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Conservation Strategy for the Singapore Freshwater Crab *Johora Singaporensis*

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Conservation Strategy for the

Singapore freshwater crab

Johora singaporensis



Freshwater Crab
Conservation Roundtable



Affiliated organisations



Wildlife Reserves Singapore Group



Note: The conservation strategy is based solely on the opinions of the authors and do not constitute a statement of policy, decision, or position on behalf of the participating organizations.

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1. STATUS REVIEW

1.1 Background

The Singapore freshwater crab *Johora singaporensis* Ng, 1986 (Crustacea: Potamidae) is one of a few species that are truly endemic to Singapore, a small equatorial island that is separated from Peninsular Malaysia by a narrow marine channel (the Straits of Johor). This species was recently listed among the world's 100 most threatened species because previous conservation assessments of this species by the IUCN Red List and by the Singapore Red Data Book classified it as 'Critically Endangered' and 'Endangered', respectively. This primarily aquatic species can be easily distinguished from the other freshwater crabs in Singapore by its typical light and dark banding patterns on its walking legs and by the fields of short hair-like setae covering its body and legs (Fig. 1). Although this species can be an icon of Singapore's national and natural heritage, relatively little is known about its ecology. Furthermore, despite the highly threatened status of *Johora singaporensis* until now, there has been no formal specific conservation action plan, although there is ongoing collaborative ecological and conservation research between National Parks Board of Singapore, National University of Singapore, and Wildlife Reserves Singapore.

1.2 Species' functions & value

Johora singaporensis is a macroinvertebrate that performs an important role in tropical hill stream food webs and nutrient recycling. The species is omnivorous and feeds on both plant and animal material, sometimes scavenging and other times opportunistically preying on small animals. *Johora singaporensis* in turn also serves as prey for other larger organisms and is a host for parasitic leeches. This crab belongs to the group of detritus-feeding animals. It breaks down leaf litter which contributes greatly to nutrient recycling in the aquatic ecosystem.

Johora singaporensis is a unique species found only in Singapore, and as such it is of national significance, featuring widely in the media and on this country's postage stamps. The fact that this species is named after Singapore underlines the fact that our nation should take a leading role in safeguarding this critically endangered species from extinction.



Fig. 1. Frontal view of the Singapore freshwater crab, *Johora singaporensis*. | Photograph © 2013 Daniel Ng Jia Jun

1.3 Historical account

Earlier published names for *Johora singaporensis* include *Potamon (Potamon) johorensis*, *Potamon johorensis*, *Potamiscus (Johora) johorensis* and *Stoliczia (Johora) johorensis*] but it took until 1986 for it to be recognised as a valid species and given a stable genus and species name by Dr. Peter K. L. Ng (National University of Singapore). Although it is not possible to determine with 100% certainty the historical distribution of *Johora singaporensis*, given its affinity for the island's remaining aquatic ecosystems on slopes on higher ground, this species was most likely present throughout Singapore's hill streams. However, not much of Singapore is hilly, and much of this habitat has been lost or has undergone drastic modification or disturbance. Urbanization over the past century has reduced the present distribution of *Johora singaporensis* to what is likely to be only a fraction of its historical range. Currently this species is only known from a few hill streams in the vicinity of Bukit Timah, Bukit Batok and Bukit Gombak.

The highly threatened status of this species has only been appreciated since 2008 when a study found that it had disappeared from its type locality in Jungle Fall Valley in Bukit Timah Nature Reserve, possibly due to stream acidification. Fortunately, a small population was subsequently discovered in another part of the Bukit Timah Nature Reserve. However, the stability of its habitat in this part of its range is unknown and its long-term survival here is far from certain, even within a protected area. Sharp declines have been observed in some of the populations of *Johora singaporensis*. Amongst the range of potential causes are the temporary drying up of stream flow, changes in water quality, particularly increased acidification, and human activities. The underlying causes are known for some effects, but not for others. Therefore the conservation status of *Johora singaporensis* was assessed as "critically endangered" by the IUCN, meaning that this is a species with a very high risk of extinction.



