DNA-based methods for indirect estimation of population size and individual body condition

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An assessment framework for riverine ecosystems

Human Pressures

- Management activity can influence

- physical / chemical characteristics of the ecosystem
- Mechanism by which pressures act on ecosystem

Stressors

- a biological reaction to a change in stressor

Ecological Response

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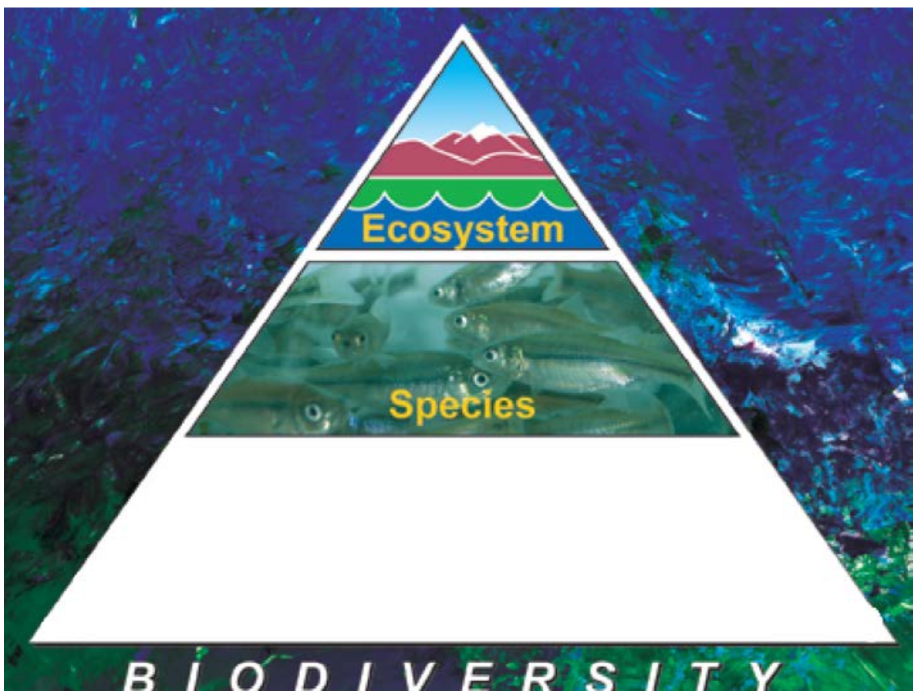
Monitoring framework – indicator selection

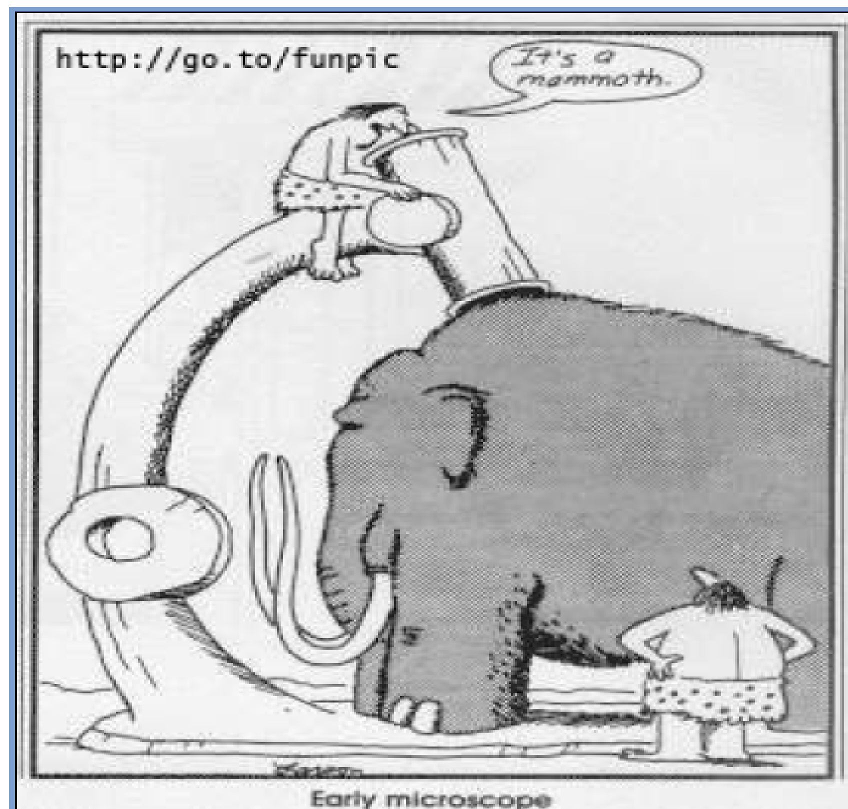
Common suite of indicators, sampling techniques and data management ?

- considered inappropriate due to regionally specific natural resource management issues – Northern Australia ?
- monitor indicators that are predicted to be sensitive to particular threats e.g. flow regimes change
- traditional focus has been on species (often family level) and ecosystem responses

