

Future of Biogeography

- Speciation and extinction natural part of the history of biota
- Humans are now altering biota to a degree equalling or surpassing all past events

Degradations of biota and impact on biogeography

- “Weeds”, invasives
- Land use changes
- Habitat fragmentation
- Pollution of -spheres
- Climate changes
- Biological extinction

Future of Biogeography

Planet of Weeds: tallying the losses of earth's animals and plants
David Quammen

“The earth has undergone five major extinction periods, each requiring millions of years of recovery”

“Biologists believe that we are entering another mass extinction, a vale of biological impoverishment”

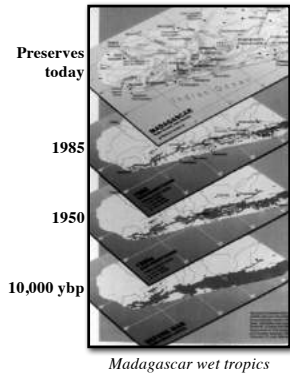
Future of Biogeography

Planet of Weeds: tallying the losses of earth's animals and plants
David Quammen

“Even by conservative estimates, huge percentages of earth's animals and plants will simply disappear”

Future of Biogeography

Planet of Weeds: tallying the losses of earth's animals and plants
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"In the next fifty years, deforestation will doom one half of the world's forest-bird species"

"The lesson to be learned from fragmented isolated habitats is Yeatsian: things fall apart"



*Kirtland's warbler
Michigan*

Future of Biogeography

Planet of Weeds: tallying the losses of earth's animals and plants
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"We confront the vision of a human population pressing snugly around whatever natural landscapes remains"

"Even Noah's Ark only managed to rescue paired animals, not large parcels of habitat"



Future of Biogeography

Planet of Weeds: tallying the losses of earth's animals and plants
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starling

"The species that survive will be like weeds, reproducing quickly and surviving almost anywhere"

"Wildlife will consist of pigeons, coyotes, rats, roaches, house sparrows, crows, and feral dogs"



purple loosestrife

Future of Biogeography

Planet of Weeds: tallying the losses of earth's animals and plants
David Quammen



Chicago - lake shore prairie

"Homo sapiens — remarkably widespread, prolific, and adaptable — is the consummate weed"

"What will happen after this mass extinction, after we destroy two-thirds of all living species?"



Weeds: the Great Biodiaspora



Haleakala silversword

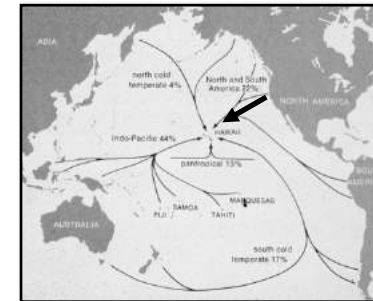
- All species evolve somewhere — **in time and space and in some form** — and may subsequently enlarge their distributions by migration or by long distance dispersal

Weeds: the Great Biodiaspora



Haleakala silversword

- The Haleakala silversword is considered “native” to Hawaii, but once (5-6 mya) there was a single colonist (a “weed” ? or “waif”) that came over from California as its ancestor



Weeds: the Great Biodiaspora



Haleakala silversword

- Kahili ginger is a species native to the Himalayas, introduced to Hawaii several decades ago, and now considered an “invasive weed” in the Hawaiian Islands



Kahili ginger

Weeds: the Great Biodiaspora



Haleakala silversword

- How is the Kahili ginger any different than from the original “waif” that made it to Kauai some 5 mya but then adaptively radiated into the silversword complex?



Kahili ginger

Weeds: the Great Biodiaspora

Weed: A plant species (or any organism) not in its normal geographic distribution, spread by human activities, and usually with some negative impact to humans and/or “native” flora/vegetation/fauna

What then is a *weed*?

- introduction
- non-native
- naturalized
- alien
- invasive



Kahili ginger

Weeds: the Great Biodiaspora

What is *not* a weed!

