Biological Control of Invasive Aquatic Plants

RINSE Best Practice Workshop, 17th October 2013, Norwich

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www.cabi.org

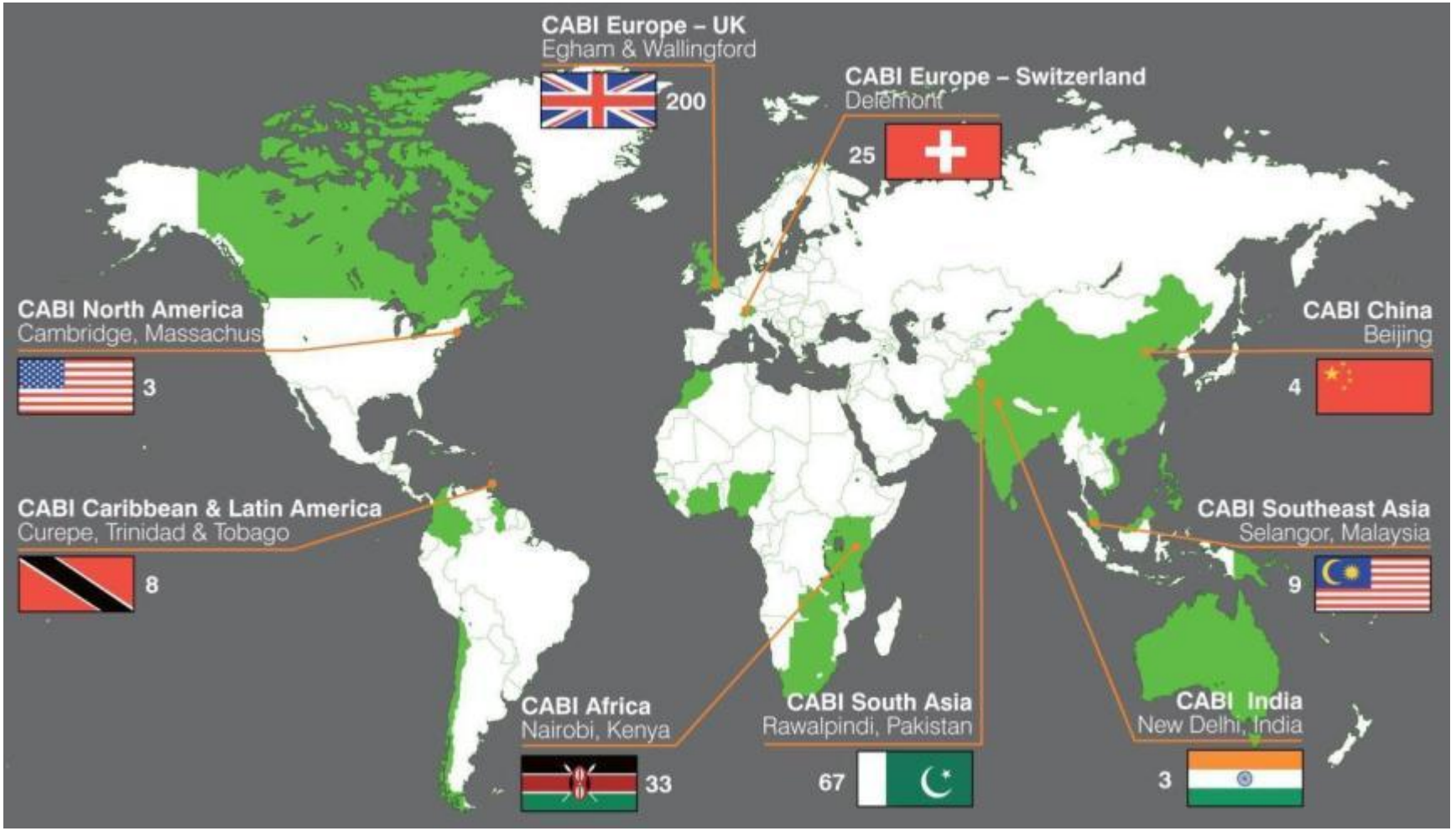
KNOWLEDGE FOR LIFE

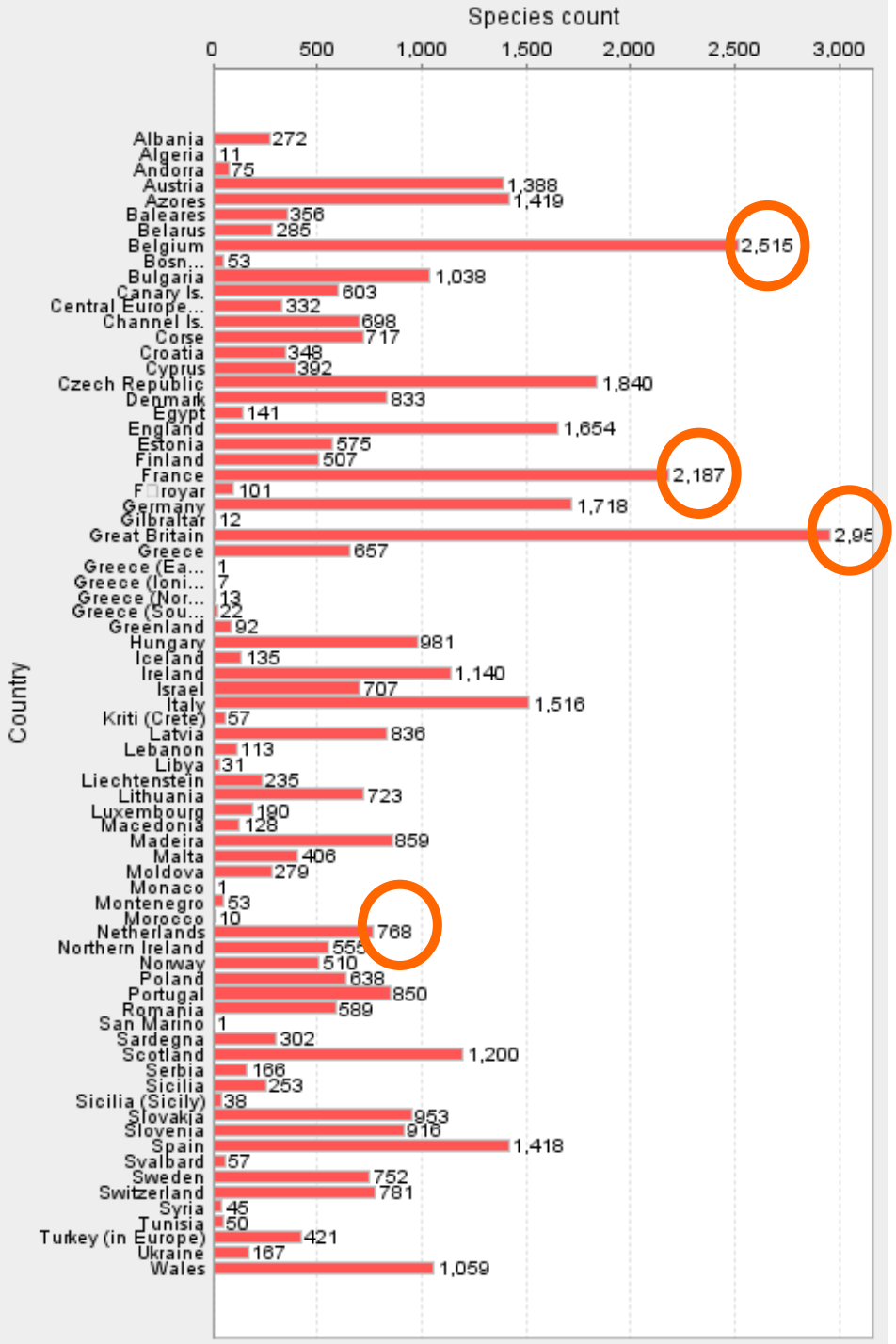
CABI in brief

- Established in **1910**
- **Not-for-profit**
- Owned by **48 member countries**
- CABI provides scientific expertise and information about agriculture and the environment
- Activities include scientific publishing, development projects and research, and microbial services

