Future of Biogeography
... our new flora & fauna ...
garlic mustard
early May, maple-basswood-oak forest
Columbia Co., Wisconsin
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
"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*

David Quammen

“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”

Madagascar wet tropics

Kirtland’s warbler

Michigan
“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
David Quammen

“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”

starling

purple loosestrife
Future of Biogeography

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

“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

• 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.

Haleakala silversword
Weeds: the Great Biodiasporea

• 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

- 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.
Weeds: the Great Biodiaspora

• 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?
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
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
Native flora/fauna of many areas (e.g., islands, “portals”) are at risk with invasive weeds.
Federal and state government agencies now consider invasion of the aliens as the newest threat to our terrestrial and aquatic biota.
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

How do you tell a weed?

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

Passiflora mollissima
Banana poca
Hawaiian invasive
Weeds: the Great Biodiaspora

How do you tell a weed?

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

Rock garden ornamental - via shoes?
Weeds: the Great Biodiaspora

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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 – prickly 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)
Weeds: the Great Biodiaspora

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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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*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

First collection - 1938
< 1948
< 1958
< 1968
< 1978
< 1988
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
2. Agriculture
3. Ballast
4. Roads & pickles (salt)

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

Sources of weeds — “rogues gallery of exotica”

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

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

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”

30 year invasion history

Dreissena polymorpha
Zebra mussel

2005
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”

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)

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

Sparrina 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
2. Agriculture
3. Ballast
4. Roads & pickles (salt)

*Muhlenbergia asperifolia* (alkali muhly) from Great Plains first seen on de-iced roads in late 1930s.
Weeds: the Great Biodiaspora

Issues with weeds after arrival:

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

Galerucella feeds on purple loosestrife leaves and then flowers

Dipteran leaf miner feeds on European honeysuckle
Weeds: the Great Biodiaspora

Issues with weeds after arrival:

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Weeds: the Great Biodiaspora

Issues with weeds after arrival:

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

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

T. latifolia
T. angustifolia
T. 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
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>
<thead>
<tr>
<th>Lineage</th>
<th>Average germination (%)</th>
<th>Average number seeds per panicle</th>
<th>Average panicles per m²</th>
<th>Estimated seed output</th>
<th>Estimated germinable seed output</th>
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<tr>
<td>Native</td>
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</table>
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**.