

Evaluating the use of remote sensing to determine changes in willow distribution in the Fish River catchment

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Key Points

- This study demonstrates the use of remote sensing as a monitoring and evaluation tool, specifically the usefulness of Landsat imagery for monitoring willow (*Salix* spp.) distribution in catchments.
- The results confirmed that the Fish River catchment has significant populations of willows along the river and tributaries, and that the distribution in some areas has decreased between 2000 and 2015.

Keywords

Weeds of National Significance, *Salix*, Landsat, NDVI, catchment management

Introduction

The spread of willows (*Salix* spp.) in catchments across Australia, particularly in New South Wales, Victoria and Tasmania, has long been an issue for landholders, community groups and environmental agencies (NWONSMG, 2011). Willows are prevalent along the riparian zones of streams and in wetlands due to their high water requirements. Considerable efforts have been directed at preventing and reducing their spread but despite these efforts, willows have remained a persistent problem (Holland-Clift and Davies, 2007).

To date, much of the monitoring of willow distributions has been through on-ground mapping. However, the emergence of remote sensing as a desktop spatial analysis tool potentially offers several advantages over ground-based mapping, particularly with regards to deciduous tree pest species, such as willow. For example:

- The use of Near Infrared (NIR) and Red (visible) wavelengths from satellites allows for calculation of vegetation indices such as Normalised Differencing Vegetation Index (NDVI) (Lyon *et al.*, 1998; Jackson and Huete, 1991). NDVI can be used to identify vegetation biomass and distinguish between different vegetation groups across large spatial areas, including remote or inaccessible terrain;
- Deciduous species, such as willow, produce a seasonal difference in light reflectance compared to evergreen, native riparian species such as *Casuarina* spp. which produce constant reflectance all year-round. Comparisons of winter versus summer images could be used to identify willow from native species based on the seasonal change in biomass and NDVI; and,
- There is a historical archive of remote sensing imagery, which could be used to evaluate changes in the distribution of willows in catchments over time.

The aim of this investigation was to demonstrate by proof of concept, the usefulness of remote sensing, specifically Landsat imagery as a monitoring and evaluation tool, particularly for large-scale catchment mapping of deciduous pest species such as willow. The spatial resolution of satellite imagery has been a major barrier to date, but on-going improvements in sensors suggests that it is becoming possible to use satellite imagery for much more detailed analysis of vegetation.

The study area is the Fish River catchment near Bathurst in central-west NSW. Here, willows are widespread along the riparian zones despite considerable efforts targeted at their removal over past decades, including a

recent Fish River Willow Removal Project. This study examines the distribution and extent of willows in the catchment, focusing on the Fish River and tributaries. For this note, only a section of the Fish River near Tarana is reported on, whereas the results for the whole catchment will be presented at the conference.

Methods

Landsat 7 and 8 imagery with 30-m resolution were obtained from the USGS covering the study area. Two years were chosen: 2000 and 2015 to assess temporal changes over the 15 year period. For each year, the December (summer) and June (winter) images were selected to determine willows from native species.

ArcMap 10.2 was used to view and process the imagery. Due to differences in the Landsat 7 and 8 sensors, processing of the images required a slightly different methodology. For Landsat 8 images (2015), the NIR and Red bands were converted from digital numbers to reflectivity using the reflectance rescaling coefficients and conversion equation supplied with each Landsat image (USGS, 2015). The results were then corrected for sun angle using the equation also supplied. For Landsat 7 (2000), the data was first converted to radiance then reflection using the equations provided by NASA (2016) and USGS (2015) respectively. Once the corrections were made, NDVI calculations were performed to derive two images for each year: NDVI winter and NDVI summer. To analyse the difference in NDVI, the winter values were subtracted from the summer values, with deciduous vegetation being shown by a higher resultant NDVI. The results were verified with observations from previous site visits and examination of aerial photography.

Results

The 2000 imagery shows a clear definition between the summer and winter images with the December image showing much higher NDVI values along the Fish River and adjoining streams than observed within the June image (Fig. 1). A sample of the pixel values along the Fish River in the December image shows an NDVI value of approximately 0.65 to 0.7 while the June imagery shows NDVI values for the same area as approximately 0.3. The results are a clear indication that there is an increase in vegetation biomass along the river during summer. This increase is directly related to the presence and abundance of willows within the river system.