Eupatorium maculatum
Joe-pye weed



Weeds: the Great Biodiaspora

What is *not* a weed!

Eupatorium maculatum
Joe-pye weed



... although the Wisconsin Cranberry Association has labeled *Eupatorium maculatum* a weed as it decreases their profits!

Weeds: the Great Biodiaspora

What is *not* a weed!

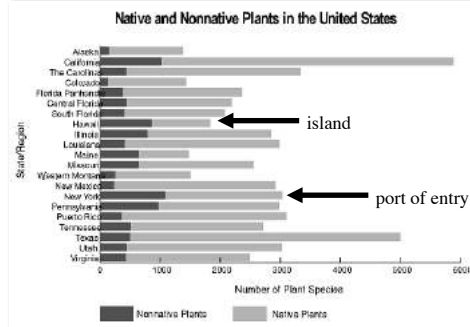
Cirsium pitcheri
Dune thistle



Weeds: the Great Biodiaspora

Weeds: negative aspects

Native flora/fauna of many areas (e.g., islands, "portals") are at risk with invasive weeds

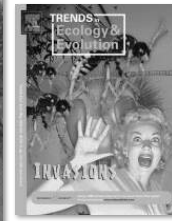


Weeds: the Great Biodiaspora

Not All Alien Invaders Are From Outer Space

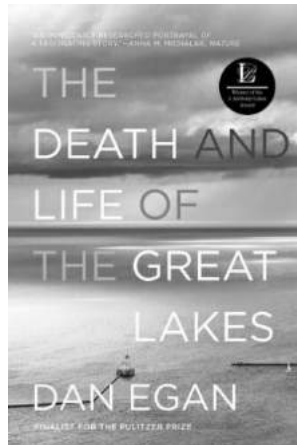
The invasive fish species, *Ameletus* (genus of spotted bass) are disrupting the natural resources and diminishing U.S. populations.

Federal and state government agencies now consider invasion of the aliens as the newest threat to our terrestrial and aquatic biota.



Recent issue of TREE

Weeds: the Great Biodiaspora



University of Wisconsin and Great Lakes region see the problem



Weeds: the Great Biodiaspora

How do you tell a weed?

1. Fossil evidence or its lack
2. Historical evidence of introductions
3. Probable means of introduction
4. Typical reproductive patterns
5. Disturbed habitats
6. Genetic diversity
7. Geographical distribution patterns

Weeds: the Great Biodiaspora

How do you tell a weed?

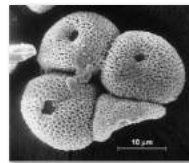
1. Fossil evidence or its lack



• are any of the cattails native to North America?



- Green River Eocene deposits of Colorado
- Holocene fossil pollen tetrads

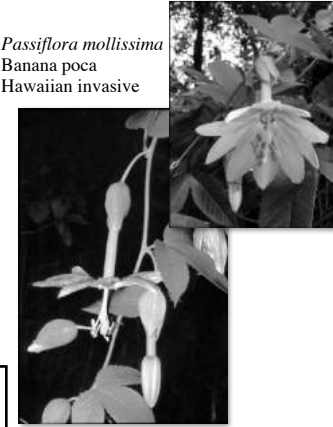


Weeds: the Great Biodiaspora

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Passiflora mollissima
Banana poka
Hawaiian invasive



Introduced from South America to Hawaii in early 1900s as a vine to hide an outhouse in Hawaii

Weeds: the Great Biodiaspora

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Rock garden ornamental - via shoes?

