Management Goals for Hatchery Broodstocks:

Genetic Integration vs. Segregation

Don Campton

(Hatchery Scientific Review Group)

U.S. Fish & Wildlife Service

Longview, WA

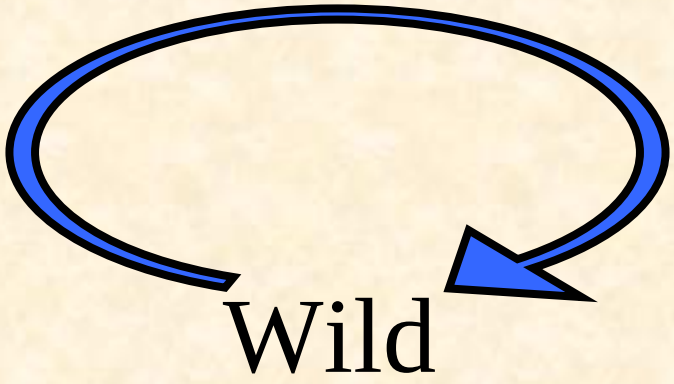
Two types of hatchery programs

1. Genetically *Segregated* Broodstocks.
2. Genetically *Integrated* Broodstocks.

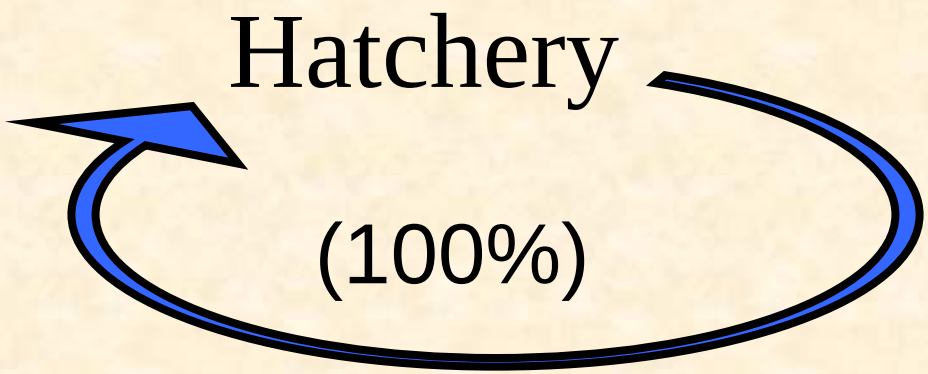
Two purposes of released hatchery fish

1. Provide fish for harvest.
2. Natural spawning.

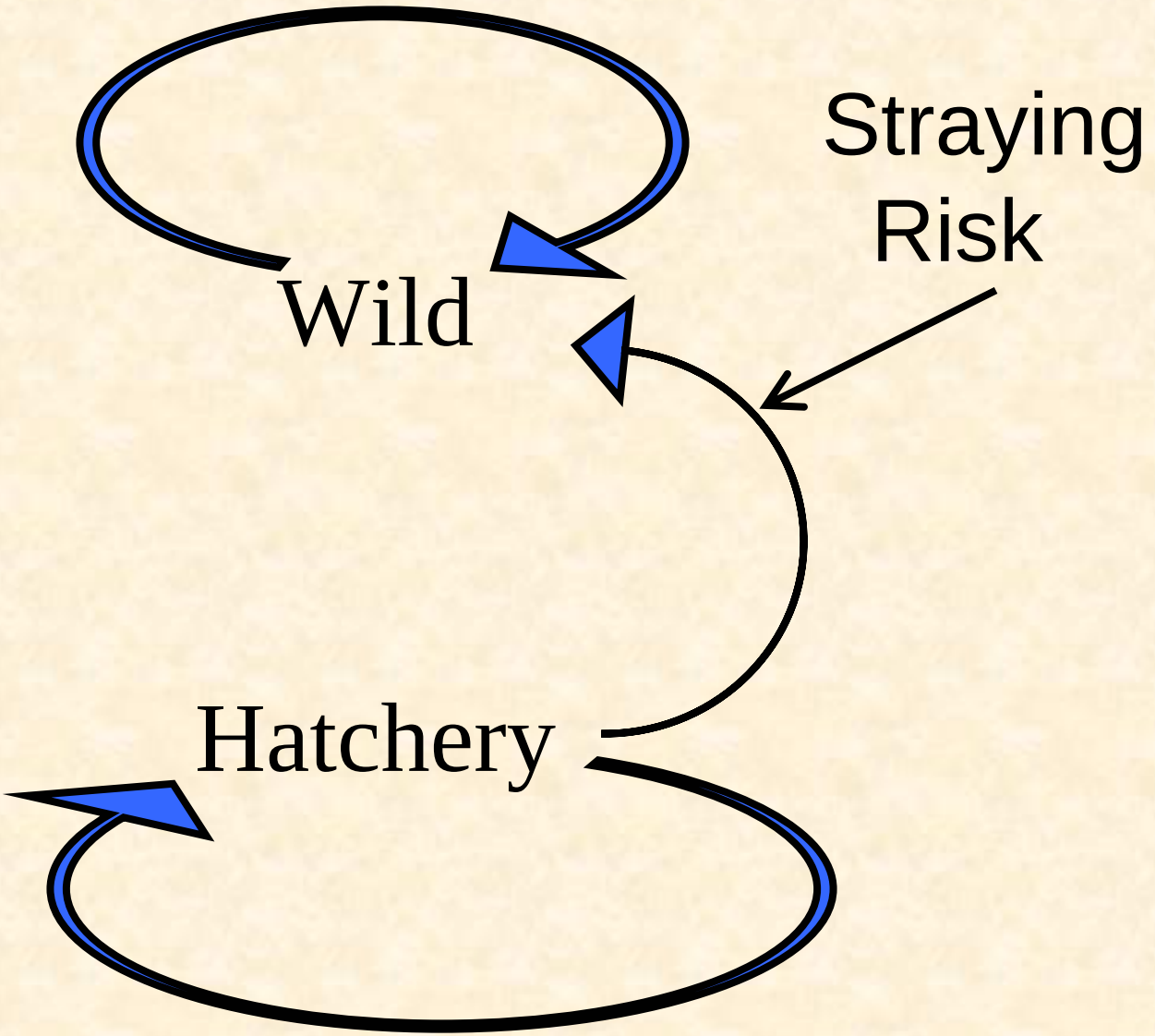
Gene Flow: Idealized *Segregated* Hatchery