An example of a hill stream habitat in Singapore.

| Photograph © 2013 Daniel Ng Jia Jun

1.4 Current distribution

Johora singaporensis is only known from Singapore (Fig. 2). Extensive surveys of all localities where this species is expected to occur detected the presence of crab populations in one stream in Bukit Timah Nature Reserve, in one stream in Bukit Batok, and in two streams in Bukit Gombak. However, *Johora singaporensis* was not detected at its type locality in Jungle Fall Valley in Bukit Timah Nature Reserve where it is now believed to be extirpated. Because crab populations in each of these hill streams are separated from each other, the species currently exists in four isolated localities. The current Extent of Occurrence of this species is estimated to be approximately 3 km², and its Area of Occupancy is estimated to be 0.003 km².

1.5 Demographic analysis

Accurate population estimates based on mark-recapture studies are unavailable but it can be conservatively estimated based on extrapolation from samples caught during surveys that there are only a few hundred mature individuals remaining in the wild. The estimated population density of *Johora singaporensis* ranged from 1 to 33 individuals/m² during our surveys, size groups in a population were mostly juvenile and sub-adult individuals and there was a male to female ratio of 1:1. Mortality and reproductive data are unavailable.

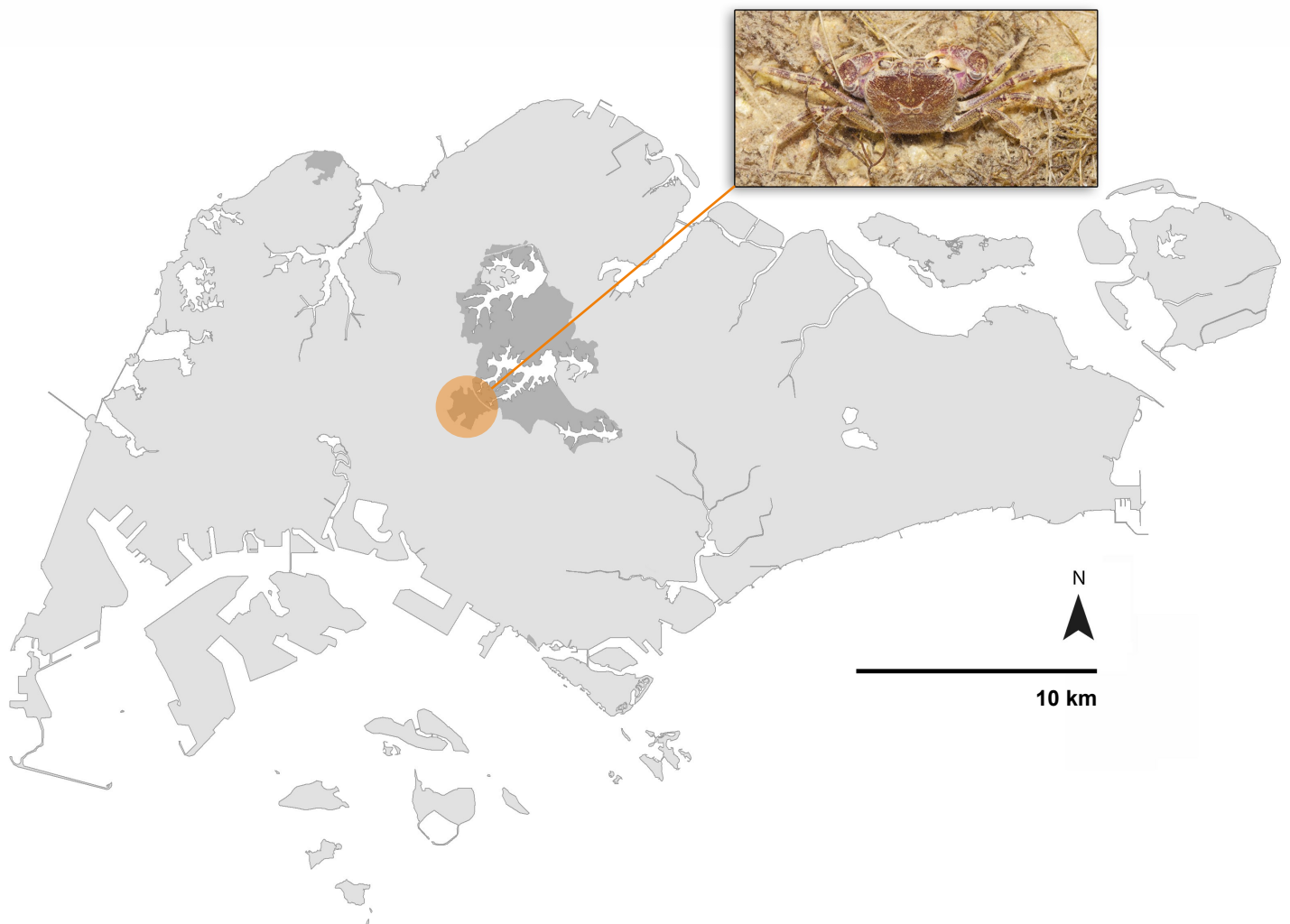


Fig. 2. Distribution of *Johora singaporensis* in Singapore (exact locations not marked). The nature reserves (protected areas) are shaded in a darker grey. | Basemap provided by Teo Siyang, used with permission and IUCN & UNEP-WCMC (2015).

1.6 Habitat & resource assessment

Johora singaporensis has a very narrow habitat range of flowing, unpolluted waters that are highly oxygenated, and have a pH between 6–8. The species favours streams with numerous rocks and boulders amongst the substrate, underneath which the crabs seek shelter and protection.

The species does not appear to have strict dietary requirements as it has been observed to feed on living or dead plant and animal materials.



