

Hybridization and “Genetic” Extinction

Can and do we preserve the genetic integrity of species, and if so, how?

Hybridization

- ***Hybridization***: mating between different **species** or two **genetically distinct populations** that produces offspring, regardless of fertility of offspring



Golden- and Blue-Winged Warblers

Blue
winged-
warbler



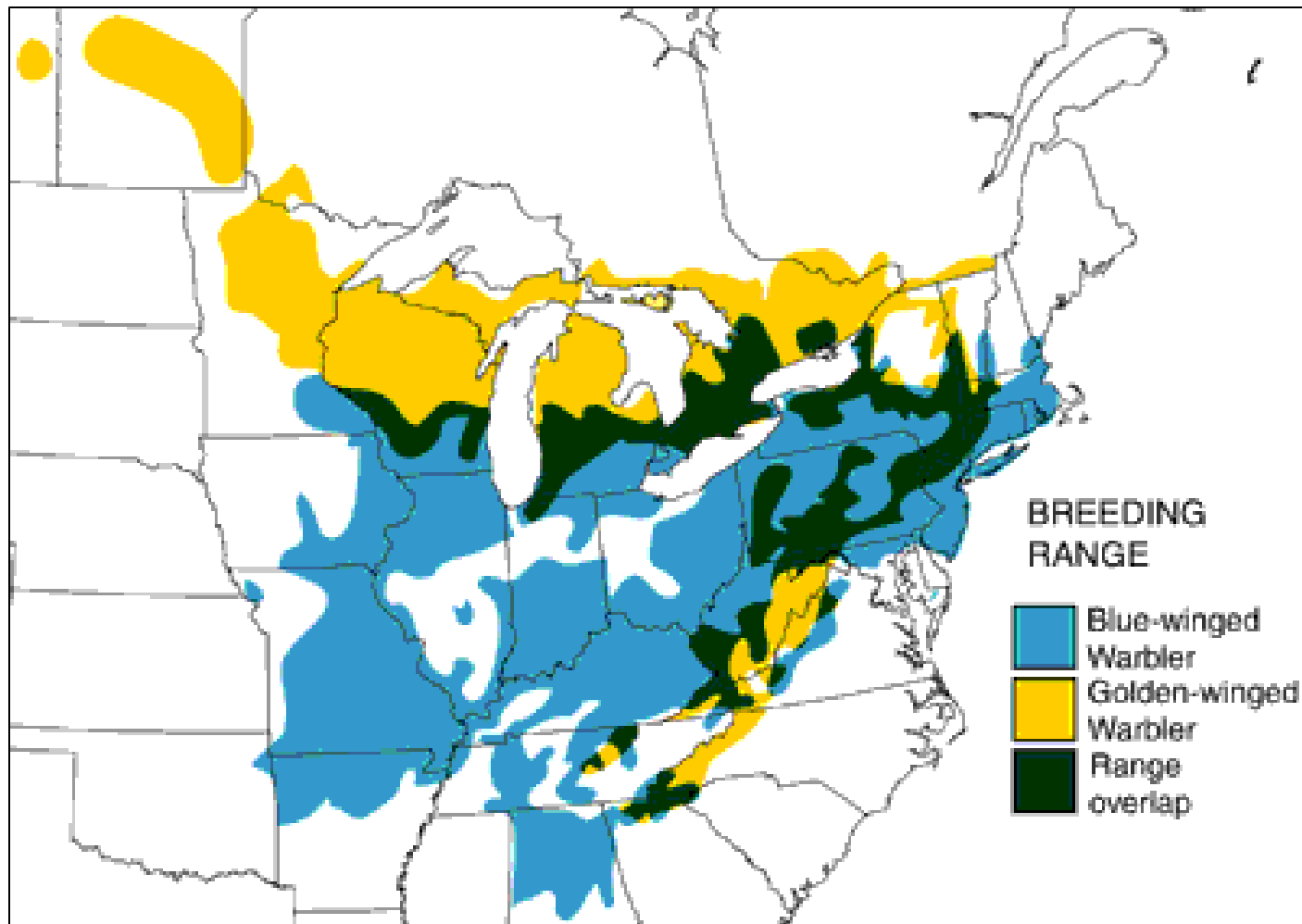
Golden
winged-
warbler



Hybrid
(Brewster's
Warbler)



