Northern Australia Environmental Resources Hub

National Environmental Science Programme

Climatic limits, spatio-temporal range, and reproductive output of stinking passionflower (*Passiflora foetida*)

Interim report

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Cover photographs
Front cover: *Passiflora foetida* infestation on the banks of Danggu (Geikie Gorge) National Park (photo Ruchira Somaweera).

Back cover: Significant infestation of stinking passionflower on a former known nesting beach of freshwater crocodiles at Danggu (Geikie Gorge) National Park. Note the human for scale (photo Ruchira Somaweera).

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1. Introduction

Stinking passionflower (*Passiflora foetida* L. *sensu lato*, Passifloraceae) is an herbaceous vine from south and central America that is 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 (Figure 1). In many of these regions the plant is a weed of concern. The first confirmed record in Australia dates from 1892 (Queensland), while the first record from Western Australia was from near Derby in 1921.

Stinking passionflower is viewed as one of the most significant problem weeds in the north west of Australia (Webber *et al.* 2014). The weed is thought to be one of the biggest threats to the highly fragmented and environmentally important rainforest patches scattered across the Kimberley. Currently, stinking passionflower is listed under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) as being amongst the main weed threats to the monsoon vine thickets of the Dampier Peninsula.

Figure 1. Stinking passionflower invasion of riparian habitats at Danggu (Geikie Gorge) National Park, photo Ruchira Somaweera.

A significant impediment for implementing effective weed management strategies for stinking passionflower 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 (e.g. by birds, bats) due to its attractive pulp-covered seeds. In Western Australia, stinking passionflower is widespread throughout the Kimberley and many parts of the Pilbara, and has been found as far south as Shark Bay.

There is *prima facie* evidence to suggest that stinking passionflower may be able to tolerate a broader range of climatic extremes than was once thought, and may have a life history that can survive the fire regimes common to the drier parts of these landscapes. This broad climatic tolerance implies that the weed is likely to be a threat to a variety of areas with high conservation value across the north west of Western Australia and beyond.

In this interim report we detail progress towards developing (i) an understanding of the climatic limits of the species, (ii) its spatio-temporal range in the Fitzroy river catchment, and (iii) the reproductive output of stinking passionflower.

2. Methodology

2.1 Climatic limits

Bioclimatic modelling using the semi-mechanistic model, CLIMEX, was used to develop an understanding of the potential range of stinking passionflower in Australia. Given the uncertain status of taxon delimitation in *P. foetida sensu lato*, the decision was made to begin with a conservative approach. We thus classified the taxon in the broadest sense and informed the model with all distribution points determined as stinking passionflower. At this point in time we do not have enough evidence to support the hypothesis presented in Vanderplank (2013), that the taxon of interest is distinct to the Kimberley coastline. Modelling methodology, including data cleaning procedures and model parameterisation techniques followed Webber *et al*. (2011). In addition to information gleaned from herbarium records, we also informed the temperature components of the model (TI) using physiological parameters derived from a series of climate-controlled germination trials that build on the approach reported for stinking passionflower in Webber *et al*. (2014). We acknowledge that the resulting model must be considered an initial insight only. With further resolution on taxonomic uncertainty and more physiological data with which to parameterise the model, confidence in the modelling projections is likely to increase.

2.2 Spatiotemporal range

Landsat and DigitalGlobe aerial imagery were used to identify the likely presence of stinking passionflower along the Fitzroy River. Imagery later than December 2015 were scanned by eye to pick patches of stinking passionflower based on general appearance and colour. Stinking passionflower has a luminous green hue, significantly contrasting to native vegetation and other weeds (Figure 2), and could be easily identified in recent aerial imagery.

Figure 2. Contrasting luminous green hue of stinking passionflower in aerial imagery, source Google Earth Pro.

In August 2016, a reconnaissance field survey was conducted along the Fitzroy River to select sites for a long-term project on the impact of stinking passionflower. Locations visited include Mornington Sanctuary, Danggu (Geikie Gorge) National Park, Cambalin, Snake Creek, Udialla and Willare. Presence and status of stinking passionflower at each location was noted through non-random walking inspections of likely infestations sites, while additional vehicle-based observations were made along the Gibb River Rd and Great Northern Hwy while traveling to the locations.

2.3 Reproductive output

Monitoring plots set at Danggu (Geikie Gorge) National Park in September 2016 as a part of this study were all completely destroyed in the extreme flooding event of 2016/17 that affected much of the west Kimberley region. The flooding resulted in damage and loss of all data-logging equipment and the associated microclimate data, prevented access to the site until much later than anticipated, and disrupted collection of data on stinking passionflower reproductive output, growth dynamics and spread. An updated schedule has taken this unanticipated disruption into account and revised plans will ensure collection of appropriate data through alternative methods (e.g. drone imagery) to deliver succesful completion of final milestones. More detailed assestment of stinking passionflower reproductive output and growth at Danggu (Geikie Gorge) National Park is already underway and will be completed in mid-2019.

