1 Million Turtles

COMMUNITY CONSERVATION PROGRAM

BACKGROUND

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FEATURE

Trouble Down Under: Problems Mount for Australia's Freshwater Turtles

Ricky Spencer

A juvenile Bellinger River Snapping Turtle. Few remain after adisease brought the species to the brink of extinction in 2015. PHOTO CREDIT: RICKY SPENCER

In a recent article in the international journal *Conservation Biology*, we demonstrate a theoretical basis for why headstarting programs are a necessary conservation strategy for stopping the declines of freshwater turtles– especially those primarily threatened by both adult mortality or removal (due to roads, predation, or harvest) and invasive predators affecting multiple life history stages.

Once common widespread species are becoming locally extinct because the longevity of turtles has hidden the impact of these threats. Australia is now at the stage since post-European settlement where the effects of foxes and urban population sprawl (and associated infrastructure) are being observed through large declines and extinction events. Declines of up to 91% have been observed along the Murray River in southeastern Australia. Wildlife diseases have become more prevalent over the last decade, a symptom of deteriorating water quality and climate change. The net effect of these threats are that freshwater turtle populations in southern Australia are at high risks of extinction without active management.

EUROPEAN RED FOXES

The European red fox was first introduced into Australia in 1845. Other successful releases followed in southern Australia in the 1870's and within 20 years, the red fox had achieved pest status. The expansion of the red fox population across mainland Australia followed the spread of rabbits, with the fox's distribution on mainland Australia limited by the northern tropics.

Fox predation is having a serious impact on many native animals and is a major contributor to extinction of some species. In the Murray River in Australia, mortality rates of eggs have increased to over 93%. This is likely to be replicated throughout the distribution range of foxes, as changes in nest predation rates are largely independent of fox density, meaning that a single fox can have a similar impact on turtle nests as a high-density population of foxes.

Long-term, high levels of nest predation have resulted in extreme aging populations, and there are few available management techniques to effectively eradicate foxes over a broad scale. Poison baiting is the only broad-scale management technique available in Australia, and our trials demonstrated

that only intensive, large-scale baiting can effectively reduce nest predation rates. Other common techniques, such as targeted shooting and fencing, may also reduce the impact of foxes but are not cost-effective techniques for broad-scale management.

Management of a population or a species under threat often focuses directly on reducing impacts on the life history stage(s) affected. In doing so, focus inevitably is directed to the threat, rather than on the impacts on the affected population. Plant biologists and conservationists have long criticized classical biocontrol for lacking quantitative assessments of effectiveness, especially post-release, yet invasive vertebrate pest management primarily focuses on reducing densities of invasive predators or herbivores. The core components of conservation policy to manage their impacts is to reduce predator numbers in an area using lethal methods. The actual efficacy (e.g., reduced impact on target species or increases in biodiversity) of such programs are rarely assessed and success is determined by the number of carcasses, reduced activity of the target species or the number of baits taken. Efficacy of these programs is vital given the limited resources available for most conservation programs and the high costs associated with lethal control. AU$21.3 million was spent on labor costs alone for red fox control in Australia between 1998 and 2003, but the benefits to native prey are largely unknown.

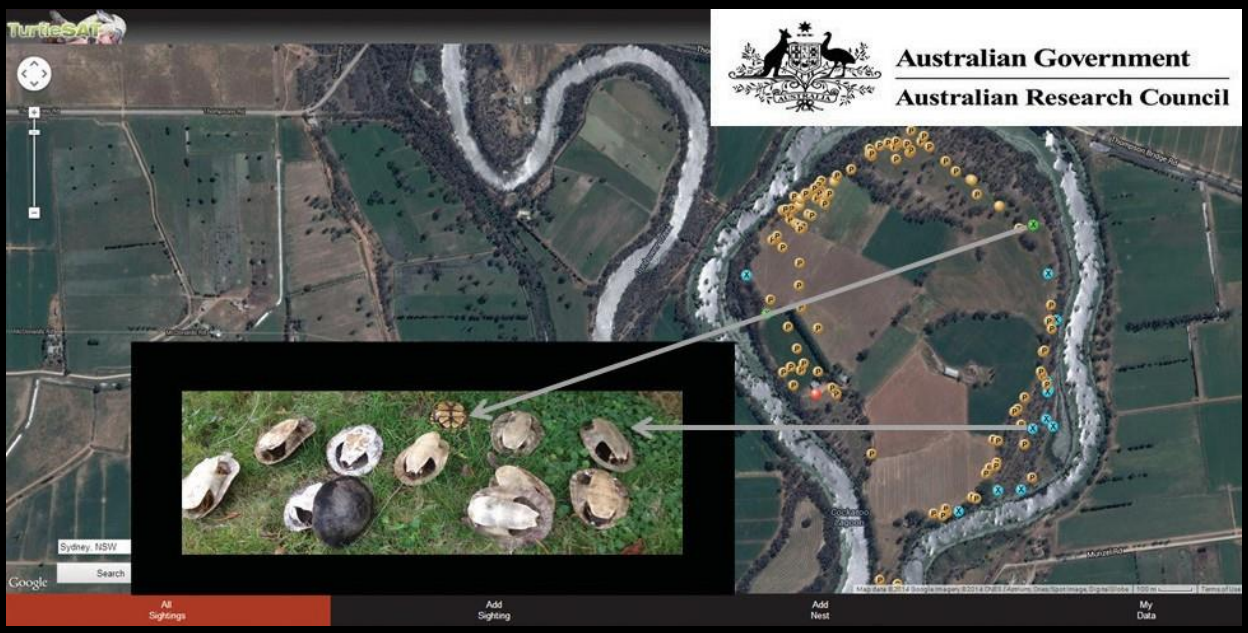
INCREASING ADULT MORTALITY

In addition to nest predation, foxes also kill adult turtles they encounter on land. Australian turtles are resilient to high levels of nest predation for sustained periods and periodic levels of reduced nest predation and pulse recruitment can maintain population viability, but high levels of adult mortality can drive populations to extinction.

Mortality of Australian turtles has increased through disease, too. In February 2015, a mystery disease almost drove the Bellinger River Snapping Turtle (*Myuchelys georgesi*), in northeastern New South Wales, Australia, to extinction in less than a month. The disease did not affect other turtle species, and the juvenile population of *M. georgesi* appears unaffected. The cause of the disease remains unknown but has been suggested to be a novel virus. Our analysis adds to the growing body of literature reporting that climate change is having a detrimental effect on organisms. The disease that brought the species to the brink of extinction may be a spectacular climax to an already declining or stressed population.

An unusual mortality event also occurred at the same time with the Johnstone River Snapping Turtles (*Elseya irwini*) in Far North Queensland, Australia. Similar to the Bellinger River Snapping Turtle, moribund animals were found lethargic with variable degrees of necrotizing dermatitis and at the time of the turtle deaths, water levels were extremely low.

Water quality and drought are significant factors that have hastened population declines of turtles in South Australia. In early 2008, Murray River Turtles (*Emydura macquarii*) infested with the Australian tubeworm (*Ficopomatus enigmaticus*) were reported at the mouth of the Murray River in South Australia, and reported cases spread upstream until 2011. This emergent condition in turtles is due to high water salinity in the region. The worms form calcareous tubes



Citizen Science data from TurtleSAT showing locations of depredated nests (yellow) and dead turtles (green and blue) killed by Foxes.

Eastern Long Neck Turtle encrusted by a marine tubeworm during the 2008-2011 drought in South Australia. PHOTO CREDIT: DEANNE SMITH (ALEXANDRINA WILDLIFE)

on hard surfaces of turtles and potentially killed thousands of turtles, although the exact number is not known. At current levels of recruitment, it takes only 1% of the adult population (~2% of adult females) to be harvested from a population each year to increase the risk of extinction (over 200 years) to over 60%.

Road mortality is another source of adult mortality that particularly targets nesting females as they emerge to nest. Our Citizen Science project, TurtleSAT, has shown extensive road mortality of Eastern Long-necked Turtles (*Chelodina longicollis*) in southeastern Australia. Eastern Long-necked Turtles are Australia's most widely distributed turtles, yet their numbers have declined by 91% over the last 40 years in some areas.

PROGRESSIVE MANAGEMENT

With no recruitment in the region and limited dispersal opportunities due to the number of dams, the near-complete absence of turtles at many sites in south Australia is particularly disturbing because it was first predicted over 30 years ago, and low numbers have been subsequently reported.

Several states have recently listed Murray River turtles as Threatened or Data Deficient, but they are not listed at the federal level, thus few conservation initiatives are occurring. Species like Eastern Long-Neck Turtles are not considered species of concern or trigger protocols associated with Environmental Impact Statements (EIS) for urban development. It takes community groups, such as Turtle Rescues NSW, to conduct last minute rescues as developers drain and fill in swamps and wetlands as urban development expands throughout the Sydney basin.

Few freshwater turtles are actively managed in Australia. The most prominent example is the Western Swamp Tortoise (*Pseudemydura umbrina*), which is one of Australia's most endangered reptiles. It has the smallest surviving population of any Australian reptile. The Western Swamp Tortoise is listed as Endangered under the Environment Protection and Biodiversity Conservation Act 1999.

There are less than 200 endangered Western Swamp Tortoises, restricted to only two wild populations, remaining near Perth in western Australia. Less than 50 individuals survived 30 years ago, but since 1988, a successful breeding program has allowed translocation of captive-bred juveniles to three sites.