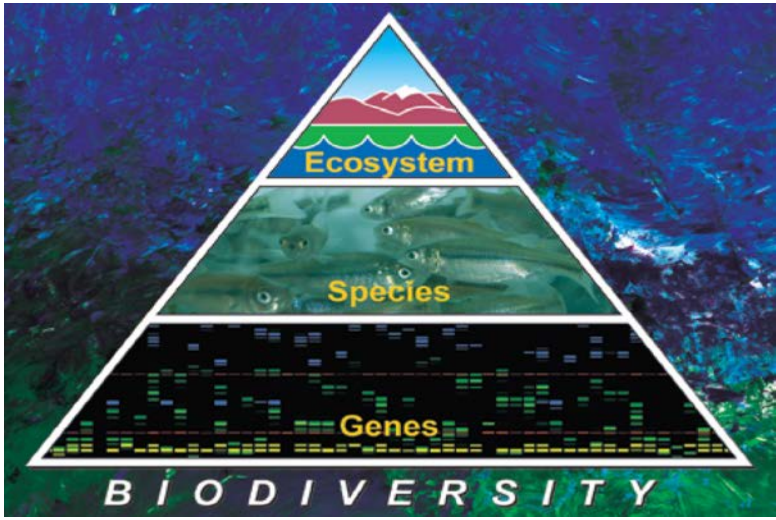
Issues of species/ecosystem monitoring

- Taxonomic uncertainty and broadness
- Assessment scale and connectivity
- Difficult to track environmental change – when gross deformities, death or extinction of species are end points





How can DNA-based methods help ?



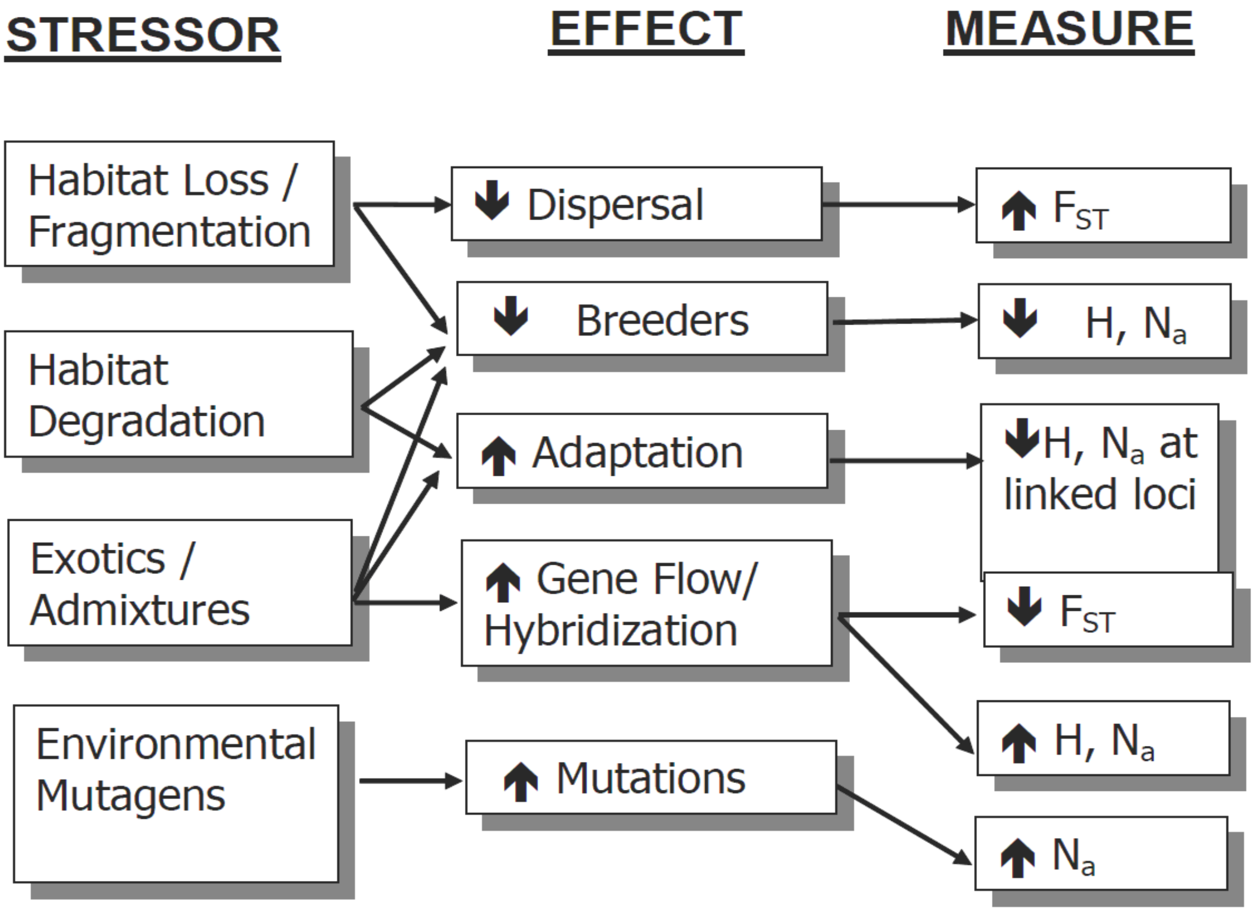
Genetic diversity is a fundamental component of biodiversity

Stressors affect genetic diversity in predictable ways (ecological indicator)

Genetic diversity sets the limits for adaptive potential and is generally a by-product of small pop size (Viability indicator)

Genetic diversity can be used to assess condition, trend and as a measurement endpoint.

Ecological Indicator



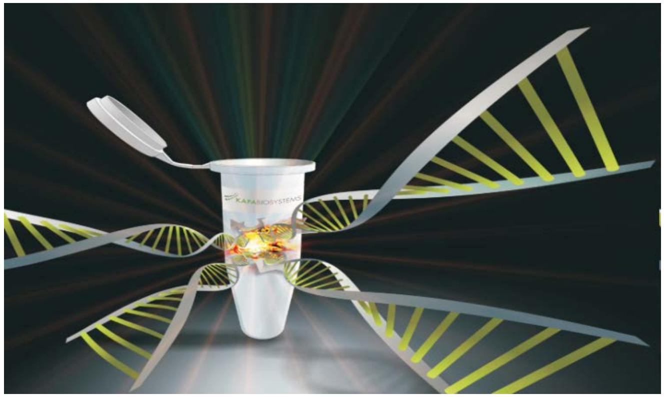
$F_{ST,}$ Allelic richness, Heterozygosity, up regulation of genes, selective pressures, RNA:DNA

How, where and who

DNA non-lethal (fin clips, blood, toes, faeces, muscle tissue and swabs).

