NYBG/125

INVASIVE SPECIES SUMMIT:
CHALLENGES, STRATEGIES,
AND PERSPECTIVES

FRI, NOV 6, 2015

Co-presented with Lower Hudson Partnership for Regional Invasive Species Management

LOWER HUDSON PRISM

NEW YORK BOTANICAL GARDEN

Lower Hudson PRISM Overview

Linda Rohleder, Ph.D.

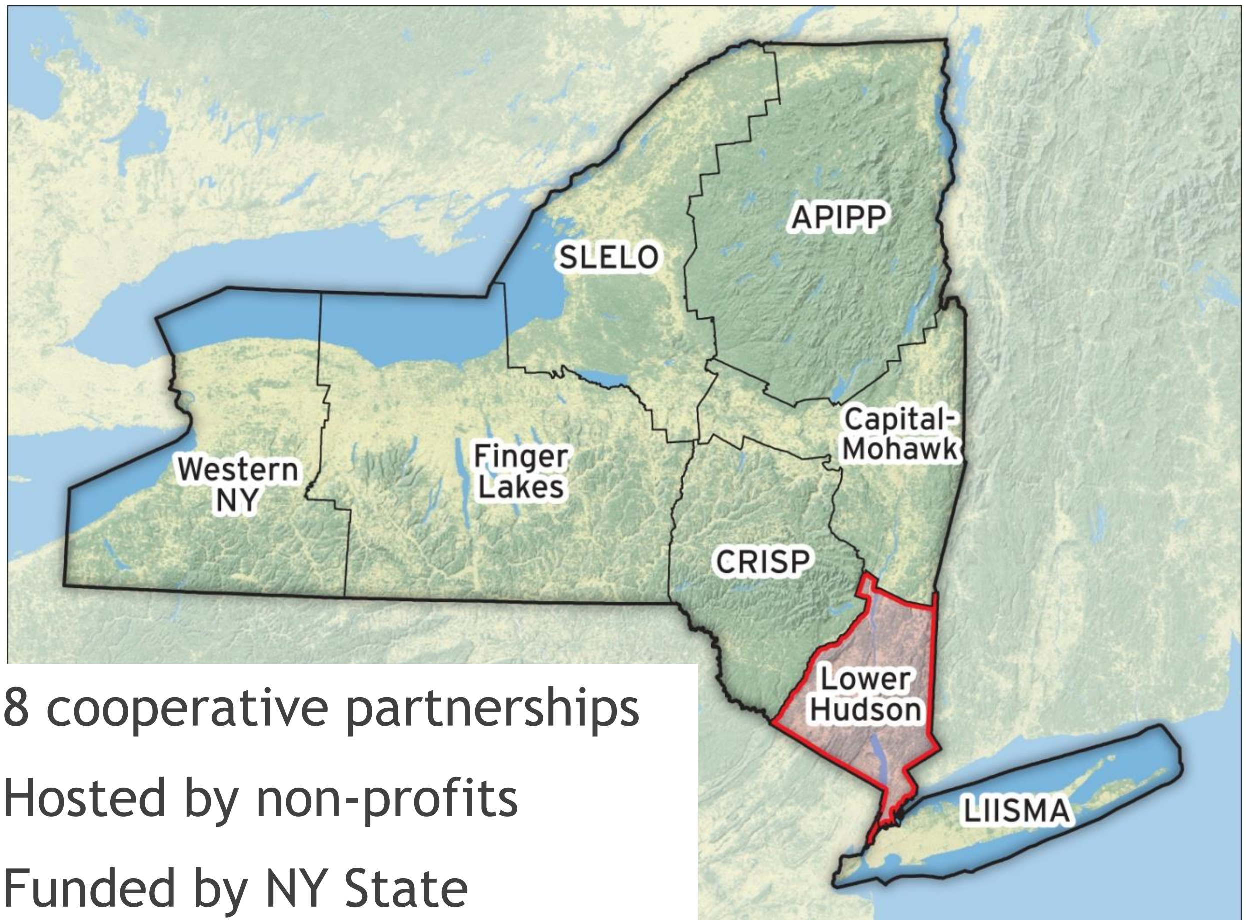
Coordinator, Lower Hudson PRISM

November 6, 2015

Linda Rohleder, Director of Land Stewardship, New York – New Jersey Trail Conference
600 Ramapo Valley Rd, Mahwah, NJ 07430 201-512-9348 x 21 lrohleder@nynjtc.org

What is a PRISM?

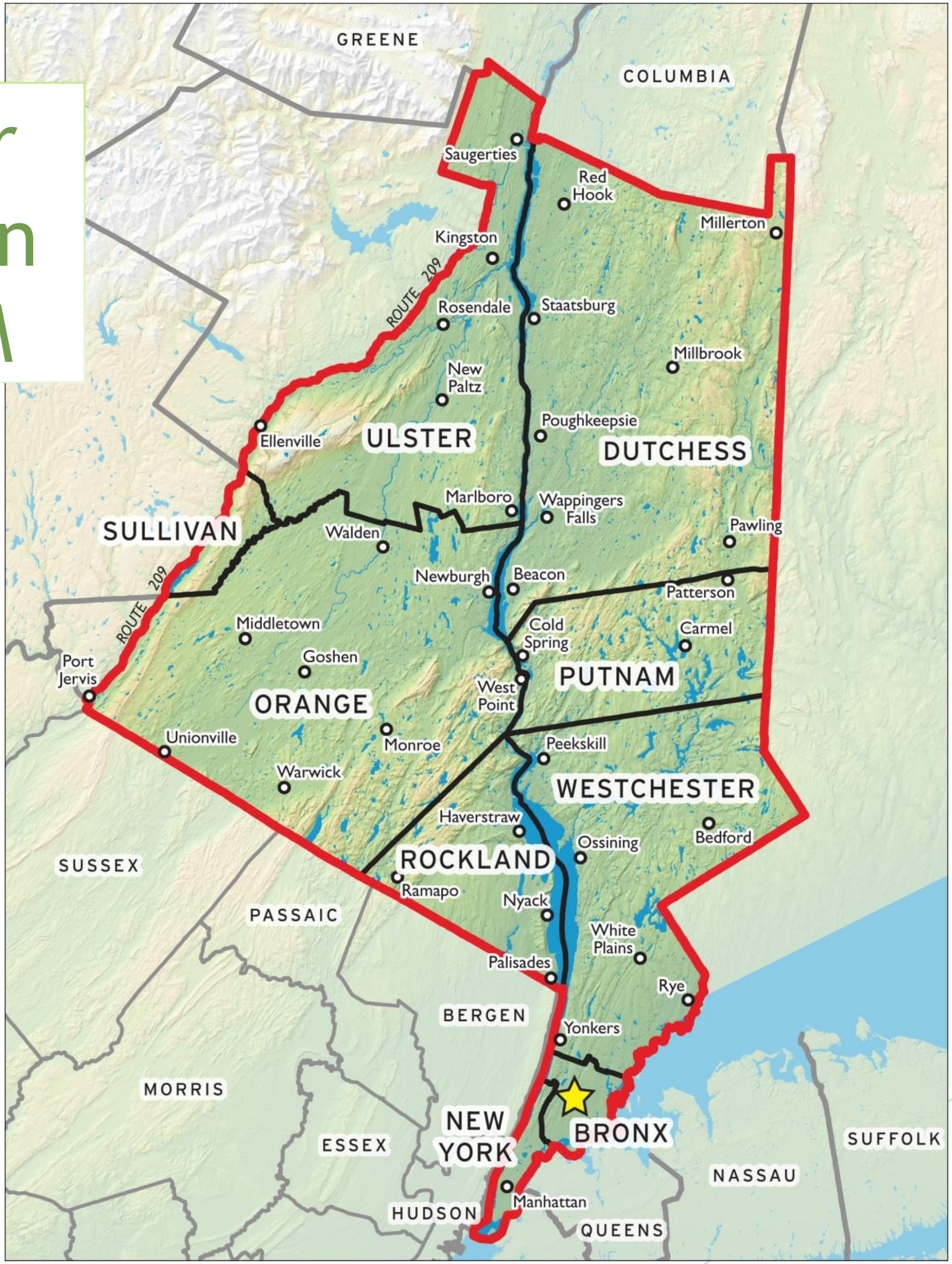
- **P**artnership for **R**egional **I**nvasive **S**pecies **M**anagement



- 8 cooperative partnerships
- Hosted by non-profits
- Funded by NY State

LOWER HUDSON PRISM

Lower Hudson PRISM



LOWER HUDSON PRISM

Partners

- 41 regional partners
- 6 steering committee members
- Dozens of additional participants

Funding

- Via the NYS Environmental Protection Fund
- Projects selected yearly to fund

LOWER HUDSON PRISM

Removing and Controlling

Prioritizing and Coordinating

Surveying and Mapping

LOWER HUDSON PRISM

Teaching and Informing

http://lhprism.org

lhprism

LOWER HUDSON PRISM

Protecting Native Species and Habitats

LOWER HUDSON PRISM

Accomplishments

- Mobilized over 2,500 volunteers who dedicated over 17,000 hours (~$450K)
- Conducted over 200 training sessions for over 8,000 attendees
- Managed invasive species on over 1,000 acres of land through more than 300 projects
- Mapped more than 50,000 invasive species occurrences

LOWER HUDSON PRISM

Accomplishments

- Identified and began controlling several new invaders to our region such as *Corydalis incisa* and hardy kiwi
- Supported over a dozen summer interns
- Boat stewards inspected 800 watercraft at 2 launches
- Hosted our first Summit

LOWER HUDSON PRISM

Key Goals

- Increasing our collective capacity to address invasive species

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- Identifying the areas and species we want to protect (Conservation Targets)

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LOWER HUDSON PRISM

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- Helping to prevent new invaders by focusing on pathways (Mitigating Pathways of Invasion)

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- Helping to prevent new invaders by focusing on pathways (Mitigating Pathways of Invasion)
- Facilitating the exchange of information

LOWER HUDSON PRISM

Join Us

- Find out more on our Web Site:

  http://lhprism.org

- Join our Mailing List
- Attend our Next Meeting

  November 12
  Beacon, NY

All are welcome to participate.

- Follow us on Facebook

  lhprism

LOWER HUDSON PRISM

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LOWER HUDSON PRISM

NEW YORK BOTANICAL GARDEN

Biological Invasions: What do they do, what can we do about them, and why are they controversial?

Dan Simberloff
University of Tennessee

EXPRESS Home of the Daily and Sunday Express

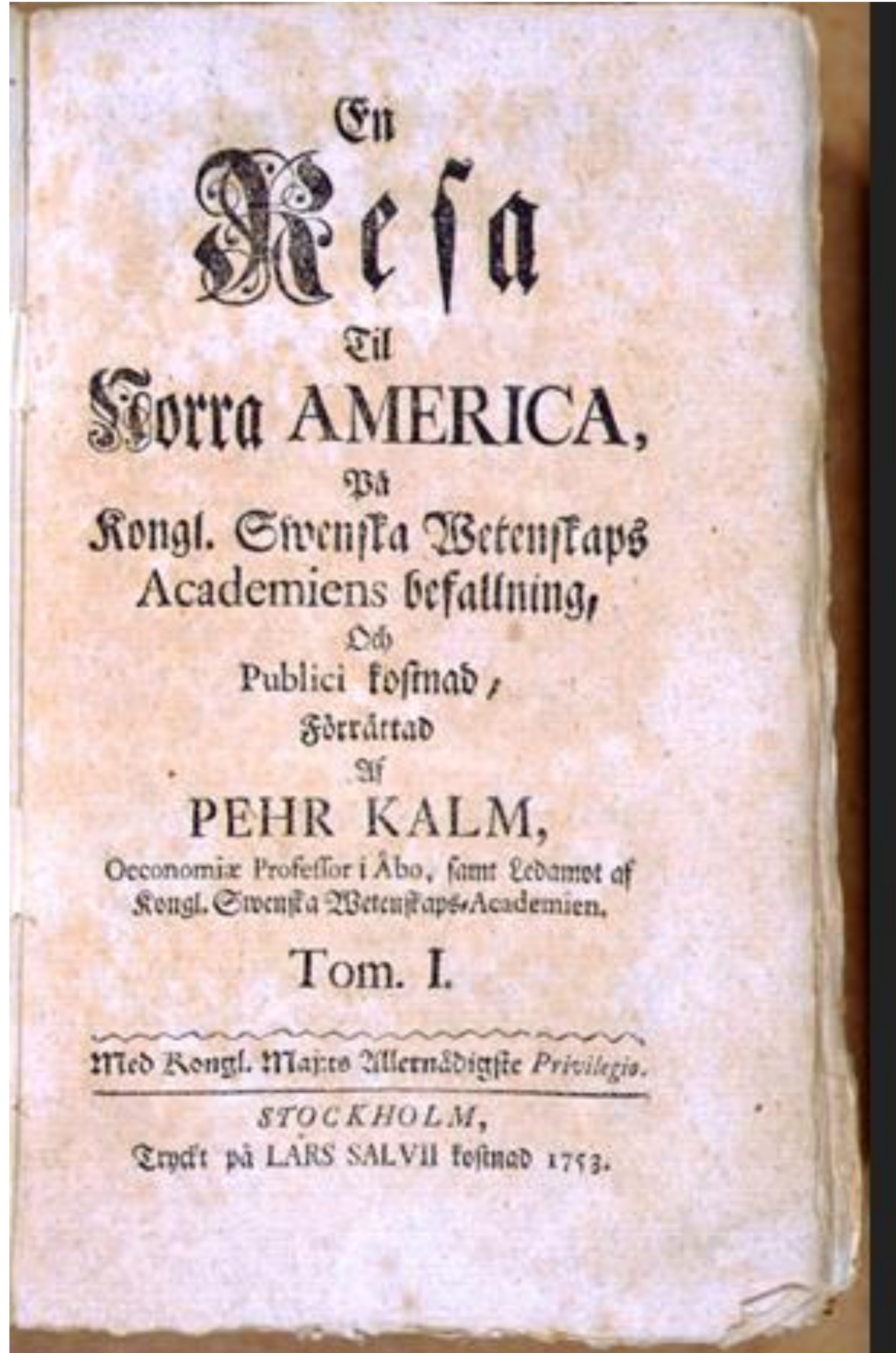
Man kills his wife then himself as he was so frightened of JAPANESE KNOTWEED

A MAN "driven mad" by Japanese knotweed murdered his wife before taking his own life.

Kenneth McRae beat his wife to death before killing himself

18th century

A picture commonly believed to portray Pehr Kalm, although some modern-day historians have claimed it might well portray Kalm's colleague Pehr Gadd.[1]



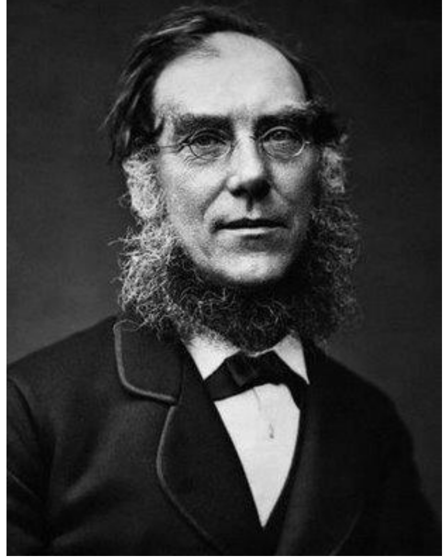
En
Resa
Til
Norra AMERICA,
På
Kongl. Swenska Wetenskaps
Academiens befallning,
Och
Publici kostnad,
Förrättad
Af
PEHR KALM,
Oeconomiæ Professor i Åbo, samt Ledamot af
Kongl. Swenska Wetenskaps-Academien.

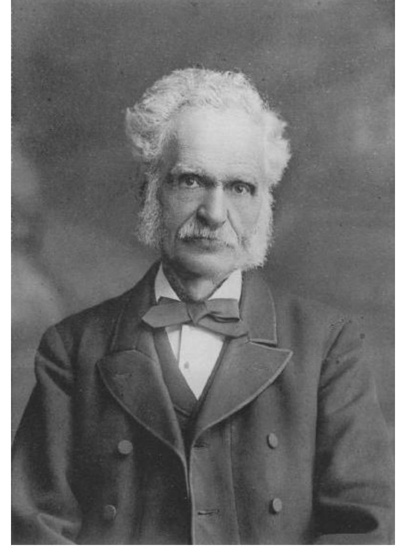
Tom. I.

Med Kongl. Maj:ts Allernådigste *Privilegio.*

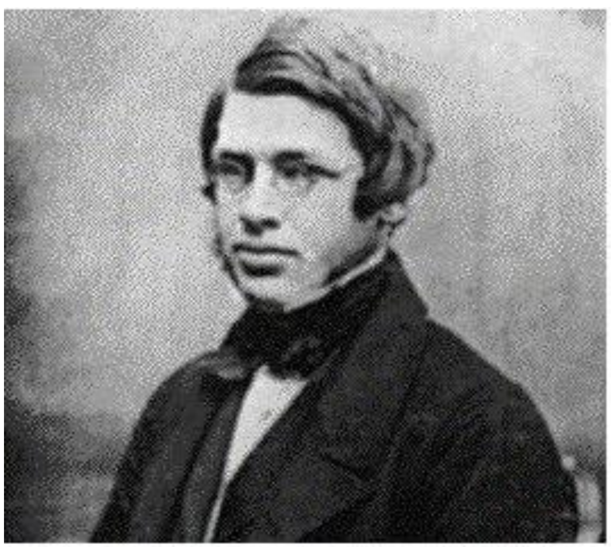
STOCKHOLM,
Tryckt på LARS SALVII kostnad 1753.


Charles Darwin


Joseph Hooker


Henry Bates


Charles Wyville Thomson


Alfred Russel Wallace

The “Victorian naturalist-explorers”

Charles Darwin in Patagonia, 1832:

"The whole country may be called one great bed of these plants. The cardoon [Europe and North Africa] is as high as a horse's back, but the Pampas thistle [southern Europe and Asia] is often higher than the crown of the rider's head. The road itself is partly, and in some cases entirely, closed."

1958

. Richardson and P. Pyšek

Figure 1 Charles Sutherland Elton (1900–1991). His book *The ecology of invasions by animals and plants* is widely acknowledged as launching the systematic study of biological invasions. Photo courtesy of the Department of Zoology, University of Oxford.

IN RETROSPECT

The book that began invasion ecology

Charles Elton's 50-year-old text founded a field and is now cited more than ever.

The Ecology of Invasions by Animals and Plants
by Charles S. Elton
Methuen: 1958. 181 pp.

Anthony Ricciardi and Hugh J. MacIsaac

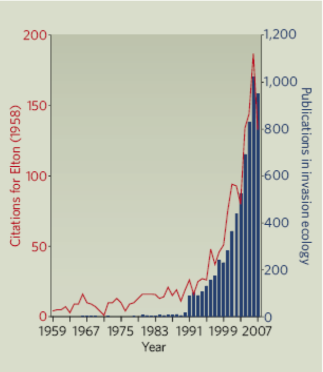
Human activities have introduced alien animals, plants and microbes to all but the remotest regions of Earth. These biological invasions threaten ecosystems, economies and human health, and are the focus of a highly productive subdiscipline of ecology, the origin of which ·an be traced to a book that was published) years ago.

The Ecology of Invasions by Animals and ·*nts* by British ecologist Charles S. Elton ·emarkably, not a scientific treatise or an ·emic text, but an expansion of a short · of BBC radio broadcasts aimed at ·blic. At the time, Elton was the most ·tial figure in animal ecology, having ·ed studies on population dynamics ·l chains. He was particularly inter- ·what he called "ecological explo- ·normous, uncontrolled increases ·on.

·v, ecologists had treated invasions ·s. Elton characterized them as ·matic of a process that could ·gical landscape of the planet. ·g one of the great historical ·the world's fauna and flora," ·effort to move the study of natural historical accounts, testable generalizations ·arate disciplines, includ- ·pidemiology and human ·ntified large-scale pat- ·her number of invaders ·ompared with tropical versus mainland areas ·recently verified by

·n demonstrated the ·uman activities in ·ons. For example, ·ts began to focus ·n aquatic species, ·on to the transport of organ- ·ships' ballast tanks, the intercontinental movement of oysters and their associated flora and fauna, and the role of canals in linking regions formerly isolated from each other for millions of years.

Many of the concepts raised in *The Ecology of Invasions by Animals and Plants* have flourished into important research themes that continue to be vigorously debated. Most notable of these is the 'biotic resistance' hypothesis: that species-rich communities



are more resistant to invasion. Elton proposed that diverse communities use reso·es more fully, leaving fewer niches for pot· nists to exploit. Recent studies· that invaders in small, species· indeed fare worse than those · biodiversity. But the pattern· over large areas, apparently d· environmental conditions· and alien species alike.

Elton also argued that · are likely to contain pr· that can control invad· food webs are more v· tion explosions. As e· the disproportionat· in environments su· boreal forests, and· and in other envi· drastically simpli· These ideas ha· subsequent eco· between a com· ity. Elton furt· are invasive · out their na· sial hypoth· studies. H· publishe· enemy r· to Tho·

Elt· inva· exti· that bec· 1980s. "The even· world will become not m· simpler and poorer," he wrote. "Ins· continental realms of life … there will only be one world." This stark prediction may have inspired yet another current research

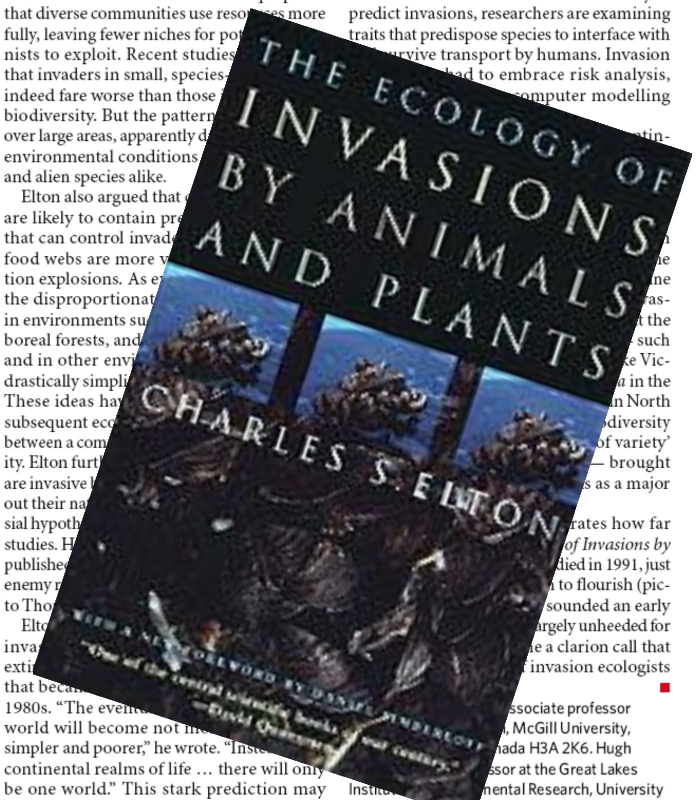
theme: the consequences of the replacement of unique assemblages of plants and animals by widespread alien species that coexist with humans, such as rats, starlings and carp.

Half a century on, invasion ecology has progressed well-beyond the scope of Elton's book. Several topics that are now crucial to our current understanding were overlooked or only touched on by Elton. These include: the number of introductions or individuals a population requires to become established; the evolutionary effects of invasions; and interactions among alien species that enhance each other's success. Commerce in agriculture, aquaculture, ornamental plants and pets has opened up the world to thousands of potential invaders, often aided by rapid unregulated trade through the Internet. The release of genetically modified organisms has added another dimension. To try to predict invasions, researchers are examining traits that predispose species to interface with ·survive transport by humans. Invasion ·had to embrace risk analysis, ·omputer modelling

·ntin- ·n ·he ·ne ·as- ·t the · such ·e Vic- ·*a* in the ·n North ·diversity ·of variety' — brought ·s as a major

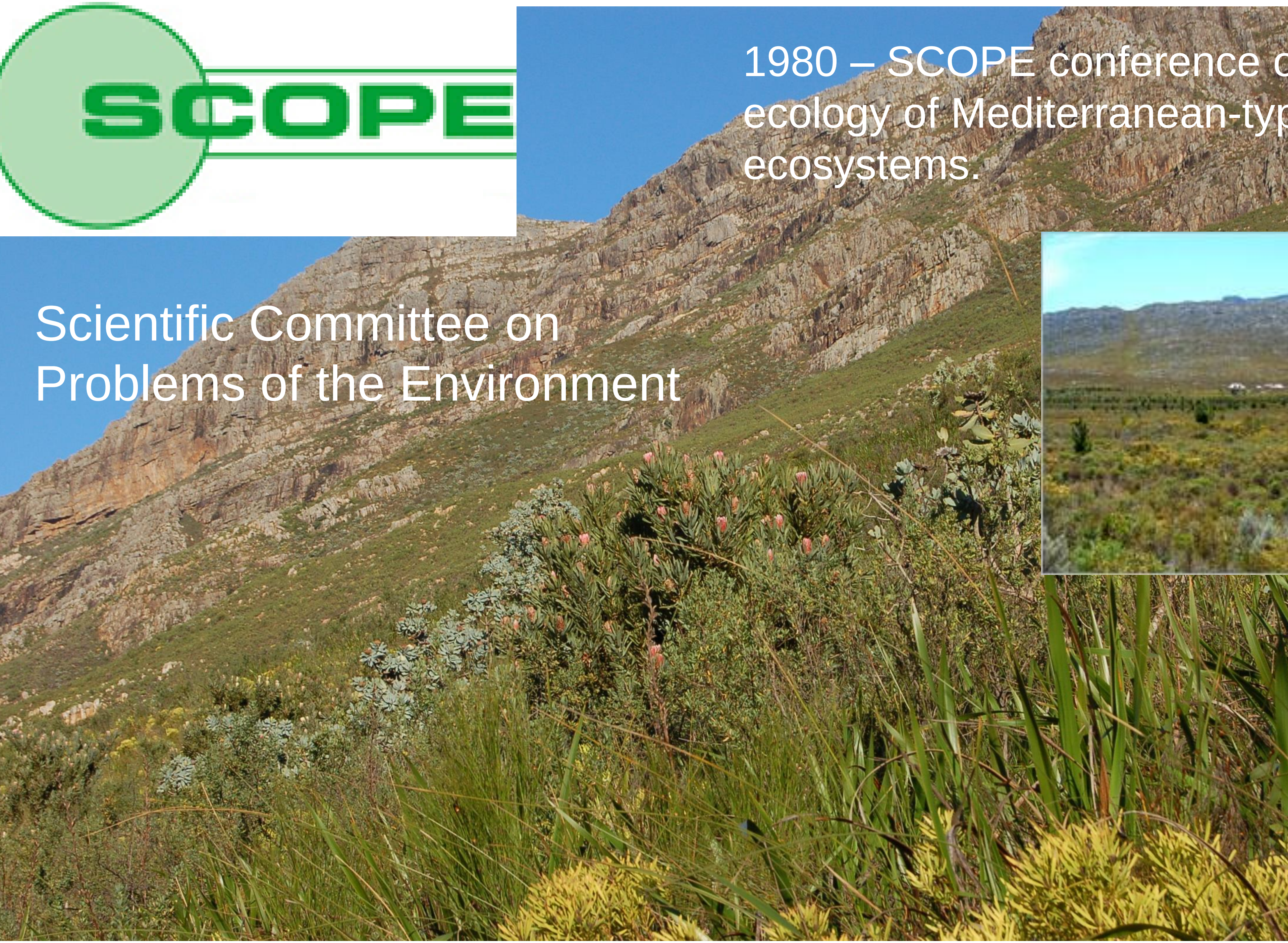
·rates how far ·*of Invasions by* ·died in 1991, just · to flourish (pic- ·sounded an early ·rgely unheeded for ·e a clarion call that · invasion ecologists ■

