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Invasive *Passiflora foetida* in the Kimberley and Pilbara: understanding the threat and exploring solutions

Interim 12 month report

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30th June 2013

For:

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Citation

Webber BL, Yeoh, PB and Scott JK (2013) Invasive *Passiflora foetida* in the Kimberley and Pilbara: understanding the threat and exploring solutions. Interim 12 month report. CSIRO, Australia.

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Important disclaimer

Acknowledgements

We recognise the considerable logistical support provided by the Department of Environment and Conservation and their staff at Kununurra, including Richard Tunnicliffe, Amanda Moncrieff and Jeremy McGinty, by Mount Gibson Iron and their staff at Koolan Island, including Cheryl Hammence, John Tomich and Matthew Hamilton, and Tracey Vinnicombe at the DAFWA Kununurra Research Station. We appreciate the contextual insight provided by Ruchira Somaweera, Greg Smith and Dick Pasfield.

1 Introduction

Passiflora foetida is a South American herbaceous vine now widely introduced into many tropical regions of the world. The vine is an invasive weed that is commonly found in forest edges, coastal vegetation and disturbed areas, including riparian habitat and roadsides. It is thought to be one of the biggest threats to the highly fragmented and environmentally important rainforest patches scattered across the Kimberley. There is *prima facie* evidence to suggest that *P. foetida* may be able to tolerate a broader range of climatic extremes than was once thought, and may be partially adapted to surviving the fire regimes common to the drier parts of these landscapes.

Fig 1: *Passiflora foetida* near Kununurra.

A significant impediment for implementing effective weed management strategies for *P. foetida* is that very little is known about its biology and life history, particularly in areas where it has been introduced. It is clear that the species has a very high dispersal ability (birds, bats) due to its pulp-covered seeds. Although the original point of introduction is not known, current observations suggest the species has spread across from the Northern Territory, is widespread throughout the Kimberley, and has been found as far south as Shark Bay.

Current control methods advise hand-pulling or herbicide application, and both of these labour-intensive methods have been used on *P. foetida* by management groups in the recent past. Current control methods are labour intensive and accessibility problems makes long term control unlikely and impractical. In the long term the only practical solution will be biological control, although all control options require an improved understanding of the biology of the plant. Other *Passiflora* species are being examined for biological control potential in Hawaii and New Zealand and an initial assessment indicates that *P. foetida* would also be a suitable target species. With a better knowledge of the threat posed by *P. foetida* to the north west of WA, significant improvements in the cost, effectiveness and efficiency of weed control may be possible. Thus, our project aims to address these gaps in current knowledge.

This two year project will characterise the life history of *P. foetida* to establish its requirements and limits for growth, reproduction and colonisation, both under current and future climates. More specifically, we will (i) measure the plant's response to temperature and moisture in the field and under controlled climate conditions, so as to understand plant growth and to define parameters for bioclimatic modelling (CLIMEX), (ii) assess seed banks, seed longevity (in anticipation of further funding), germination characteristics and dispersal potential, (iii) describe plant-herbivore and plant-pathogen interactions as part of an assessment of biological control potential, (iv) characterise the encroachment of *P. foetida* for freshwater crocodile nesting sites at Lake Argyle, and (v) model potential current and future distributions taking into account climate change.

Fig 2: *Passiflora foetida* on the shores of Lake Argyle.

2 Project progress

2.1 Progress towards planned outcomes

OUTCOME 1: AN ASSESSMENT OF THE THREAT OF SPREAD BY THE WEED AND AN IMPROVED UNDERSTANDING OF ITS ECOLOGY

Field site selection & installation

Field site scoping was undertaken in the two primary study regions (i.e. Kununurra, Koolan Island) in the Kimberley in 2012. It quickly became apparent that (i) it would be impossible to identify individual *P. foetida* plants, and that a cover-based approach would be required for assessing change in vegetative dynamics, (ii) access to vine thicket sites would not be possible with available time and logistics, and (iii) the vine was far more prevalent in drier, fire-prone landscapes. The final sampling design for monitoring vegetation dynamics saw the installation of paired transects (30-60m long) installed across moisture gradients at six sites on Koolan Island, two sites near Kununurra (Darram Conservation Reserve and on DAFWA land on the riverbank of the Lower Ord), and three sites at the northern end of Lake Argyle. Sites were installed and the first sample (i.e. pre-wet season) collected in November 2012. Sites were chosen for their large size and high density of *P. foetida* invasions, on the presumption that we needed to know the current upper limits of what might be possible for growth, reproduction and any associated threats. Regional variation in the Pilbara will be captured in the second half of the funding period so as to allow for better prioritisation of sample collection times.