Extracted DNA – a single tissue sample can be used for many tests, stored, quality controlled and used as reference or standard.

Microsatellite, MtDNA, allozymes, AFLP, nuclear genes ……

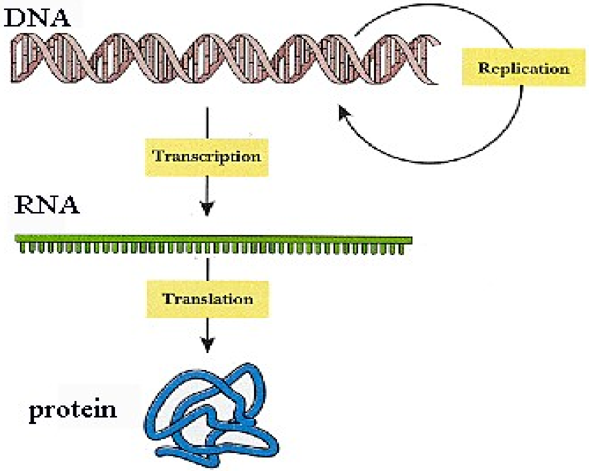


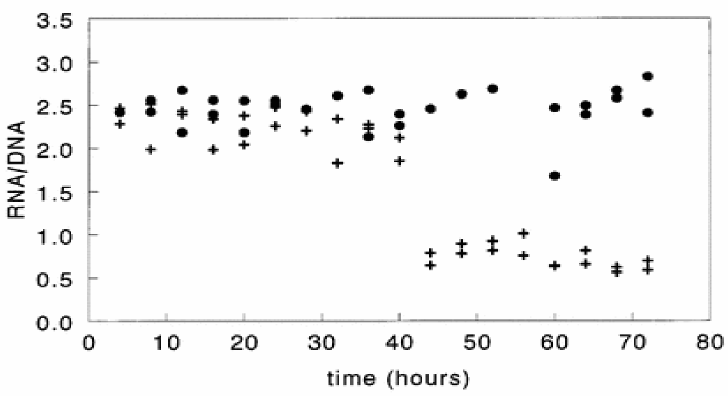
Raw genetic data can be used for many indicators depends on effect and stressor now and in the future.

Simple data storage formats, databases of genetic material

Ecological Indicator – RNA:DNA

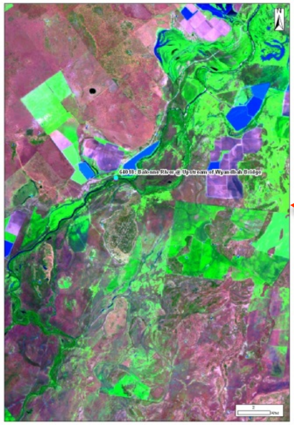
- Ecophysiological index of condition (growth, nutrition, reproduction, secretion etc)
- RNA levels vary with protein synthesis and DNA remains fairly constant
- Numerous aquaculture studies showing fed fish have higher ratios, may continue through lifespan
- Simply the higher the ratio the better the nutritional condition
- Short term (days to weeks)[1] growth rate
- Not that simple (age, length, time of day, sex, tissue, temp.)

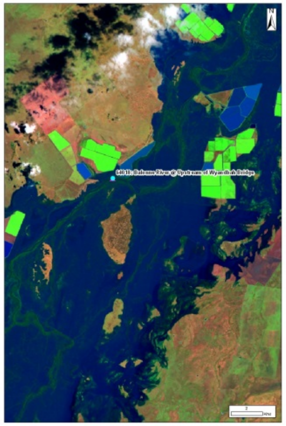


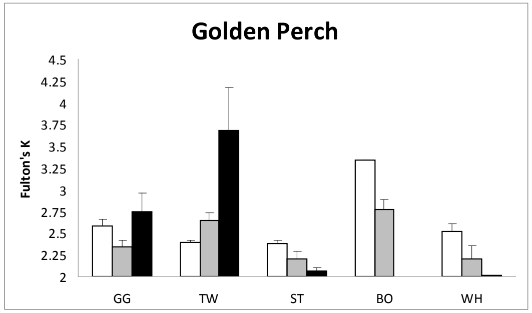


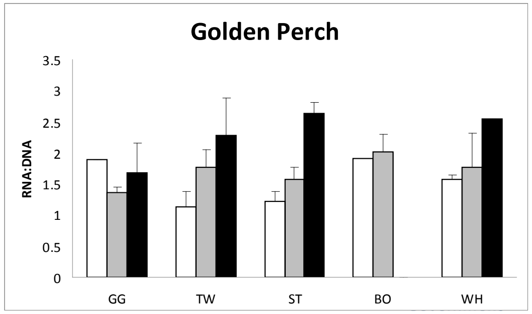
Current Use

- LEB – gradient of riparian cover affects fish growth[1]
- MDB – food quality, quantity influences consumer condition[2]
- Aquaculture – Barramundi strong larvae -> strong adults[3]
- Canada – change to summer flood frequency and intensity depressed Atlantic salmon growth[4]
- Portugal – Fulton's K little change between years but R/D annual and interspecific variation among nursery habitats -> salinity[5]
- Wet Tropics – Barramundi exposed to metals lower RNA:DNA but not Fulton's K[6]
- Ecological health assessments – relative value to detect changes over time under a given set of environmental conditions[7]