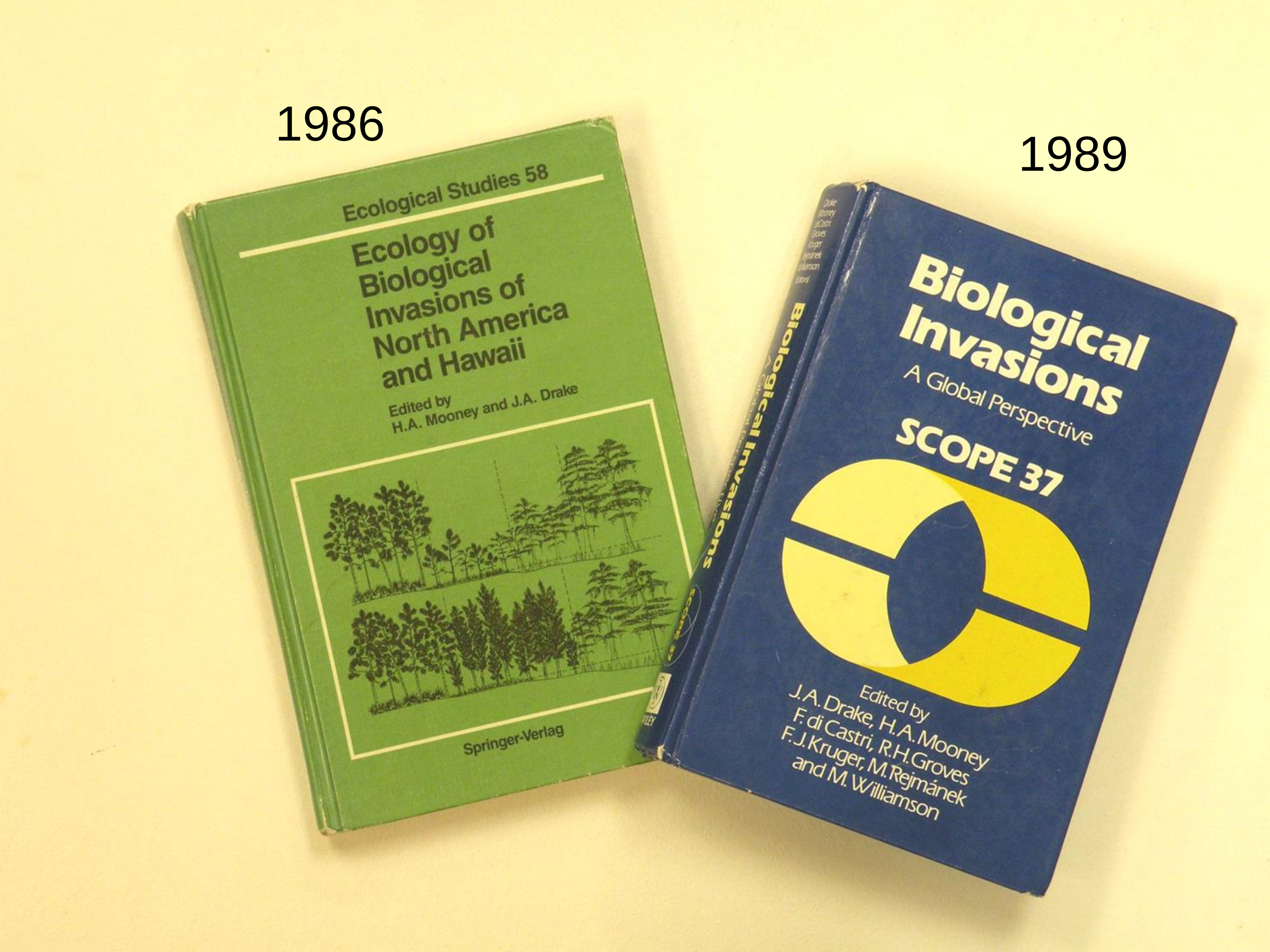
·ssociate professor ·, McGill University, ·ada H3A 2K6. Hugh ·ssor at the Great Lakes ·nental Research, University of Windsor, O· · Canada N9B 3P4

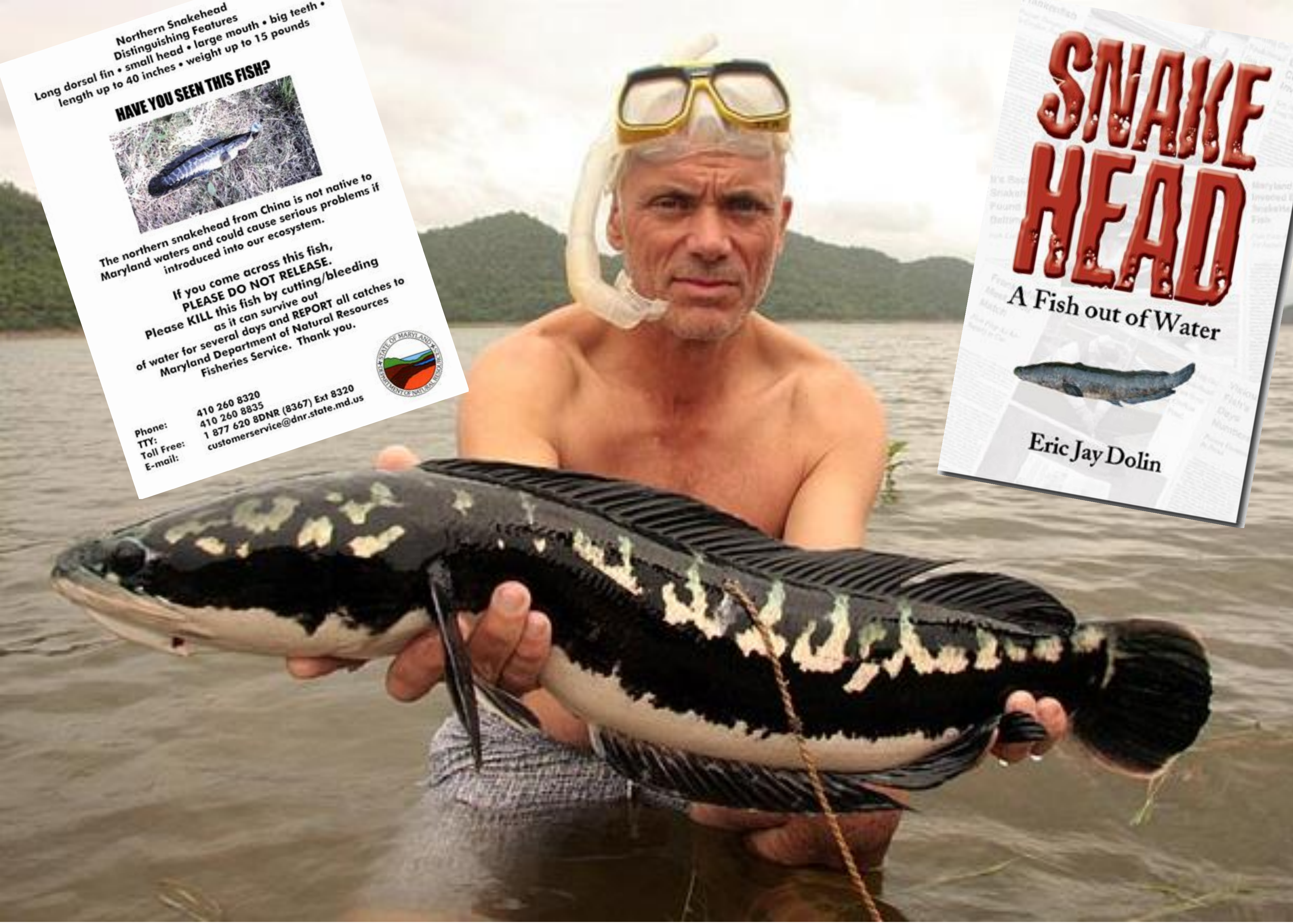


1980 – SCOPE conference c
ecology of Mediterranean-typ
ecosystems.

Scientific Committee on
Problems of the Environment




1986
1989
Ecological Studies 58
Ecology of Biological Invasions of North America and Hawaii
Edited by H.A. Mooney and J.A. Drake
Springer-Verlag
Biological Invasions
A Global Perspective
SCOPE 37
Edited by J.A. Drake, H.A. Mooney, F. di Castri, R.H. Groves, F.J. Kruger, M. Rejmánek and M. Williamson


Northern Snakehead
Distinguishing Features
Long dorsal fin • small head • large mouth • big teeth •
length up to 40 inches • weight up to 15 pounds
HAVE YOU SEEN THIS FISH?
The northern snakehead from China is not native to
Maryland waters and could cause serious problems if
introduced into our ecosystem.
If you come across this fish,
PLEASE DO NOT RELEASE.
Please KILL this fish by cutting/bleeding
as it can survive out
of water for several days and REPORT all catches to
Maryland Department of Natural Resources
Fisheries Service. Thank you.
Phone: 410 260 8320
TTY: 410 260 8835
Toll Free: 1 877 620 8DNR (8367) Ext 8320
E-mail: customerservice@dnr.state.md.us
SNAKE HEAD
A Fish out of Water
Eric Jay Dolin

Boiga irregularis,
the brown tree snake
on Guam

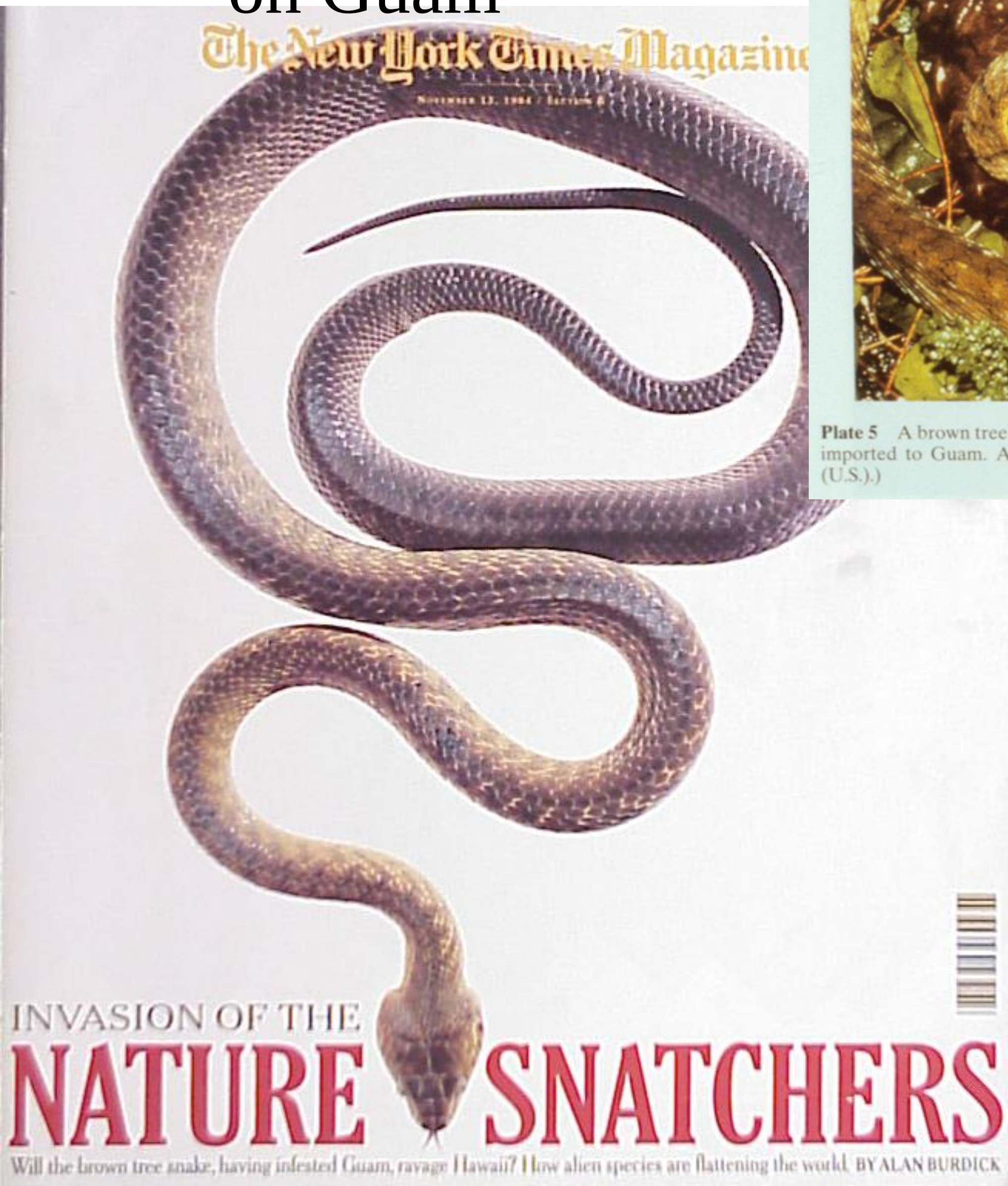
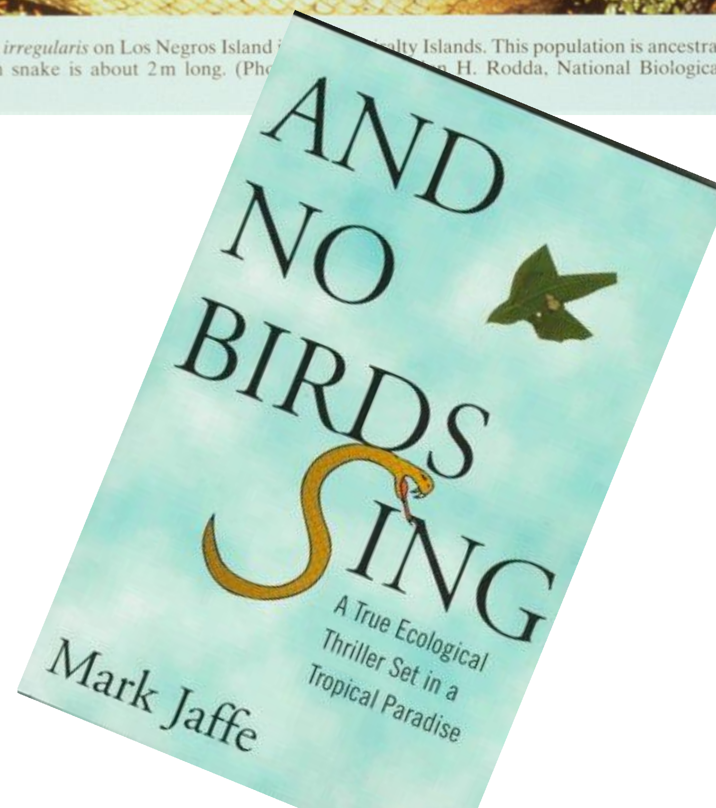
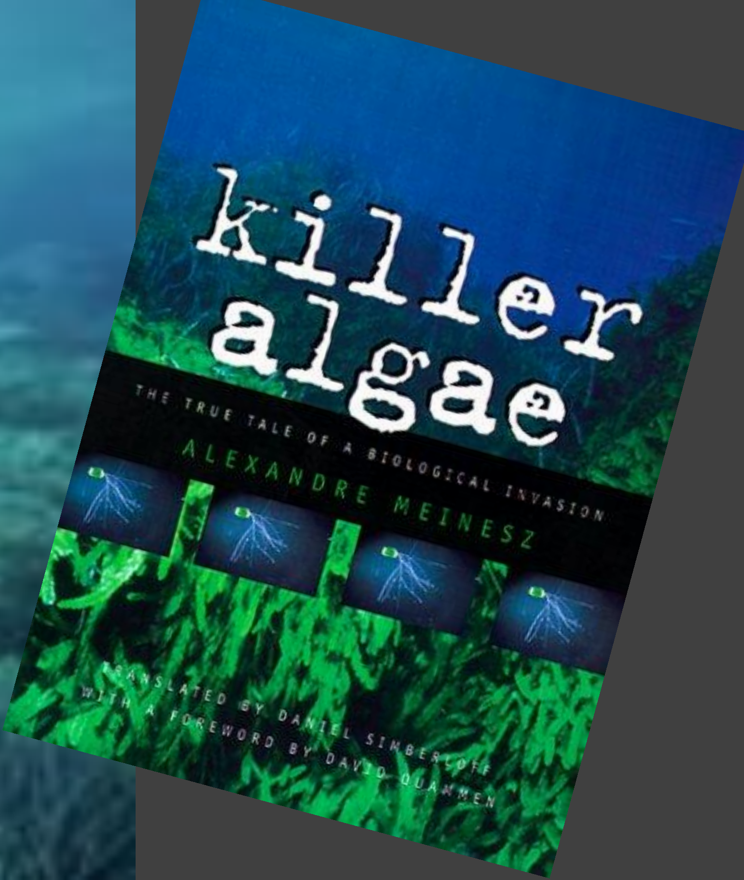


Plate 5 A brown tree snake *Boiga irregularis* on Los Negros Island i … alty Islands. This population is ancestral to those imported to Guam. A fully grown snake is about 2 m long. (Ph… n H. Rodda, National Biological Service (U.S.).)



Burmese python, Florida



Caulerpa taxifolia

Mediterranean

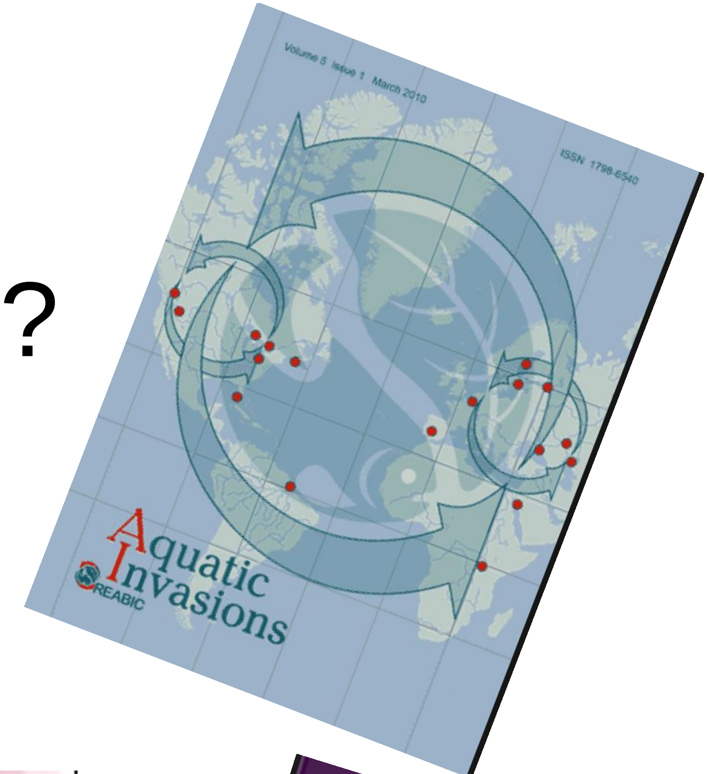

CHEATGRASS
FIRE AND FORAGE ON THE RANGE
JAMES A. YOUNG
CHARLIE D. CLEMENTS

And introduced species also:

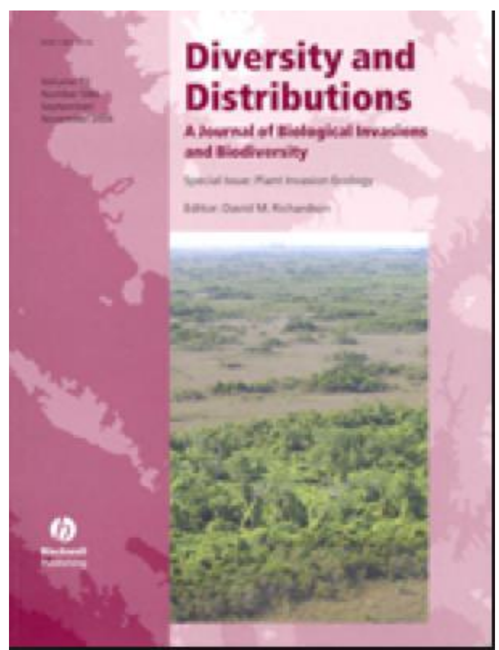
- Compete with native species
- Parasitize or infect native species
- Vector diseases to native species
- Hybridize with native species
- Etc., etc., etc.

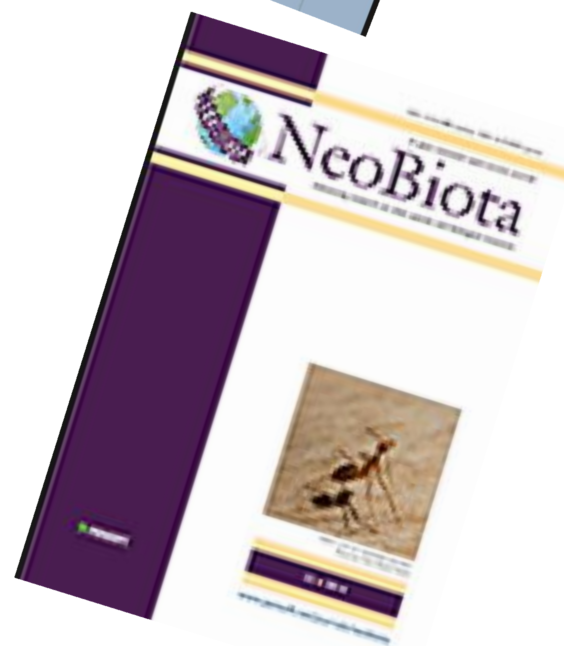

Biological
Invasions
Springer

What’s new?


Volume 5 Issue 1 March 2010
ISSN 1798-6540
Aquatic
Invasions
REABIC


BioInvasions
Records
REABIC


Diversity and
Distributions
A Journal of Biological Invasions
and Biodiversity
Blackwell
Publishing


NeoBiota

BIOLOGICAL INVASION BY *MYRICA FAYA* IN HAWAI'I: PLANT DEMOGRAPHY, NITROGEN FIXATION, ECOSYSTEM EFFECTS[1]

PETER M. VITOUSEK AND LAWRENCE R. WALKER[2]
Department of Biological Sciences, Stanford University, Stanford, California 94305 USA

1989. Ecol. Monogr.
59: 247-259

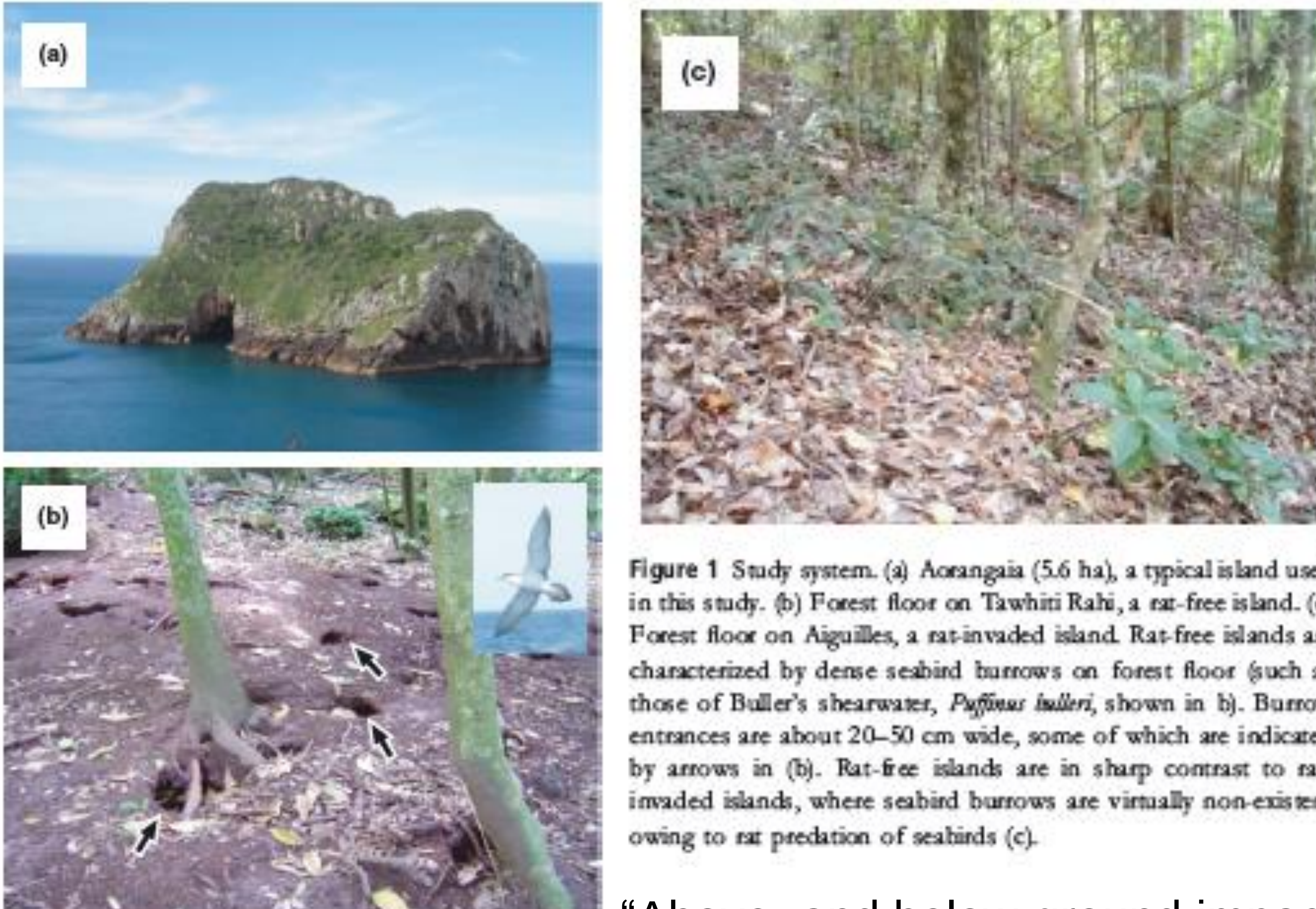


Figure 1 Study system. (a) Aorangaia (5.6 ha), a typical island used in this study. (b) Forest floor on Tawhiti Rahi, a rat-free island. (c) Forest floor on Aiguilles, a rat-invaded island. Rat-free islands are characterized by dense seabird burrows on forest floor (such as those of Buller's shearwater, *Puffinus bulleri*, shown in b). Burrow entrances are about 20–50 cm wide, some of which are indicated by arrows in (b). Rat-free islands are in sharp contrast to rat-invaded islands, where seabird burrows are virtually non-existent owing to rat predation of seabirds (c).

