biodiversa

(c) Pieter Lemmens_Tippingpond

POLICY BRIEF

Measures to increase ecosystem resilience and avoid tipping points

Main findings

Global change can reduce the resilience of ecosystems and cause them to cross **tipping points**, leading to a rapid reduction in function and service provision which may be difficult to reverse. However, incorporating resilience considerations into policy is challenging because they are difficult to define, measure and anticipate.

BiodivERsA-funded research has characterized tipping points for two types of European ecosystems, i.e. forests and ponds, proposed key indicators to monitor these ecosystems and anticipate tipping points, and suggested management strategies.

In a changing climate, **forest stands** with more diverse tree species have more stable productivity over time, and the loss of certain species may represent a tipping point in the ecosystem. Managing forest diversity could thus increase forest resilience.

Due to nutrient inputs, **ponds** can reach a tipping point with a shift from clear water favourable to aquatic vascular plants to turbid water dominated by phytoplankton. Researchers identified an aquatic vascular plant tipping point at around 60 µg/l of chlorophyll α and developed a pond management toolkit.

Key policy recommendations

Incorporate measures into forest policy instruments that increase resilience of forest ecosystems:

- Maintain the genetic diversity of forest tree species and increase tree species diversity by **using Common Agricultural Policy (CAP) funding opportunities**.
- Create better guidance for forest managers on maintaining tree and genetic diversity that is adapted to local situations and matches future conditions.
- Provide information on the genetic makeup of tree planting material, for example by **developing a central database of provenance trials** for tree planting materials.

Take account of resilience and tipping points in policies that affect freshwater body management:

- **Revise the guidance on aquaculture in Natura 2000 to incorporate research findings on management that avoids tipping points and how to monitor** indicators in water bodies to anticipate tipping points.
- Adapt CAP cross-compliance and greening rules and agri-environment requirements to make sure buffer strips provide adequate protection for sensitive water bodies.

Context

Resilience is the degree to which an ecosystem can buffer disturbance and return to functioning at a similar level. When an ecosystem's resilience is reduced, it may approach tipping points in terms of its structure and function. **A tipping point is a threshold at which a small change in conditions leads to a large, abrupt alteration in ecosystem state.** An ecosystem can only be returned to the desired state with active intervention, which may be practically impossible.

Pressures such as climate and land use change can reduce the resilience of ecosystems and cause them to cross tipping points, leading to a rapid reduction in function and service provision which may be difficult to reverse. It is thus **of great policy interest to identify early-warning signals of tipping points in ecosystems**. However, there is still a lack of scientific evidence on what factors are key to maintaining resilience and what to monitor in order to anticipate and avoid tipping points.

This brief considers how the results of some BiodivERsA-funded projects are helping to build up the scientific evidence base showing the importance of resilience and avoiding tipping points in ecosystem management, especially under climate change. It uses results from the research projects EC21C, TIPTREE and TIPPINGPOND.

Key results

Loss of tree diversity reduces forest productivity stability and can induce tipping points in productivity, calling for forest diversity management

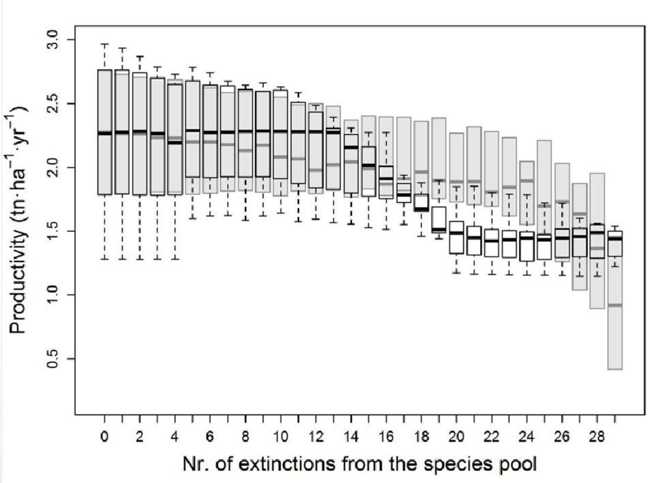
Although ecological tipping points and resulting regime shifts have been demonstrated, there is still limited evidence of their impacts in forests. It is known that forest ecosystems are changing, but it is not clear whether these changes represent tipping points. Consequently, understanding the mechanisms of resilience and tipping points in forests would guide better management practices.

