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?

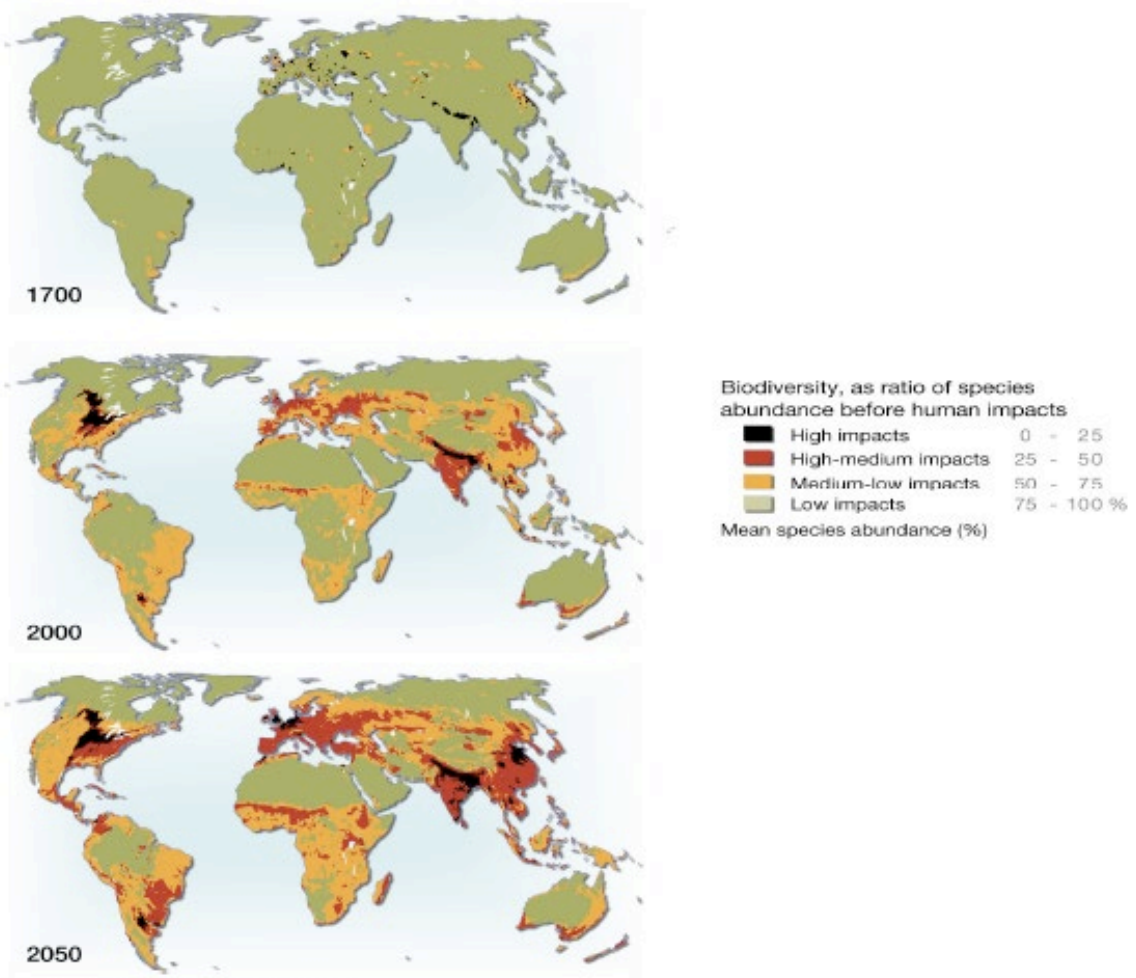
How quickly can genetic factors cause extinction?