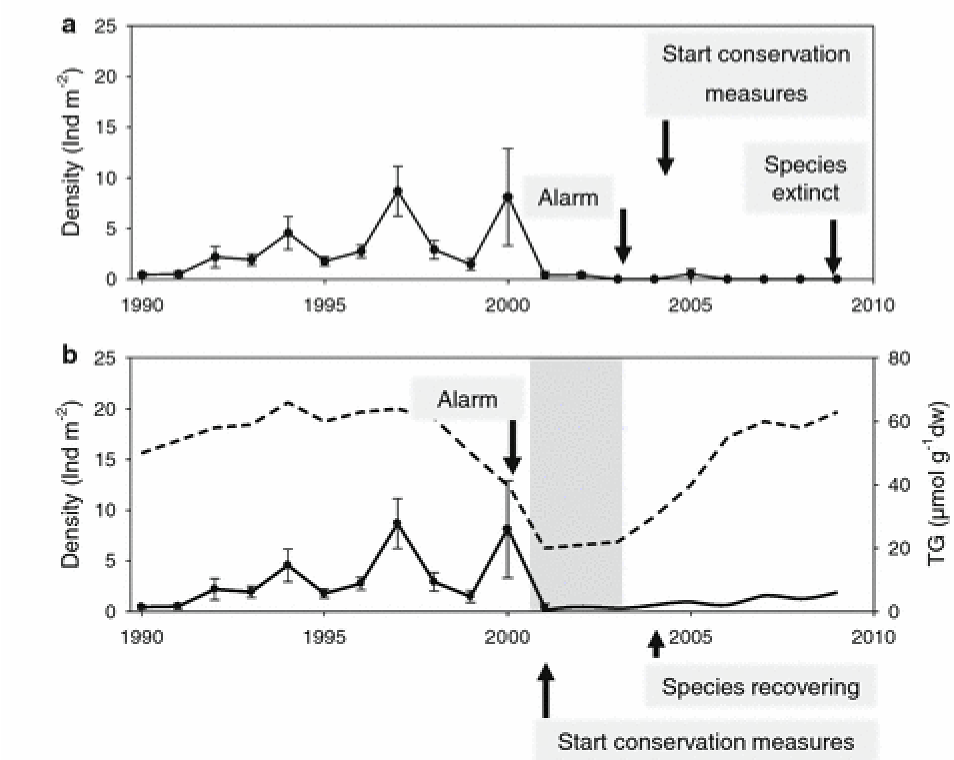


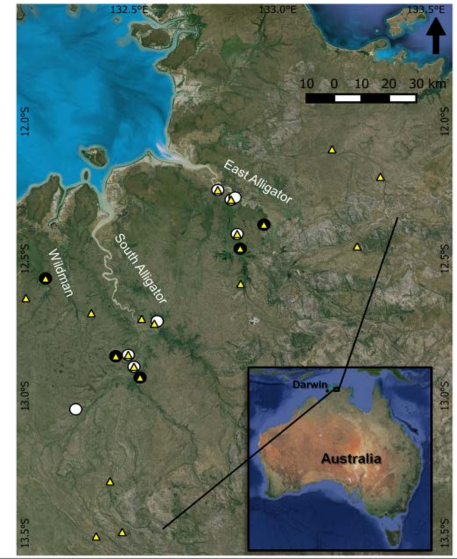


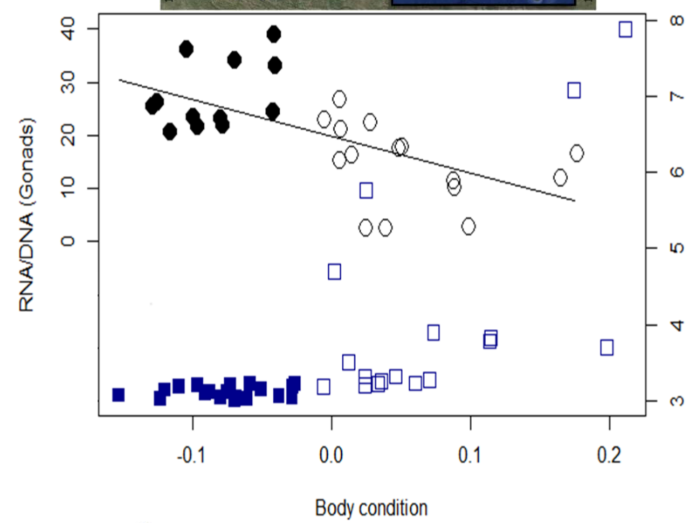


Northern Australia

- Temporal uncoupling between energy acquisition and allocation to reproduction – Diamond mullet
- Nursery habitat, food sources and quality, flow
- Recruitment success through to adult
- Barramundi and Prawns

