Investigation into Dieback, Katherine River
September 2014

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1 Background

Dieback is a phenomenon where trees prematurely die or decline in condition (Nadolny 2002). It often occurs at a stand-level, meaning that it occurs within a whole stand or part of a stand, rather than isolated trees (Mueller-Dombois 1988). It can occur rapidly or gradually, and can be caused by natural or anthropogenic agents (Nadolny 2002; Department for Environment and Heritage 2005). Dieback can pose a significant threat to native vegetation, especially if the causative agent is persistent and increasing in distribution, such as the root fungus *Phytopthora cinnamomi* that has had widespread and devastating impacts on Australian native species (Cahill et al. 2008).

During May 2014 a landowner observed a patch of dieback in native vegetation near Donkey Camp Weir on the Katherine River and reported it to the Department of Land Resource Management (DLRM). There was concern within DLRM that the dieback may have been caused by an agent that could cause further damage to native vegetation. DLRM vegetation scientists subsequently led an investigation into the cause of the dieback. This report provides a record of the investigation as a reference for any potential future occurrences of dieback in the region.

2 Investigation

Officers of DLRM conducted an investigation to confirm that dieback had occurred and to investigate its cause. Firstly the potential causes for dieback were considered. The investigation began with a site visit and further research included soil sample testing, discussion with experts, examination of river records, and an analysis of satellite imagery.

2.1 Possible causes

There are many possible reasons why a patch of vegetation may suffer from dieback. These range from natural causes such as ageing trees, mistletoes or severe fire through to anthropogenic causes including salinity and introduced pathogens (Nadolny 2002; Department for Environment and Heritage 2005). In many cases a number of factors combine to cause dieback (Nadolny 2002).

A list of possible causes that would be possible for sudden dieback at a single site on the Katherine River includes the following:

- Insects, usually easily observed by the visible effects of leaf, stem or trunk damage (Nadolny 2002; Department for Environment and Heritage 2005);
- Diseases similar to *Phytophthora cinnamomi* or *Armillaria luteobubalina* which cause root rot (Nadolny 2002);
- Drought (Nadolny 2002);
- Waterlogging (Department for Environment and Heritage 2005);
  - Extended periods of waterlogging can damage vegetation, but only in times of exceptional rainfall. This is unlikely to be a cause because rainfall in recent years has been reasonably average.
- Fire (Nadolny 2002);
- Increase in soil nutrients (Department for Environment and Heritage 2005);
- Herbicide spray drift or spillage in waterways (Nadolny 2002);
- Localised pollution (Nadolny 2002).
2.2 Site visit

On the 28th of May 2014, officers of the Northern Territory Government (NTG) visited the site of the dieback that had been observed by the landowner. Officers in attendance for the visit were Tahnee Thompson, Mandy Trueman and Peter Brocklehurst (Rangelands, DLRM) and Austin McIlenan and Mike Kahl (Entomology, Department of Primary Industries and Fisheries (DPIF)).

2.3 Site description

The site is a rocky, sandy dissected back channel of the Katherine River with the predominant vegetation being a Melaleuca leucadendra woodland of 10-12 metres (young stand). Other species present include Pandanus aquaticus, Barringtonia acutangula (Freshwater Mangrove) and some larger emergent trees including Lophostemon grandiflorus (Northern Swamp Box) and Nauclea orientalis (Leichardt Pine). The site is seasonally flooded in the wet season as indicated by debris present on and around trees. The wet season occurs annually between December and March.

2.4 Site observations

Officers immediately observed that there was a discrete patch of vegetation of about 1ha to 1.5ha that consisted of trees lacking leaves, indicating dieback (see photos in Appendix 1). This area of dieback appeared to occur in the lowest sections of the back channel. Identifiable affected trees mostly included M. leucadendra, Barringtonia acutangula and Nauclea orientalis. Most of the Melaleuca trees had lost their leaves or retained only dead leaves and had a complete lack of green growth, thus were presumed dead. Many Nauclea orientalis and Barringtonia acutangula had also lost their leaves, although on some of them new green growth was present in the form of epicormic shooting. There were also dead remains of the vine Flagellaria indica. Very few of the dead trees still had some dead leaves attached. Most of the Pandanus in the affected area appeared reasonably healthy, though some were dead. Eucalypt species higher up the bank appeared healthy and unaffected.

