

# Plant of the Day



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*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?

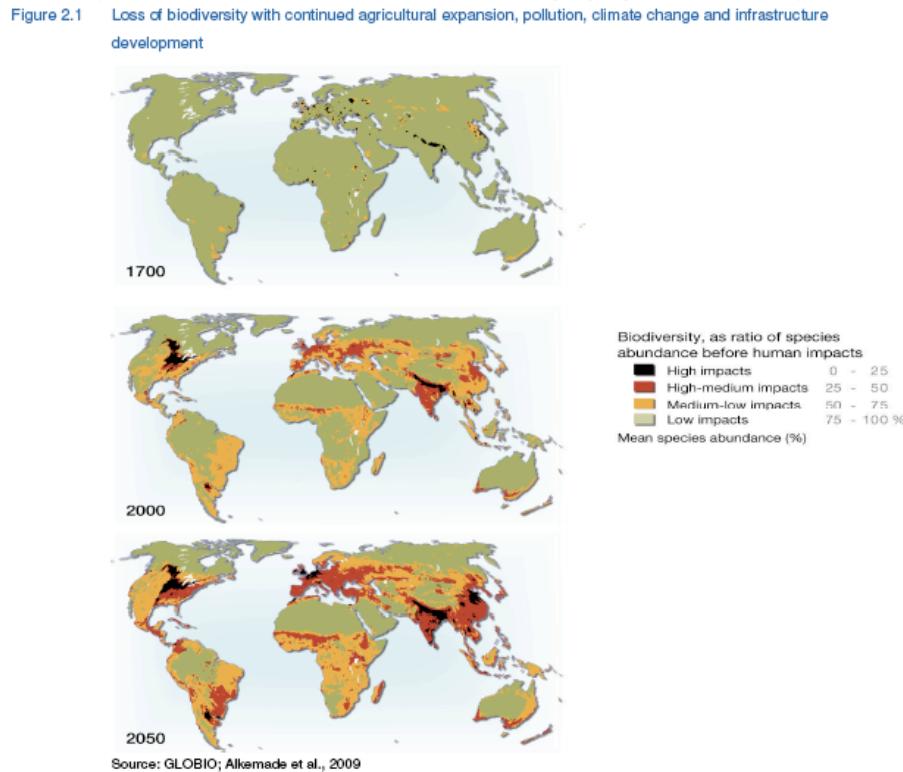


"We've worked out what the creature looked like – now all we need to do is find out why it became extinct."

# 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



# 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

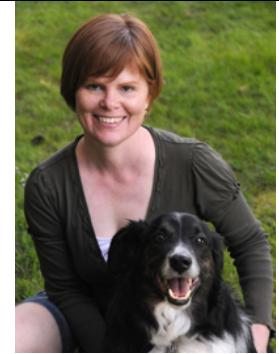
Aesthetic value and recreation

# 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
Extripated/ 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