Johora singaporensis consuming a mole cricket (Orthoptera: Gryllotalpidae).

| Photograph © 2013 Daniel Ng Jia Jun

1.7 Conservation & management

Monitoring

Regular monitoring of the different populations has been initiated to detect potential threats with a view to identifying control measures.

Research

The current distribution is based on regular surveys of the hill streams where this species is found.

Captive breeding

A preliminary breeding programme has recently been initiated to breed this species.

2. CONSERVATION STRATEGY

2.1 Vision

The Singapore freshwater crab will become a living ambassador for freshwater conservation into perpetuity. Wild populations in their natural range will be resilient to the threats they face, and the species will no longer be critically endangered. The innovative conservation efforts implemented will serve as an inspiring national and global model.

2.2 Goals

The Goals state in practical terms what is needed to achieve the Vision. Two Goals were agreed for Singapore freshwater crab, one concerned with identifying and securing the best available sites for action and the other ensuring that such sites are managed well. These were:

Goal A: The Singapore freshwater crab will continue to be found in the hill stream ecosystems of Singapore well into the future.

Goal B: The Singapore freshwater crab will become a symbol of national pride for all Singaporeans and will be an ambassador for the management of the country's freshwater habitats.

2.3 Objectives & actions

The objectives outline how the Vision and Goals will be turned into reality. They were identified through a problem analysis. The actions then describe the discrete activities to be undertaken to achieve each Objective.

2.3.1 Problem analysis

The analysis that we conducted was designed to assess the key threats to *Johora singaporensis* and the major constraints on overcoming these threats (Fig. 3). Given the limited knowledge of this species and limited resources for conservation there is a need to identify the major threats to *Johora singaporensis* and the constraints that limit responses to address these threats.