To provide better characterisation of local site characteristics, two systems have been deployed. At two sites in each primary region (i.e. Kununurra, Koolan Island), data logging stations were set up in each stratification across one of the transects, recording soil moisture and temperature (at 30cm below the surface), air temperature, relative humidity and photosynthetically active radiation. Remote camera traps have also been installed at two of the Kununurra sites to capture temporal change in *P. foetida* cover.

Field-based plant growth measures

Three randomly assigned quadrats (1 × 1m) of vegetation were quantified for each of three stratifications along the transect (either defined by vegetation change where present or equal distances when within a single vegetation type). Within each quadrat, cover scores and vegetation profiles for native, non-native (excluding *P. foetida*), and *P. foetida* were recorded, before the entire *P. foetida* biomass was removed (Fig. 3). This biomass was separated into organ components stratified by age for leaves, stems, fruits and flowers to be weighed, measured and counted. This sampling approach was first carried out in November 2012 (i.e. pre-wet season) and then repeated in April/May 2013 (i.e. post-wet season) using a paired quadrat on the other side of the transect. To capture year-on-year differences, we plan to repeat the same approach for the 2013/14 dry/wet/dry seasons.

Fig 3: Quadrat sampling after *Passiflora foetida* cover has been removed.

Plant-pest interactions

An ongoing monitoring approach during fieldwork and through targeted visits to unmonitored *P. foetida* populations is providing baseline information on the pest and disease load carried by the vine.

Crocodile nesting site encroachment

A range of known freshwater crocodile nesting sites on Lake Argyle (identified during the PhD research of Ruchira Somaweera) were scoped for suitability as study sites during both field sampling trips. Further investigation of the dynamics of the nesting site encroachment situation has revealed it to be far more complex than initially imagined. It became clear that a better understanding would require, at a minimum, tracking the interaction between vine cover, suitable nesting space, actual nest locations and the relative position of the water level throughout the year. Moreover, this would need to be done at a very high resolution. Initial attempts using existing aerial or satellite imagery, as well as a differential GPS system (sub-metre accuracy) were not successful. Current investigations are exploring alternative methods, subject to budget limitations, whereby this data could be generated by ground-truthed aerial photography taken before and after the nesting season.

Glasshouse trials

Plants have been established from cuttings for general monitoring in the CSIRO glasshouses in Perth. Seeds have been collected for upcoming growth cabinet trials.

OUTCOME 2: AN ASSESSMENT OF ITS SEED ECOLOGY SO AS TO BETTER INFORM CONTROL STRATEGIES

Reproductive phenology

Standard field sampling procedures (as outlined in Outcome 1) are providing a measure of seasonal variation in reproductive output. Daily observations during field trips of flower phenology are documenting flower development cycles and flower visitation by putative pollinators.

Seed traits

The first set of seeds was collected in April/May 2013, upon which germination and viability studies will be undertaken.

OUTCOME 3: A PRELIMINARY CONTRIBUTION TOWARDS DEVELOPING BIOLOGICAL CONTROL FOR *P. FOETIDA*.

Literature review

Building upon our initial literature collection for *P. foetida* has continued steadily over the past 12 months, particularly in relation to the harder to source grey literature.

Establishing negative impacts

Establishing negative impacts on native ecosystems is an essential component of justifying the need for a new biological control agent. After the site scoping phase, it was clear that establishing negative impacts of *P. foetida* on native vegetation would be extremely challenging. Avoiding confounding factors and bias due to site selection is already difficult for impact studies, and impacts may not be evident for many years. Given the short duration of the current funding, the emerging ecological understanding of *P. foetida* and the challenges associated with quantifying changes in native vegetation, we decided to prioritise quantification of the possible impact of *P. foetida* on the availability and quality of freshwater crocodile nesting sites at Lake Argyle. Preliminary data on possible impacts on native vegetation will be collected via the established transects, with the view to quantify this relationship in more detail if we find a way to continue the research beyond the current phase.

Plant bioclimatic modelling

Growth cabinet trials remain on track to begin later in 2012, and seed has been sourced from both Koolan Island and the Kununurra region.

2.2 Preliminary science summary & highlights

Vegetative growth dynamics

Fig 4: After *Passiflora foetida* removal, little native vegetation remains alive underneath.

