Plant of the Day

Nymphaea thermarum is the world's smallest water lily (lily pads about 1cm)

Self compatible

Discovered in 1987

Extinct from the wild (habitat destruction)

Grew in a hot spring in Rwanda (a few square meters of habitat)

Saved by growing from seed at Kew Gardens

Big Questions in Conservation Genetics

What fraction of the world's species are in danger of extinction?

What is the role of genetic factors in extinction?

How quickly can genetic factors cause extinction?

"We've worked out what the creature looked like – now all we need to do is find out why it became extinct."

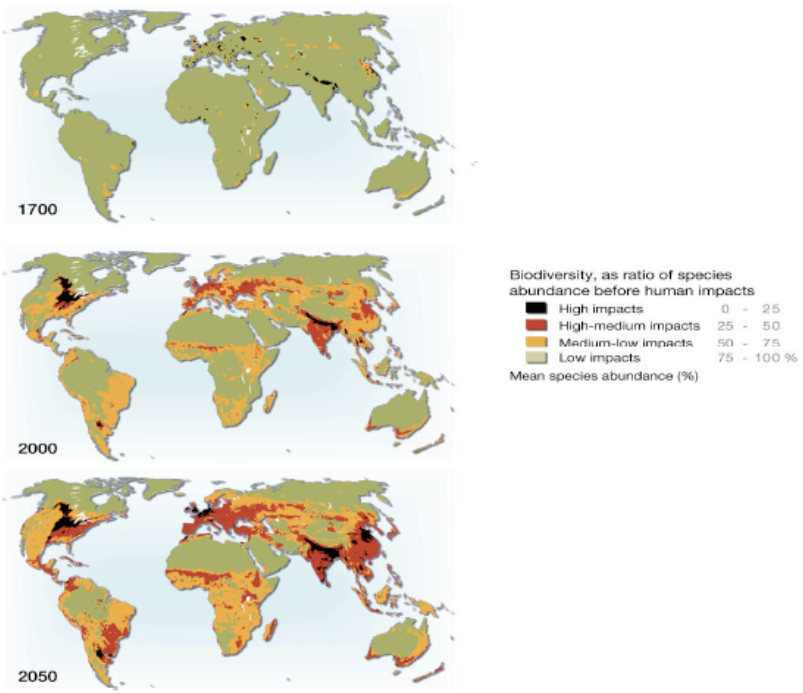
Biodiversity in trouble: the sixth mass extinction

Globally, one in five vertebrate and plant species are going extinct

Within 100 years 1/2 to 2/3 of all species are will be extinct or endangered

Current extinction rates are at least 1000 times that of background levels

Figure 2.1 Loss of biodiversity with continued agricultural expansion, pollution, climate change and infrastructure development



Source: GLOBIO; Alkemade et al., 2009

What are the major causes of the current biodiversity crisis?

People: the ultimate invasive species!

-Habitat destruction, degradation and fragmentation

-Overexploitation

-Invasive species

-Climate change

Why should we care about biodiversity?

-intrinsic value:

Moral argument

-extrinsic value:

Economic benefits, both direct (goods) and indirect (services)

Genetic resources

Aesthetic value and recreation

Why should we care?

"The future of humanity is inextricably tied to the fate of the natural world. In perpetuating this, the Earth's sixth mass extinction, we may ultimately compromise our own ability to survive." - Letter to U.S. Senate by E.O. Wilson and 10 other prominent scientists.

Conservation biology of plant species in Canada

COSEWIC:(Committee on the Status of Endangered Wildlife in Canada) is a committee of experts that assesses and designates which wildlife species are in some danger of disappearing from Canada.

Jeannette Whitton

Status / Statut	Mammals / Mammifères	Birds / Oiseaux	Reptiles / Reptiles	Amphibians / Amphibiens	Fishes / Poissons	Arthropods / Arthropodes	Molluscs / Mollusques	Vascular Plants / Plantes vasculaires	Mosses / Mousses	Lichens / Lichens	Total / Totaux
Extinct/ Disparue	2	3	0	0	7	0	1	0	1	0	**14**
Extirpated/ Disparue du pays	3	2	4	1	3	3	2	3	1	0	**22**
Endangered/ En voie de disparition	20	29	17	9	46	25	18	94	8	4	**270**
Threatened/ Menacée	17	24	11	4	33	6	3	49	3	3	**153**
Special Concern/ Préoccupante	27	20	9	7	49	5	6	39	4	6	**172**
Total / Totaux	**69**	**78**	**41**	**21**	**138**	**39**	**30**	**185**	**17**	**13**	**631**

*There are now 617 wildlife species in COSEWIC risk categories which include Extirpated, Endangered, Threatened, or Special Concern / Il y a maintenant 617 espèces sauvages dans les catégories de risque du COSEPAC qui incluent les catégories << disparue du pays >>, << en voie de disparition >>, << menacée >> et << préoccupante >>.