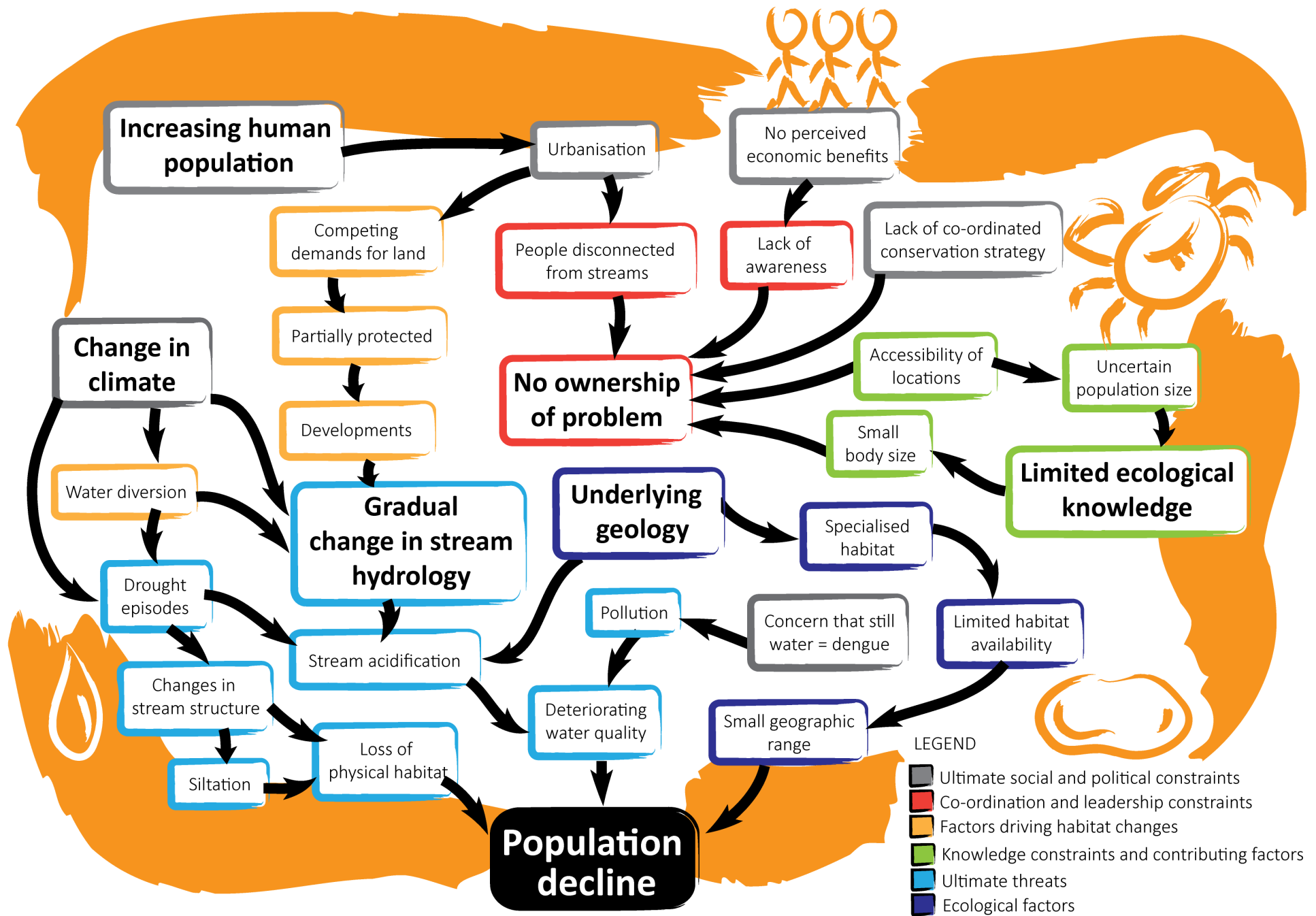