There was no evidence of undue damage by insect, disease or other biotic agent. There was no evidence of extreme alteration of the landscape that would alter edaphic conditions or water regimes. There was no evidence of fire at the site. Thus no obvious conclusion could be made about the cause of the dieback at the time of the visit. The officers present agreed that the type of damage and range of species affected tended to indicate possible chemical damage from herbicide, though not from spray drift because of the discrete nature of the patch affected.

Soil samples were taken in the area containing the dead trees and from neighbouring areas on higher ground where the vegetation appeared healthy. Soil salinity, measured on site, was very low and considered consistent with upland soils in the Katherine region and other parts of the Top End.

Further soil samples were collected to later test for possible pathogenic organisms and possible remnant traces of herbicide.

2.5 Further research

Soils were tested using two methods to determine if herbicide might be present. Firstly, pot bioassay trials were conducted by DPIF. Tomato and mung bean seeds germinated and grew in soil from both the dieback area and neighbouring healthy areas, indicating that there was no herbicide present. Secondly, Tebuthiuron and Hexazinone were thought to be the most probable herbicides that would cause the dieback observed, so soil samples from
inside and outside the dieback area were chemically tested for the presence of these two herbicides. Test results showed that neither of these herbicides was detected in the soil from the dieback area (2 tests) nor in the soil from outside of the dieback area (1 test; Appendix 2).

A preliminary “field” soil pH test indicated that the soil of the dieback site could be very acidic. As this was a singular result using field methods, a further site visit was conducted on 19th August to collect further samples for robust soil pH testing. Samples from various depths at locations both within and outside the dieback area were collected (Appendix 3), with the aim of first determining the pH of the soils in the dieback area. If the pH of these soils fell outside the normal pH range for the region, pH tests would be run on the soils from outside the dieback area for comparison. The soil samples were sent to the Queensland Government soil testing lab for analysis. Results showed that all samples from the dieback area had a pH of between 5.1 and 6 (Appendix 3), which is categorised as “acid” (Hazelton and Murphy 2007), but are considered normal for a stream channel soil in the region. Samples from outside the dieback area were thus not tested for pH but were stored for possible future use.

To check for other areas of dieback, the river was flown from Katherine Gorge to Galloping Jacks (~50 km) in conjunction with weed survey work, during June 2014. Although some dead trees were noticed elsewhere, no additional patches of vegetation dieback were observed.

To check for possible changes to the water regime, river gauge records from Knotts Crossing and Katherine Bridge were assessed. These records indicated that the last few wet seasons were average, with no extreme events, although 2013 river flows were slightly lower than previous years (Appendix 4).

An analysis of satellite imagery (Appendix 5) indicated that the dieback, measured in terms of a reduction in green foliage, occurred in the late 2013, between October and November. Specifically, satellite-derived data indicated that compared with surrounding vegetation, the vegetation at the dieback site started to become disproportionately less green in October 2013. It continued to lose greenness until January 2014, in contrast to the surrounding vegetation which exhibited the normal pattern of increasing greenness during the wet season. The dieback site remained less green than surrounding vegetation until at least May 2014.

The landowner who reported the dieback stated that he had earlier observed that the vegetation at the dieback site was healthy in late 2013, possibly October or November although he could not remember the exact date. He did not revisit the site until mid-May 2014, when he observed the dieback.