T Fukami et al. 2006

"Above- and below-ground impacts of introduced predators in seabird-dominated island ecosystems"

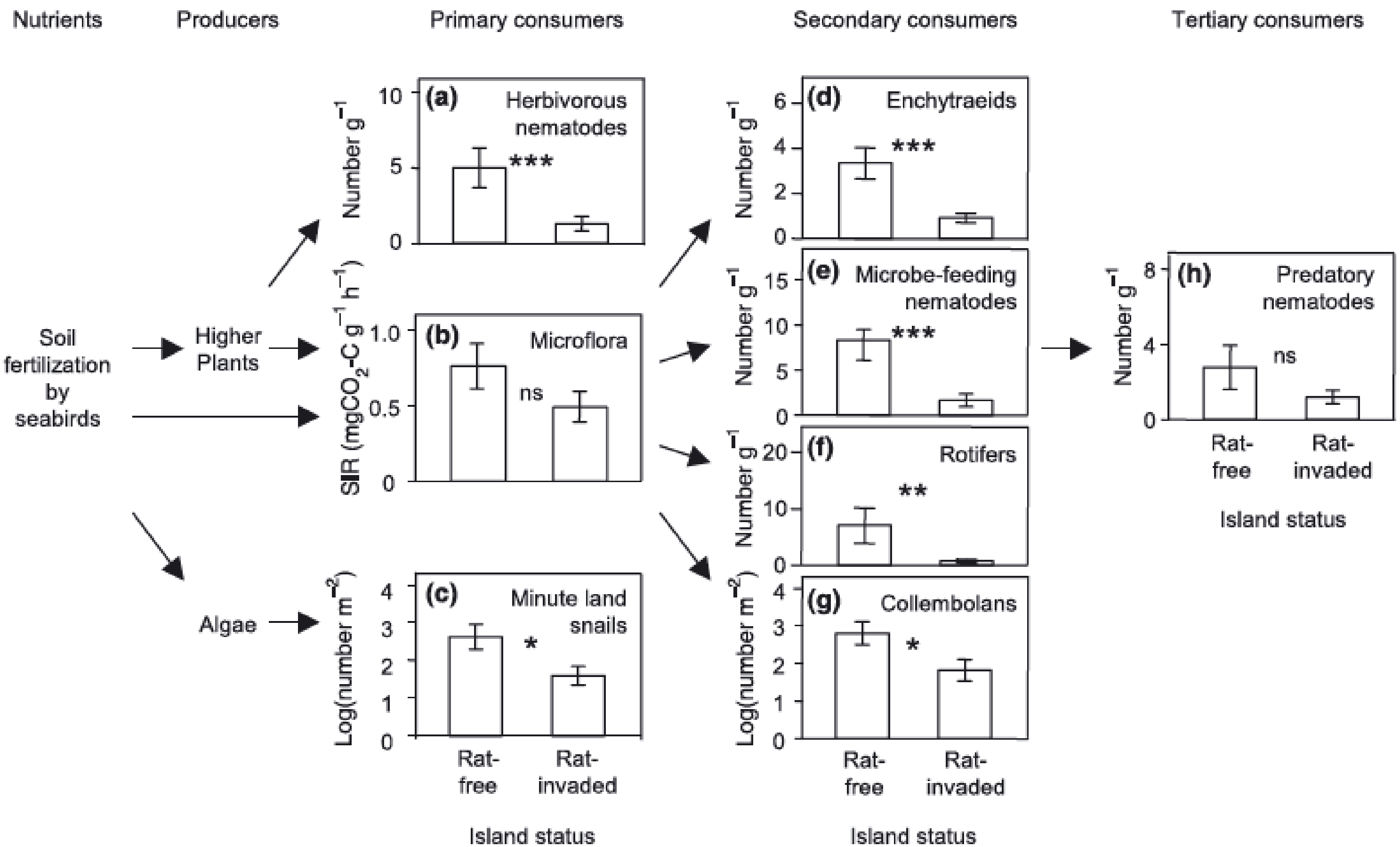
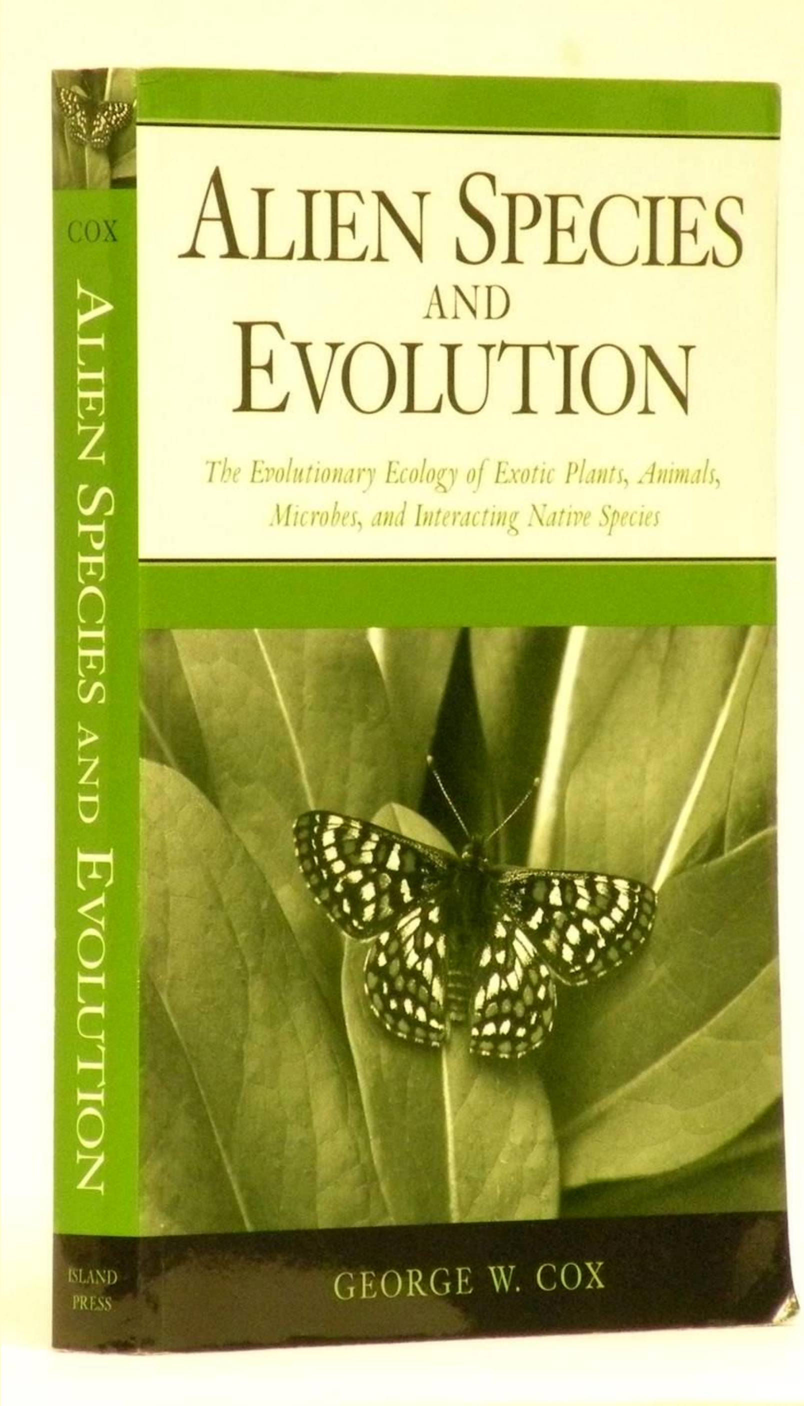


Figure 2 Response of belowground trophic groups to rat invasion of islands. Arrows indicate directions of nutrient flow (note that only a subset of the soil food web is shown). Results are shown as means ± SEM (n = 9 rat-free and 9 rat-invaded islands). * $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$; ns, non-significant; SIR, substrate-induced respiration in litter and soil.

T Fukami et al. 2006

Above- and below-ground impacts of introduced predators in seabird-dominated island ecosystems

2004


COX
ALIEN SPECIES AND EVOLUTION
ISLAND PRESS
ALIEN SPECIES
AND
EVOLUTION
The Evolutionary Ecology of Exotic Plants, Animals,
Microbes, and Interacting Native Species
GEORGE W. COX

Increased genetic variation and evolutionary potential drive the success of an invasive grass

Sébastien Lavergne* and Jane Molofsky

Department of Plant Biology, University of Vermont, Marsh Life Sciences Building, 109 Carrigan Drive, Burlington, VT 05405

reed canary grass
Phalaris arundinacea

2007. Proc. Natl. Acad. Sci. 104: 3883-3888

HYBRIDIZATION

Phytophthora alni, new pathogen on *Alnus* first seen in 1939.

Nature 2011

A forester engages in efforts to eradicate the velvet tree *Miconia calvescens* in Hawaii.

Don't judge species on their origins

Conservationists should assess organisms on environmental impact rather than on whether they ar natives, argue **Mark Davis** and 18 other ecologists

Over the past few decades, 'non-native' species have been vilified for driving beloved 'native' species to extinction and generally polluting 'natural' environments. Intentionally or not, such characterizations have helped to create a pervasive bias against alien species that has been embraced by the public, conservationists, land managers and policy-makers, as well by as many scientists, throughout the world.

approaches to the conservation ment of species — approach to our fast-changing plane

The concept of nativen by the English botanist By the late 1840s, b terms native and help them disting posed a 'true' British

Over the next century,

exaggerated claims of impending harm to help convey the message that introduced species are the enemies of man and nature.

Certainly, some species introduced by humans have driven extinctions and undermined important ecological services such as clean water and timber resources. In Hawaii, for instance, avian malaria — probably introduced in the early 1900s when European settlers brought in song and game birds — has killed off more than half of the islands' native bird species. Zebra mussels (*Dreissena polymorpha*), originally native to the lakes of southeast Russia and accidentally introduced to North America in the late 1980s, have cost the US power industry and water utilities hundreds of millions (some say llions) of dollars in damage by clogging

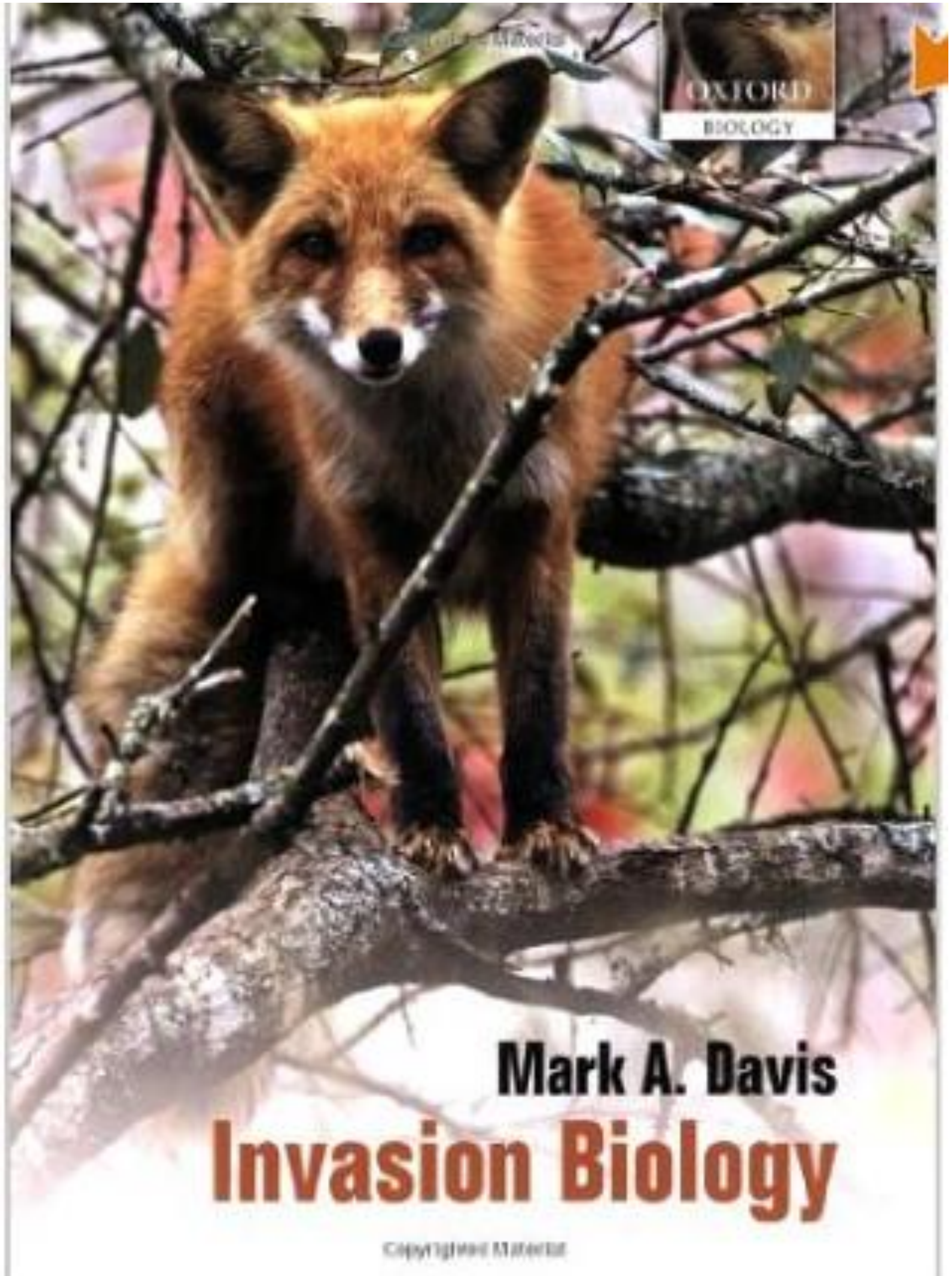
But many of the claims perception that introduc apocalyptic threat to backed by data. Take a 1998 paper[4] that greatest threat t or endangere tion. Little o this clai author recer re

CORRESPO

Non-natives: 141 scientists object

We the undersigned feel that in advocating a change in the environmental management of introduced species (*Nature* 474, 153–154; 2011), Mark Davis and colleagues a straw men.

First, most co biologists a



2009

Oikos 2013

Another call for the end of invasion biology

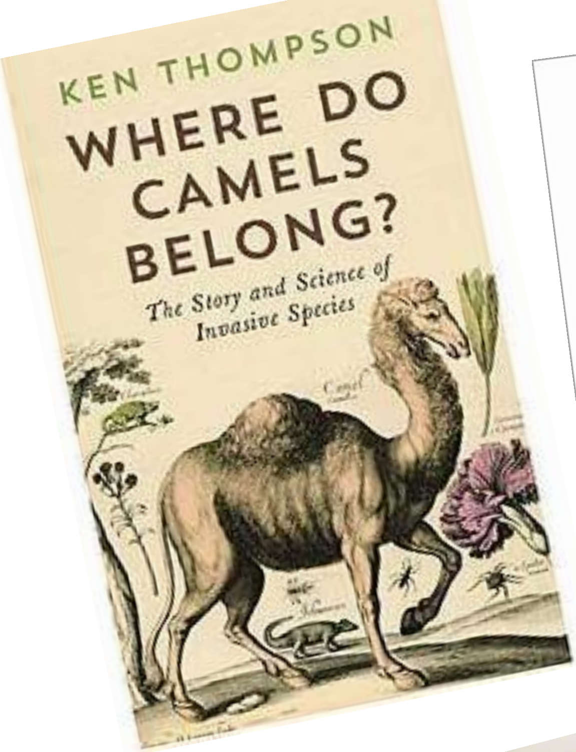
Loïc Valéry, Hervé Fritz and Jean-Claude Lefeuvre

L. Valéry (lvalery@mnhn.fr) and J.-C. Lefeuvre, Dépt d'Ecologie et de Gestion de la Biodiversité, Muséum National d'Histoire Naturelle, and URU Biodiversité et Gestion des Territoires, Univ. de Rennes 1, Bât 25 – Avenue du Général Leclerc, FR-35042 Rennes cedex, Franc – H. Fritz, Laboratoire de Biométrie et Biologie Evolutive, Univ. Lyon 1; CNRS; UMR 5558, 43 boulevard du 11 Novembre 1918, FR-69622 Villeurbanne, France.

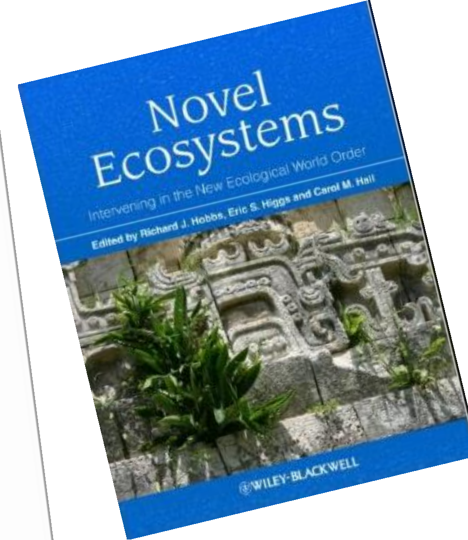
A call for an end to calls for the end of invasion biology

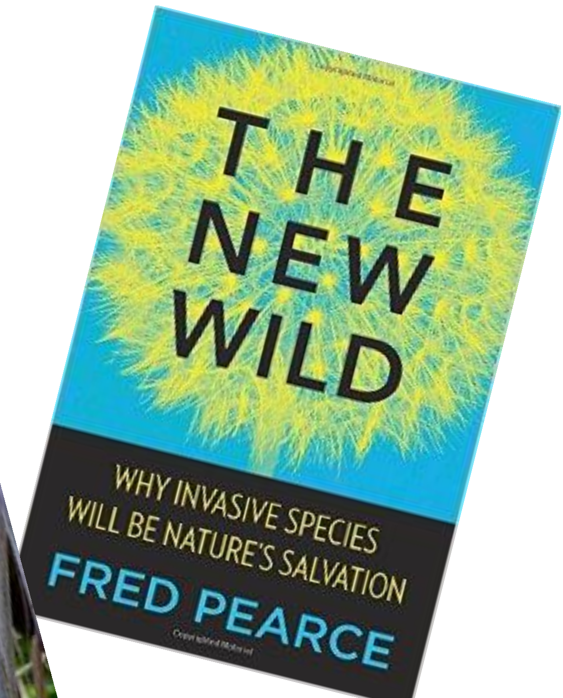
Daniel Simberloff and Jean R. S. Vitule

D. Simberloff (dsimberloff@utk.edu), Dept of Ecology and Evolutionary Biology, Univ. of Tennessee, Knoxville, TN 37996, USA. – J. R. S. Vitule, Laboratório de Ecologia e Conservação, Depto de Engenharia Ambiental, Setor de Tecnologia, Univ. Federal do Paraná, 81531, 980, Curitiba, Paraná, Brazil.


KEN THOMPSON
WHERE DO CAMELS BELONG?
The Story and Science of Invasive Species


JACQUES TASSIN
LA GRANDE INVASION
QUI A PEUR DES ESPÈCES INVASIVES ?
Odile Jacob
sciences


Novel Ecosystems
Intervening in the New Ecological World Order
Edited by Richard J. Hobbs, Eric S. Higgs and Carol M. Hall
WILEY-BLACKWELL

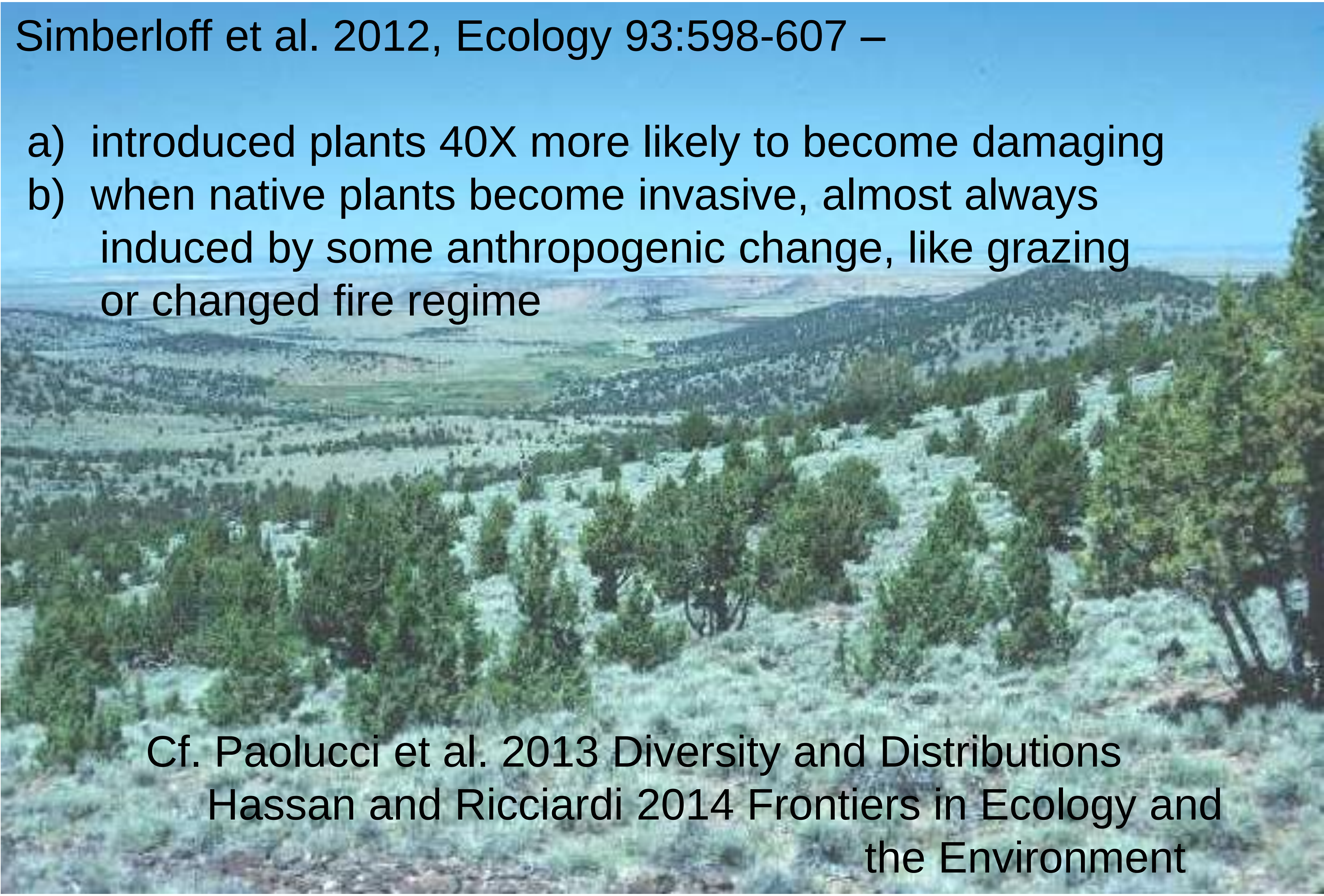

THE NEW WILD
WHY INVASIVE SPECIES WILL BE NATURE'S SALVATION
FRED PEARCE


RAMBUNCTIOUS GARDEN
SAVING NATURE IN A POST-WILD WORLD
EMMA MARRIS

1) How many introduced species are harmful?

1) How many introduced species are harmful?

a) Some native species become “invasive.”



Simberloff et al. 2012, Ecology 93:598-607 –

a) introduced plants 40X more likely to become damaging
b) when native plants become invasive, almost always induced by some anthropogenic change, like grazing or changed fire regime

Cf. Paolucci et al. 2013 Diversity and Distributions
Hassan and Ricciardi 2014 Frontiers in Ecology and the Environment

Encroachment by *Juniperus occidentalis*

1) How many introduced species are harmful?

2) Introduced species often increase local biodiversity.

114 native species
At least 55 extinct

Hawaiian birds

VS

53 established
Introduced species

1) How many introduced species are harmful?

2) Introduced species often increase local biodiversity.

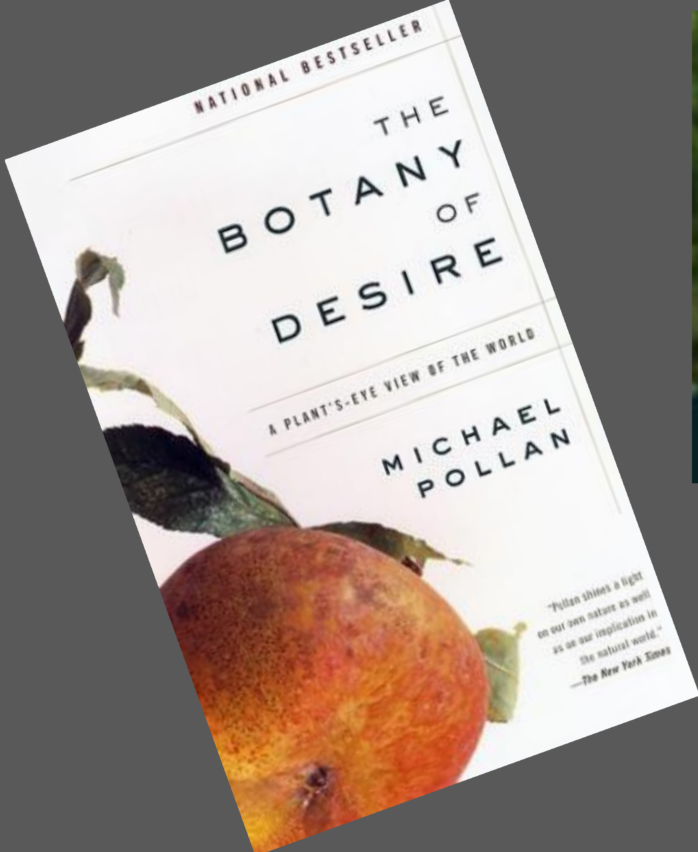
3) Are actions against introduced species xenophobic?

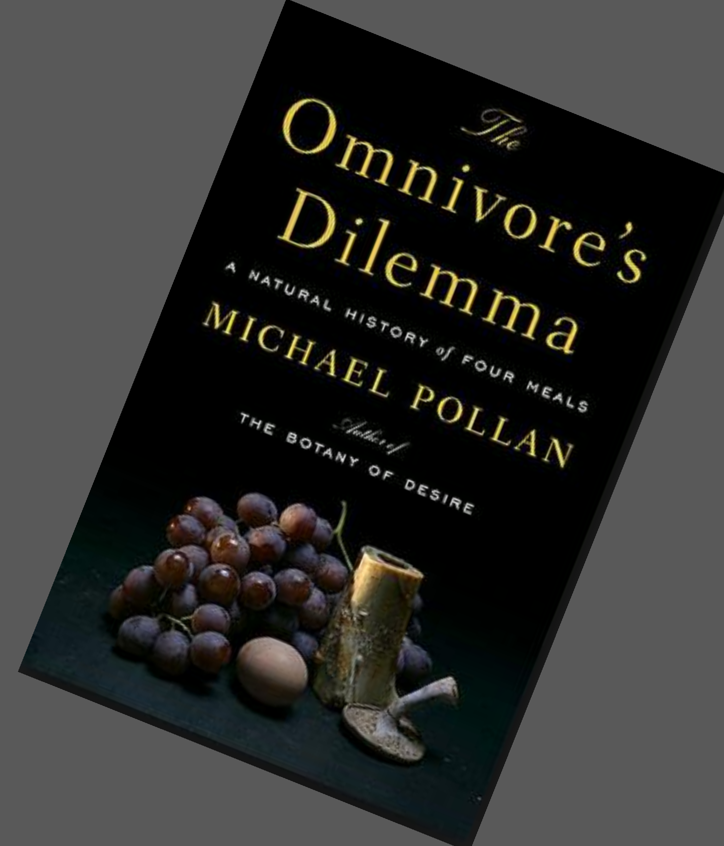
"…to cleanse the German landscape of unharmonious foreign substance." – R. Tuexen, 1939

Reinhold Tuexen

"As with the fight against Bolshevism, our entire occidental culture is at stake, so with the fight against this Mongolian invader, an essential element of this culture, namely the beauty of our forest [is at stake]." – R Tuexen, 1942

Impatiens parviflora





“The ‘natural garden’ movement has all but seized control of official garden taste in this country. [It] is decreed that the ‘new American garden’ is henceforth a place that …grants citizenship exclusively to native plants (any immigrant to be treated as ‘flora non grata’ with ‘invasive aliens’ subject to deportation).” – M Pollan, 1994

“Am I implying that natural gardening in America is a **crypto-Fascist movement**? I hope not. I mention the historical precedent partly to suggest that the ‘new American garden’ is neither as new nor as American as its proponents would have us think.” – M Pollan, 1994

“The German example also suggests we would do well to beware of ideology in the garden masquerading as science. It’s **hard to believe that there is nothing more than scientific concern about invasive species** behind the current fashion for natural gardening and native plants in America – not when our national politics are rife with anxieties about immigration and isolationist sentiment.” – M Pollan, 1994

This does **not** mean that anyone who wants the trains to run on time is a Fascist!

