Genomic Biodiversity Knowledge for resilient Ecosystems

G·BiKE

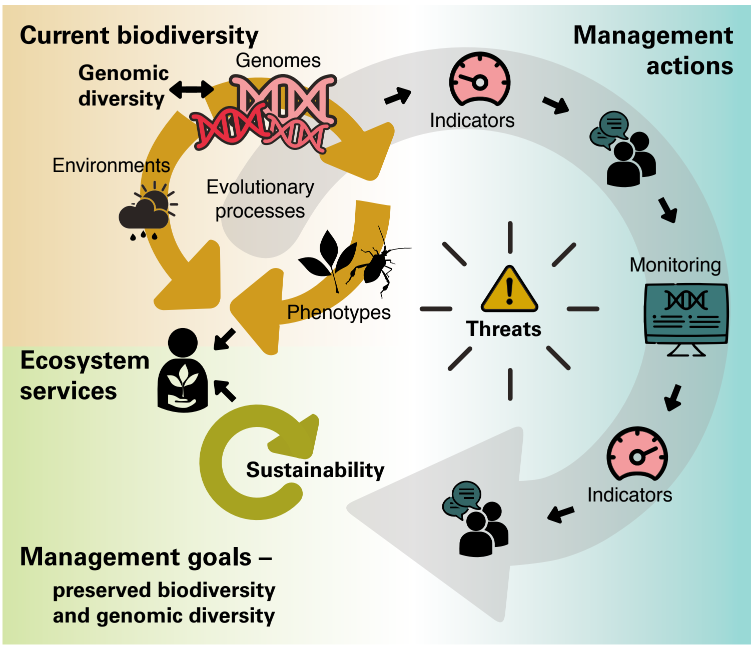
Brief for nature managers - Genomic applications for the conservation and management of biodiversity and ecosystem services

- The ongoing loss of biodiversity impacts ecosystem services (ES), the benefits that ecosystems provide to people (e.g., pollination, timber production, water filtration)
- High biodiversity within species, i.e., genetic diversity, allows populations and species to adapt and be resilient in the long-term
- Long-term resilient communities yield sustainable ES
- Nature managers can use genetic diversity information to more effectively
  - achieve biodiversity conservation and sustainable nature management goals
  - comply with biodiversity policies

Why and how

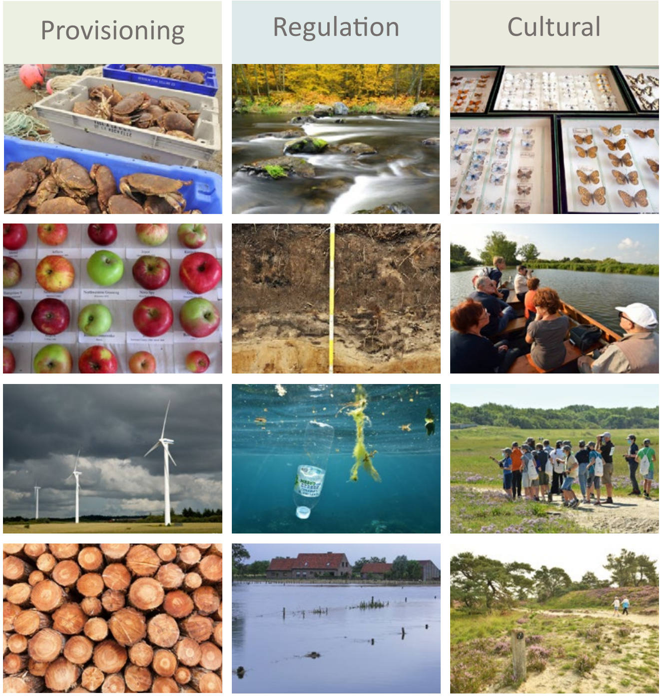
Collaboration with scientists can provide genetic or genomic diversity knowledge (BOX) that benefits nature managers to:

- Design management actions based on genetic indicators to meet their ES goals
- Monitor the success of implemented management actions
- Adjust management actions as necessary to achieve sustainability



Ecosystem service-related nature management goals that benefit from genomic diversity knowledge

- Conservation of threatened species and delineation of conservation/ management areas
- Management
  - for sustainable productivity
  - for adaptation to climate change
  - of invasive species
  - of host-microbe interaction, e.g., pest control
  - of microbial communities
  - for ES derived from water, soils and sediments
- Species, habitat and ecosystem restoration
- Implementation of new biodiversity policies
- Adjust management actions as necessary to achieve sustainability



Genetic diversity

Genetic diversity is the intraspecific diversity between individuals within a species, encoded in DNA and expressed in diverse phenotypes and adaptations to environments.