Is this all of the endangered plant species in Canada?

800 additional species on a prioritized candidate list

What are we doing?

SARA: Species at risk act (2003)

–prevent Canadian species, subspecies, and distinct populations from becoming extirpated or extinct

–provide for the recovery of endangered or threatened species

–prohibit harming individuals of a listed species and their residence

–encourage the management of other species to prevent them from becoming at risk

What are we doing?


Pink sand verbena

The "success" of SARA

-Listing (449/551 recommended)

-Recovery plans/action strategies-few identify critical habitat to be protected

-only one species has an action strategy (Banff Springs snail, located entirely within a National Park)

-Habitat protection principally applies to federal land (1% of BC)

-BC has NO legal protection for endangered species (94% provincial crown land 5% private land)

The B.C. Wildlife Act prevents the direct killing of wildlife. Of the 1,597 species known to be at risk of extinction in B.C., only 4 are listed under the act

http://www.vancouversun.com/opinion/op-ed/losing+battle+diversity+life/3768751/story.html#ixzz1CTdKllOX

What is conservation genetics?

aims to apply genetic methods to the conservation and restoration of biodiversity

Some issues in plant conservation genetics:

1) population size: genetic drift and inbreeding

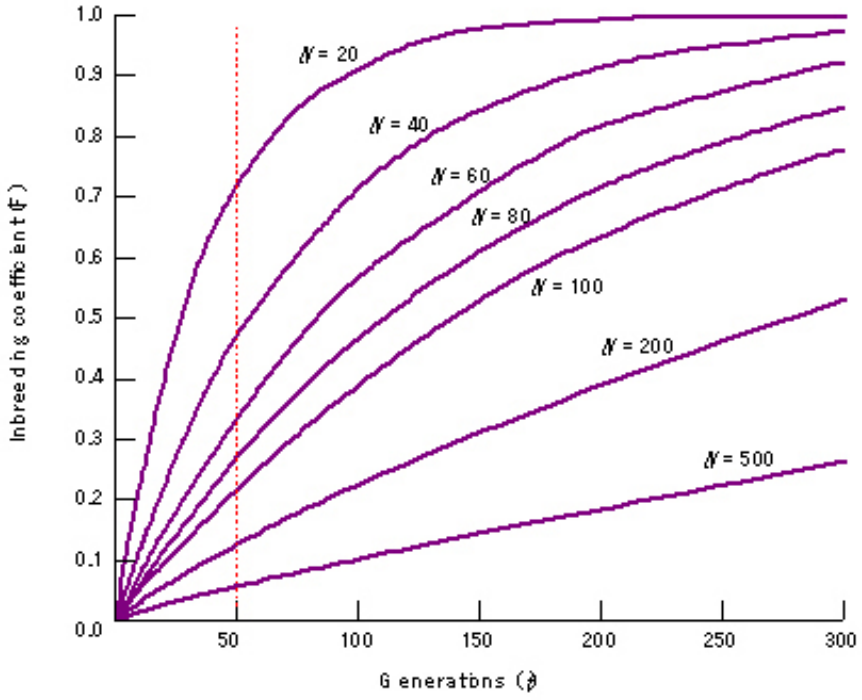
-short term (inbreeding depression)

-long term (effects of genetic diversity and ability to adapt)

2) gene flow: outbreeding depression, genetic assimilation, transgenes

3) units of conservation

Population size, genetic variation and fitness



Leimu et al 2006 meta-analysis of plants

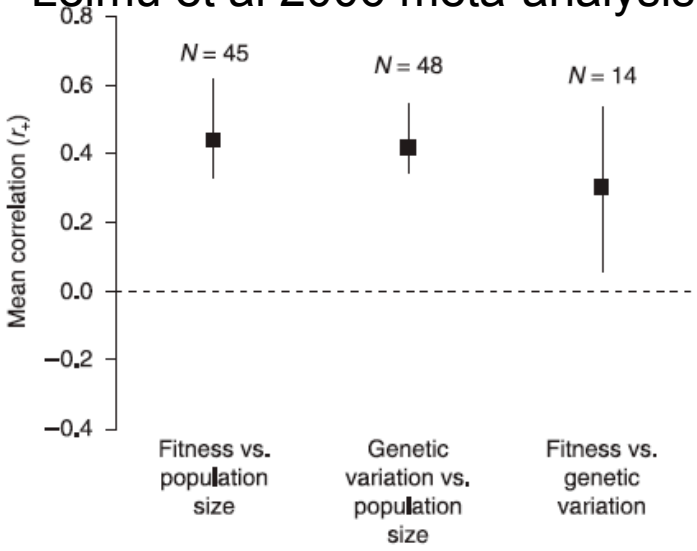


Fig. 1 Mean correlations (r_+) between population size, female fitness and genetic variation. In all figures, bars denote 95% confidence intervals obtained by bootstrapping, and sample size N denotes the number of independent studies included in meta-analysis. The relationships are considered significant if the confidence intervals do not include zero.