"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

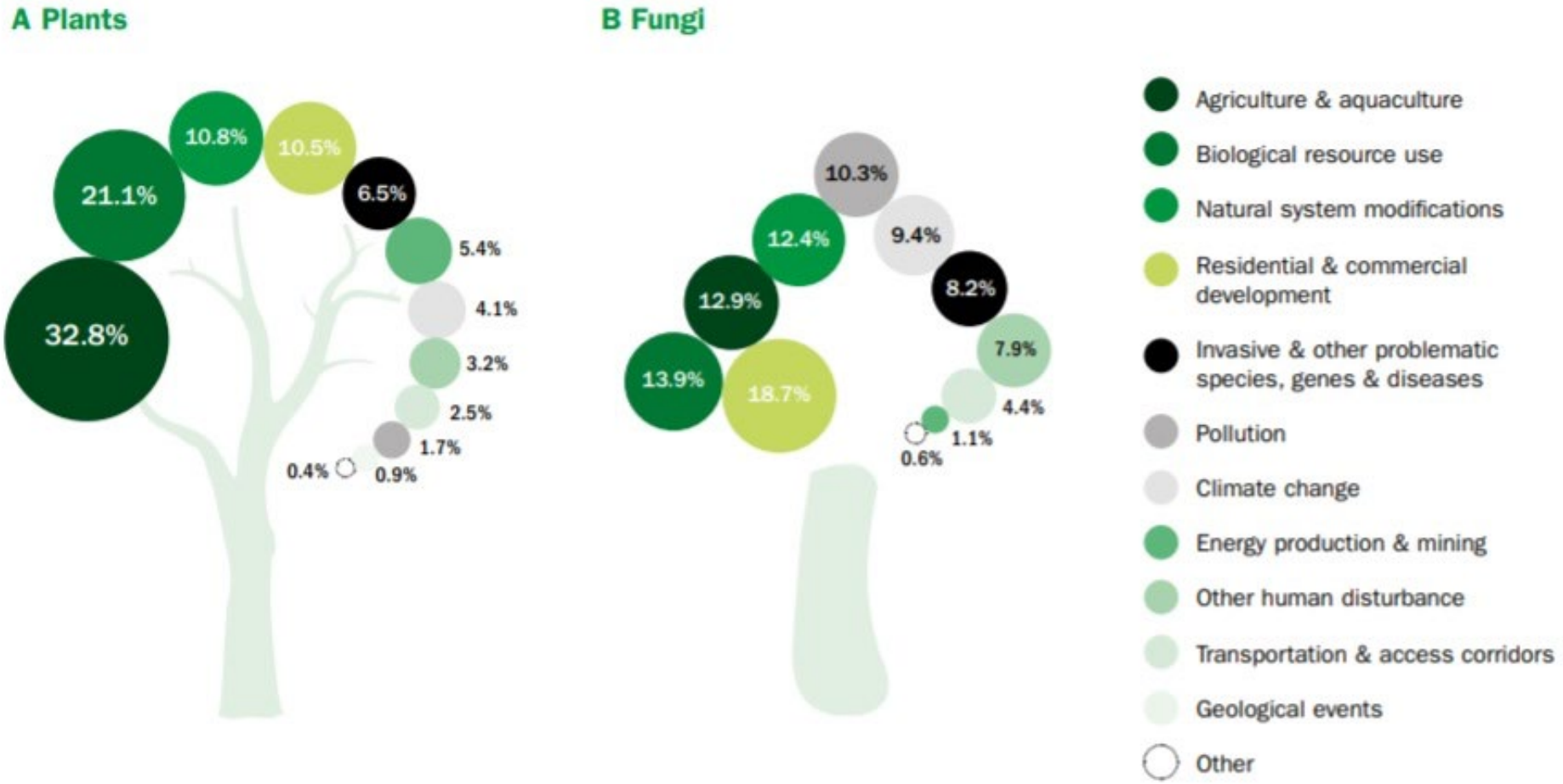
- Globally, one in five vertebrate and plant species are going extinct
- Within 100 years 1/2 to 2/3 of all species will be extinct or endangered
- Current extinction rates are at least 1000 times that of background levels

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?

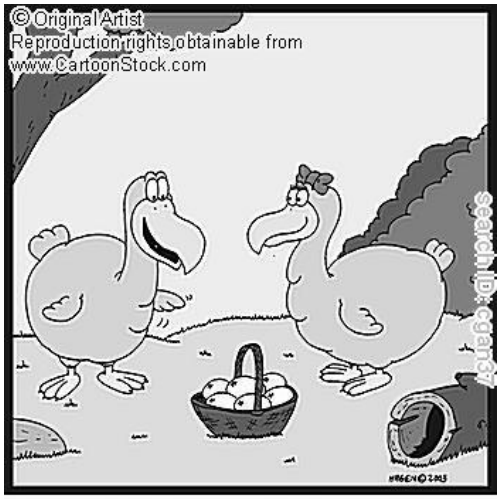


*The research described in this chapter was based on the IUCN Red List of Threatened Species 2020.1, current at the time. In the most recent IUCN Red List update (2020.2), this figure has increased to 120,372.

Why should we care?

Intrinsic value:

- Ethical argument (species have a
- right to exist)



Extrinsic value:

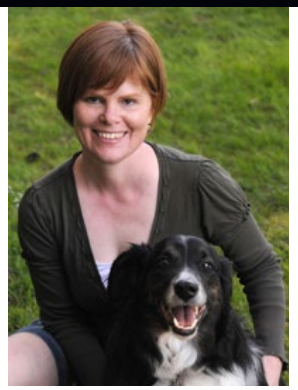
- Economic benefits, both direct (goods) and indirect (services)
- Genetic resources
- Aesthetic value and recreation

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 (as of 2019)

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

Category	Vascular Plants	Mosses	Lichens
Extirpated	2	1	0
Endangered	81	6	2
Threatened	51	2	1
Special Concern	24	4	3

Golden Paintbrush

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

- Circa 800 species listed

- 77 Recovery plans/action strategies

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

- BC has NO legal protection for endangered species (94% provincial crown land, much of which is unceded traditional First Nations territory; 5% private land)

The B.C. Wildlife Act prevents the direct killing of wildlife.

What is conservation genetics?

Conservation genetics is a subfield of population genetics that aims to understand the dynamics of genes in a population for the purpose of natural resource management and extinction prevention.

