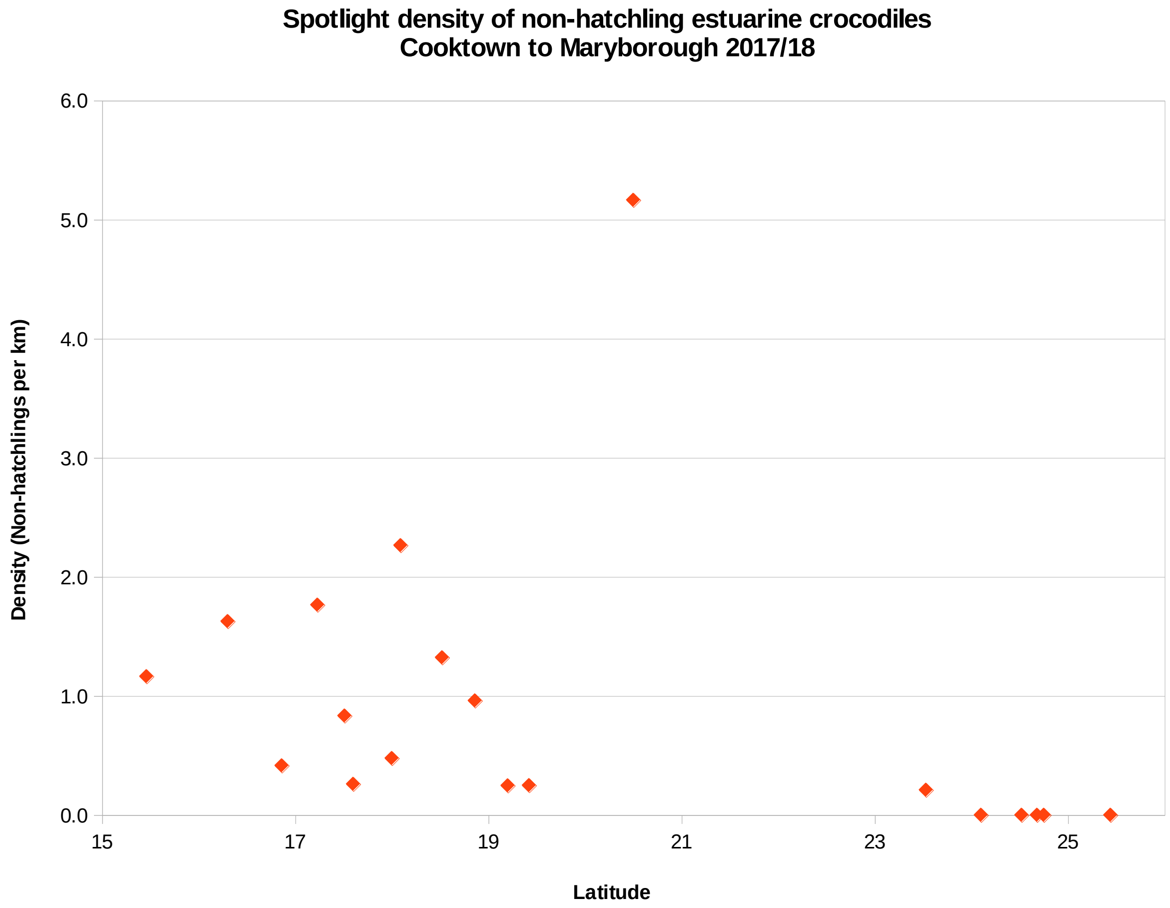
Appendix 6. Report on an aerial survey of estuarine crocodile nesting habitat on the Proserpine River and Goorganga Plains

1. This short report was produced to capture the principal results of a reconnaissance survey of the wetlands in the vicinity of the Proserpine River.

Introduction

2. In the context of estuarine crocodile habitat on the populated east coast (PEC) of Queensland between Cooktown and Rockhampton, the Proserpine River system stands out as very different from most of the surrounding waterways for some hundreds of kilometres to the north and south.
3. Setting aside the Proserpine River system, the density of non-hatchling crocodiles sighted in spotlight surveys tends to decline with increasing south latitude along the populated east coast (Figure 1). While there is much local variation, the highest densities occur between Cooktown and Ingham, while south of Townsville numbers and densities are low – falling to zero south of the Fitzroy River.
4. The Proserpine River at about latitude 20°S stands out for its very high density of non-hatchlings - over 5 per km. Comparable densities are found only in the far north-west of Cape York Peninsula at Port Musgrave – Queensland's prime estuarine crocodile habitat.