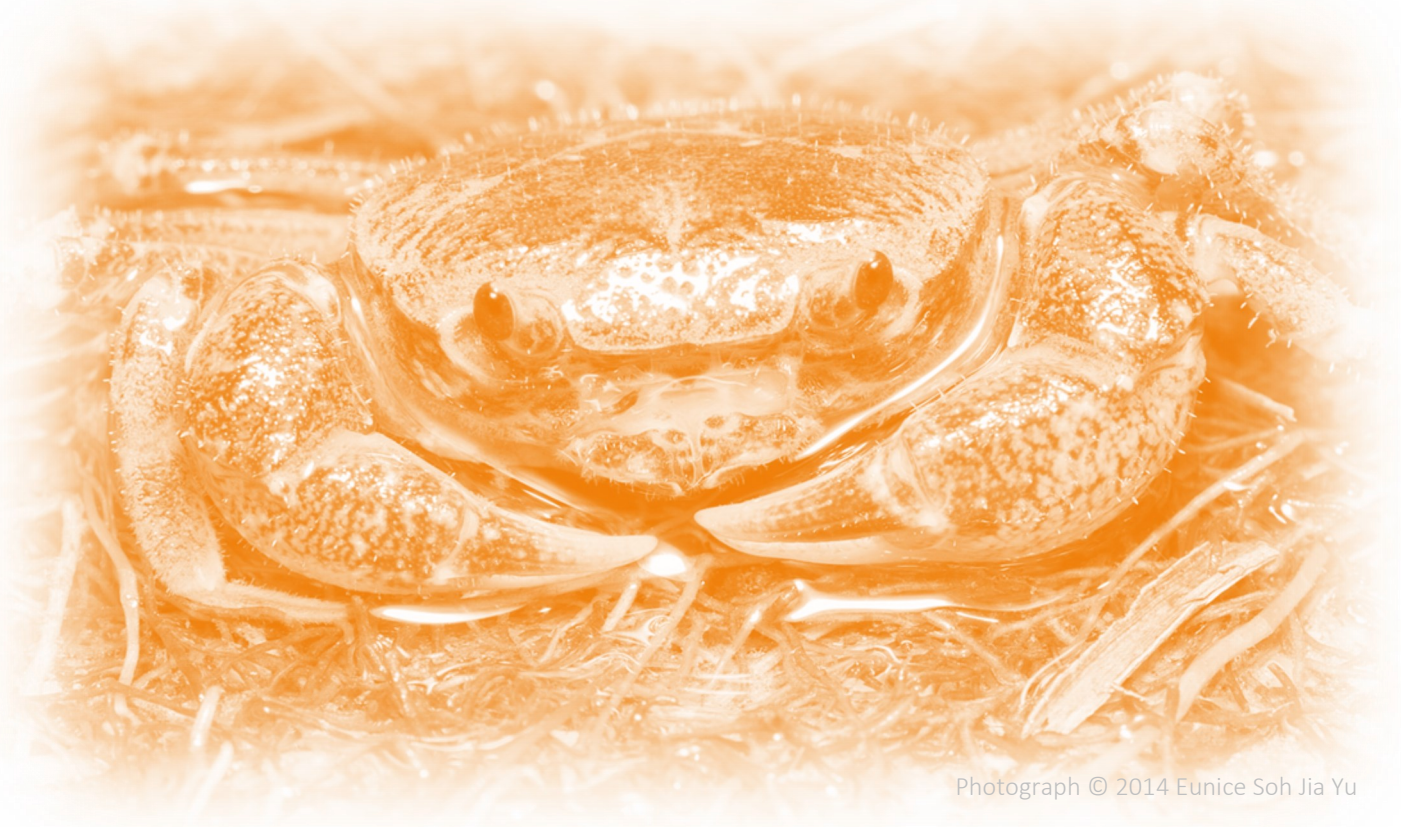