Global reach for a global problem

- 9 Centres
- 350+ staff
- 48 Member countries





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Invasive Species in Europe

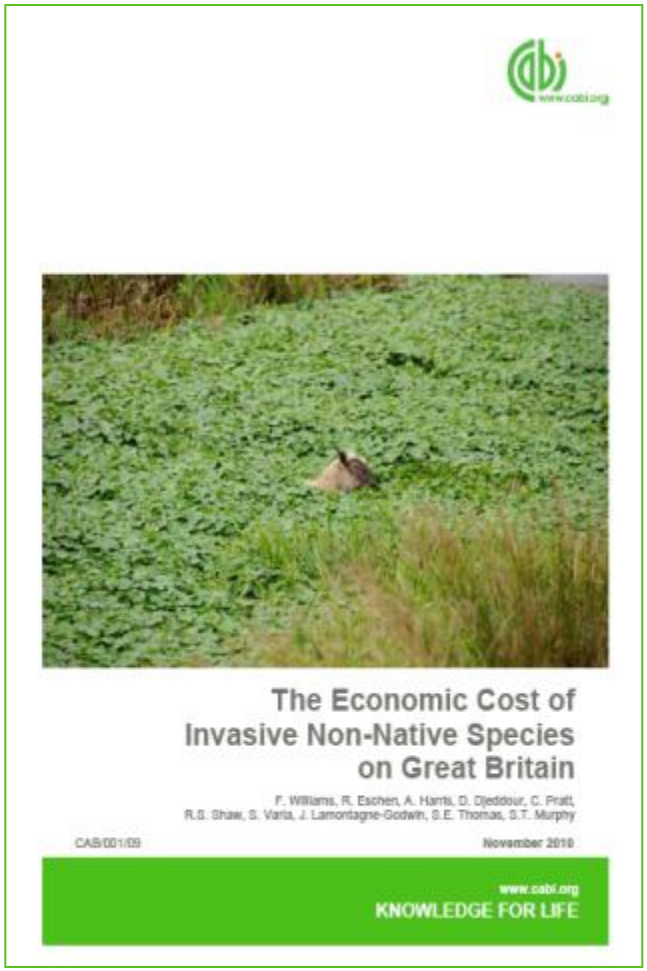
GB = nearly 3000

BE = ~2500

FR = ~2200

NL = ~770

Economic assessment for GB



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£1.7bn to save wildlife from the alien invaders: Battle to protect species from Japanese knotweed, American grey squirrels and Russian zebra mussels

- It would cost every Brit £25 each to save our wildlife from foreign 'killers'
- BBC1's Countryfile revealed American mink and crayfish are also culprits
- The government spent £70m removing knotweed from the Olympic Park

By DAILY MAIL REPORTER

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The battle to stop foreign invaders killing off native British wildlife is costing £1.7billion a year.

Among the biggest culprits are Japanese knotweed, American grey squirrels, Russian zebra mussels and Eastern European 'killer' shrimp.

BBC research revealed that the total bill for defending British animals and plants from the 'alien' invasion costs £1.7billion a year – or more than £25 for every person in the country.

Only humans do more harm to native biodiversity than foreign species.

Water Hyacinth in the Guadiana river, Spain

€23 million

Floating pennywort in Holly Bank Basin, Staffordshire, UK

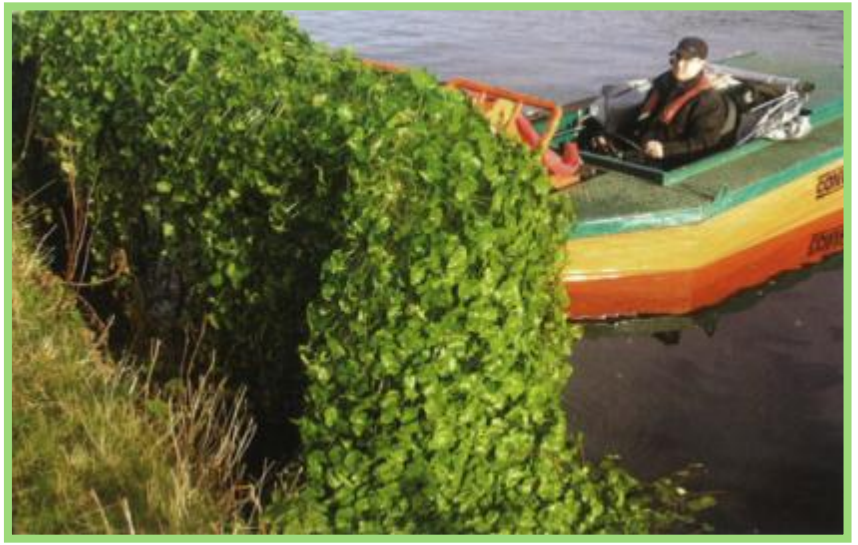
£1800-£2000/km

Photo: T. Renals, Environment Agency

Photo: Langham Pond (SSSI), Surrey. Corin Pratt

Manual Control

Photo: Airthrey Loch, Stirling. Scottish Government



Recent legislation

BANNED from sale in the UK (from April 2014):

1. Water fern (*Azolla filiculoides*)
2. Parrot's feather (*Myriophyllum aquaticum*)
3. Floating pennywort (*Hydrocotyle ranunculoides*)
4. Water primrose (*Ludwigia* spp.)
5. Australian swamp stonecrop (*Crassula helmsii*)

Aquatic ecosystems

- Are vulnerable and biodiverse
- More easily invaded
- Herbicide use is increasingly unacceptable in waterbodies
- **Water Framework Directive** – The presence of an invasive non-native species on or in a waterbody should seriously threaten “Good ecological status”
- Great targets for biocontrol

Regulatory Drivers for Biocontrol

Instrument	Classical Biological Control
Sustainable Use Directive promotes alternative approaches or techniques such as non-chemical alternatives to pesticides.	Provides a non-chemical tool which can often be integrated with traditional chemical treatments
Water Framework Directive requires all water bodies to reach good ecological status	In or beside water, where chemical use is restricted, biocontrol can provide the means to manage IAS that are impacting on status
Invasive Species Directive 2014 will aim to regulate the prevention and management of the introduction and spread of IAS	Specifically mentions classical biocontrol as a tool for management. Invasions previously considered unmanageable and effectively ignored will be back on the radar