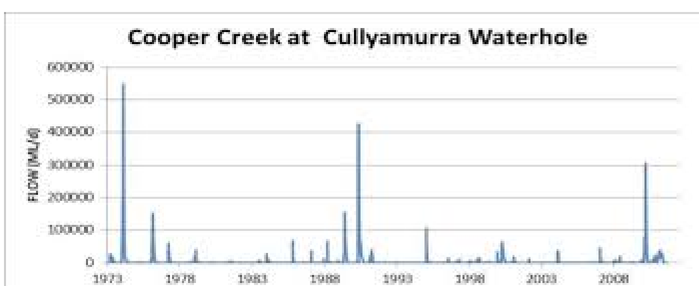


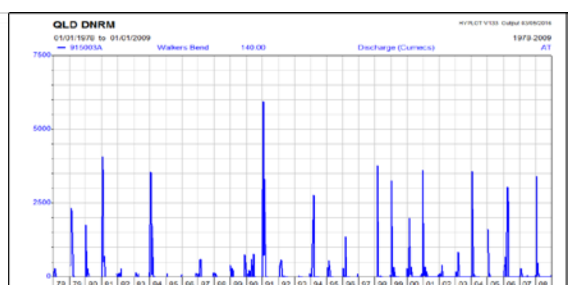




RNA:DNA - future

- Stable systems - Sensitive, relative indicator
- Lab studies to calibrate target species response to stressors
- Need to determine threshold of concern i.e minimum values
- Use in predictive models of community change
  Bottom-up: nutrient productivity models
  Top-down effects: environmental stress gradients
- Research focused on the not so simple aspects (age, length, time of day, sex, tissue, temp.)
- Multiple measures (lipids, SIA, otolith microchemistry)

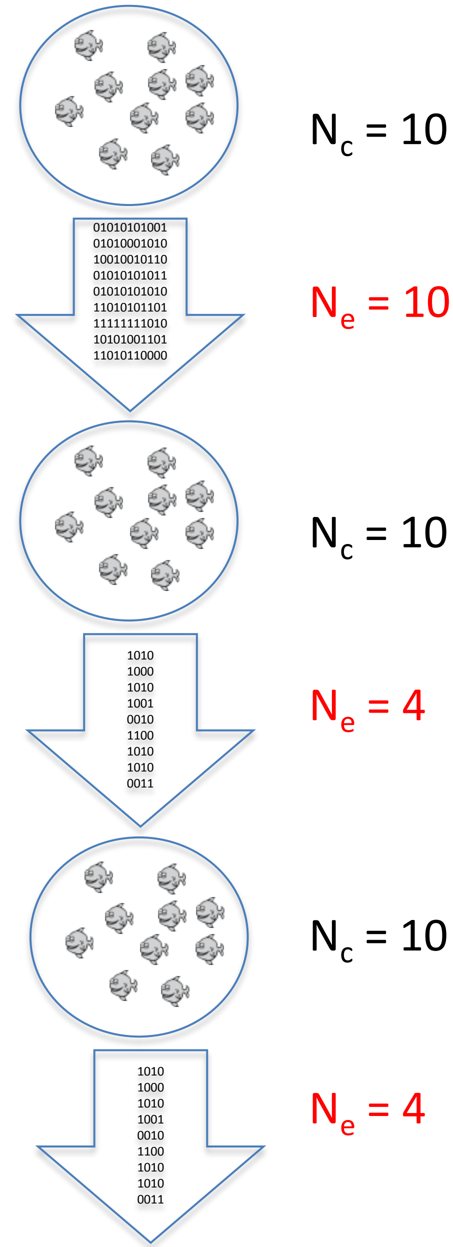




Different ways to think about population size:

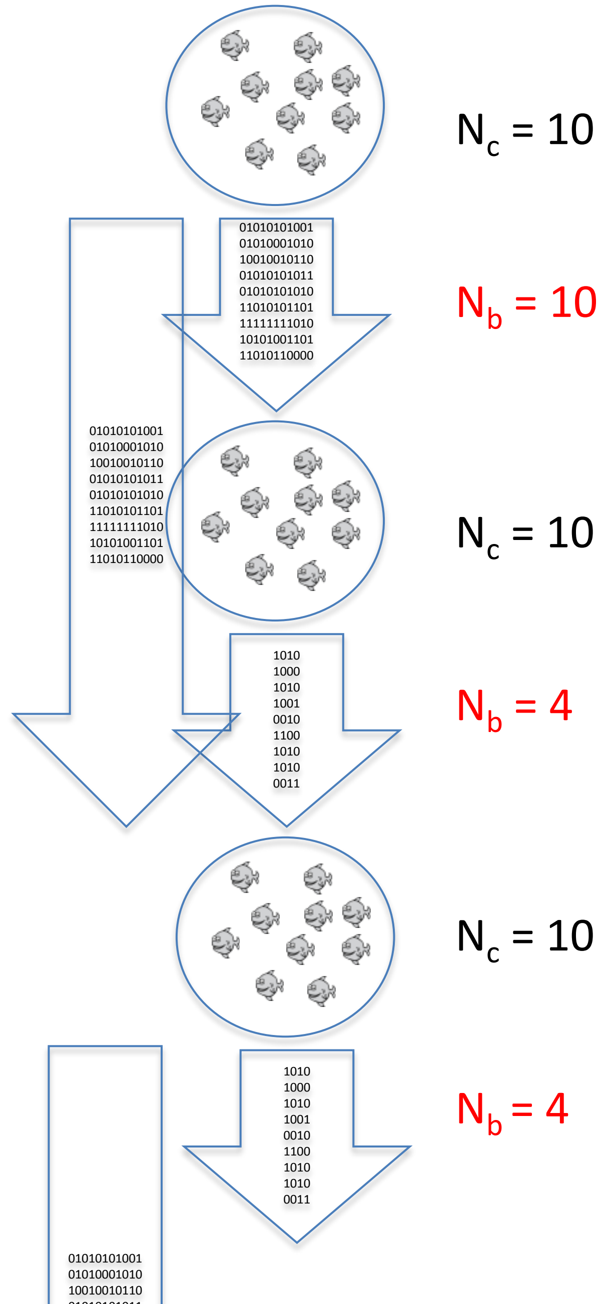
Census size = number of individuals within a generation.

Genetic effective size (Ne) = information transmitted between generations.



Different ways to think about population size:

Overlapping generations = estimates of N_e converge towards N_b (number of breeders).



