevation mode

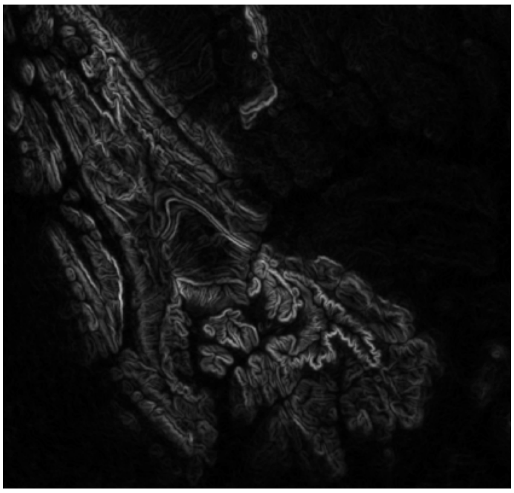

Fig 1b. Topographic roughness

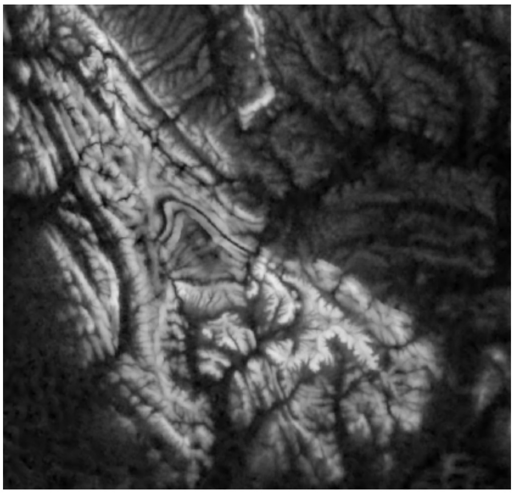

Fig 1c. Cold air drainage

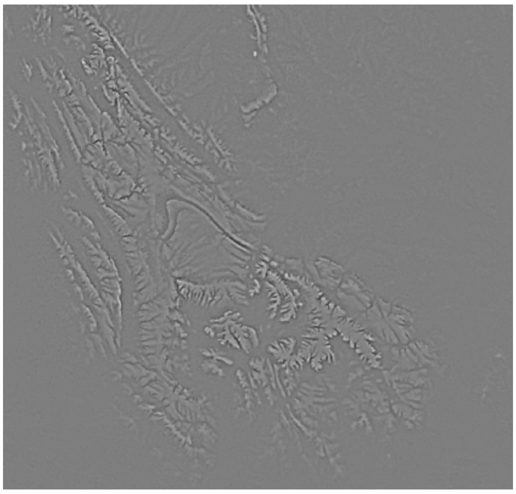

Fig 1d. Topographic position

Classified water count layer

Water bodies were detected in a single Landsat image using an existing algorithm developed by OEH and partners (Danaher and Collett, 2006). By taking a time series of these water indices it was possible to determine the persistence of a water body through time. The water count layer was generated by taking each of the water index images generated from the Landsat archive and adding them resulting in a count of the number of times that each pixel has been identified as water. Land obscured by cloud and cloud shadow were taken into account by applying masks . This water count layer includes all available images from 1987 to 2013 on a 16 day repeat cycle, meaning in the order of 600 individual image dates were used per scene. These water count layers have been further refined into the percentage of the total number of observations that a particular pixel is identified as water, and the further simplification of these percentages into a decile classification.

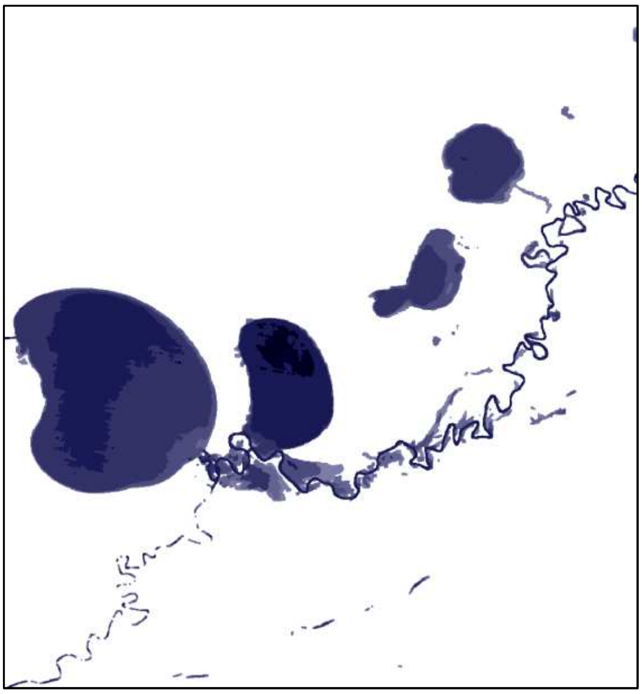

Fig 2. Classified water feature layer: darker blues indicate more frequently inundated

Green accumulation index layer

A different method to identify run-on areas was required where persistent water bodies are not visible due to water being underground, obscured by vegetation or the size of the water body is too small to be detected by the satellite image. An area that stays green for a long period after wetting is more likely to be a refuge than an area which immediately dries out. As such, the period of time that an area stays green may indicate potential run on areas. For each image in the Landsat archive the following fractions were calculated; green vegetation (photosynthetically active), not-green vegetation (senescent vegetation, branches, litter) and bare ground using the method of Scarth et al (2011). The green accumulation index is the time integrated green fraction and indicates likely run on areas. An example of this index is presented in figure 3.