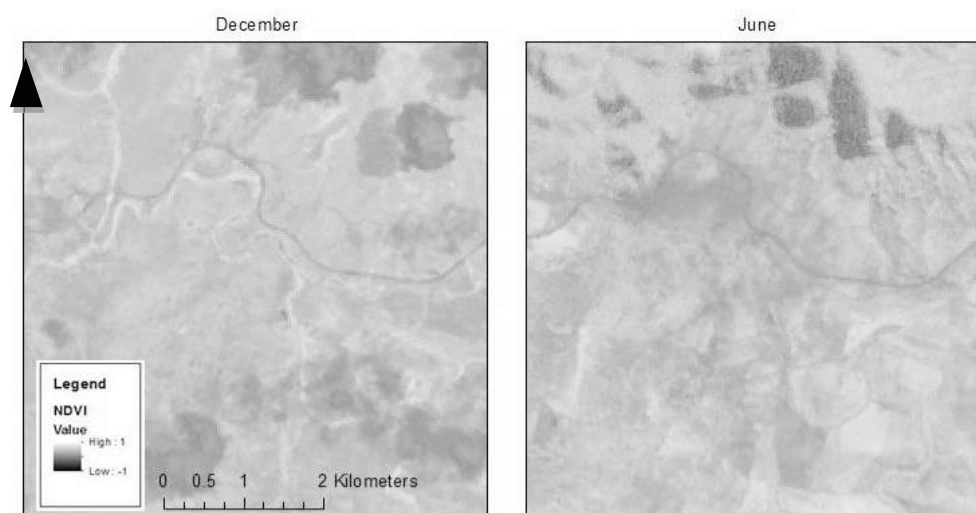


Figure 1. 2000 NDVI images for December (left) and June (right), focusing on a section of the Fish River near the Tarana Quarry railway station. The dark line is the railway track. The Fish River is located south of the railway track and appears as white in the December image. NDVI values are -1 to 1 for each pixel: <0.1 indicates bare ground, water or dormant deciduous trees; > 0.7 indicates dense green leaves.

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Similar to 2000, the 2015 December and June images also show a large contrast in NDVI values along the Fish River and adjoining streams (December = 0.65; June = 0.45) (Fig. 2), indicating a greater vegetation density during summer compared to winter associated with widespread willows.

Comparison of the images for the two years indicates that the distribution of willows within the Fish River has remained the same or decreased over the 15 year time period in the focus area. This finding is similar across the catchment as a whole, with one possible exception. The catchment images (not shown here) have a higher contrast in NDVI along the Fish River in small parts of the upper catchment in 2015, compared to the 2000 imagery, suggesting that the numbers of willows may be locally increasing here.

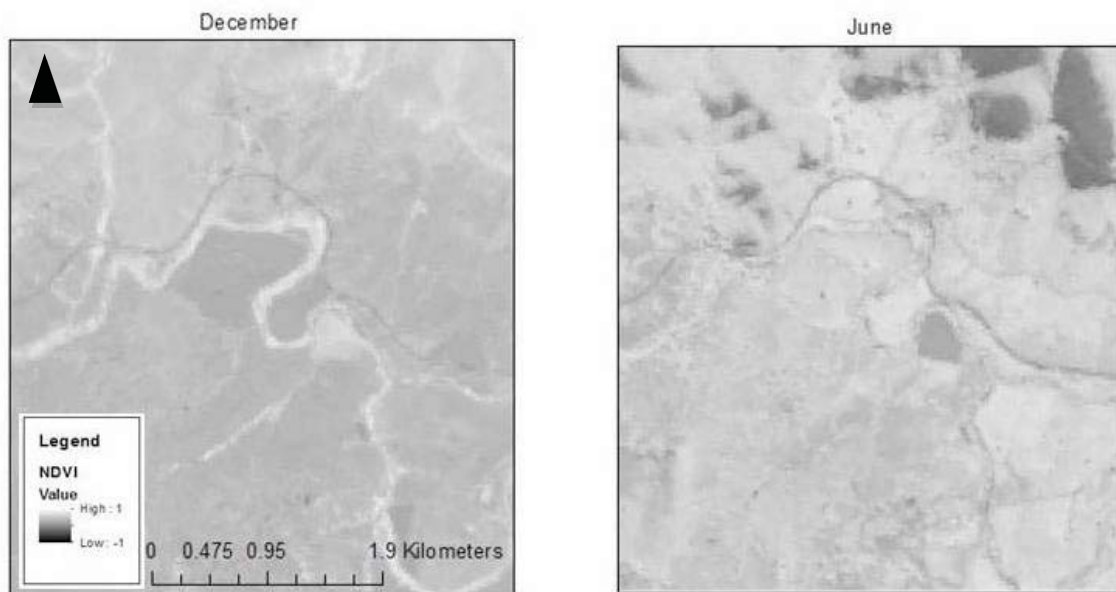


Figure 2. 2015 NDVI images for December (left) and June (right), covering the same area and features as outlined in Fig. 1.

Conclusions

The use of remote sensing to analyse willow populations in the Fish River catchment has shown promising results, with the potential for the method to be extended further. There are, however, some limitations to our results, one of which is the resolution of Landsat (30-m) which confined our analysis to the main river and tributaries, precluding the smaller streams. This could be resolved by using higher resolution imagery such as Sentinel-2 (10-m). Remote sensing has proved to be a useful monitoring tool that could be used instead of, or in conjunction with, on-ground mapping of willows. It offers several advantages particularly where large-scale or long-term analysis of willow distributions is required or where on-ground mapping isn't possible.

References

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