Fig. 3. Problem analysis showing the threats facing the Singapore freshwater crab and the constraints that limit responses to address them. The decline of the species in its small geographic range is acknowledged as the immediate problem.



Photograph © 2014 Eunice Soh Jia Yu

Goal A: The Singapore freshwater crab will continue to be found in the hill stream ecosystems of Singapore well into the future.

Objectives that will make this happen are:

Objective 1: To provide the scientific knowledge necessary to both inform management of the Singapore freshwater crab and to monitor changes in its population and habitat as a result of management.

Despite recent advances in our knowledge of the biology of *Johora singaporensis*, our knowledge of its ecology is still limited, especially at the level necessary to inform management. The complexity of the ecology of hill streams, and the impact of the pressures suspected of driving the population declines in this species, require an understanding of a range of ecological characteristics so that future trends can be predicted, both in the absence of any active management and also under a range of management scenarios. This knowledge will allow assessments of population status to be made with greater accuracy, and allow management decisions to be made with greater confidence.

Objective 2: To promote management that will stabilise population levels and then lead to an increase in crab numbers and distribution.

The sites where the species is known to occur, and those where it is either suspected to occur or which may prove suitable for translocation, are either deteriorating in quality or are already at risk. Each site, therefore, will require management to ensure that it remains suitable for the species in the medium to long-term.

2.3.2 Actions for Goal A, Objective 1

Objective 1: To provide the scientific knowledge necessary to both inform management of the Singapore freshwater crab and monitor changes in the population and habitat as a result of management.

Action 1.1: Understanding the habitat and range of *Johora singaporensis*.

This research objective has several related components, all to be achieved within 24 months.

- a) Determination of the optimal abiotic habitat requirements (e.g., temperature, oxygen levels, pH levels, etc.) and the optimal biotic habitat parameters (e.g., description of the ecological communities in the streams and the interactions between crabs and key species). This will be achieved by environmental niche modelling and by ground surveys. The optimal levels and limits of these key parameters will then be determined through manipulation.
- b) Determination of the Extent of Occurrence and the Area of Occupancy (current + potential) of this species through surveys of streams that record the presence/absence of crabs.
- c) Identification of potentially suitable streams beyond the current Extent of Occurrence that might be rendered suitable for the support of additional populations of *Johora singaporensis*, and the measures required to do so.

Action 1.2: Understanding the demographics and genetics of *Johora singaporensis*.

This research objective has several related components, including:

- a) Monitoring of trends in population size and structure including seasonality and recruitment. Protocols will be developed and implemented within 12 months.
- b) Determination of the minimum viable population (MVP) to inform management, and the possible supplementation of existing and/or new populations. The MVP model will be developed, data on key threats will be collected, and the MVP model will be refined within 12 months.
- c) Understanding and maintaining, or if possible increasing, the genetic diversity of populations. A population genetic study of *Johora singaporensis* will be conducted within 12 months.
- d) Understanding the life history of *Johora singaporensis*. A study of the life history patterns and population dynamics will be conducted within two years.



2.3.2 Actions for Goal A, Objective 2

Objective 2: To promote management that will stabilise population levels and then lead to an increase in crab numbers and distribution.

Action 2.1: Develop site-specific management plans for each location where the species currently occurs and for each potential reintroduction site.

Each site where the species is found has different characteristics (setting, threats, and ownership) and will require site-specific management. Management prescriptions will need to be tailored to each site and then implemented with appropriate local stakeholders. The management prescriptions should draw on knowledge generated from Objective 1.

Action 2.2: Establish a healthy breeding population in captivity to act as a source for the introduction/ re-introduction of healthy individuals into suitable habitats to complement the in-situ strategies.

A captive population can also contribute to Action 1.2 under Goal B. A workplan for the establishment of a captive breeding programme will be developed. The plan will include: (1) the source of founder stock based on numbers in the wild and their population characteristics; (2) the establishment of multiple breeding facilities; (3) the development of husbandry protocols and securing of sufficient resources; and (4) the identification of appropriate success indicators for captive management—such as survival rate to breeding size. The workplan will be completed and then initiated by the middle of 2016. The husbandry protocol will continue to be refined through knowledge gained during successful keeping and breeding of the species.