3. Results & discussion

3.1 Climatic limits

The presence of distribution records for Africa, Asia, Australia and the Pacific Islands represents the known introduced range for stinking passionflower as currently determined (i.e. *Passiflora foetida sensu lato*; Figure 3). This introduced range, as well as the native range in south and central America, represents a considerably broad climatic niche. This niche breadth may be related to the ongoing taxonomic uncertainty for the species. Even so, it was possible to model the broader concept of a species potential distribution.

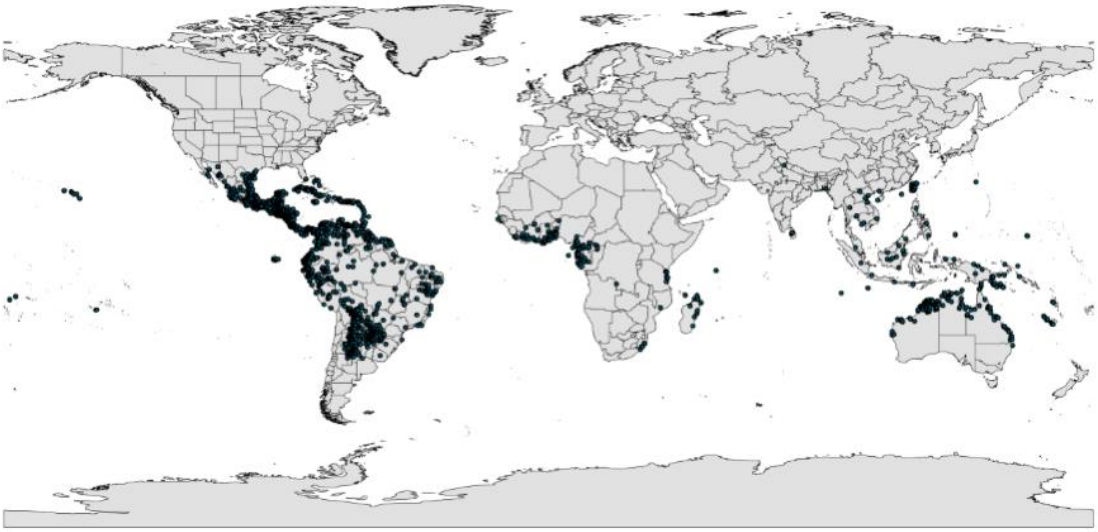

Figure 3. Global distribution records of Passiflora foetida sensu lato*. Points were downloaded from GBIF and quality controlled where necessary.*

A CLIMEX niche model was parameterised in an iterative manner using a combination of information derived from distribution points in the Americas and information from controlled condition trials (Table 1). At this interim point in the modelling process, with minimal model calibration to ecophysiological data and a heavy reliance on distribution records, model projections should be regarded as a first approximation of the possible climatic limits.

Table 1. CLIMEX parameters values used for modelling the distribution of Passiflora foetida sensu lato *based on the temperature requirements for development and the native distribution. Note that parameters without units are a dimensionless index of plant available soil moisture scaled from 0 (oven dry) to 1.0 (field capacity). See Sutherst et al. (2007) for a detailed description of parameters.*

Index	Parameter	Values	Units
Temperature	DV0 = lower threshold	20	°C
	DV1 = lower optimum temperature	32	°C
	DV2 = upper optimum temperature	37	°C
	DV3 = upper threshold	45	°C
Moisture	SM0 = lower soil moisture threshold	0.2	
	SM1 = lower optimum soil moisture	0.5	
	SM2 = upper optimum soil moisture	0.9	
	SM3 = upper soil moisture threshold	1.5	
Cold stress	DTCS = cold stress degree day threshold	15	DD
	DHCS = cold stress accumulation rate	-0.001	$Week^{-1}$

The modelled suitability projection (Ecoclimatic Index, EI; (Sutherst *et al.*, 2007) showed high modelled suitability for the native range. The model is based for the most part on the native range records, so a close match is expected. The model also encompasses the introduced range with a few exceptions. These exceptions mostly relate to records from regions where there is a high likelihood of microclimates relating to soil moisture (e.g. riparian environments; Figure 4).

There is a high correspondence between the modelled suitability (EI) and known distribution records in Australia (Figure 4). In particular, all records in the Kimberley region fall within the projected region of moderate to high suitability. The model projection also indicates that stinking passionflower may have reached its full distribution in northern Australia and further spread would be due to infilling between infestations. Based on this modelling, it appears that stinking passionflower is unlikely to represent a threat to central and southern Australia – it is either too dry or too cold.

We caution again that further information is needed to properly develop the model, using more physiological information to inform the parameterisation process (particularly response to soil moisture) and revisiting the assumption that only a single species is involved.