Similarly, the Bellinger River Snapping Turtles is now Critically Endangered under the Environment Protection and Biodiversity Conservation Act 1999. During the disease outbreak with the Bellinger River Snapping Turtle, I was part of a large rescue team that collected 16 healthy adult turtles before the disease reached the upper stretches of the River. These turtles are now part of a breeding

Some of the 2000 headstarted Murray River Turtles released into South Australia. PHOTO CREDIT: RICKY SPENCER

program that will hopefully implement a successful headstarting program over the next few years.

Headstarting is generally seen as a management tool of last resort when species crash and become critically endangered. Captive breeding and headstarting has not been commonly used as a conservation strategy for freshwater turtles in Australia. High financial costs, as well as landscape level disconnectivity among populations, have probably restricted its use, and past population modelling suggests that conservation efforts are more effective when focused on reducing adult mortality. However, we clearly show that the criticism of headstarting as "halfway technology" is erroneous, especially in cases where external threats affect multiple life history stages of freshwater turtles. The "halfway technology" argument assumes that all perturbations or mitigating factors affecting turtle populations can be eradicated, but in Australia, factors that impact turtles in southern Australia are multi-factorial and will never dissipate until populations are extinct or technology to reduce threats from invasive predators becomes more effective. Headstarting should be the primary conservation tool for managing freshwater turtles in decline.

Headstarting programs with small captive populations of Galapagos tortoises and Burmese star tortoises have proven successful at restoring population numbers. But the value of headstarting as a management tool goes beyond critically endangered species. In cases where "common" turtles are declining, developing suitable harvest populations *in situ* is the key. Many common species of turtle occur in integrated wetlands and water treatment plants (e.g., constructed wetlands) throughout their range, and these facilities may provide a tool for low cost headstarting programs for widespread but declining populations. The reproductive potential of turtles in constructed wetlands represents a potential pre-existing resource for developing localized headstarting programs *in situ*. A simplistic model where relative densities of the Eastern Long-necked Turtle are based on surface area of water demonstrates that all eggs/hatchlings collected from 1 hectare of water can service ~25 hectares of water in a region to maintain population growth at pre-European levels and completely eliminate the risk of population extinction.

Our models also demonstrate that periodic increases in recruitment can sustain populations, potentially allowing populations in a region to be managed in a mosaic fashion. In other words, not all populations need to be actively managed each year.

That is the key. Their longevity ensures that they are resilient to annual variation in mortality, which provides management with the flexibility to manage populations over wide spatial and temporal scales.

ACKNOWLEDGEMENTS: Research has been supported by the Australian Research Council Linkage Grant Program (LP150100007), North-Central Catchment Management Authority, Yorta Yorta Aboriginal Corporation, Foundation for National Parks and Wildlife, Victorian Department of Land, Environment, Water and Planning, Winton Wetlands, Turtles Australia, Inc. and Save Lake Bonney Group Inc.

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Loss of habitat from urban sprawl puts turtles at risk, but community groups like Turtle Rescues NSW and Alexandrina Wildlife, relocate and rehabilitate turtles. PHOTO CREDIT: TURTLE RESCUES NSW

HEADING FOR EXTINCTION



The clock is ticking for Australian freshwater turtles. Over the last 40 years, the most common and widespread species have **declined by up to 91%** because of introduced **foxes** and increased **urbanisation**. We are also seeing **mass die-offs** as a result of habitat-quality related **diseases**. Traditional management strategies to reduce these impacts are not working and we are running out of time to reduce their risks of extinction. Turtles are iconic, but are also of major importance in river ecosystems and a loss of abundant **scavengers**, will have serious effects on general **river health**.





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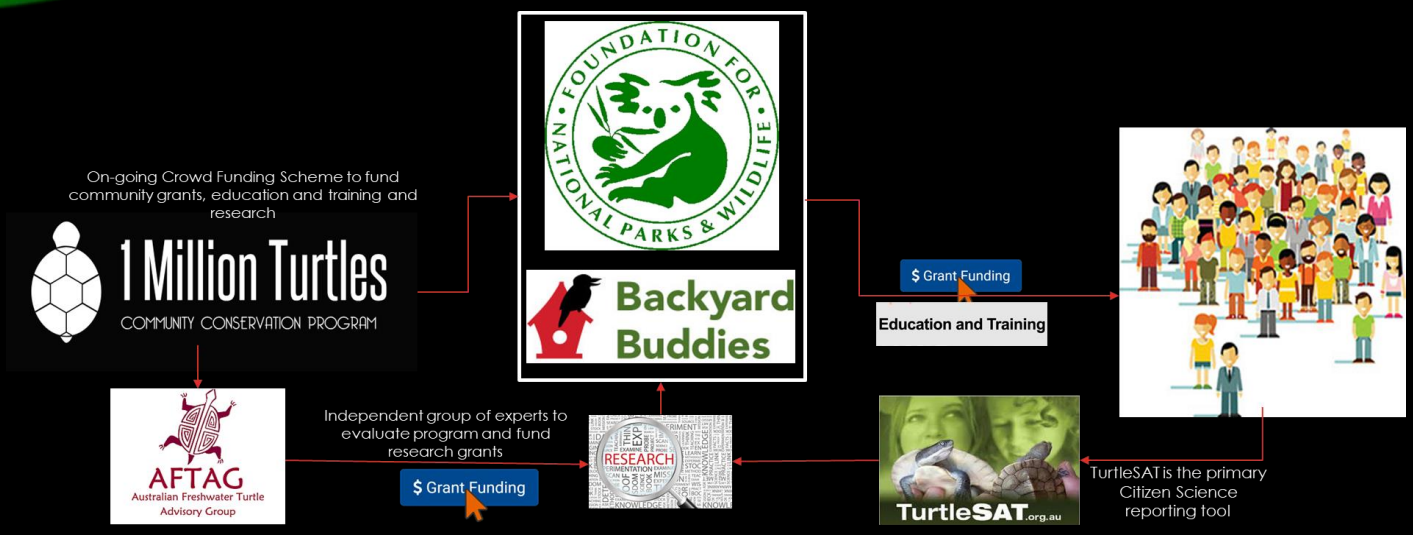
THE 1 MILLION TURTLE CONCEPT



We are proposing Australia's largest, community-empowered, conservation program. Local communities will lead "expansionary conservation", where we aim to release more than 1 million extra turtles throughout South-Eastern Australia each year. A Crowd-Funding program to support the 1 Million Turtles Community Conservation Program will support turtle conservation initiatives, such as "Turtles in the Classroom" or the creation of protected islands and nesting grounds around local wetlands, urban parks, and constructed wetlands. This will ensure that our freshwater turtle populations persist into the future.

The Australian Freshwater Turtle Advisory Group (AFTAG) will oversee continued cutting-edge research and community education and training will be the 'heartbeat' of the program. In a world with increasing human-wildlife conflicts, the 1 Million Turtles Community Conservation Program pioneers a new era in conservation, where communities & urban development become the solution.

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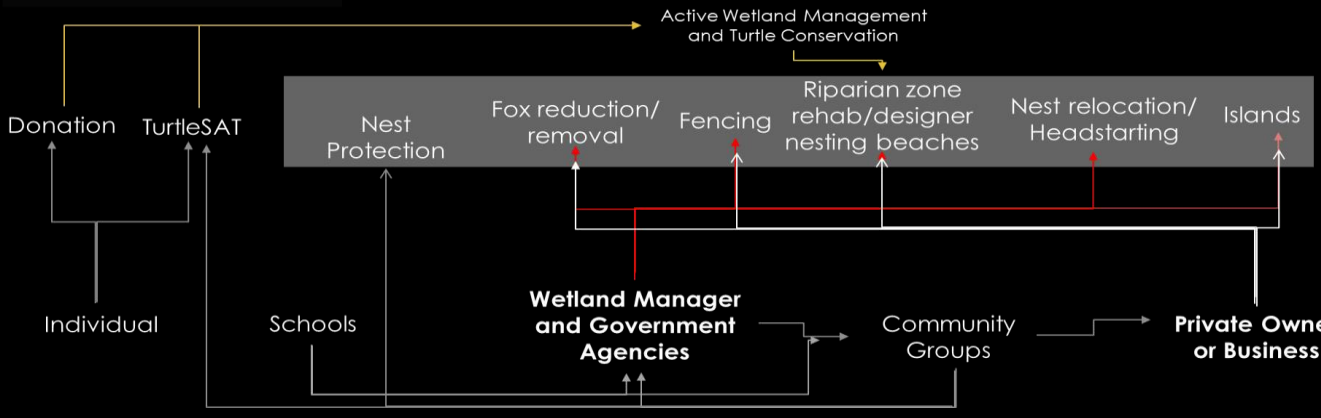
TurtleSAT.org.au



1 Million Turtles Community Conservation Program is based on Active Wetland Management or Creation. All levels of the community can participate , but key to the program are wetland management agencies and private wetland owners where initiatives, such as artificial islands or designer nesting beaches can be constructed.

These initiatives can be combined with traditional methods, such as reductions in fox numbers and fencing, to ensure turtles are returned to local wetlands each year. This will be Australia's largest community conservation program. It is a facilitated breeding program in the wild before species they become critically endangered. It is conservation beyond a fence !