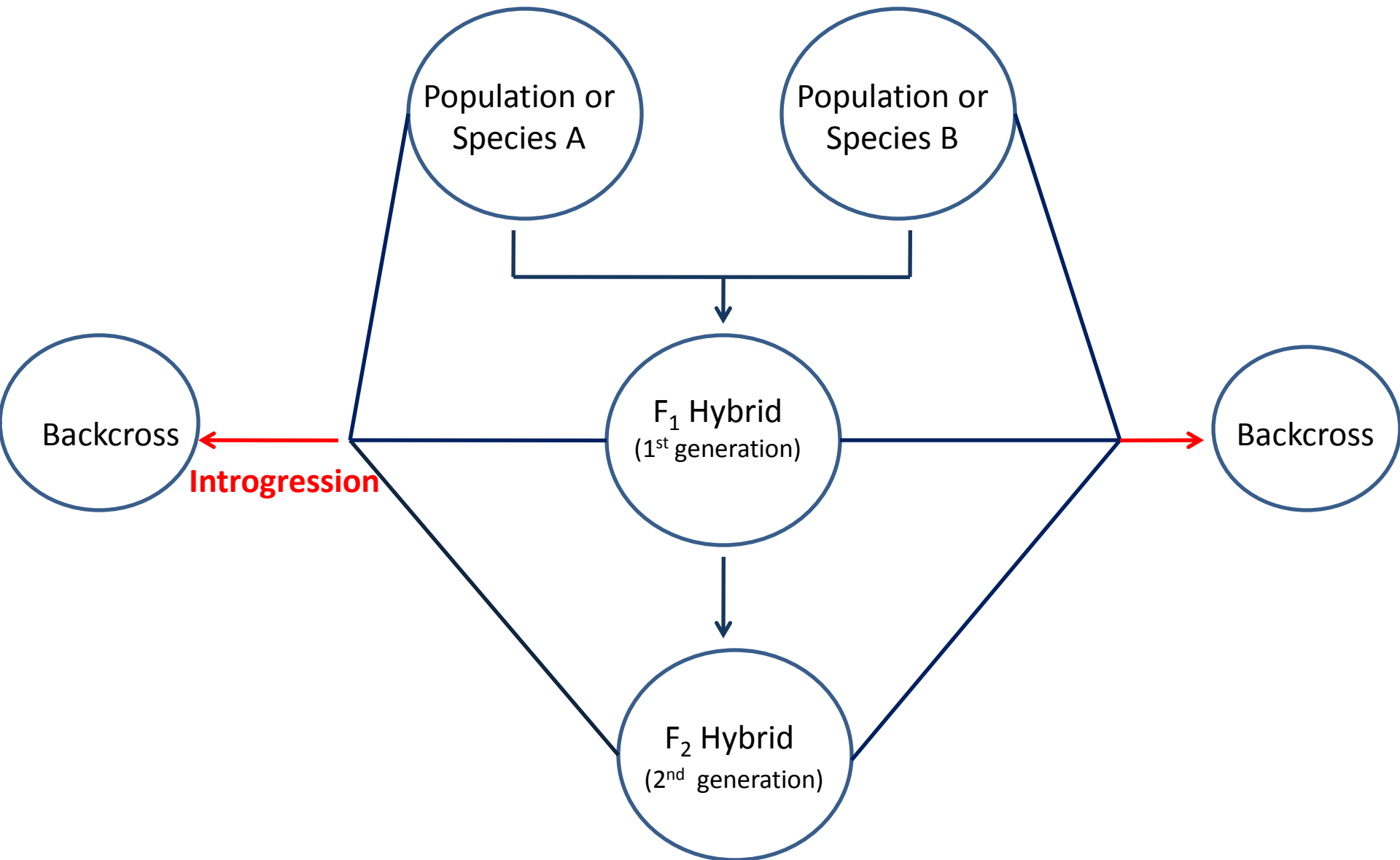
Golden- and Blue-Winged Warblers



Introgression

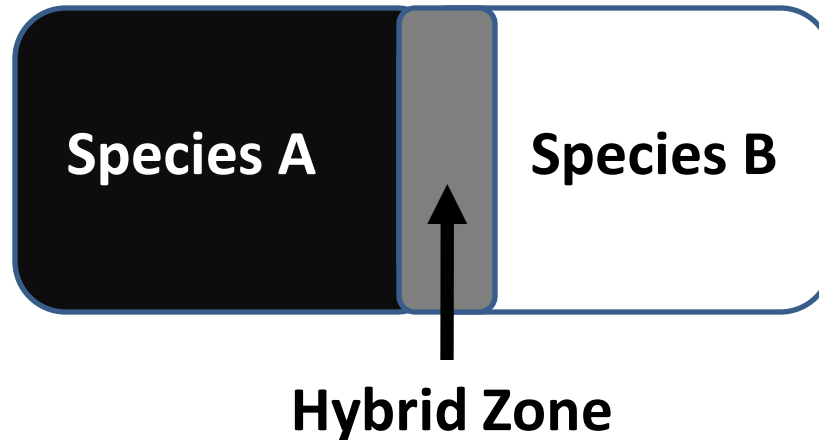
- **Introgression**: the incorporation of genes from one population or species to another through hybridization that results in **fertile offspring** that **further hybridize** with parental populations or species (“**backcross**”)
- Over several generations, introgression can result in a complex mixture of parental genes, while in simple hybridization 50% of genes will come from each of the two parental species.
- Without introgression, the parental species or populations are not “contaminated” by hybridization

Levels of Hybridization



Hybrid Zones

- Hybrid zones are often observed in nature...



- How are hybrid zones maintained?
 - Hybrids may be less fit than parental taxa and selected against, but dispersal into the zone maintains a narrow band of F_1 's
 - Hybrids may be more fit than parental taxa in habitats that are intermediate to parental taxa's native habitat

Hybridization and Conservation

- Human-caused habitat changes have resulted in distribution changes and expansions for many species
- Species and genetically distinct populations that were formerly geographically isolated are more likely to come into contact and breed
- The frequency of hybridization has increased dramatically, posing unique practical and philosophical problems for managers

Spotted Owl – Barred Owl Hybridization



“Sparred” Owl Hybrids

Spotted Owls



Sparred Owls



Barred Owls



Hybridization and Species Diversity

- Two competing perspectives about the relationship between hybridization and species diversity....
- **The negative view:** “Hybridization, with or without introgression, frequently threatens populations in a wide variety of plant and animal taxa because of various human activities” (Rhymer and Simberloff 1996)