2 environments, 2 populations



Gene Flow: Segregated hatchery

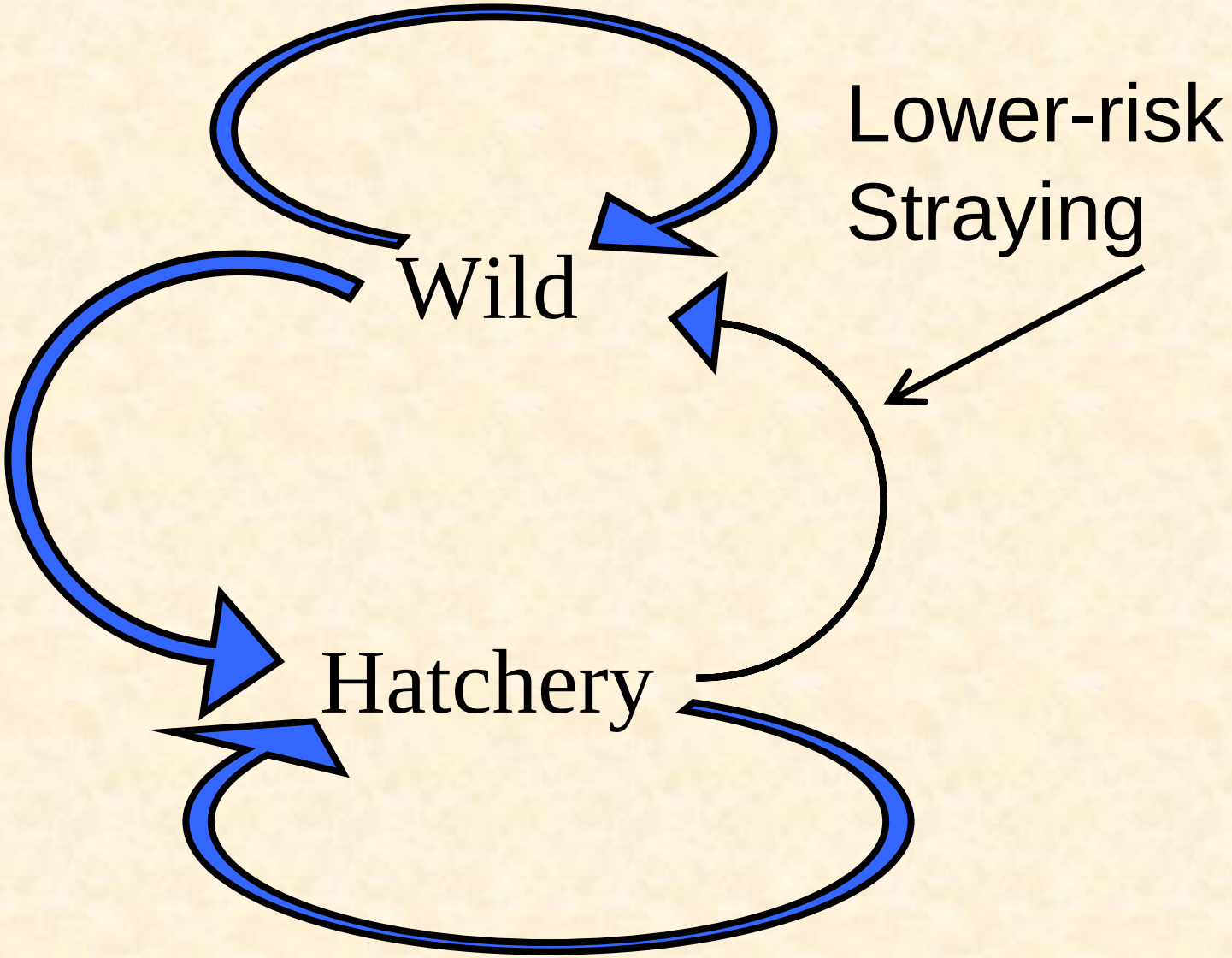


Segregated Hatchery Programs

- Hatchery broodstock is managed as a reproductively distinct population.
- Hatchery-origin adults only for broodstock.
- Hatchery population will diverge genetically from natural populations due to random genetic drift and domestication selection.
- Hatchery fish may pose ecological and genetic risks to naturally spawning populations.

Gene Flow: Idealized *Integrated* Hatchery

Gene Flow: Integrated hatchery



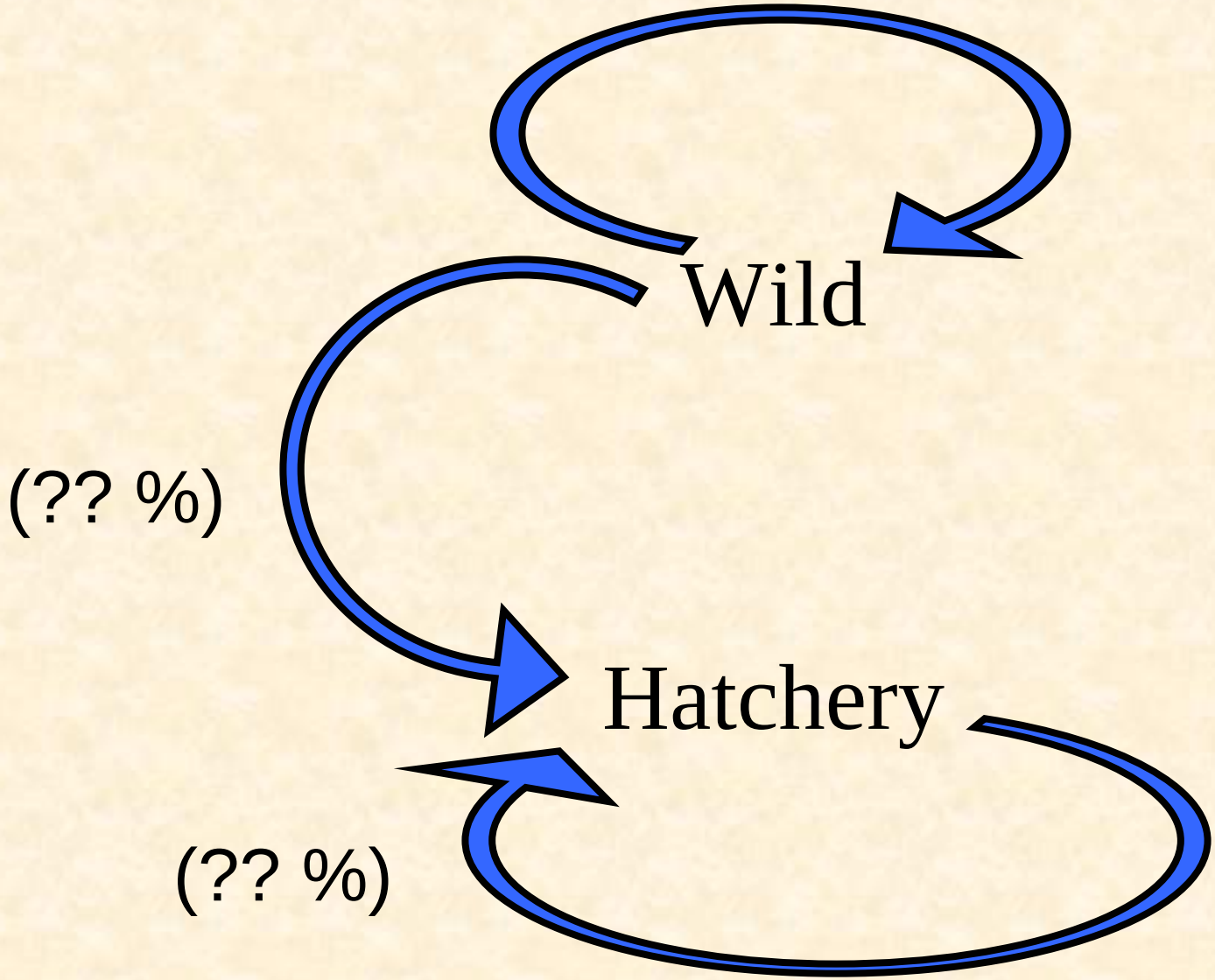
Goal of integration: Natural selection in wild drives genetic fitness of the system

Two sources of genetic divergence between hatchery and wild fish:

1. Random genetic drift

2. Divergent natural selection ("domestication")

Gene Flow: Integrated hatchery



Gene flow vs. genetic drift

$$F_{ST} = \frac{(1-m)^2}{2N_e - (2N_e-1)(1-m)^2}$$

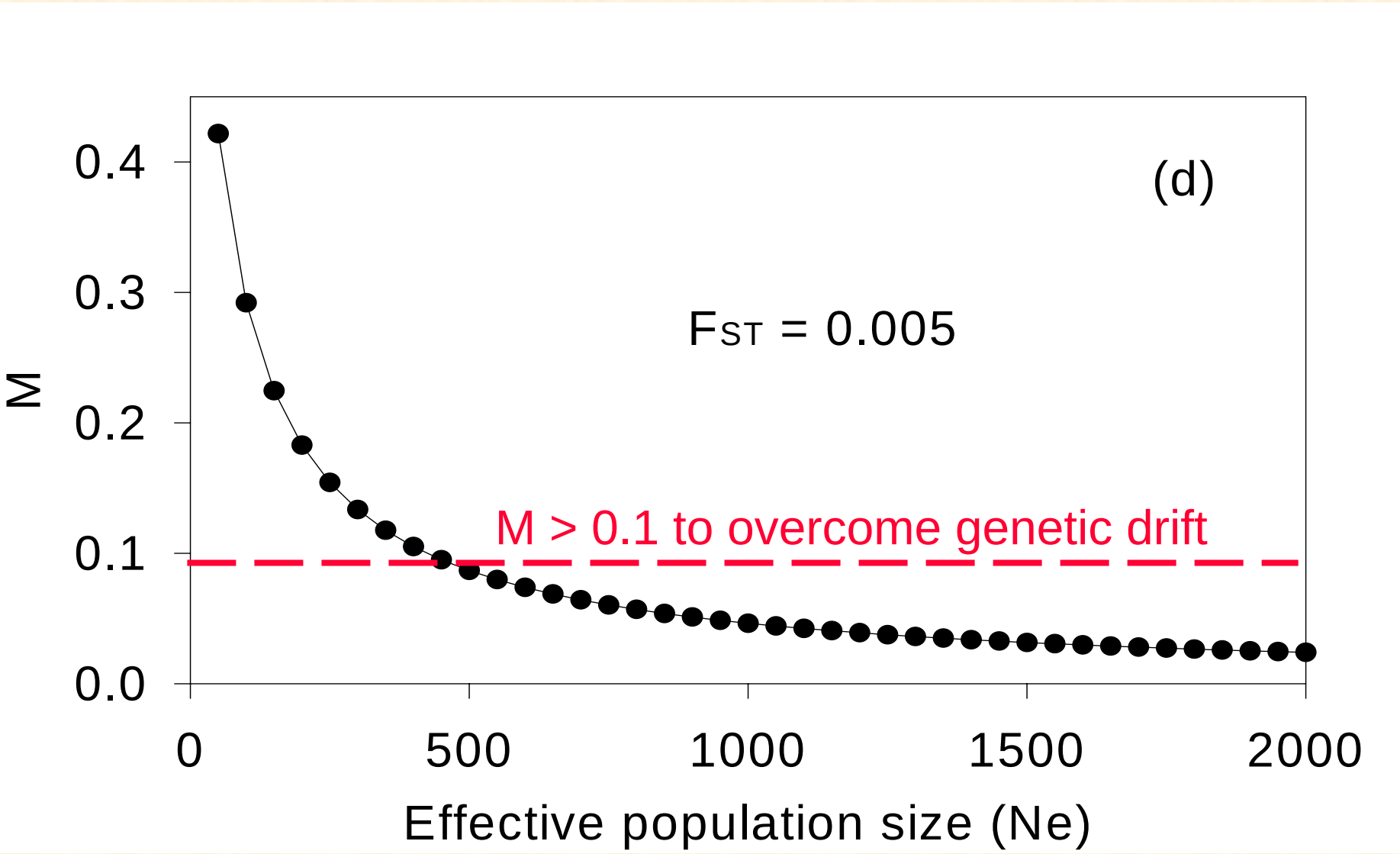
$0 \leq F_{ST} \leq 1.0$

N_e = effective population size

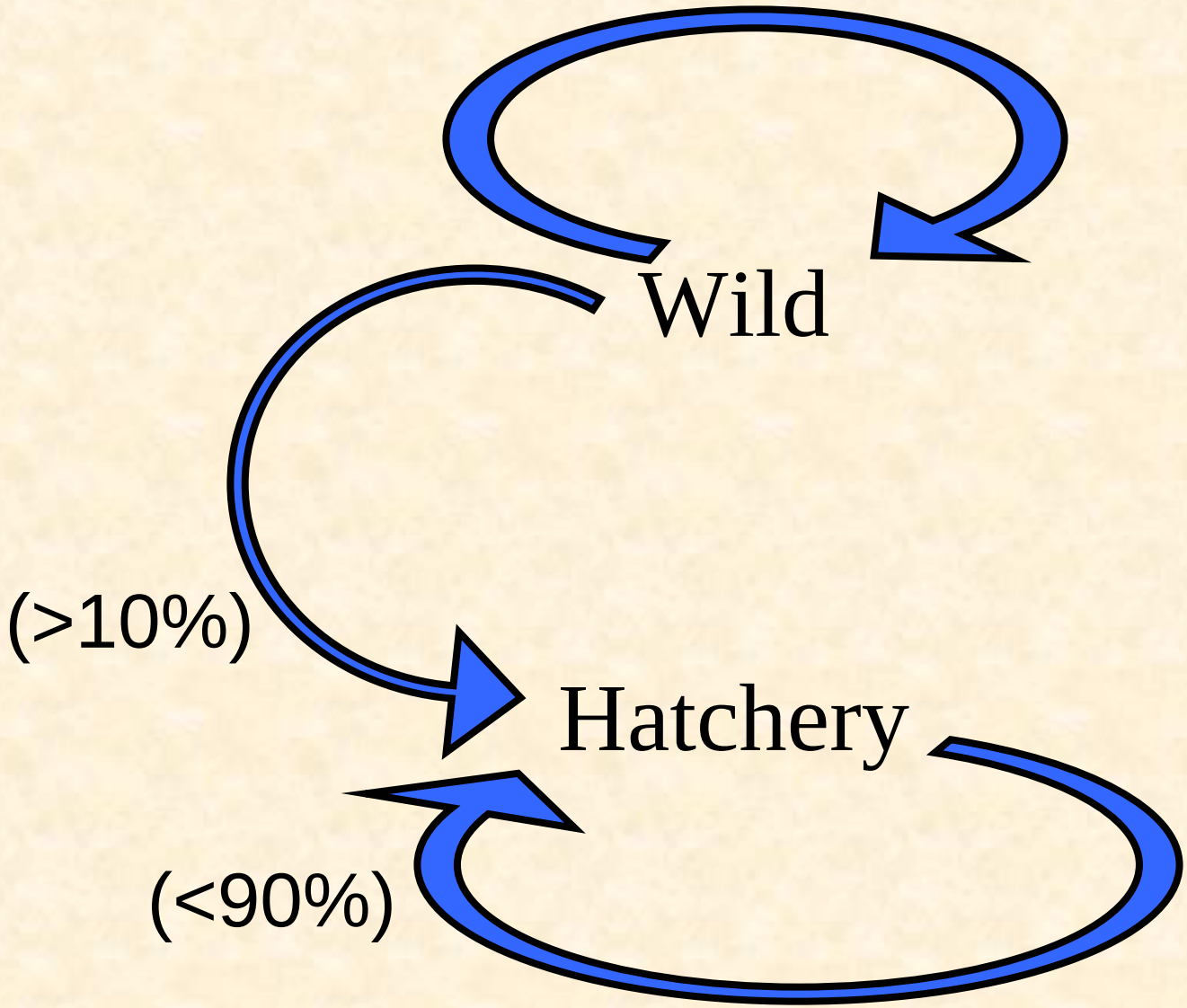
m = migration (gene flow) proportion

(Wright 1940)

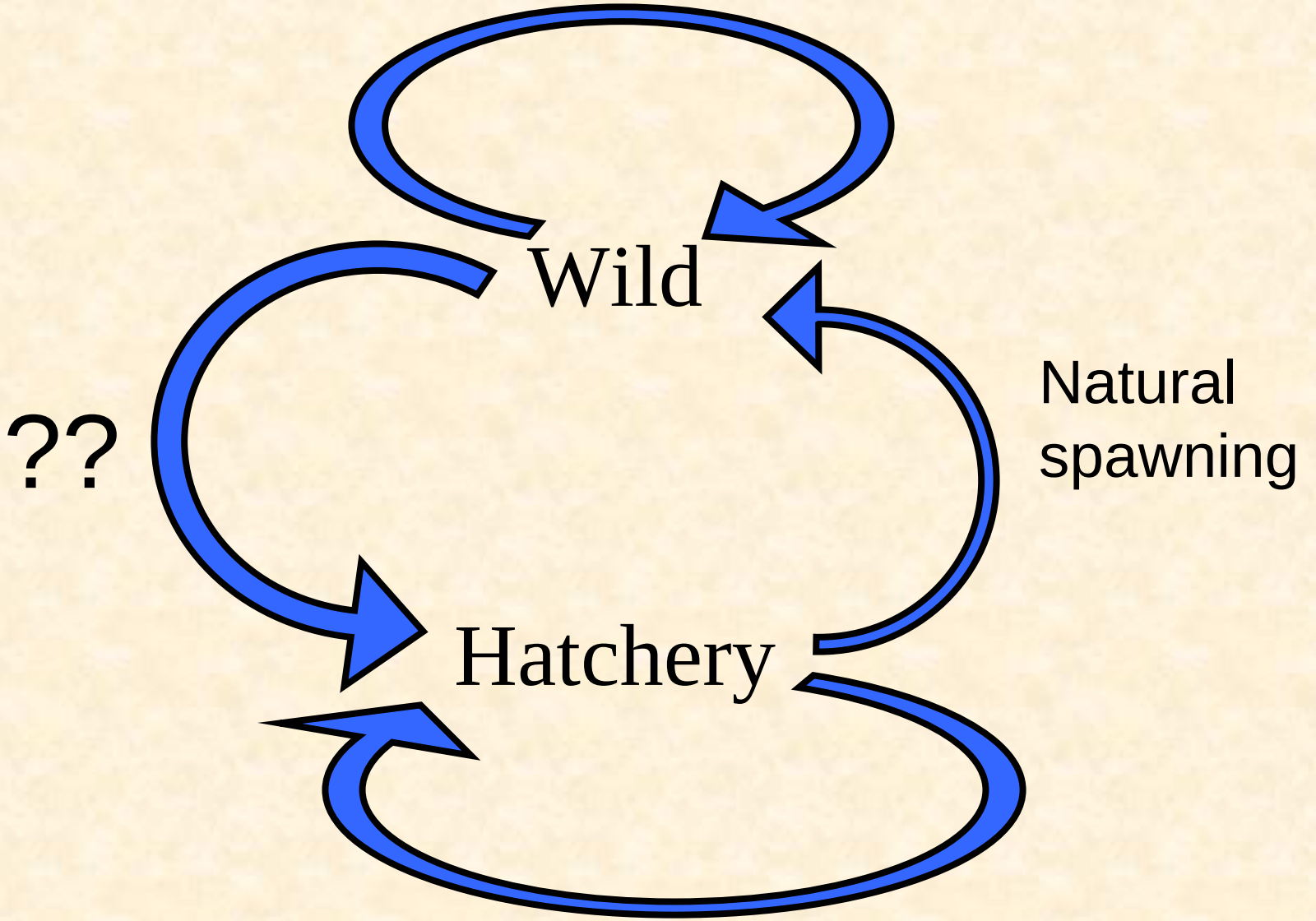
Natural-origin proportion (M) of broodstock per generation to overcome genetic drift