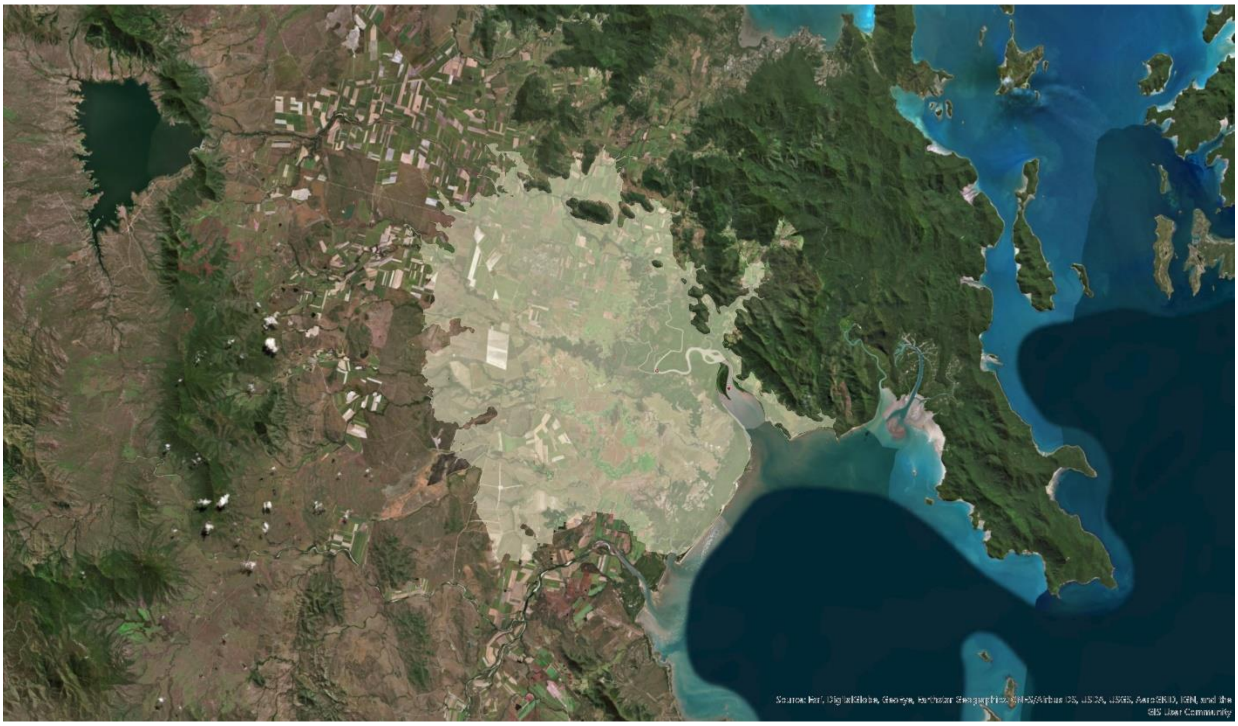
Figure 1



5.

6. What might account for the very high (by Queensland standards) density of crocodiles in this system? The river system itself is, by and large, unremarkable in comparison to other waterways of the populated east coast. It occupies a broad and fairly flat plain bounded by the Normanby Ranges to the west and the Conway Ranges to the east and encompasses some 2500km^2. The main area of relevance for this study, however, is a much smaller area of some 330km^2 lying below the 20m contour which encompass the principally mangrove-fringed waters of the Proserpine River proper and Lethe Brook, aka Lethebrook Creek (Figure 2).

Figure 2



7. The one distinguishing feature of this area is the extensive wetlands that lie north and south of Lethe Brook in areas referred to as the Goorganga Plains, Campbell's Plain and Pocket Paddock. The plains are listed by DES as a nationally important wetland.[1] These show up clearly as bright green areas of grasses and sedges, much of which follows former river courses in the deltaic plain, and some of which is taken up by billabongs and lagoons with standing water (Figures 4a, b).
8. These wetland areas have not previously been investigated as part of Queensland's crocodile research program, so their conservation significance is unknown. However, the structural and floristic composition of the vegetation communities originally present on these plains (Queensland Regional Ecosystems Database – pre-clearing vegetation maps) appear likely to have made them historically, and perhaps currently, important as focal points of crocodile nesting. Comparable areas in the Northern Territory have been found very favourable habitat and capable of supporting quite high densities of nests.[2]
9. The history of crocodile numbers in the Proserpine River system is poorly known. No surveys were undertaken during the major 1980s survey program, as attention was concentrated north of Townsville and particularly in remote river systems of the Gulf and Cape York. Three surveys in the late 1990s suggest the population was increasing quite

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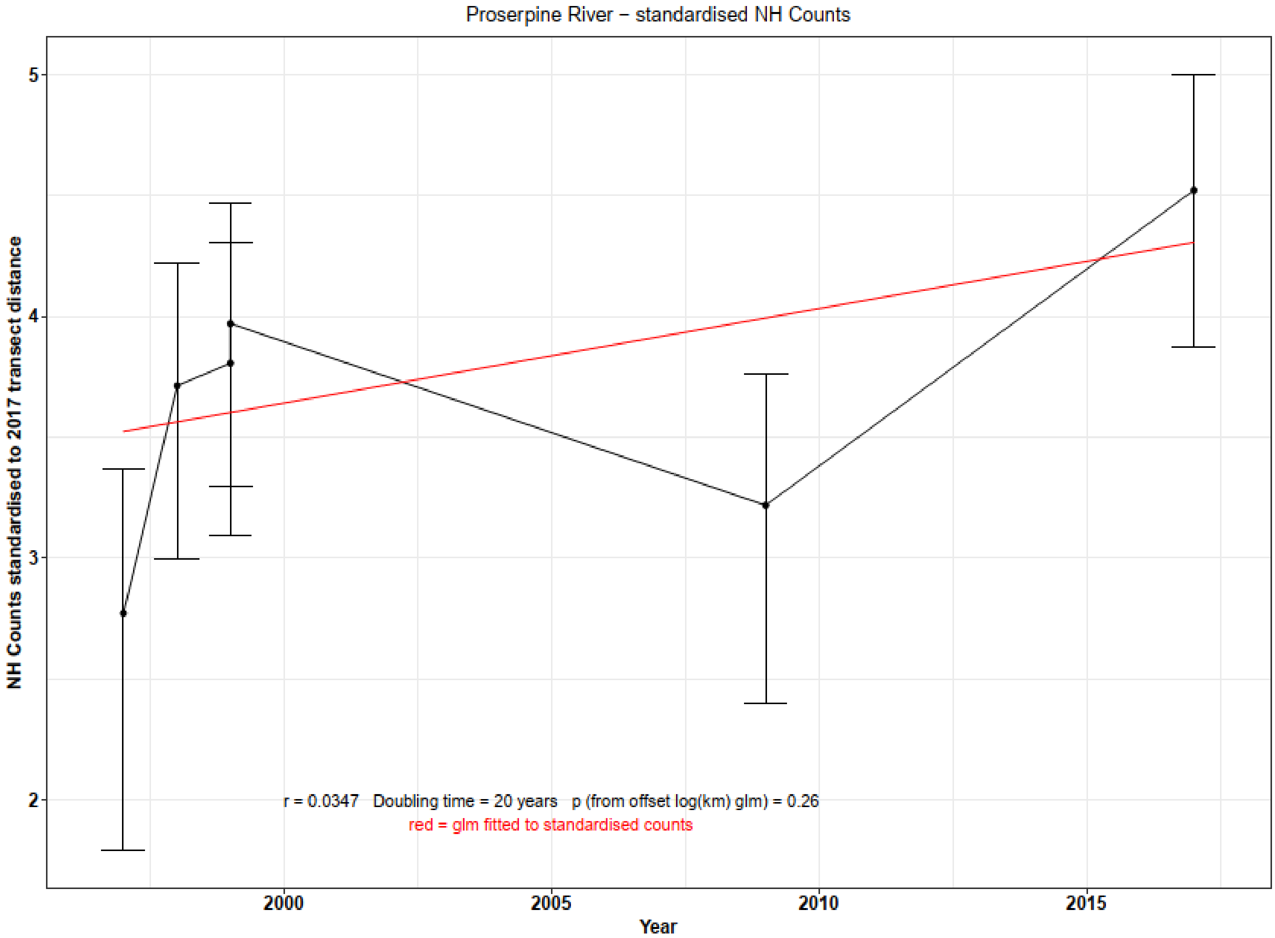
[1] https://wetlandinfo.des.qld.gov.au/wetlands/facts-maps/diwa-wetland-proserpine-goorganga-plain