Small populations become inbred more rapidly than large populations

Substantial empirical evidence that there is a positive association between population size, genetic variation and fitness

Population size, genetic variation and fitness

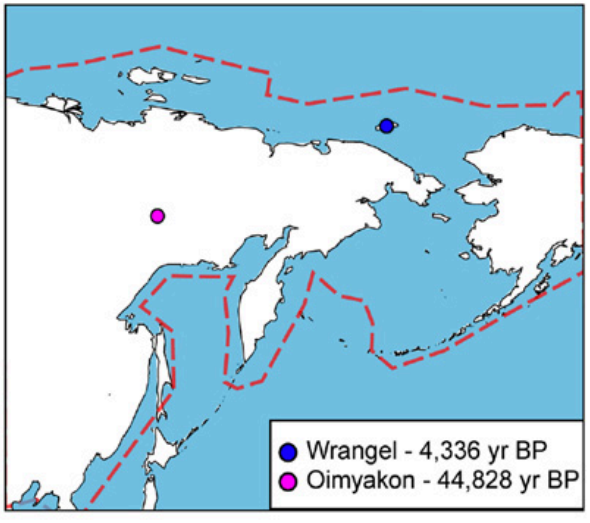
Would you expect a stronger association between population size, genetic variation and fitness in SI or SC species?
-SI

Why?
-restricted mating opportunities in small SI populations
-inbreeding depression may be weaker in SC species (purging)
-inbreeding maybe high in SC populations irrespective of size