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THE SCIENCE

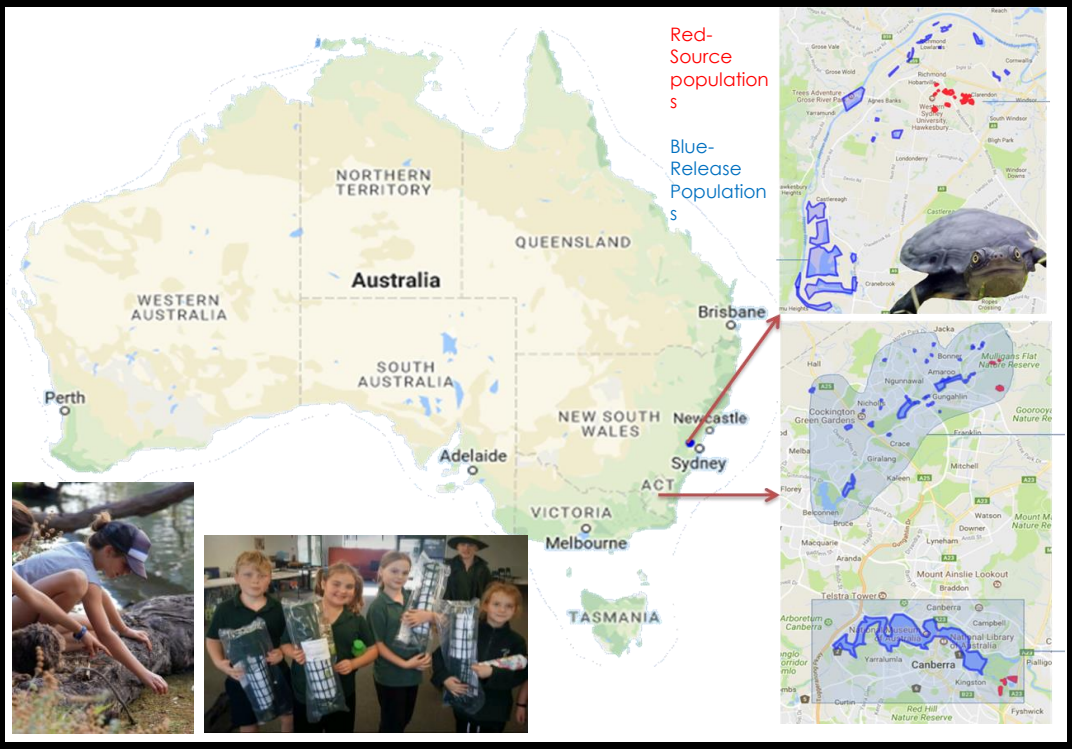
We are proposing to develop Australia's largest conservation network. The focus is on creating regional harvest populations or 'headstarting' programs.

Because of their longevity and high reproductive output, turtles are unique in that a small number of populations can supply hatchlings to many more populations throughout the region.

We will harness that reproductive potential to create a community conservation network throughout Southern and Eastern Australia.

Creating "source populations" is key and these will consist of natural wetlands, as well as, integrated constructed wetlands, farm dams and water treatment plants throughout each species' range. These facilities may provide a tool for low cost headstarting programs for widespread, but declining populations.

Constructed wetlands, urban wetlands and farm dams are small water bodies that have enormous biodiversity potential. They are important for new estates and urban development, as natural wetlands are removed. They are also important for drought mitigation strategies through stormwater capture.



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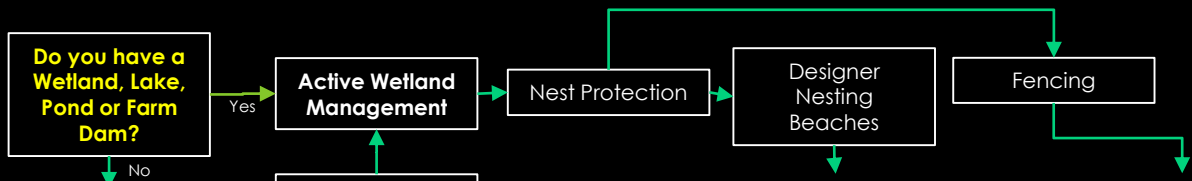
FLEXIBLE SOLUTIONS

TURTLES IN THE CLASSROOM

"Regardless of the turtle conservation model selected, we will provided detailed Standard Operating Procedures (SOPs), as well as, develop site-specific programs for each school. Schools will have a 24h hotline for advice and regular on-site visits by us."



Turtles in the Classroom is a program where eggs are incubated at the school, turtles are raised for a period of time, and are then released into wetlands in the region.

At a minimum, schools will be required to dedicate a secure room/shed/shipping container for egg and turtle husbandry. Strict biosecurity and animal ethics protocols will need to be adhered to.

Eggs will require temperature control (incubators or room regularly heating to 30C(or constant temps of 25-30C) and daily husbandry at times. Hatchlings can be maintained in the same room or in dedicated ponds for 1-12 months. Strict biocontrol protocols minimise disease risk of both hatchlings and endemic populations that they will be released into.

Schools will be required to
1) Establish facilities and have them approved by appropriate government agencies.
2) Have a dedicated teacher or staff member trained to lead the program, as well as train students
3) Ensure husbandry and biosecurity protocols are strictly adhered to
4) Engage with a local vet who can provide advice and treatment
5) Egg incubation is Nov-Jan for most species. Turtle husbandry Feb-Mar or Feb-Sep (if turtles over-winter)

Schools should also
1) Establish display ponds or tanks where non-release turtles can become part of classroom teaching.
2) Engage with local community groups and herp societies to aid with husbandry and advice.

Designer Nesting beaches involve creating areas where turtles will concentrate their nesting activities.

Nesting beaches can be created though long-term strategic revegetation of the riparian zone or through direct manipulation of the area (e.g. laying sand and erecting drift fences to guide turtles to particular areas).

School activities would include
1) Habitat manipulations
2) Monitoring and protecting nests during the nesting period.
3) Collection of hatchlings for release

Advanced activities would include
1) Harvesting of hatchlings for release into different populations.

Potential low cost option. Main activity late Spring/early Summer

Fencing involves excluding foxes from a wetland or part of a wetland.

Fencing could potentially be seasonal, particularly if it is only protecting small nesting beaches. Standard fence plans are available.

School activities would include
1) Monitoring nesting grounds and protecting nests
2) Collection of Hatchlings for release
3) Fence patrols and maintenance

Advanced activities would include
1) Harvesting of hatchlings for release into different populations.

Higher cost option, but less reliant on patrols and nest protection

SCHOOL TURTLE CONSERVATION PROGRAMS

TURTLE PODS

"Turtle Pods" are modified self-contained shipping containers that will allow up to 1000 eggs to be incubated each year

They require no building approvals and only require to be connected to electricity onsite

Viewing windows are installed to allow students to view eggs and turtles hatching.

Temperatures are maintained by reverse cycle air conditioning

Optional insulation can be fitted before delivery.

Turtle Pods meet quarantine standards required to release hatchlings as part of conservation programs

Cost- $5k-10k

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WETLAND REVITALISATION AND CREATION

Revitalised wetlands and wetland creation in urban landscapes are at the forefront of or translocation programs for the future. At a landscape level, revitalised wetlands may become designer wetlands that create nurseries for a range of endangered species that can be repopulated throughout the region- a hub for conservation programs.

The concept is simple: Create areas to maximise reproductive potential and survival of a suite of species for translocation throughout a region. Each site may target a different suite of species, but the core values of each revitalisation project are to improve water quality and provide optimal habitat.

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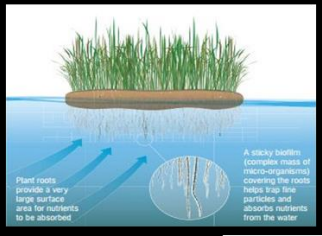
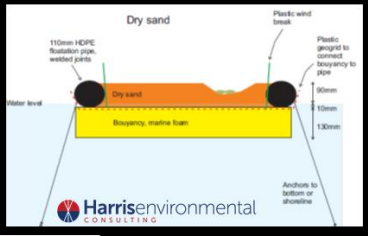
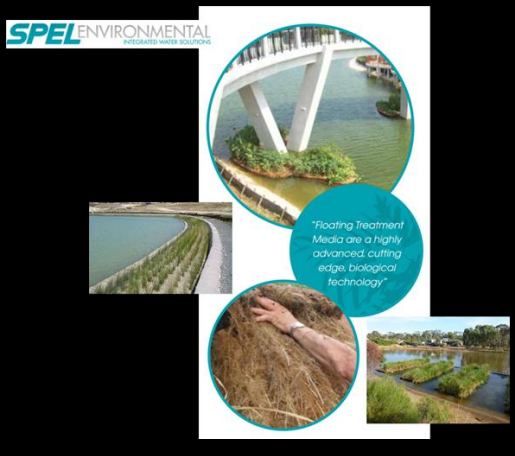
FLOATING HABITAT ISLANDS

- Floating habitat islands are the perfect solution for urban or constructed open water wetlands, where riparian zone nest protection or habitat rehabilitation is not available
- Floating islands are potentially lifeboats for a range of species threatened through urban development and will become the focus for environmental education and engagement through Citizen Science.
- The floating habitat islands serve a range of purposes, including
  - Improving water quality, due to mitigated pollutants from development;
  - Wetland restoration, from where land use changes have caused wetlands to be lost to development;
  - Natural beautification, and increased abundance of wildlife;
  - Reduction of erosion, because of wave lap erosion control with the floating media and
  - Carbon sequestration, since treatment media reduces the natural processes that tie up carbon.
- We are working with a range of companies to modify existing designs to add modules to provide refuge for egg laying species like turtles and wetland birds.