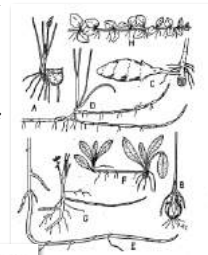
Reseda lutea (mignonette) from Mediterranean found "natively" in pristine Thompson Prairie west of Madison

Weeds: the Great Biodiaspora

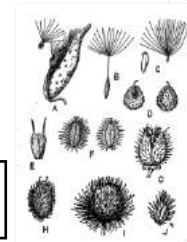
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Modified vegetative features



Modified dispersal features



Weeds often possess modified vegetative and sexual reproductive features as part of the "weed syndrome"

Weeds: the Great Biodiaspora

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Dipsacus fullonum - teasel
Introduced and adventive

Weeds: the Great Biodiaspora



Zanthoxylum americanum – pricky ash
Native (!) but invasive in disturbed
lower marginal sites at Muralt Prairie

Weeds: the Great Biodiaspora

How do you tell a weed?

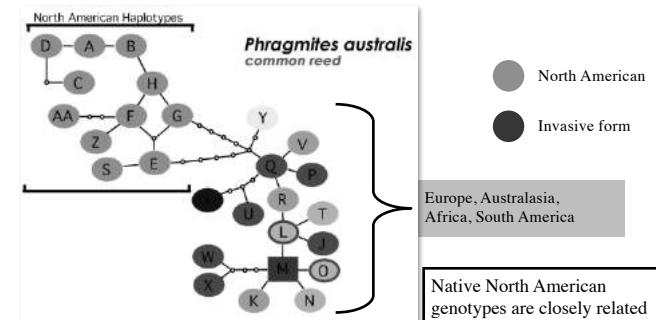
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Phragmites australis (common reed)
native or invasive?

Weeds: the Great Biodiaspora

How do you tell a weed? *phylogeography*



Genotype tree based on chloroplast DNA

(Saltonstall 2002)

Native North American
genotypes are closely related
and they are unrelated to the
invasive form from the Old
World

Weeds: the Great Biodiaspora

How do you tell a weed?

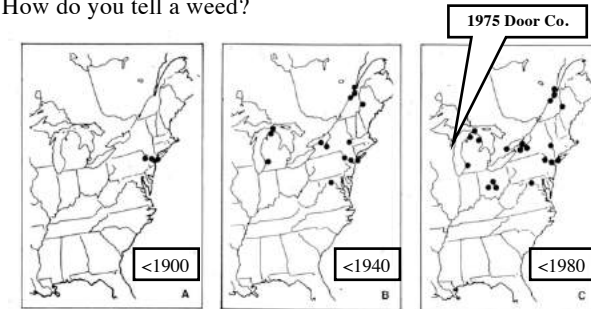
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Veronica beccabunga (water speedwell) native to Europe

Weeds: the Great Biodiaspora

How do you tell a weed?



Historical herbarium specimens of *Veronica beccabunga* in North America

Weeds: the Great Biodiaspora

How do you tell a weed?



Veronica beccabunga (water speedwell) native to Europe

Weeds: the Great Biodiaspora

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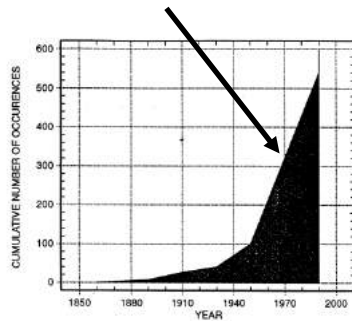
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Alliaria petiolata (garlic mustard) native to Europe

Weeds: the Great Biodiaspora

How do you tell a weed?



Garlic mustard collections in U.S. herbaria
Typical collection pattern of weeds

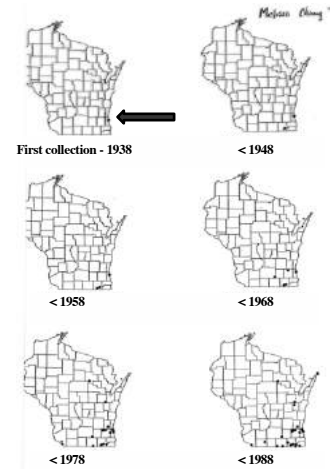


Weeds: the Great Biodiaspora

How do you tell a weed?