Some issues in plant conservation genetics:

1) population size: genetic drift and inbreeding

-short term (inbreeding depression)

-long term (reduced genetic diversity and ability to adapt; accumulation of deleterious mutations)

2) gene flow:

– too little gene flow (reduced genetic diversity, inbreeding, reduced evolutionary potential)

– too much gene flow (outbreeding depression, genetic assimilation)

3) units of conservation

Population size, genetic variation and fitness

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

Why?

Population size, genetic variation and fitness

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

Why?

SI species most strongly affected.

-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

Population size, genetic variation and fitness

Leimu et al 2006 meta-analysis of plants

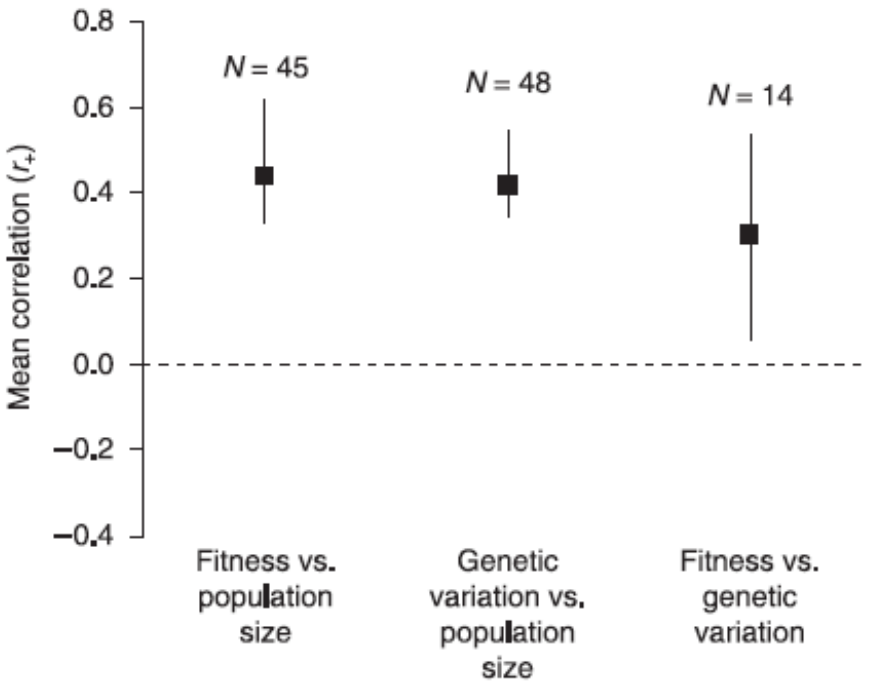
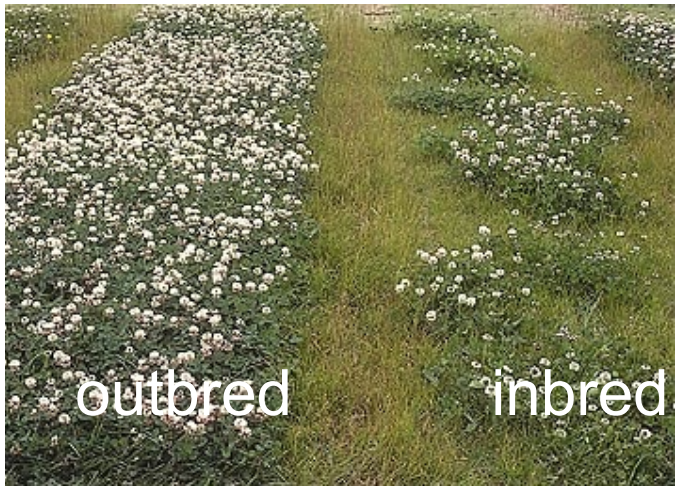
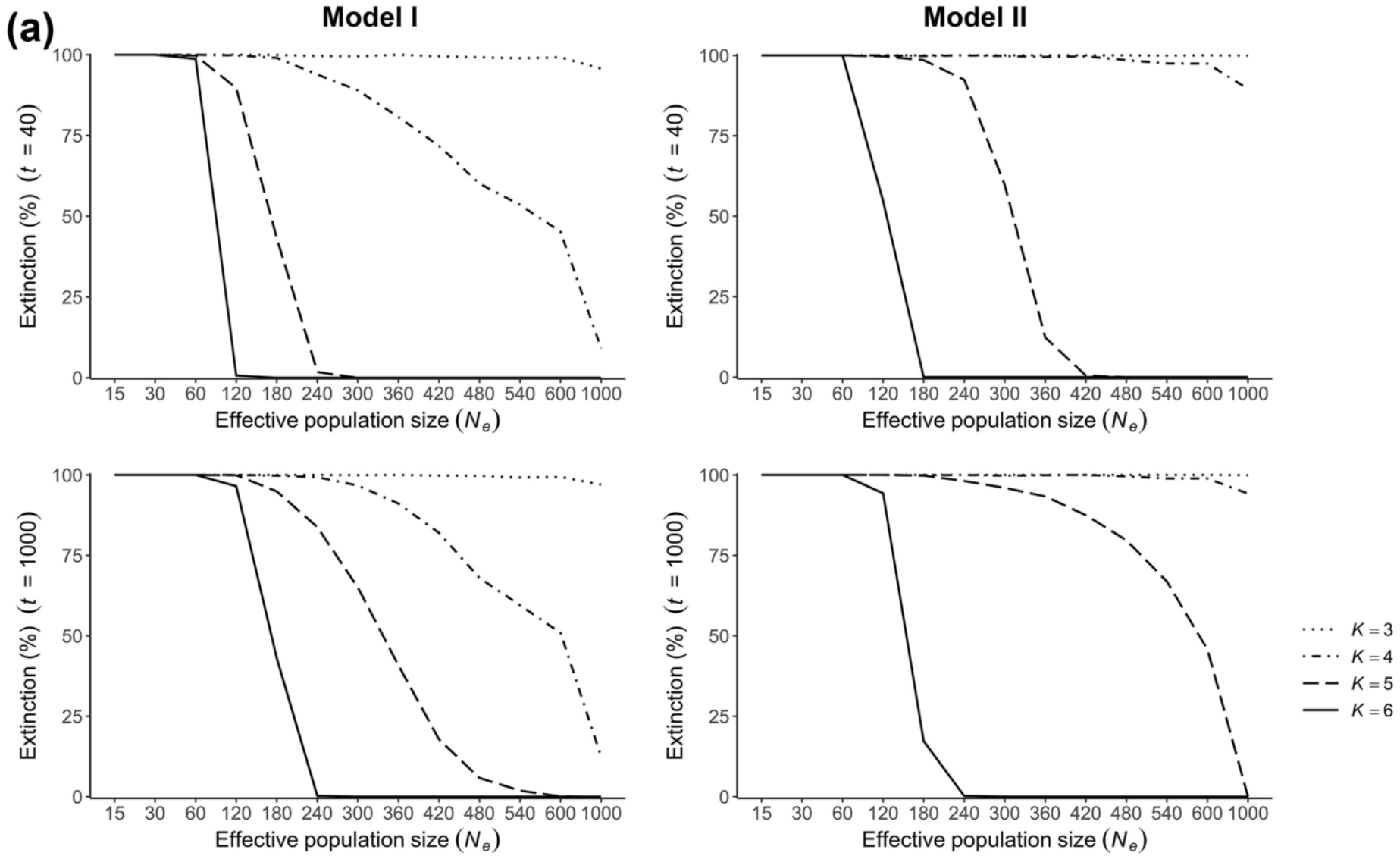