Unfair advantage

Impatiens glandulifera in the native range the foothills of the Himalayas Pakistan

- Non-native plant species arrived in the exotic range without the natural enemies that keep them in check in their native range
- Those species native to the introduced range which do attack them do not cause enough damage
- Some of the many insects and diseases in the native range may be safely released as biological control agents

The Enemy Release Hypothesis

Listronotus elongatus feeding on Floating pennywort (*Hydrocotyle ranunculoides*) in the native range (Argentina)

In their introduced range exotic plants should experience

‘ a decrease in regulation by herbivores and other natural enemies, resulting in an increase in distribution and abundance’

(Keane and Crawley, 2002)

Evolution of Increased Competitive Ability Hypothesis

Impatiens glandulifera
monoculture on the river Torridge
North Devon

‘The success of invasive plants results from a shift in biomass allocation patterns. In the absence of herbivores and plant pathogens, selection favors genotypes with improved competitive abilities and reduced resource allocations to natural enemy defence.’

(Blossey and Nőtzold 1995)

Biological control

Two *Listronotus elongatus* weevils on Floating pennywort

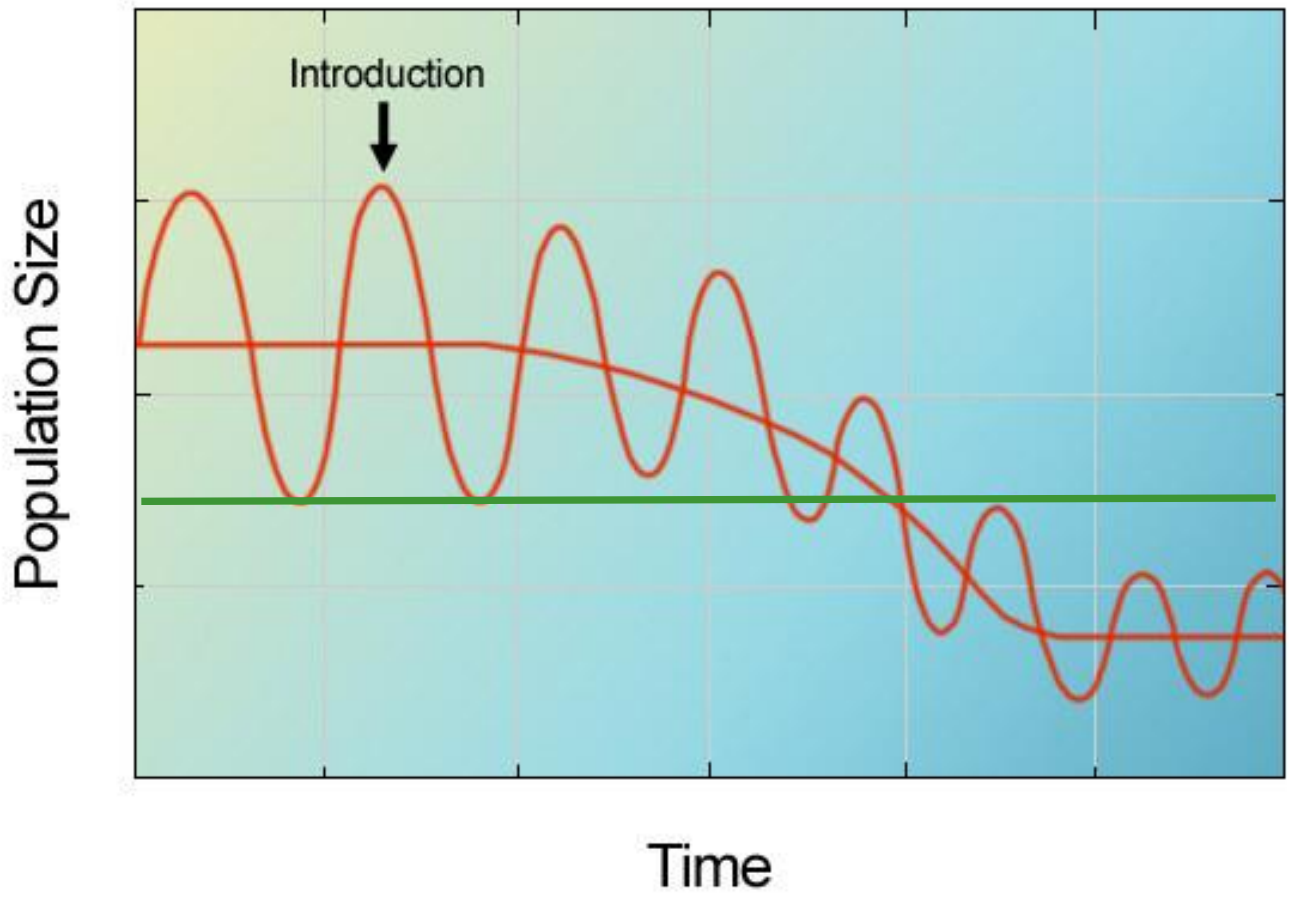
Three main types

Inundative - the mass production and periodic release of large numbers of biocontrol agents to control a pest

