Towards sustainable forest management and monitoring

Report of the Bottoms-up project final conference

Cost action nr CA28307

Botanical Garden, Rome Italy

19-21 March 2024

Colophon

Project website: https://www.bottoms-up.eu/en/

And at the Biogeographical Process WIKI:

https://biogeoprocess.net/past-events/

Citation: T. Van der Sluis, C. Sunyer, E. Hermanowicz, S. Munzi, N. McIntosh, I. Doerfler, S. Burrascano (2024). Towards sustainable forest management and monitoring. Report of the Bottoms-up project final conference, 19-21 March 2024, Botanical Garden, Rome Italy.

Organizers:

Sabina Burrascano - Sapienza University of Rome – sabina.burrascano@uniroma1.it

Theo van der Sluis – Wageningen Environmental Research – Theo.vanderSluis@wur.nl

Facilitators:

Ewa Hermanowicz, Communications Manager, Europe, Forest Stewardship Council (FSC) International e.hermanowicz@fsc.org
Carlos Sunyer, TerraEcogest csunyer@terracentro.org
Neill McIntosh, Europarc Head capacity building & Communications Neil.mcintosh@europarc.org
Silvana Munzi, University of Lisbon Ssmunzi@ciencias.ulisboa.pt
Inken Doerfler, Lead Action WG 4, Inkendoerfler@googlemail.com
Theo van der Sluis, Project leader BGP & Cost Action Communication Theo.vanderSluis@wur.nl
Alessia Portaccio, Alessia.portaccio@unipd.it

Integrating biodiversity conservation in forest management

Introduction

European forests have been altered by management actions aimed at timber production for millennia. Forest habitats acknowledged by the Habitat Directive (92/43/EC) make no exception, and in the last State of nature in the EU Forestry is reported as the main pressure to forest habitats, of which about 80% are in an unfavourable conservation status.

The current indicators of forest sustainability are mostly based on forest stand structure and landscape properties that may, but not always are, related to forest biological diversity.

The COST Action BOTTOMS-UP aimed at increasing the degree of the biodiversity sustainability of European forest management. The project gathered the most comprehensive knowledge of European multi-taxonomic forest biodiversity through the collaboration of research groups that collect data locally. Information about the COST action can be found at https://www.bottoms-up.eu/en/

The COST Action had seven major goals:

1. Building a platform for forest multi-taxon biodiversity and stand structure data;
2. Creating a network of forest monitoring sites with baseline information;
3. Defining shared protocols for multi-taxon and structure sampling;
4. Creating a coordinated network of forest manipulation experiments;
5. Assessing the relationships between forest biodiversity, structure and management;
6. Assessing indicators and thresholds of SFM directly tested on biodiversity;
7. Provide management guidelines primarily for forest certification and within protected areas.

During the conference several researchers covering leadership positions within the project showcased the project results relative to each of these goals.

Goal 1. A platform for forest multi-taxon biodiversity and stand structure data

The platform of forest multi-taxon biodiversity and stand structural data was presented illustrating its strength and weaknesses, and specifically addressing the data gaps that exist in Europe, such as the one relative to Mediterranean and thermophilous forests (Burrascano et al., 2023).

Goal 2. A network of forest monitoring sites with baseline information

The platform includes data on species, standing trees, lying deadwood and sampling unit description from 34 local datasets across 3591 sampling units. The location of these sampling units and the data associated to each of them can be explored through the COST Action website (https://www.bottoms-up.eu/en/results/data-explorer.html) and many research project using them are ongoing.

Goal 3. Defining shared protocols for multi-taxon and structure sampling

The Action created the basis for a thorough discussion on the methods that should be used in forest multi-taxon biodiversity studies, from field sampling protocols (Burrascano et al., 2021) to sampling effort (Burrascano et al., under review) and terms to describe forest management and compositional type (Trentanovi et al., 2023).

Goal 4. A coordinated network of forest manipulation experiments

One of the Action working group was focused on forest manipulation experiments that monitored multi-taxon biodiversity. After a long work or search and networking, it was possible to identify a network of such experiments either performed in the past two decades or ongoing. The results show

how most experiments focused on thinning and gap creation, as well as on herbivores exclosure and deadwood creation (Tinya et al., 2023).