Preliminary analyses on the data collected from the pre-wet (November) and post-wet (April/May) fieldwork suggests a very different growth pattern to what had been expected. Rather than growing during the wet season, *P. foetida* appears to generate the bulk of its biomass over the dry season. Very dense mats of cane form during the dry season, with the vast majority of canes dying back as the vine mat increases in thickness. For quadrats with dense vine mats, very few native plants remained alive underneath (Fig. 4). Over the wet season, the canes that have died back appear to break down quickly, leaving only a thin layer of live canes toward the end of the wet season. Those canes that do survive can thicken and become woody very quickly, and these appear to have the ability to re-sprout over multiple seasons. Very thick canes in areas known not to have burnt on Koolan Island exceed 40mm in diameter.

Although we had no plans to investigate fire dynamics as part of this project, one site on Koolan Island was completely burnt by a lightning strike fire in February 2013. This inadvertently allowed us to observe establishment of seedlings in a field situation. Of particular note was that first flowering and fruiting can take place in less than 3 months after germination.

Plant-pest interactions

Initial observations suggest very low herbivory across all seasons. Small outbreaks of Pterophorid moth larvae (Fig. 5a; reared adult Fig. 5b) during both harvest periods and some patchy but intense fungal dieback, including affected leaves, stems and fruits (with aborted seeds) during the pre-wet fieldtrip (Fig. 5c), are the predominant observations to date.

Fig 5: Pterophorid larvae (a) and adult moth (b). Fungal dieback affecting *Passiflora foetida* leaves, stems and fruits (with aborted seeds; c).

Crocodile nesting site encroachment

Further investigation of the dynamics of the nesting site encroachment situation has revealed it to be far more complex than initially imagined. The record wet season watermark in 2011 seems to have changed the *P. foetida* invasion baseline, but it remains unclear if this is due to substrate changes, seed deposition, vegetation change, or a combination of one or more of these drivers or other factors. Furthermore, the extremely low wet season maximum for the level of Lake Argyle in 2012/13 may represent an additional significant change in the dynamics of nesting site encroachment. Investigation of all possible alternatives continues in earnest to try and find an affordable solution to ensure we can capture the right data before the 2013 nesting season begins.

2.3 Risks and challenges

Vegetative growth dynamics

By choosing sites with a higher chance of exposure to fires, there is a risk that paired quadrats across seasons will not be directly comparable. This situation has already happened for one site on Koolan Island (Fig. 6). This issue was considered during site selection, and it was felt that the possible gains outweighed the known risks. One main advantage we now have from the burn site on Koolan Island is that we have a baseline characterisation for how *P. foetida* may respond to fire. Ongoing measuring at this site has already been modified to maximise the information we can obtain on post-fire regeneration dynamics.

Fig 6: Regrowth at the burnt Koolan Island site three months after a lightning strike fire in February 2013.

Crocodile nesting site encroachment

Having identified the necessity for increased resolution and a greater complexity in the dynamics of nesting site encroachment, the risk now faced is that methods for generating this data (i.e. helicopter charter) may be more expensive than the funds that could be freed up by reprioritising the existing budget. Conversations are underway investigating all possible options in this regard so as to try to not miss out on the significant opportunity represented by the unique properties of the 2013 nesting season.