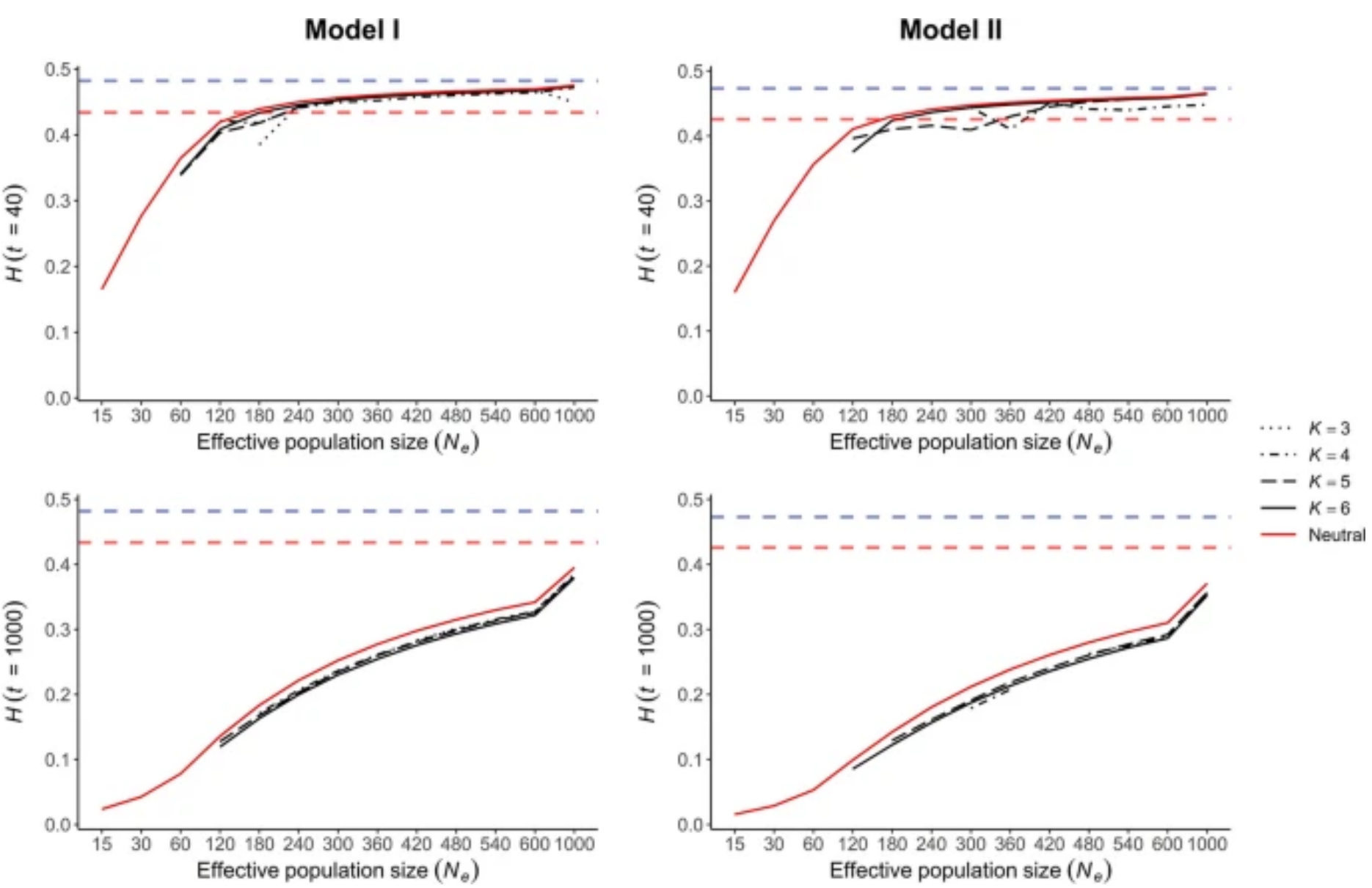
Fig. 1 Mean correlations (r_+) between population size, female fitness and genetic variation. In all figures, bars denote 95% confidence intervals obtained by bootstrapping, and sample size N denotes the number of independent studies included in meta-analysis. The relationships are considered significant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