- **The positive view:** “We conclude that when viewed over the long-term of millenia, introgressive hybridization may have contributed importantly to the generation of species diversity in birds” (Grant and Grant 1998)

Negative Impacts of Hybridization

- **Genetic extinction:** fertile hybrids displace one or both parental populations or species through the production of **hybrid swarms**.
- **Hybrid swarm:** populations or species in which all individuals are hybrids to various degrees
- **Outbreeding depression:** hybrid offspring have lower reproductive success or survival than either parent.

Example of Genetic Extinction

- Cichlid fish in Lake Victoria
 - Increased turbidity in Lake Victoria due to agriculture and deforestation
 - Cichlids use visual cues to identify conspecifics for mating
 - Matings between species are now common and seriously threatened this classic example of adaptive radiations (almost half of cichlid species are believed to be extinct)



Genetic Extinction, Why the Big Deal?

- Species and genetically distinct populations reflect the product of evolution over hundreds to many thousands of generations
- Retaining genetic diversity among species increases evolutionary potential
- Hybridization compounds effects of loss of genetic diversity in small populations due to other factors

Hybridization and Outbreeding Depression

- **Outbreeding depression:** hybrid offspring have lower reproductive success or survival than either parent.
- **Hybrid vigor:** hybrids often have enhanced performance or fitness relative to either parents
- **First-generation hybrids:** (F1's) often exhibit hybrid vigor – with outbreeding depression often occurring in subsequent generations (F2's and beyond).