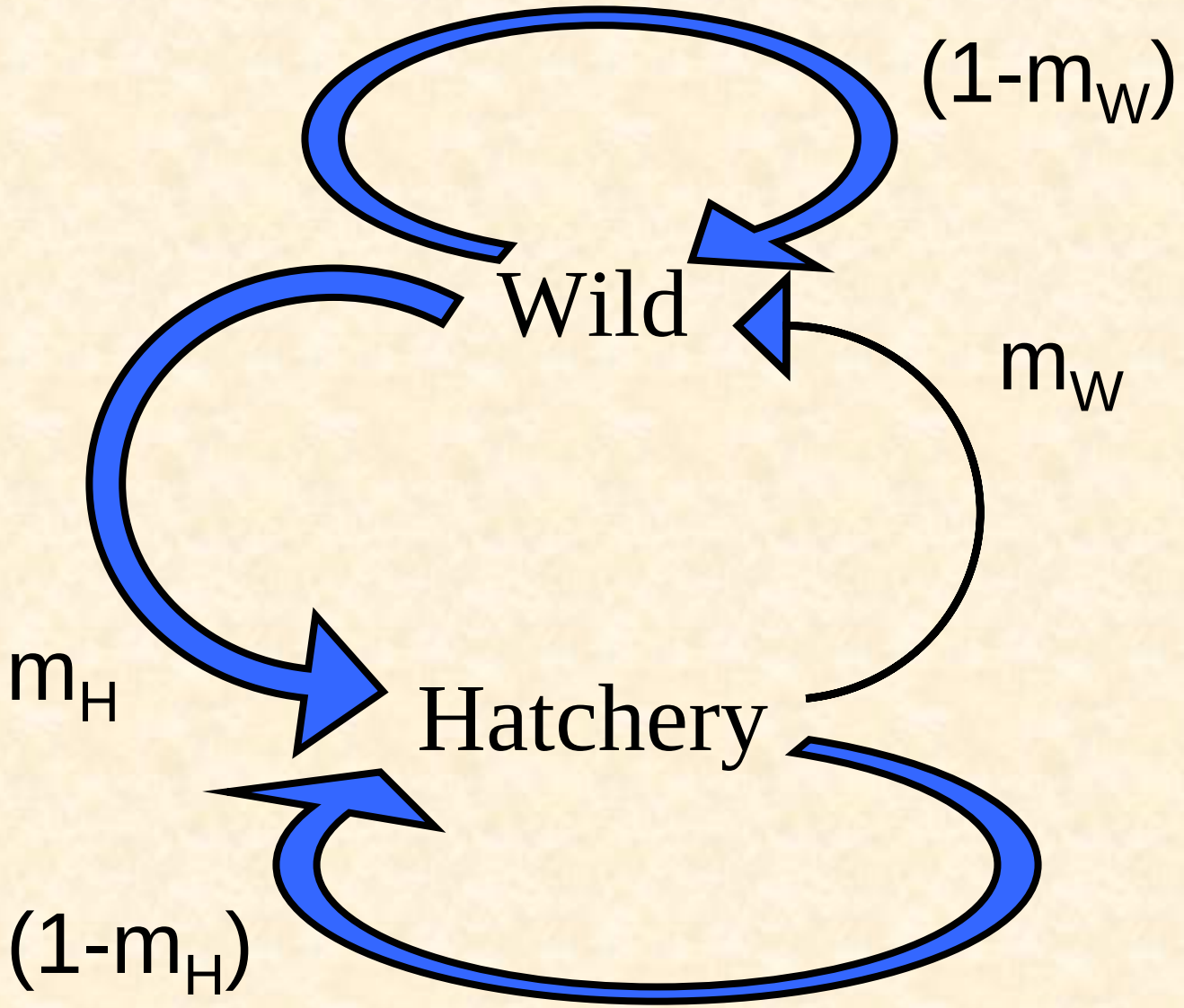
Gene Flow: Integrated hatchery



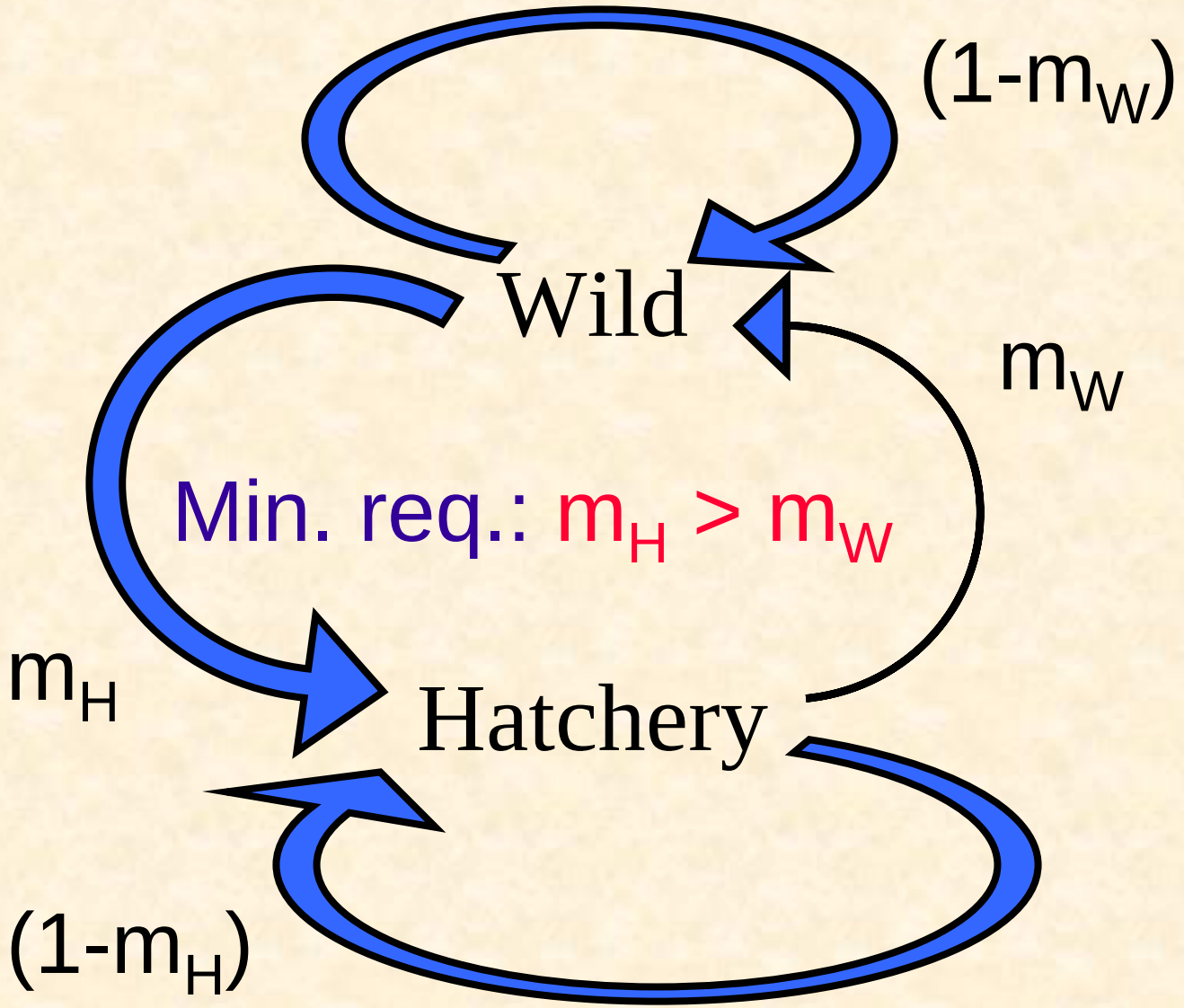
Integrated: gene flow constraints



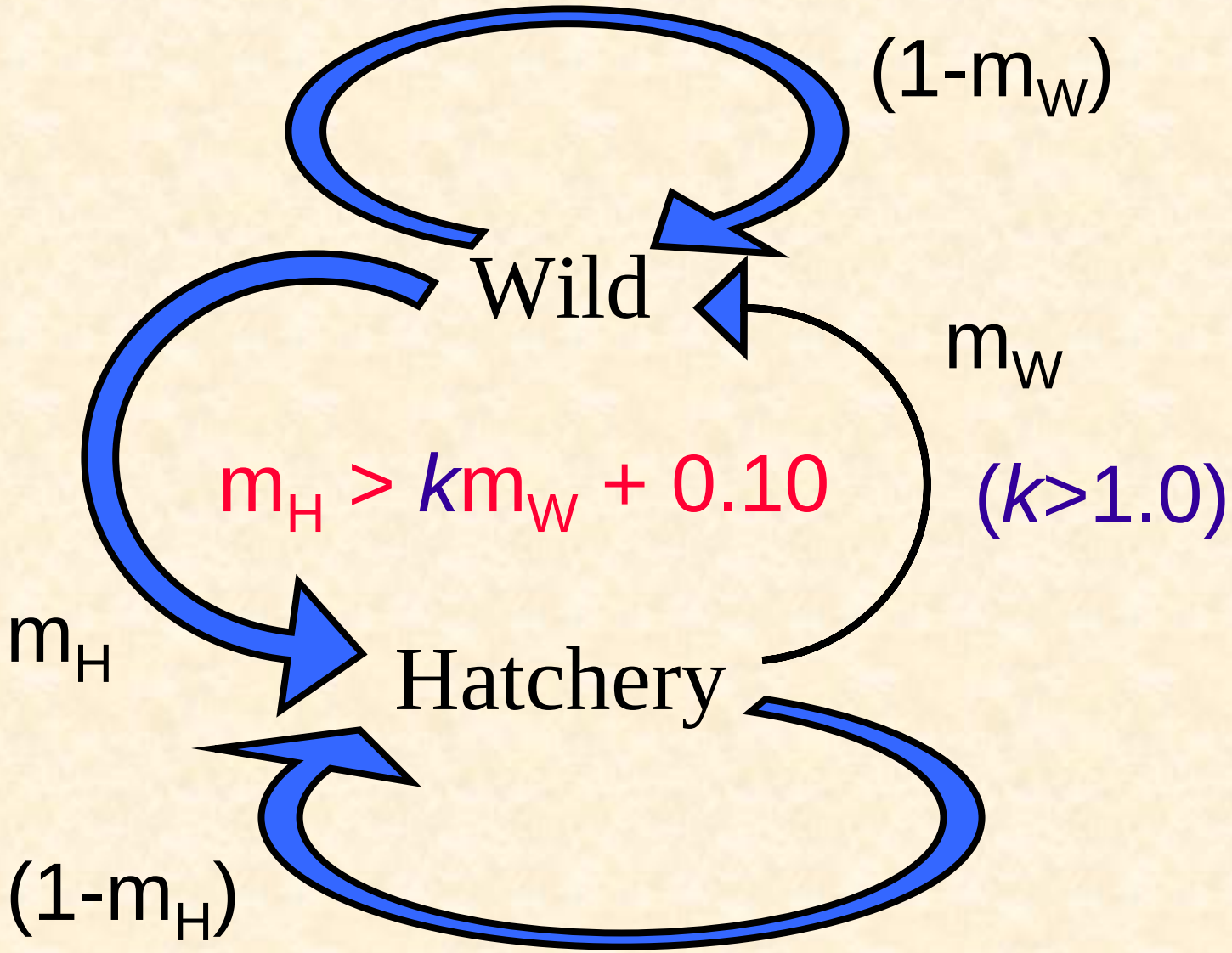
Integrated: gene flow constraints



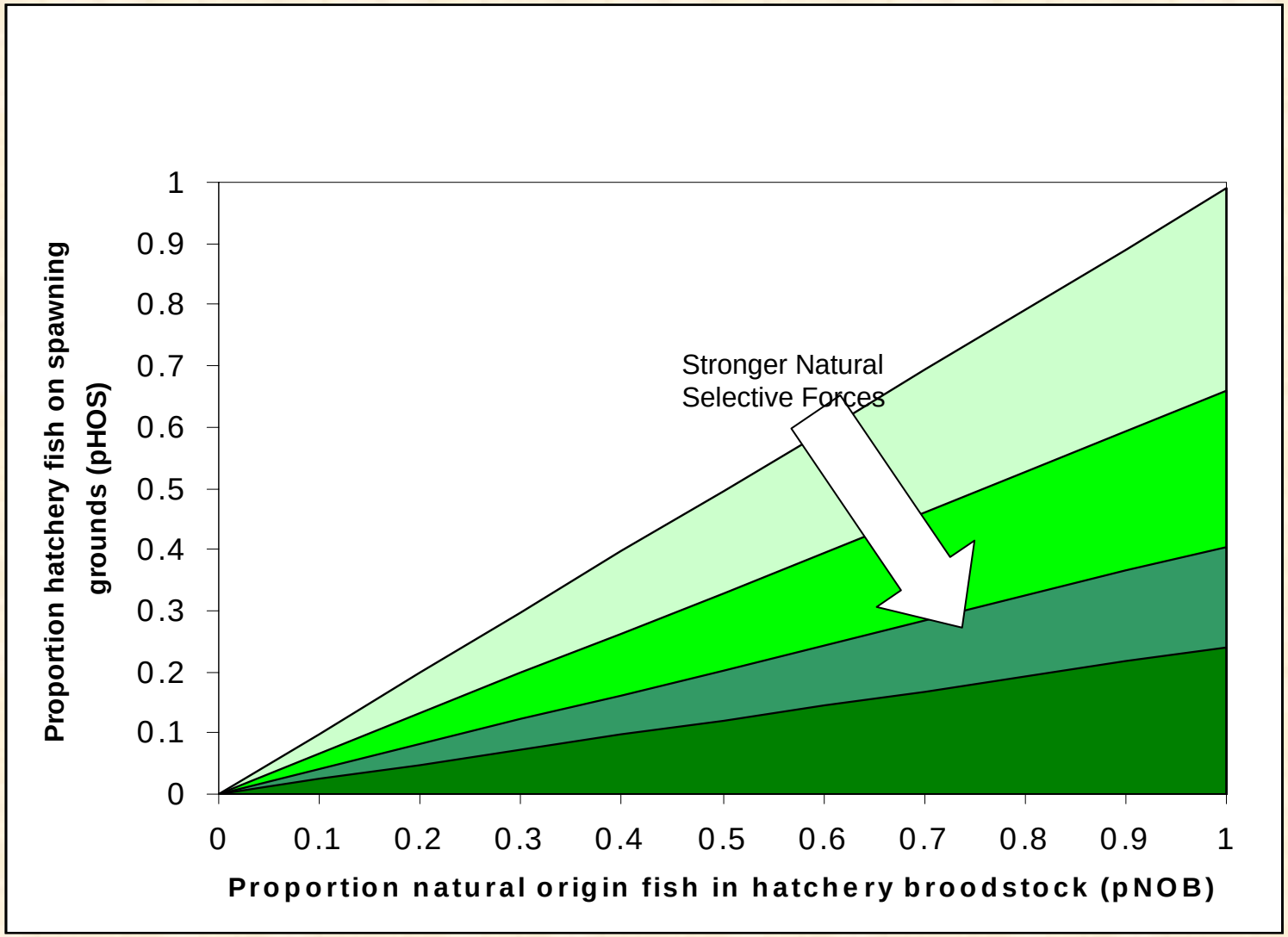
Integrated: gene flow constraints



Integrated: gene flow constraints



Gene flow vs. fitness (no genetic drift)



% Nat. fitness

50%

60%

70%

80%

100%

Figure 1. Proportionate effects of natural selective forces in integrated hatchery programs at equilibrium.

Constraints of *integrated* programs

- At least 10% of the broodstock must be composed of natural-origin fish each year.

- Gene flow from wild to hatchery (m_H) must exceed opposite gene flow (m_W):