Genomic signal of inbreeding depression

Woolly mammoths historical population size from genome data

A

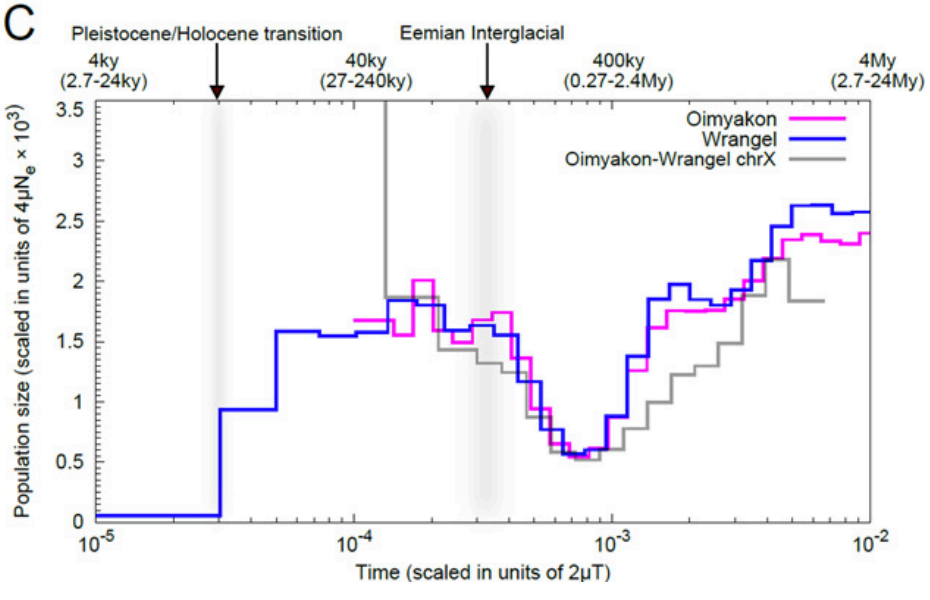


Palkopoulou et al 2015

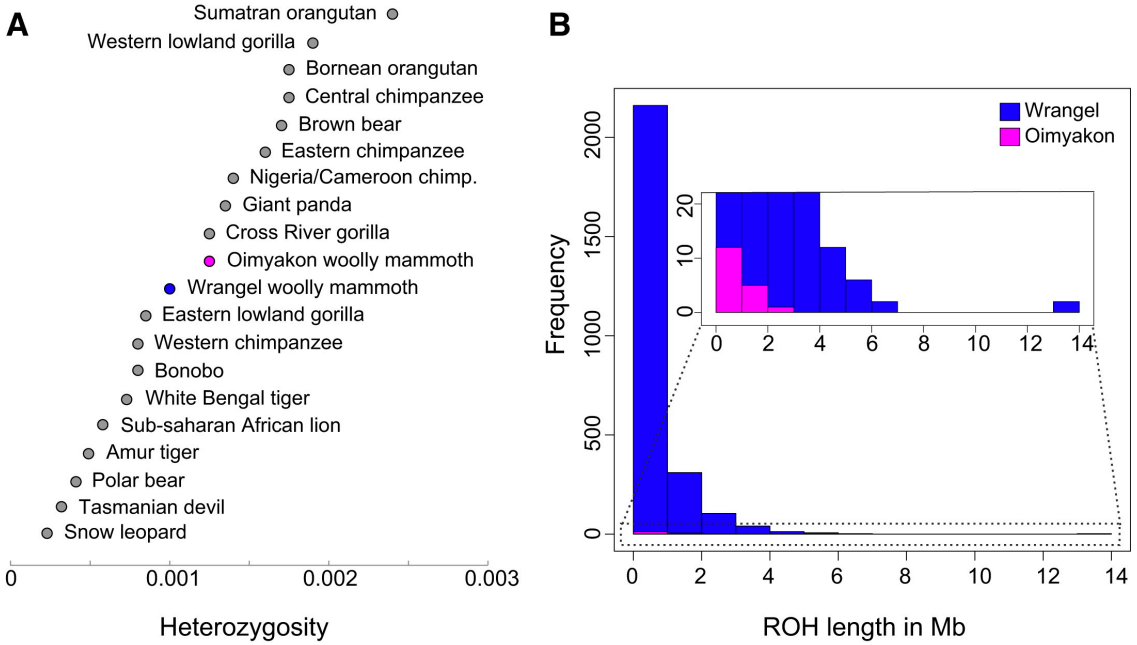
B

Sample	^{14}C date ± error (years)	Median calibrated date (years)	# raw reads ($\times 10^6$)	Average coverage	Average read length (bp)
Wrangel	3,905 ± 47	4,336	1,262	17.1	69
Oimyakon	41,300 ± 900	44,828	1,401	11.2	55