Outbreeding Depression

- **Intrinsic mechanisms**

- Genetic: reduced fitness of hybrids due to interactions between genes originating in different taxa

- **Extrinsic mechanisms**

- Reduced fitness of hybrids because of a loss of adaptation to local environment
- Wasted effort in unsuccessful reproduction

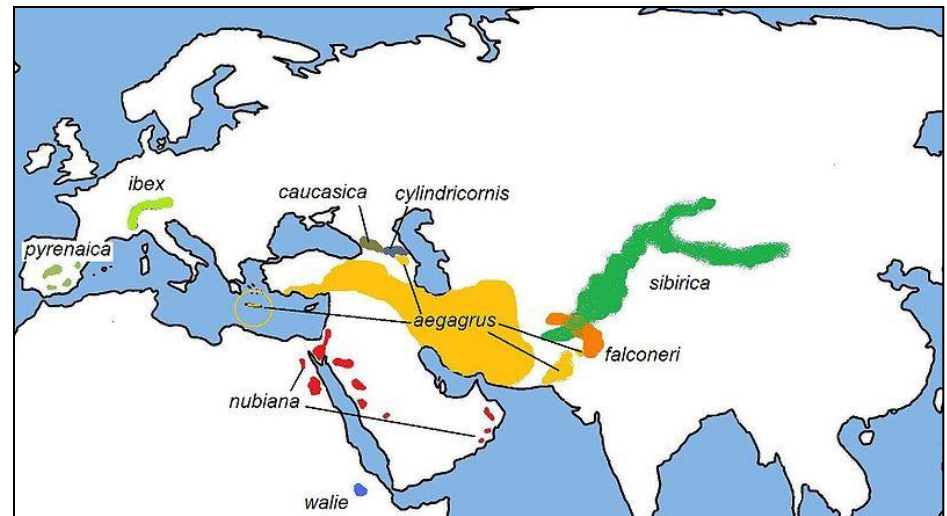
Outbreeding Depression

Extrinsic mechanisms

- Alpine Ibex overhunted in European Alps and augmented by translocations from population in the Sinai Peninsula and Turkey



- Southern ibex breed earlier in the fall and hybrid young were born in the middle of alpine winters.



Outbreeding Depression

Extrinsic mechanisms

- Hybrid Northwestern Garter Snakes are more susceptible to predation by hawks.

Striped Morph



Spotted Morph



Outbreeding Depression

Extrinsic mechanisms

- Outbreeding depression can threaten species even in the absence of successful reproduction by the parental species
- For example, female European Mink hybridize with introduced male North American mink
 - Embryos aborted
 - Wastage of eggs has accelerated decline of European species



The Positive Side: Hybridization and Speciation

- Hybridization occurs more frequently than previously recognized and is an important source of speciation
 - Almost 50% of plant species originated from the hybridization of different species
 - All vertebrates may have gone through an ancient hybridization event.
 - 10% of bird species are believed to hybridize with another species naturally.

Philosophical Issues with Hybridization and Conservation

- How much do we want to control hybridization in the wild?
- Should a threatened species be protected if it's hybridized with a common species?
- Is it ethical to remove the “guilty” species or their hybrid offspring?
- Should hybrids be allowed to persist if they fill an ecological role?
- What constitutes a genetically pure species?