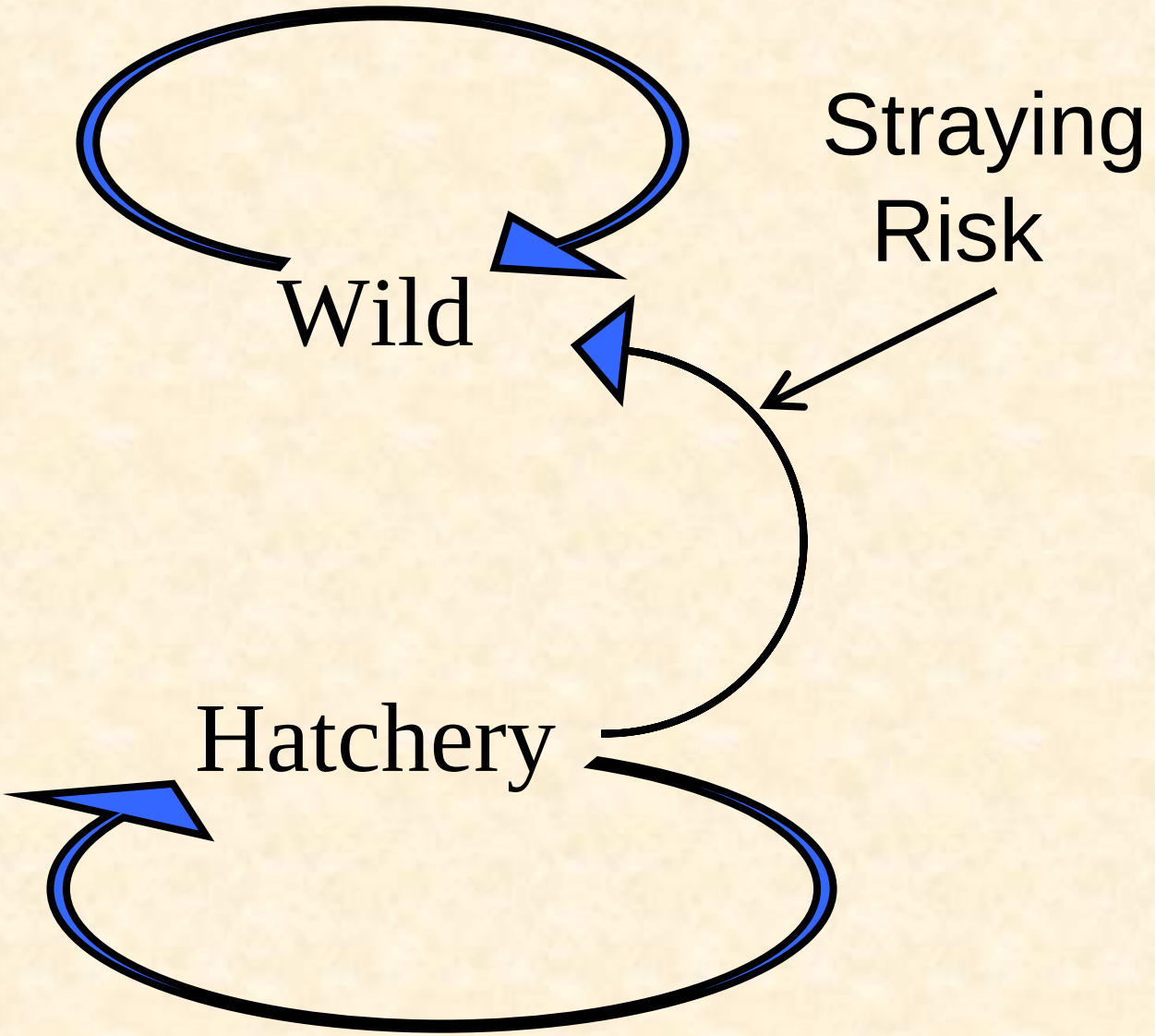
$$m_H > km_W + 0.1 \quad (k>1.0)$$

- Demographic constraint: Number of adults (H + W) used for broodstock (program size) must be less than the number of natural-origin adults returning to a watershed:

Integrated Hatchery Programs

- Manage hatchery and wild fish as one gene pool. Include natural-origin fish in the broodstock.
- Goal: Natural selection in the wild drives the fitness of the population as a whole.
- Requires a self-sustaining natural population to provide fish for the broodstock.
- May be most appropriate for hatchery programs with conservation goals or when the risks of natural spawning by HORs needs to be minimized.

Gene Flow: Segregated hatchery



Segregated Hatchery Programs

May be appropriate when:

- Very low probability of hatchery fish spawning with natural populations.
- Mitigation programs where spawning habitat no longer exists (e.g. mitigation for a hydro-dam).
- Where smolt release and adult recollection facilities are physically separated from natural population spawning areas.

Summary

- The genetic management goals for each hatchery broodstock must be identified as either *integrated* or *segregated* (1 gene pool or 2 gene pools).
- *Integrated* programs are intended to artificially increase the demographic abundance of a natural population gene pool.
- *Segregated* programs create a new, hatchery-adapted population.
- Both strategies represent trade-offs between operational efficiency and genetic risks to natural populations.

Western Washington Hatchery Reform

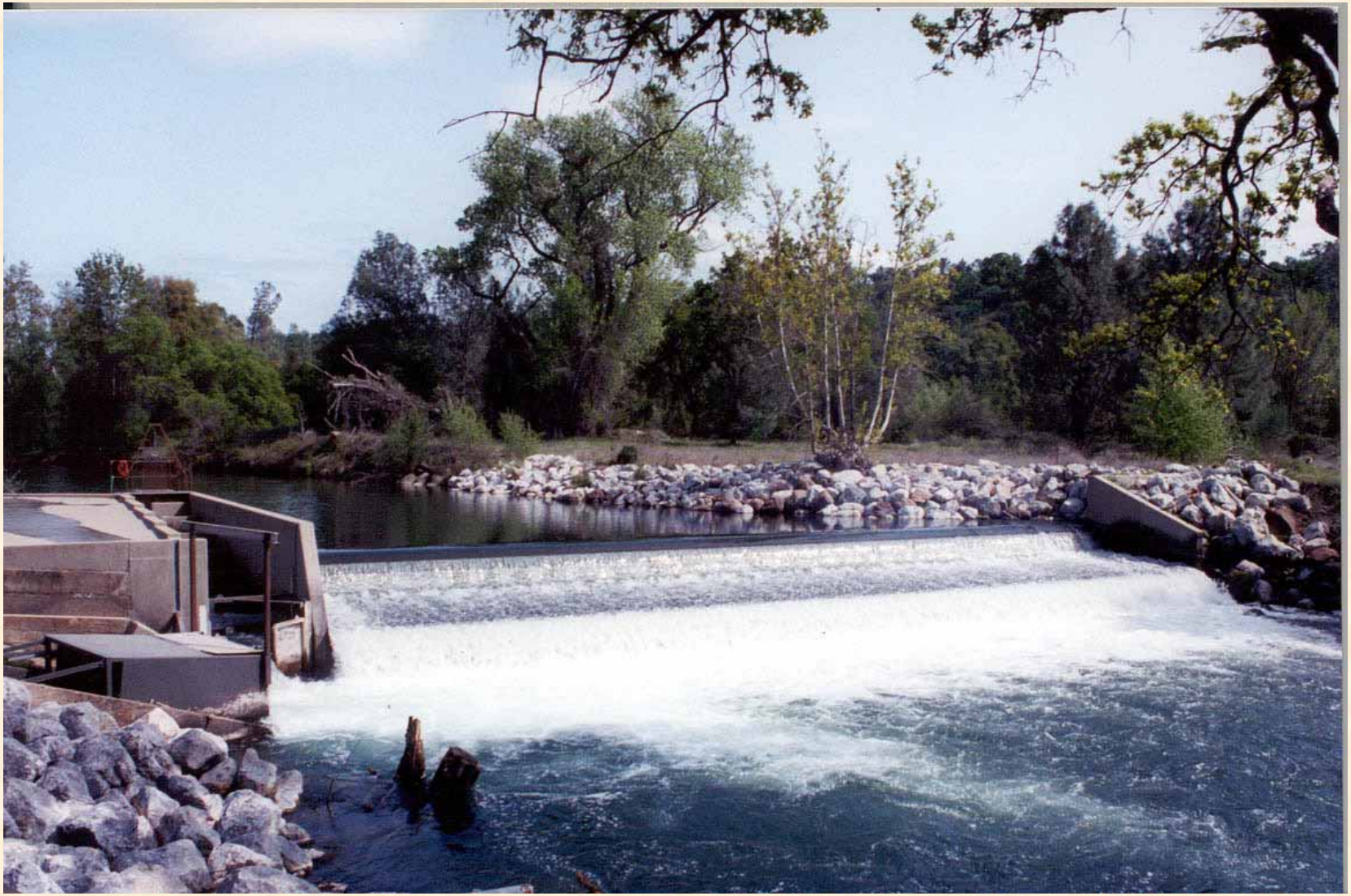
Northwest Indian

Fisheries Commission

Congressional Hatchery Science Advisory Team

www.hatcheryreform.org

Integrated programs: intensive population mgmt.



Major uncertainty of *integrated* programs:

How much gene flow is necessary from the natural environment to hatchery environment to minimize genetic divergence between hatchery and natural-origin fish?