Plant pathologist Barry Conde (DPIF) was consulted regarding pathogens that may cause dieback in more than one species. Whilst a *Fusarium oxysporum* forma specialis can infect several species, it can be ruled out as the cause of a sudden dieback of several species in a restricted area. *Phytophthora cinnamomi* is well known as a continuing cause of devastating disease in Australian native vegetation causing dieback in a range of native species. However, there are no genuine reports of *Phytophthora cinnamomi* dieback in the Northern Territory. *Phytophthora cinnamomi* was reported to be involved in the dieback problem at Gove (Weste 1983, cited in Cahill et al. 2008). However, this fungus was later found to be mis-identified and was actually the closely related species, *Phytophthora drechsleri* (which does not cause dieback). Evidence is that *Phytophthora cinnamomi* is a cool temperature organism.
3 Conclusion

The investigation confirmed that dieback had occurred between October and December 2013, affecting multiple plant species in an area of 1 to 1.5ha in a back channel of the Katherine River. In May 2013 many trees appeared dead, while others exhibited new growth in the form of epicormic shoots. An aerial survey of the Katherine River from the Gorge to Galloping Jacks did not find further patches of dieback.

The investigation was unable to identify the exact cause of dieback, though it did negate most of the potential causes. Observation and expert opinion indicated that the dieback was not caused by insect attack or a disease or pathogen, mainly evidenced by the fact that multiple plant species were affected. Additionally, drought during the extended 2013 dry season is an unlikely cause because there would be more evidence of similar effects at other places along the river. A recent, extended period of waterlogging is also an unlikely cause because rainfall and river flows in recent years have not been sufficiently high to result in exceptionally long periods of waterlogging. Localised pollution is also unlikely as there is no local industry that releases pollutants. An increase in soil nutrients is also unlikely because it would not affect multiple species equally.

The only remaining possibility from the list in section 2.1 is herbicide damage. Officers were of the opinion that herbicide drift would not be the cause of such a distinct patch of dieback. Herbicide spillage (or runoff) remains a possibility as the cause of the dieback. Although tests failed to detect traces of herbicide, it is possible that chemicals may have been earlier present (during October to December 2013) and since washed out of the affected area in the 2013/2014 wet season.

In conclusion, no definitive statement can be made as to what caused the dieback at the site. It appears to have been a temporally and isolated event with possible unknown natural cause or possible anthropogenic cause (herbicide spillage or runoff). Importantly, it does not appear to be caused by pathogens and does not appear to have spread. During the site visit in May 2014 some recovery of species was evident within the dieback area. If there is no further disturbance to the site the vegetation should recover gradually over time by natural processes. Further monitoring of the site and other stretches of the river by local residents would be beneficial. If the site or other sites in the Katherine area appear to suffer dieback then a detailed investigation using the information and conclusions in this report should take place.
4 References


Appendix 1: Site Photos 28 May 2014
# Appendix 2: Test Results

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Results in parentheses are duplicate assays. LOQ = Limit of Quantitation = 0.01 mg/kg

Brendan Cook  
2014.06.16  
15:21:02 +10'00'

Brendan Cook  
Authorised Analyst
Appendix 3: Soil pH testing

Map of soil sample locations; red = dieback area; green = unaffected area

pH test results for sites in the dieback area

Queensland Government

Soil Analysis Report

Job No: 14-0541
Report ID: 14-0541-J-V1

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Name: Angus McElnea
Title: Team Leader Soil and Plant

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Appendix 4: River Gauging Stations

Department of Land Resource Management

Period 7 Year  Plot Start 00:00_01/01/2008
Interval 5 Day  Plot End 00:00_01/01/2015

- G8140535  Kath Riv @ Ironwood 140.00 Max & Min Discharge (Cumecs)
- G8140535  Kath Riv @ Ironwood 100.00 Max & Min Level (m)
Appendix 5: Analysis of satellite-derived data to assess timing of the dieback

By Mandy Trueman & Grant Staben, Rangelands DLRM, June 2014

Introduction

DLRM undertook investigations into the cause of dieback in a patch of vegetation on the Katherine River. Part of this investigation required knowledge of the timing of the incident for helping to identify or eliminate possible causes of the dieback. Satellite data can help identify the timing of changes in vegetation because it is collected regularly and gives information on many parameters including measurable foliage cover (photosynthetically active material, or live green leaf material). This can be useful in assessing dieback, because if dieback occurs in vegetation, the foliage cover changes – plants die and become less green or non-green. The fractional cover dataset derived from Landsat satellite data provides a measure of vegetation greenness, so is useful for assessing dieback. This report describes an analysis that used this dataset to assess temporal changes in greenness over the dieback site and nearby sites of similar vegetation. The aim of the study was to identify the timing of the vegetation dieback.