[2] Fukuda Y & Cuff N (2013). Vegetation communities as nesting habitat for the saltwater crocodiles in the Northern Territory of Australia. Herpetological Conservation and Biology 8(3):641-651

rapidly at that time from what undoubtedly would have been a very low base at the time of protection in 1974 (Figure 3). The 2009 survey is included here but is problematical as it was undertaken at a sub-optimal time during the wet season and is not strictly comparable with the other surveys. The 2017 survey is reliable and suggests the population increased slowly or not all in more recent years. This is not an uncommon pattern in Australian crocodile populations.[3]

Figure 3: Spotlight count density of non-hatchling crocodiles (NH/km) in the Proserpine River as known from Qld Government surveys. Counts have been standardised to the transect distance of the 2017 survey which was designed to be closely comparable in length and location to the earlier surveys. The 2009 count is problematical but does give an estimate of the minimum number of crocodiles present at that time.



10. We considered it possible that these areas might be contributing significantly to the high density of crocodiles in the Proserpine River and its tributaries and the high numbers of hatchlings observed there in many surveys. We planned, therefore, a helicopter survey to assess the nesting vegetation and the crocodile habitat more generally and to locate nests. The survey was carried out on a single day in early May 2019, judged favourable timing to allow identification of active nests likely to be laid down after major floods in the region in February 2019.

3 Fukuda Y et al (2011) Recovery of Saltwater Crocodiles Following Unregulated Hunting in Tidal Rivers of the Northern Territory, Australia. Journal of Wildlife Management 75(6):1253–1266

Figure 4a: Overview of the Proserpine River plains.

Figure 4b: Detail of the southern sector

Pre-clearing vegetation communities of the Proserpine River delta

11. The vegetation maps and regional ecosystem description (in italics) below are quoted directly from the Queensland Herbariums Regional Ecosystems Database (Neldner et al, 2012).[4]

4 Neldner, VJ, BA Wilson, EJ Thompson and HA Dillewaard. 2012. Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland. Version 3.2 Updated August 2012.

RE 8.1.1 Mangrove closed forest of marine clay plains and estuaries

12. Estuarine crocodiles do nest occasionally in associations mapped as mangrove forest, despite a lack of ground cover. It is most common to find nests in more open habitat on or close to the landward fringe of the mangrove belt, where ferns, sedges and grasses develop but they will, on occasion, build nests of poor quality under fringing mangroves.

RE 8.1.2 Samphire open foreland on saltpans and plains adjacent to mangroves

13. Comparable vegetation associations are used for nesting in the NT (Fukuda & Cuff, 2013) but no nests are known to the authors from such areas in Queensland so far. This may reflect, in part, the relatively low density of crocodiles in many Queensland rivers compared to NT systems. It also likely reflects the scale at which mapping has been carried out, which would map small patches of Sporobolus and perhaps broad-leafed grasses suitable for nesting into samphire associations.

RE 8.1.3 Sporobolus virginicus tussock grassland on marine sediments

14. *Sporobolus virginicus open tussock grassland to closed tussock grassland. … Other ground layer species which may be present include Fimbristylis ferruginea, Cyperus victoriensis, C. scariosus, C. polystachyos var. polystachyos, Eleocharis spiralis, Diplachne fusca, Eriochloa procera, Fimbristylis polytrichoides, Gymnanthera oblonga. Ipomoea coptica, Epaltes australis, Paspalum vaginatum, Cyperus difformis, Cyperus javanicus, Sarcocornia spp. and Tecticornia spp.*
15. Estuarine crocodiles do nest in such areas adjacent to perennial waterways in both the NT and Queensland, not uncommonly in small patches of broad-leaved grasses mixed in with Sporobolus. See, for example, Britton 2007, 2009, 2012; Taplin (2017); Magnusson et al; 1979, 1980.