- Determines species' adaptive potential to environmental change,
- Increases ecosystem resilience in the face of climate change and anthropogenic risks,
- Supports all the other levels of biodiversity that deliver ecosystem services, benefiting people

Genomic diversity

Genomic diversity refers to genetic diversity measured at hundreds to millions of DNA sites spread across the genome. It provides highly detailed information on

- Genetic diversity and inbreeding within populations
- Genetic structure among populations
- Species' past demographic and selection history
- Genes involved in adaptive variation and adaptive potential
- Genomic signatures of hybridization

Which data

Genomic diversity information to support management can be collected

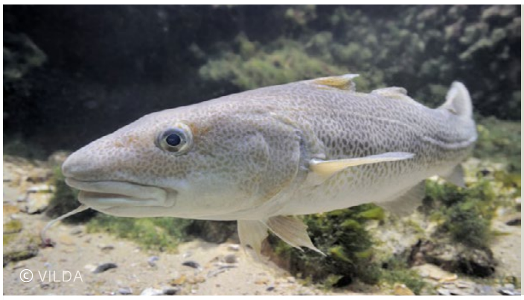
- in a species threatened by extinction
- in the species most relevant for the ecosystem function or service of interest
- in interacting species, e.g., invasive species, hybrids, host-pest systems
- in a community of microbes

Management goals	▷	Genomics-informed management actions
Population or species conservation	▷	reduce inbreeding to prevent inbreeding depression, preserve gene pools, assist colonisation, design conservation areas that maximise adaptive potential
Sustainable productivity	▷	identify populations (stocks) for management, breed for/promote productivity while conserving genetic diversity
Climate adaptation	▷	favour adaptive alleles while conserving genetic diversity, assisted gene flow, assisted colonization
Restoration	▷	perform climate-adjusted provenancing while conserving genetic diversity
Pest control	▷	monitor disease dynamics, identify and promote co-evolved resistance, prevent pest spillover
Microbial community management	▷	characterise community function and manage it, e.g., through associated vegetation or inoculation to promote desired properties
Control of invasives	▷	identify alien species to prevent invasion, identify invasive genotypes

In practice, nature managers can

- Collaborate with scientists on data, methods and implementation of new policies
- Discuss the need for genomic data, its collection and use for a given management goal
- Use genomic information to identify risks of management options, including inaction
    - e.g., inbreeding, maladaptation and local extinction risks in the absence of active management
    - e.g., risks of co-translocated pathogens in the case of translocation or population supplementation
- Implement the best genomics-informed management actions and monitor their risks and successes

Examples of genomic applications for nature management



Genomic applications help to secure the future of seafood. Genomic applications revealed the geographic distribution of distinct Atlantic cod ecotypes and the genome regions responsible for their differential adaptation.

Genomics-informed provenancing strategies for woodland restoration that account for the drivers of genomic divergence achieve better proofing to future climates than strategies based on distribution similarity of tree species.

Genomic biosurveillance of tree pathogens and pests can be reliably conducted on plant lesions, even *in situ* in remote forests, allowing for fast and accurate identification that can speed up management interventions.

Including information on adaptive genomic variation in species distribution modelling improves projections for future range losses and the potential for population rescue using population genetic connectivity or assisted colonization.

Monitoring of gene flow from exotic plantations into native relict stands of Mediterranean conifers demonstrated that the proportion of exotic-sired offspring decreased from seeds to established seedlings. Exotic pollen did not lead to fitness reduction in offspring in native stands.

Metabarcoding of soil microbial communities informs on the effectiveness of soil reclamation activities, as shown on the site of an abandoned iron and sulfur mine in southern Poland where soil restoration measures were conducted in the 1970s.

Benefits for policy implementation

Genomics-informed management is adapted to an ambitious policy framework for nature conservation and management. It helps to meet the requirements of

- the EU Habitat directives,
- the EU Natura 2000 network management,
- the CBD Post-2020 global biodiversity framework,
- the UN 2030 sustainable development goals,
- the EU 2030 Biodiversity strategies,
- the EU Forest strategy for 2030,
- the EU Green deal and infrastructure strategy,
- the EU Water Framework Directive,
- the EU Common fisheries policy and Marine Strategy Framework Directive

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