BIODIVERSITY PONTOONS: CITIZEN SCIENCE FOR URBAN WETLANDS

- Biodiversity Pontoons is a Citizen Science Project that will engage visitors to local parklands with wildlife. Citizen Scientists will snapshot animals using constructed refuges located in the wetland.
- The program provides habitat for aquatic wildlife and will capture data on seasonal bird migrations, as well as, often cryptic aquatic animals, such as turtles, water rats, water dragons and platypus. The pontoons also provide additional wetland areas to deliver quantifiable improvements in water quality.
- Biodiversity Pontoons will be at the forefront of monitoring for one of the world's most invasive pest species, the Red-eared Slider Turtle. Red-eared Sliders readily bask and are distinguished from native turtles by their colouration.
- Observational areas around the wetland are established to monitor the pontoons. Citizen Scientists can directly download an app to snap photos and learn about local wetland species at the same time.
- Seasonal events will occur across the Biodiversity Pontoon network to monitor long-term changes in species and numbers.

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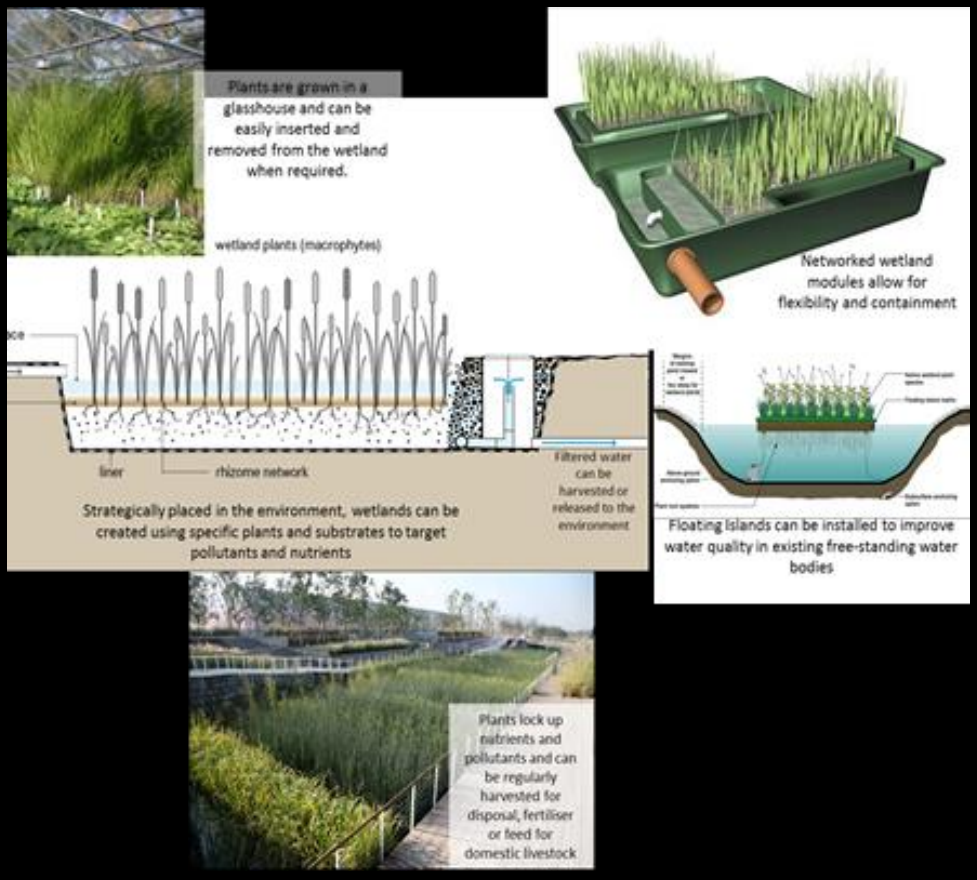
FLEXIBLE FUNCTIONAL WETLANDS



- Riparian zones are the "kidneys" of any wetland.
- Water flows through a range substrates and vegetation before it flows into the lake, pond or river.
- Microbes in the soil and the plants themselves provide efficient biological filtration and importantly lock up or convert many pollutants before they enter the environment.
- We are proposing to create a flexible wetland system where specific wetland plants are grown in modules in glasshouses and are mobilised rapidly to target specific pollutants, such as agricultural nutrient run-off, heavy metals and biological hazards (e.g. PFAS and endocrine disruptors)
- A demonstration site will be created on the WSU Hawkesbury campus, where a brand new Experimental Wetland facility has been established.
- Real-time, cutting-edge monitoring stations will be installed to pioneer teaching and engagement activities and demonstrate WSU as a leader in water conservation, environmental health and drought resistance.

DESIGNER NESTING BEACHES

- Designer Nesting Beaches create areas around existing wetlands where turtles are attracted to and can nest in.
- Nests are concentrated to a small area, which can be protected by volunteers and wetland managers
- There are several options we are exploring.
  - Firstly, material like clean sand may provide a "beacon" in the environment to attract turtles. A small layer of sand is placed on the ground before nesting season and while turtles may be attracted to the area, incubation of eggs occurs in the natural substrate.
  - Secondly, the creation, or manipulation, of wetland habitat can naturally direct turtles to normal or created nesting areas at a site. This option works well in conjunction with our "Flexible Functional Wetland" idea
  - Lastly, all options can involve the use of temporary fencing around a wetland to direct turtles where to nest, or exclude foxes from the nesting beach. Turtles will often nest along fence lines, making them easy to check and protect.
- A range of temporary and more permanent landscape design options are being explored.

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GET INVOLVED

1 Million Turtles

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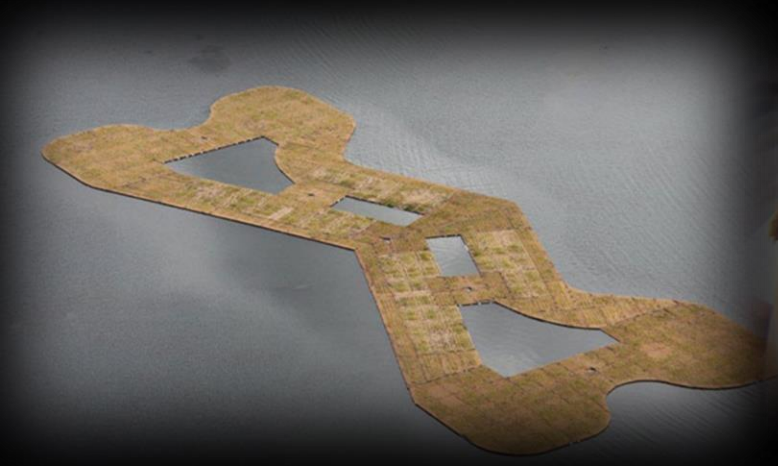
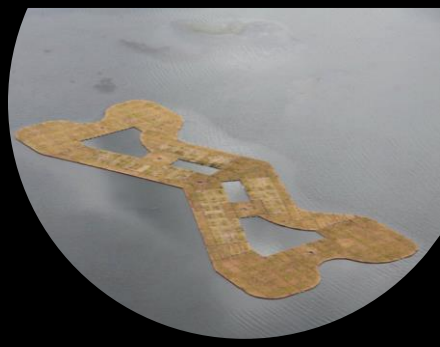
ARC LINKAGE GRANT

- An Australian Research Council Linkage Grant Proposal will pioneer the research for the program.
- This is an opportunity to become a foundation member of the network
- The Linkage Program promotes research partnerships between researchers and business, industry, community organisations and other publicly funded research agencies.
- It provides cash up to $300,000, matching the cash and in kind contributions of partners.
- There are several levels of investment depending on the program you are participating in
    - **Island and wetland creation requires a total investment of $20K-$100K** (Cash and in kind). 80% of the construction will be met by your cash contribution, 20% will be met by the ARC contribution. The equivalent of a 0.75-1.5FTE position will be employed at the site through the ARC contribution. This will consist of academic and research staff, PhD students and education officers that will work with local staff.
    - **Nest beach creation and monitoring requires a total investment of $5K-$25K** (Cash and In Kind). Smaller in kind contributions are also most welcome at this level. This program largely requires the ability to engage volunteers or school groups to drive the monitoring. Academic and Research staff, PhD students and education officers will also work with local staff and we will provide a range of monitoring tools (e.g. TurtleSAT app) and workshops to train volunteers and aid with translocations and permits.
    - **Turtles in the classroom program requires an investment of $5k-$25K** (Cash and in kind) investment. Upper level investment allows the purchase of incubators for eggs and aquaria for in school programs. Turtle Pods cost ~$10K. *In situ* monitoring requires lower level investments. Both programs will receive intensive support from academic and research staff, PhD students and engagement officers. Local vets will also be supported to provide health checks.



FAQS

- What is a cash contribution?
  - A cash contribution are funds that can be contributed annually to the grant. These must be considered new funds, but if current initiatives are re-focused towards the turtle project, then they can be used as a contribution.