RE 8.1.4 Schoenoplectus subulatus and/or Eleocharis dulcis sedgeland or Paspalum vaginatum tussock grassland

16. *Schoenoplectus subulatus and/or Eleocharis dulcis sparse sedgeland to closed sedgeland or Paspalum vaginatum sparse tussock grassland to closed tussock grassland. Often consists of areas of permanent, slightly tidally-influenced open water, often with a zoned distribution (from deepest to shallowest) of sedges and grasses (usually concentrated around the edges). Some species tend to occur in isolated clumps (e.g. Schoenoplectus subulatus and Phragmites spp.). Other species may include Sporobolus virginicus, Cyperus scariosus, Blyxa spp., Nymphaea spp., Typha domingensis and Persicaria attenuata. There may be occasional emergents of mangrove spp. or Melaleuca spp.*
17. Comparable closed grasslands and sedgelands are important nesting areas in the NT and are used by crocodiles in Queensland.

RE 8.1.5 Melaleuca spp. and/or Eucalyptus tereticornis and/or Corymbia tessellaris woodland with a ground stratum of salt tolerant grasses and sedges, usually in a narrow zone adjoining tidal ecosystems.

18. *Melaleuca spp. and/or Eucalyptus tereticornis and/or Corymbia tessellaris low open woodland to open forest (to open shrubland) (2-20m tall). Canopy dominants are very variable, ranging from dense stands of Melaleuca quinquenervia or M. leucadendra, to more open stands of Melaleuca spp. and/or eucalypt species. Acacia spp. … may be present. … There is usually a mid-dense to dense ground layer (often interspersed with large bare areas of saline silts), most often dominated by Sporobolus virginicus, Baumea juncea or*

Queensland Herbarium, Queensland Department of Science, Information Technology, Innovation and the Arts, Brisbane, Qld.

Acrostichum speciosum. Other dominants may include Cynanchum carnosum, Baumea rubiginosa, Eleocharis dulcis and Paspalum vaginatum. Other typical associated species are Imperata cylindrica, Phragmites spp., Eriochloa procera, Gymnanthera oblonga, Juncus kraussii, Ceratopteris thalictroides and Cyperus javanicus.

19. Comparable vegetation associations in the NT are well-favoured for nesting in both the NT (Fukuda and Cuff, 2013) and Queensland (Taplin, pers obs).

RE 8.3.4 Freshwater wetlands with permanent water and aquatic vegetation

20. *Freshwater wetlands with permanent or semi-permanent water and aquatic vegetation. Includes sedgelands, grasslands and forblands with areas of open water in the deepest sections. Dominant and associated species may include Leersia hexandra, Nymphoides indica, Eleocharis dulcis, Nymphaea gigantea, Nymphaea violacea, Eleocharis sphacelata, Panicum paludosum, Pseudoraphis spinescens, Azolla pinnata, Phragmites australis, Utricularia aurea, Utricularia gibba, and Persicaria decipiens. …*
21. The open water areas of this type unsuitable for nesting but nests are not uncommon in fringing beds of dense sedges and grasses.

RE 8.3.6a Eucalyptus tereticornis and/or Corymbia intermedia (or C. clarksoniana) and/or C. tessellaris ± Lophostemon suaveolens open forest on alluvial levees and lower terraces.

22. These associations are not, in the broad, suitable for nesting except where they occur as fringing vegetation along waterways that provide access to suitable areas of ferns, sedges or grasses close to water. It is not uncommon to find nests that map into such associations, often because the scale at which is done does not distinguish the small areas of suitable vegetation crocodiles may select.

RE 8.3.11 Imperata cylindrica and/or Sorghum nitidum forma aristatum and/or Ischaemum australe tussock grassland on alluvial and old marine plains

23. *Imperata cylindrica and/or Sorghum nitidum forma aristatum and/or Ischaemum australe closed tussock grassland to open tussock grassland. Other frequent to occasional associated species are Fimbristylis ferruginea, Eremochloa bimaculata, Centella asiatica, Cyperus flavidus, C. polystachyos, C. victoriensis, C. scariosus, Bothriochloa decipiens, Eriochloa procera, Diplachne fusca, Lobelia concolor, Flemingia lineata, Glycine tabacina and Lobelia concolor. The most common emergent is Pandanus cookii.*
24. This can provide areas suitable for nesting, but there is only a relatively small amount of this RE in the south-eastern quadrant of the study area.

RE 8.3.12 Imperata cylindrica and/or Sorghum nitidum forma aristatum and/or Ischaemum australe tussock grassland on alluvial and old marine plains.

25. *Imperata cylindrica and/or Sorghum nitidum forma aristatum and/or Ischaemum australe closed tussock grassland to open tussock grassland. Other frequent to occasional associated species are Fimbristylis ferruginea, Eremochloa bimaculata, Centella asiatica, Cyperus flavidus, C. polystachyos, C. victoriensis, C. scariosus, Bothriochloa decipiens, Eriochloa procera, Diplachne fusca, Lobelia concolor, Flemingia lineata, Glycine tabacina and Lobelia concolor. The most common emergent is Pandanus cookii.*
26. Can provide very suitable nesting habitat.

RE 8.3.13 Eucalyptus tereticornis and/or Corymbia tessellaris and/or Melaleuca spp. woodland on alluvial and marine plains, often adjacent to estuarine areas.