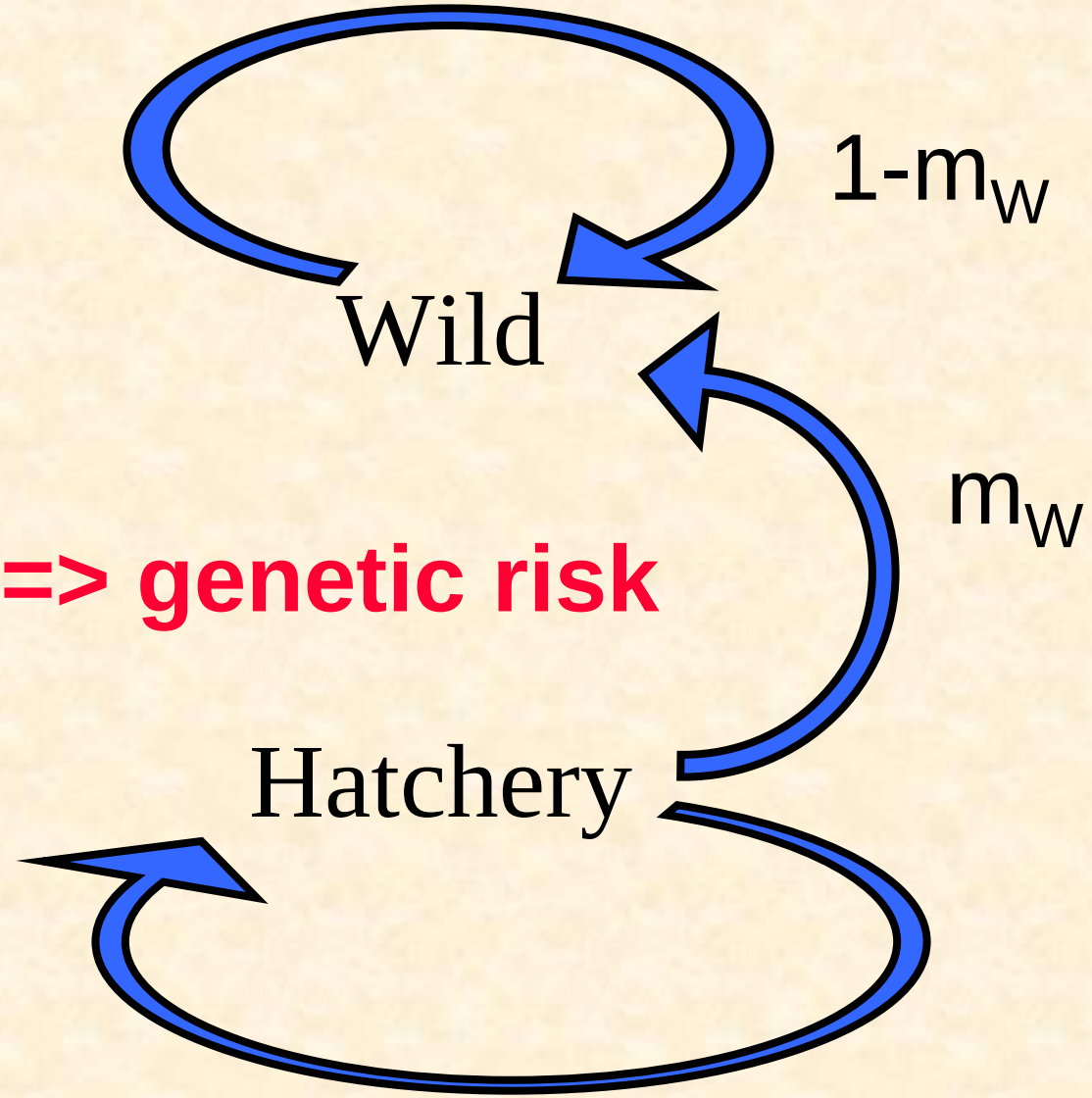
Two sources of genetic divergence:

1. Random genetic drift
2. Divergent natural selection ("domestication")

Principles of Hatchery "Reform"

- Identify goals of each hatchery program in terms of intended benefits of released fish:
  - Harvest.
  - Natural spawning.
- Scientific oversight of hatchery operations
  - Genetic oversight.
  - Ecological oversight.
- Increase monitoring & evaluation (M&E).

Segregated: gene flow constraints

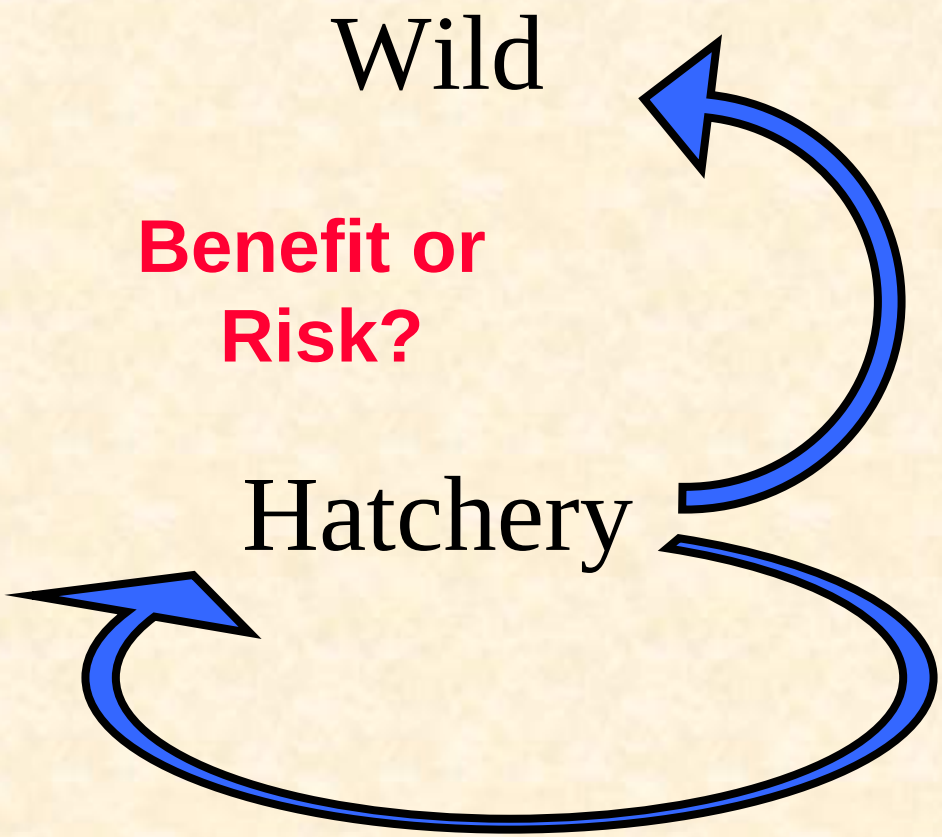


m_W > 0 => genetic risk

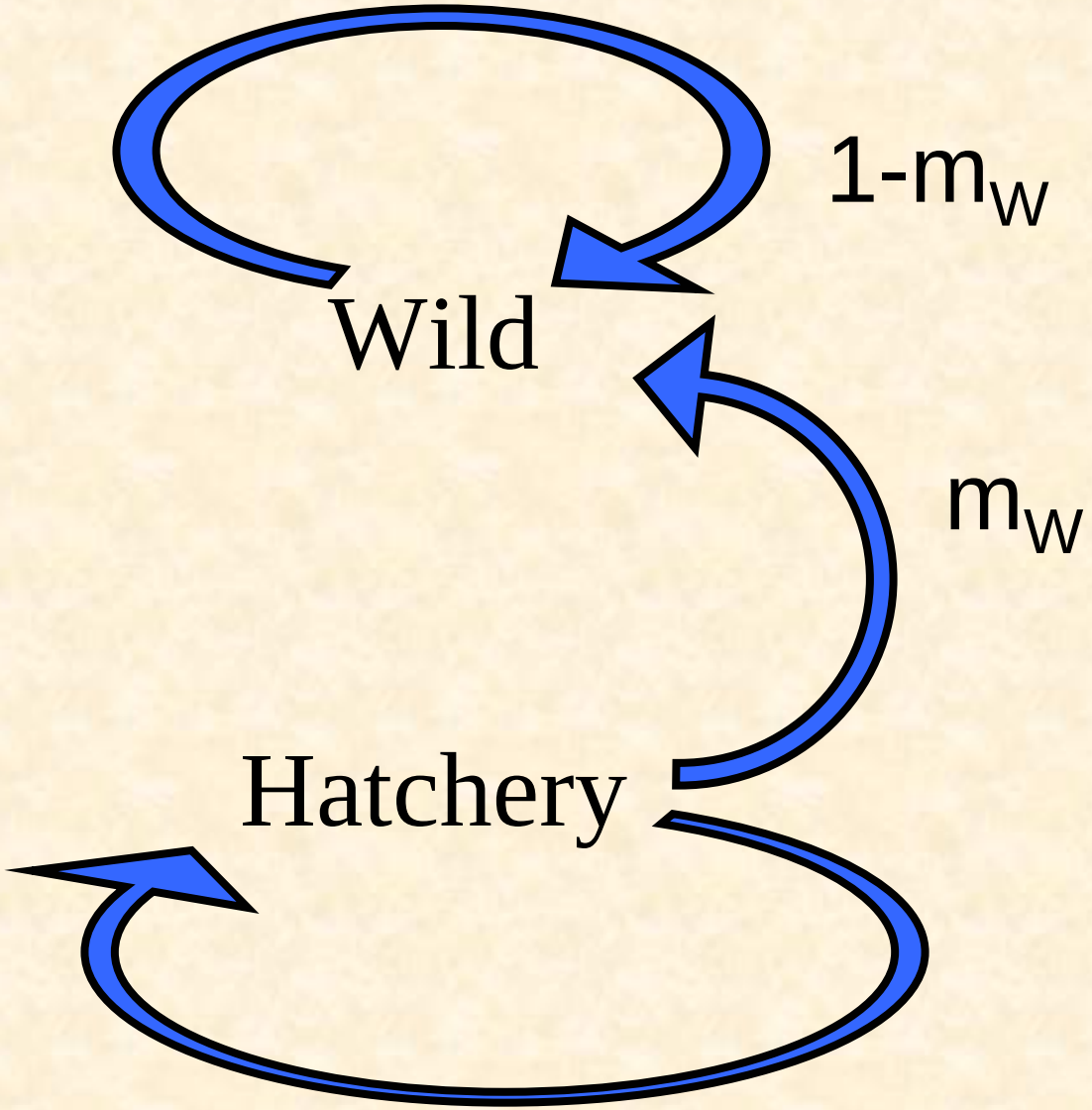
Population restoration: Supplementation

Wild (depressed or extirpated)