2	VIRGINIANUM	CAREX AGGREGATA	OBOVATA	ROBINSONII	NAJAS MARINA	ESCHSCHOLTZII	URTICIFOLIA VAR	PALLIDUM	SSP DEPRESSA	ENEMION SAVILEI	JUNCUS SUBTILIS	ARCTICA	IPISILLUS SSP	HENDERSONII
3	AESCRULUS GLABRA	CAREX ALATA	DEPAUPERATUM	SCABRUM VAR	DIVARICATA SSP	GASPENSIS	LACKSCHEWITZII	RUGULOSUM	SCAMMANIANA	GLABERRIMUM SSP	KOBRESIA SIBERICA	BESSEYI VAR	SUBSIBERICUS	SILENE REPENS
4	AGALINS MAREMMA	CAREX GULLATTA	LEIBERGII VAR 2	SIMOCARPOUM	ATTENUATUM	PENSylvANICA	FRICULAE SSP	SATHYLATUM	TUBerosa	HORNemannii SSP	TRIPLIFLORA	CAMPETRIS VAR	BIRLORA	TAMYRENSIS
5	NEOSCOTIA	CAREX NEONENS	TRICARPA	CARPENTERII	CARPENTERII	MONTANA	MONTANA	WADDESTONIANA	LEUCADA	LEUCADA	CALYCANTHIFOLIA	CALYCANTHIFOLIA VAR	DIVERSIFOLIA VAR	PERFOLIATUM
6	PURPUREA	CAREX PALMYRI	DEARMORI	DISCOLOR	DISCOLOR VAR	HYDROPHILUM	DRENCKEANUM	NOBLIGIRLEI	ONCOPHYLLUM	REGGENSENSIS	MONTANUM	ALLOSONII	DIVERSIFOLIA VAR	SEPTENTRIONALE
7	SOROPHILARIBES	CAREX RIBES CORV	ALATISSIMA	IRIS-BREVICULIS	PINICARUM	ANGUSTIFOLIUM	MEDIUM-VULGARUM	NOTOTTORIANUS	OFFICINALIS	HYPERSPIRODES	ARTICULATA VAR	LAGERBERGII VAR	DRUMMONDI	OVALIS
8	ALATISSIMA	CAREX COLLECTANEA	MONTANA	INTERIOR	IMBRICATUS	NERVOSEA	ALNUS-SERRULATA	DESCHAMPSIOIDES	WILLIAMSII	LACKSCHEWITZII	INTEGRIFOLIUM	SCAMMANIANA	ELEGANS	SMILAX ILLINOENSIS
9	HYEMALIS	FESTUCAEA	ELEGANS	ACADIENSIS	CAMPESTRIS VAR	SEDUM VILLOSUM	ACANTHICARPA	BISTORTA	ODONTORNIZA	ERIGERON LANATUS	LEWISIA TRIFOLYLLA	CONTERNINA	SAGITATA	VAR GILLMANI
10	ALCHEMILLA AHENII	FLACCIDERA	ROMA-GIAGIETII	ISOCYBE HUMULI	MICROCENSIS VAR	GLABELLUS	FERNALDI	CAMPIS RADICANS	ODONTORNIZA VAR	LEIBERGII	LIATRIS ASPERA	CYMBALARIA	IUNIPOLIA VAR	VAR ONTARIENSIS
11	GLOMERULUS	FLACCIDERA	VAR DIVERGENS	LEUCADAE	BIODON	POCOTOMIPLORUM	HYDROPHILUS	ANAGALLIS MINIMA	ANGULATA	HOOKERI	ERIGERON MEXICAE	CALDERI	MORESBiensis	AMBIGUA
12	RETRORSIA	FLACCIDERA	FLACCIDERA	LEUCADAE	LILIACAPITIS	MONTANUM	INTEGERRIMUS VAR	CHAMAEMAJESMAE SSP	BREWERI VAR	OCHOTENSE	POLIOSPERMUS	VERTICILLATUM	PANICUM RIGIDULUM	ARCTICA
13	CORYMBOSEA	CAREX LAXA	DRABA MURRAYI	COMMUNIS VAR	MCCONNELLII	SENNIA HEBECPARA	DRUMMONDI SSP	ADELOSTOMA	OCHOTENSE VAR	PARKERI	LILAEA SOLLOIDES	VAR PUBESES	DESCHAMPSIOIDES	MICROTHeca VAR
14	FRIESIANA SSP	LEAVENWORTHII	DRABA NORVEGICA	KOELERA ASIATICA	CANADENSIS	HERMAPHRODITA	MULTICEPS	ALBOLUTESCENS	FLAVULA	CERNUM	LILUM CANADENSE	ALBOROSEUM	DISTANS SSP	CHORELEUCIA
15	LIZZULOIDES	CAREX LONGII	VAR SORBORGERI	NOVAE	FASTIGIATA	OREGANA VAR	IANEMONE PIPERI	CAREX AMPLIFOLIA	VAR CONNATA	PYROLIOPOLUM VAR	DOUGLASII SSP	PYGMÆUM	LAURENTIANA	VAGINIFLORUS VAR
16	VAR IRISIUM	MESOCOREA	DRABA OGIVIENSIS	BULGATUS	PARRYI MUDICULUS	SSP WILLIAMSII	AROMATICA	VAR XANTHO-CARPA	BRainerdii	SPLENDENS	SEPTENTRIONALIS	RADIATUM SSP	VERTICILLATUM	ALASKANA
17	SPARSIFLORA	MUELENBERGII	DRABA PEASEI	VAR	PENICILLATA	VAR SCOLULERI	EUCOSMA	APPALACHICA	CORUSCA	ARENICOLA VAR	VAR ANAGALLIDEA	PAPAYER WALPOLEI	CARTHAMOIDES	AMERICANA
18	ALPINIA VAR	OLOSPERMA VAR	PYRONOSPERMA	LECHEA MINOR	PHACELIA MOLLIS	SILENE TAYLORAE	ESCHSCHOLTZIANUS	SSP CAPILLACEA	LUMARIA	MONTANUM	LINUM MEDIUM	SETACEUM	PRIMOIDES	DICRANOIDES
19	DICHOTOMIA	VAR ANDROGYNA	DRABA SCOTTERI	LECHEA PULCHERRIMA	PHACELIA PURSHII	SSP OGIVIENSIS	HYEMALE	CAREX BICKNELLII	OKENNONII	PAUCICAPITATUS	MEDIUM	PALUSTRIS	ALLENII	STELLARIA OBSTUSA
20	PURPURASCENS	RETROFLEXA	YUKONENSIS	LECHEA STRICTA	PILOSA	SILENE VIRGINICA	AGULEGIA JONESII	BRUNNEOSCENS SSP	PHIPPSII	EURYBIA PYGMAEA	LINUM VIRGINIANUM	VERTICILLATA	CALIFORNICUS	UMBELLATA
21	PURPUREA	CAREX SHORTIANA	FRAGRANS VAR	OXYCARPUM	SSP BRITTONII	LADINUM	ARABIS LIGNIFERA	CAREX FETA	SUBORICULATA	GALEOTORUM	AURICULATA	PELLAEA GASTONYI	SULPHUREUS	SSP RICII
22	SSP GRISCOMI	CAREX TUMULICOLA	ECHINACEA PALLIDA	PROCUMBENS	OPPOSITIFOLIA	FUSCATUM	LYRATA	CAREX FRANKII	MODOCENSIS SSP	MINUTIFLORA	LISTERA AUSTRALIS	SP OCCIDENTALIS	PATIDIUM PINNATA	SUAEDA MOQUINI
23	LOBULARIA	VAR VALLICOLA	ATROPURPUREA	VIOLACEA	AVENACEUM	OVALIS VAR OVALIS	ARABIS MURRAYI	CAREX GMELINII	AMBIGUA	PROFUNDI	SSP FLAVA	VIRGINIA SSP	OXYACANTHOIDES	DUMOSUM VAR
24	LACINATA	VAR ELATIOR	GENICULATA	MULTIRIDA	FIGURATUS	VAR JUNCSEA	ARABIS SHORTHII	HELEONASTES SSP	KELSEYANA	SSP ASPERULUM	BRANDEGEEI	ATTENUATUS VAR	OXYACANTHOIDES	HEUCHEROFORMS
25	HIRTELLA	VAR	QUADRANGULATA	TRITICOIDES	FIGURATUS SSP	VAR CHLOROLEPIS	LONGESPICA	CAREX HOSTIANA	CASCADENSIS	GAURA BIENNIS	POLYCARPA	GORMANII	TRACYI	REVOLUTUM
26	LANUGINOSA	WILDENOWII	ARCTICUM	SPHEROCREA	OLIARS	VAR MONTICOLA	LONGESPICA VAR	FLAVESCENS	HUMILE	LUPINUS KUSCHEI	PHACELIA LYALLII	TRIFOLIUM	TRIFOLIUM	TRIFOLIUM
27	QUADRIFOlia	LYCOPODIOIDES	CAPILLARIS	HARNESSII	FIMBRIOLATIA	VICTORIANI	LONGESPICA VAR	CAREX INTERRUPTA	ARISTINUM	FREMONTII	LUPINUS MINIMUS	SSP LONGIFOLIA	LASIOPLOCUS	LAUCINATUM VAR
28	VARIEGATA	CASTILLEJA FULVA	HYSSOPIFOLIUM	LEPAGEI	AMMOPHALA	MUNROANA	CHAMISSONIS VAR	MALCOVIANA	GUTTATUM	PUBERULENTA	GROENLANDICA	PIHLIA LANCEOLATA	RUBUS NIVALIS	MILLEFLORUM
29	ADULTERINUM SSP	SSP MINOR	ERIGERON SALISHII	TEXANUM	BANFRIANA	NITIDA	LANEOLATA	OLIGOCEARIA	LAURENTIANA	QUINQUEPOLIA	VAR ACADEMIENSIS	DIDYMOCARPA VAR	VAR SCIOS	THLASPI ARCTICUM
30	BODINII	CASTILLEJA TENUIS	STRUCTUM SSP	LIMUM STRATUM	YUKONENSIS	SPLENDENS	AROMA LONGIFOLIA	CAREX PANSA	PROTRUSA	ROSSII	LULZULA RUPESCENS	LEDINGHAMII	RUMEX ALTISSIMUS	CONDENSATA