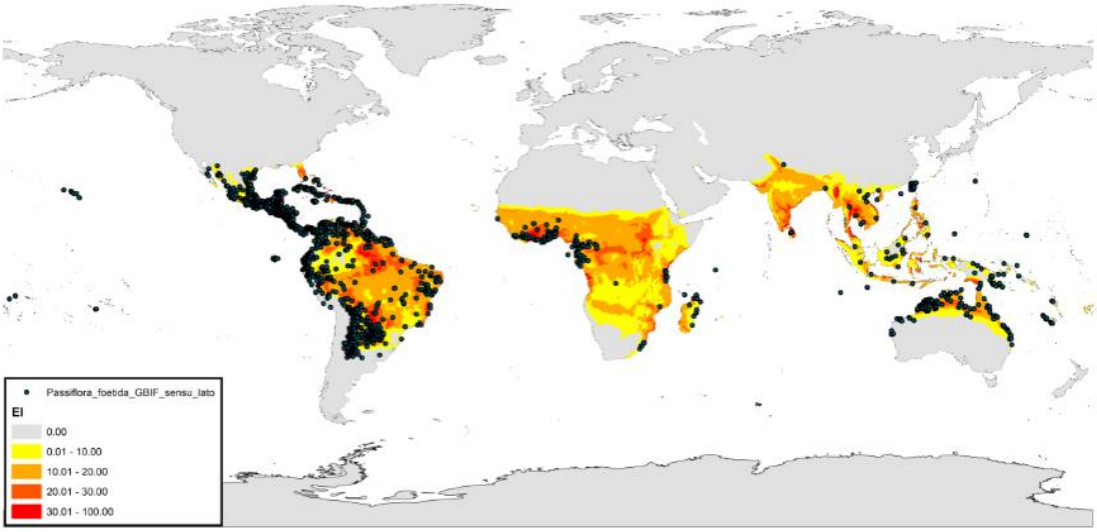

Figure 4. Modelled climatic suitability (Ecoclimatic Index, EI) for a CLIMEX model of Passiflora foetida sensu lato. *The colour gradient (yellow to red) shows the increasing EI values projected with current climate averages (CliMond 10' gridded climate data centred on 1975). The higher the EI value, the more suitable is the climate for the plant's survival. Values of EI = 0 (grey areas) indicates regions where populations are projected not to persist on an annual basis. Black dots indicate the global distribution of quality-controlled herbarium records as sourced from GBIF.*

3.2 Spatiotemporal range

Based on study of aerial imagery, likely patches of stinking passionflower could be detected within the riparian zone of most sections of the Fitzroy River that had recent, high resolution aerial imagery available. Eleven of these sites were ground truthed in 2016 during the reconnaissance field survey along the length of the Fitzroy River to confirm the presence of the weed and to construct a preliminary map of the distribution of stinking passionflower along the Fitzroy River and other parts of the Fitzroy catchment based on the aerial imagery and field-based observations (Figure 5).

The weed was present as distinct patches within the riparian zone along most of the river, with numerous significant infestations at Mornington and Danggu (Geikie Gorge) National Park (Figure 6, Figure 7). As noted by Webber et al. (2014) there was no relationship observed between abundance of individual plants and total biomass of the local infestation. Its presence was largely restricted to the riparian habitats, near wetlands or in microclimates with what appeared to be relatively higher soil moisture (Figure 5). Its distribution along the Gibb River Rd and Great Northern Hwy roadside edges was also scattered and in general it was only seen with scattered individuals and low biomass at creek/river crossings, many of which were dry at the time we visited them and most of which were accessible for grazing by feral cattle and kangaroos. Of 87 areas examined whilst travelling; no large infestations of stinking passionflower was seen in over half of the locations, although due to the observation methods we cannot rule out the presence of smaller scattered plants. The overall average percent cover of the stinking passionflower was 1.3 ± 0.49% (SE) for the 87 roadside locations.

Towards the downstream areas of the catchment in the Cambalin, Snake Creek, Udialla and Willare areas, we examined 46km of river/billabongs banks (by boat and by foot) and again the average percent cover of stinking passionflower was patchy and low. This is an area of

cattle stations with high cattle grazing densities, which clearly had an impact on reducing most ground layer vegetation biomass. The average percent cover of stinking passionflower was only 0.8±1.7% of the total riparian-bank area examined, with the weed being only found with high biomass infestations in 45 patches. Much of the weed biomass was found when the plants were overtopping tree canopies, with much lower biomass smothering ground vegetation relative to infestations at Mornington and Danggu National Park. In targeted searching of patches on foot, however, it was almost always possible to find small, often grazed plants. It was obvious that cattle severely impact the density and abundance of stinking passionflower within these riparian habitats with severe cattle grazing/trampling on the banks being noted (Figure 8, Figure 9).