Goal B: The Singapore freshwater crab will become a symbol of national pride for all Singaporeans and will be an ambassador for the management of the country's freshwater habitats.

Objectives that will make this happen are:

Objective 1: All key groups of Singaporeans will become aware and proud of the species and of the importance of its ecosystem.

Although there is an important message to be conveyed that this critically endangered species is found only in Singapore, the message is likely to have a greater impact if it is set in the context of Singapore's hill streams, which support a near-natural aquatic faunal community, provide ecosystem services such as assisting in nutrient cycling and are under very heavy pressure from development. The Singapore freshwater crab will be used to promote ecosystem awareness and to promote action by particular stakeholder groups.

Objective 2: Provide co-ordination and focus to all conservation efforts.

There is an urgent need to share knowledge and co-ordinate research, management and outreach efforts amongst all of those parties who can either have an impact on the species and its habitat or who may be affected by the implementation of this strategy.

2.3.4 Actions for Goal B, Objective 1

Objective 1: All key groups of Singaporeans will become aware and proud of the species and of the importance of its ecosystem.

Action 1.1: Develop multi-stakeholder specific conservation communications and messaging that highlights the unique characteristics of this freshwater crab, evokes national pride and awareness of the ecosystem and its ecosystem services, and stimulates conservation action. The first step will be to identify all stakeholders and understand ways to engage them in freshwater crab and ecosystem conservation. Once the messages to be conveyed are determined, there will be a need to customise delivery (episodic & extended) to each stakeholder group. Specific activities may include the development of a number of freshwater ecosystem kiosks across the island.

Action 1.2: Establish a healthy breeding population and develop a captive display of *J. singaporensis* that engages the public's attention and connects, inspires, and educates the public about freshwater crabs. The specific activities for the establishment of a captive population are given under Goal A, Objective 2, Action 2.2 above.



A mating pair of *Johora singaporensis*.
| Photograph © 2014 Daniel Ng Jia Jun

2.3.5 Actions for Goal B, Objective 2

Objective 2: Provide co-ordination and focus to all conservation efforts.

Action 2.1: Establish a Working Group chaired by the Singapore National Parks Board, the country's statutory conservation body. The Working Group will keep all relevant partners informed and encourage the sharing of relevant information on research and management of the crab. The Working Group will promote the implementation of the Conservation Strategy and monitor its implementation. It will evaluate progress after 3 to 5 years.

Action 2.2: Establish an electronic repository of communication material to support conservation activities. It will be important to have easy access to knowledge that will allow rapid communication if needed or for the development of communication to support awareness-raising and education activities.

The primary purpose of the strategic planning process was to build a consensus that action is needed and to identify what should be done. The Working Group (see Page 12) will seek to develop an implementation plan that will include appropriate detail for the actions identified so that they are, for example, measurable and timebound.

3. THE WORKING GROUP

A working group to implement the Singapore Freshwater Crab Conservation strategy has been formed. The group has representatives from the National Parks Board (NParks), National University of Singapore (NUS) and Wildlife Reserves Singapore (WRS). All other stakeholders and participants of the Freshwater Crab Conservation Roundtable are consulted and updated on a regular basis. The working group is active in following up on various actions arising from recommendations of this strategy plan. The working group meets on a quarterly basis for 2014 and 2015, following which on a half yearly basis for the consequent years.