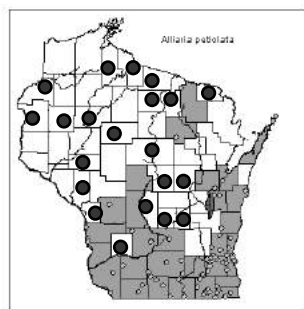


Garlic mustard distribution – 2006

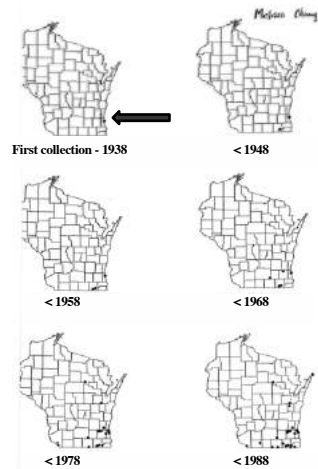


Weeds: the Great Biodiaspora

How do you tell a weed?



Garlic mustard distribution – 2006
Garlic mustard distribution – 2007
Garlic mustard distribution – 2008
Garlic mustard distribution – 2009-2018



Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

1. Direct introduction
2. Agriculture
3. Ballast
4. Roads & pickles (salt)



Pueraria lobata - Kudzu



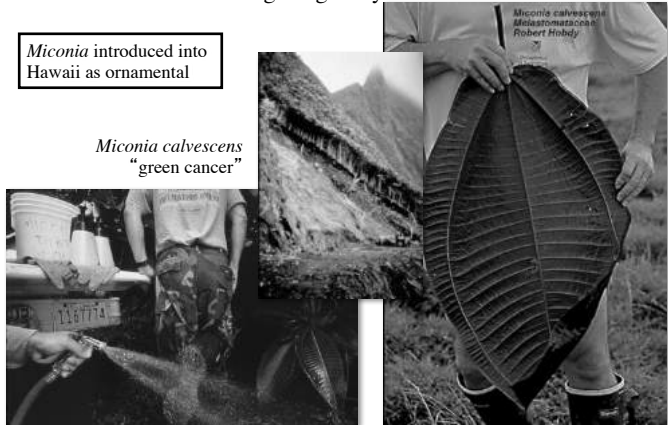
Kudzu introduced from Japan into SE U.S. for soil erosion control

Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

Miconia introduced into Hawaii as ornamental

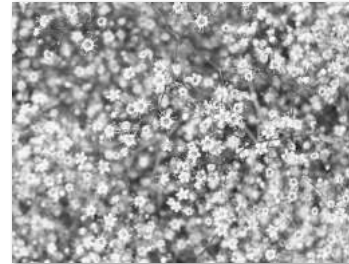
Miconia calvescens
“green cancer”



Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

Gypsophila introduced into Great Lakes (now invasive on dunes) as “baby-breath” ornamental



Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

Heracleum mantegazzianum
(hogweed) introduced from Asia by gardeners



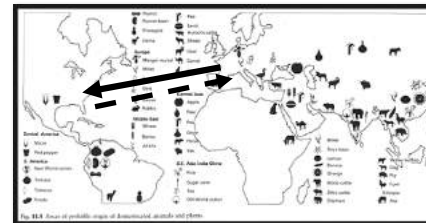
Hogweed: over 6 ft and looks like cow's parsnip but bigger and with purple stem splotches; phototoxic!



Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

1. Direct introduction
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Agriculture basically came from Eurasia to North America
Many of our weeds are agriculture based
Few North American weeds in Eurasia

Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”



Three of the five Wisconsin state listed “obnoxious” weeds arrived with agriculture

Convolvulus arvensis
field bindweed



Euphorbia virgata
leafy spurge



Cirsium arvense
“Canada” thistle

Weeds: the Great Biodiaspora

American weeds in Europe – the empire strikes back



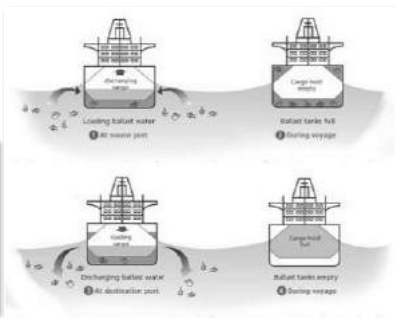
‘Neophytes’ in the upper Rhine valley near Heidelberg — first recorded after 1492

<http://www.guenther-blaich.de/pflgs.php?par=kune&lan=e>

Weeds: the Great Biodiaspora

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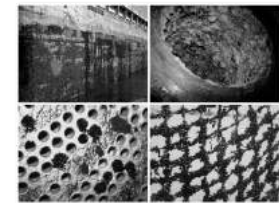
Ballast (water now; soil/gravel before) used to stabilize ships is a major source of aquatic organisms and seeds

Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”



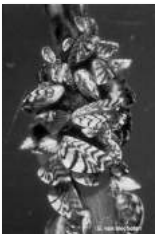
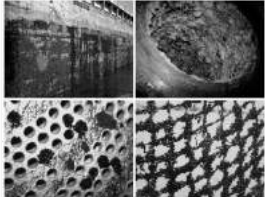
Dreissena polymorpha
Zebra mussel



The most infamous ballast species


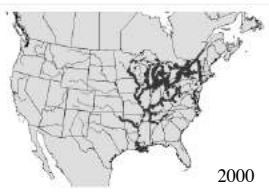
Weeds: the Great Biodiaspora

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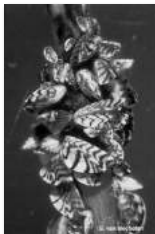
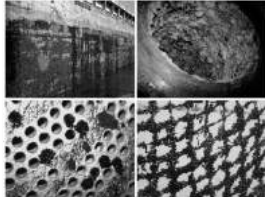
Dreissena polymorpha
Zebra mussel

30 year invasion history



Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

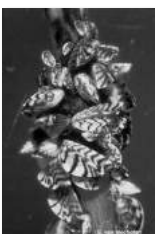
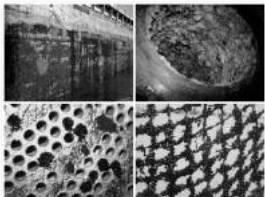
Dreissena polymorpha
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30 year invasion history



Weeds: the Great Biodiaspora

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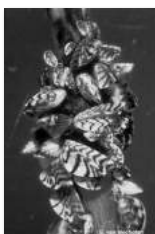
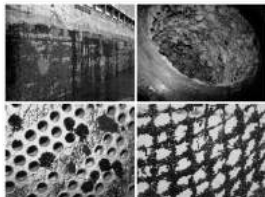
Dreissena polymorpha
Zebra mussel

30 year invasion history



Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

Dreissena polymorpha
Zebra mussel

30 year invasion history

Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”



Lythrum salicaria
Purple loosestrife

Centaurea maculosa
Spotted knapweed

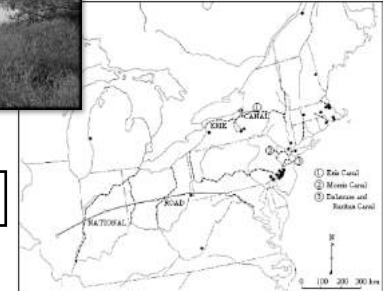


Myriophyllum

Ballast plants

Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”



Canals allowed early spread of *Lythrum salicaria* by 1880.

Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

1. Direct introduction
2. Agriculture
3. Ballast
4. Roads & pickles (salt)



Spartina patens (east coast salt marshes) first collected in Michigan pickle sites in 1910



Railway yards, disturbed areas around brine wells, and medians of salted expressways

Salt used on roads or as brine (pickle factories) has brought in halophytic (salt loving) weeds from the Great Plains and East Coast

Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

1. Direct introduction
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Muhlenbergia asperifolia (alkali muhly) from Great Plains first seen on de-iced roads in late 1930s

Salt used on roads or as brine (pickle factories) has brought in halophytic (salt loving) weeds from the Great Plains and East Coast

Weeds: the Great Biodiaspora

Issues with weeds after arrival:

1. Control with source area organisms
2. Invasive complex formation
3. Hybridization with native species



Dipteran leaf miner feeds on European honeysuckle



Galerucella feeds on purple loosestrife leaves and then flowers

Weeds: the Great Biodiaspora

Issues with weeds after arrival:

1. Control with source area organisms
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Cyrtobagous salviniae on Common Salvinia, *Salvinia minima*



Sapik River Lagoon in New Guinea Covered with Giant Salvinia



Same Lagoon Less Than Two Year after Release of *C. salviniae*

Weeds: the Great Biodiaspora

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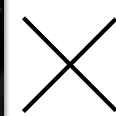


Narrow leaf cattail
Typha angustifolia

Weeds: the Great Biodiaspora



Broad leaf cattail
Typha latifolia



Narrow leaf cattail
Typha angustifolia

Weeds: the Great Biodiaspora

Issues with weeds after arrival:

1. Control with source area organisms
2. Invasive complex formation
3. Hybridization with native species



Hybrid cattail
Typha x glauca

Weeds: the Great Biodiaspora

Hybridization with native species

- Has invasive *Phragmites australis australis* hybridized with native *P. australis americanus*?
- Is this part of the recent (delayed) invasive nature of the weed?



Native population in Great Lakes



Invasive population in Great Lakes

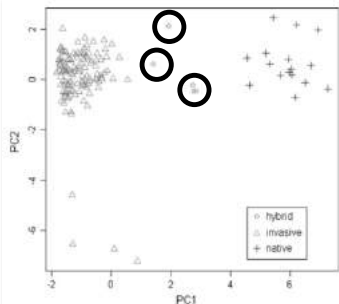
Weeds: the Great Biodiaspora

Biol Invasions (2009) 12:2807-2875
DOI 10.1007/s10530-009-9434-z

INVASION NOTE

Molecular data provide strong evidence of natural hybridization between native and introduced lineages of *Phragmites australis* in North America

Jennifer Paul · Nicole Yachon · Colin A. Garraway · Joanne R. Fredford



Biol Invasions (2009) 12:100-111
DOI 10.1007/s10530-008-9434-3

ORIGINAL PAPER

Hybridization of invasive *Phragmites australis* with a native subspecies in North America

Laura A. Mejerian · David V. Viola · Rebecca N. Brown

- Previous studies found no evidence of hybridization, although experimental hybrids could rarely be made with natives as maternal line
- 2000 mile survey in E North America using microsatellites showed strong evidence of hybridization – in both directions (i.e., both species can be maternal source or pollen source)

Weeds: the Great Biodiaspora



now it is just an issue of trying to control the invasive

TABLE 6. Determination of estimated seed output and germinable seed output for each lineage calculated from average germination, number of seeds per panicle, and number of panicles per square meter.

Lineage	Average germination (%)	Average number seeds per panicle	Average panicles per m ²	Estimated seed output	Estimated germinable seed output
Native	32.5	5671	18	102,078	33,175
Introduced	11.9	7950	48	380,640	45,296
Hybrid	9.4	25517	42	1,071,214	100,741

Weeds: the Great Biodiaspora

A final thought:

Unlike some other threats such as logging or pollution, which in theory can be stopped and allowing native vegetation/flora/fauna to recover, **alien invasions** are **self-sustaining** once started and extremely **difficult to reverse**