Conservation - modification of the environment or existing practices to protect and enhance specific natural enemies or other organisms to reduce the effects of pests

Classical (CBC) - the utilisation of co-evolved natural enemies in the regulation of host populations

The theoretical process

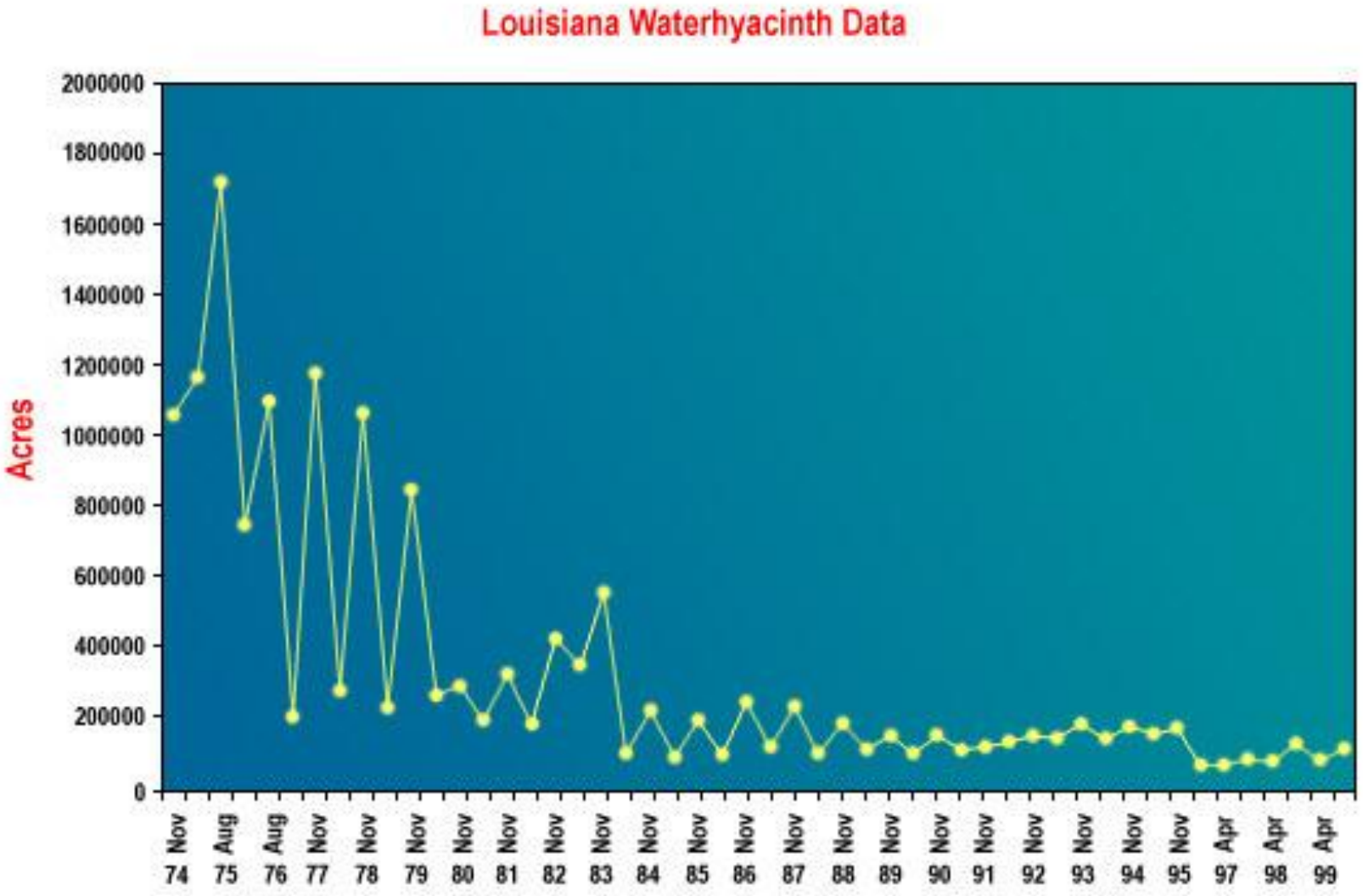


Graph courtesy of APIS

Eichhornia crassipes - Water Hyacinth

Neochetina eichhorniae

The real sequence of events



Graph courtesy of APIS

Salvinia molesta

Cyrtobagous salviniae

Photo-CRC

Salvinia weed

Before

After

Biocontrol of *Salvinia molesta* in Sri Lanka

Alternanthera philoxeroides: Alligator weed

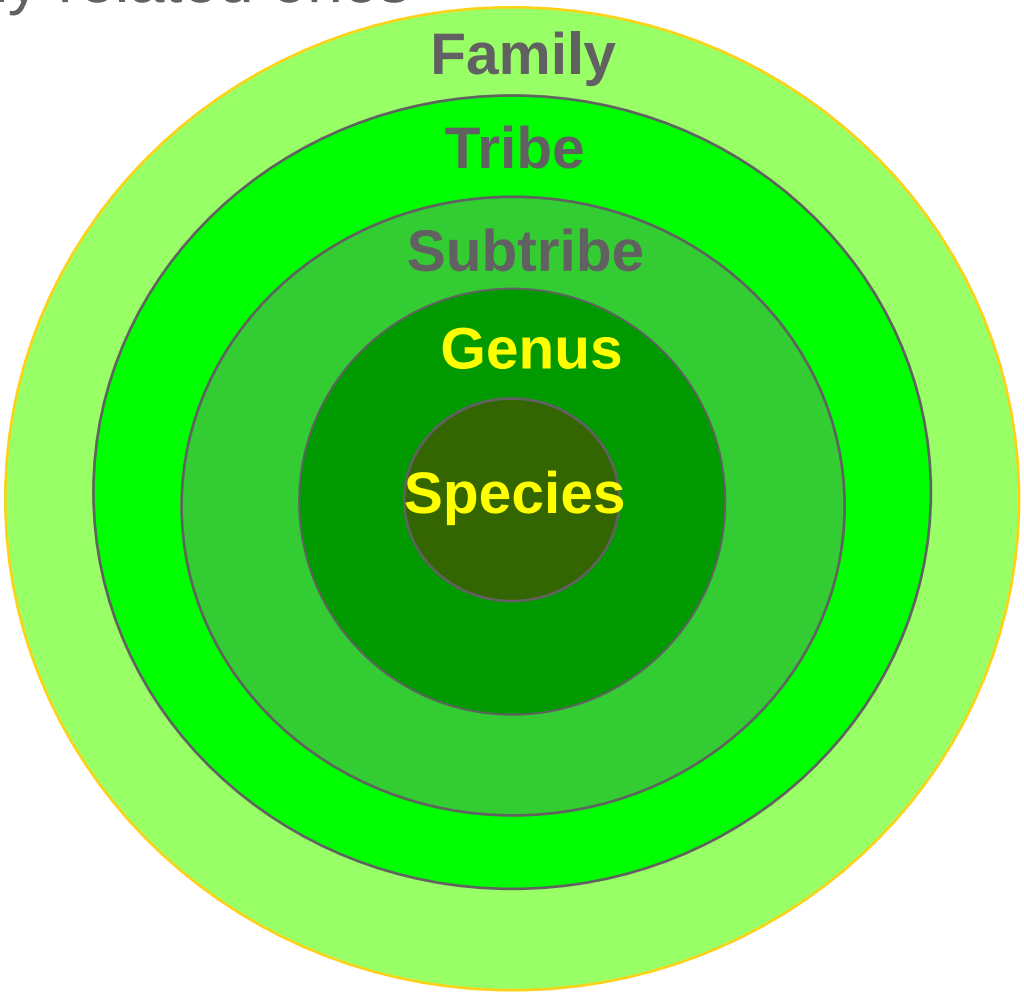
Agasicles hygrophila

Photos-CSIRO

Host range testing

Phylogenetic centrifugal method (devised by Wapshere, 1974)

Closely related species are more likely to be attacked than more distantly related ones



Is Weed Biocontrol Safe?

- Over 1,300 releases of biocontrol agents around the world
- Over 400 agents against 150 target weeds
- A century of research
- Any non-target effects are predictable by the vigorous safety testing
- An International code of conduct
- Less than 5% have ever been found feeding on non-target plants (almost all were predicted or predictable the science applied today)
- A review of cost:benefit ratios from over 30 weed biocontrol projects showed a range from 1:2.3 to 1:4000 with an average of around 1:200 (Culliney, 2005)

Is It Effective?