27. *Melaleuca quinquenervia and/or M. leucadendra and/or M. dealbata and/or Eucalyptus tereticornis and/or Corymbia tessellaris closed forest to low open woodland (to tall open forest) (5-35m tall). … The ground layer is very variable depending on the substrate and*

degree of inundation. Dominants may be one or several of Imperata cylindrica, Paspalum scrobiculatum, Ischaemum australe, Eremochloa bimaculata, Sorghum nitidum forma aristatum, Paspalidium distans, Themeda triandra and Cyperus polystachyos var. polystachyos.

28. Can provide suitable nesting habitat.
29. Vegetation associations favourable for nesting, particularly natural grasslands and sedgelands and periodically water-logged Melaleuca woodlands dominated the area pre-clearing. Setting aside for the moment some 44km^2 mapped as mangroves, some 92% of the 174km^2 of wetlands was covered by potentially favourable or very favourable nesting vegetation. The remainder consists of samphire flats and Sporobolus grasslands that are used for nesting but tend to have lower nest densities (Fukuda and Cuff, 2013).

Transect pattern – as planned and as flown

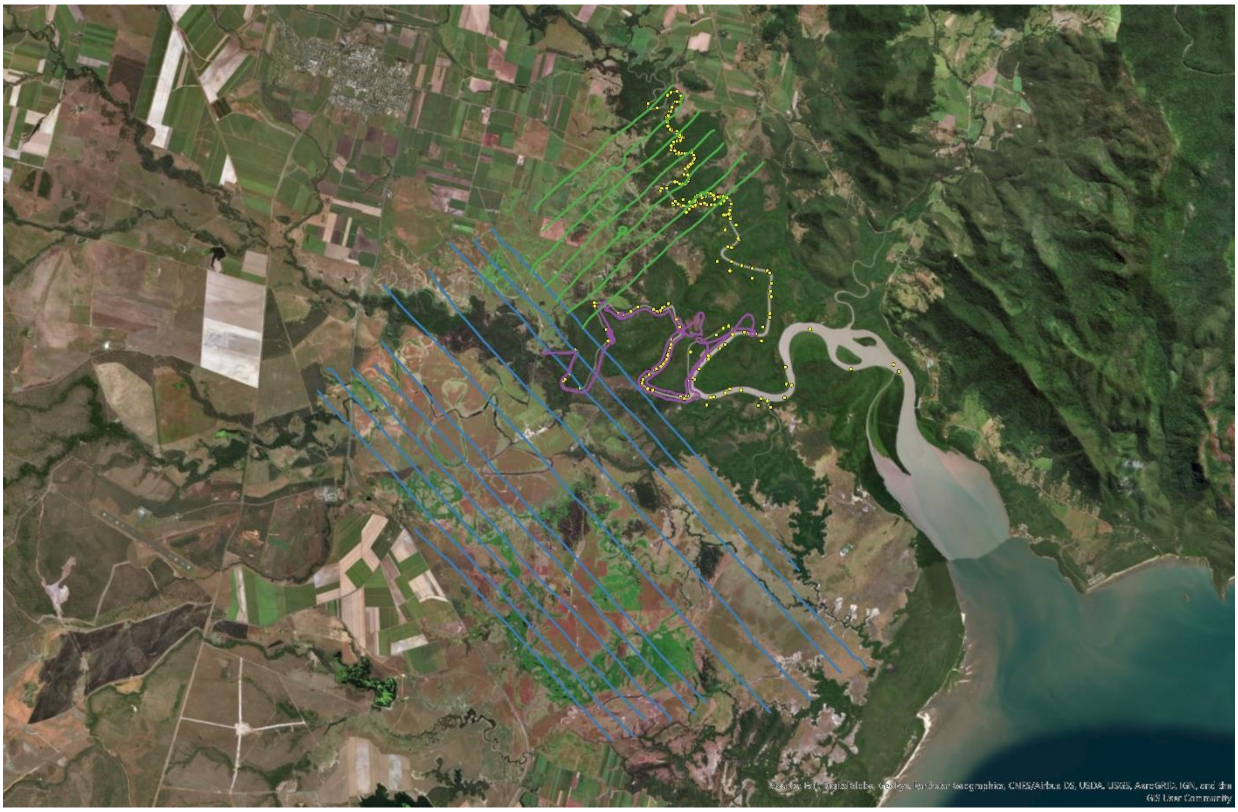
30. Assessment of the main swamplands was planned using straight-line transects spaced 200m apart (Figure 5a). We planned to fly every second transect for the first run, holding over an option to fly the intervening transects depending on our findings. In the event, we flew six NW-SE transects spaced at 400m apart at the southern end of the plains and, at that separation, were confident we would have sighted any nests under or between the transect lines. We then flew three transects at 800m separation to sample the remaining 'south-section' plains and reverted to 400m separation for the remaining 'south-section' transects as we cut across denser woodland and forest close to Lethe Brook.
31. We then flew the river banks of Lethe Brook and part of the Proserpine River mainstream – this transect was more constrained than originally planned because of the dense vegetation (in which nests were located), which made the search slow and somewhat difficult.
32. In the northerly section of the plains where transects ran SW-NE, every second transect was flown. Transects were cut short where it became evident that the remaining habitat to be surveyed had been sampled elsewhere and was very unlikely to carry nests.
33. Straight-line transects flown across the open plains sampled the different vegetation associations in the plains in approximate proportion to their representation in the study area as a whole (Table 1). Mangrove associations were over-represented because the upstream river-bank transects were focused on areas where large numbers of hatchlings and yearlings had been found during spotlight surveys and where straight-line transects made little sense.