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Why is Ne/Nb important

– Gives an idea of the number of males and females contributing genes to the next generation

– Populations with low Ne will have low genetic diversity
  - Low diversity implies:
    - higher risk of extinction due to disease
    - Lower ability to adapt to environmental change
    - Increased risk of inbreeding depression

- 50/500 rule (Franklin, 1980)

MOLECULAR ECOLOGY
Molecular Ecology (2015) 24, 5507–5521 doi: 10.1111/mec.13398

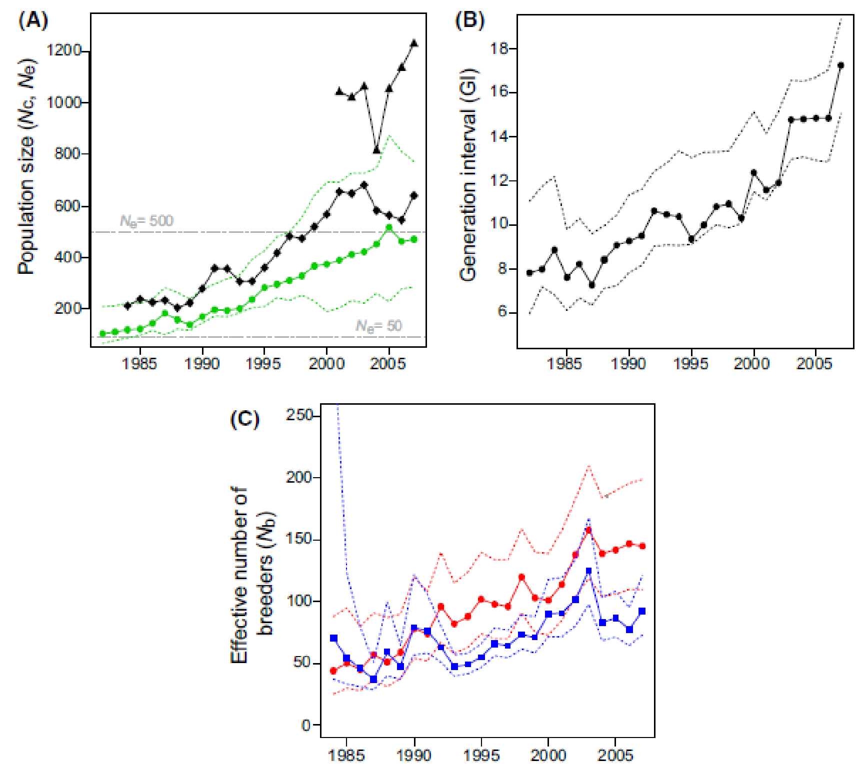
How could N_e/N_b be used for monitoring?

Multiple estimates of effective population size for monitoring a long-lived vertebrate: an application to Yellowstone grizzly bears

PAULINE L. KAMATH,* MARK A. HAROLDSON,* GORDON LUIKART,† DAVID PAETKAU,‡ CRAIG WHITMAN* and FRANK T. VAN MANEN*

N_b is an index for comparison of "genetic health" among populations.

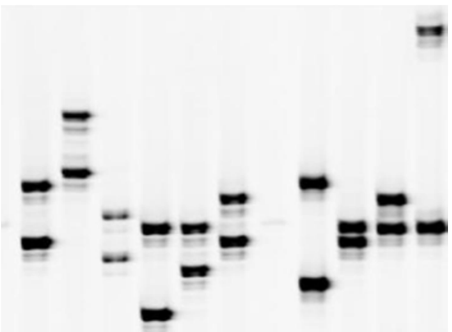
GRIZZLY BEAR EFFECTIVE POPULATION S

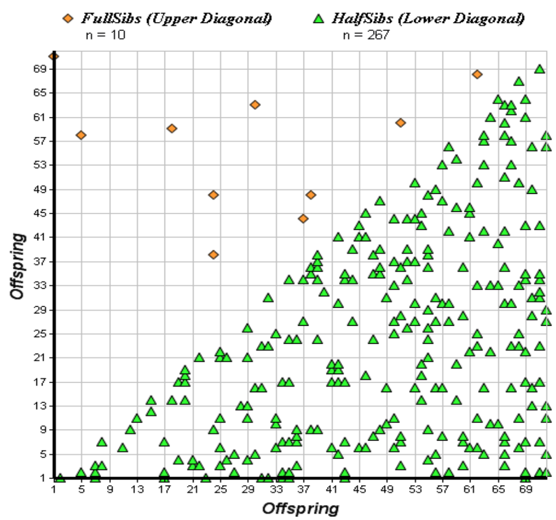


Estimating N_e (or N_b) using sibship relationships.

$$N_e = \frac{2S - 1}{\frac{\sum(k_i^2)}{2S} - 1}$$

where S = number of sampled progeny;
k_i = number of offspring contributed by each parent