31	CONVALLARIUS VAR	EXALTATUM	CAPITATUM VAR	LOMATIUM COUS	ORICULTA	VAR	AROMA LOUISEANA	CAREX PAYSONIS	SPECIAROIDES	LYCORUS RUBELLUS	PIPERIA CANDIDA	PALUFIOLUS	DIVERSILOBUM	TRIFOLIUM
32	KENTROPHYTA	MUELENBERGII	INDISPICUUM VAR	LOMATIUM GRAYI	BIFLORUM VAR	OVALIS	ALASKANA	CAREX RUFINA	SOPHOROIDES	LEPTOSTACHYNA	VIRGINICUS	TENELLUS	SALIX CHAMISSONS	OMENSIS
33	KENTROPHYTA VAR	ALPINUM VAR	OCCIDENTALIS VAR	ORIENTALE	DOUGLASII SSP	AIROIDES	VAR	VAR	CANECENSIS	OCIDENTALIS	MALAXIS PALLIDOSA	CANESENSIS	RICHARDSONII	DICHTOTUM
34	MICROCYSTIS	CANADENSIS	ALTISSIMUM	VAR DOUGLASII	KWAKIUTLII	MACLEANII	PURPURASCENS	SCHWEINTZII	ROTUNDIFOLIUM	HIRSUTULA SSP	MARAH OREGANUS	ALBIDA VAR	VAR	CONDINNA
35	ATRIPLEX POWELLII	LTUETUM	DUBIUM	ALTERNIFOLIA	SETIGERUM	STREPTOPOIDES	SULLIVANTI	CAREX SEORSA	DCENTRICA UNIFORM	HACKELIA CLAVATA	SPECTABILIS	CHORISIANA	VAR OVALIFOLIA	GASPENSIS
36	ATRIPLEX TRUNCATA	COMMUTATA	SSP	TRIFOLIUM	LANCEOLATUM VAR	VERTICILLATA	CAREX SUBRECTA	BOREALE VAR 1	HACKELIA DIFFUSA	MMULUS ALATUS	DLATATA VAR	SALIX SESSILIFOLIA	TRISETUM WOLFI	ALTERNIFOLIA
37	VIRGINICA	INCANUM	MACROPHYLLA VAR	ARGENTEUS VAR	PULCHER	SUBLATUM VAR 1	ADULTERIUM	CAREX WIEGANII	LEIBERGII VAR 1	VAR DIFFUSA	MMULUS BREWERI	POA HARTZII	ISALIX TWEEDYI	RADIATA
38	BIDENS EATONII	VAR MONTICOLUM	EURYBIA RADULINA	BINGENGENIS VAR	SUBJUGA	ACALIS VAR	MURARA	LYCOPODIODES	WILCOXIANUM	SSP BRENTONIANA	ELEGANS	FERNALDiana	MENTZESII	SUBLATA
39	HETERODOKA	CISTANTE TWEEDYI	SCREBERI	LUPINUS LERDUS	VANILLIANA	DASYCARPUM VAR	ALPINUS VAR	AMBIGUA	DISPORUM SMITHII	WHITEII	MACROCARPA	POA LAXIFLORA	CANADENSIS VAR	VIOLA HOWELLII
40	BLEPHILIA CLAVATA	OGIVIENSIS	GYMNOispermoide	OREGANUS VAR	CONTRACTA	BARBINODE	LENTIGINOSUS	AMBIGUA SSP	GORMANI	OCIDENTALE	YUKONENSIS	POA NERVOSA	SAUSSUREA DENSA	VAR EDULIS
41	BLEPHILIA HIRSUTA	SUBTILIS	BREVISSIMA	LUPINUS VALLICOLA	LEMNONII	SUBNUDUM	NUTZOTINENSIS	CUSICKII	LAEVIGATA	AUTUMNALE VAR	CAULESSIMA	POA PORSILDII	DESPISTOSA SSP	ALTERNIFOLIA
42	STRICTA	STRATA VAR	HYPERPORA	SSP APRICUS	MACRA	SUBNUDUM VAR	RAEOMOSIS VAR	CASTILLEJA ELMERI	LAEVIGATA VAR	HERATICA NOBILIS	MONTA BOSTOCKII	PSEUDABBREVITAT	NELSONIANA SSP	VIC CAROLINIANA
43	ACUMINATUM	TINCTORIA VAR	PUBERULA	LUPINUS WYETHII	POACEA	NEVADENSIS	SCLEROCARPUS	HYPERBOREA	CORYMBOSA	PUMILUS	MONTA CHAMISSOI	POA SYLVESTRIS	REDOSKII	CARLOTTAE
44	ASCENDENS	DISPERMA	FRAXINUS LATIFOLIA	LULZULA ECHINATA	VERTICILLATUM VAR	DICHTOMIUM	UMBELLATUS	THOMPSONII	DRABA DENSIFOLIA	AMERICANA	MONTA HOWELLII	MACULINI	SERPYLLIFOLIA	VIOLA HOWELLII
45	BOREALE	MARGARETTIAE	FURENA PUMILA	TANACETIFOLIA	QUERCUS IUCIPOLIA	OBONGLUM	ACADENSIS	ARVENSE SSP	LONGOCARPA VAR	ERCOIDES	SYLVATICA VAR	CERATOPHYLLUM	SAXIFRAGA SPICATA	VIOLA PALMATA
46	LINEARE	PERSIMILIS	GALIUM CONONIUM	MADIA MINIMA	LOGII	CYATHIMERUM	FRANKTONII	CERASTOIDES	LONGOCARPA VAR	CONOLOR	TENUIFLORA VAR	BOREALE	STARLIS	DILATATA
47	PARADOXUM	MODOCENSIS SSP	MULTIFLORUM	LINDLEYI	MAXIMUM	TRIFOLIUM MACRAEII	BAPTISIA TINCTORIA	PSCHERERIANUM	DRABA MACONII	APPENDICULATUM	CALIFORNICA	ELEGANS	TAYLORII	SSP LINGUIPOLIA
48	PEDUNCULOSUM	OCIDENTALIS SSP	RACEMOSUM	MIMULUS DENTATUS	RIBES MONTGRENENSI	REFLEXUM	VIRGINICA	PROCUMBENS	PALANDERANA	TENUIPES	OCIDENTALE SSP	SOZIAZIA PUSILLA	SSP VENOSA	IPISILLUS SSP
49	PSEUDOPINNATUM	WATSONII	RAMOSISSIMUM	SSP PUNCTATA	OXYACANTHOIDES	ANGUSTIFOLIUM	BETULA MICHAUXII	PROCUMBENS VAR	DRABA PORSILDII	PROLIRIUM	USSURIENSE	VERTICILLATA VAR	ANDROSTROCHAETUS	AREOLATA
50	BOTRYCHIUM SP 3	ARISTATIS VAR	GENTIANA CLAUSIA	VAR VILLOCALIS	RUBUS GULOSUS	CHENOPODIOPOLIA	HYPERBOREA VAR	GRACILLIMA	DRABA RUAXES	SCOULERI SSP	NAJAS GRACILLIMA	BOREALE	ISCRUPS CLINTONII	VAR BREVIS
51	RAYA PILOSA	BRACHYCENTRUM	QUINQUEFOLIA SSP	ODORATISSIMA SSP	RUBUS SUPRAR	UMBILICATA	DENSIFLORA	STANDELLEANUM	STENOPELATA	IDAHO SCAPIGERA	INTERTEXTA	CAURIANUM SSP	HETEROCHAETUS	
52	NARDOSMA	CAROLINIANUM SSP	DETOMSA	ODORATISSIMA SSP	SABATIA ANGULARIS	FASCICULATA	GLABELLA	WATSONII	DRABA VENTOSA	IMPATIENS AURELLA	NELUMBIO LUTEA	DOUGLASII SSP	ANGUSTIFOLIA	
53	CINNIDES	CESPITOSSA SSP	DETOMSA SSP	SQUARROSA	CALYDONIA VAR	FASCICULATA SSP	ASTERIOIDES	LOWENSE	ECLIPTA PROSTRATA	ECALCARATA	CUSPIDATA	DOUGLASII SSP	PARVULA VAR	
54	PURPURASCENS	CESPITOSSA SSP	GEUM VIRGINIANUM	MONTIA DIFFUSA	BOREALIS	GIGANTEA	ASTERIOIDES VAR	WRIGHTII	ELEOCHARIS NITIDA	LINARIIFOLIUS	NEMOROSA	FRANKONII	OREGANA	
55	MARGINATA	CESPITOSSA SSP	GILIA SIMULATA	ANDINA	SALIX FUSCESCENS	VIOLA BICOLOR	CAMPESTRE	ORSINUS EDULE	VAR RACEMOSA	JAUMEIA CARNOSA	PSAMMOPHILA	POLYGALOIDES SSP	ATROPPURPUREUS	
56	TERRESTRIS	CILIATA	GILIA TERRERRIMA	FLIFORMIS	SALIX LEMMONII	BIFLORA	ORENULATUM	UMBELLATA VAR	ELODEA BIFOLIATA	JUNCUS CONFUSUS	NORVEGICA	POLYGONUM TENUI	SENECIO FUSCATUS	
57	ANDINA	MARLICANUM	HIBISCUS LAEVIS	SOLIBIFERA	SALIX RAUPII	VITIS VULPINA	HESPERIUM	SSP VIMINEA	ELYMUS CALDERI	MARGINATUS VAR	CORYMBOSA SSP	IMBRICANS	NEWCOMBEI	
58	BREVIFLORA	SESSILIFOLIUM	LONGIPILUM	MACROSPERMUM	SSP	MICROCARPA	MONTANUM	RHOMBOIDEA	LANCEOLATUM SSP	JUNCUS OXYMERSIS	OXALIS OREGANA	IMBRICANS SSP	ISHELDONENSIS	
59	CONTORTA	DIANTHUS REPENS	MARLICANUM	PINNATUM	CESPITOSSA SSP	PAUPERICULA VAR	MORMO	CLAYTONIA ARCTICA	EYMIUS SIBERICUS	JUNCUS SECUNDUS	OXYPOLIS RIGIDOR	KRUECKEBERGII	Rostrata	