Methods

Study area
The dieback site was located next to the Katherine River approximately 8km north-east of Katherine town centre and behind private properties along Gorge Road (Figure 1). The affected area was approximately 1 – 1.5 ha in size. Comparative vegetation in areas near the dieback site, particularly on the southern side of the river both upstream (north-east) and downstream (south-west), had similar species composition and no signs of dieback.

Figure 1: Location of the dieback site by the Katherine River.
Satellite-derived data
The analysis employed tiles of Landsat-derived data called “fractional cover”, which give the percentage of cover in the three categories of green vegetation, non-green vegetation, and bare ground (http://data.auscover.org.au/xwiki/bin/view/Product+pages/Landsat+Fractional+Cover). These data have a resolution of 30m pixels.

Part 1: Visual Analysis
All eight cloud-free datasets over the study area from August 2013 to May 2014 were used:
- 18th August 2013
- 3rd September 2013
- 5th October 2013
- 6th November 2013
- 9th January 2014
- 14th March 2014
- 15th April 2014
- 17th May 2014

All datasets were visually assessed over the study area compared with adjacent areas of similar vegetation to identify differences in greenness of the vegetation.

Part 2: Time-trace analysis
The greenness of the dieback site was compared with nearby sites of similar vegetation over the full time-frame of the fractional cover dataset, using a time-trace of the average green fraction (of pixels) in each site. The time-trace dataset covered the period from January 1989 to May 2014. We identified and delineated comparative vegetation by visual interpretation of Google Earth imagery (Figure 2). We delineated the affected area more precisely than for the visual analysis above, using Geo-referenced GPS points of the approximate perimeter of the dieback site, obtained during a site visit on 28th May 2014.

Results and Discussion

Part 1: Visual analysis
The greenness of vegetation in the dieback site was similar to surrounding comparative vegetation (to the east and south-west) in August and September 2013 (Figure 3). On 3rd October 2013 the greenness of the dieback site was lower than previously, and also slightly lower than comparative vegetation. On 6th November, the greenness over the dieback site was further reduced and the difference between it and the comparative vegetation was more pronounced. The greenness of the dieback site remained lower than the greenness of
comparative vegetation until the end of the data time-series on 17th May 2014. It appeared to be at its lowest on 14th March 2014.

**Figure 3:** Fractional cover over the study area between August 2013 and May 2014. The dieback site it represented by the red ellipse. In each image, green represents the green vegetation fraction, blue represents non-green vegetation fraction, and red represents the bare ground fraction or water.
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Part 2: Time-trace analysis

The greenness of vegetation in the dieback site and comparative sites has tracked similarly over the 28-year data time series. Greenness fluctuated annually with the seasons; dropping during the dry season and increasing in the wet season (Figure 4). Typical low greenness values have ranged between 30% - 50%, usually for a single date in each year. During more recent years, 2009 – 2013, the vegetation at the dieback site was 7% - 15% lower than comparative sites during the dry season. Towards the end of 2013, the greenness at the dieback site continued to drop after the end of the dry season, whilst the greenness at the comparative sites increased in the usual seasonal pattern from October onwards (Figure 4). At the dieback site the lowest greenness, 24%, was detected on 30th November, and was 25% - 30% lower than comparative sites. From January 2014 the greenness at the dieback site increased, but was still 25% - 40% lower than comparative sites.

Figure 4: Time trace of average greenness within the dieback site and four comparative sites since 1989. Where data are missing (due to clouds or other anomalies), lines are not drawn.

Synthesis of results

The results of this analysis clearly show the greenness of the vegetation at the dieback site was reduced from October 2013 to May 2014, compared with nearby comparative vegetation and compared to previous seasonal fluctuations. The greenness of vegetation increased at comparative sites from October 2013 onwards, while it continued to decline at the dieback site until January 2014.