The Wolf Imbroglia

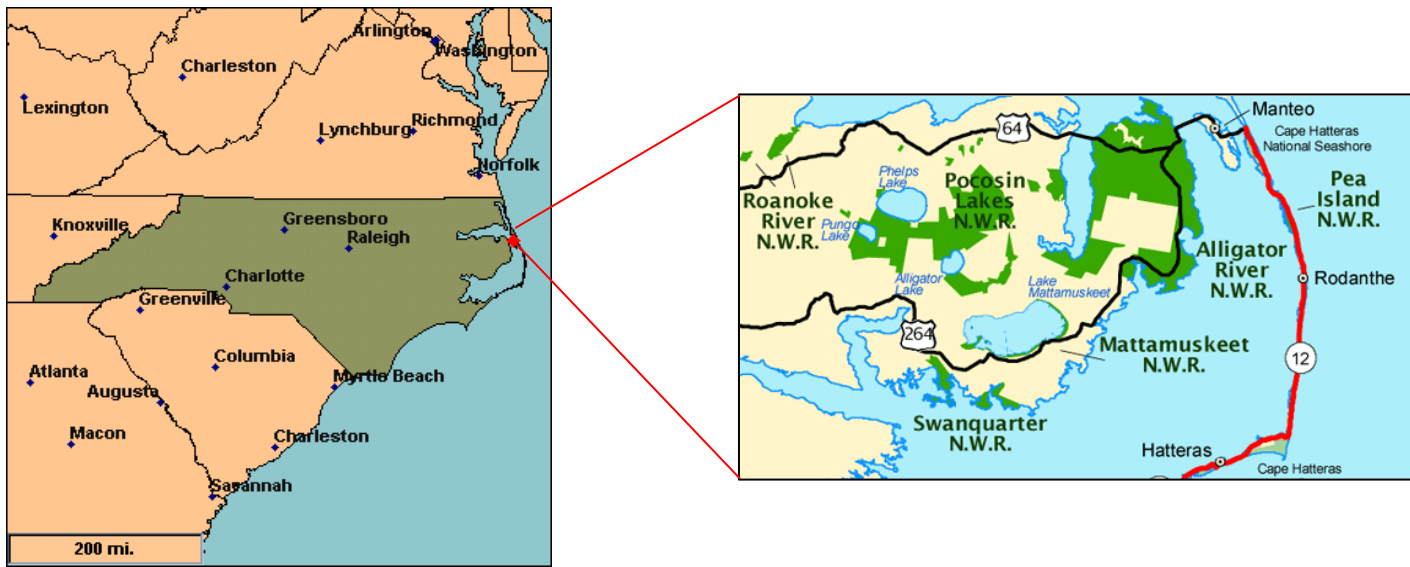
Red Wolf Conservation

- Red wolves may be a separate species from grey wolves, or possibly a subspecies of grey wolves
- Historically ranged throughout the SE U.S., but declined to a few hundred individuals due to persecution and habitat loss
- Loss of forested habitat increased interactions and hybridization with coyotes



Red Wolf Conservation

- Last wild “red wolves” were captured in 1980 in Texas. Most were wolf-coyote hybrids - only 14 of were “pure-bred” wolves
- Captive breeding program initiated and wolves reintroduced Alligator River National Wildlife Refuge in 1987 in North Carolina
- Managers “holding” the line at southern border of the refuge by trapping coyotes to prevent further hybridization with red wolves



The Wolf Imbroglia

“The New England Canid”

- Eastern wolves were largely eradicated from New England in the 1800s due to habitat loss and persecution
- Coyotes moved in and hybridized with the few remaining wolves resulting in the “New England Canid” that today has some small shreds of wolf DNA
- These canids play a similar role in the ecosystem as a wolves historically; do they merit protection?