1) How many introduced species are harmful?

1) Introduced species often increase local biodiversity.

2) Are actions against introduced species xenophobic?

3) Efforts to contain invasions are futile.

Mark Gardener, Director, Charles Darwin Research Station, Galapagos, 2011:

“It’s time to embrace the aliens. Blackberries now cover more than 30,000 ha here, and our studies show that island biodioversity is reduced by at least 50% when it’s present. But as far as I’m concerned, it’s now a Galapagos native, and it’s time we accepted it as such.”

Rubus niveus


Courtesy CSIRO Marine Research Division

Kochia scoparia in Western Australia

1990 – introduced

1992 – eradication campaign begun

1993 – 3,200 ha over 900 km

1995 – 139 ha

1999 – 5 ha

2000 - eradicated

Rinderpest, Scourge of Cattle, Is Vanquished

2011

F. Paladini

BEGONE Dr. William P. Taylor, in 1987 in Sudan, examined a cow for rinderpest. The United Nations is announcing this week that the disease has been wiped off the face of the earth.

MAINTENANCE MANAGEMENT

physical and mechanical control

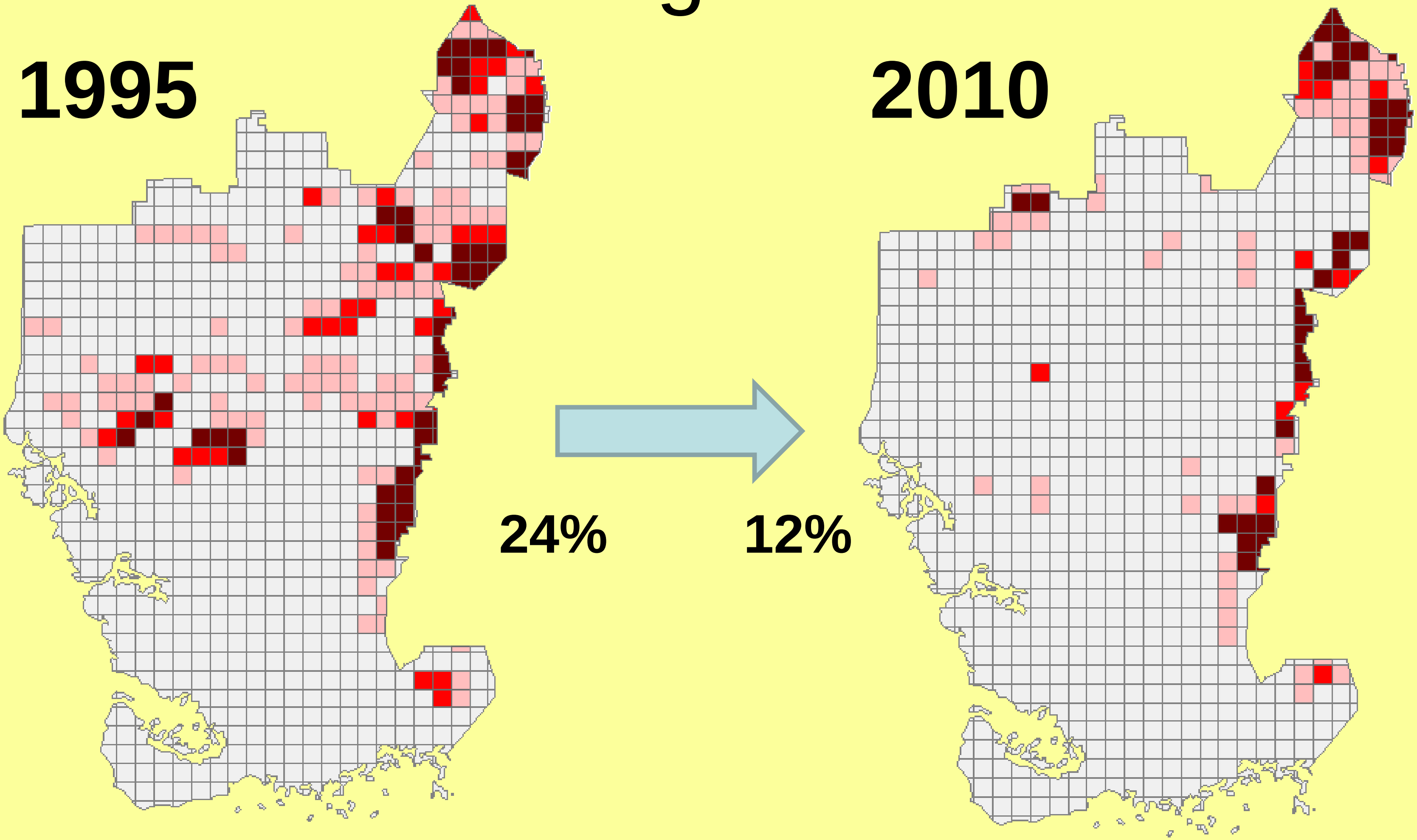
chemical control

biological control

sterile male, mating disruption, etc.

Australian paperbark,
Melaleuca quinquenervia

15 Years of Melaleuca Management



Control Methods "Toolbox"

- Mechanical
- Manual
- Chemical
- Biological
- Prescribed Fire

adapted from T. Pernas/F. Laroche

Microencapsulated BioBullets for the Control of Biofouling Zebra Mussels

DAVID C. ALDRIDGE,*,† PAUL ELLIOTT,† AND GEOFF D. MOGGRIDGE‡
Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, U.K., and Department of Chemical Engineering, University of Cambridge, Pembroke Street, Cambridge CB2 3RA, U.K.

The widespread invasion of freshwaters by the zebra mussel, *Dreissena polymorpha*, during the last 2 decades has made it one of the world's most economically and ecologically important pests. Since arriving in the North American Great Lakes in the 1980s, zebra mussels have become a major biofouler, blocking the raw water cooling systems of power stations and water treatment works and costing U.S. $1−5 billion per year. Despite the development of numerous control methods, chlorination remains the only widespread and licensed technique. Zebra mussels are able to sense chlorine and other toxins in their surrounding environment and respond by closing their valves, thus enabling them to avoid toxic effects for up to 3 weeks. Furthermore, prolonged dosing of chlorine in raw water produces ecotoxic trihalomethanes (THMs) by reaction with organic material in the water. We have developed a novel, environmentally safe, and effective method for controlling the zebra mussel: the BioBullet. Our method uses the encapsulation of an active ingredient (KCl) in microscopic particles of edible material. The mussels' natural filtering ability then removes and concentrates the particles from the water, without stimulating the valve-closing response. By using the mussels' filtering behavior to concentrate BioBullets the absolute quantity of active ingredient added to the water can be reduced substantially. Our approach allows us to engineer the particles to break up and dissolve completely within a few hours, thus eliminating the risk of polluting the wider ecosystem. We demonstrate that the effectiveness of a toxin in the control of biofouling filter-feeders can be enhanced greatly by using our technique. This paves the way for a new approach to the control of some of the world's most important economic pests.

Introduction

The introduction of nonnative taxa into novel localities represents one of the greatest threats to the world's ecosystems and economies (*1−3*). One of the most well-known examples comes from the invasion of the zebra mussel, *Dreissena polymorpha*, into the Laurentian Great Lakes of North America during the 1980s (*4*). Zebra mussels are unusual among freshwater bivalves in possessing byssus which enables them to attach to hard substrates and form encrustations many individuals deep (*5*). Rapid population growth and invasion is assisted by high fecundities and the possession of planktonic veliger larvae that can disperse passively in the water column for up to 4 weeks before settling (*6*).

Zebra mussels can lead to system-level changes in invaded ecosystems and have led to local extirpation of some species of North American unionid mussels (*7, 8*). For industry, zebra mussel biofouling of pipelines that carry raw water can be devastating. In North America, numerous power plants have experienced fouling and blockage of the heat exchange pipes, screenhouses, steam condensers, and trash bars (*9*). In Britain, the recent spread of zebra mussels (*10*) has resulted in many water treatment works experiencing blockage of microstrainers and pumps, the occlusion of pipes, and the compromising of filter bed efficiency (*11*). In Spain, where zebra mussels were discovered in the Ebro River in 2001 (*12*), many thousands of kilometers of irrigation pipeline are threatened by zebra mussel fouling (J. Insausti, Government of Aragon, Spain, 2003, personal communication). In North America alone, zebra mussels are estimated to cost industry ca. U.S. $1−5 billion ($10^9$) each year (*1, 13*).

Considering the immense economic cost of zebra mussels, it is unsurprising that much effort has been put into developing control strategies (*6*). Physical removal, generally using high-pressure water jets, is only feasible within sections of industrial facilities where ready access is possible. Antifoulant coatings (e.g., copper-based) may offer practical preventative measures for new facilities or retrofitted screens but are difficult to apply to existing pipelines. Biological control using natural enemies offers an attractive option, and while fish and crayfish can regulate zebra mussel populations under some circumstances (*14, 15*), there appear to be no grounds for expecting the development of a practicable biological control method in the foreseeable future. Chemical control options are favored by industry because treatment can be applied throughout the entire facility from a single dosing point. Many chemicals will kill zebra mussels given sufficient concentration and contact time, but the suitability of a particular chemical is determined by considerations of water quality (e.g., residual concentrations, byproducts), cost, and practicality. Chemicals which have been tested to some success include chloramines, chlorine dioxide, ozone, hydrogen peroxide, potassium permanganate, pH adjustment, and inorganic salts, such as KCl (*6*).

While numerous physical and chemical techniques have been proposed and tested, chlorination remains the only widespread and licensed option (*6*). However, chlorination poses a number of problems for industry and regulators. First, chlorine reacts with organic material in the water to produce trihalomethanes (THMs) which are toxic to humans and other animals. This restricts greatly the chlorine doses that can be applied to water in infested water treatment works. Second, zebra mussels respond to unfavorable environmental conditions by closing their valves for prolonged periods (*6*). This means that control agents, such a chlorine in the form of sodium hypochlorite, must be dosed continuously for up to 3 weeks to have their desired effects. Third, hypochlorite is rather expensive and hazardous to transport, store, and handle. Fourth, chlorine dosed into pipelines that exit into open ecosystems can impact deleteriously on nontarget biota in the recipient waters. Indeed, many of the chemicals used

* Corresponding author phone: +44 (0)1223 334436; fax: +44 (0)1223 336676; e-mail: d.aldridge@zoo.cam.ac.uk.
† Department of Zoology.
‡ Department of Chemical Engineering.

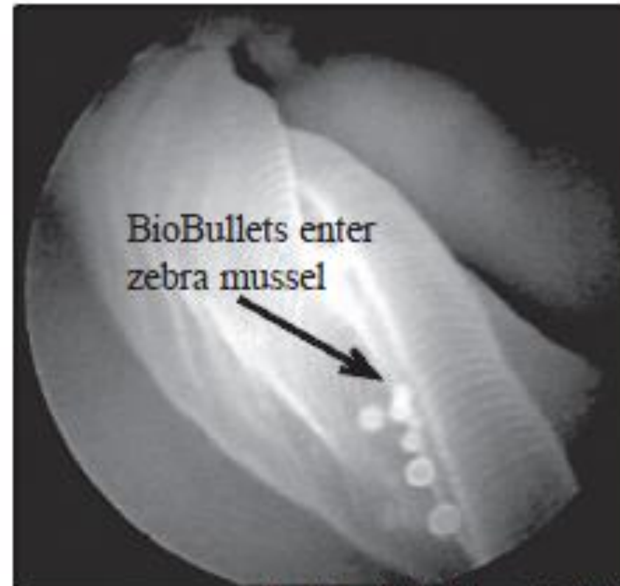


Photo by David Aldridge, University of Cambridge

BioBullets being transported along the gill of a live zebra mussel. The mussel has been fooled into treating the bullets as food, and will ingest their toxic payload.

Critical Reviews in Plant Sciences, 23(5):381–389 (2004)

ISSN: 0735-2689 print / 1549-7836 online
DOI: 10.1080/07352680490505123

Invasive Ornamental Plants: Problems, Challenges, and Molecular Tools to Neutralize Their Invasiveness

Yi Li*
Department of Plant Science, University of Connecticut, Storrs, CT 06269, USA

Zongming Cheng*
Department of Plant Sciences, University of Tennessee, Knoxville, TN 37996, USA

William A. Smith, Donna R. Ellis, Yongqin Chen, and Xuelian Zheng
Department of Plant Science, University of Connecticut, Storrs, CT 06269, USA

Yan Pei
Biotechnology Center, Southwest Agricultural University, Chongqing, P. R. China

Keming Luo
Department of Plant Science, University of Connecticut, Storrs, CT 06269, USA, and Biotechnology Center, Southwest Agricultural University, Chongqing, P. R. China

Degang Zhao
College of Life Sciences, Guizhou University, Guiyang, P. R. China

Quanhong Yao
Agro-Biotechnology Research Center of Shanghai Academy of Agricultural Sciences, 2901 Beidi Rd., Shanghai, P. R. China

Hui Duan
Department of Plant Science, University of Connecticut, Storrs, CT 06269, USA, and Department of Cell & Structural Biology, University of Illinois, Urbana, IL 61801, USA

Qi Li
Department of Plant Science, University of Connecticut, Storrs, CT 06269, USA, and Section of Cardiovascular Medicine, Yale University, New Haven, CT 06510, USA

October 30, 2011

Concerns Are Raised About Genetically Engineered Mosquitoes

By ANDREW POLLACK

These mosquitoes are genetically engineered to kill — their own children.

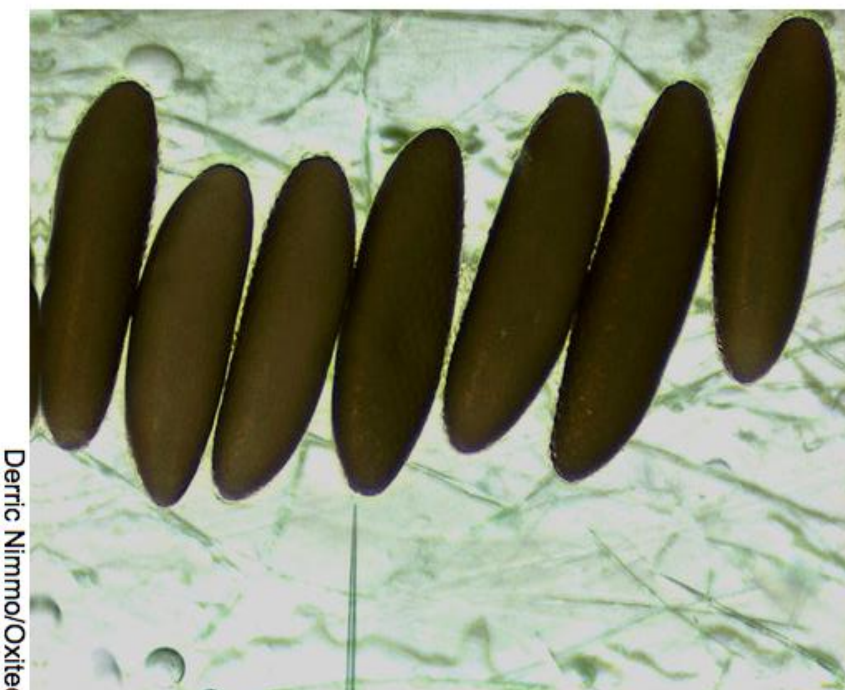
Researchers on Sunday reported initial signs of success from the first release into the environment of mosquitoes engineered to pass a lethal gene to their offspring, killing them before they reach adulthood.

The results, and other work elsewhere, could herald an age in which genetically modified insects will be used to help control agricultural pests and insect-borne diseases like dengue fever and malaria.

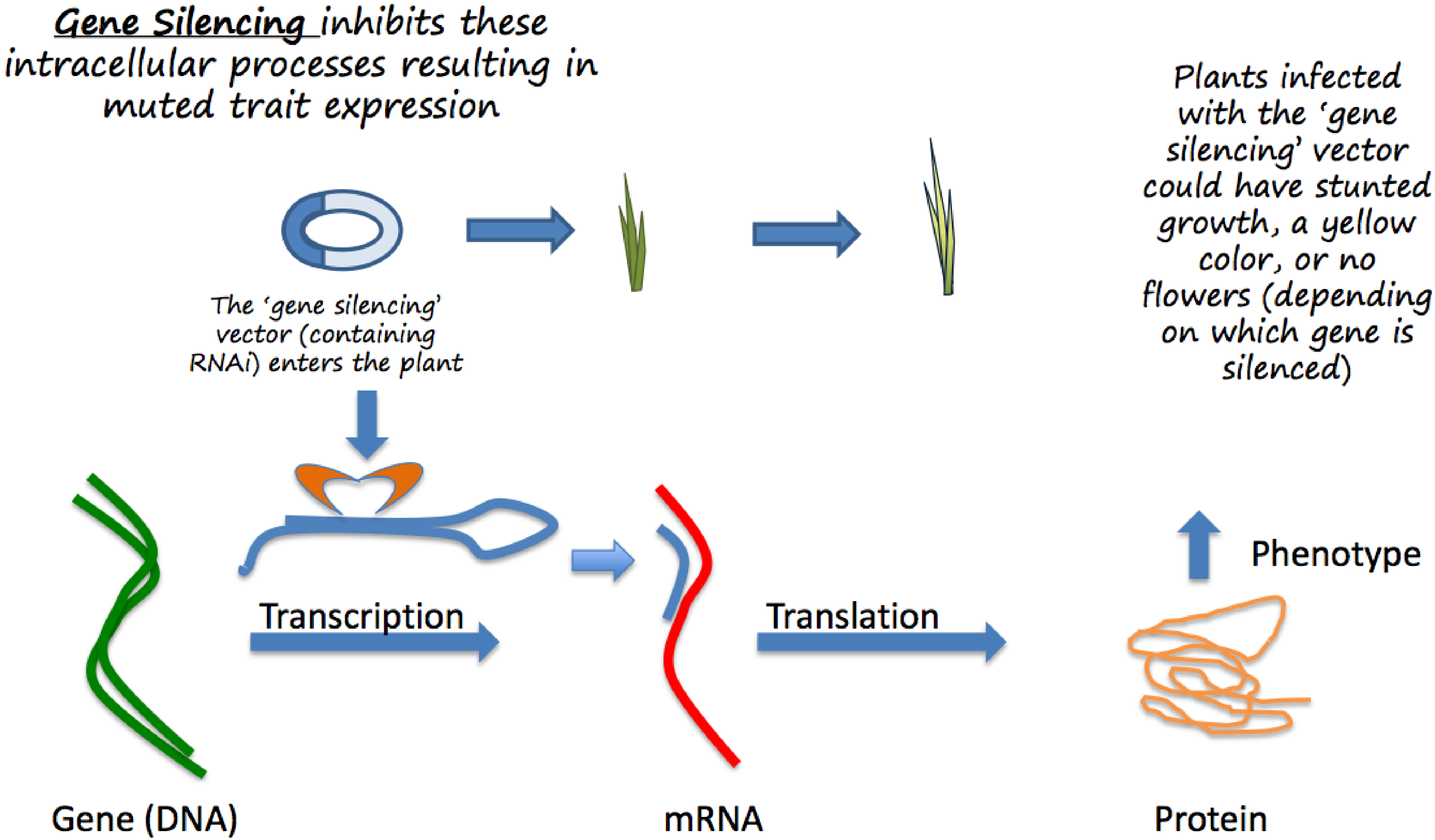
But the research is arousing concern about possible unintended effects on public health and the environment, because once genetically modified insects are released, they cannot be recalled.

Authorities in the Florida Keys, which in 2009 experienced its first cases of dengue fever in decades, hope to conduct an open-air test of the modified mosquitoes as early as December, pending approval from the Agriculture Department.

Oxitec injected DNA into mosquito eggs to modify the species.



Derric Nimmo/Oxitec



from E.M. Golenberg -

http://greatlakesphragmites.net/files/GLC-Webinar.pdf

eLIFE
elifesciences.org
FEATURE ARTICLE

EMERGING TECHNOLOGY

Concerning RNA-guided gene drives for the alteration of wild populations

KEVIN M ESVELT*, ANDREA L SMIDLER, FLAMINIA CATTERUCCIA* AND GEORGE M CHURCH*

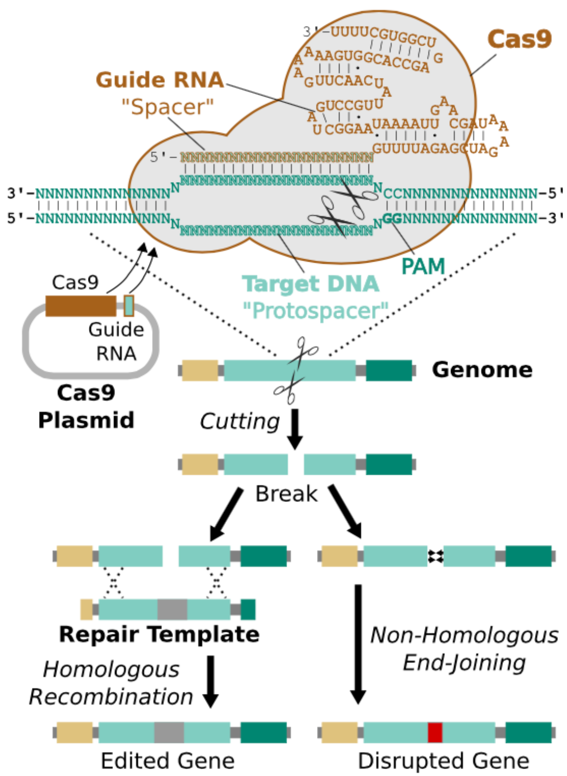


Figure 3. RNA-guided genome editing via Cas9. 1

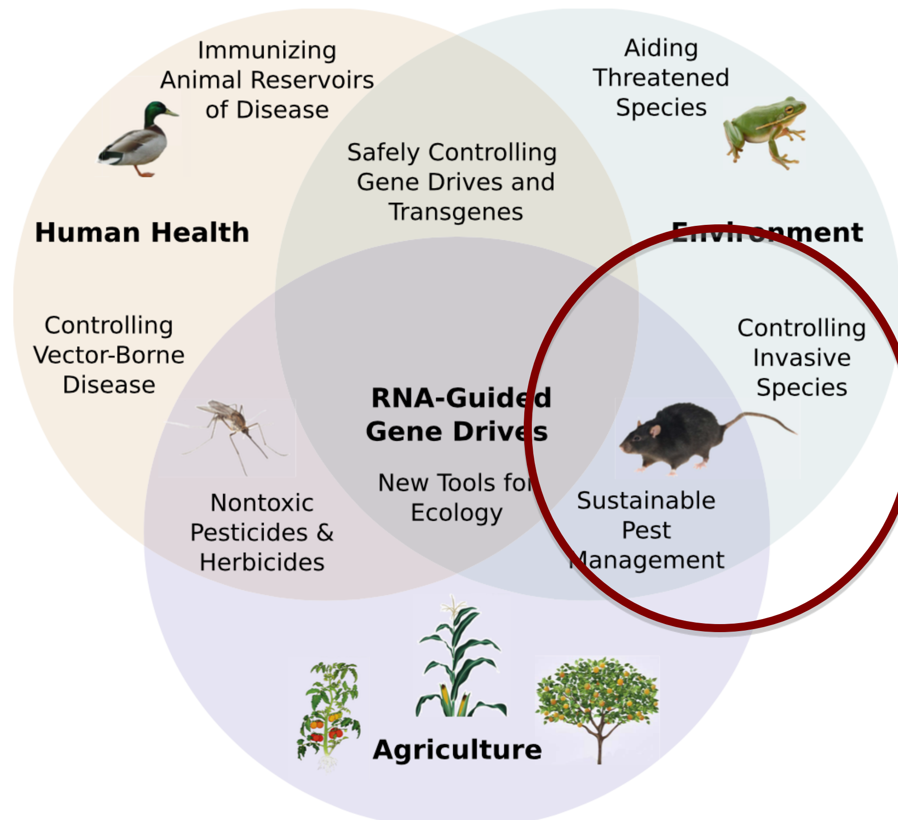


Figure 7. Potential applications of RNA-guided gene drives. Clockwise from left. Disease vectors such as

1) How many introduced species are harmful?

2) Introduced species often increase local biodiversity.

3) Are actions against introduced species xenophobic?

4) Efforts to contain invasions are futile.

5) Animal rights objections to eradication and management of (some) invasive vertebrates.

North American gray squirrel, *Sciurus carolinensis*

rights of species to exist
vs.
rights of individual animals to exist

PeTA
PEOPLE FOR THE ETHICAL TREATMENT OF ANIMALS

The Fund for Animals
we speak for those who can't

1) How many introduced species are harmful?

2) Introduced species often increase local biodiversity.

3) Are actions against introduced species xenophobic?

4) Efforts to contain invasions are futile.

5) Animal rights objections to eradication and management of (some) invasive vertebrates.