Participants of the Freshwater Crab Conservation Roundtable in March 2014.
| Photograph © 2014 Tan Heok Hui

Appendix 1. Summary table of Vision, Goals, Objectives & Actions of the Singapore freshwater crab conservation strategy

Vision	The Singapore freshwater crab will become a living ambassador for freshwater conservation into perpetuity. Wild populations in their natural range will be resilient to the threats they face, and the species will no longer be critically endangered. The innovative conservation efforts implemented will serve as an inspiring national and global model.	
Goals	A: The Singapore freshwater crab will continue to be found in the hill stream ecosystems of Singapore well into the future.	B: The Singapore freshwater crab will become a symbol of national pride for all Singaporeans and will be an ambassador for the management of the country's freshwater habitats.
Objectives	<p>1: To provide the scientific knowledge necessary to both inform management of the Singapore freshwater crab and to monitor changes in the population and habitat as a result of management.</p> <p>2: To promote management that will stabilise population levels and lead to an increase in crab numbers and distribution.</p>	<p>1: To make all key groups of Singaporeans aware and proud of the species and of the importance of its ecosystem.</p> <p>2: To provide co-ordination and focus to all conservation efforts.</p>
Actions	<p>1.1: Understand <i>Johora singaporensis</i> habitat and range.</p> <p>1.2: Understand <i>Johora singaporensis</i> demographics and genetics.</p> <p>2.1: Develop site-specific management plans for each location where the species currently occurs and for each potential re-introduction site as it is/ they are identified.</p> <p>2.2: Establish a healthy breeding population in captivity to act as a source for the introduction/ re-introduction of healthy individuals into suitable habitats to complement the in-situ strategies.</p>	<p>1.1: Develop multi-stakeholder specific conservation messaging that highlights the unique characteristics of this freshwater crab, evokes national pride and ecosystem awareness, and stimulates conservation action.</p> <p>1.2: Establish a healthy breeding population and develop a captive display that captures the public's attention and connects, inspires, and educates the public about freshwater crabs.</p> <p>2.1: Establish a Working Group chaired by the National Parks Board of Singapore.</p> <p>2.2: Establish an electronic repository of communication material to support conservation activities.</p>

Appendix 2. List of participants, Singapore Freshwater Crab Conservation Roundtable



Name	Organisation	Name	Organisation
Bernard Ng	URA	Matthew Linkie	FFI
Brian Ng	SLA	Monika Rademacher	Panzerwelten
Cai Yixiong	NParks	Nathanaël Maury	Reptile Farm
Cheryl Chia	NParks	Neil Cumberlidge	IUCN
Daniel Ng Jia Jun	NUS	Neoh Mei Wei	NEA
Darren Yeo Chong Jinn	NUS	Ng Boon Hong	NUS
Dheva Seelan	Mindef	Nikki Ye	PUB
Frances Warren	WRS	Oliver Mengedoht	Panzerwelten
Geoffrey Davison	NParks	Paige Lee Bi Qi	WRS
Hon Yein Chow	WRS	Peter Ng Kee Lin	NUS
Huang Junjie	URA	Philip McGowan	IUCN
Idris Jani	NEA	Razak Jaffar	WRS
James Gan	NParks	Roopali Raghavan	WRS
Jason Tan	NEA	Sim Yueh Bing	URA
Jayce Chua	WRS	Sivasothi N.	NUS
Jeanne McKay	DICE	Sonja Luz	WRS
John Sha	WRS	Tan Heok Hui	NUS
Kenny Chua Wei Jie	NUS	Vanessa Lee Hsiang Ling	WRS
Lena Chan	NParks	Vinayagan Dharmarajah	NSS
Li Tianjiao	NParks	Wang Nan	BFU
Lim Wei Hao	NParks	Yaoprapa Mathura	WRS
Linda Goh	NParks	Yeo Suay Hwee	NSS
Low E Wen	PUB	Yong Bi Wen	URA

Abbreviations:

BFU – Beijing Forestry University, DICE – Durrell Institute of Conservation and Ecology, FFI – Flora & Fauna International, IUCN – International Union for Conservation of Nature, Mindef – Ministry of Defence, NEA – National Environmental Agency, NParks – National Parks Board, NUS – National University of Singapore, NSS – Nature Society (Singapore), PUB – Public Utilities Board, SLA – Singapore Land Authority, URA – Urban Redevelopment Authority, WRS – Wildlife Reserves Singapore

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