Table 1: Representation of regional ecosystems in the study area and in the transects as flown

34. **Regional Ecosystem – Level 1**	35. **Short Description**	36. **Distance surveyed on transects (km)**	37. **% of survey distance**	38. **Area in study area (km^2)**	39. **% of study area**
40. 8.1.1	41. Mangrove	42. 31.50	43. 20.4	44. 43.7	45. 30.5
46. 8.1.2	47. Samphire	48. 1.34	49. 0.9	50. 1.6	51. 1.1
52. 8.1.3	53. Sporobolus grasslands	54. 7.53	55. 4.9	56. 12.6	57. 8.8
58. 8.1.4	59. Grassland	60. 3.40	61. 2.2	62. 2.1	63. 1.5
64. 8.1.5	65. Melaleuca woodland	66. 3.14	67. 2.0	68. 2.8	69. 2.0
70. 8.3.11	71. Grassland	72. 0.79	73. 0.5	74. 3.6	75. 2.5
76. 8.3.12	77. Broad-leaf grassland	78. 57.59	79. 37.4	80. 49.3	81. 34.5
82. 8.3.13	83. Closed forest with grasses/sedges	84. 20.46	85. 13.3	86. 10.8	87. 7.6
88. 8.3.4	89. Freshwater wetlands and fringing sedges	90. 28.39	91. 18.4	92. 16.4	93. 11.5
94. Total	**95.**	**96. 154.14**	**97. 100**	**98. 142.9**	**99. 100**

Figure 5a: Helicopter transects as planned

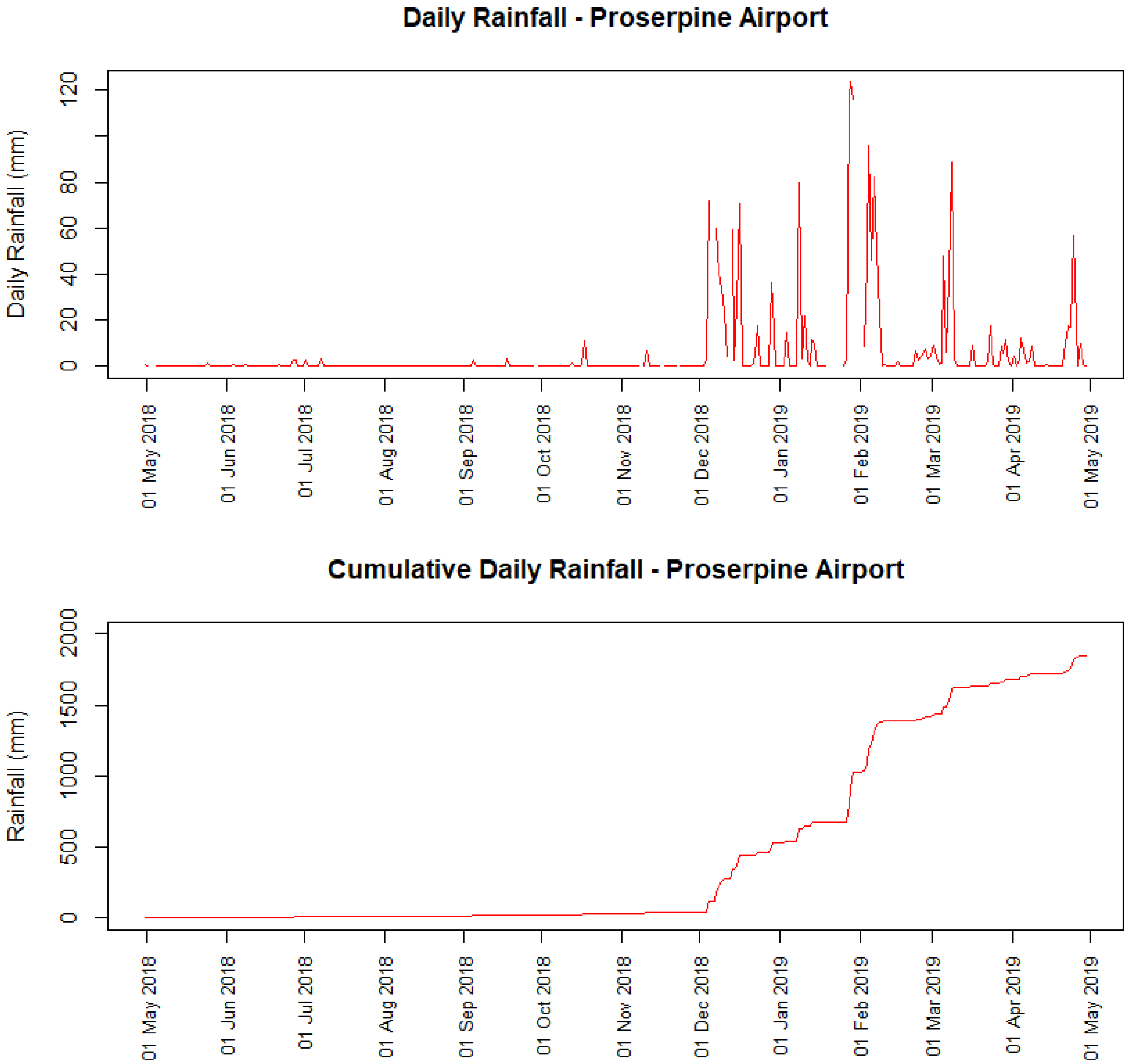
Figure 5b : Helicopter transects as flown. Yellow dots show the locations of hatchlings identified in surveys of the system between 1998 and 2017.



Assessment of the nesting season 2018-19

34. After a typically dry winter, the wet season began in early December with above-average rainfall from December to February (Figure 6). There were well-documented floods in early February, evidence of which could be seen on the plains in extensive areas of flattened grass and debris build-up along fence lines. After that there was a lull until early March and then through most of April, suggesting conditions would have been favourable for a second burst of nesting activity after flood losses of nests laid down December and January. In any event, there is sufficient diversity in the terrain and swamplands that crocodiles should have had plenty of opportunity to move to the fringes of flooded areas and find suitable nest sites.

