Future of Biogeography
. . . our new flora . . .
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”
“Even by conservative estimates, huge percentages of earth’s animals and plants will simply disappear”
“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”

Future of Biogeography

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

Preserves today

1985

1950

10,000 ybp

Madagascar wet tropics

Kirtland’s warbler
Michigan
Future of Biogeography

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

“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.
Weeds: the Great Biodiaspora

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

Haleakala silversword
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

**Habitat**
- Based on data collected by John T. Curtis (1959) as compiled by C.E. Umbanhowar, Jr.
  - Bog
  - Boreal Forest
  - Northern Lowland Forest
  - Prairie
  - Sedge Meadow
  - Shrub Carr
  - Southern Upland Forest
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
The economics of weeds (human impact) drives a huge business and academic industry.
Weeds: the Great Biodiaspora

Weeds: negative aspects

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

![Graph showing native and nonnative plants in the United States]
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

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
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

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3. Probable means of introduction
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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

How do you tell a weed?

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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
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?

1. Fossil evidence or its lack
2. Historical evidence of introductions
3. Probable means of introduction
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7. Geographical distribution patterns

*Phragmites australis* (common reed) native or invasive?
Weeds: the Great Biodiaspora

How do you tell a weed? *phylogeography*

Cryptic invasion of a non-native genotype of *Phragmites australis* (common reed) into North America (Saltonstall 2002)

Native population in Great Lakes

Invasive population in Great Lakes
Weeds: the Great Biodiaspora

How do you tell a weed? *phylogeography*

Genotype tree based on chloroplast DNA

North American

Invasive form

Europe, Australasia, Africa, South America

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
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

How do you tell a weed?

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Alliaria petiolata (garlic mustard) native to Europe
Weeds: the Great Biodiaspora

How do you tell a weed?

Garlic mustard distribution - 2006

Garlic mustard collections in U.S. herbaria (1990)

Typical collection pattern of weeds
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 - 2009-2014
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

Does *Phragmites australis* show the same pattern?
Weeds: the Great Biodiaspora

How do you tell a weed?

- Herbarium specimens over all Quebec mapped to 10 X 10 km quadrats
- All genotyped for invasive vs. native forms
- Linear lag phase of invasion from 1916 to 1970
- Logistic expansion phase of invasion from 1970 to present
- Illinois/Wisconsin have 89/77 yr lag phase and logistic inflection point at 1976/1977

Invasive *Phragmites* collections in Quebec – the invasion curve (Lelong et al. 2007)
Weeds: the Great Biodiaspora

How do you tell a weed?

- . . . and replacement of native genotypes by invasive form through time in Quebec

All specimens

Specimens along rivers

Specimens along roads
Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

1. Direct introduction
2. Agriculture
3. Ballast
4. Roads & pickles (salt)
Weeds: the Great Biodiasporea

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

ragweed
smooth aster
pokeweed
lupine
evening primrose
smooth sumac
black locust

‘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

12 year invasion history

States with zebra mussels in inland and adjacent waters.

2000
Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

Dreissena polymorpha
Zebra mussel

12 year invasion history

1988
States with zebra mussels in inland and adjacent waters.

2005
Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

Dreissena polymorpha
Zebra mussel

12 year invasion history
Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

Dreissena polymorpha
Zebra mussel

12 year invasion history
Weeds: the Great Biodiaspora

Sources of weeds — “rogues gallery of exotica”

Lythrum salicaria
Purple loosestrife

Ballast plants

Myriophyllum

Centaurea maculosa
Spotted knapweed
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

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

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

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:

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

Sepik River Lagoon in New Guinea Covered with Giant Salvinia

Same Lagoon Less Than Two Years after Release of C. salviniae
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
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).
A final thought:

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