Goal 5. Assessing the relationships between forest biodiversity, structure and management

Several research projects that have started in the framework of the Action addressed this aim. These range from analyses of management effect on plant traits (Chianucci et al., under review), to direct and indirect links between forest structural attributes, including carbon stocks, and multi-taxon biodiversity.

Goal 6. Indicators and thresholds of SFM directly tested on biodiversity

The Action data relative to six taxonomic groups was used to test the current indicators used to assess the sustainability of forest management for biodiversity conservation. We found that no indicator covers all the studied taxonomic groups, among the current indicators deadwood volume and tree species richness were those giving relevant results for at least four taxonomic groups (Paillet et al., Under review). Further work is being implemented especially on deadwood threshold relevant for multi-taxon biodiversity.

Goal 7. Guidelines primarily for forest certification and within protected areas

The Action results were summarized and delivered in two policy briefs, one on forest monitoring and one on forest management, both addressing especially forest multi-taxon biodiversity. These policy briefs were intended as drafts to be integrated with the results of the discussion carried out during the two conference days.

The seminar

The final Conference of the COST action was held at the Botanical Gardens in Rome. A two-day conference programme entailed morning sessions where presentations were given during mornings, and during afternoons the participants engaged in discussions on forest management, monitoring and indicators. The conference was followed by a field excursion.

Two keynote speakers gave relevant insights on forest management, both on the outcomes of different management regimes and especially on retention forestry (Prof. Lena Gustafsson) and on the society perception of forest ecosystem services and management (Prof. Georg Winkel).

The key-note lectures were followed by two parallel sessions. Contributions, ranging from Spain to Latvia, and from United Kingdom to the Po exposed the different issues that biodiversity conservation

poses in forest ecosystems: from communication with stakeholders (among which forest owners), to the need for reliable indicators of biodiversity, from forest habitat conservation status to restoration actions. The different contributions created the optimal substrate for the afternoon discussions, which addressed questions related to the most urgent challenges relative to forest biodiversity in Europe. The presentations summarized the COST outcome, and papers that have been published or are near its final stage to be published (see 'key literature').

The final conference was particularly directed towards forest managers, researchers, decision makers, Natura 2000 site managers and NGOs involved in forest and biodiversity management. There were more than 100 researchers from 33 European countries (see figure below) together to provide their contribution and perspective on the project topic.

This Conference was also supported by the Natura 2000 Biogeographical Process, a support programme by the European Commission. Adrian Tistan from DG-Environment gave a presentation on new forest policies and forest monitoring. Theo van der Sluis presented the Biogeographical Process, and their activities in supporting Member States in achieving the aims of the Biodversity Strategy 2030. The Biogeographical Process developed also the facilitation programme for the discussions and workshops at this final seminar, with help of a group of facilitators.

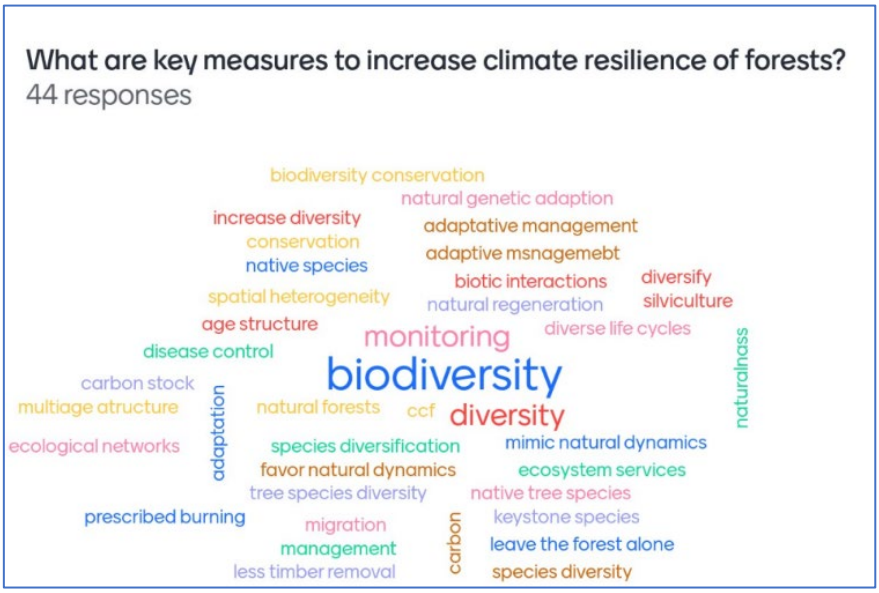
Discussion outcomes

Day 1:

Forest monitoring, management and conservation in Europe

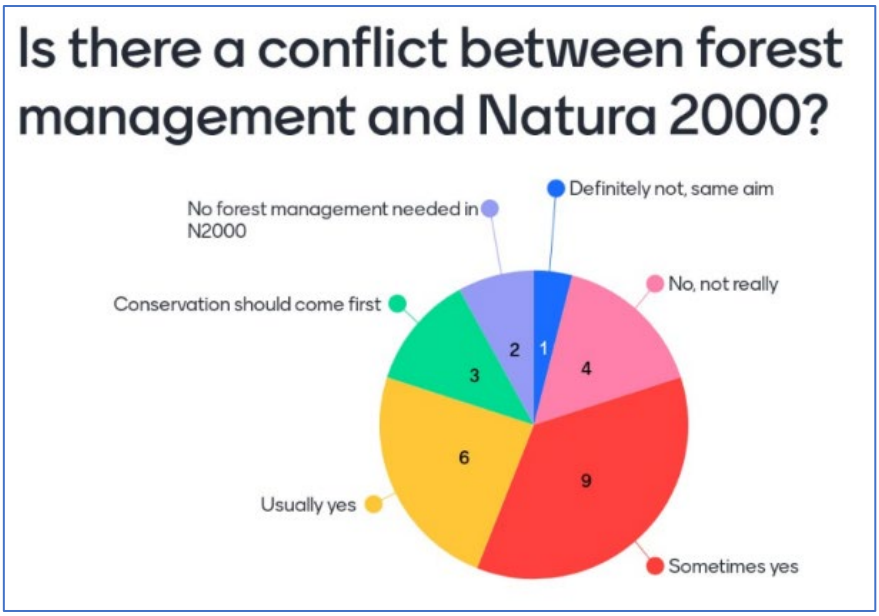
The discussion on the conference topics brought to a wide range of comments and recommendations. The following points emerged across all groups and are relevant for multiple goals:

- For forest monitoring, apart from lack of financial resources, there is also a lack of relevant expertise. In this regard, linking university courses on ecology and conservation to the institutions in charge of forest monitoring could represent a crucial step forward. Teaching programmes could embed in monitoring activities , and then represent one of the first steps in students' careers.
- Since forest monitoring disposes of limited resources, it needs toto build on existing data and networks, and to use standardized European methods which can be adapted to different forest types locally but still be suitable for harmonization and comparison.
- It is crucial to involve relevant stakeholders, which are, besides universities, protected area manager NGOs, forest owners.
- Monitoring should be legally regulated but also covered by incentives.
- Stakeholders should share data, stressing the relevance of monitoring for both biodiversity and forest functioning.
- Pathways to resilience should incorporate heterogeneity at different scales and across different ecosystem components. Promoting heterogeneity from landscape to genomes would allow for a "don't put all eggs in one basket" approach. Mixed landscapes, where open areas co-occur with mixed and un-even aged forests with high structural heterogeneity would boost the resistance and resilience of European forests to environmental changes.



Mentimeter result obtained during the conference. Diversity is the key to resilience.

Within this range of different environmental conditions, undisturbed, old-growth forests, large enough to host natural disturbance regimes and as connected as possible play a key role for biodiversity conservation.



Unmanaged forests guarantee the occurrence of species and ecological processes that lack in managed forests.

Summary report, break-out group discussions

Day 1

Question (s) discussed throughout groups 1-6:

- H**ow can we come to forest indicators with more relevance for biodiversity?**
- **How can we ensure that multi-taxa field data collection becomes a pillar stone of forest monitoring?**
- **What is the best way to increase resilience of forests to climate change?**
- **How should we assess the sustainability of forest management for biodiversity impacts?**

Group 1 (Carlos Sunyer)

H**ow can we come to forest indicators with more relevance for biodiversity?**

Indicators

- Simplification: indicators should be easy to calculate and use
- Standardization at EU level: of criteria and procedures

Stakeholders

- Citizen science: can play an important role in delivering basic data for indicators
- The scientific community should be involved in monitoring
- Monitoring should be linked to research activities.