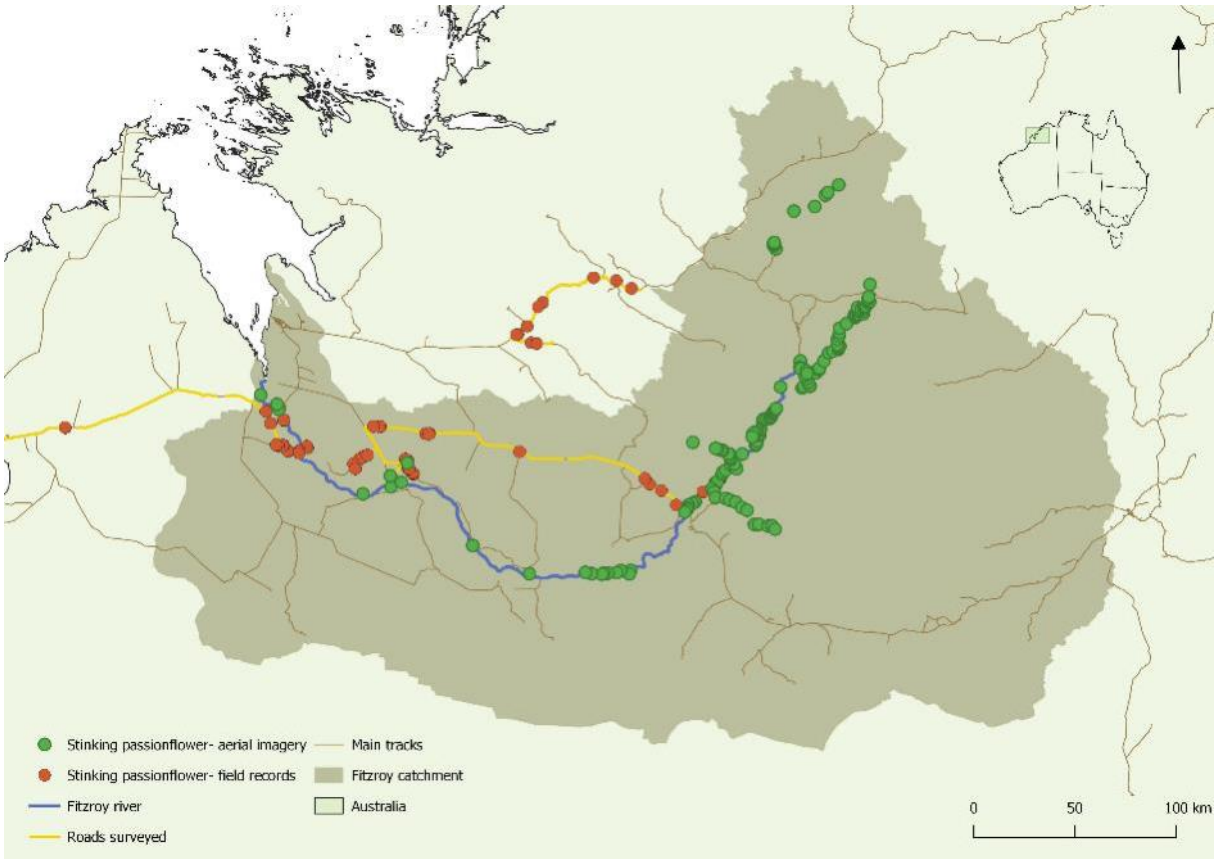

Figure 5. Distribution of stinking passionflower at Fitzroy catchment in August 2016 based on records from aerial imagery (green dots) and field observations (yellow dots).

Figure 6. Dense infestation of stinking passionflower on river edge at Mornington. Cattle have been actively excluded in the region by fencing and culling, photo Bruce Webber.

Figure 7. Significant infestation of stinking passionflower on a former known nesting beach of freshwater crocodiles at Danggu (Geikie Gorge) National Park. Note the human for scale, photo Ruchira Somaweera.

Figure 8. Stinking passionflower growth forms in the vicinity of Udialla and Snake creek in the lower Fitzroy river catchment (a) on steeper banks where cattle access is impeded seedlings are able to regenerate amongst leaf litter, (b) where cattle can access riparian vegetation, stinking passionflower was generally found overtopping shrubs and trees, photos Bruce Webber.

Figure 9. Signs of heavy cattle activity along the lower Fitzroy River near Cambalin, including, left, an absence of understorey vegetation and strong grazing pressure and right, erosion and trampling around a billabong, photos Bruce Webber and Ruchira Somaweera.

3.3 Reproductive output

Due to the damage sustained to field monitoring plots, we are unable to report on reproductive output at this stage in the project. Revised plans supplemented with field data from the broader stinking passionflower research program we are running will ensure milestones are met for the overall project.

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