2.4 New opportunities

Additional priorities for field sites

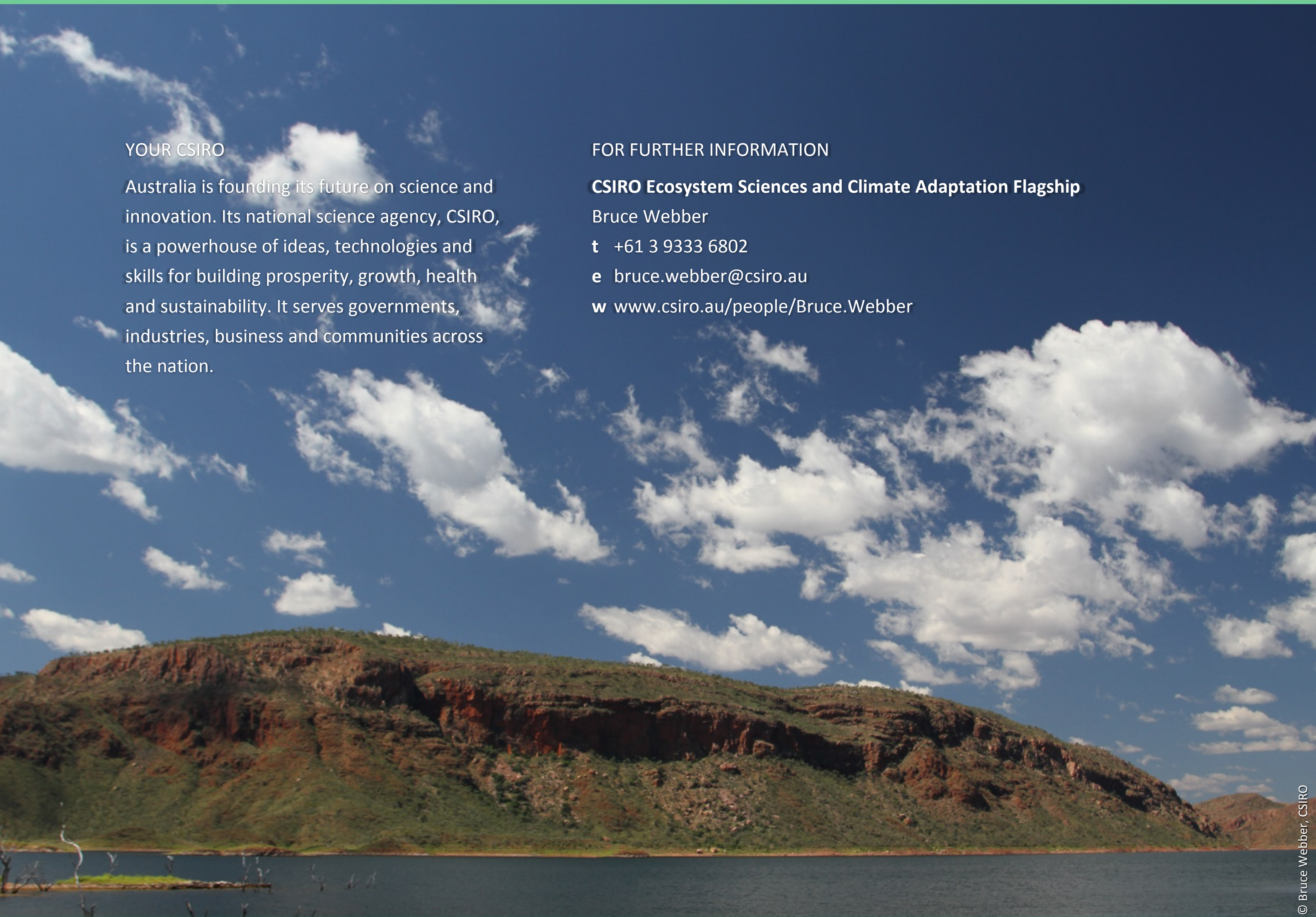
Two additional focal points for the *P. foetida* research have come out of other work in the Kimberley region. Firstly, as part of fieldwork for another project, we visited 32 of the remote vine thickets in the western Kimberley. The widespread coverage, density and invasiveness of *P. foetida* in this region, and its ability to overtop and infiltrate these vine thickets was very noticeable. Given the preliminary observations on vegetative growth dynamics and the possible interaction with fire, there appears to be considerable scope and relevance to consider broadening the current study to consider the contrasting dynamics in these threatened communities. Secondly, conversations with rangers from other regions outside our focal study areas has highlighted the contrasting dynamics of *P. foetida* across the Kimberley. In the Purnululu National Park, *P. foetida* appears to be spreading rapidly in recent years, but concentrated in the more remote areas, away from human disturbance. At Geikie Gorge National Park, preliminary observations suggest that *P. foetida* is now dominating local landscapes at a level not observed anywhere else in the Kimberley. These contrasting dynamics may well provide critical and complementary insight into the invasion dynamics of *P. foetida* and, therefore, greater insight into strategies for biological control.

Establishment of long-term nesting site monitoring program

Greater clarity on the likely influential factors regulating the interplay at Lake Argyle between freshwater crocodile nesting site space and *P. foetida* encroachment suggests an ongoing monitoring program could generate significant insight for the creation and maintenance of a successful management plan. In that regard, we have already formed a collaborative association with Ruchira Somaweera (Biologic Environmental) to establish an appropriate sampling and monitoring design.

3 Conclusions

At the mid-point of this two year project, considerable progress against the outcomes has been made. Unexpected findings have changed the anticipated approach to some of our aims, but contingency plans have been formed and scoping for these alternative options is already underway. These unexpected findings have also generated new insight that has been used to improve aspects of the project that are still to be completed.



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