NYBG/125

INVASIVE SPECIES SUMMIT:
CHALLENGES, STRATEGIES,
AND PERSPECTIVES

FRI, NOV 6, 2015

Co-presented with Lower Hudson Partnership for Regional Invasive Species Management

LOWER HUDSON PRISM

NEW YORK BOTANICAL GARDEN

Developing Effective Strategies to Mitigate Invasive Species Impacts in Eastern New York Forests

The Nature Conservancy
Protecting nature. Preserving life.™

Chris Zimmerman
The Nature Conservancy

Executive Summary

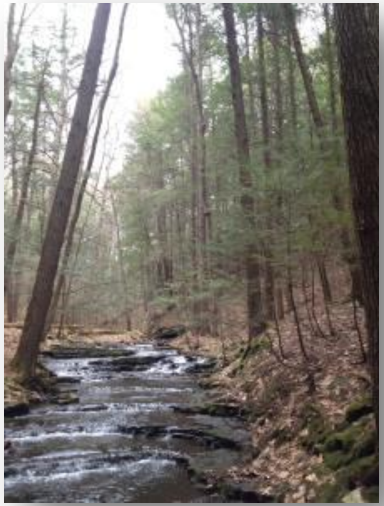
Challenge	Invasive species are increasing and management is complex
Solution	Decision Analysis Tool
Benefit	Higher rate of project success

New York's Forest

- 63% forest cover

  (~ 19 million ac.)
- 24% public forest
- 76% private forest

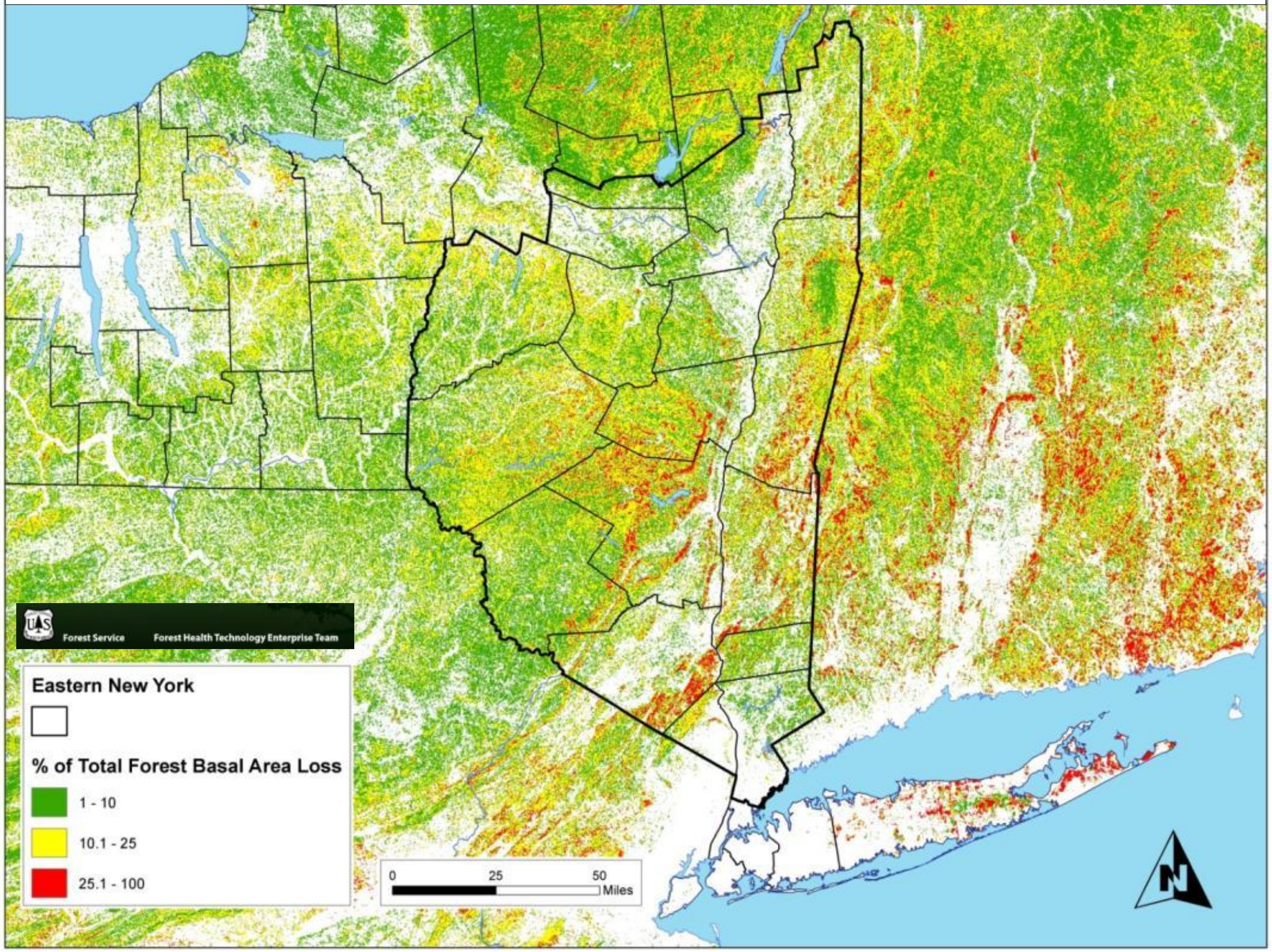
Healthy Forest, Healthy Communities



Challenge – Invasive Pests and Pathogens

2013 – 2027 National Insect and Disease Risk Map



Chestnut blight

Dutch elm disease

Balsam woolly adelgid

Dogwood anthracnose

Emerald ash borer

Gypsy moth

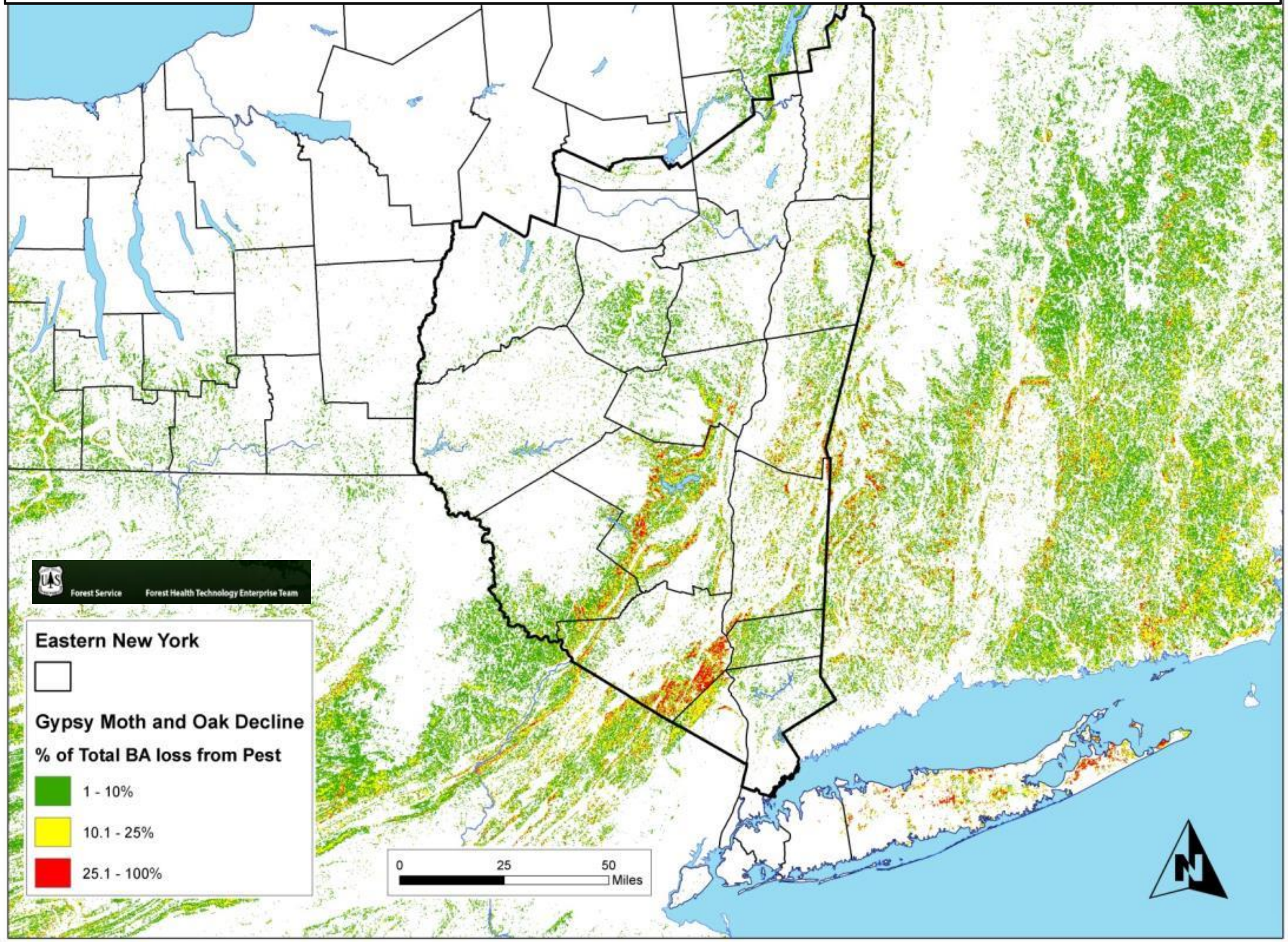
Beech bark disease

Hemlock woolly adelgid

To name a few…

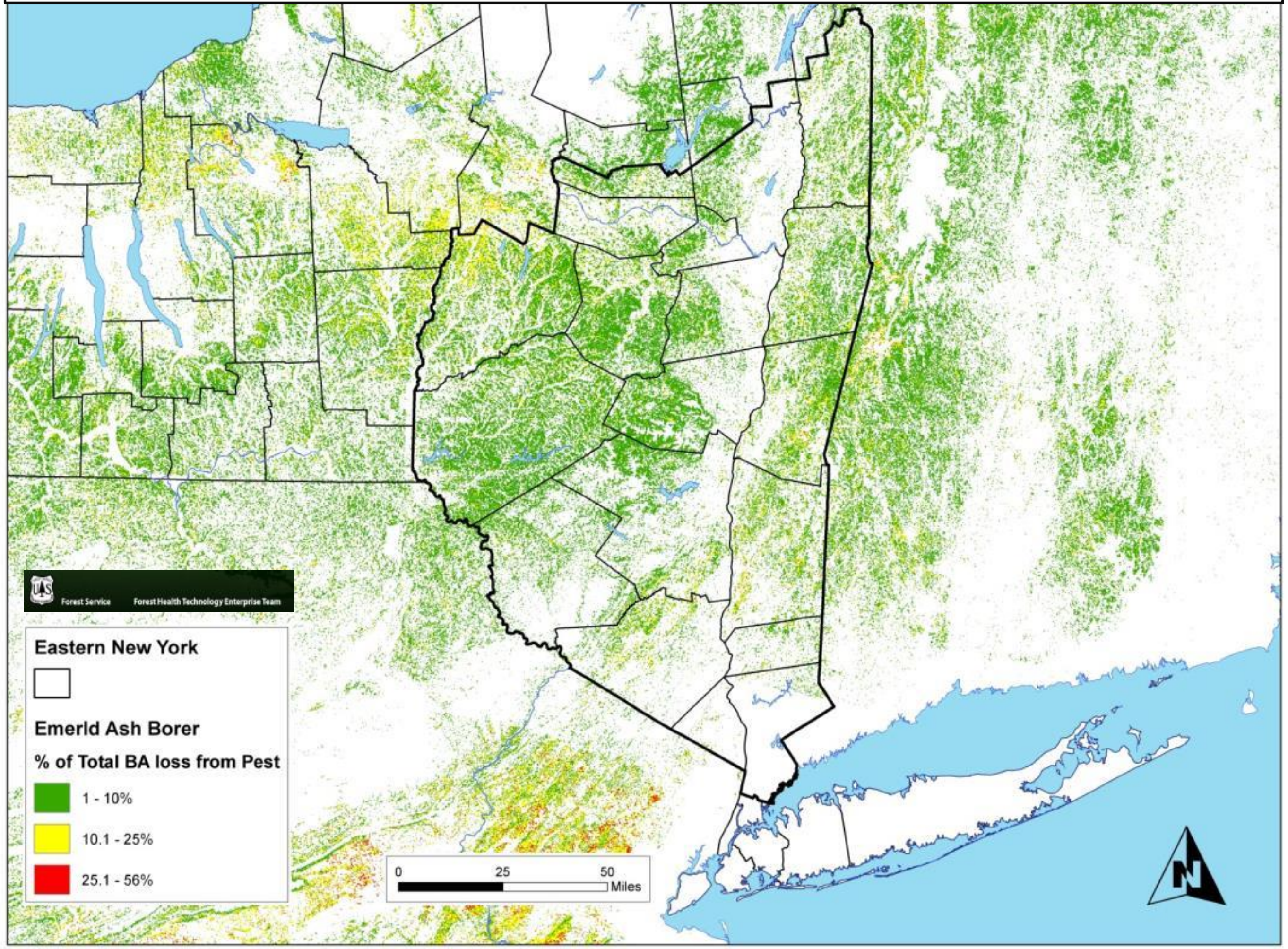
Gypsy Moth and Oak Decline

2013 – 2027 National Insect and Disease Risk Map



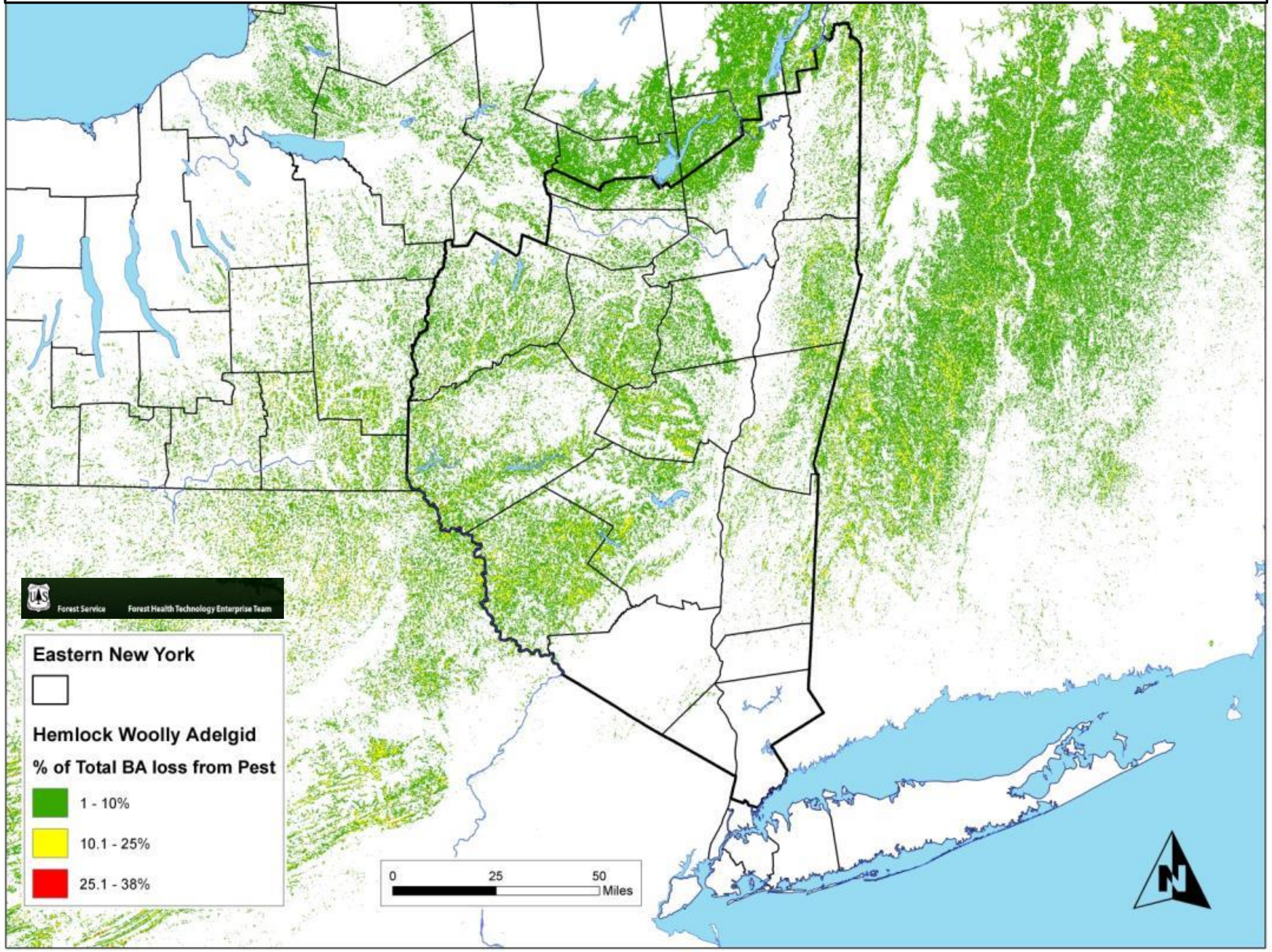
Emerald Ash Borer

2013 – 2027 National Insect and Disease Risk Map



Hemlock Woolly Adelgid

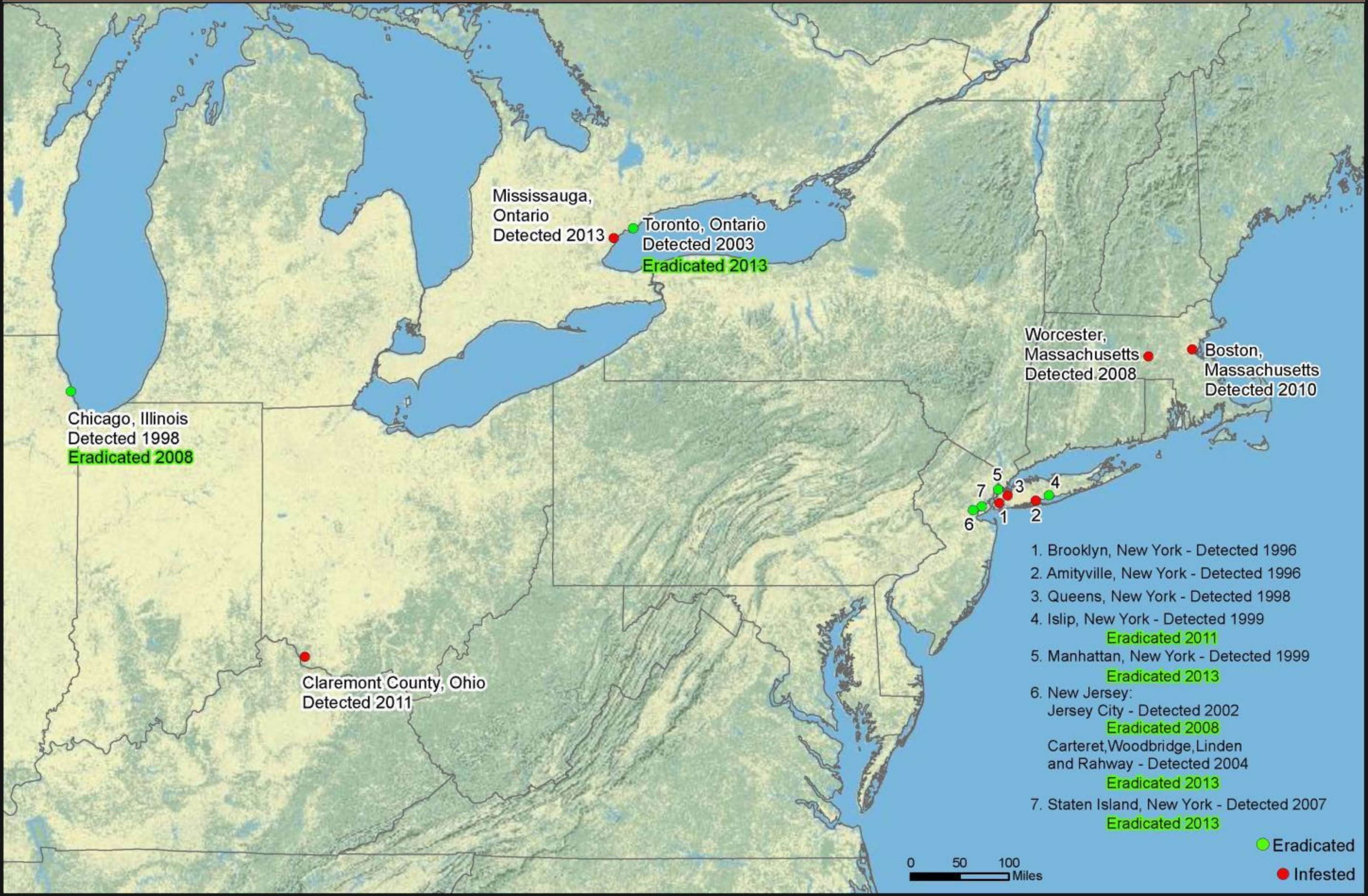
2013 – 2027 National Insect and Disease Risk Map