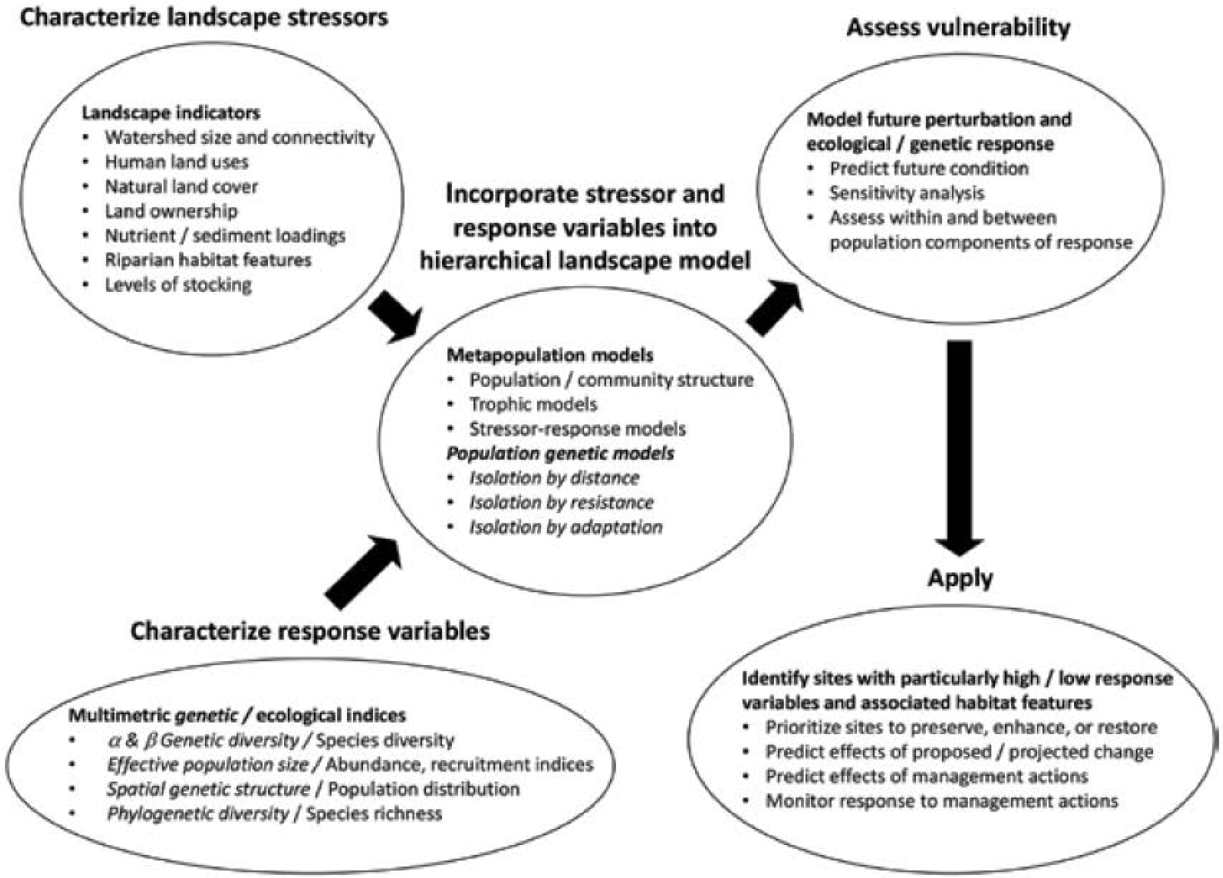


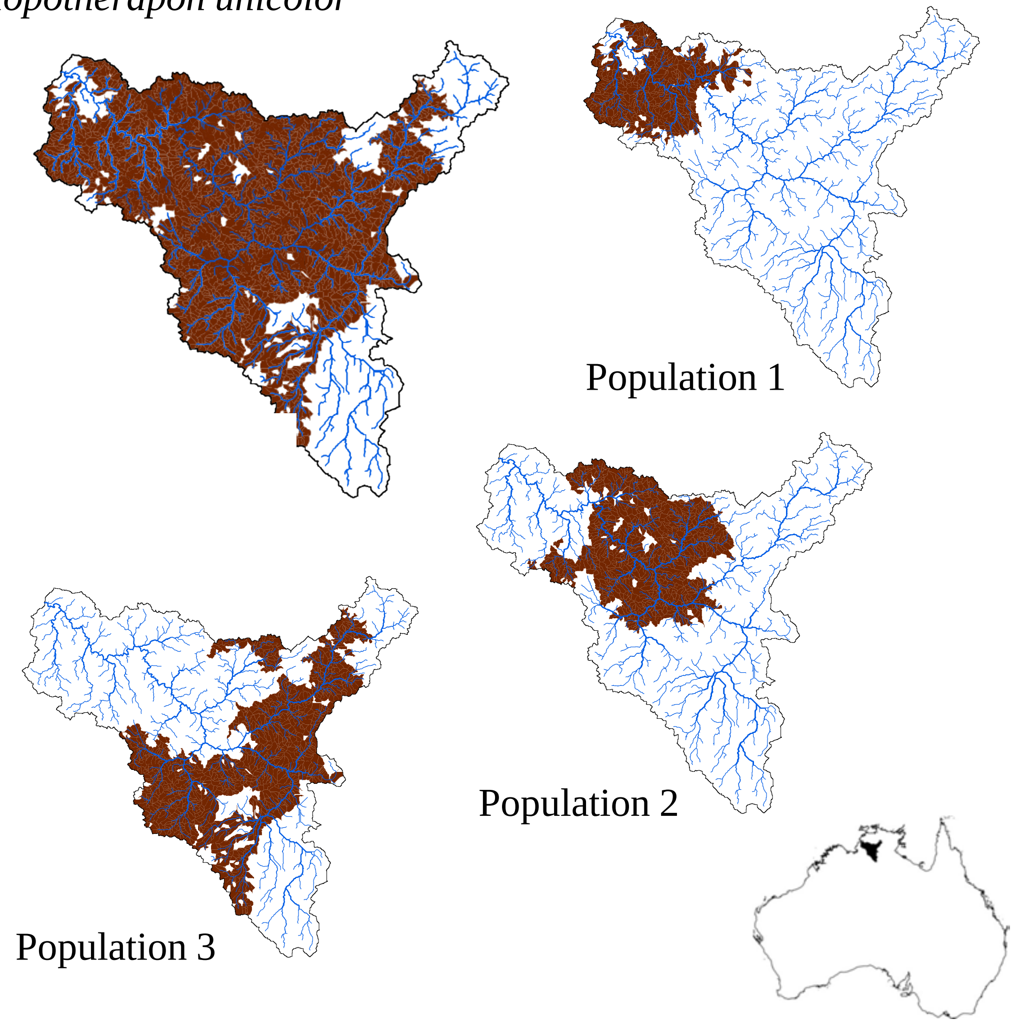
Figure 1. Landscape approach integrating genetic (in italics) and traditional aquatic assessment data to establish associations between measures of genetic and ecological diversity at each of several hierarchical spatial scales involving natural environmental and anthropogenic stressors or surrogates.