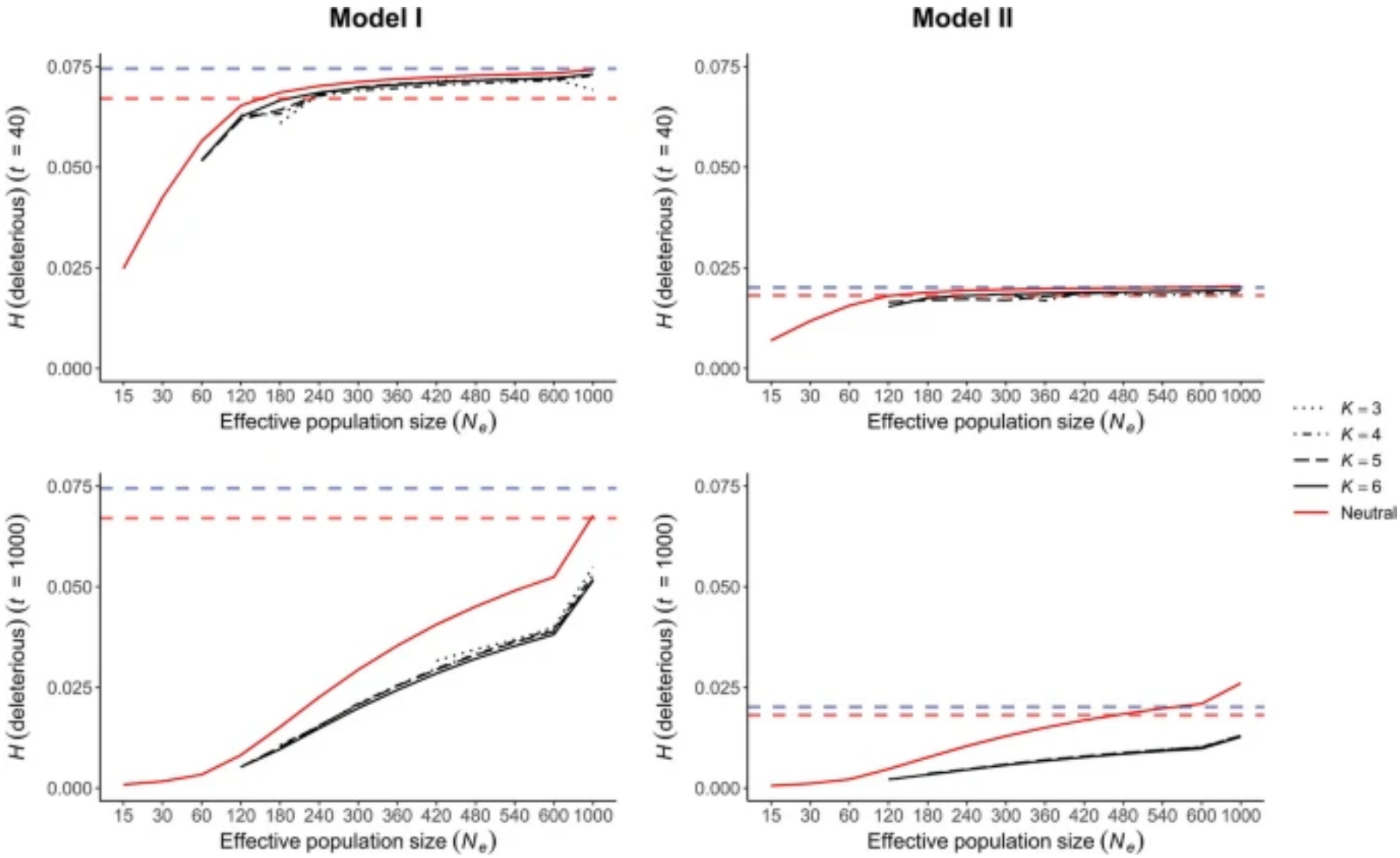
Substantial empirical evidence that there is a positive association between population size, genetic variation and fitness