Legislation: Create a legal framework.

Sensibilization

- Communication should be improved, and for effective communication a special effort should be made to translation.
- Young students in forest management & research, should be qualified for forest monitoring and the use of indicators.

Incentives: Tax reduction for landowners participating in monitoring

Other policies: Integration of already existing monitoring tools (Natura 2000, forest inventories, etc)

- For forest certification we need to improve qualification and standardization of criteria and procedures
- Focus on organisms directly linked to forest management.
- Focus on grouping species into habitat functions.
- Use artificial intelligence for remote sensing.
- Develop the indicators according to forest type.
- Who should be responsible for assessing relevance?

Group 2 (Ewa Hermanowicz)

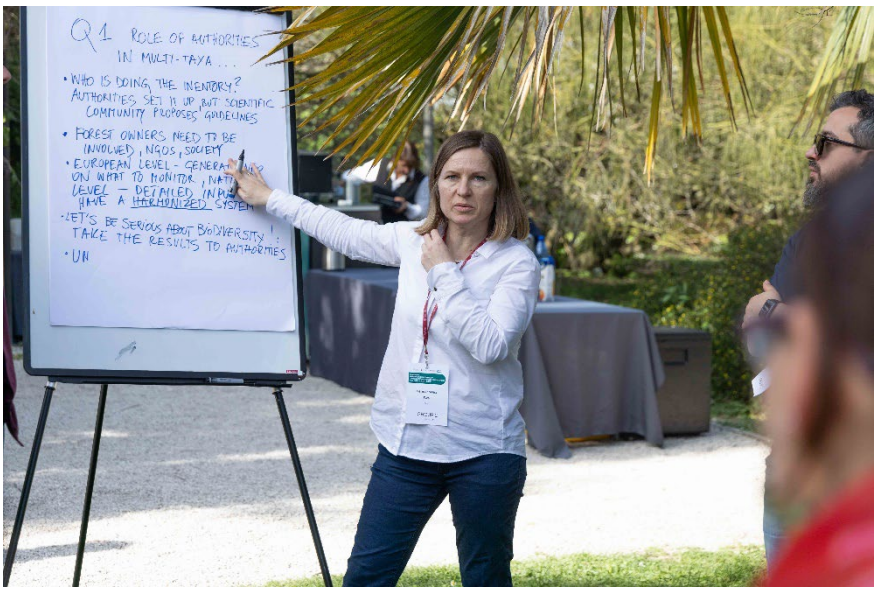
How can we ensure that multi-taxa field data collection becomes a pillar stone of forest monitoring?

For the multi-taxa sampling to be effective, key stakeholders need to be involved. These should include authorities, forest owners, NGOs. New technologies can help, but they cannot go without the traditional in situ sampling approaches.

There is a dire lack of experts to carry out sampling, so the educational systems need to be rethought to build capacity of the new generation of experts along with motivation for this job. Sampling teams should be multidisciplinary and include historical and cultural experts.

Once completed, sampling data should be made open-access with exception of geolocation that might be misused, for example, for manipulating forest management and retaining trees in location marked for next check of protection measures.

SFM assessments for biodiversity impact need to be policy-resilient to promote continuous cover forestry. Every country is different but we cannot leave every decision to member states. There needs to be a balance between criteria imposed at European level and the reflection of national specificities in the rules. The regulation should leverage positive actions rather than focus on punishing the wrongdoings.



Group 3 (Silvana Munzi)

How can we ensure that multi-taxa field data collection becomes a pillar stone of forest monitoring?

We must address a multitude of factors. Sometimes it is lack of financial resources and expertise, in others the available funding is used improperly. Standardization and simplification of protocols are essential, as is ensuring that they are accessible and feasible for a wide range of participants. Legislative measures could further support these actions, potentially making forest monitoring mandatory by law, building upon existing directives like the Natura 2000 directive.

Local action is crucial, requiring collaboration between scientists, authorities, and forest owners. This collaboration should promote a perspective aligned with the interests of forest owners and encourage their active involvement in monitoring efforts. Additionally, we must prioritize data integration and accessibility through the development of common inventories and databases. Modern technologies,

such as environmental DNA and LiDAR, can greatly enhance the efficiency and effectiveness of data collection processes.