# 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#ixzz1CTdKlOX>

# 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

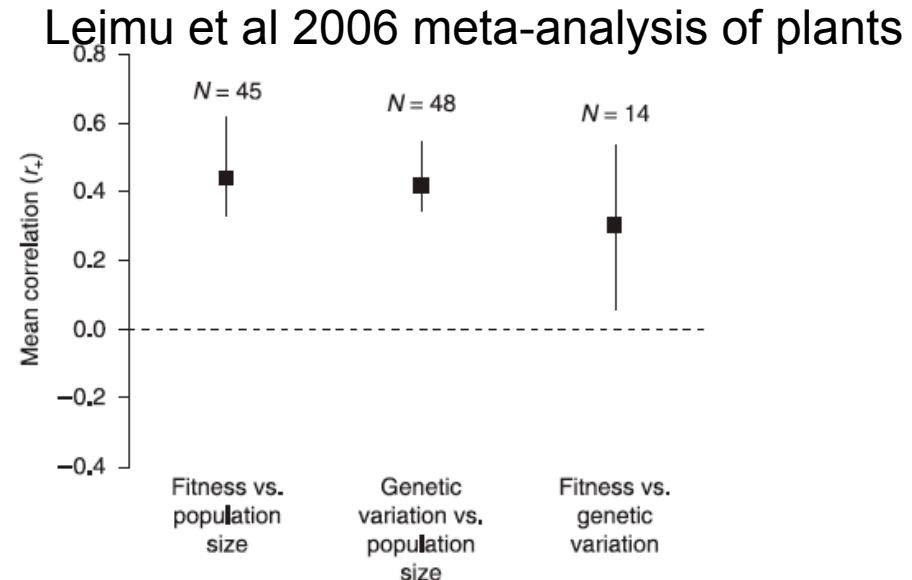
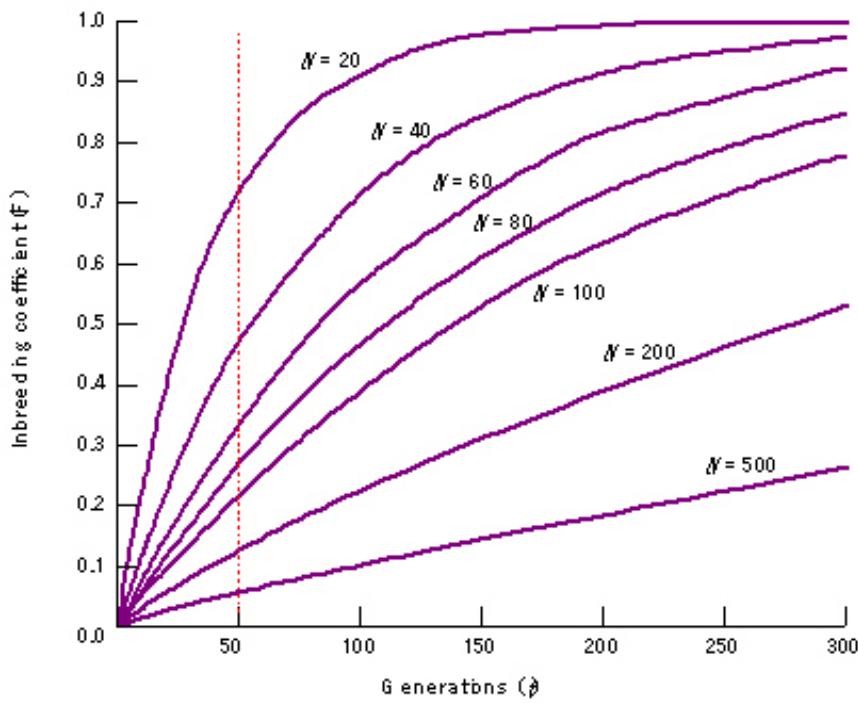