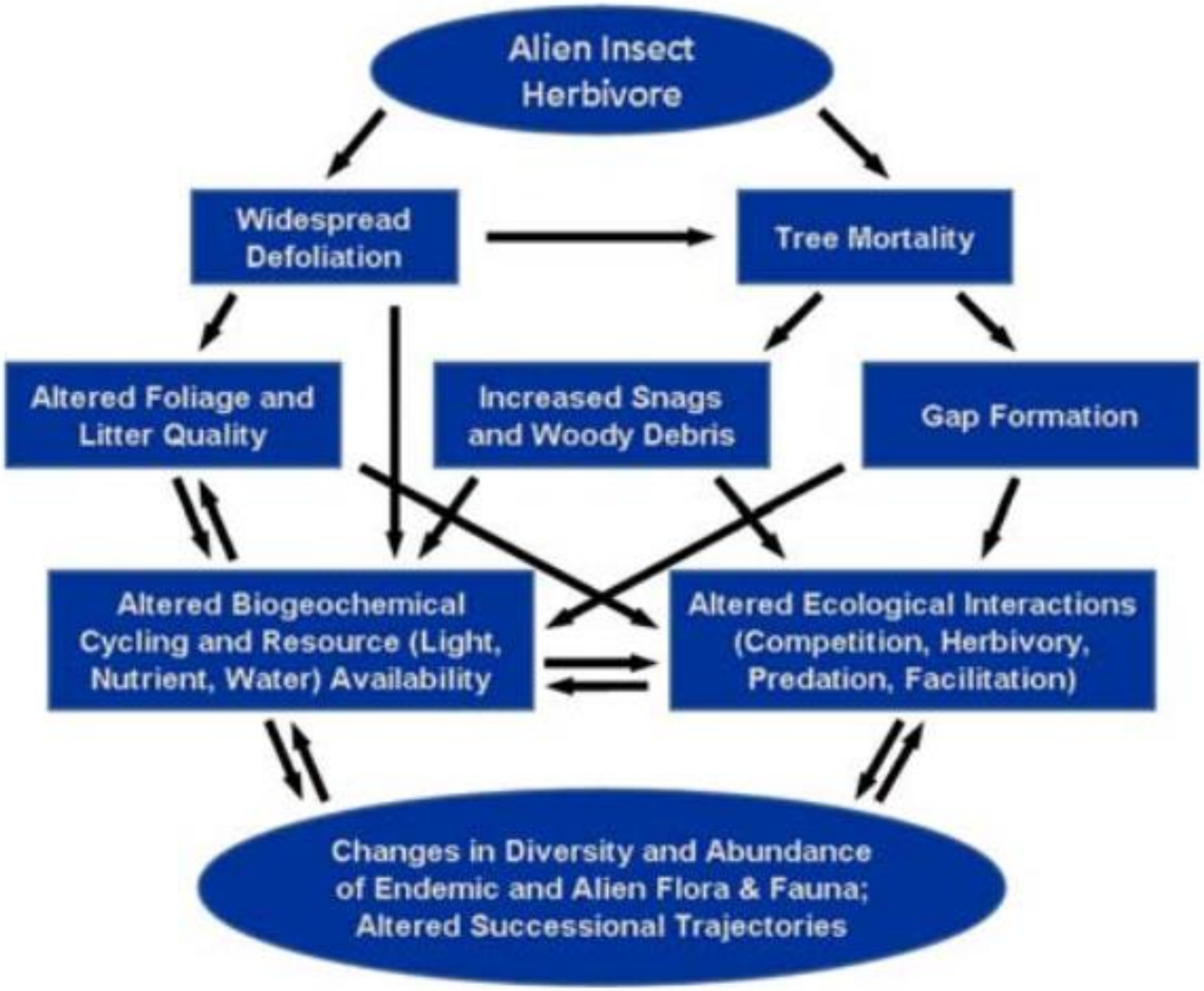
Asian Longhorn Beetle

Asian Longhorned Beetle Infestations in North America

Created: October 27th, 2013



Direct and Indirect Effects

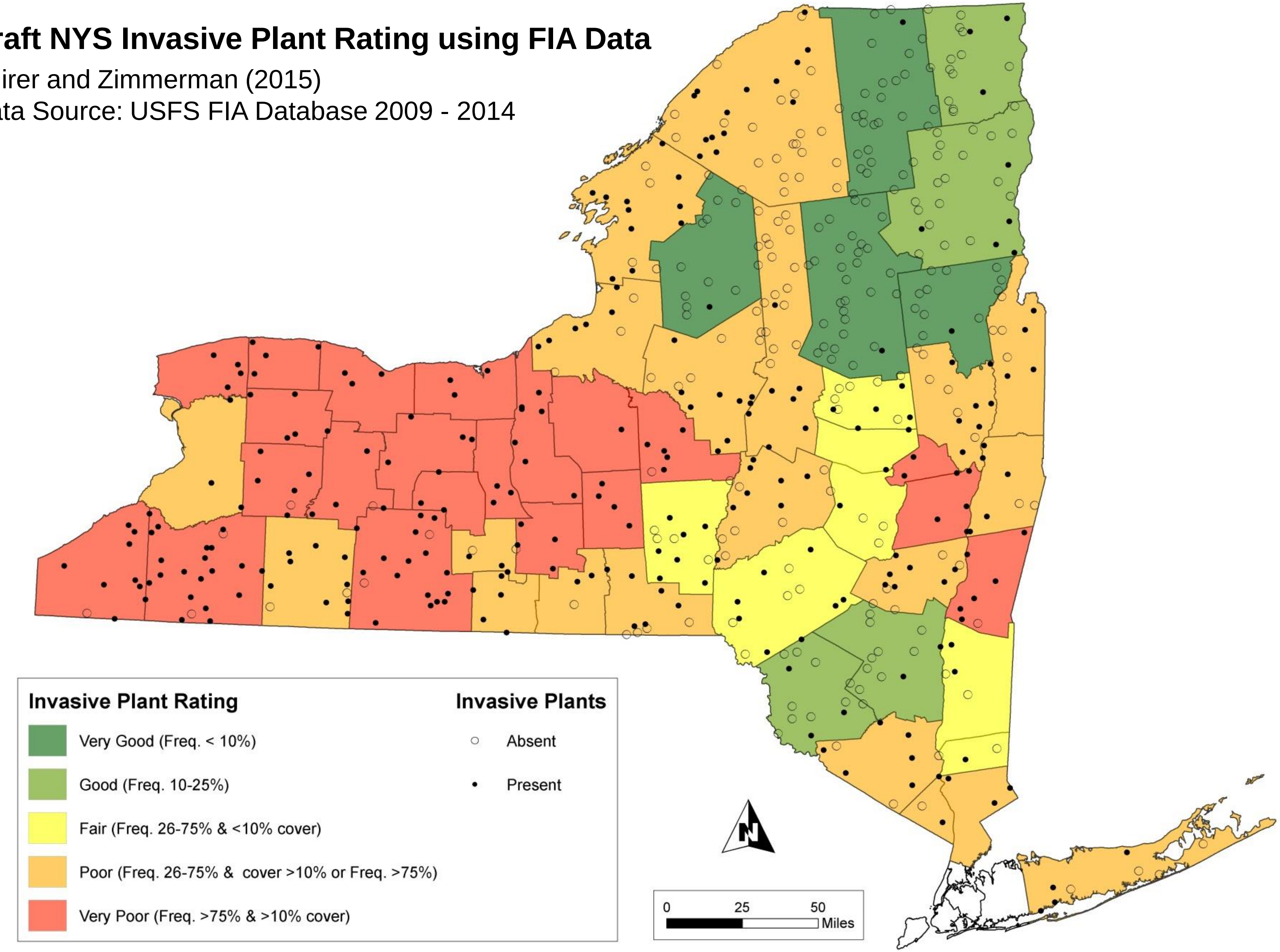


Gandhi and Herms 2010

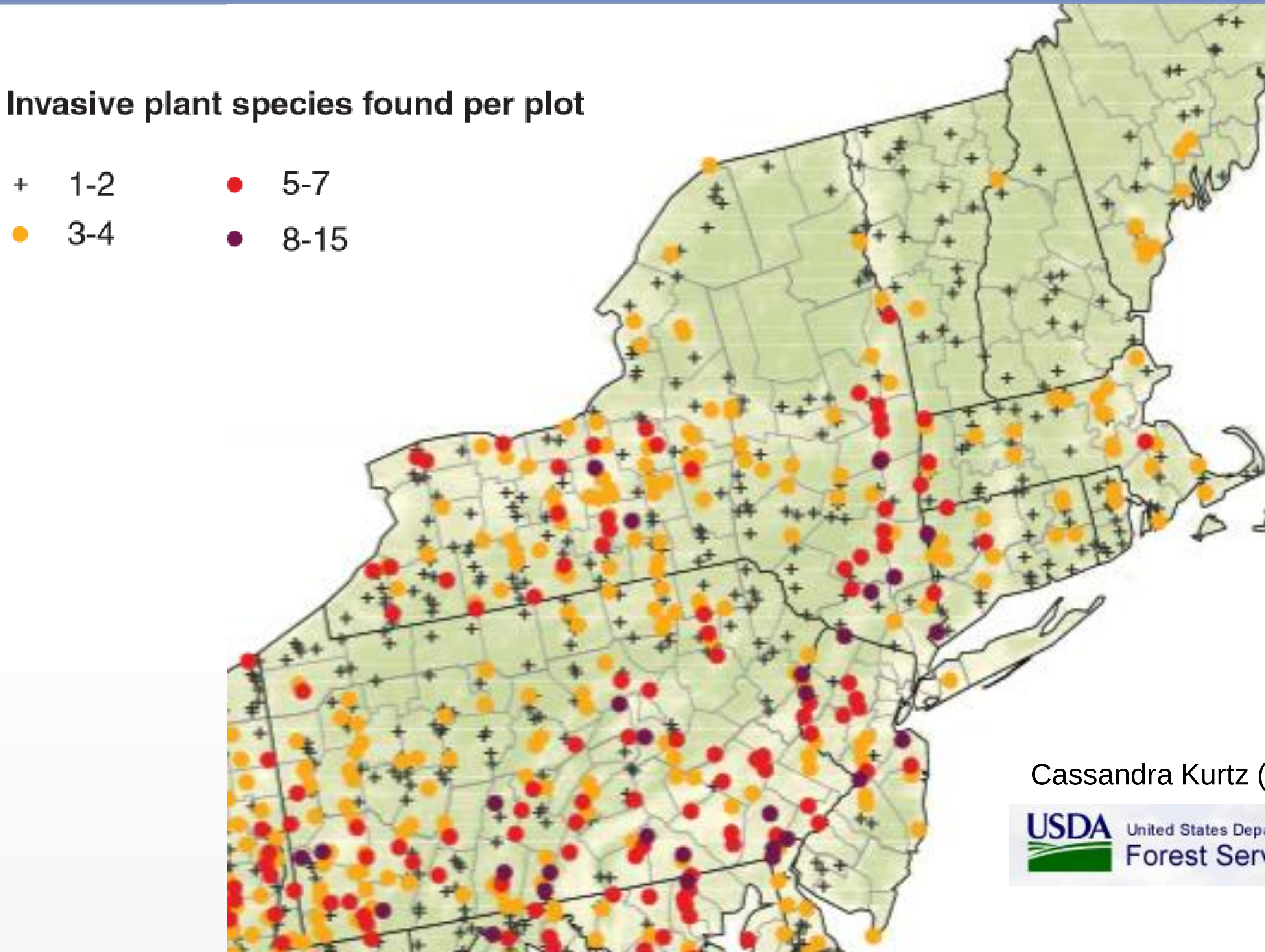
Challenge – Widespread Invasive Plants

Draft NYS Invasive Plant Rating using FIA Data

Shirer and Zimmerman (2015)
Data Source: USFS FIA Database 2009 - 2014



Number of Invasive Plant Species



Cassandra Kurtz (2013)

USDA United States Department of Agriculture Forest Service

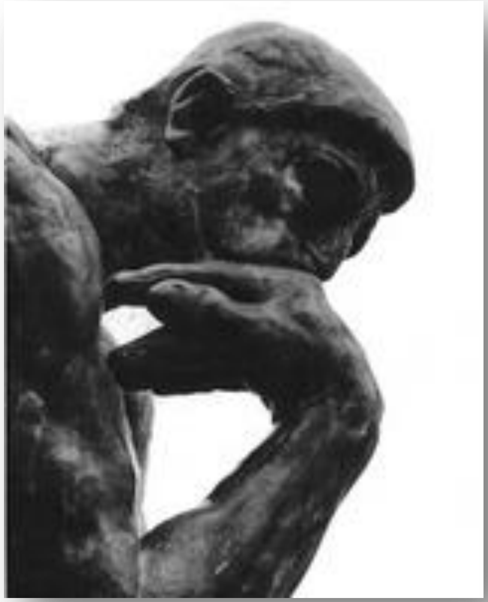
Invasive Plants with Moderate Distribution

Mile-A-Minute Weed (*Persicaria perfoliata*)

Princesstree (*Paulownia tomentosa*)

Invasive Plant Control is Complex

1. Ecological Impact or harm?
2. Effective control technique?
3. Long-term feasibility of invasive plant control given limited funding?
4. Cost/benefit assessed?



Solution - Decision Analysis Tool

INVASIVE PLANT MANAGEMENT
IPMDAT
DECISION ANALYSIS TOOL

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Get Started!

To Control or Not to Control? It's a Difficult Question.

The **Invasive Plant Management Decision Analysis Tool** (IPMDAT) helps natural resource managers to determine if an invasive plant control project is likely to be successful and if it warrants an investment of their agency's or organizations resources.

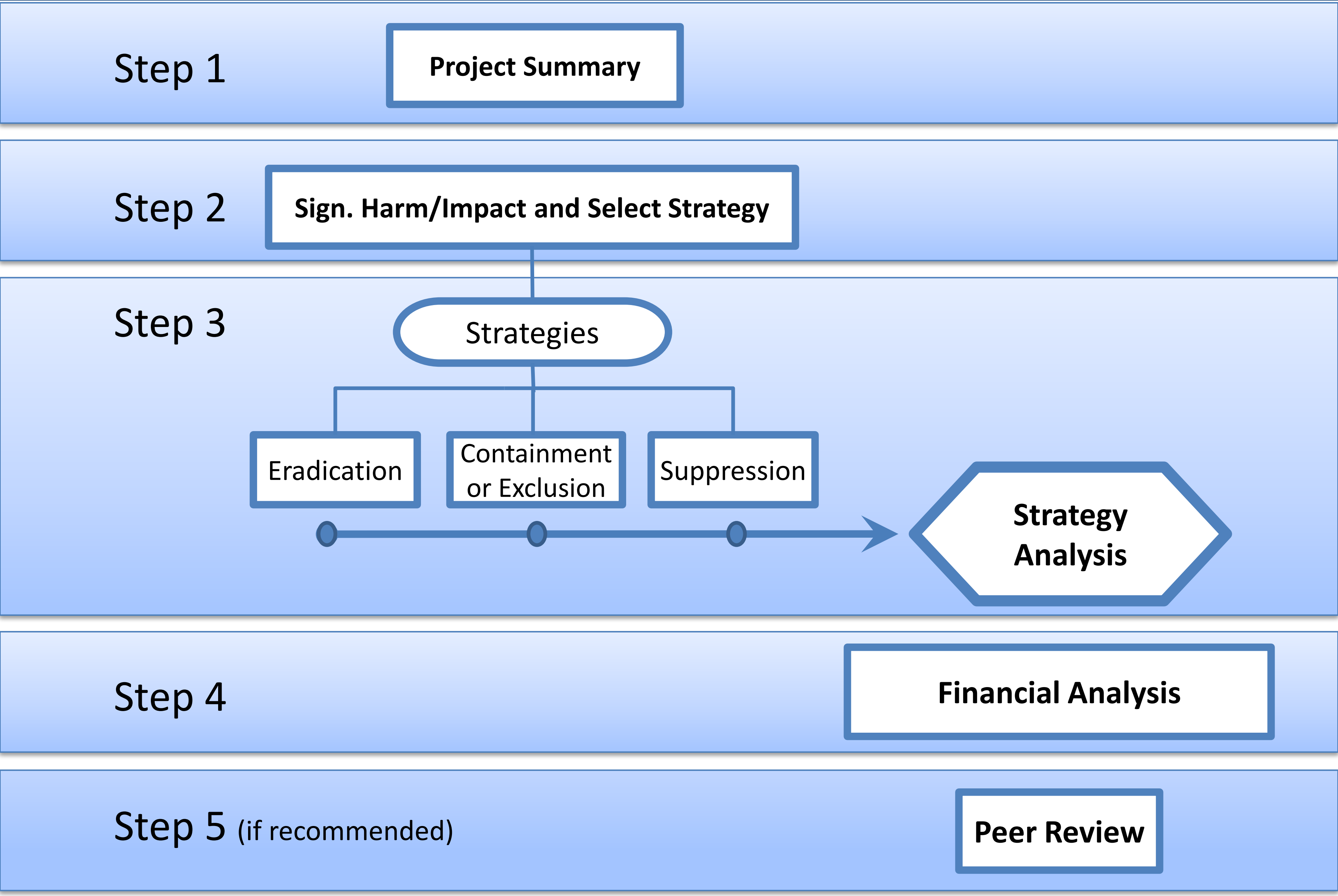
To justify spending resources on an invasive plant control project:

- The invasive species must cause serious environmental or economic harm or harm to human health.
- The project should be feasible.
- The project should give a good return on the investment of resources.

In practice, it is often difficult to decide if all these criteria are met. The IPMDAT helps guide the decision to control or not to control. Using this tool makes decisions on invasive plant control more transparent, understandable, and fully documented and ensures that resources will be used effectively.

Is the project feasible? Is there a good return on investment?

IPMDAT Steps



Step 1 – Project Summary

PROJECT BACKGROUND	STRATEGY SELECTION	STRATEGY ANALYSIS	FINANCIAL ANALYSIS	SUMMARY

View Help File

Your Name & Organization:	Chris Zimmerman, The Nature Conservancy, Eastern New York
Today's Date:	7-15-2014
Scientific Name:	Polygonum cuspidatum; Fallopia japonica var. japonica
Common Name: (Click to lookup after the scientific name is chosen)	Japanese Knotweed
Project Scale:	Local (< 2,000 Acres)
CISMA/CWMA/PRISM:	Catskills Regional Invasive Species Partnership
Project Area (site) Name:	Neversink Preserve

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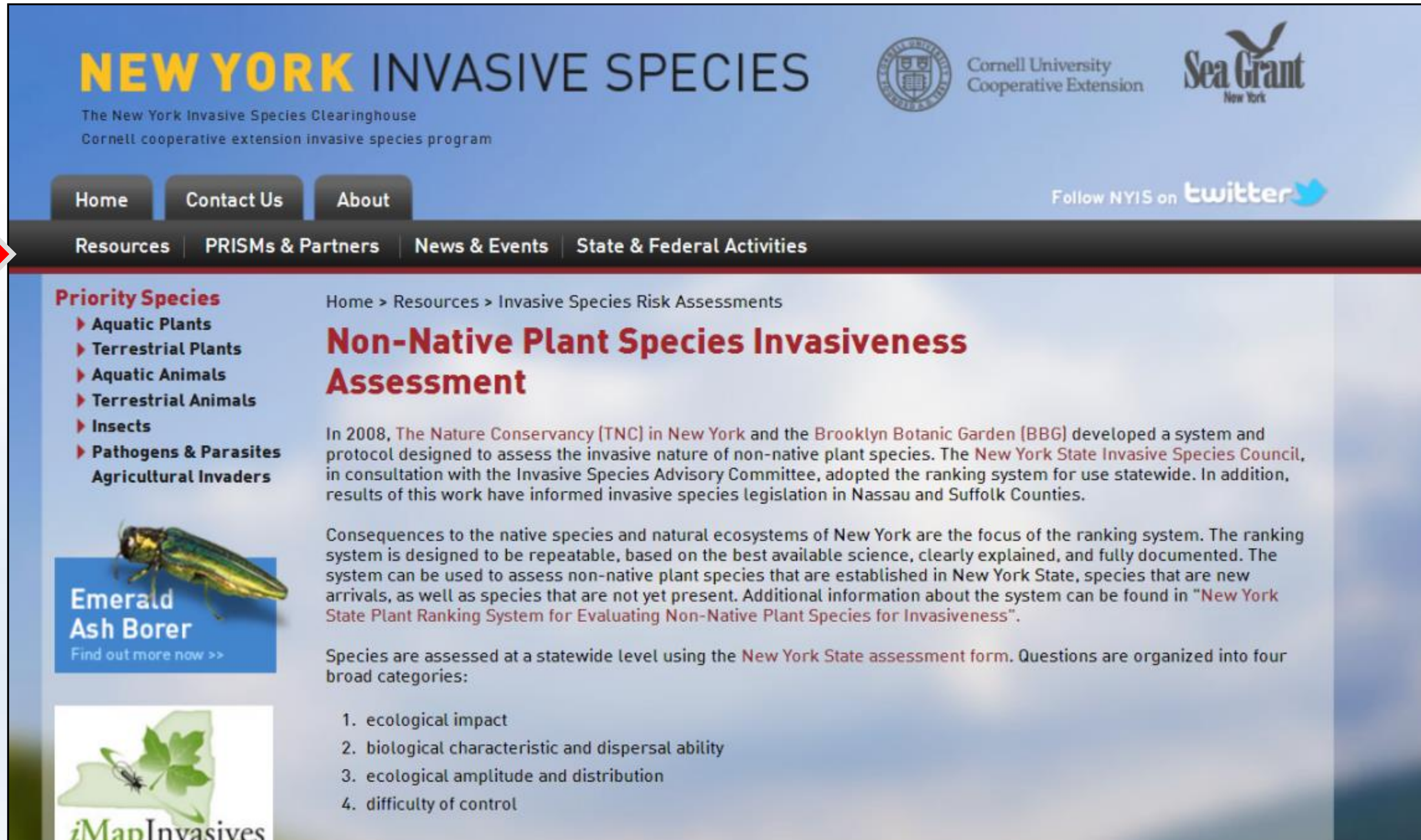
Step 2 - Ecological Impact?

NYS Invasive Plant Rankings - **www.nyis.info**

Resources Tab



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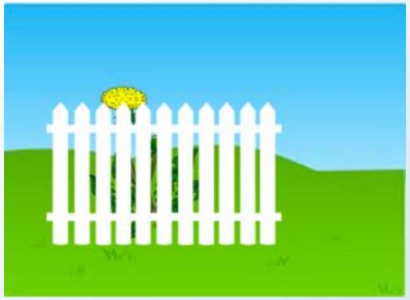
Step 2 - Strategy Selection

Eradication

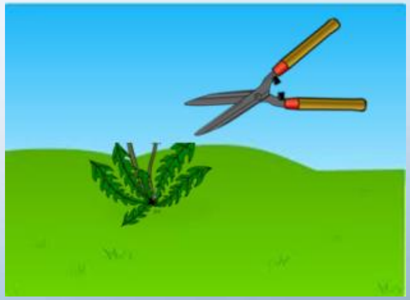
- ***Goal* – Eliminate all individuals and seeds.**
- Low likelihood of species returning (10 year timeframe).
- Greatest success for small infestations (< 2.5 acres).

Exclusion or Containment



- ***Goal* – Prevent infestation from spreading to uninfested areas.**
- Best for slow spreading species and when effective barriers exist.
- May require long term management.

Suppression



- ***Goal* – reduce cover or density to a level that maintains native species or ecosystem processes.**
- May require long term management.

Step 3 – Strategy Analysis

PROJECT BACKGROUND | STRATEGY SELECTION | **STRATEGY ANALYSIS** | FINANCIAL ANALYSIS | SUMMARY

View Help File

Containment - Effective Control Method

Select One: **Is there a method available to eliminate small patches (e.g. 0.25 hectare, 0.62 acres) of the invasive and the seed bank within a sufficient timeframe to maintain a successful rapid response program?**

Satellite occurrences must be eliminated at a rate faster than they occur. Consider the number of treatments required to kill the largest plants and longevity of seed or vegetative propagules in the soil.

- [x] Yes
- [ ] No
- [ ] Uncertain

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1. Social Political Environment Suitable?

A. Is social resistance to control expected (i.e. use of herbicides)?

B. Within the invaded area, do all key agencies, organizations and/or landowners agree to participate?

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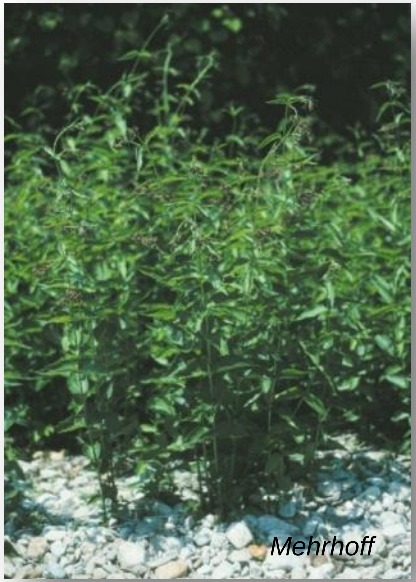
2. Is the Species Difficult to Detect?

A. Is the species always inconspicuous within the matrix vegetation?

B. Detectability and search- time main factor influencing cost.



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3. Can Reinvasion be Prevented?

Are spread prevention measures and EDRR underway and funded for 2 years?

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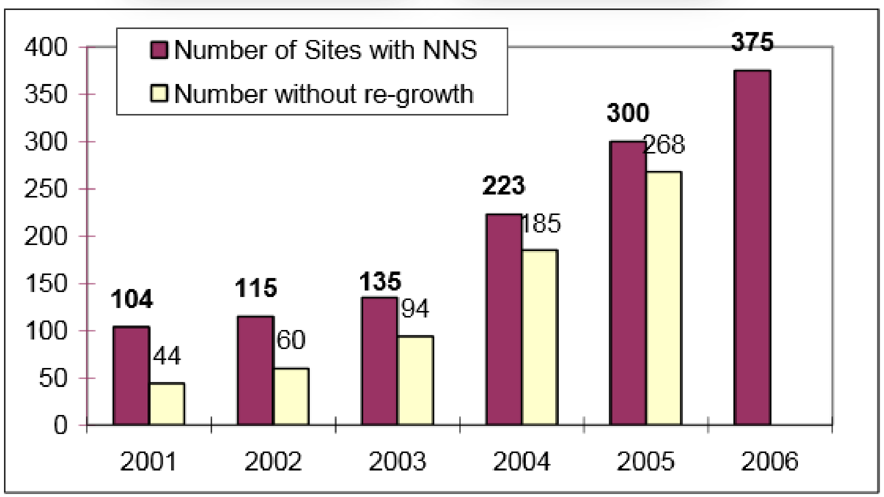
4. Effective Control Method?

Knotweed - Sandy River Oregon

Can small infestations be eliminated?



Soll et al. 2008

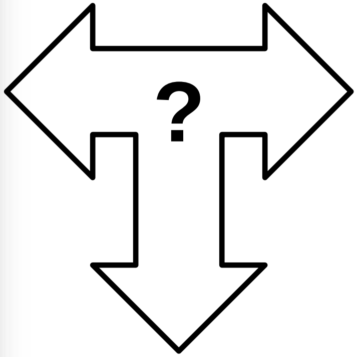
Japanese Barberry - CT

Second treatment	Mortality'	
None	14%	a
Propane torch	39%	b
Glyphosate	90%	c
Triclopyr	96%	c

Ward et al. (2009) Forest Ecology and Mgt.

5. Non-target impacts or Unintended Consequences?

Bush Honeysuckle



Barberry

Garlic Mustard

Stiltgrass

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Step 4 - Resources Available?

INVASIVE PLANT MANAGEMENT
IPMDAT
DECISION ANALYSIS TOOL

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PROJECT BACKGROUND | STRATEGY SELECTION | STRATEGY ANALYSIS | FINANCIAL ANALYSIS | SUMMARY

View Help File

Assessing Resource Availability

Is funding for core operations secure for at least two years, and the project has undertaken the necessary financial planning and achieved partial success in developing sources of long-term funding to sustain core costs for the next 5 years?

- [x] Yes
- [ ] No
- [ ] Uncertain

Return on Investment?

High Cost and Low Benefit **(Do not proceed)**	High Cost and High Benefit **(Peer Review)**
Low/Moderate Cost and Low Benefit **(Peer Review)**	Low/Moderate Cost and High Benefit **(Proceed)**

Cost

Benefit

Strategy: Containment (Project Scale)

Proceed

Project Background

Assessor(s):	Chris Zimmerman, The Nature Conservancy, Eastern New York
Date:	7-15-2014
Scientific Name:	Polygonum cuspidatum; Fallopia japonica var. japonica
Common Name:	Japanese Knotweed
Project Scale:	Local (< 2,000 Acres)
CISMA/CWMA/PRISM:	Catskills Regional Invasive Species Partnership
Project/Site Name:	Neversink Preserve and adjacent Nowak parcel
Size:	710 Acres
Project Area Description:	The project area encompasses the Neversink Preserve and Norwak parcel. A small Japanese knotweed patch (0.06ac, 50ft x 50ft) was observed on the border of the Neversink Preserve and Norwak parcel in 2012 after a major flooding event (see attached map). Knotweed had not been previously seen within the 625 acre preserve.

Recommendations and Benefits

Adopt tool as common standard for invasive plant control project review.

1. Minor time commitment.

2. Increase probability of successful projects.

3. Method to document decisions.

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Adapt and Learn

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Questions?

NYBG/125

INVASIVE SPECIES SUMMIT:
CHALLENGES, STRATEGIES,
AND PERSPECTIVES

FRI, NOV 6, 2015

Co-presented with Lower Hudson Partnership for Regional Invasive Species Management

LOWER HUDSON PRISM

NEW YORK BOTANICAL GARDEN

Restoration Targets
in a Changing Biotic Landscape

Steven N. Handel
Rutgers University
handel@aesop.rutgers.edu

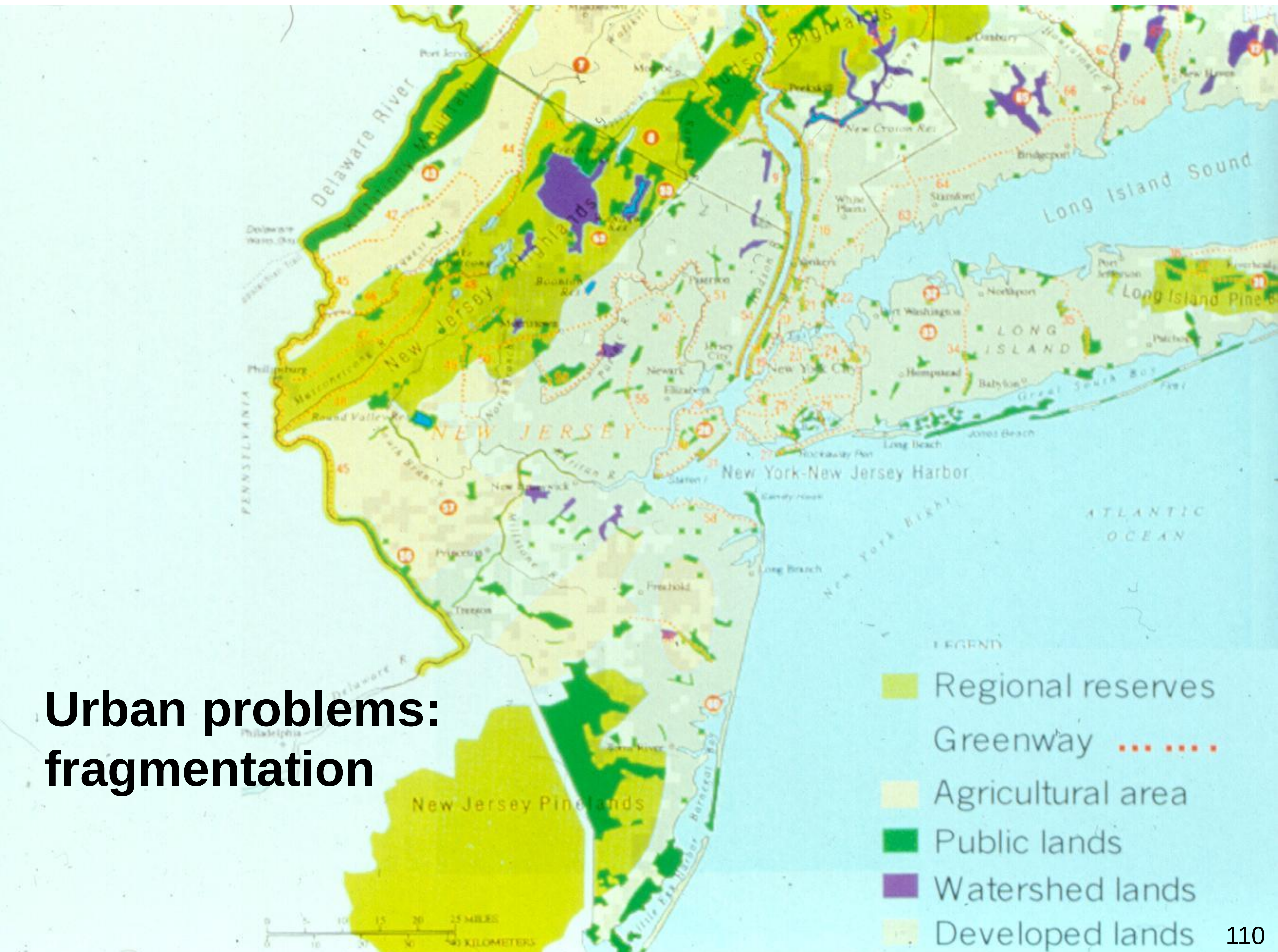

THE PORT AUTHORITY
CB SUSSEX
MAGTECH

Ecosystem Services:

Benefits Supplied by Natural Ecosystems

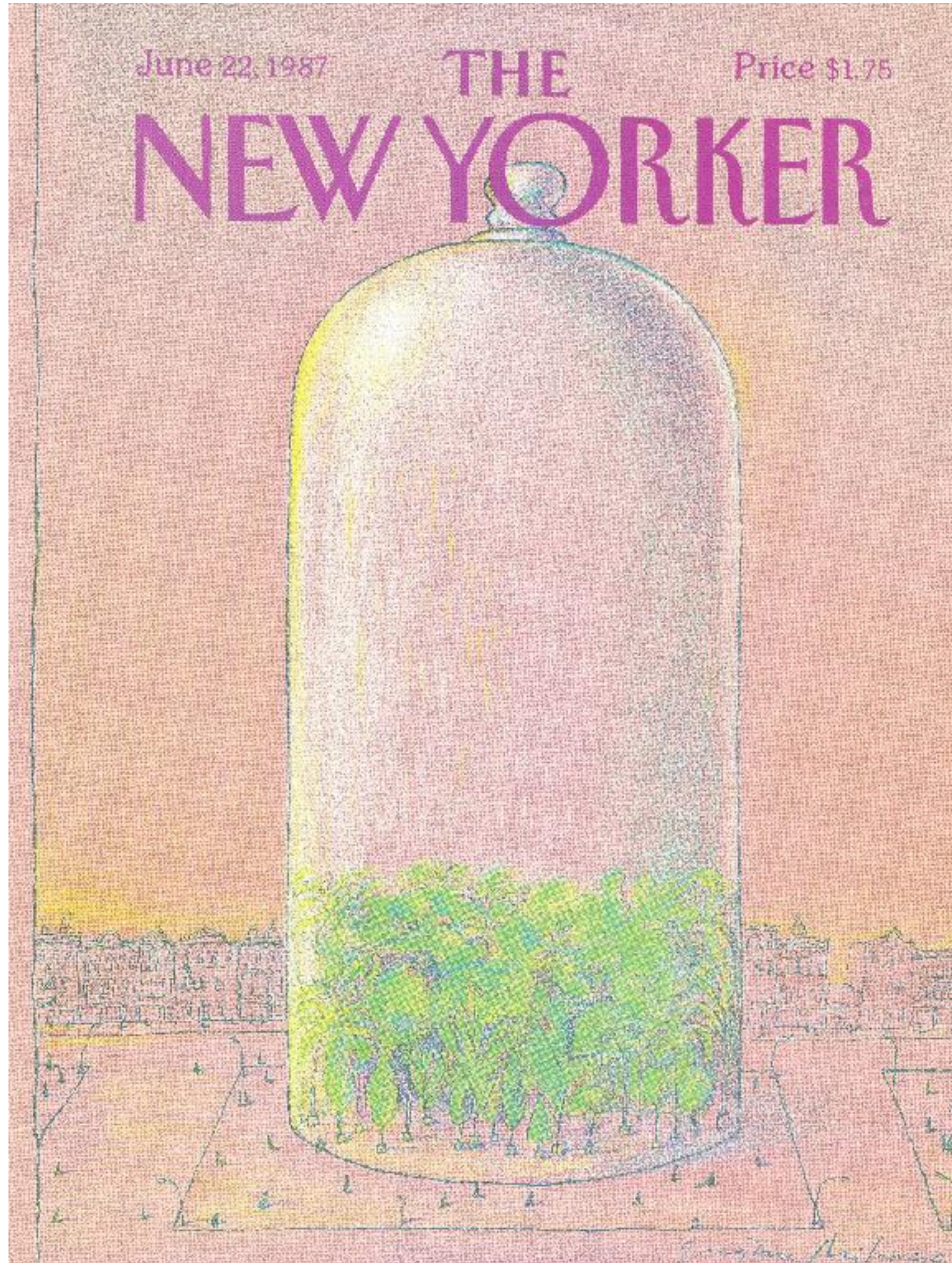
- Purification of air and water
- Mitigation of droughts and floods
- Generation and preservation of soils
- Cycling and movement of nutrients
- Partial stabilization of climate
- Support of agriculture, fisheries………

ESA *Issues in Ecology*, #2, 1997

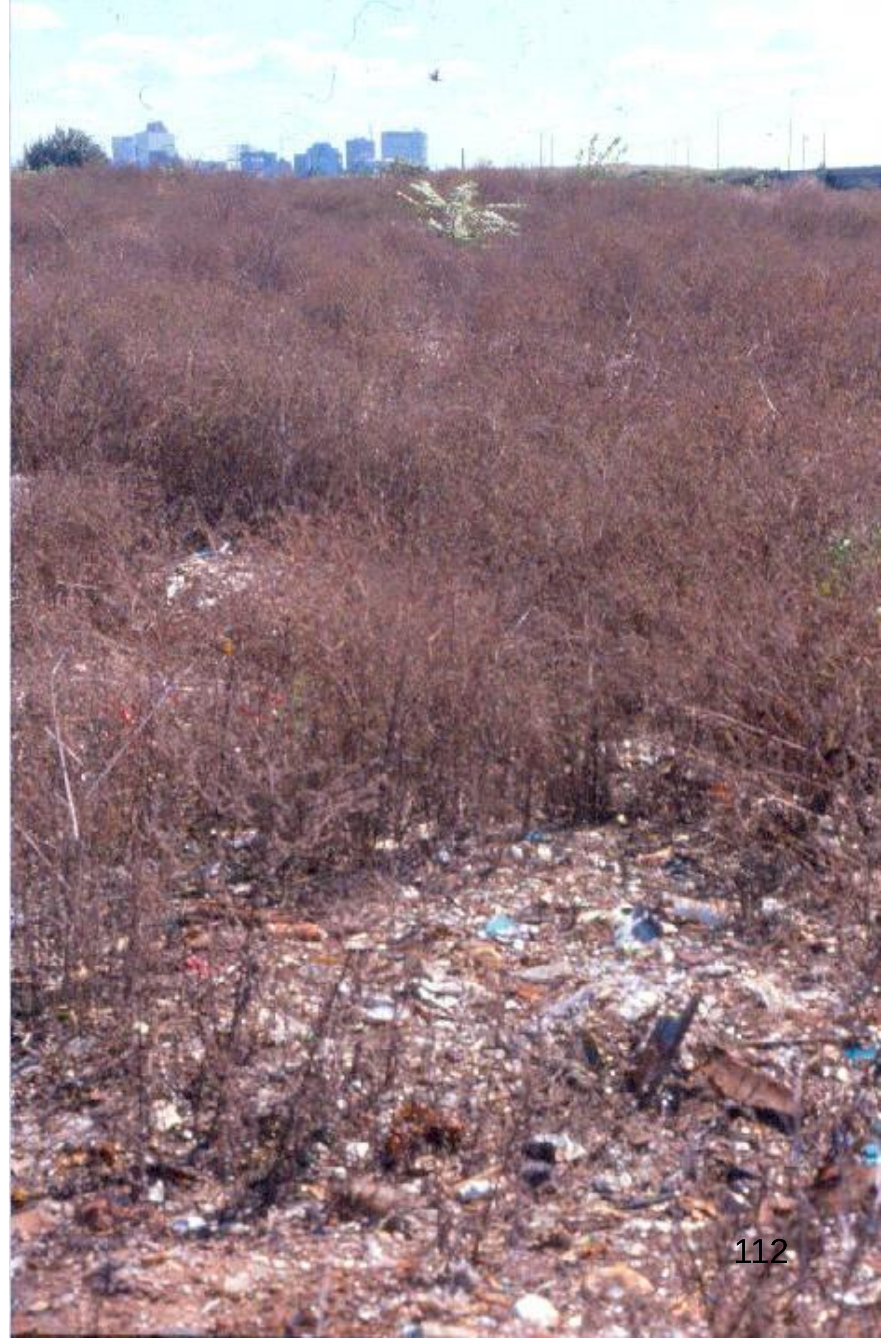


Urban problems: fragmentation

Urban problems: Heat island effect & climate change



Urban problems: Degraded landscapes

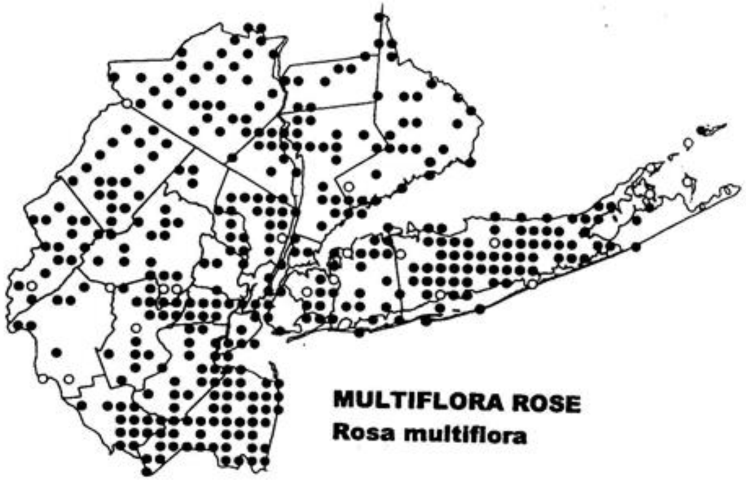


Urban Soils

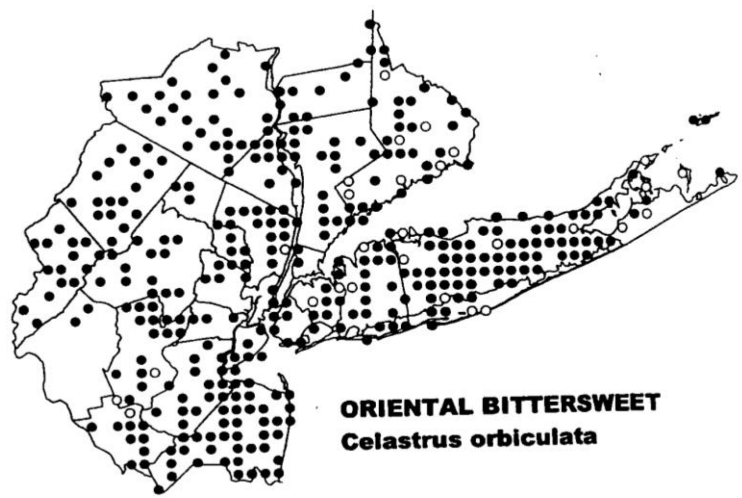
- Variable
- Compaction
- Hydrophobic crust
- Elevated pH
- Restricted aeration and water drainage
- Nutrient cycling and soil organisms
- Pollution
- Higher soil temperature

Urban problems: troublesome new species

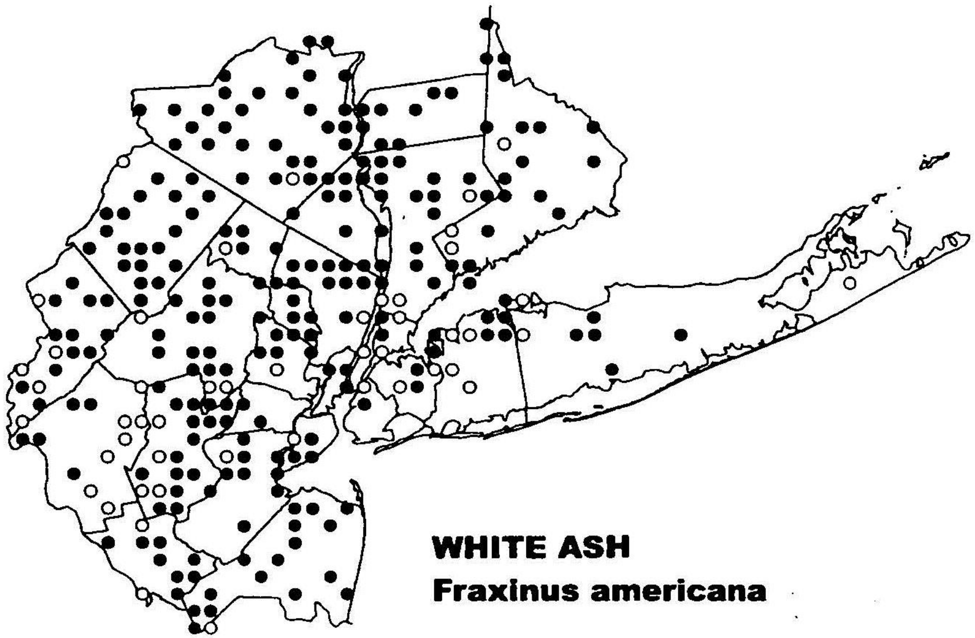
Microstegium vimineum – **Japanese stiltgrass**



MULTIFLORA ROSE
Rosa multiflora



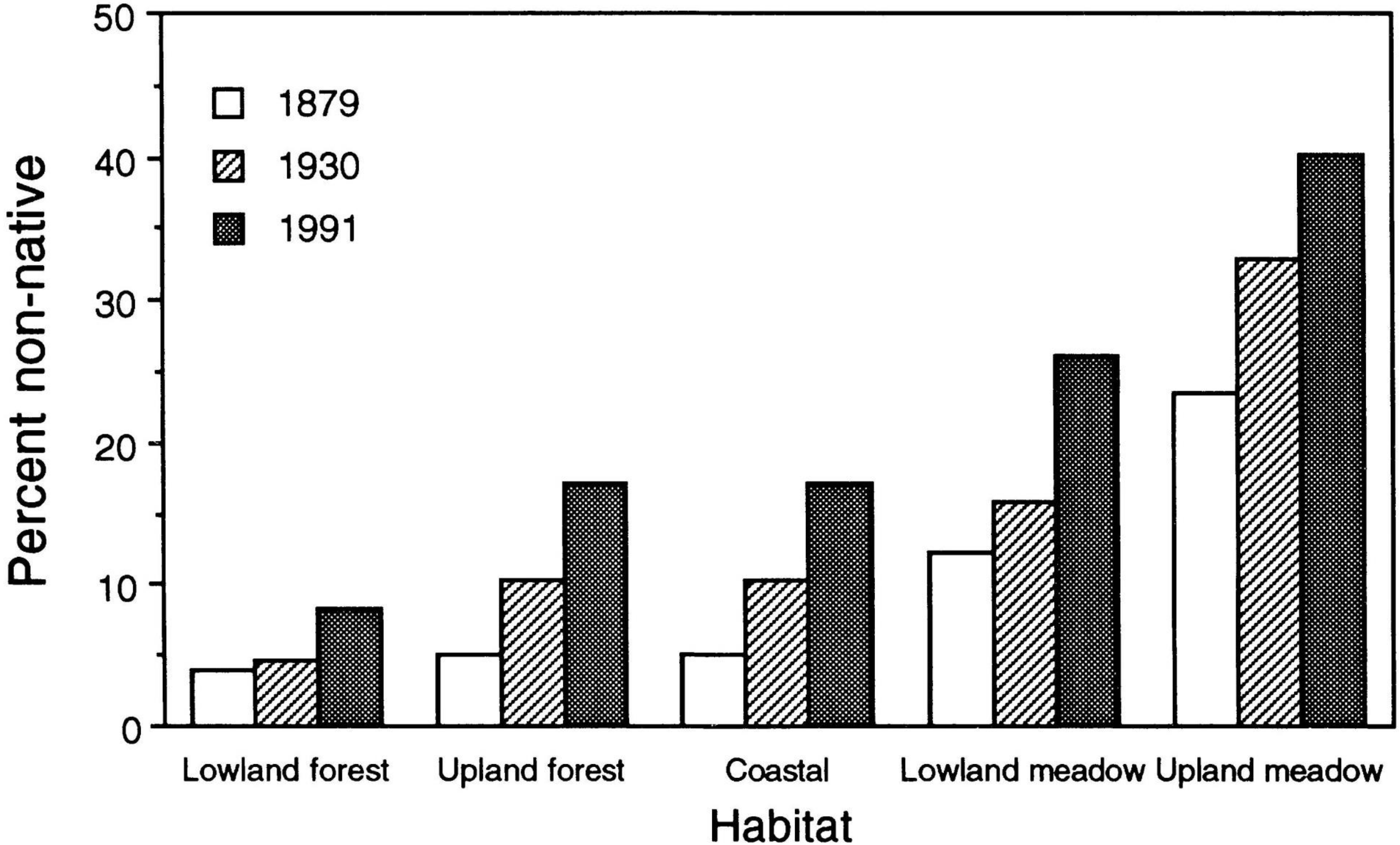
ORIENTAL BITTERSWEET
Celastrus orbiculata



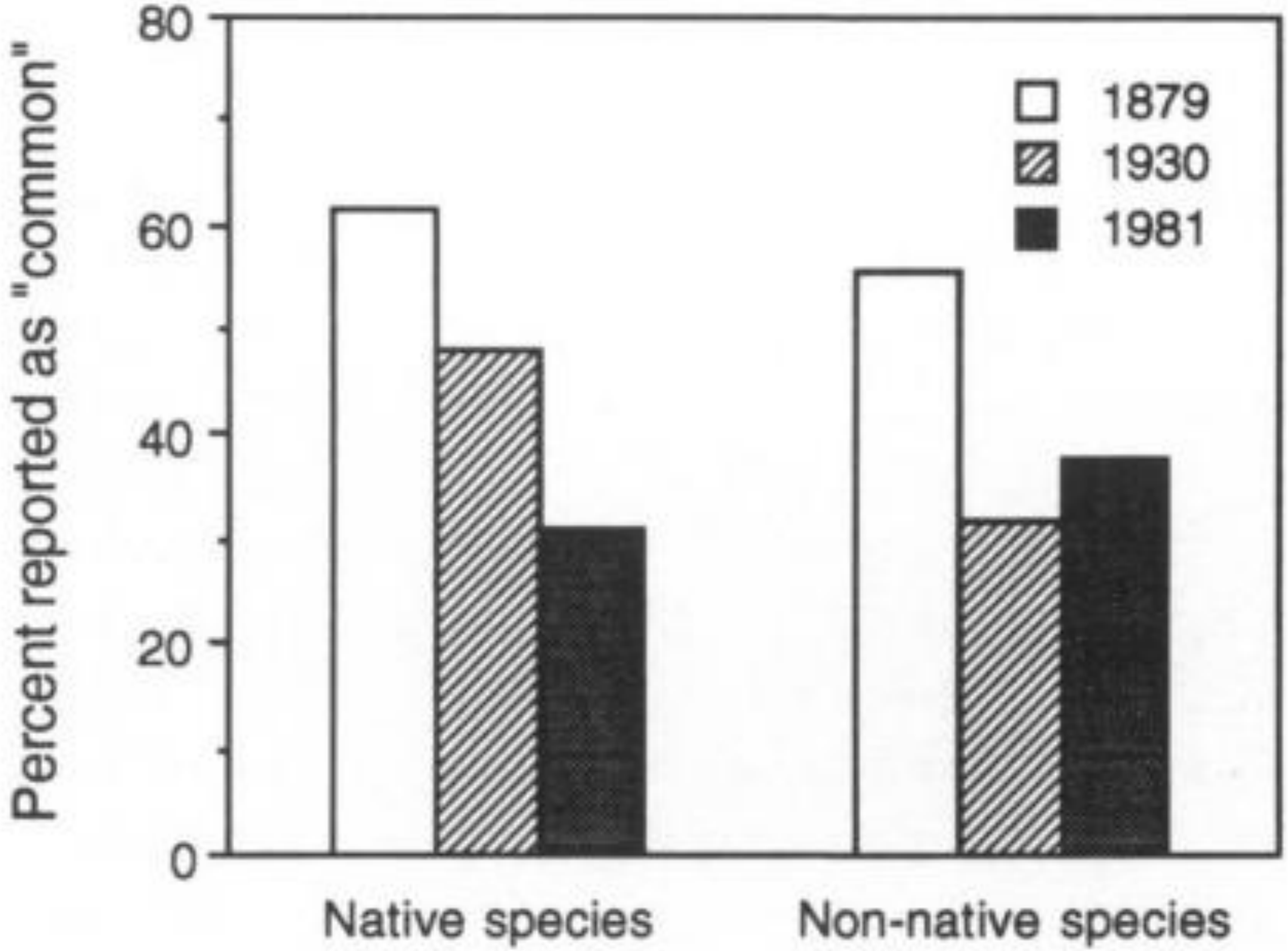
WHITE ASH
Fraxinus americana

Green, lush, dying

Urban problems: what is the ecological target?



Bulletin Torrey Bot. Club **121:119**



Bulletin Torrey Bot. Club 121:119

Fresh Kills Landfill, NYC

New ecological links:

Will seed dispersers come?

Fresh Kills Landfill Demonstration Plantings

Hackberry	*Celtis occidentalis*
Sumac	*Rhus copallina*
Shadblow	*Amelanchier canadensis*
Beach plum	*Prunus maritima*
Blueberry	*Vaccinium corymbosum*
Blackberry	*Rubus allegheniensis*
Wild rose	*Rosa nitida*

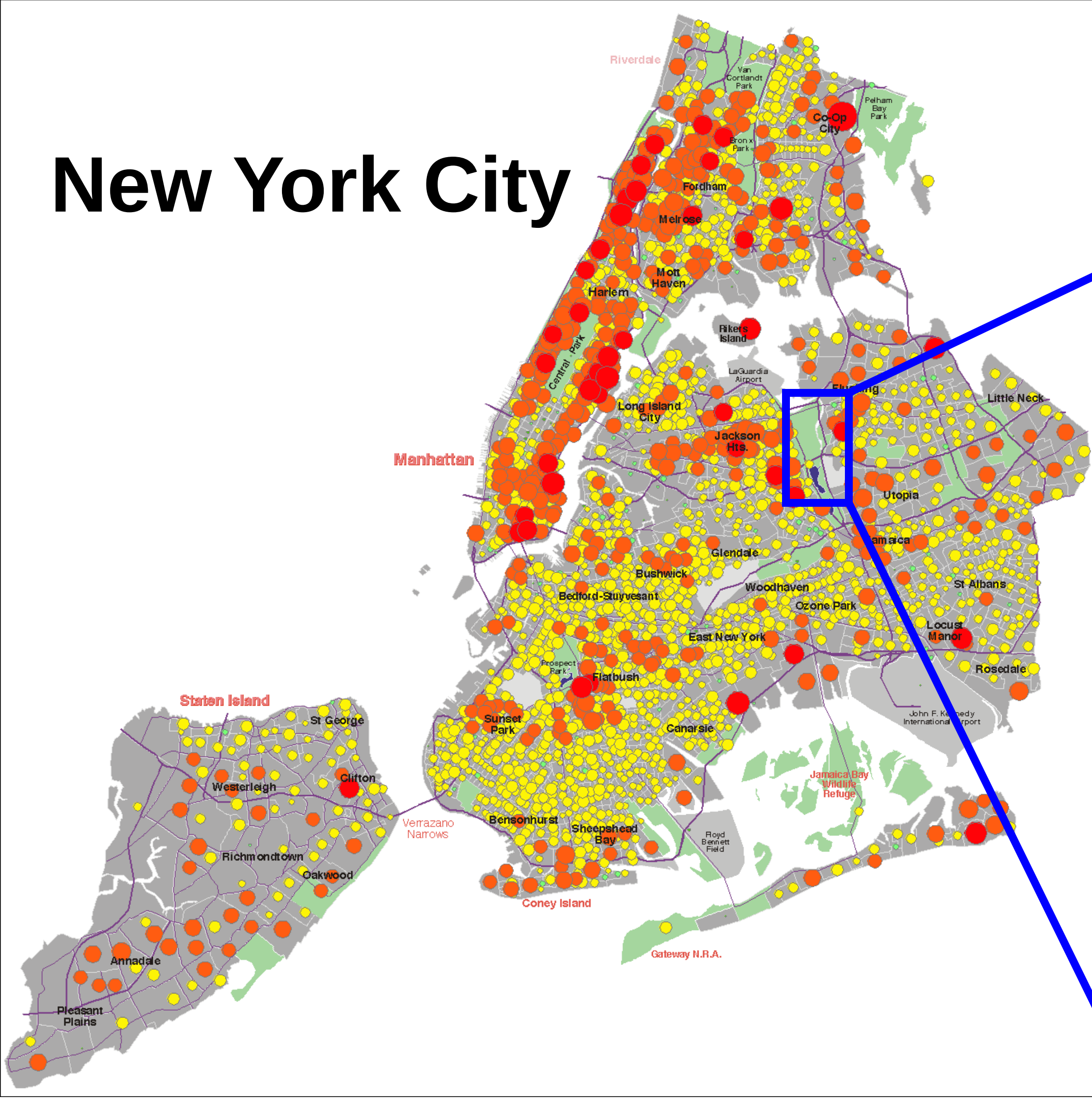
Number of woody plant seeds collected by species from all of the seed traps at the NSF site from August - November 1994

Virginia Creeper	7,581
Arrowwood	3,113
Black Gum	1,440
Winged Sumac	957
Bayberry	457
Sassafras	205
+14 others	730
TOTAL	14,483
Outside Plots	14

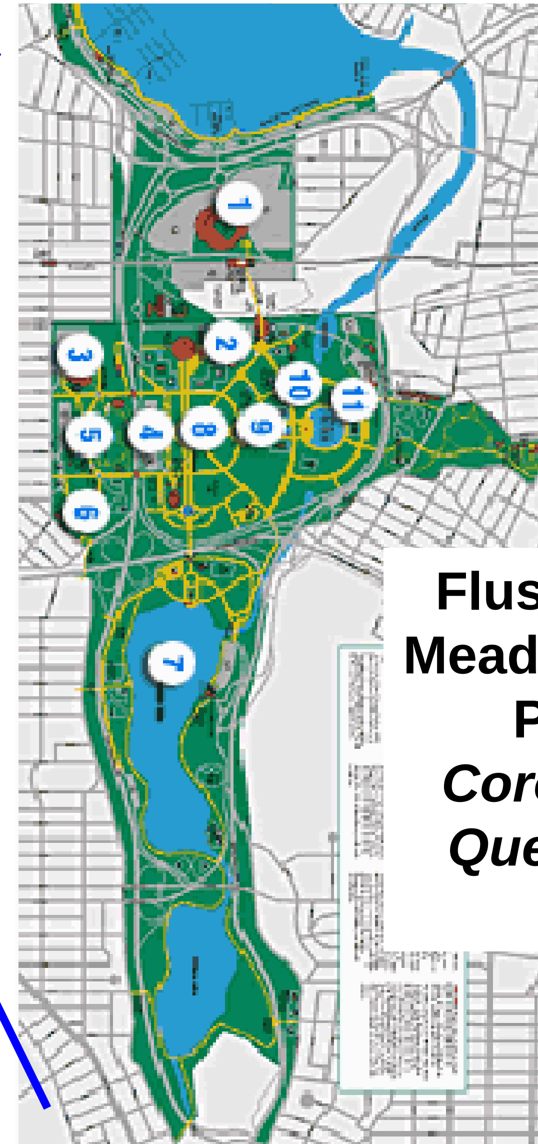
Seeds deposited in traps

PLANTED	NATIVE		INVASIVE
Blackberry	Black cherry	Poison ivy	Bittersweet
Hackberry	Catbriar	Red Cedar	Hercules club
Shadblow	Dogwood	Red maple	Honeysuckle
Sumac	Elderberry	Red Oak	Porcelainberry
Wild rose	Grape	Sassafras	Russian Olive
	Grey birch	Spicebush	Tree of heaven
	Holly	Tulip tree	
	Mulberry	Tupelo	NON-NATIVE
	Nightshade	Viburnum	Crab apple
			Yew

New York City



California Geographical Survey, http://geogdata.csun.edu/NYpage1.html



Flushing Meadows Park,
Corona, Queens NYC

New York City Parks, http://www.nycgovparks.org

Installing the sewer pipeline across the Park (West to East)

The Story: *Problems*

GENERAL

- Physical properties of site were poorly characterized
- Removal of *Phragmites* was not permitted
- Stolen plants; arson
- Invasion of purple loosestrife
- No vegetation management or monitoring
  - lack of funds after 3-yr period
- No public access or education plan
  - Public access now impossible
  - No community interest or support group exists