We must tackle the perception among stakeholders that monitoring initiatives may impose restrictions on resource use, emphasizing the benefits of sustainable forest management. Clear communication with stakeholders is essential, tailoring messages to resonate with their interests and fostering a culture of collaboration and data sharing. Interdisciplinary collaboration with sociologists and psychologists can provide valuable insights into stakeholder attitudes and behaviors.

Lastly, engagement with the private sector, particularly through conservation projects, can make available additional resources and expertise to support multi-taxa field data collection initiatives.

H**ow can we come to forest indicators with more relevance for biodiversity?**

First, it's crucial to establish a clear definition of biodiversity, encompassing various dimensions such as species richness, genetic diversity, and ecosystem functionality. A scientific approach is essential for identifying indicators that align with our conservation objectives. Universal indicators may not be applicable across all forest ecosystems. Instead, we should consider utilizing a suite of indicators tailored to specific landscapes and ecological contexts. A good example is the Restoration Law: without proper monitoring we don't even know what we are going to restore.

It is time to move away from the notion of maximizing biodiversity and focus on what is feasible. More initiatives like BOTTOMS-UP are needed and an effort must be made to standardize/harmonize protocols and agree on definitions. Stakeholder engagement is crucial in the process of selecting relevant forest indicators and improving inventories. Involving scientists, policymakers, and local communities ensures that indicators are practical, applicable, and relevant for biodiversity conservation efforts.

What is the best way to increase resilience of forests to climate change?

The first group of actions should be implemented in the field. Protection of old-growth forests and increasing the proportion of unmanaged forests are recognized as crucial, as well as safeguarding plant species that are best adapted to environmental conditions. Conversely, increasing tree species diversity, including functional diversity (redundancy in traits), and favoring uneven-aged forests can enhance tolerance to abiotic stress and enable genetic adaptation. Management of invasive alien species is also deemed necessary.

Management practices must be diversified, for example favoring a combination of forest trees and grassland/pasture management. Microclimate stabilization could be achieved by increasing soil water retention capacity through the promotion of humus formation or a higher number of pools. When available, the utilization of historical data to produce more accurate models is recommended.

The other group of actions emphasizes the pivotal role of stakeholders in addressing climate change. There is a call for increased investment in research to generate evidence-based solutions. Better communication with stakeholders is essential to foster changes in the attitudes of forest owners and policymakers. The utilization of simple models depicting future scenarios, such as the "no forest at all" scenario, alongside tangible examples, could facilitate changes in the mindset of forest managers, prompting them to prioritize survival over production and mitigate deforestation rates.

Furthermore, the diversification of income sources in forestry, beyond solely relying on timber production, is advocated to promote more sustainable management practices. Implementing a low-

cost-low-income profit model would ensure long-term sustainability and foster a more resilient forestry sector.

Important: While many actions can be taken to enhance the resilience of forests to climate change, it is crucial to acknowledge that certain changes are inevitable. Assisted migration and range expansion may offer viable solutions to maintain forests adapted to new environmental conditions. It is imperative to prioritize feasible measures, such as promoting the growth of potential natural vegetation types, and be prepared to make sacrifices by prioritizing forest types that are unsustainable in the long term.

Group 4 (Neil McIntosh)

How can we ensure that multi-taxa field data collection becomes a pillar stone of forest monitoring?

To make data collection central to forest monitoring, the strong view of the group was that it is necessary to use what data already exists. This could be achieved by several practical steps, such as incorporating biodiversity monitoring into forest monitoring protocols, scaling-up sharing of countries' ICP forest monitoring sites and by identifying and making links to existing databases to see what is already available and identify gaps.

In terms of data use, it is essential to clarify who the audiences – policy-makers, practitioners, research institutions, other experts and the public can and will need to be mobilized in order to make the case for data collection a core component of forest monitoring.

It is foreseen that there would be value in making available data easy to use by non-experts, but that this should be subject to standardized guidelines, including protocols and indicators, which are made available for flexible use according to different needs, circumstances and purposes. Although consistency of interpretation could be a problem, it was felt that good design of the guidelines, specifying what data needs to be gathered and where to gather it from and how it should be monitored, would address this problem. Furthermore, providing a comprehensive model sampling scheme would help significantly.