Fig. 1 Mean correlations ( $r_+$ ) between population size, female fitness and genetic variation. In all figures, bars denote 95% confidence intervals obtained by bootstrapping, and sample size  $N$  denotes the number of independent studies included in meta-analysis. The relationships are considered 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

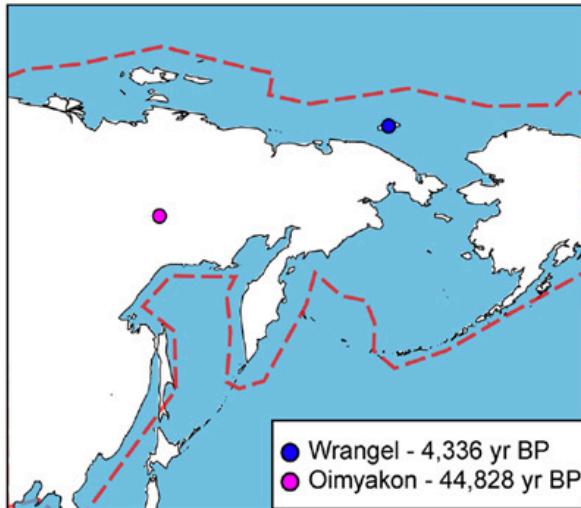
Why?

- 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

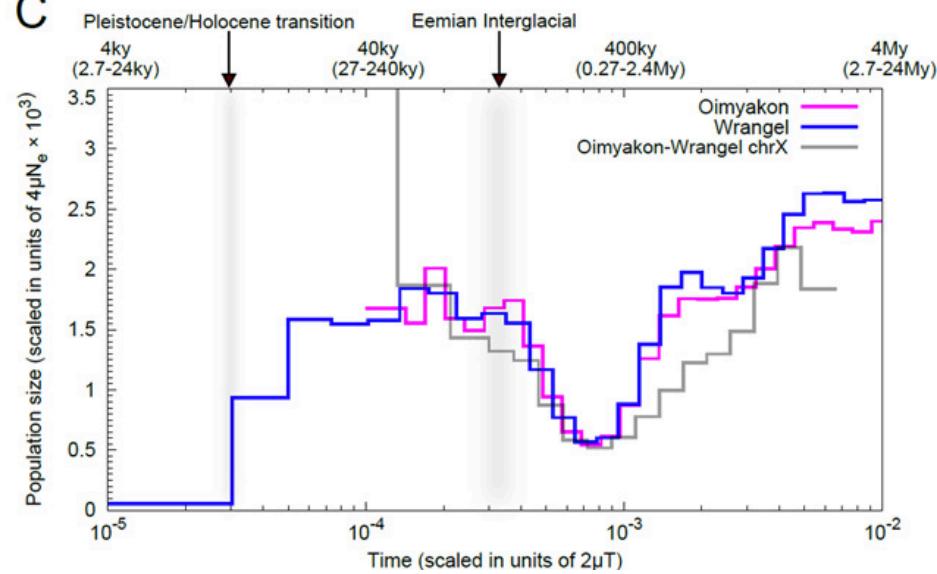
A



B

Sample	$^{14}\text{C}$ 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

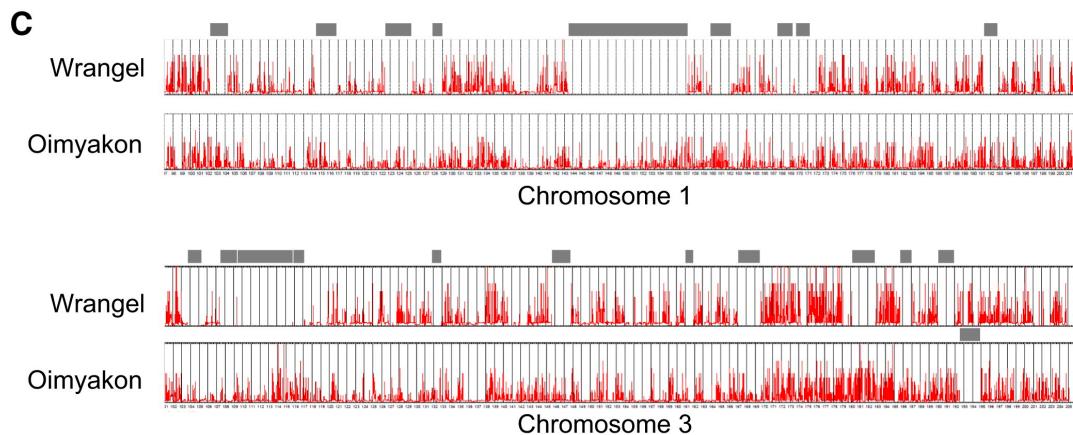
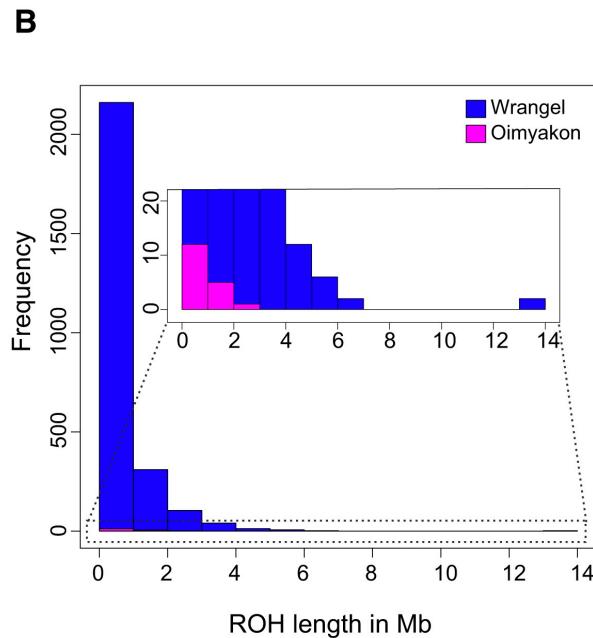
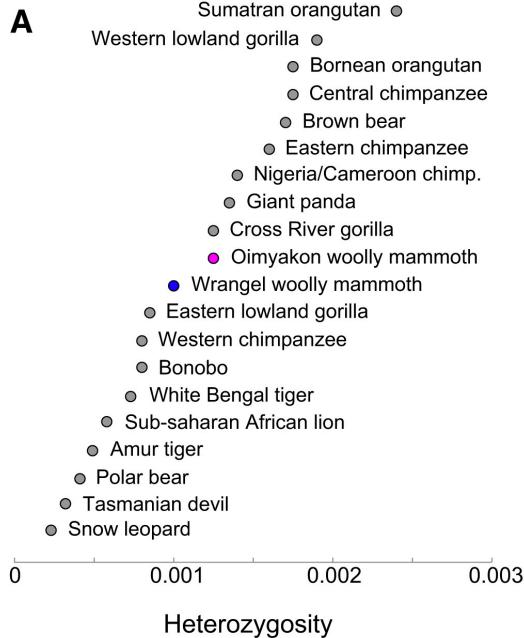
C