- What is an in kind contribution?
  - An in kind contribution is usually the proportion of staff time employed at the partner that will be now focussed onto the Turtle Project.
- When do we need to provide the cash contribution ?
  - A letter indicating your support is all that is required right now. It is not a contract or even an MOU at this stage. The total level of commitment is spread over three-four financial years and the University will bill you directly. A sample letter is provided in this document.
- Who is involved?
  - The project is being led by a team of researchers from Western Sydney University, La Trobe University, University of Sydney and University of Canberra in collaboration with the Foundations for National Parks and Wildlife. Associate Professor Ricky Spencer is the project leader. More information can be found at www.1millionturtles.com

THE PROPOSAL

APPLICANTS

Associate Professor Ricky-John Spencer (WSU)
Professor Michael B. Thompson (USYD)
Professor Arthur Georges (UCAN)
Dr James Van Dyke (La Trobe)
Professor Edward Holmes (USYD)
Professor Willem Roosenburg (Ohio U)

PROJECT TITLE

"1 million Turtles" Community Conservation Program: Preventing the Extinction of Australian Freshwater Turtles

AIMS AND BACKGROUND

The clock is ticking for Australian freshwater turtles, 44% of which are listed as vulnerable or worse (Van Dyke et al. 2018). Over the last 40 years, some the most common and widespread species have declined by up to 91% (Chessman 2011), with almost total extirpation from some areas in SA where they were once abundant (Van Dyke et al 2019). Nest predation by invasive foxes, as well as adult mortality due to roads and drought, are likely to blame (Spencer and Thompson 2002; Santori *et al*. 2018; Chessman 2011). There are also mass die-offs as a result of habitat-quality related diseases (Spencer et al. 2018). Once-common widespread species are becoming locally extinct because the longevity of turtles has hidden the impact of these threats ("*the perception of persistence*"; Lovich et al. 2018). Turtles are important in river ecosystems and their decline has serious effects: worsened water quality, disrupted foodwebs and subsequently, disrupted nutrient and mineral cycling, reduced seed dispersal, and altered bioturbation (Lovich et al. 2018). These impacts seriously threaten the biodiversity and general ecological "health" of river ecosystems, and threaten the human services these ecosystems currently provide (Lovich et al. 2018). Worryingly, turtles are also very slow to recover from mortality events due to their uniquely slow life histories. Thirty years after a mass mortality of snapping turtles in Ontario Canada, the population has not recovered even though subsequent mortality has been low (Keevil et al. 2018). Our project revolutionises turtle conservation and uses a multifaceted approach to recover turtle populations in Australia.

The aim of this project is to pioneer community driven "macro-conservation" programs to halt the decline of Australian freshwater turtles and recover them to pre-European levels, using "headstarting". In a recent article in *Conservation Biology* (Spencer *et al.* 2017), we demonstrated a theoretical basis for why headstarting programs (captive incubation and release of hatchling turtles) are a necessary conservation strategy for halting the declines of freshwater turtles. We suggest that headstarting is especially effective for managing species that have experienced losses of recruitment for so long that demographic collapse is a major threat, along with increasing adult mortality. Here, we propose to use develop a landscape model of headstarting that will achieve the following aims:

1) Apply newly developed (Spencer et al. 2016, 2017) ecological theory for long-lived organisms to cutting-edge landscape level conservation biology for re-stocking turtle populations throughout south-eastern Australia to address declines that have been occurring since European settlement.
2) Create a conservation network blue-print for managing native species before they become endangered. The fundamentals of the program have a strong scientific background and will be implemented by an educated community within their own communities. An approach highly desirable for our industry partners and conservation management agencies worldwide.

EUROPEAN RED FOXES

The European red fox was introduced in Australia in 1845. Other successful releases followed in southern Australia in the 1870s and within 20 years, the red fox had achieved pest status. The expansion of the red fox population across mainland Australia followed the spread of rabbits and their distribution has only been limited by the northern tropics. Fox predation is having a serious impact on many native animals and is a major contributor to extinction of some species (Woinarski et al. 2015). In the Murray River in Australia, mortality rates of turtle eggs have increased to over 93% (Thompson 1983; Spencer 2002). This high mortality rate is likely to be pervasive throughout the distribution of foxes, because changes in nest predation rates are largely independent of fox density – instead, single foxes are capable of destroying massive numbers of nests, even after fox numbers are reduced (Spencer et al. 2016; 2017). Long-term high levels of nest predation have reduced recruitment to the point that turtle populations are composed primarily of older individuals, with very low numbers of juveniles (Chessman 2011; Van Dyke et al. 2019). Though these

populations appear healthy due to large numbers of adults (**perception of persistence**), they result in local extinction once the old adults die, if recruitment is never improved. There are few techniques available for management to effectively eradicate foxes over a broad scale. Poison baiting is the only broad-scale management technique available in Australia, and our trials demonstrated that only intensive, large scale baiting can effectively reduce nest predation rates (Howard unpubl. data; Spencer et al. 2018b). Other common techniques, such as targeted shooting and fencing, may also reduce impacts of foxes but are not cost-effective techniques for broad-scale management (Spencer et al. 2016). Management of a population or a species under threat often focuses directly on reducing impacts on the life history stage(s) affected. The core components of conservation policy is to reduce invasive species numbers in an area using lethal methods. In doing so, focus inevitably is directed to the threat, rather than on the impacts on the affected population. Efficacy of these programs is vital given the limited resources available for most conservation programs and the high costs associated with lethal control. AU$21.3m was spent on labor costs alone for red fox control in Australia in 1998–2003, but the benefits to native prey are largely not known (Reddiex et al. 2006). Fort turtles, we have demonstrated that standard fox management is ineffectual (Spencer et al 2016, 2017), thus we propose headstarting as a potentially important alternative strategy for mitigating the impacts of foxes on turtles and standard fox management practices involving poison baiting and shooting becomes part of an integrated management program.

INCREASING ADULT MORTALITY

Our Citizen Science program, TurtleSAT, has demonstrated that foxes also kill adult turtles they encounter on land (Fig. 1). Even relatively low levels of adult mortality can drive populations to extinction rapidly, especially in conjunction with high levels of nest destruction (Spencer et al. 2017).

Fig. 1. Citizen Science data from TurtleSAT showing locations of depredated nests (yellow) and dead turtles (green and blue) killed by foxes

Fig. 2. Eastern Long Neck Turtle encrusted by a marine tubeworm during the 2008-2011 drought in South Australia. Photo Credit: Deanne Smith (Alexandrina Wildlife)

Besides foxes, mortality of Australian turtles has increased through disease. In February 2015, a mystery disease almost drove the Bellinger River Snapping Turtle (*Myuchelys georgesi*), in north-eastern New South Wales, Australia, to extinction in less than a month. The disease did not affect other turtle species, and juvenile *M. georgesi* appear unaffected (Spencer et al. 2018a). The disease was caused by a novel virus (Zhang et al. 2018), but our analysis indicates that environmental conditions may have made *M. georgesi* more susceptible (Spencer et al. 2018a). The disease that has brought the species to the brink of extinction may be a spectacular climax to an already declining or stressed population. An unusual mortality event also occurred at the same time with the Johnstone River snapping turtles (*Elseya irwini*) in Far North Queensland, Australia (Ariel at al. 2017). Similar to the Bellinger River Snapping Turtle, moribund animals were found lethargic with variable degrees of necrotising dermatitis and at the time of the turtle deaths, water levels were extremely low (Ariel at al. 2017).

Water quality and drought are significant factors that have hastened population declines of turtles in South Australia (Van Dyke et al. 2019). In early 2008, infestation of Murray River turtles with the Australian tubeworm (*Ficopomatus enigmaticus*) was reported at the mouth of the Murray River in South Australia. This emergent condition in turtles is due to high water salinity in the region and the reported cases spread upstream until 2011 (Fig. 2). The worms form calcareous tubes on hard surfaces of turtles and potentially killed thousands of turtles, although the exact number is not known. At current levels of recruitment, it takes only 1% of the adult population (~2% of adult females) to be harvested from a population each year to increase the risk of extinction (over 200 years) to over 60% (Spencer et al. 2017). In addition to direct effects, we have preliminary evidence that environmental changes may also be impacting turtle diets, which may have consequences for their survival, growth, and reproduction (Petrov et al. 2018).

Road mortality is another threat that particularly impacts nesting females as they emerge to nest. TurtleSAT has again proved important and shown extensive road mortality of Eastern Long-Neck Turtles in South Eastern Australia (Fig. 3a; Santori et al 2018). Eastern Long-Necks are Australia's most widely distributed turtles, yet their numbers have declined by 91% over the last 40 years in some areas (Chessman 2011).

PROGRESSIVE MANAGEMENT

With no recruitment in the region and limited dispersal opportunities due to the number of dams, the near-complete absence of turtles at many sites in South Australia (Fig. 4) is particularly disturbing because it was first predicted almost 30 years ago (Thompson 1988), and low numbers have been subsequently reported (Chessman 2011). Several states have recently listed Murray River turtles as threatened or data deficient, but they are not listed at the federal level, thus few conservation initiatives are occurring. Species like Eastern Long-Neck Turtles (*Chelodina longicollis*) are not considered species of concern, nor do they trigger protocols associated with Environmental Impact Statements (EIS) for urban development. It takes community groups, such as Turtle Rescues NSW, to conduct last minute rescues as developers drain and fill in swamps and wetlands, as urban development expands throughout the Sydney basin (Fig. 3b).

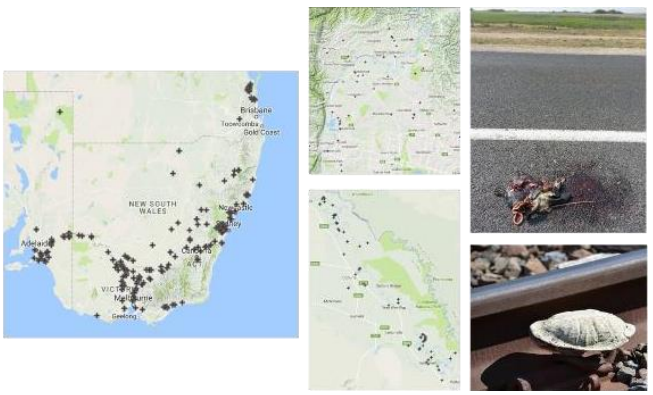


Fig. 3a. Citizen Science data from TurtleSAT showing locations of roadkill Eastern Long Neck Turtles throughout south eastern Australia (since 2015)- From Spencer *et al.* 2017 *Conserv. Biol.*

Fig. 3b. Loss of habitat from urban sprawl puts turtles at risk, but community groups, like Turtle Rescues NSW, Turtles Albury Wondonga and Alexandrina Wildlife, relocate and rehabilitate turtles. Photo Credit: Top- NearMap. Bottom- Turtle Rescues NSW.