Figure 6: Daily rainfall and cumulative rainfall at Proserpine Airport for the nesting season 2018-2019



Findings

35. Based on our preliminary assessment of the habitat and the nesting season it was reasonable to expect that the survey would identify:
36. a reasonable number of crocodiles scattered among the many floodplain billabongs, but most likely in the deeper ones offering better shelter; and
37. a modest number of nests (based on past records of recruitment to the Proserpine River system) located mostly in favourable grasslands and sedgelands close to watercourses and lagoons.
38. It was striking, therefore, that we found only two crocodiles outside the river system proper and absolutely no sign of any nests or nest-related activity in any of the freshwater swamplands. This is not attributable to difficulties in spotting conditions. Fine weather and a good pilot made sighting conditions excellent over the un-treed plains and swampy open Melaleuca woodlands that covered much of the area. If there were any numbers of crocodiles in these billabong/lagoon systems they were highly likely to have been sighted. Indeed most of the waterholes were sufficiently shallow and clear that crocodiles would have been sighted even if they were underwater. Only a 3-4ft and a 4-5 ft crocodile were

sighted (Figure 7) - quite possibly animals that dispersed during floods and will move back to the Proserpine River as the plains dry out.

Figure 7: Nests (red stars) and crocodiles (green dots) sighted during helicopter surveys

39. Sighting conditions for nests and nesting activity over the more open plains were also excellent (Figure 8). We judge it unlikely that nests within 100-200m of the aircraft flight path would have been missed on the open plains and within 50-100m in the open woodlands and Melaleuca open woodlands/swamps and in grasslands fringing closed forest areas closer to the river.
40. Nests were found, however, under dense riverine cover along Lethe Brook and the Proserpine River mainstream – notwithstanding the challenging sighting conditions (Figures 7 & 9). Three were located during the riverine transect and one was spotted from a straight-line transect. These nests were spotted at lateral distances of up to 50m from the flight track, but there can be little question that nests would have been missed given the density of the cover.
41. Only one nest (Nest 4) was sighted in the north-western quadrant of the study area. It lay some 45m from the flight track on the river bank. It seems very likely, given the numbers of hatchlings and yearlings in this area that more nests would be found if water-based surveys of the fringing forest were conducted here. The transects, including their turning circles where spotting continued but which are not shown in Figure 5, covered considerable areas of open grassland abutting the riverine fringing forest but no nests were located. This was a very surprising result.

Figure 8: Representative photos of wetlands/swamplands on the Goorganga Plains south of the Proserpine River showing excellent sighting conditions for crocodiles and their nests.

(a) 

(b) 

(c) 

42. Importantly, none of these nests was in a location that could be regarded as better than marginal for nesting. While the nests appeared to have a fair content of vegetable matter, the general environment surrounding them was heavily shaded and muddy. Crocodiles will scratch up nests in sites even more unfavourable than this (e.g. on the southern and western Gulf plains where nests of little more than mud and sticks are found) – but their prognosis for producing hatchlings is likely to be fairly poor. Past surveys of the Proserpine River have returned hatchling counts of 43 (1998), 38 (1999), 16 (2007), 4(2009), and 34 (2017). The 2007 and 2009 surveys were conducted at the wrong time of year to detect hatchlings, so can be discounted. The counts suggest only a small handful of nests are actually producing hatchlings in any particular year.

Condition of the nesting habitat

43. Broadly speaking, the plains to the south of the Proserpine River are very heavily grazed and the swamplands extensively modified by introduced grasses and cattle impact on their margins (Figures 8&10). Many of the swamps appear heavily infested with what appeared from the air to be Para grass, *Urochloa mutica* (Figure 8a). Much of this change appears likely to have been a matter of good agricultural practice for the station owners. John Cox, who described his family in 1996 as operating cattle properties at Sarina, Collinsville and Goorganga, wrote of the economic imperative to improve pastures and remove native grasses on their properties saying *inter alia* "On the fattening block [Goorganga] improved pastures are essential to finishing cattle to the required standard. … Native grasses tend to assist only when seasons are favourable." [5] Cox commented that Goorganga was "…almost completely covered in Para grass swamps or pangola [*Digitaria eriantha]* flats." Para grass has been used extensively in Queensland for ponded pasture beef production (Qld DAFF, 2012).[6]
44. In contrast, waterholes in the north-easterly quadrant were in considerably better condition and the country less heavily grazed close to the river – at least at the present (Figure 11).

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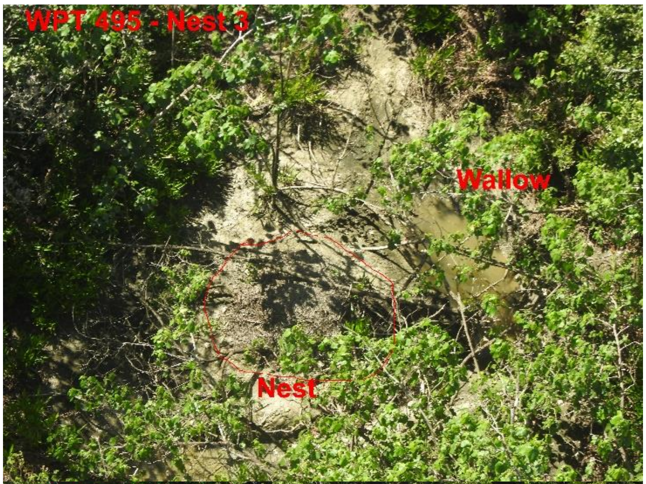
[5] Cox, J (1996) Pastures for Prosperity – Beef Coastal Forum. 2. Grazing in the nineties – The role of improved pastures. Tropical Grasslands 30: 116-119.