a Probability of extinction, represented as percentage of extinct lines after 40 generations (first row) or 1000 generations (second row) for different effective population sizes (N_e) and reproductive rates (K) under two mutational models Pérez-Pereira et al. (2022)

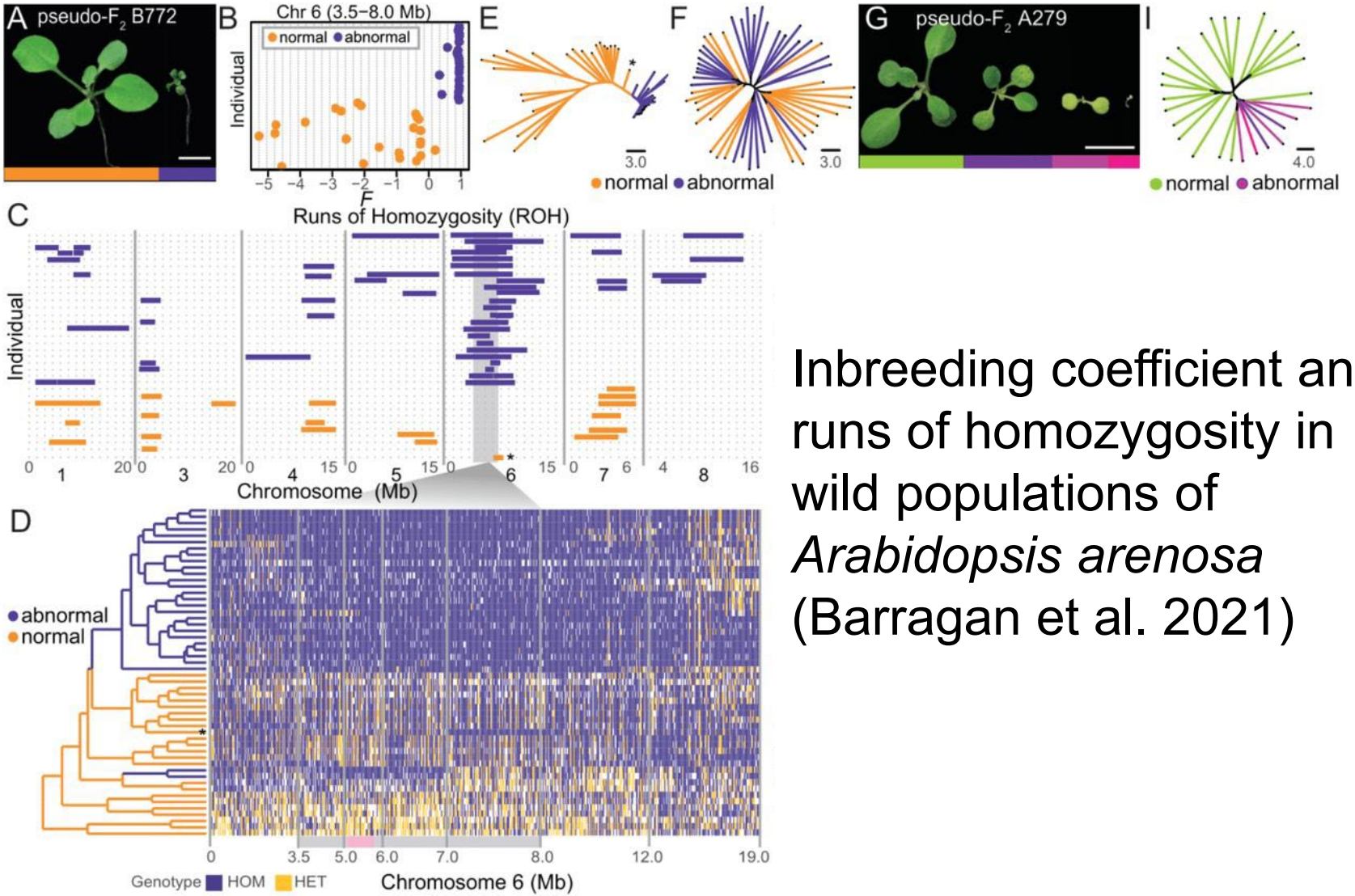


Observed mean heterozygosity (*H*) for neutral alleles as a function of effective population size (N_e) of the lines at generations $t = 40$ (first row) and $t = 1000$ (second row) under two mutational models (see Table 1).