Morin and co-workers (2014) developed a dynamic multi-trait simulation model to test how tree species diversity affects ecosystem stability and productivity in Central European forests. They found that stands with more diverse tree species have more stable productivity over time, mainly because of differences in the tree species responses to small disturbances. For example, a canopy opening created by a few fallen trees is re-occupied more efficiently by the canopies of a diverse group of tree species, than by just one.

A forest tree community model by García-Valdez and co-workers (2018) showed a decline in forest biomass and a decline in the stability of forest productivity in tree communities that lose species as a consequence of climate change, even though tree adaptation and natural selection were accounted for.

A random loss of tree species (grey boxes) results in a gradual decline in forest productivity until most species are gone, whereas loss of species according to sensitivity to climate change (white boxes) results in an abrupt drop in productivity when half the species are lost. The loss of certain species may thus represent a tipping point for these forests.

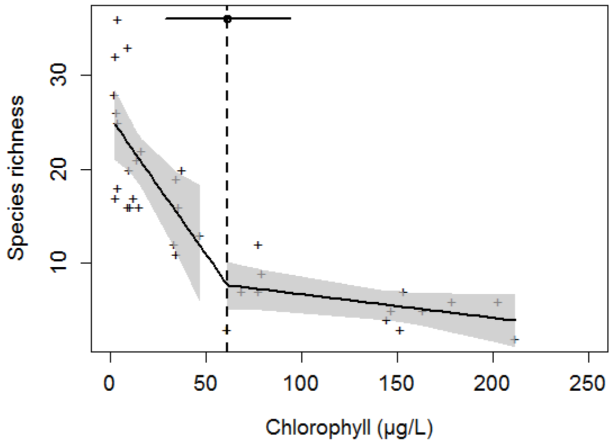
A model was developed by Oddou-Muratorio and Davi (2014) to combine tree genetics, physiology and demographics to predict the evolution of forest populations under climate change. The model showed that natural selection developed locally adapted beech tree genotypes along an altitudinal gradient within five generations. However, a high level of genetic diversity within forest stands is a key prerequisite for forests to adapt and be resilient to the unpredictable effects of climate change.



Surveying nutrients and chlorophyll in ponds to anticipate tipping points and preserve their fish stocks and biodiversity

Aquaculture ponds in Natura 2000 sites need to be managed to benefit both fish production and protected species, such as dragonflies, frogs, bats, herons and egrets. Fish production requires nutrient inputs, but ponds with too high nutrient loading can reach a tipping point at which there is a fast regime shift from clear water with a high coverage of aquatic vascular plants to turbid water dominated by phytoplankton. **Turbid ponds are much poorer habitat for most protected species and are inadequate for the fish stock.**

Vanacker and co-workers (2015, 2016) looked for indicators that can predict tipping points in ponds in the temperate zone. The research identified tipping points for total nitrogen, total phosphorus and chlorophyll α which were associated with loss of diversity of aquatic vascular plants, aquatic macro-invertebrates and dragonflies. These points can easily be monitored using electronic probes and fluorometers. The species diversity of aquatic vascular plants in ponds showed **a tipping point at chlorophyll α concentrations above 60 µg/l**, which corresponds to a shift from 'good' to 'poor' ecological status under the EU Water Framework Directive.



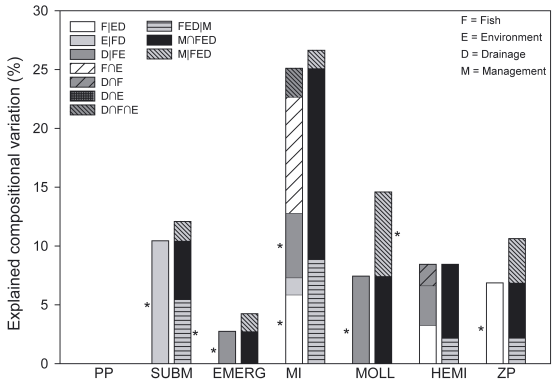
Tipping point for aquatic vascular plant diversity when chlorophyll α increases. Graph shows one of three statistical methods and five biodiversity indices used to calculate tipping points.

Managing pond water nutrients to favour fish stock while avoiding tipping points and preserving biodiversity

Lemmens and co-workers (2015) found that the fish pond drainage regime and fish community characteristics have strong and independent effects on the community composition of plankton, aquatic macro-invertebrates, and submerged and emergent vascular plants.