Palkopoulou et al 2015



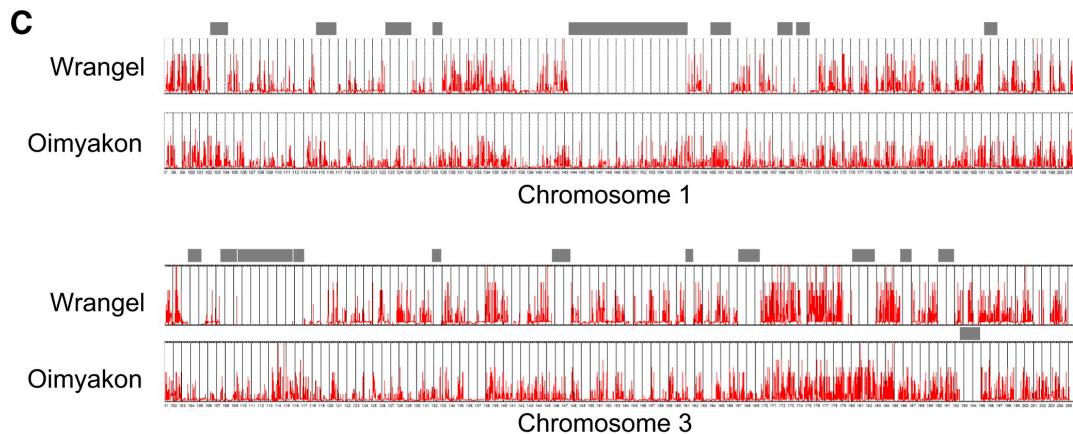
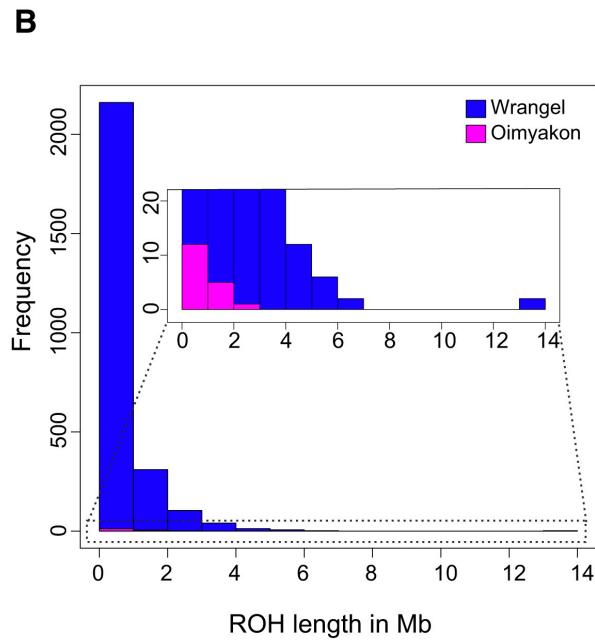
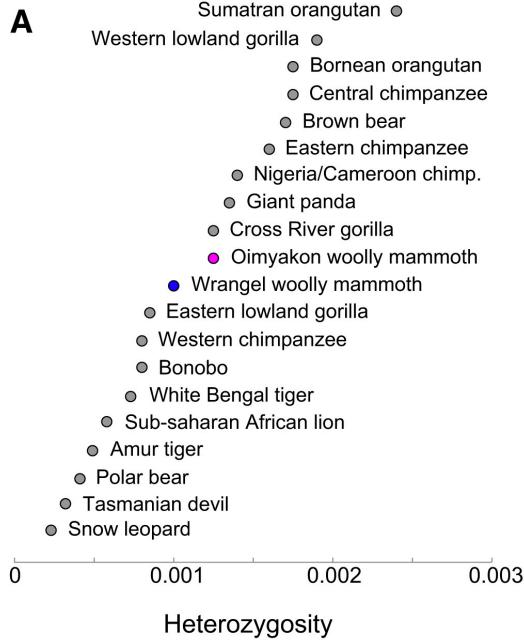
# Genomic signal of inbreeding depression



Extended runs of  
homozygosity (ROH)  
in inbred mammoth

Red = diversity  
Grey = ROH

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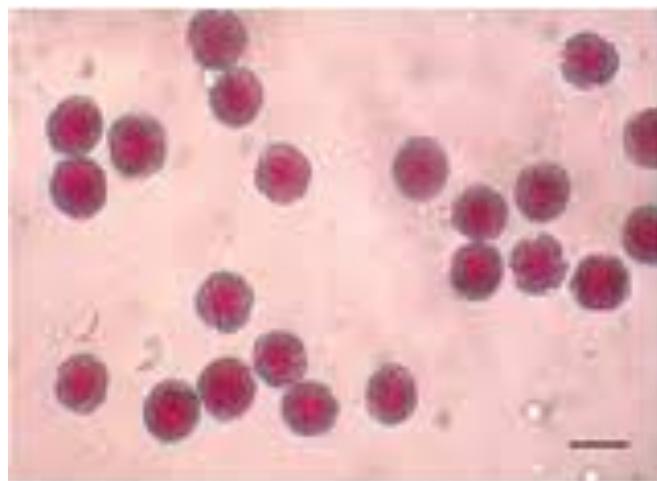