Mean heterozygosity (H) for deleterious alleles as a function of effective population size (Ne) at generations t = 40 (first row) and t = 1000 (second row) under two mutational models (see Table 1).

Genomic signatures of inbreeding depression



Inbreeding coefficient and runs of homozygosity in wild populations of *Arabidopsis arenosa* (Barragan et al. 2021)

Gene Flow: outbreeding depression

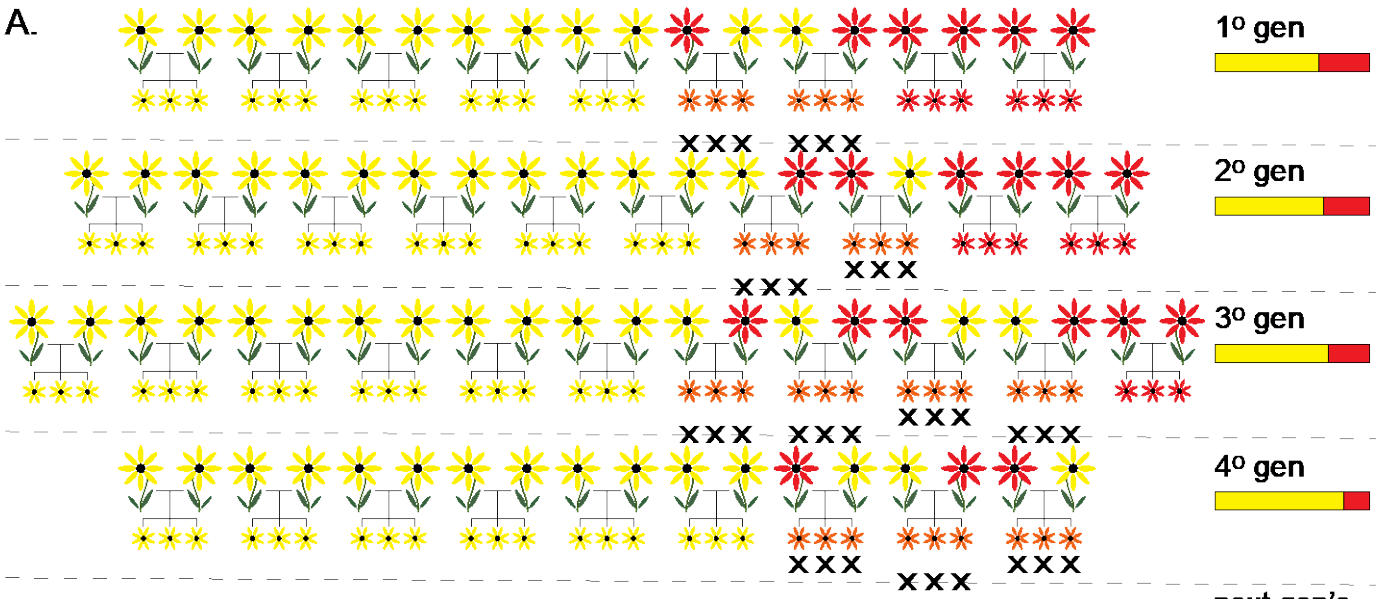
Outbreeding Depression – reductions in the fitness of hybrids relative to that of parental individuals