In relation to data gathering, use of non-experts would depend on different taxonomic groups given that data gathering is more difficult for some taxa compared to others. However, there was a strong agreement that citizen scientists could be mobilized as part of public outreach and commitment to collect data as a core feature of forest biodiversity monitoring.

How should we assess the sustainability of forest management for biodiversity impacts?

The group agreed that it is necessary to assess the attributes present as part of defining any measures of sustainability. This means, for example, identifying key structural indicators (while noting that these differ per country) – for example, deadwood and set-aside etc. These should be incorporated for use directly into adaptive management plans. Also, structural indicator levels should be used to set threshold levels, which are then monitored. In addition, the relationship between sustainable forest management and biodiversity needs to be refined, for example, by improving multi-taxon experimental studies, as well as more clearly defined monitoring ranges.

Echoing the answers to Q1, the group felt that good data and models are essential to assess the sustainability of forest management for biodiversity impacts, but they should be made easy to use. This can be achieved by, for example, working together with practitioners to incorporate models in management plans; also, by developing guidelines and investing in capacity building training to reach 'people in the field'. Croatia has run practical capacity building workshops.

This also reflects the fact that sustainability of forest management needs to take into account a spectrum of issues. This includes that, whilst accepting some non-management is good for biodiversity, for managed forest areas, biodiversity sustainability targets are essential. It was noted that the new Nature Restoration Law could likely increase the percentage of non-managed forest areas, which could be positive for biodiversity.

Group 6 (Theo van der Sluis)

How can we ensure that multi-taxa field data collection becomes a pillar stone of forest monitoring?

It will be difficult to do multi-taxa monitoring in most countries: there is a lack of data (at least for some taxa), lack of species experts, expert knowledge. Moreover, the aims for forest management are often not clear, then also the purpose of monitoring is not clear.

The monitoring should be kept simple, (multi) taxa should only be included if they have an added value, if the information is not derived from e.g. structural indicators. The authorities should provide funds and guidance for monitoring. The owners should contribute financially, in return they have valuable input for their management planning. Science can provide the expertise for smart indicator species.

The indicator species are (bio-geographical) region specific and even period specific. Indicators should be chosen with relevance for society and economy: for people, culturally significant. They should be understandable for the general public or politicians.

Particular recommendations:

- For Habitats Directive monitoring data is collected but not in a way that it is suitable for forest monitoring; this could be improved.
- Multi-taxa assessments can still be used for validation of conservation status of habitats
- Use rather 'resilience' than biodiversity, better to understand for layman or policy makers
- Outcome of the Action could be taken up through Sapienza and ISPRA, both partners in the ETC-BE and therefore having access to EEA, and EIONET networks, FISE etc.: European policy

Day 2

Question (s) discussed throughout groups 1-6:

What is the best way to increase resilience of forests to climate change?

How can we identify key-areas for strict forest protection?

How can we apply science-based forest planning at the landscape scale?

Group 1 (Ewa Hermanowicz)

How can we increase resilience of forests in the view of climate change?

The best way to **increase resilience in forests to climate change** is by taking care of the heterogeneity at different levels: functional, genetic, landscape, age, structural. We need to increase knowledge on species and genetic diversity and IAS through additional studies.

Other important factors include reduction of intensity of forest use and establishment of an early warning system with possibility to take immediate action based on the warnings. Forests need more soil and water retention.

To **identify areas for strict protection**, we should use a system that is already in place and add another layer to it (N2000 or national protected areas). In addition, forest owners can be encouraged through regulations and subsidies for certification or set-aside areas.

To identify areas for strict protection, the following criteria should be considered: Remote forest stands (low-hanging fruit); Degraded areas; High conservation values; forests representative of all habitat types; use past land use maps; ecological connectivity; assess value of Ecosystem Services.

Group 2 (Carlos Sunyer)

What is the best way to increase resilience of forests to climate change?

Take time, let forests grow and they will adapt. Favor mixed forests with native species, as "insurance concept". Favor species with different life cycles (longevity). Aim for continuous cover forestry, with continuous regeneration. Allow for more flexible forestry regulations (allow for southern provenances). Position unmanaged forests in a network of nature reserves.

How can we identify key-areas for strict forest protection?