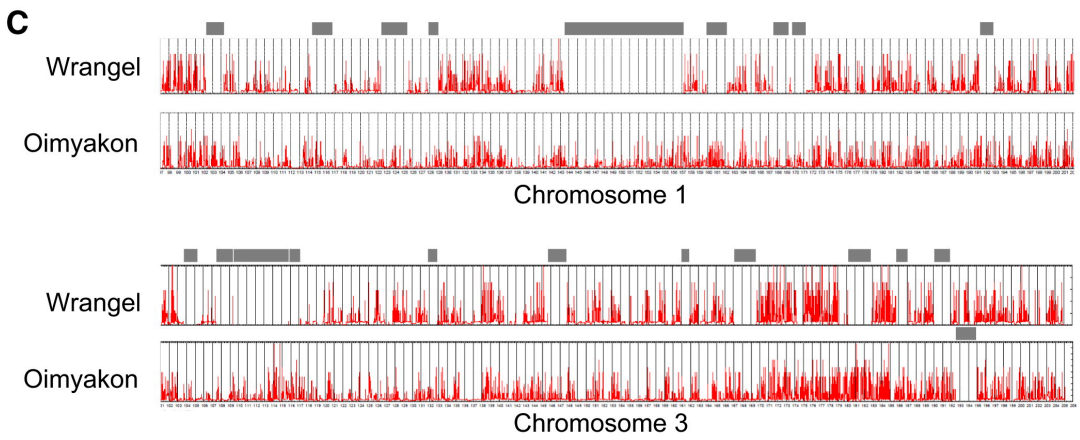
C



Genomic signal of inbreeding depression

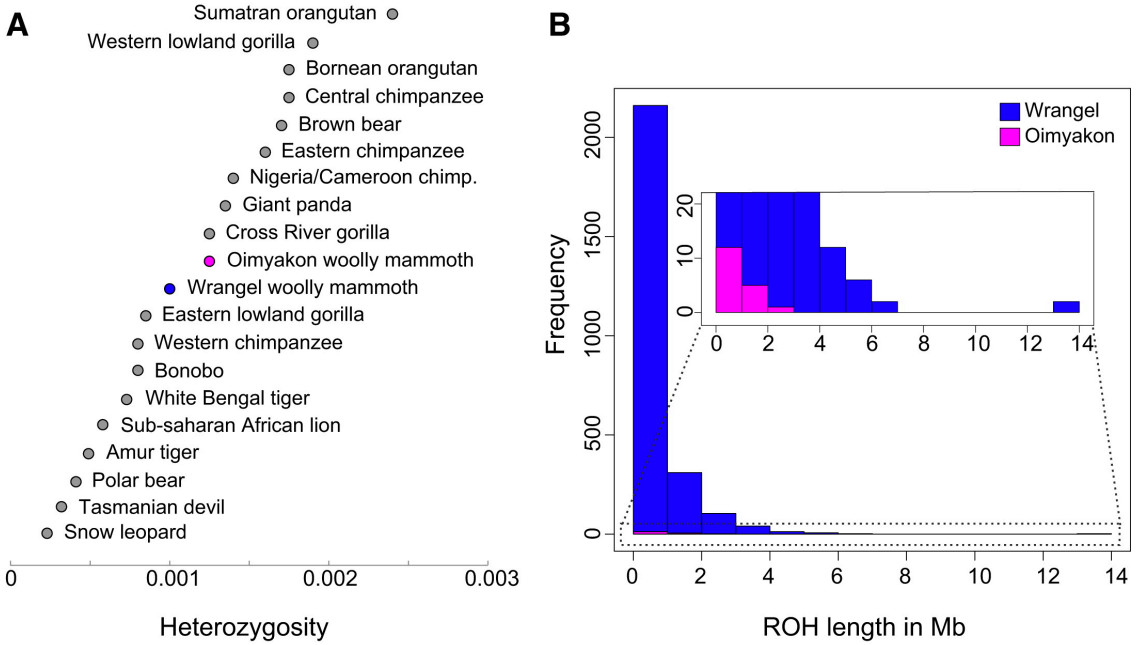


Extended runs of homozygosity (ROH) in inbred mammoth



Red = diversity
Grey = ROH

Genomic signal of inbreeding depression



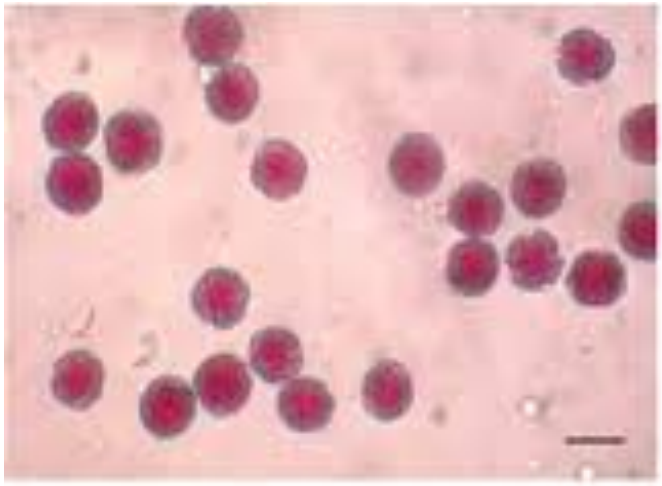
Extended runs of homozygosity (ROH) in inbred mammoth

Red = diversity
Grey = ROH

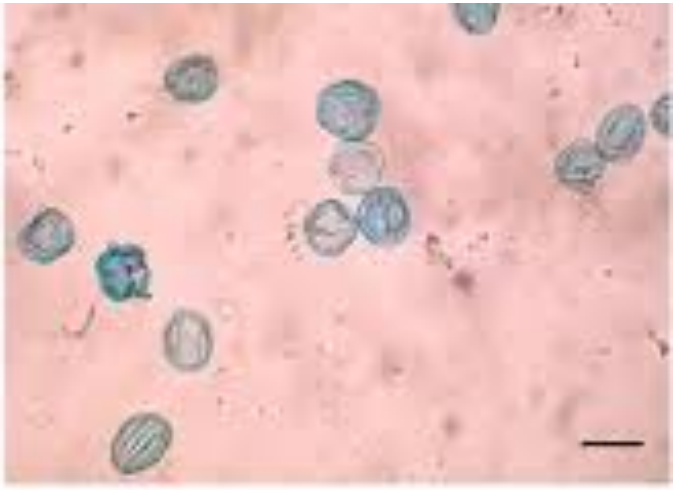
Gene Flow: outbreeding depression

Outbreeding Depression – reductions in the fitness of hybrids relative to that of parental individuals

Can result from either intrinsic (hybrid sterility / inviability) or extrinsic (ecological) factors