The ratio of nitrogen to phosphorus can be adjusted to arrive at a stable regime that favours fish stock, through balancing the levels of phytoplankton and aquatic plants, without risk of a regime shift that damages aquatic macro-invertebrates, dragonflies, and other species. This is done by adjusting fish feed inputs, liming, fertilisation and drainage.

The researchers in the TIPPINGPOND project have produced a pond management toolkit to avoid regime shifts away from a pond environment that supports biodiversity, particularly in aquaculture in Natura 2000.



The stacked bars show how much of the variation in community composition of phytoplankton (PP), submerged and floating vegetation (SUBM), emergent vegetation (EMERG), aquatic macro-invertebrates (MI), molluscs (MOLL), Hemipterans (HEMI), and zooplankton (ZP) is due to fish stocking, drainage, other management or environmental processes. Left-hand bars show that most of the variation is uniquely due to: fish (F|ED), pond environmental variables (E|FD), or pond drainage (D|FE). Right-hand bars show that most of the variation is explained by pond management uniquely (M|FED) or by pond management, fish, pond environment and drainage together (M\FED).

Policy recommendations

Maintaining ecosystem resilience and avoiding tipping points is an important policy goal to ensure continuing ecosystem services and biodiversity conservation, including ecosystem production. However, incorporating resilience considerations into policy is challenging, as it requires a clear definition and the ability to monitor key ecosystem properties that are relevant to anticipating tipping points.

BiodivERsA-funded research helps to clarify what makes ecosystems such as forests and ponds resilient, and how to monitor indicators of tipping points to avoid abrupt alterations in ecosystem state.

Maintaining and restoring the diversity of local tree species increases forest resilience to the effects of climate change, and helps maintain their ecosystem services, as recommended by the EU Forest Strategy. National and regional forest policies could incorporate measures to encourage forest managers to adapt their silvicultural systems to increase long-term resilience to future threats, such as pests and diseases, drought and storms.

- **Maintain the genetic diversity of forest tree species and increase tree species diversity.** The Common Agricultural Policy includes a measure to support conservation of forest genetic diversity, for example for marginal and peripheral forests. CAP can also support replanting and management to increase forest tree species diversity. Only 18 Member States are funding forest genetic conservation through CAP in 2014 to 2020.

- **Use** sustainable forest management plans **to specify criteria for the genetic diversity of planted trees to increase resilience**, whilst ensuring that planting of resistant genotypes is not at the expense of locally native species.

- **Create better guidance on maintaining tree and genetic diversity for forest managers**. Forest managers want to know whether they need to adapt to climate change by changing the types of tree species they plant, or the genetic providence of their trees, or the tree density in their forest stands. EUFORGEN, the European Forest Data Centre, and national forest information services all have roles.

- **Provide information on the genetic makeup of tree planting material**. Create a central database of provenance trials containing the provenance of tested tree genotypes, and the type of climate, soil, etc. conditions they are adapted to. For example, Austria has done this.

Policies that affect freshwater body management should take account of resilience and tipping points. In particular:

- **Revise the guidance on aquaculture in Natura 2000 to incorporate research findings on management that avoids tipping points and how to monitor** nutrient and chlorophyll concentrations and other indicators in water bodies to anticipate tipping points.

- Revise **Common Agricultural Policy cross-compliance and greening rules** to make sure buffer strips provide adequate protection for ponds and other freshwater on farmland against nutrient leaching.

Links to sources

TIPTREE project website

TIPPINGPOND project website

EC21C project website

Scientific publications used in this policy brief can be found in the Information Sheet of this briefing, downloadable from: www.biodiversa.org/policybriefs

About this Policy Brief

This Policy Brief is part of a series aiming to inform policy-makers on the key results of BiodivERsA- and Horizon 2020-funded projects, and provide recommendations to policy-makers based on research results.

The series of BiodivERsA Policy Briefs can be found at www.biodiversa.org/policybriefs.

This publication was commissioned and supervised by BiodivERsA, and produced by the Institute for European Environmental Policy (IEEP).

The key research results presented here were validated by researchers from the EC21C, TIPTREE, and TIPPINGPOND research projects.

The policy recommendations made do not necessarily reflect the views of all BiodivERsA partners.

The BiodivERsA project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 62420

Contact

contact@biodiversa.org
www.biodiversa.org
@BiodivERsA3

MIX Paper from responsible sources FSC® C019064

Produced in May 2018.