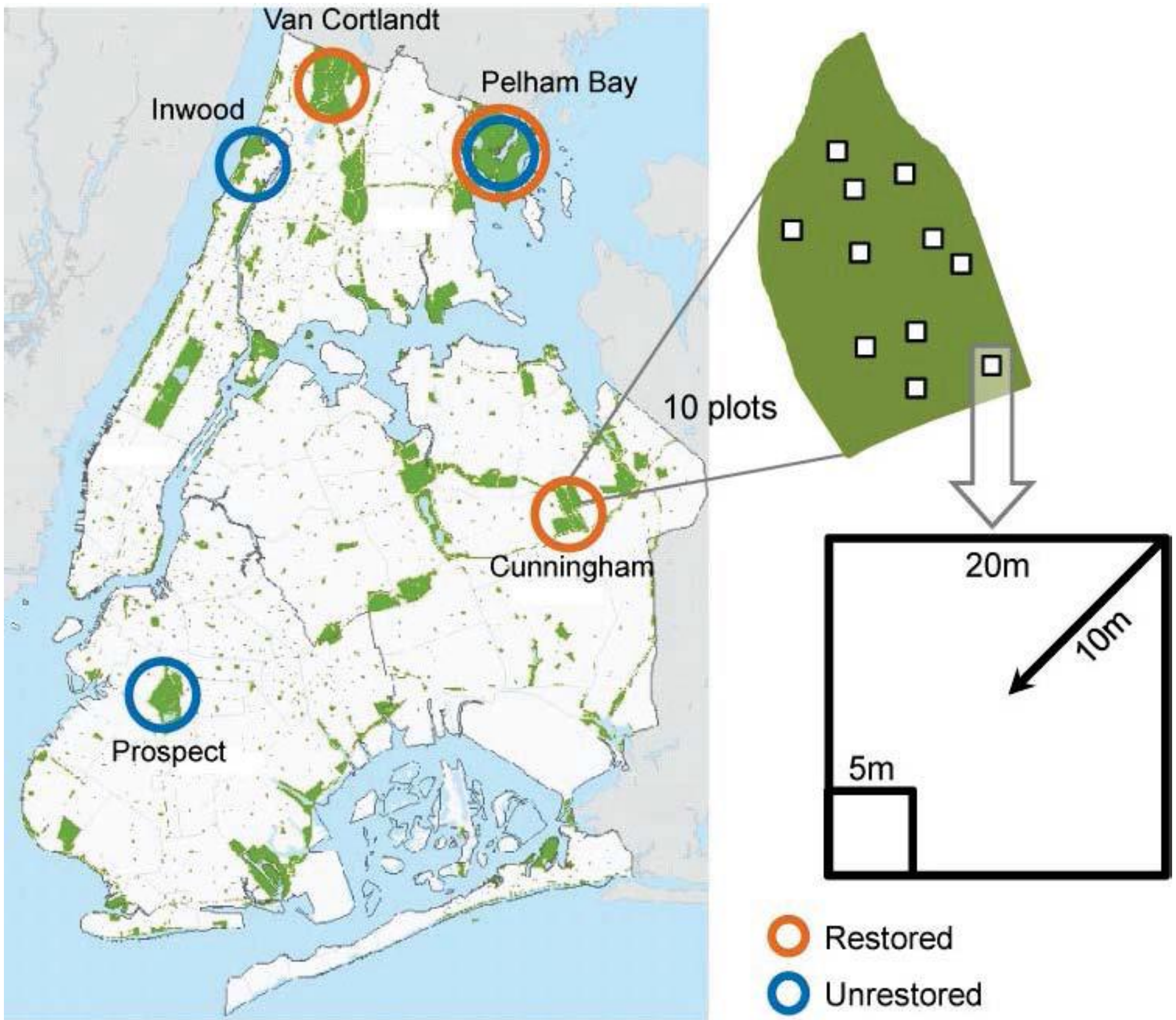
(Galbraith–Kent and Handel *Ecological Restoration* 25:123)

The Story: *Successes*

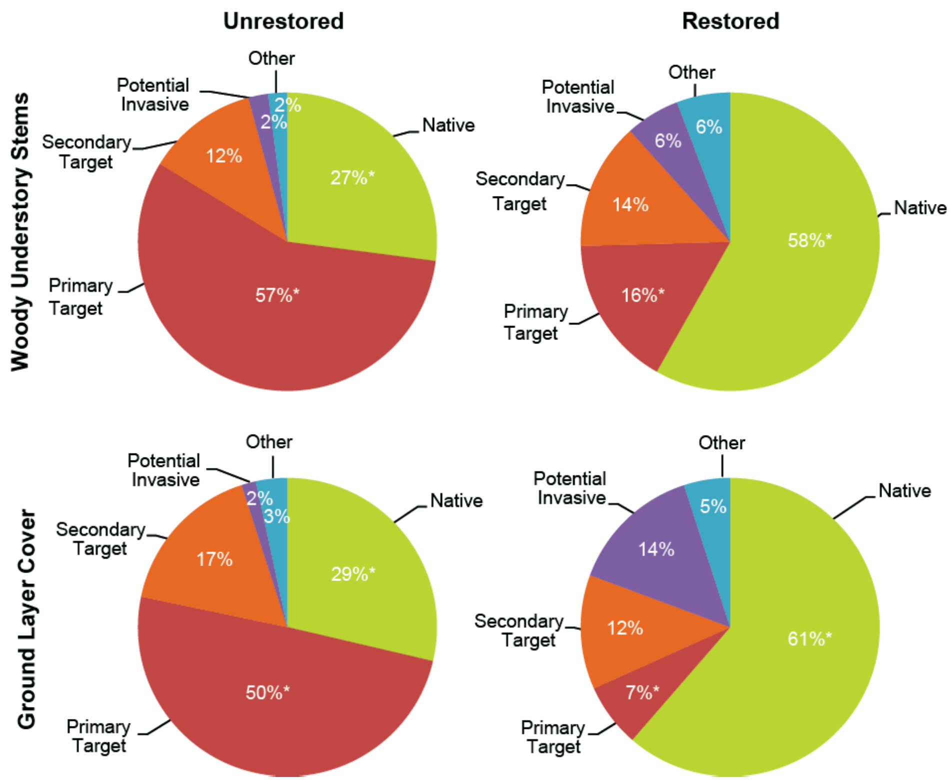
GENERAL

- Biodiversity increased from initial survey
- Increased understanding for future urban restorations
- Habitat complexity is greater
  - from *Phragmites* to a mosaic of uplands, wetlands, herbs
- Site closure has eliminated vandalism (*i.e.,* arson, dumping, theft)
  - a trade-off in urban environmental management may be necessary?

(Galbraith–Kent and Handel *Ecological Restoration* 25:123)



Johnson and Handel, *Ecological Applications*, in press.



Johnson and Handel, *Ecological Applications*, in press.

Brooklyn waterfront, before restoration

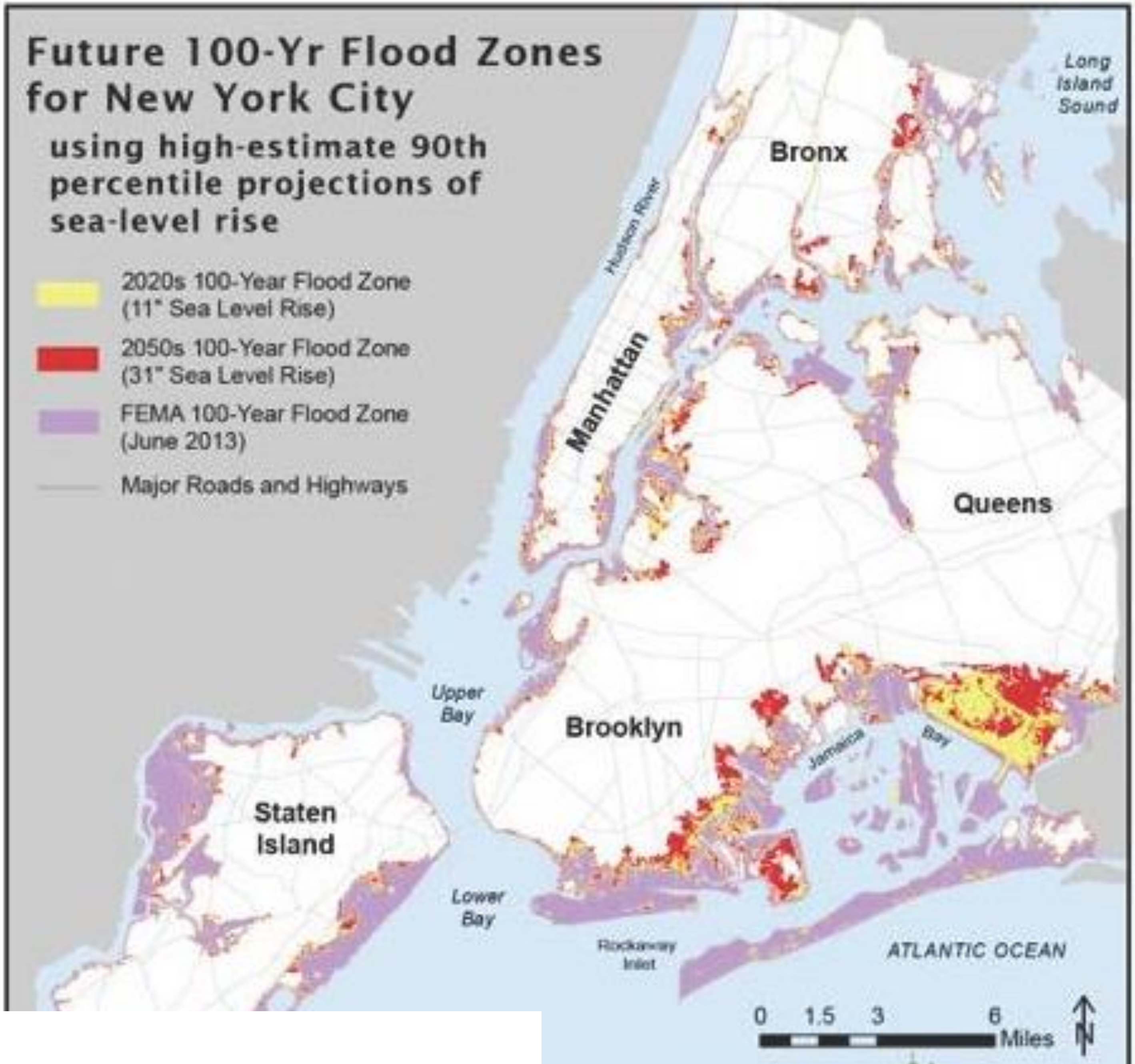
Promenade, Brooklyn Bridge Park

Michael Van Valkenburgh Associates

Michael Van Valkenburgh Associates

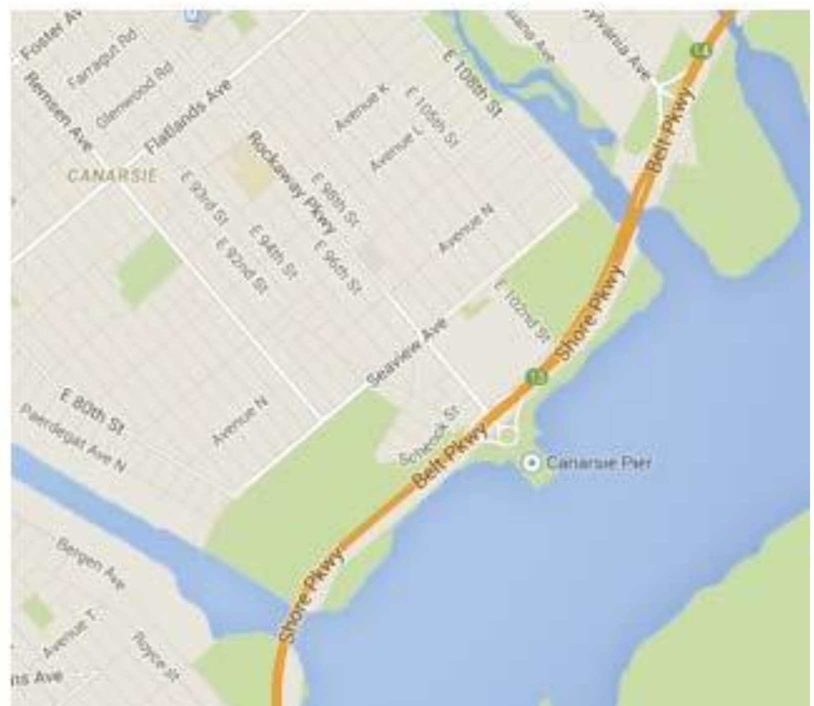
2013 Climate Risk Info: NYC

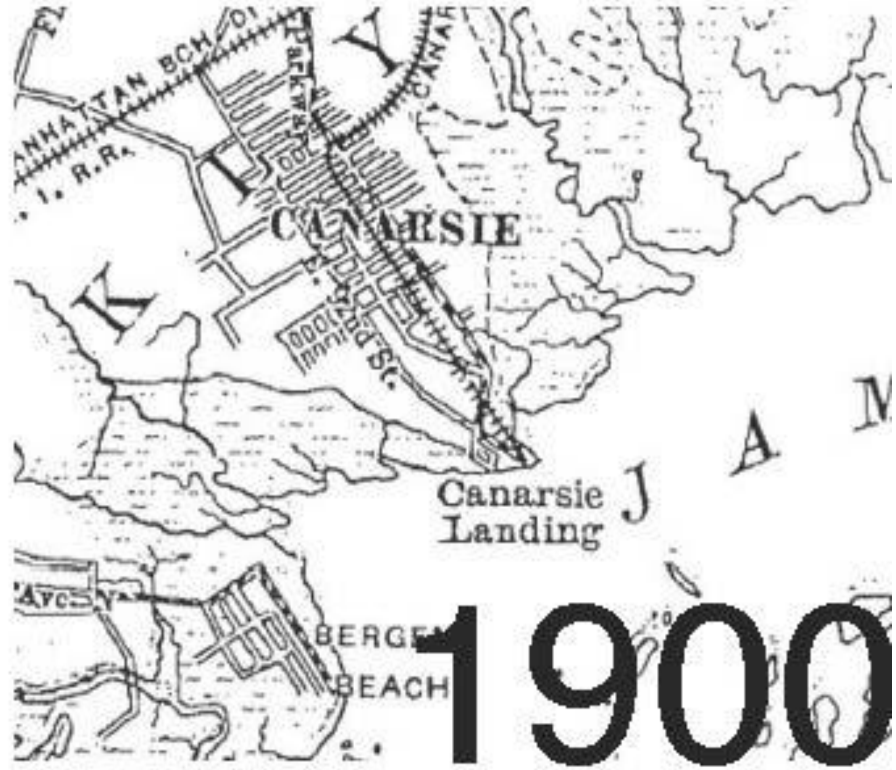
- Sea level rise: 2020s + 11 inches
  2050s + 31 inches
- Air temperature: 2020s + 3.0 F
  2050s + 6.5 F
- Annual chance of today's 100-yr flood:
  5.0% (= now a 20-yr flood)
- Flood heights with a 100-yr flood:
  now, 15.0 feet; 2050s, 17.6 feet


Future 100-Yr Flood Zones for New York City
using high-estimate 90th percentile projections of sea-level rise
2020s 100-Year Flood Zone (11" Sea Level Rise)
2050s 100-Year Flood Zone (31" Sea Level Rise)
FEMA 100-Year Flood Zone (June 2013)
Major Roads and Highways
Long Island Sound
Bronx
Hudson River
Manhattan
Queens
Upper Bay
Brooklyn
Jamaica Bay
Staten Island
Lower Bay
Rockaway Inlet
ATLANTIC OCEAN
0 1.5 3 6 Miles
N

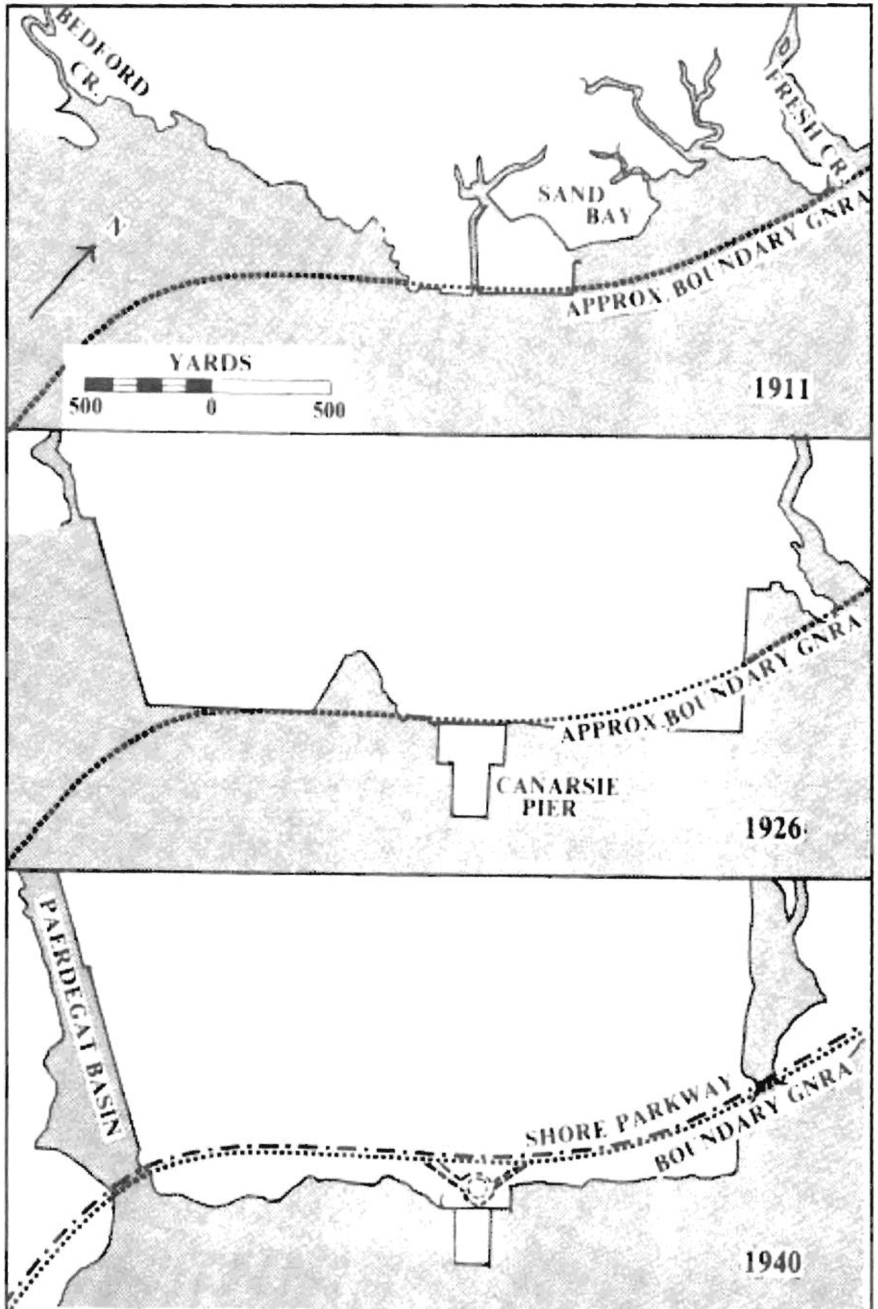
JAMAICA BAY

Canarsie PIER
NYC





AMERICAN
SOCIETY OF
LANDSCAPE
ARCHITECTS

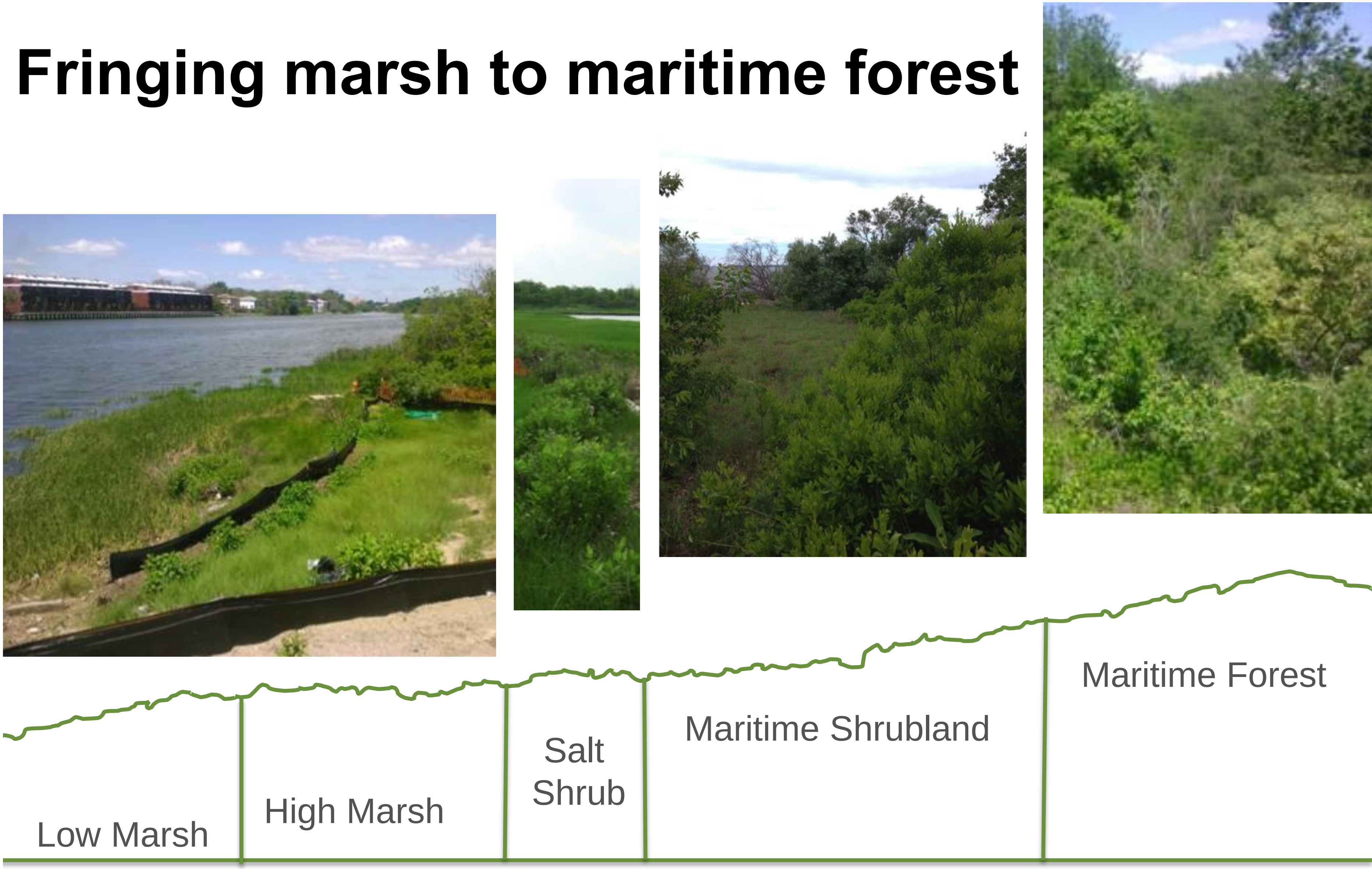


1911

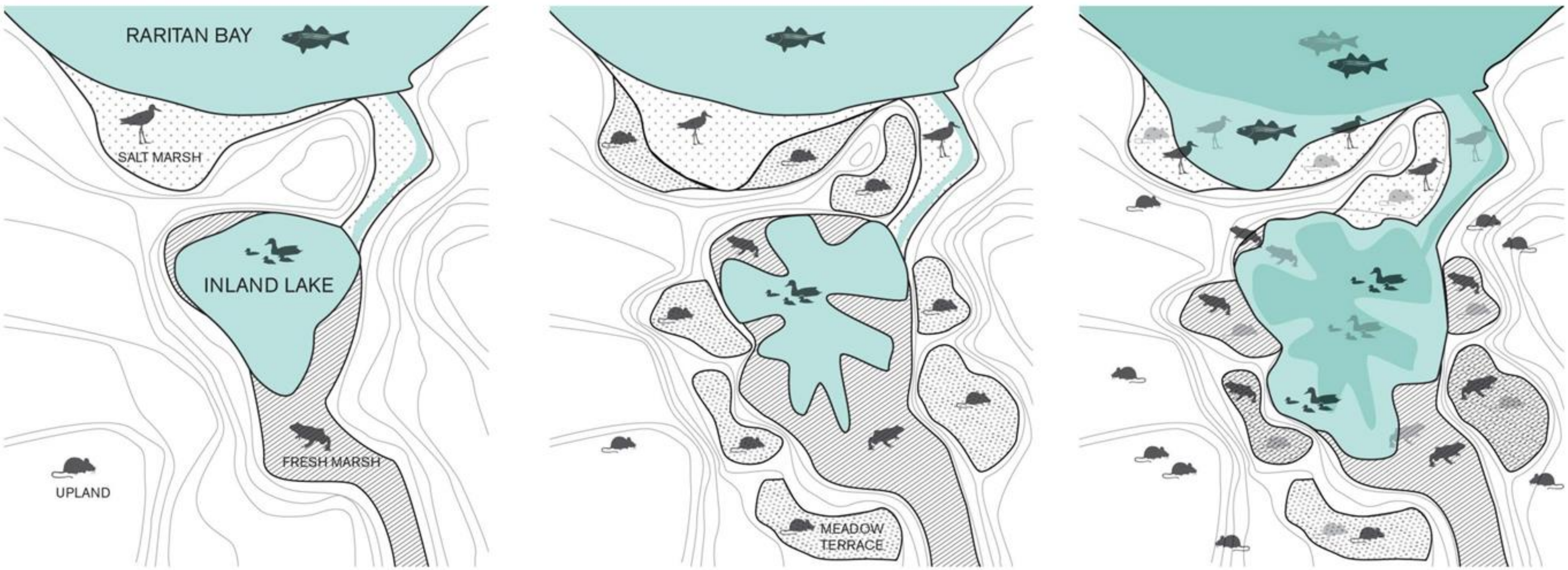
1926

1940

Fringing marsh to maritime forest



The Habitat Engine



Sasaki Associates + Rutgers University

Ecological Constraints

- Dispersal
- Degraded plant and animal communities
- Soil quality and biota
- Successional processes (natural disturbance)
- Invasive species are lurking
- Lack of migration corredors
- Fragmentation & hardscape

Social Constraints

- Beauty and the eye of the beholder
- Different strokes for different folks
- The numbers game
- “I vant to be alone”
- Here comes the sun

Targets for Restoration

- Historical approach
- Status quo approach
- Functional approach
- Design approach

Ecological Opportunities

- Restore ecological functions
- Improve resiliency
- Restore natural heritage
- Reduce management needs
- Improve regional biodiversity
- Advance environmental education

NYBG/125

INVASIVE SPECIES SUMMIT:
CHALLENGES, STRATEGIES,
AND PERSPECTIVES

FRI, NOV 6, 2015

Co-presented with Lower Hudson Partnership for Regional Invasive Species Management

LOWER HUDSON PRISM

NEW YORK BOTANICAL GARDEN

Invasive Species Summit: Meeting venues and dining and shopping options. 10% discount at Pine Tree Café, La Casa Azul Tacos, Hudson Garden Grill, and Shop in the Garden, with All-Garden Pass