Make forest areas/sites large and heterogeneous enough for long-term preservation. The location of the site is important. For mountain areas: flood protection, water catchment, erosion prevention, protect against landslides and avalanches. For river basins: flood protection, erosion prevention. Aim for the highest representation at biogeographical level, to ensure the conservation of the associated genetic pool.

Group 3 (Neil McIntosh)

What is the best way to increase resilience of forest to climate change?

In short: don't put all your eggs in one basket! Go for a mix of tree species and aim for genetic diversity. In addition, mitigation and adaptation measures are necessary, which include introduction of non-native species to increase resilience, whilst being aware and working to manage risks. Another example includes us of hunting as a practical means to manage deer where that is necessary to maintain desired species.

Resilience also includes monitoring and managing natural processes, such as temperature and moisture levels. Some members of the group felt that leaving nature to its own devices would be the best way to increase resilience of forests to climate change. In either case, there is a need for hard data and solid science-based evidence in order to determine ways to increase resilience.

That said though, there are deeper, arguably psychological, aspects to this question: as well as ecological, there are human, social, economic and (geo-) political dimensions which may need to be

considered. In addition, values of resilience are relative: for example, for forest managers, it may be best to maintain productivity; for forest visitors, the values they have may relate to access for leisure and hiking for example. In all cases, there is unlikely to be 'one' best way.

How can we identify key areas for strict forest protection?

Group participants agreed that it would be necessary to work through the established network of Natura 2000 sites to identify strict protection areas. This could involve establishing 'core zones' for strict protection, surrounded by buffer-zones along with ecological corridors to boost biodiversity. In some countries, there is a need for more mapping of forest in order to identify where the opportunities to create strict protected areas would lie. However, in order to reach 10%, it will be essential to consider low quality forest areas and consider their scope to become ecologically connected and more biodiversity-rich over time. This includes (and specifically deliberately does not therefore exclude) working to include intensely managed productive forests for strict protection.

Group 4 (Silvana Munzi)

How can we identify key-areas for strict forest protection?

A multifaceted approach must be employed that integrates species indicators and cutting-edge technologies to discern ecological patterns and prioritize conservation efforts. By combining various parameters, such as designating N2000 habitats with forests exceeding 120 years of age, we can pinpoint areas of exceptional ecological significance. Furthermore, low productivity forests should be protected, recognizing their importance in supporting unique biodiversity and ecological functions. We should also reinforce existing conditions, particularly inaccessible sites, to minimize human disturbances and preserve pristine ecosystems.

In decision-making process, biodiversity conservation, connectivity enhancement, and productivity goals should be prioritized while ensuring the feasibility of conservation actions. A key aspect is protecting essential ecological processes critical for maintaining ecosystem health and resilience. This includes maintaining intact habitats, preserving natural disturbance regimes, and safeguarding key ecosystem functions. Moreover, our approach should encompass a comprehensive coverage of environmental gradients, targeting well-dispersed areas across diverse environmental conditions. This enhances the adaptive capacity of ecosystems and ensures resilience to future environmental changes.

Small and large forest patches must be protected since they offer different advantages. Feasibility considerations can result in a flexible approach tailored to the specific context and constraints of each situation.

How can we apply science-based forest planning at the landscape scale?

An assessment of the distribution and extent of intensive and extensive management zones is necessary to determine where conservation efforts should be concentrated. The main challenge lies in persuading foresters to adopt science-based management plans. The incorporation of structurally-based measures that balance production goals while maximizing biodiversity is recommended. By monitoring and selecting structures that enhance productivity and biodiversity, timber production can be optimized by focusing on higher-value species and utilizing them more efficiently.

When owners of small properties cannot afford sustainable practices, harmonizing management plans for private owners to encourage collective management approaches could be a solution. The approach

should involve using models that consider climate projections to anticipate future forest conditions and ensure resilience to environmental changes.

Finally, translating scientific findings into actionable advice that can be easily applied by foresters and incorporated into management strategies can bridge the gap between science and practice.

Group 5 (Theo van der Sluis)

How can we increase resilience of forests in the view of climate change?

It was agreed that the measures or options differ over (biogeographical) regions, therefore we identified elements which are important to consider for each region:

Starting point is: what do you aim for: natural ecosystems, or production forest? For both totally different outcome is likely. So resilience for wood production or Ecosystem Services?