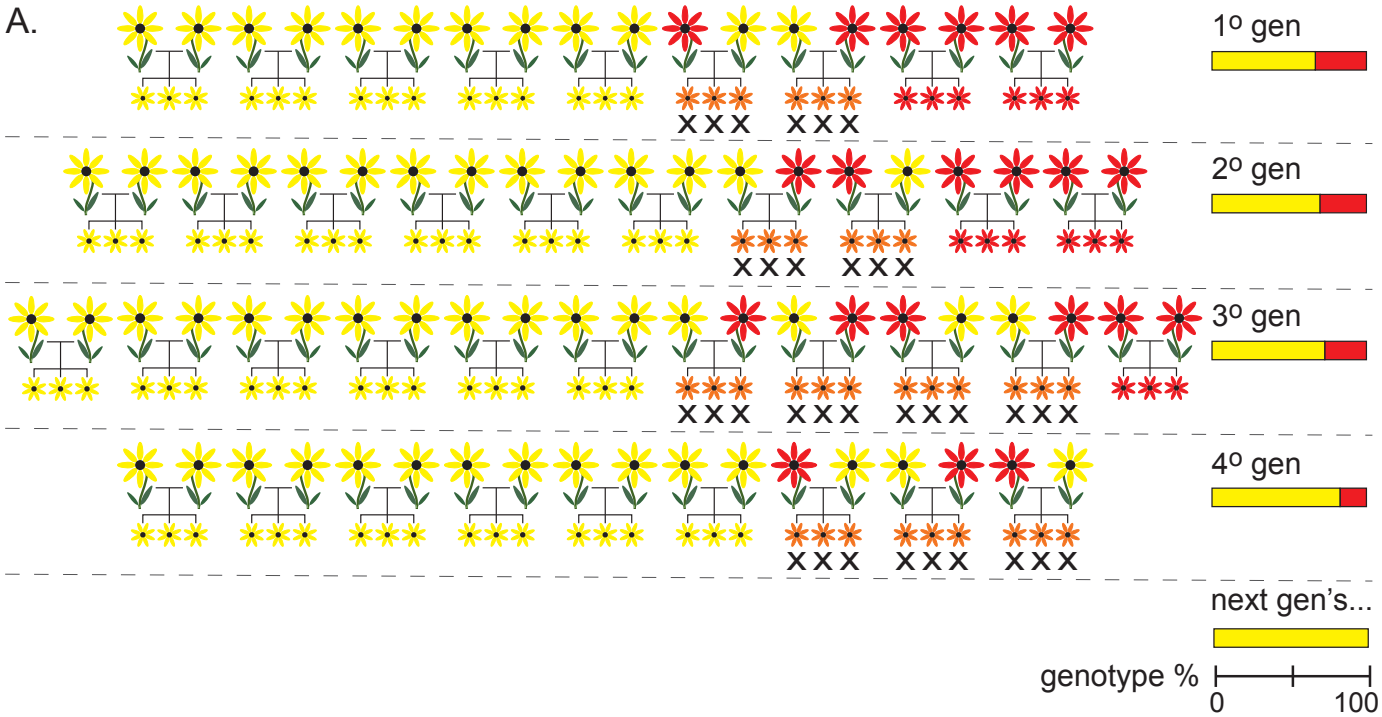


Control



Sterile

Demographic swamping – extinction due to production of maladaptive hybrids



Genetic swamping – parental populations replaced by hybrids

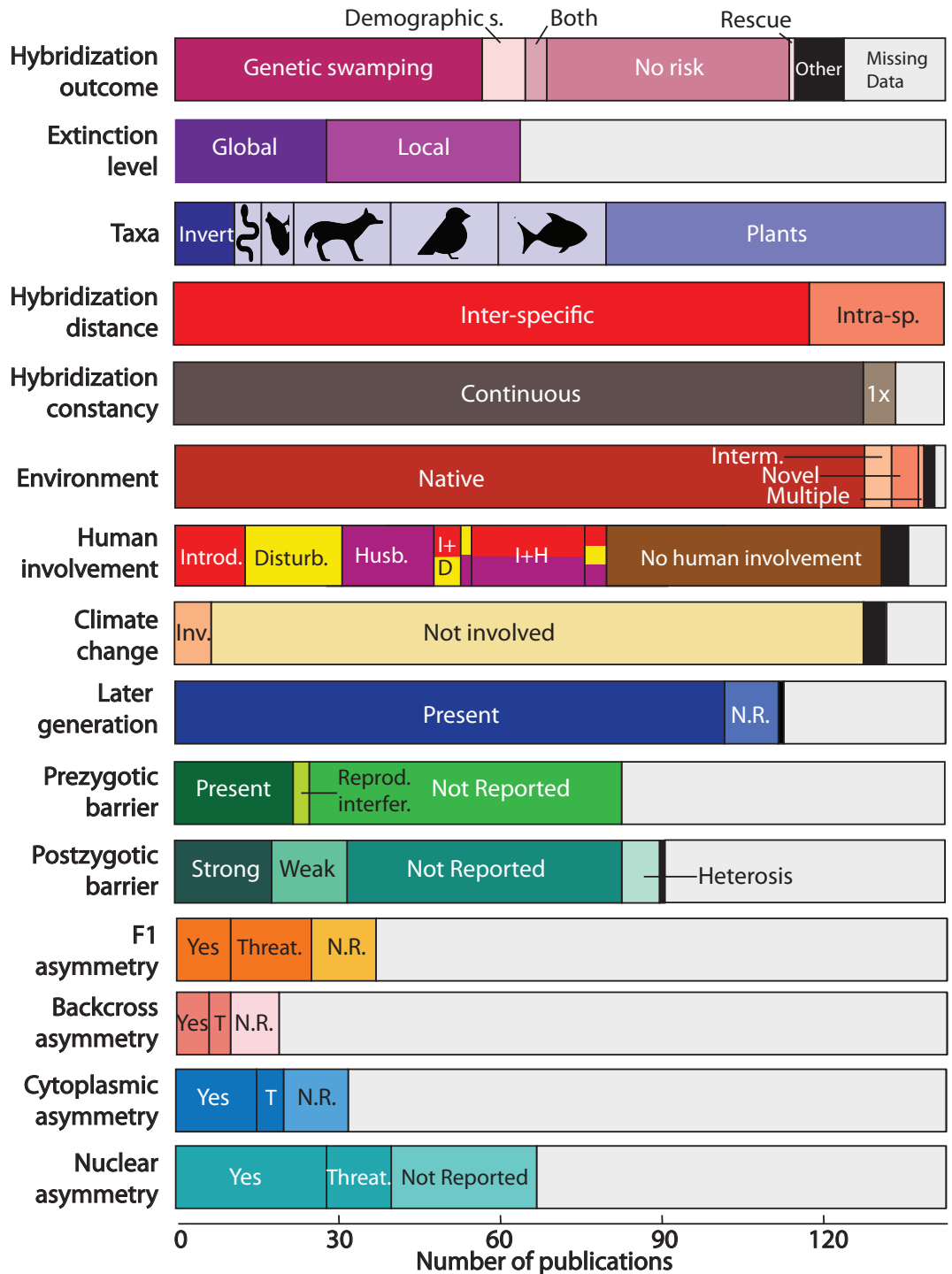
Todesco et al. 2016

Example of species at risk through genetic assimilation

Argyranthemum coronopifolium, a rare plant species known from only seven populations in the Canary Islands. Three of the seven populations now contain only hybrids and pure individuals of the invading congener

Cercocarpus traskiae, a rare plant species known from only one population on the Santa Cantalina Island. This population now contains only four pure individuals of the species. All others are hybrids (or the more abundant congener).

Figure 2 Overview of results from literature survey of 143 empirical papers (Todesco et al. 2016)



Gene Flow - the escape of engineered genes

Gene flow from crop plants into their wild relatives may lead to the escape of engineered genes.

Prevalence of Crop x Wild Hybridization

Wheat	**Yes**	Millet	**Yes**
Rice	**Yes**	Common Bean	**Yes**
Maize	**Yes**	Rapeseed	**Yes**
Soybean	**Yes**	Groundnut	**No**
Barley	**Yes**	Sunflower	**Yes**
Cotton	**Yes**	Sugar Cane	**Yes**
Sorghum	**Yes**		

Gene escape is inevitable for most crops.

Ellstrand et al. (1999)

The escape of engineered genes

Bt protein Cry1Ac
toxic to Lepidopteran Insects

Suleima helianthana
Sunflower Bud Moth (stem/developing bud)

Plagiomimicus spumosum
(developing bud; > 50% seed loss)