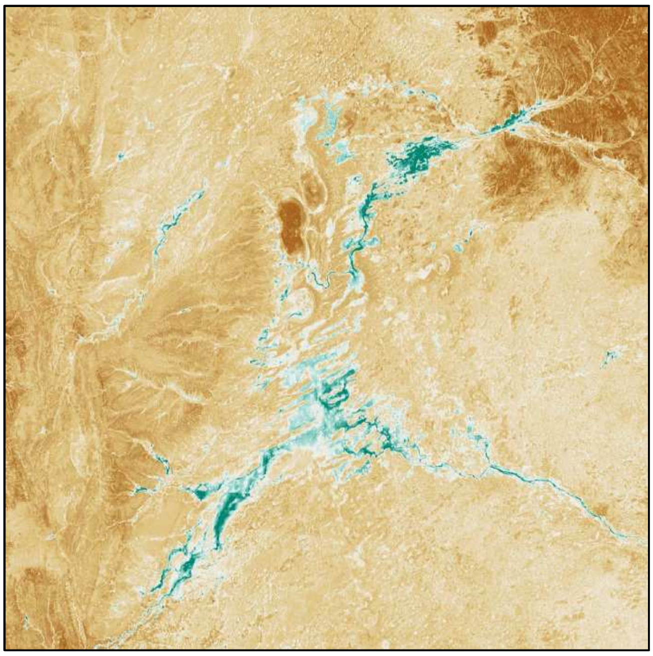

Fig 3. Green accumulation index. Darker green indicates longer green period and likely run-on areas

Woody vegetation layer

The woody vegetation extent layer for NSW was created by the OEH for the year 2008, and is representative of the current woody vegetation extent (figure 4). The layer is a raster with a pixel size of 30 m. It is a result of over a decade of research in mapping woody vegetation in Queensland and New South Wales using an inter-annual time series of Landsat satellite images (Danaher et al., 2011).

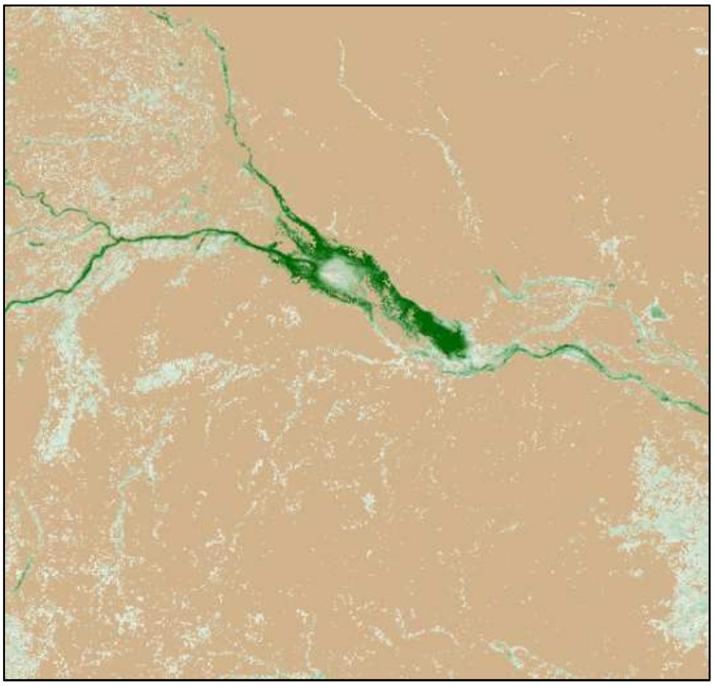

Fig 4. Woody vegetation. Darker green is higher proportion of woody vegetation

Discussion

The next step is to combine the spatial-layers with local knowledge using a desktop GIS environment, The sites that are most likely to offer the best refuge are those that are located in run-on areas, near to water and shade, and receive cold air drainage. When clear relationships such as this exist, they can be used to predict locations of refugia across the catchment to provide a map of predicted refuge sites, which can be inspected by field officers.

However, it is unlikely that a single rule-set for identifying refugia will be applicable across the catchment and all bioregions. A different ruleset or combination of the layers can be used to identify likely refuge areas based on hypothesised scenarios for each bioregion. The spatial layers can then be used to identify similar locations within the vicinity of the known site or elsewhere in western NSW.

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