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

Control

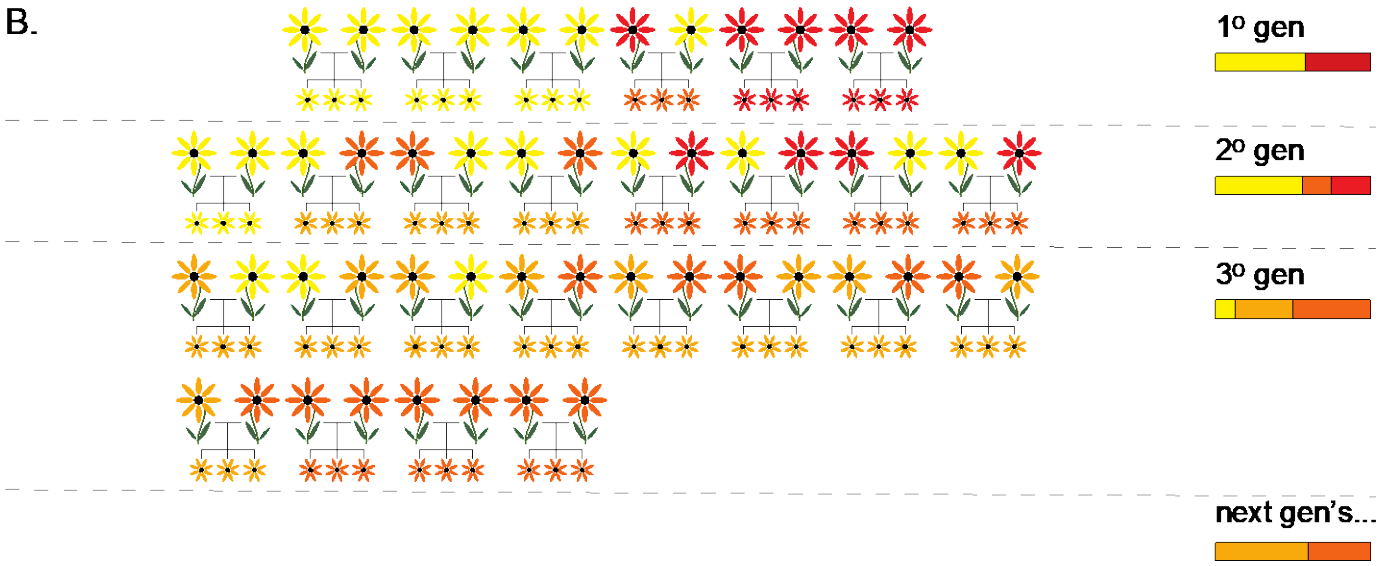
Sterile

Demographic swamping – extinction due to production of maladaptive hybrids



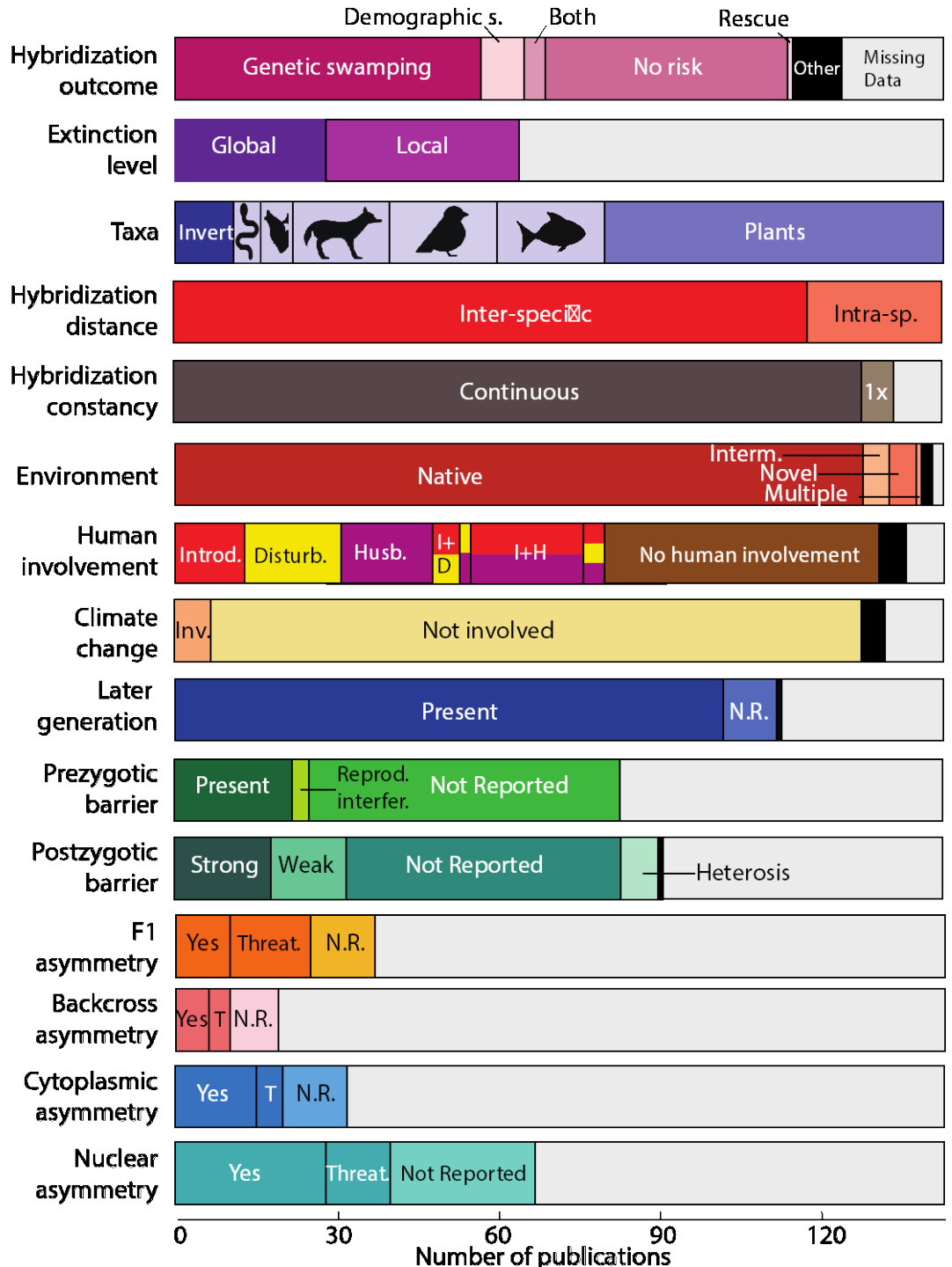
Which is more frequent? Why?

Genetic swamping – parental populations replaced by hybrids



Todesco et al. 2016

Figure 2 Overview of results from literature survey of 143 empirical papers (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).

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?