Few freshwater turtles are actively managed in Australia. The most prominent example is the Western Swamp Tortoise (*Pseudemydura umbrina*), which is one of Australia's most endangered reptiles (Kuchling 2008). It has the smallest surviving population of any Australian reptile. The Western Swamp Tortoise is listed as endangered under the Environment Protection and Biodiversity Conservation Act 1999. Since 1988, a successful breeding program has allowed translocation of captive-bred juveniles to three sites, and the population has grown from 50 to nearly 200 (Kuchling 2008). Similarly, the Bellinger River Snapping Turtles is now critically endangered under the Environment Protection and Biodiversity Conservation Act 1999. During the disease outbreak with the Bellinger River Snapping Turtle, a rescue team collected 16 healthy adult turtles before the disease reached the upper stretches of the River and these turtles are now part of a breeding program that will hopefully implement a successful headstarting program over the next few years (Spencer et al. 2018a).

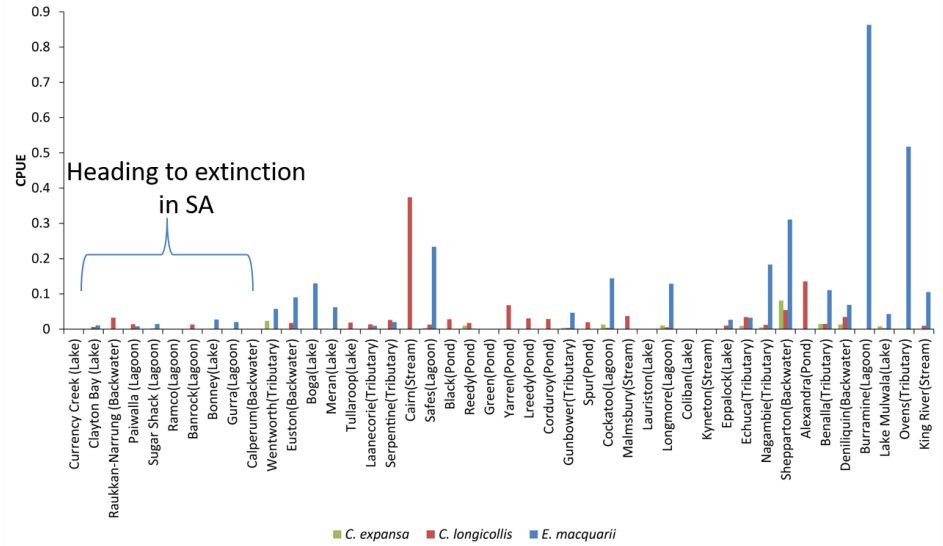


Fig. 4. Catch Per Unit Effort (CPUE) as an index of abundance of all three Murray River species captured in wetlands throughout its entirety. Note the extremely low abundance of species in South Australia. (Fig. 4A; Van Dyke *et al.* 2019. Scientific Reports)

In general, headstarting is seen as a management tool of last resort when species crash and become critically endangered. Captive breeding and headstarting has not been commonly used as a conservation strategy for freshwater turtles in Australia. High perceived financial costs, as well as landscape level disconnectivity among populations, have probably restricted its use, and past population modelling suggests that conservation efforts are more effective when focused on reducing adult mortality (eg. Heppell 1998, Heppell et al. 1996). However, headstarting should be effective for replacing losses of recruitment caused by invasive predators, which is likely the **primary** threat to the turtle species we study (Spencer et al. 2017). Headstarting is often criticized as a strategy for species that have long lifespans, like turtles (Frazer 1992), but in our system, declines will continue as a result of demographic collapse until invasive predators are eradicated and recruitment can recover naturally. Headstarting programs with small captive populations of Galapagos tortoises and Burmese star tortoises have proven successful at restoring population numbers (Jensen et al 2015). Our approach aims to go a step farther and use a comparatively inexpensive *in situ* approach to headstarting that can be applied at the landscape scale to prevent declining species from becoming critically endangered.

SIGNIFICANCE AND INNOVATION

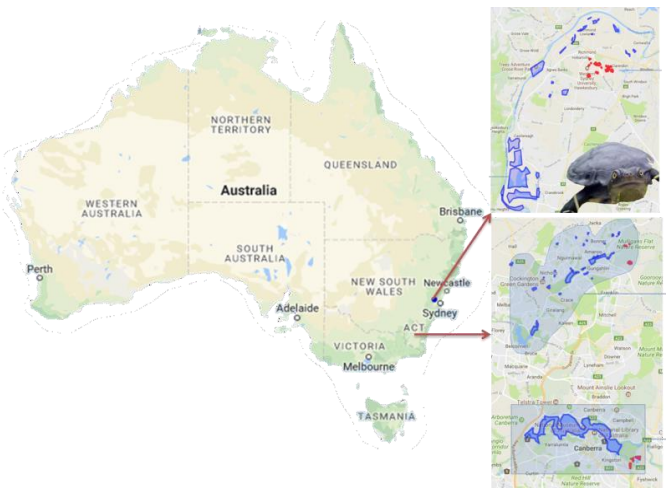
We will create the blueprint for headstarting as an inexpensive landscape-scale approach to conservation. The innovation of our approach is that it is an inexpensive way to manage declining species *before* they become critically endangered. We are proposing a conservation initiative that integrates existing landscape resources with communities. It will be at the forefront of conservation biology and citizen science and the proposed model will not rely on government funding, allowing communities to initiate programs before species become endangered. The **"1 million Turtles"** initiative aims to increase recruitment rates of hatchlings by 1 million turtles each year across south-eastern Australia. Without strategic intervention, most turtles will be extinct by the end of the 21st century. *We will create a conservation network blue-print for managing native species **before** they become endangered. The fundamentals of the program have a strong science background and will be implemented by an educated community within their own communities. The application of newly developed (Spencer et al. 2016, 2017) ecological theory for long-lived organisms to cutting-edge landscape level conservation biology for re-stocking turtle populations throughout south-eastern Australia will address declines that have been occurring since European settlement.*
The impact of the program will be significant, not only for changing attitudes on how and when to manage declining species (ie. before they become endangered), but for modelling how adaptive conservation programs can be integrated into new community and housing developments as cities expand and affect natural resources. In the future, networked conservation zones will need to be as integral to community and developer planning as schools and parklands are.

APPROACH AND TRAINING

We are proposing to develop one of Australia's largest on ground conservation network. The focus will be on creating regional harvest populations for affected species. Many common species of turtle occur in urban and/or agricultural

areas, in integrated constructed wetlands and water treatment plants throughout their range, and these facilities may provide a tool for low cost, *in situ*, headstarting programs. Golf courses, constructed wetlands, urban wetlands, and farm dams are small water bodies that have enormous biodiversity potential. Integrated constructed wetlands (ICWs) are artificial surface-flow wetlands formed by interconnected ponds that mimic natural wetlands in order to integrate water treatment capabilities with ecological functions, such as biodiversity enhancement and carbon sequestration. Creation of ICWs has exploded throughout Europe in the last twenty years, but is becoming more common in new estates and as part of drought mitigation strategies through stormwater capture. The reproductive potential of turtles in constructed wetlands represents a potential pre-existing resource for developing localized headstarting programs *in situ*. Our partners include agencies that manage wetlands in golf courses in Sydney (Oatlands Golf Course), water treatment plants in Albury-Wodonga (North East Water), large commercial stone fruit farms in the Riverina (Tiverton Farm Fund), as well as councils and conservation agencies that manage local native wetlands (Greening Australia and Blue Mountains City Council).

But how do we create a network that will both maximise hatchling turtle recruitment and be community led? There are two aspects to this question. Maximising hatchling turtle recruitment will require testing of broadscale ecological theory around meta-population dynamics of long-lived organisms- ie. Where and when should turtles be released to ensure landscape level population restoration? We will test the meta-population models that we have developed by assessing factors that affect survival and dispersal, and conduct population genetics analyses to compare historical movements of turtles in each region with the movements we observe after release. The research team are world leaders here and have produced a seminal publication in this field (Spencer et al 2017). We developed a simplistic model where relative densities of the "common" Eastern Long Neck Turtle are based on surface area of water and demonstrated that all eggs/hatchlings collected from 1 ha of water can service ~25 ha of water in a region to maintain population growth at pre-European levels and completely eliminate the risk of population extinction (Spencer et al. 2017). Our models also demonstrate that periodic increases in recruitment can sustain populations, potentially allowing populations in a region to be managed in a mosaic fashion (Spencer et al. 2017, Spencer 2018). In other words, not all populations need to be actively managed each year. That is a key to our proposed program; turtle longevity ensures that they are resilient to annual variation in mortality, which provides management with the flexibility to manage populations over wide spatial and temporal scales. A key approach to this project is to produce an easy online tool for communities to manage local populations. The tool will include specific release areas for each community and allow them to visualise the range that their conservation efforts are positively impacting.