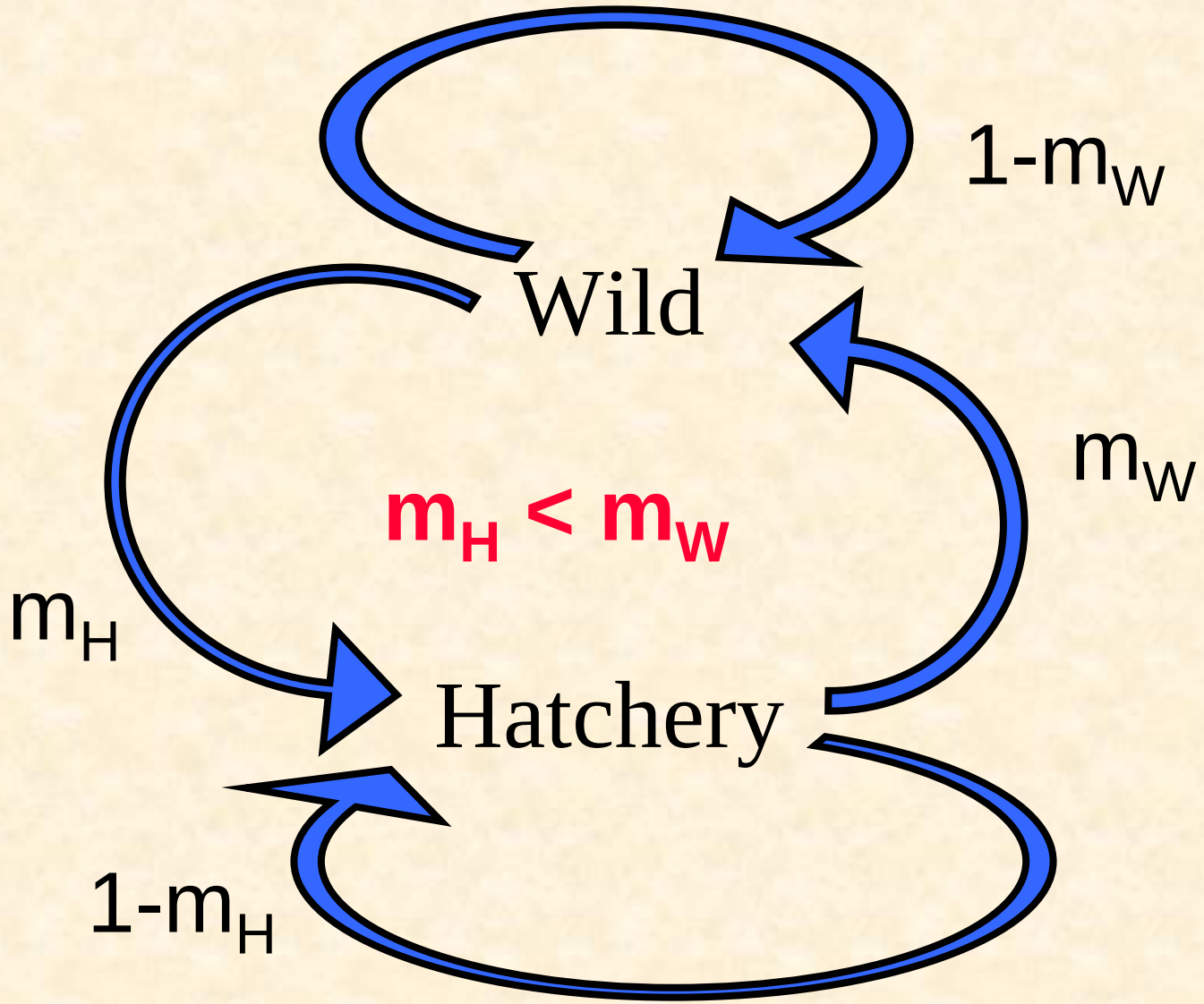
Population restoration: Supplementation
Goal #1: successful natural reproduction



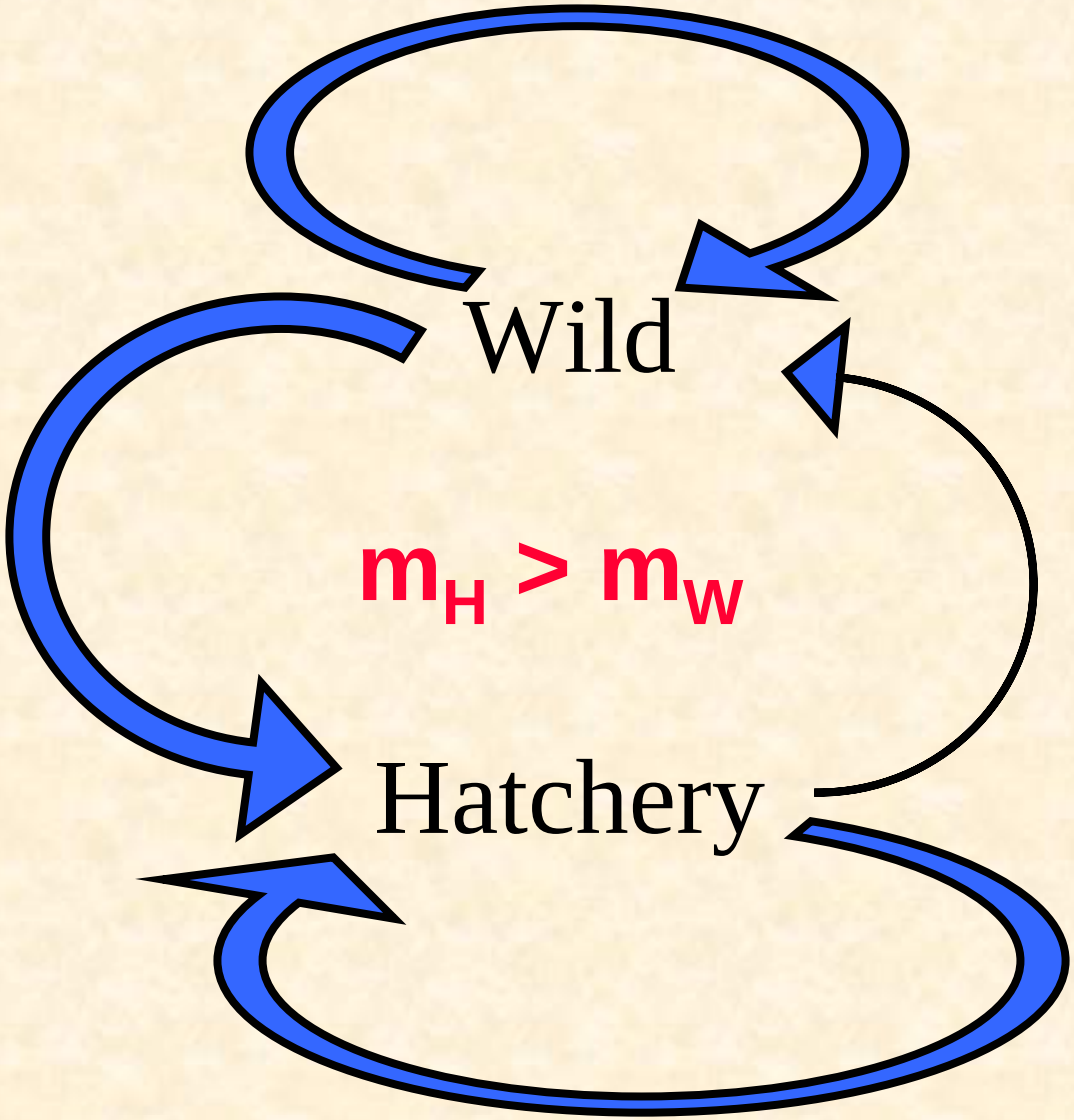
Population restoration: supplementation



Population restoration: supplementation



Population restoration: reduce supplementation



Population Restoration Complete