Red = diversity  
Grey = ROH

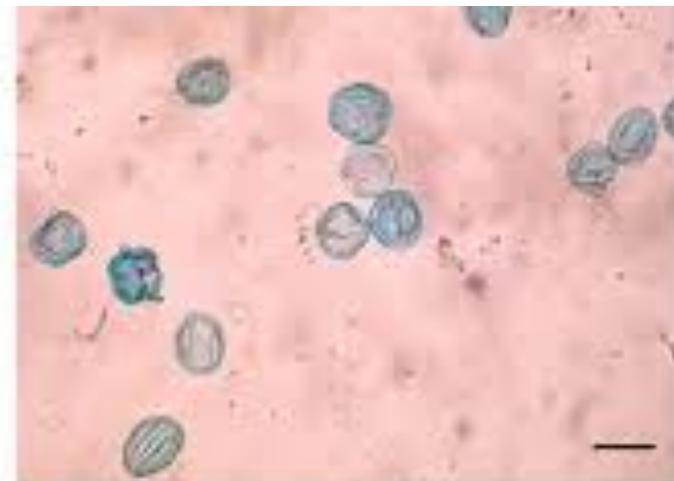
# Gene Flow: outbreeding depression

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

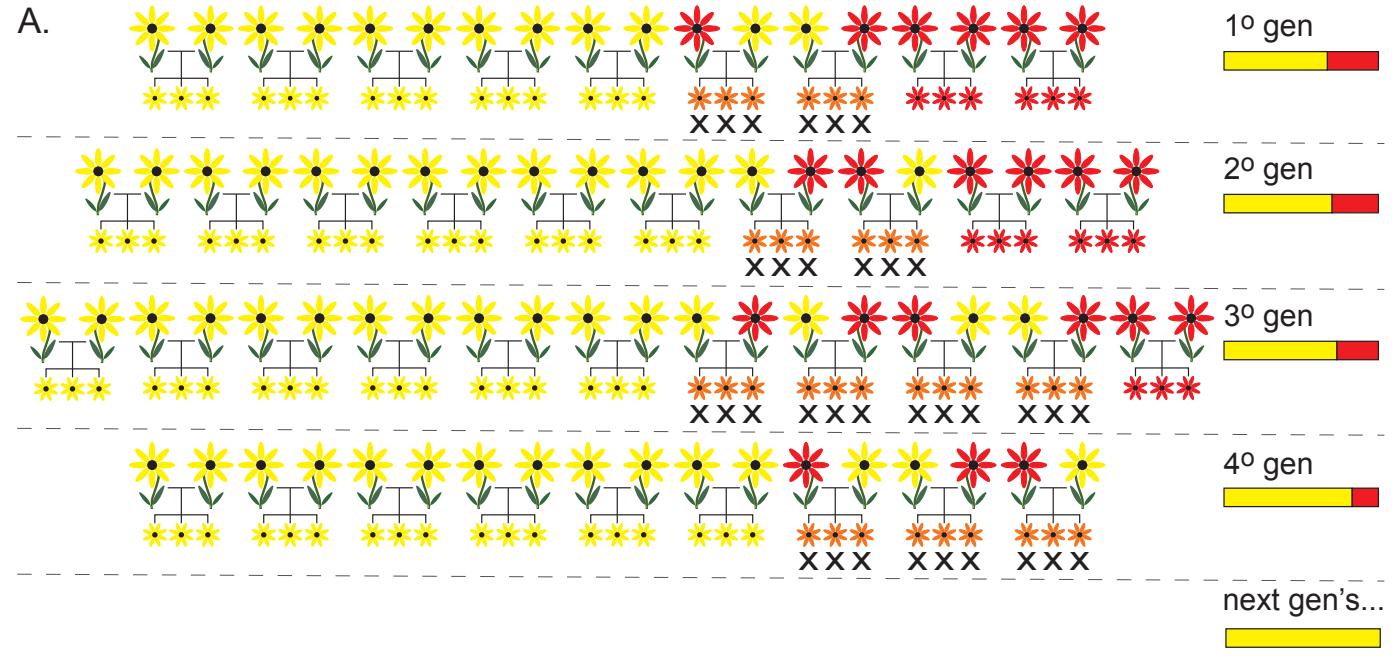


Control

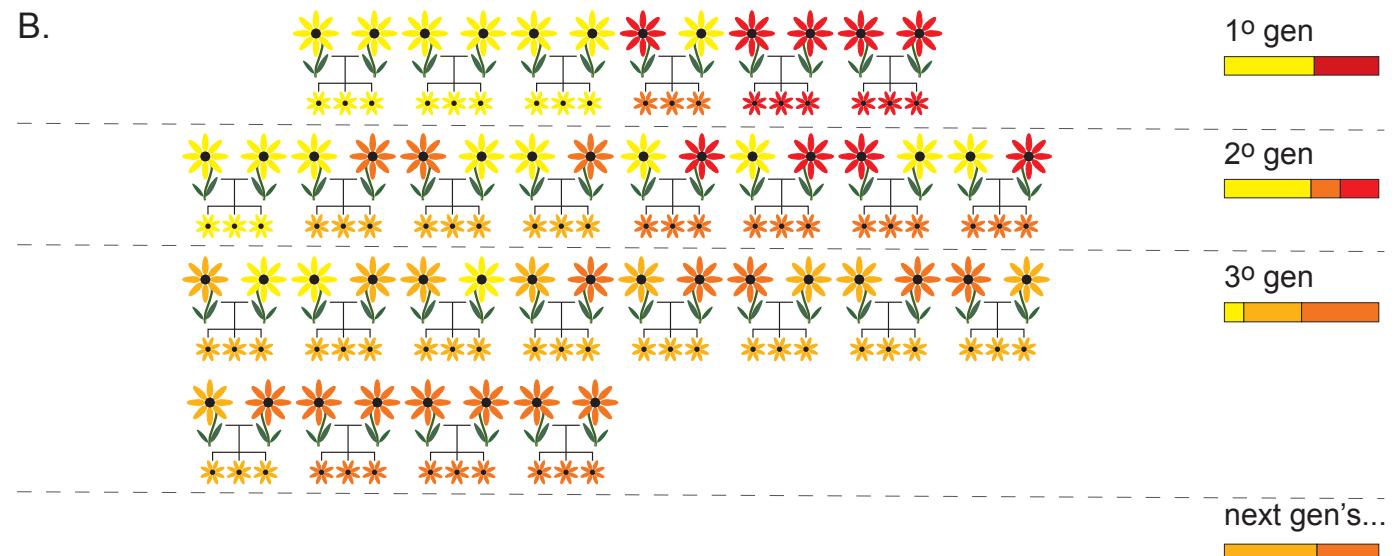


Sterile

Demographic swamping – extinction due to production of maladaptive hybrids



Genetic swamping – parental populations replaced by hybrids



# Example of species at risk through genetic assimilation

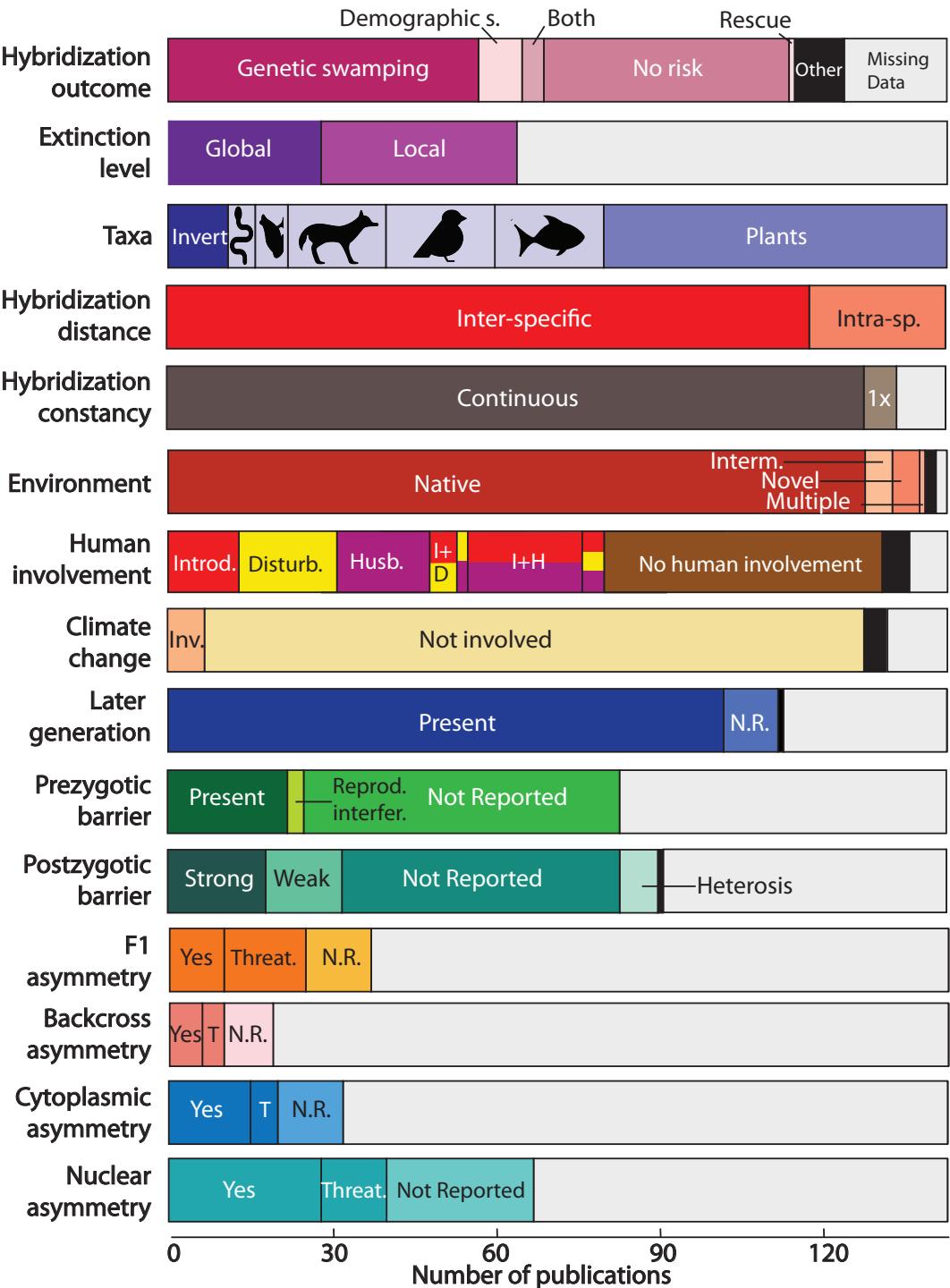


*Argyranthemum coronopifolium*, a rare plant species known from only seven populations in the Canary Islands. Three of the seven populations now contain only hybrids and pure individuals of the invading congener