Clewley et al (2012) - The effectiveness of classical biological control of invasive plants

- Meta-analyses of 61 published studies (2000-2011)
- Biocontrol agents significantly reduced:

  plant size (28 ± 4%),

  plant mass (37 ± 4%),

  flower and seed production (35 ± 13% and 42 ± 9%, respectively) and

  target plant density (56 ± 7%).
- Non-target plant diversity significantly increased by 88 ± 31%
- Beetles are best

Biocontrol activity in Europe

In Europe there have been more than 300 releases of 176 predators and parasitoids against insects

……..

with very little regulation / Pest Risk Analyses

Harmonia axyridis larva

Weed CBC activity in Europe

Country	Recipient	Source
Austria	0	48
Finland	0	5
France	0	111
Germany	0	46
Greece	0	29
Italy	0	71
Portugal	0	18
Spain	0	9
Sweden	0	3
UK	1	41
Total	1	381

Classical Biological Control (CBC) in Europe

First weed CBC release in European Union (EU) made in 2010 by CABI:

Target: Japanese knotweed, *Fallopia japonica*

Agent: Psyllid, *Aphalara itadori*

However, this is not the only example of weed CBC in the EU…

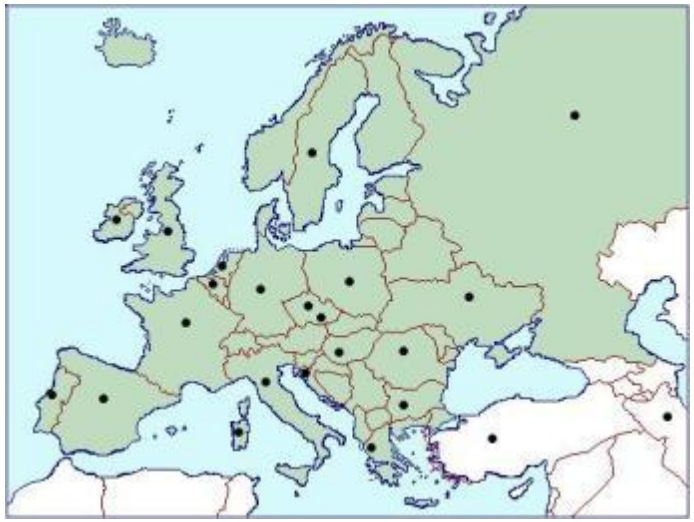
Introducing *Azolla*

Azolla filiculoides
- Daniel J Layton

Azolla filiculoides – a floating invader

- Native to the subtropical and temperate Americas
- First introduced to Europe in the mid-19th Century as an ornamental (and repeatedly since)
- Floating freshwater weed that forms dense mats
- Rapid colonisation via vegetative propagation; spore production late in the season
- Slow moving water – canals, ponds, lakes, irrigation channels, rivers

Azolla distribution and impacts



- Well established the UK, the Netherlands, Belgium, France and much of mainland Europe
- Absent primarily from high elevation sites

Impacts of *Azolla*:

- Blocks out light and reduces oxygen available to plants, fish and invertebrates
- Blocks pumps and filters and can lead to flooding
- Can be mistaken for land covered by grass, leading to cattle deaths
- Affects recreation, e.g. fishing, boating

Biological control?

Stenopelmus rufinasus
– Rob Reeder, CABI

Biological Control of *Azolla*

- *Azolla* biological control research undertaken in South Africa – extensive host range testing
- Weevil, *Stenopelmus rufinasus* found to be an *Azolla* specialist and released in 1997
- Hugely successful biological control agent
- Benefit-cost ratio of *Azolla* biocontrol programme in South Africa 15:1 by 2010

Azolla biocontrol in Europe?

European distribution of *Stenopelmus rufinasus*

- The weevil is already present in a number of European countries including France, the Netherlands, Belgium and the UK
- Introduced as a stowaway on *Azolla,* now naturalised
- Potential for countries in western Europe to rear weevil populations for *Azolla* biocontrol

RINSE

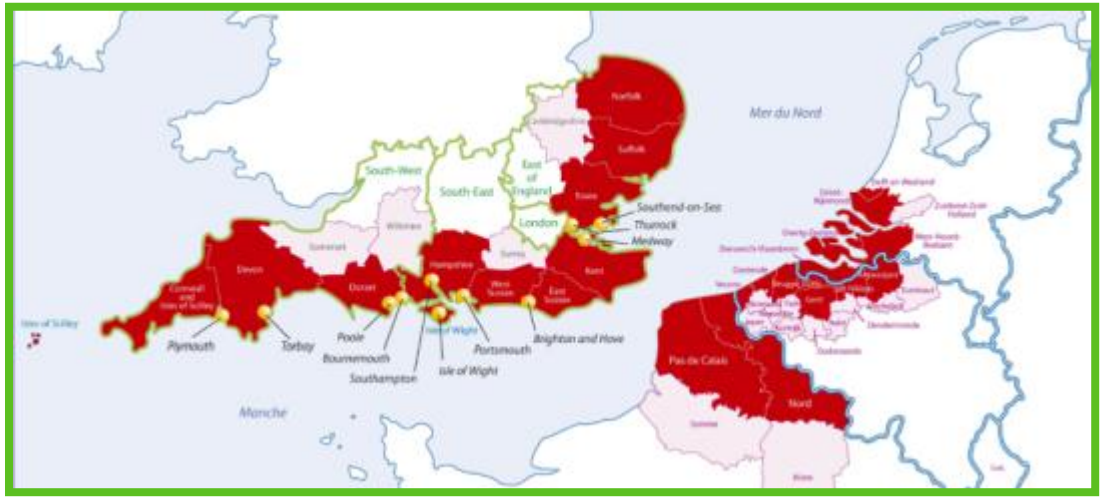
RINSE - Reducing the Impact of Non-native Species in Europe