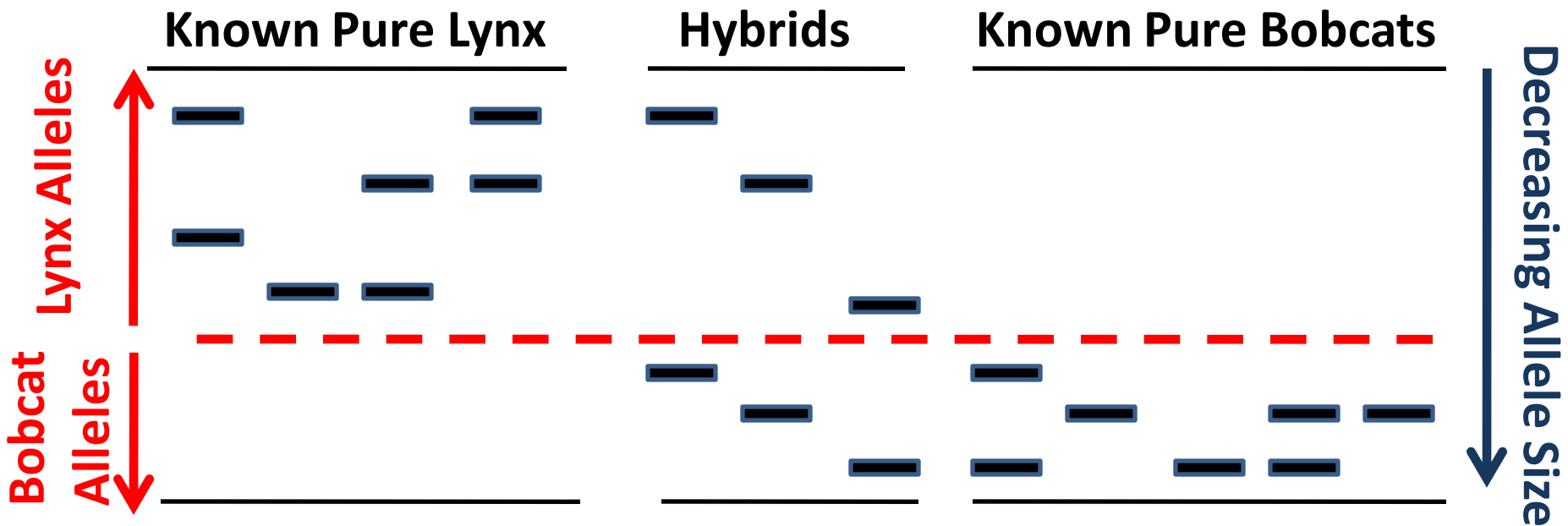


Detecting Hybridization

- Primarily using morphology until the mid-1960's, but not often not effective
- Genetic methods have become increasingly important for identifying hybrid individuals
- A simple approach: use a locus where each species has completely different alleles
 - For example, all individuals of species 1 are **AA** and all individuals of species 2 are **aa**.
 - Hybrid individuals are **Aa**.

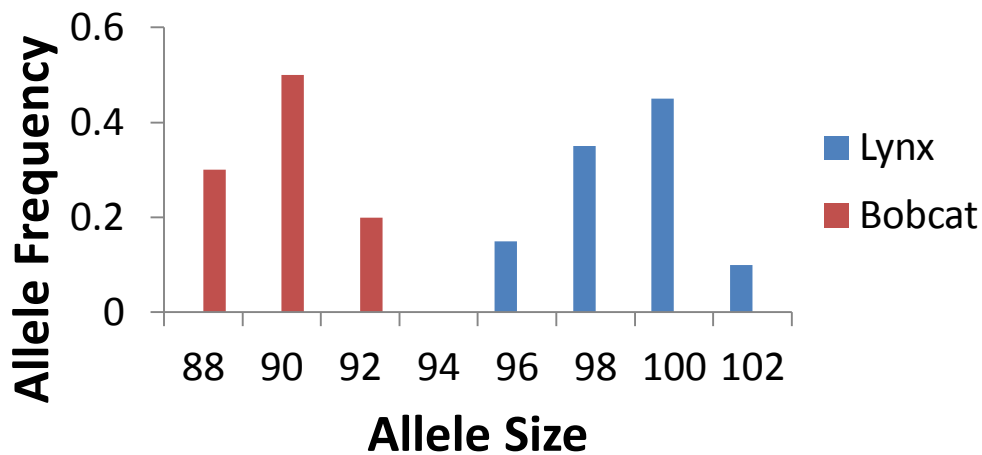
Identifying Lynx-Bobcat Hybrids

Diagnostic Microsatellite Loci



Canadian Lynx

Bobcat



Hybrid Conservation Strategies

- Due to the complexity of the hybridization issues, there are currently no formal under the Endangered Species Act: decisions are made on a case by case basis
- **A general strategy:** remove hybrids when the cause is humans, but leave alone when hybridization is natural.
- Management and conservation is easiest when no introgression occurs; hybrid swarms are a virtually intractable problem.
- Rapid detection of hybridization and response is critical