*Cercocarpus traskiae*, a rare plant species known from only one population on the Santa Catalina 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:

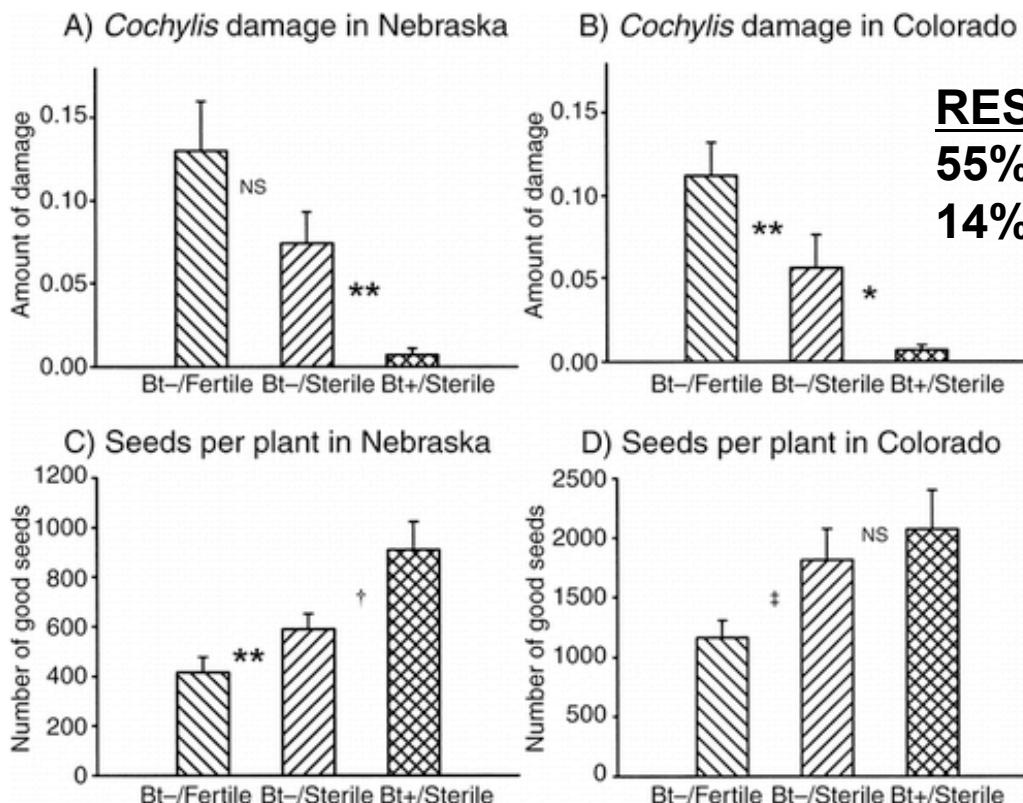
Will the Bt transgene provide an advantage to weedy sunflowers?



## 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;  $N = 58\text{--}60$  plants in Nebraska,  $N = 47\text{--}49$  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). \* $P < 0.05$ ; \*\* $P < 0.01$ ; † $P = 0.054$ ; ‡ $P = 0.077$ ; 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?