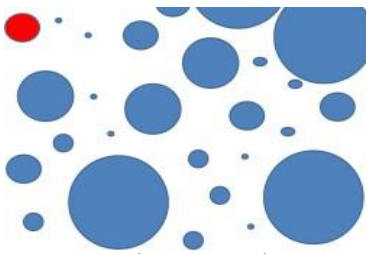


Fig 5. Harvest populations are shown in red and populations serviced by harvested populations are shown in blue. The theoretical diagram to the right is to scale and demonstrates that a 1ha harvest population can service 25ha of neighbouring populations. We then mapped it in practice throughout Western Sydney and the ACT. From Spencer *et al.* 2017 *Conserv. Biol.*

We are currently conducting a pilot study in the ACT. We predict that predator-proofed wetlands at Mulligans Flat Nature Reserve in the ACT can service almost 50% of the remaining ACT wetlands with Eastern Long-Necked Turtle hatchlings every year (Fig. 5). Similarly, wetlands associated with the Sydney Water's water harvesting and recycling scheme in Richmond, Western Sydney, should be sufficient to provide turtles to almost half of Western Sydney's extensive wetland network, which are under threat from urban sprawl and Sydney's second airport at Badgery's Creek (Fig. 5). We also predict that wetlands in Oatlands Golf Course in Sydney can provide enough hatchlings each year to service up to 75% of the Parramatta River catchment. Our partner's commercial farms on the Murray River and in the Riverina are part of the Australia's most extensive irrigation channel network, which will provide a unique opportunity to test their effectiveness as habitat, as well as, providing "super highways" for dispersal.

The second part of the question is based around the practicalities of community led hatchling harvesting for release. We need to create nesting areas where turtles will nest and where hatchlings can be easily collected for release to other areas. What we are creating are *in situ* headstarting programs, where a network of harvest populations are established throughout south-eastern Australia simply by identifying favourable wetlands that either already provide protection from foxes (eg. islands or are already fenced) or can be retrofitted with a range of predator-proof options. Fences are certainly an important tool to predator proof small areas, but in wetlands where fences are not feasible, modular floating islands will create dynamic riparian zones that improve water quality and secure terrestrial predator-free habitat for native species. We will also be working with several of our partners, particularly in urban areas, to revitalise wetlands (eg. golf course water features and water treatment ponds). The revitalising process requires riparian zone modification to (1) slow and clean polluted water and (2) create distinct nesting areas for turtles. We are proposing that through our partner network (Greening Australia, Blue Mountains Council) that have an extensive proven record, to create re-vitalised turtle friendly wetlands through vegetation planting and propagation. Riparian zones containing vegetation that filters water and provides important food and habitat for all trophic levels, set in a way that turtles can only emerge from particular access points. Areas behind this thick vegetation will open into optimal conditions for nesting (Spencer and Thompson 2003) and turtles can be restricted to nest in these areas though inexpensive drift fencing, which we are currently trialling in the ACT. At a landscape level, revitalised wetlands may become designer wetlands that create nurseries for a range of endangered animal species that can be repopulated throughout a region- a hub for conservation programs. Be it revitalised wetlands, or biodiversity islands, the concept is simple: create areas to maximise reproductive potential and survival of species for translocation throughout a region. Our project will serve as a model for similar conservation efforts for other declining species and each site on the landscape may target a different suite of species, but the core values of each revitalisation project are to improve water quality and provide protected habitat for declining species.

Fig. 6. SPEL floating islands. We have been working with the company since 2016 to design islands that will allow wildlife, like turtles to nest in. The islands are modular and can be retro-fitted to any wetland with open water. Habitat can be created to easily harvest hatchlings or nest on the islands. The islands also improve water quality.

Traditional headstarting techniques will be required in many areas. They provide the basis for education and community engagement. *The Australian Reptile Park* near Sydney will conduct the traditional species recovery/headstarting model, whereby the endangered Manning River turtle (*Myuchelys purvisi)* will be bred in captivity through a $120k investment into ponds and egg incubation facilities. Hatchling turtles will be released annually and survival will be monitored and compared to less traditional *ex situ* headstarting programs that we will develop. In North America, The National Aquarium's "Terrapins in the Classroom Program" brings Maryland students face to face with the state reptile, the diamondback terrapin. Hatchling terrapins are collected from Poplar Island and provided to 45 schools for students to observe and study throughout the year (Pfau and Roosenburg 2010). During the turtle's stay, students collect growth data, observe behaviours, learn animal care techniques, and research the natural history of the species. At the end of the school year, students take a field trip to Poplar Island to release the terrapins back into their natural habitat. The combination of scientific applications, hands-on involvement, and the emotional attachment to the terrapins provides an unprecedented opportunity to inspire a meaningful connection with the species and, as students release the terrapins, they begin to understand the direct impact the health of the environment will have on the animal. These activities spark a lifelong sense of environmental stewardship and respect for the natural world. We aim to initiate a similar program in Australia, with a major goal of implementing a conservation program to halt declines of common species. We will create a pioneering headstarting network led by Australian schools. We currently have school partnerships from three states (NSW, SA, VIC). Species local to the region will be the focus and schools will be trained to potentially create breeding programs, incubate and raise turtle eggs at the school and release hatchling turtles back into local environment. Many common species, like Eastern Long Necked Turtles, have declined by up to 91% in the wild (Chessman 2011) but are easily kept as pets that are commonly sold throughout south-eastern Australia. "Turtles in the Classroom" is a joint collaboration between community groups, schools and scientific experts. The "Turtles in the Classroom Network" will bring together world leading scientists, community groups and land managers to help reduce the impacts of invasive species and humans.

CONSERVATION AND ECOLOGICAL CHALLENGES

The extent of this conservation network has not been seen in Australia before, thus there are significant risks that will need to be addressed and tested. It also provides an opportunity to test important conservation and ecological questions and theories that can only be addressed at this scale. The IUCN have identified major risks that need to be addressed for conservation translocations and reintroductions. 1) Risk to source populations; 2) Ecological risk; 3) Disease risk; 4) Associated invasion risk; 5) Gene escape. There are no risks to the source populations in this conservation network. Source populations will see overall reduced mortality and increased recruitment. Ecological risks are minimal as the turtles are being released into their current range. The accidental release of invasive species associated with the turtle release is also minimal. Gene escape or the risk of hybridisation will be minimised by establishing *in situ* harvest populations for nearby translocations, within the home ranges of local turtles. We will also genetically screen source and local populations to minimise risks of hybridisation and genetic pollution. Australian Freshwater Turtle Advisory Group (AFTAG) will oversee species and location selection in the broader conservation program once established.

We will manage biosecurity and disease risk by using Next Gen sequencing to compare pathogens present in our source and release populations. In our *ex-situ* headstarting (eg. Turtles in the Classroom, Reptile Park) programs, strict quarantine procedures will be implemented, but hatchlings will also be screened for pathogens before release. We have designed a modified shipping container, dubbed the "Turtle Pod", for use by schools, where eggs will be incubated and hatchlings kept before release. Fully airconditioned and insulated, Turtle Pods are a low cost solution for our schools that will enable quarantine conditions to be maintained. We currently have approval from the ACT government to translocate turtles. We have also had approval from SA government to release turtles in the wild that were incubated in shipping containers similar to the Turtle Pods. We are currently working with NSW and Victoria for similar approvals. Our *in situ*, local population reintroductions will not increase the risk of novel pathogens being spread in a region, because turtles are currently migrating in and out of these habitats. The risk of zoonotic transfer to humans is low because it is unlikely that the general public will encounter any released hatchlings until they mature and nest on land at ~10 years of age.

The reintroduction of a species into its historic or current range is a critical component of conservation programs designed to restore extirpated or declining metapopulations. However, many reintroduction efforts fail, and the lack of rigorous monitoring programs and statistical models have prevented a general understanding of the factors affecting metapopulation viability following reintroduction. We are providing a template for sustainable continuous efforts of "stocking" to improve success and will employ spatially explicit metapopulation theory as the basis for understanding the dynamics of fragmented populations linked by dispersal, which has rarely been used to guide stocking and reintroduction programs. We will develop a spatial occupancy models that allows for inference about metapopulation extinction risk and connectivity (Chandler 2015). Our network approach in declining, or recently extirpated populations, will generate precise predictions of extinction risk and produce connectivity maps that can guide conservation efforts following reintroduction. This work will be at the forefront of broad-scale conservation biology theory and will demonstrate in practice, how spatio-temporal statistical models based on ecological theory can be applied to forecast the outcomes of conservation actions such as reintroduction- critical for assessing success of any conservation program.