The escape of engineered genes

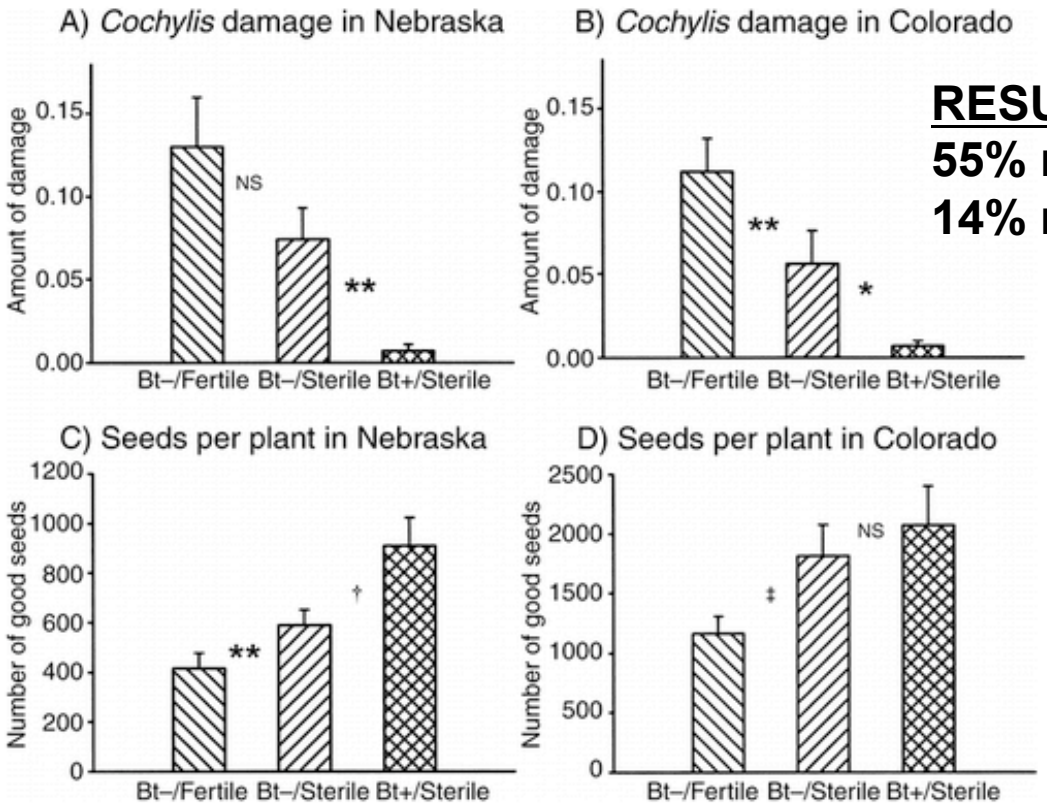
Question:

Will the Bt transgene provide an advantage to weedy sunflowers?

Experimental Design

- **backcrossed transgene into wild plants**
- **planted backcross plants that segregated for transgene at two localities**
- **compared fitness (fecundity) of plants with or without transgene**

Will the Bt transgene spread into weedy sunflowers?



RESULTS:

55% more seeds in NE

14% more seeds in CO

Snow et al 2003

FIG. 1. Effects of the Bt transgene and male sterility on relative amounts of sunflower seed damage by *Cochylis* moth species and the number of good seeds (undamaged) per plant in Nebraska and Colorado (USA). Untransformed means and 1 SE are shown; $N = 58–60$ plants in Nebraska, $N = 47–49$ plants in Colorado. Levels of statistical significance are based on planned contrasts between adjacent treatment means (see Table 1 for details, including methods for reporting damage levels). $^{*}P < 0.05$; $^{**}P < 0.01$; $\dagger P = 0.054$; $\ddagger P = 0.077$; NS, $P > 0.10$.

Transgenes: conclusions

- Bt transgenes are highly advantageous and will spread rapidly into wild sunflower populations
- Why should we care about this?
  - Evolution of weedy sunflowers; threat to specialist insects
- Not all transgenes are beneficial in wild species and thus likely to spread (e.g. resistance to white mold
- Decisions on environmental release should be made on a case-by-case basis.

Units of Conservation

An **Evolutionarily Significant Unit** (ESU) is a population of organisms that is considered distinct for purposes of conservation.

This term can apply to any species, subspecies, geographic race, or population.

Definitions of an ESU generally include at least one of the following criteria:

1) Current geographic separation,

2) Genetic differentiation at neutral markers (see below) among related ESUs caused by past restriction of gene flow, or

3) Locally adapted phenotypic traits caused by differences in selection.

The equivalent term used by COSEWIC is "Wildlife Species", or for brevity just "species", which is used to refer to biological species, subspecies, varieties, or geographically or genetically distinct populations of organisms.

Some unanswered questions in conservation genetics/genomics

Does population size reduce the adaptive potential of populations (strong association with neutral markers but will selected loci also be as strongly effected)?

What are the genomic causes of lower fitness in genetically depauperate populations (i.e. genes/pathways are responsible for inbreeding depression)?

How do drift and inbreeding influence plasticity and gene expression?