2 Mers Seas Zeeën
INTERREG IV A
FRANCE - ENGLAND - VLAANDEREN - NEDERLAND

"Investing in your future"
Crossborder cooperation programme
2007-2013 Part-financed by the European Union
(European Regional Development Fund)

www.cabi.org

- European Union, Interreg IV 2 Seas Programme funding
- 9 partners from France, England, Belgium and the Netherlands



- Awareness and management of INNS
- CABI conducting demonstration trials with the *Azolla* weevil

RINSE

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Azolla Weevil Identification


After


After


After

Himalayan balsam

Impatiens glandulifera

- Highly invasive annual plant
- Introduced to Europe in the early 1800s
- Spread rapidly throughout riparian systems and damp woodlands
- Impacts on biodiversity, river networks and infrastructure
- Outcompetes native plants for pollinators
- For successful manual/chemical control, it must take place on a catchment scale

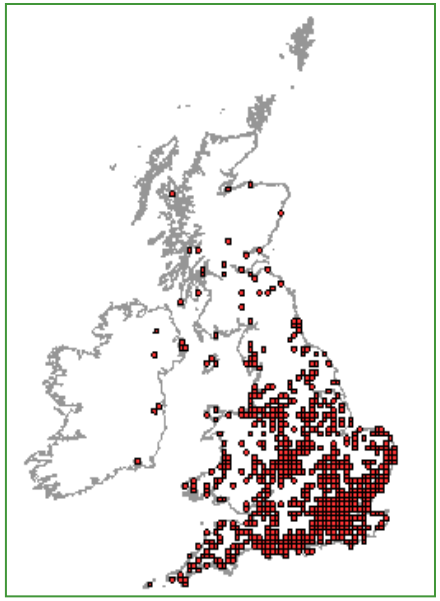
Biological Control?

- Programme commenced in 2006
- 9 surveys conducted to the plant's native range
- Numerous natural enemies collected and identified
- Based on field observations and laboratory studies most organisms have been rejected
- One organism shows considerable promise - a plant pathogen *Puccinia komarovii* var. *impatiens*
- Likely to be the first fungal biocontrol agent considered for release against a weed in Europe

Australian swamp stonecrop

Crassula helmsii

- Originating from Australia and New Zealand
- Naturalised in the UK in the 1950s
- Spread to over 2000 sites in the UK
- Semi-aquatic plant can grow submerged in deep water and on bank sides
- Dominates slow moving waterbodies including ponds, lakes and ditches
- Can outcompete native plants



Biological Control?

- Biocontrol programme began in 2010
- 4 surveys to native range
- Natural enemies imported to CABI's quarantine for host-range testing
- Several tested and rejected because of non-target effects
- Stem mining fly, Eriophyid mite and several pathogens currently in culture

Floating pennywort

(T. Renals, Environment Agency)

Hydrocotyle ranunculoides

- Extremely fast growing floating aquatic weed - can grow up to 20cm per day
- Very difficult to control due to ability to grow from tiny sections
- Forms dense impenetrable mats across water bodies, not only to the detriment of native species but also to flood defences, navigation and leisure activities

Biological Control?

- Origins in South/Central America
- Surveys and initial host range testing in the plant's native range have revealed a particularly promising weevil, *Listronotus elongatus*
- A leaf/stem mining fly, *Eugaurax* sp.
- A rust pathogen, *Puccinia hydrocotyles*
- The weevil has recently been imported to CABI's quarantine facility for further study and host range testing

Take home message

- Classical biological control offers a sustainable solution to many weeds that are beyond eradication
- Proposed Invasive Species Directive will require better control methods for invasive weeds, with biological control being a key component of Integrated Management approaches
- Water weeds make excellent biocontrol targets
- CABI are currently working on biocontrol projects for a number of aquatic invasive weeds
- *Azolla* is a European weed with an already proven biocontrol agent, and through the RINSE project we aim to demonstrate its effectiveness for Europe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Waterways


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2 Mers Seas Zeeën
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Thank You

Dank U wel

Merci beaucoup