[6] DAFF (2012) Para grass – Invasive species risk assessment. Qld Department of Agriculture, Forestry and Fisheries.

Quite dense fringing sedges were present on numerous waterholes, though pig damage was evident at some sites (Figure 11 a, b). This area presented as more favourable for crocodiles, though the numerous billabongs and waterholes were also quite shallow.

45. Overall, however, given the complete absence of sightings of breeding size crocodiles and nesting activity in any of the open swamplands and Melaleuca swamplands surrounding the Proserpine River and Lethe Brook, we conclude that the impact of agricultural activity has been very considerable and the environment is now inhospitable for crocodiles and nesting. In effect, it can be essentially written off as crocodile habitat.
46. This is clearly not the case, however, for the river mainstreams and their dense fringing forests which evidently support a number of nests. This survey was not sufficiently concentrated or intensive to estimate how many nests might be present. Indeed, it was not possible to be confident that all the nests located were laid down this year. Nest 4 had been excavated on one side and shell was scattered nearby, suggesting predation or successful hatching this season. The others looked as though they could be from the 2017-18 nest season or from 2018-19 but possibly compacted from flooding.
47. A more detailed assessment of nesting would best be made through boat surveys between February and May looking for signs of nesting crocodiles and assessing how many nests are being laid down

Figure 9: The four nests found in dense riverine fringing forest in Lethe Brook and the Proserpine River mainstream


WPT 495 - Nest 3
Wallow
Nest


WPT 279 Nest 4
NO STEP


NO STEP

Figure 10: Condition of wetlands in the southerly section of the Proserpine River/Goorganga Plains.

Figure 11: Condition of swamplands north of the Proserpine River

Discussion

48. There remain several significant and unanswered questions about this river system:
49. Why does it support such a high density of crocodiles relative to any other waterways in Queensland outside north-western Cape York Peninsula?
50. Why is the remnant crocodile population so constrained to the main waterways and what does this mean for its future survival?
51. What is happening to the ‘excess production’ of crocodiles from this area, which appears to likely to have reached or be coming close to some sort of ‘carrying capacity’ today?
52. The answer to the second question may be that there has been sufficient pressure of one sort or another on the population outside the waterways that the mainstreams and densely vegetated areas have become their last remaining refuge. They may also have been protected in some measure by the long-term existence of crocodile-spotting safaris on the mainstreams.
53. The apparent absence of juvenile and sub-adult crocodiles in the 3-7 ft size classes in the swampland billabongs and lagoons is especially surprising, as we would expect the high overall density of non-hatchlings and the presence of large and very large crocodiles in the rivers would impose pressure on them to disperse. This effect is quite apparent in other east coast rivers in Queensland, such as the Daintree where numbers of juvenile and sub-adults appear to have dispersed moved into upstream areas at remarkably high elevations (up to ~400m ASL).
54. The results suggest that the real amount of habitat effectively available for estuarine crocodiles in the Proserpine River system amounts to little more than 40-50km of waterway buffered from surrounding developments by dense fringing forest. We would expect numbers to decrease upstream as the river is increasingly encroached upon by cane farms, the river narrows and shallows, and the fringing vegetation thins out markedly. At a density of 5 NH/km that extent of habitat would equate to a population of around 300-400 animals, allowing for a spotlight sighting probability of about 65%.
55. As to the first question, no real answer can be ventured at present. There is nothing very obviously different about the Proserpine River system when compared with other more northerly PEC river systems that would explain its high crocodile numbers. The few counts available do suggest a high rate of increase during the 1990s from what would likely have been a very low base in the late 1970s and then slowed through to the present (Figure 2). Similar patterns have been seen in other populated east coast systems (DES – current survey program).
56. One possibility that shouldn’t be excluded is that the high density is, in part, a consequence of breeding size crocodiles moving back into the river system as external pressures on surrounding habitats impacted them. That could have resulted in a somewhat concentrated population of breeding animals in a small area that has been able to sustain recruitment with a modest amount of nesting success. Larger crocodiles can be very long-lived absent hunting pressure, so a somewhat artificially concentrated breeding population could persist for a long time and might persist at higher than ‘normal’ densities if the influences forcing concentration also inhibited emigration of juveniles and sub-adults.
57. That possibility raises some interesting questions and research opportunities, with direct management implications, relating to such things as:
58. the numbers and size distribution of the nesting females (e.g. are they recent recruits or large old females that are not being replaced), the numbers of nests being laid down and their success rate, causes of nest losses (predation, flooding etc).
59. the role of the several very large crocodiles in the system in regulating (or not) the density of crocodiles in the system, the size distributions, locations and movement patterns of smaller male animals, and their reproductive roles (are they senescent and contributing nothing to breeding while posing a threat or are they reproductively successful?).

60. the short-term and longer-term movements and dispersal of animals in and out of the core mainstream areas.
61. As to the last question, it begs the question as to whether there is any ‘excess’ production available for emigration. The rapid increase apparent in the 1990s surveys followed by stasis or a slight increase up to the present suggest that the population is currently producing more hatchlings than the system can accommodate. They could be expected to disperse as they grow into the 3-4ft size class after about two years – but this presumes they are surviving that long. We should not yet exclude the possibility that the high density of crocodiles and the constrained environment is leading to high mortality and greatly reducing or eliminating the numbers available to disperse.