RESEARCH ENVIRONMENT

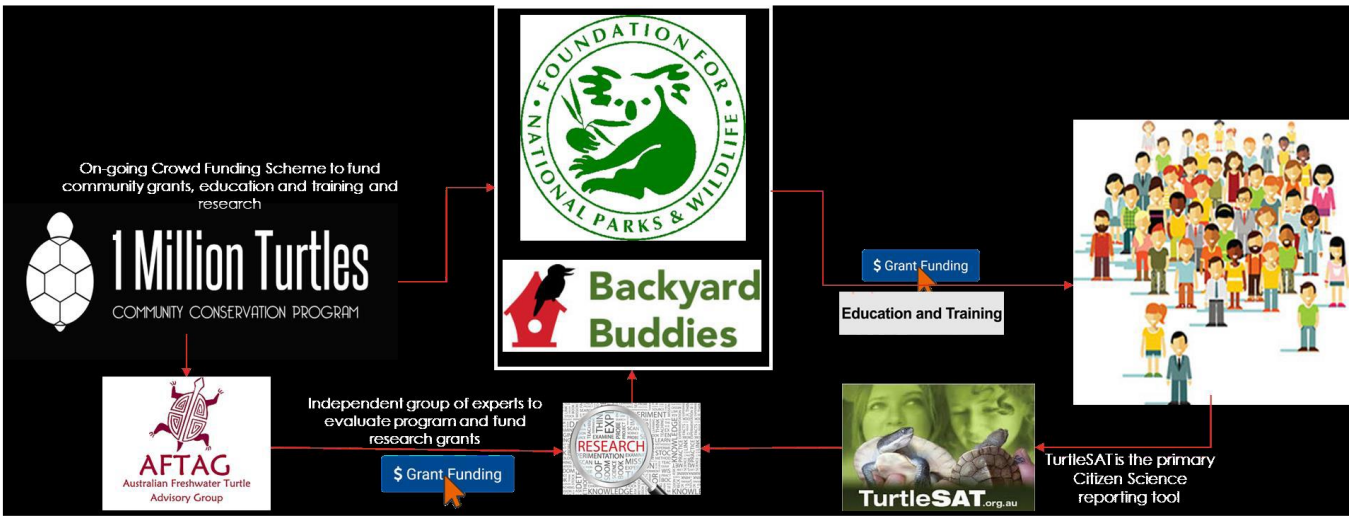
The research environment at the WSU, USYD, UC and LTU are outstanding and the support services are excellent. The long-standing collaborations between **Spencer (CI)**, **Thompson (CI)**, **Georges (CI) and Van Dyke (CI)** provide a firm link between the Universities. Our proposal is an excellent example of a cross-disciplinary collaboration that unites major science disciplines (ecology, physiology, and molecular biology), with local communities and industry. The host university (WSU) has established the Hawkesbury Institute for the Environment (HIE), which is the highest level of recognition of nationally benchmarked research excellence. The physical infrastructure is available for all aspects of this proposal, including the field gear (2 boats, traps), fleet 4WD, and tissue harvesting equipment and molecular sequencing and analyses (WSU, USYD and UCAN). The Hawkesbury campus also hosts the Australian Freshwater Turtle Facility, which includes indoor/glasshouse/outdoor laboratories, turtle housing and egg incubating facilities. Over 20 years ago, WSU and the federal and state governments established a unique large-scale stormwater recycling facility in Richmond, NSW (http://www.uws.edu.au/__data/assets/pdf_file/0020/134903/Water_2003.pdf). Eleven large stormwater ponds are well established at WSU Hawkesbury and this unique facility will allow us to conduct a large-scale translocation experiments under controlled out-door conditions.WSU is committed to this project and will dedicate one APA in 2018 directly to the project. Each university is ERA ranked 5 in one or more of the Fields of

Research codes (0501, 0502, 0602, 0608) associated with this project.

PARTNER ORGANISATION COMMITMENT AND COLLABORATION

This project will pioneer "macro-conservation re-introduction programs" for wide ranging species. It is a joint collaboration between management agencies, community groups, schools and scientific experts to create an outcome driven Citizen Science program throughout Australia. Community groups, like **Turtles Australia** and **Turtle Rescues NSW**, will be enabled in this conservation program model. They will be at the forefront of nest protection hatchling release and Citizen Science. They will also be facilitated to develop new initiatives in their area and grow their own networks. The network partnership is one of the strongest aspects of this proposal. It demonstrates that ongoing broader conservation program will be a success. We have several levels of partnership that are strategically located throughout southern and south-eastern Australia. On-ground partners participating directly in island or wetland revitalization include commercial farms in the upper Murray River and Riverina (**Tiverton Farm Fund and Odonata**), an urban golf course in the Parramatta River Catchment (**Oatlands Golf Course and Our Living River**), and natural wetlands in Gippsland Victoria (**Greening Australia**). **NE Water** will provide significant funding and in kind contributions for revitalizing wetlands at their facilities near Wodonga. Schools that will participate in the Turtles in the Classroom program come from South Australia (**Milang Primary, Cambrai Primary and Morgan Primary** Murray-Darling), NSW (**PLC-** Parramatta River Catchment) and Victoria (**Lilydale High School**). Our partner community groups and management agencies that will contribute significant time to the project include **Turtles Australia and Turtles Albury Wodonga** that will facilitate activities on the Murray-Darling and Victoria, and **Turtle Rescues NSW** and **Our Living River** that will facilitate activities in urban areas of Sydney. **Odonata** will contribute significant in kind contributions to facilitate activities at our working commercial farms on the Murray and Murrumbidgee Rivers. Foundations for National Parks (**FNPW**) will contribute significant cash and in kind for project management and establishing the broader conservation program's fundraising initiatives (**1 Million Turtles**). They will also work closely with **Edge Pledge,** who will contribute cash and time to establish education initiatives with our school partners through the **FNPW Backyard Buddies** program. **The Australian Reptile Park** has a long history in the conservation of Australian animals and will be at the forefront of breeding and headstarting the endangered Manning River Turtle. They will also play a major role in our education programs with our other partners. The research team will also contribute significant time to the project.

The **1 Million Turtles** Conservation program will be established in parallel to this project, the science developed from this ARC Linkage Project will provide the program's foundations. So how will the **1 Million Turtles** program work? Our partner, *Foundations for National Parks and Wildlife (FNPW)* will manage the broader conservation initiative. The proposed funding model is via crowd funding and industry, which will provide grants for community conservation programs. FNPW have a proven record in this area. The Australian Freshwater Turtle Advisory Group (AFTAG) consists of an expert panel of turtle biologists and ecologists, members of the community and relevant government agencies that will develop the master plan and ensure that best management practices are adopted and implemented. AFTAG will direct funding into ongoing research and development. Education is also a major focus of the project and AFTAG will work directly with the FNPW Backyard Buddies program, as well as our other partner Edge Pledge. TurtleSAT- a world leading turtle Citizen Science program developed by the team in 2015, will lead the Citizen Science education, community data collection and feedback component of the model. The major focus of this current Linkage Grant proposal is to conduct and establish the science behind the program. The research team has identified the extent of the turtle declines throughout south-eastern Australia (Van Dyke et al. 2019), the failings of current management practices (Spencer et al. 2016) and what is required to halt turtle extinctions (Spencer et al. 2017). The next phase is to do what no other conservation program in the world has ever done and this requires bold initiatives backed by solid science. There is a common benefit and outcome for all of our partner organisations: Restocking of native species, on-going funding opportunities within a conservation network and improved natural and community engagement. Our partner organisations have responsibilities to both manage invasive pests and conserve endangered native animals and their habitats. Beyond our partners, the outcomes from this project are significant to agencies that are mandated to maintain the health and biodiversity of river systems throughout south-eastern Australia, including the River Murray (e.g. Murray Darling Basin Authority).



ROLE OF PERSONNEL

Spencer (WSU) will contribute 0.3FTE to project management, staff and student supervision, national community group coordination and Citizen Science initiatives through TurtleSAT. Thompson (**USyd**) will contribute 0.1FTE to community engagement, student supervision and "Turtles in the Schools" program management. Van Dyke (**La Trobe**) will contribute 0.2FTE for student supervision and upper Murray and Riverina on ground project management. Georges (**UCan**) and Holmes (**USyd**) will contribute 0.1FTE for student supervision and population genetics and biosecurity disease screening. Professor Willem Roosenburg (Ohio U) runs the "Terrapins in the Classroom" programs in the USA will be an advisor to the Turtles in the Classroom program. Dr Bruno Ferronato with be the post-doc on the program and will dedicate 1.0FTE to the on-ground projects related to island and wetland re-vitalisation aspects of the project, as well as, develop and prepare all state permit and ACEC applications, which will be a critical aspect of project development.

[Partner Organisation official letterhead]

Director Linkage Program

Australian Research Council

[Date]

Dear Sir/Madam,

Re: Letter of support for **ARC Linkage Project ID: LP190100593 Project Title: "1 million Turtles" Community Conservation Program: Preventing the Extinction of Australian Freshwater Turtles**

(Letter to be no more than 2 A4 pages in length; if the PO is not providing cash, then the cash certification wording below is not required)

<A paragraph or two on a profile of the Partner Organisation and their business>

<Details regarding how the Project aligns with the Partner Organisation's objectives>

< Partner Organisation's expectations about industry outcomes, products and/or market value relevant)>

<Details of the amount of cash and/or in-kind support that will be provided, including (if decided) the details of how these contributions might be allocated (eg PhD stipend, research assistance) and indicate the source of the Cash Contribution, eg. operating funds. Ensure it is clear whether the amounts listed are 'per annum for x years' or 'in total.'>

Total In-Kind Contribution ($)	**Total Cash Contribution ($)**	**Source of Cash Contribution**
$	$	Cash contribution will be sourced from …

(DO NOT alter or delete the following two paragraphs – they are MANDATORY

"I certify that no part of [Partner Organisation name]'s Cash Contribution is drawn from funds previously appropriated or awarded from Commonwealth or Australian State or Territory sources for the purposes of research." [This certification is not required if a Cash Contribution is not being made].

"I certify that [Partner Organisation name] will meet the requirements outlined in a standard ARC Funding Agreement, including the requirement to enter into arrangements regarding Intellectual Property which do not unreasonably prevent or delay academic outputs."

Yours sincerely,

<SIGNATURE of CEO / Managing Director/ Head of Organisation / Delegated Officer>