Applications of Genetic Data to Improve Management and Conservation of River Fishes and Their Habitats.
Scribner *et al*. 2016 *Fisheries*

NERP - Aquatic Biodiversity Conservation - Project 3

Biodiversity patterns, conservation planning and resilience of freshwater fauna

Leiopotherapon unicolor



Species distributions represent intraspecific genetic diversity of freshwater fish in conservation assessments. Hermoso *et.al. Freshwater Biology* (submitted)

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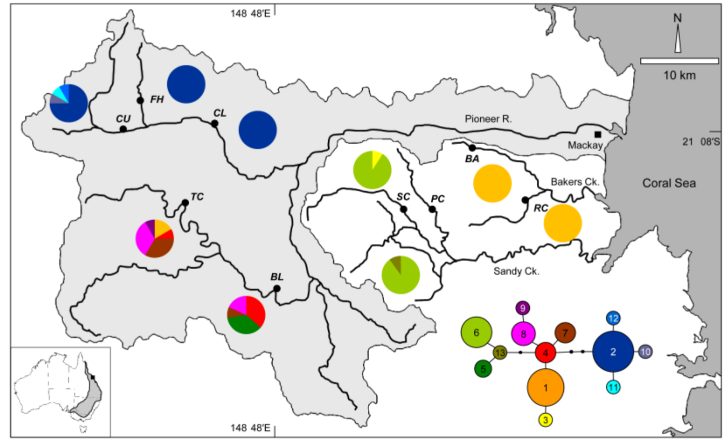
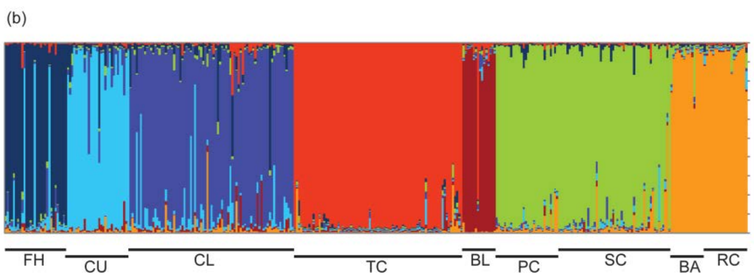
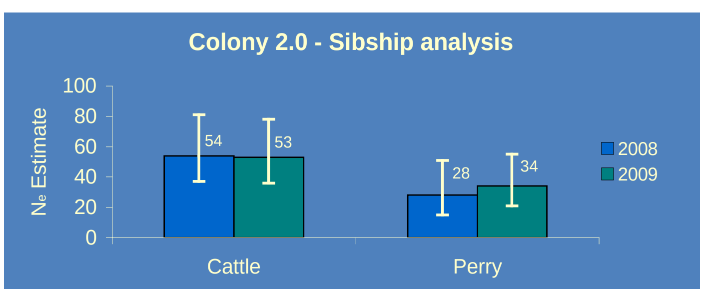
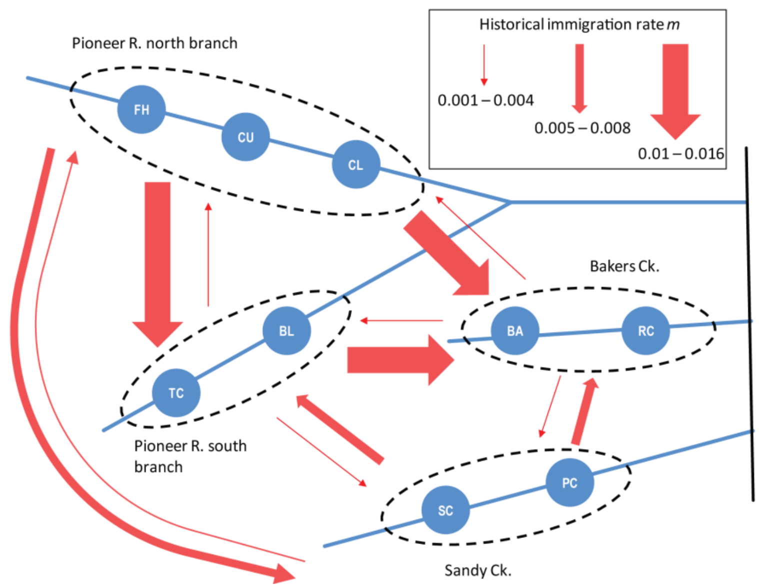
Extreme Genetic Structure in a Small-Bodied Freshwater Fish, the Purple Spotted Gudgeon, *Mogurnda adspersa* (Eleotridae)

Jane M. Hughes[1*], Kathryn M. Real[1], Jonathan C. Marshall[2], Daniel J. Schmidt[1]









Conclusions:

- DNA obtained from a small tissue sample provides access to a diverse range of metrics relevant to population monitoring.
- Obtaining and storing tissue samples is relatively easy; extracting the information out of the samples requires Molecular Ecology expertise.