- Promote mixed forests (patch-wise)
- Intra-specific genetic management
- Enrichment forestry; possibilities for rewilding?
- Fires are part of natural systems; Regeneration of some species and some biodiversity is depending on fires
- Fires pose a risk for some ecosystems and forests. Solutions are region specific and should incorporate measures for fire management
- Connectivity is important; in some cases 'assisted migration', helping species to expand their range in view of climate change, through corridors, or transplanting seeds.
- Manage the forest microclimate to reduce effect of droughts and heatwaves
- Disturbance processes are important, but what is natural disturbance? Sometimes replanting might be necessary.

Some general notes: the soils are important too for resilience, and should adapt. Land abandonment results in a lot of Quercus ilex forests, this may require management to make it more resilient. In general, land use change is the biggest threat of forests, and should be controlled. In particular in view of the energy transition.

How can we identify key areas for strict protection?

First of all, define strict protection! Some participants interpret it as absolute non-intervention in the view of old-growth forest. However, a wider definition is used in the biodiversity strategy 2030:

Strict protection does not necessarily mean the area is not accessible to humans, but leaves natural processes essentially undisturbed to respect the areas' ecological requirements. The Biodiversity Strategy calls for including all remaining old-growth forests in strictly protected areas, as well as some carbon rich ecosystems.

To identify suitable areas, make primarily a selection from:

- State owned land (e.g. army);
- in some countries also private land?
- National reserves
- National parks (in Italy core areas, Zone A)
- Natura 2000 sites

Identify within these areas biodiversity hotspots, and ensure a relevant sample of all different forest types. Allow for sufficient dynamics of the forests, base it also on the forest structure, its complexity and processes.

Finally, herbivory may require management, e.g. hunting or grazing. Connectivity is needed, this requires also forested private land connecting the strictly protected areas.

Group 6 (Inken Doerfler)

How can we increase resilience of forests in the view of climate change?

The best way to increase resilience of forests to climate change will not have one uniform solution, especially since the future climate is unclear. Therefore, all action must be in the context of ecosystems and landscapes. However, mixed stands with tree species adapted to a wide climatic gradient, as well as a high structural heterogeneity and a good connectivity for forest habitats, can lessen the impact of climate change.

The identification of key areas for strict forest protection will depend on the condition within the respective countries. In general, a selection of areas with existing protection, such as Natura 2000 could decrease the opposition against strict protection. These should be combined with large enough buffer to allow for forest dynamics and stepping stones to allow for colonization. The main focus should thus be on forests with the best preconditions for protection, e.g. old growth forests (> 60 years) and unmanaged forests. The representativeness of forests should be an additional target.

Science-based forest planning at the landscape level needs decisions supported by data. Generally, these are forest inventories or remote sensing data. However, also biotic data are needed and inventories should be enhanced by high quality data collected by forest departments for management planning.

Conclusions

These discussions carried out during the final conference on forest biodiversity concluded the Bottoms-up project aiming at facilitating the networking and cooperation on this topic within Europe and beyond.

The discussion involved more than 100 researchers from more than 30 countries both involved in this project or only joining the final conference.

As such the discussion started from a sound basis of two draft policy briefs addressing respectively forest monitoring and forest management in regards of forest multi-taxon biodiversity.

The main point of the discussion will be embedded in the policy brief after being linked with specific scientific evidence.

Key literature

Burrascano, S., Chianucci, F., Trentanovi, G., Kepfer-Rojas, S., Sitzia, T., Tinya, F., Doerfler, I., Paillet, Y., Nagel, T. A., Mitic, B., Morillas, L., Munzi, S., Van der Sluis, T., Alterio, E., Balducci, L., de Andrade, R. B., Bouget, C., Giordani, P., Lachat, T., … Ódor, P. (2023). Where are we now with European forest multi-taxon biodiversity and where can we head to? *Biological Conservation*, *284*, 110176. https://doi.org/10.1016/j.biocon.2023.110176

Burrascano, S., Trentanovi, G., Paillet, Y., Heilmann-Clausen, J., Giordani, P., Bagella, S., Bravo-Oviedo, A., Campagnaro, T., Campanaro, A., Chianucci, F., De Smedt, P., García-Mijangos, I., Matošević, D., Sitzia, T., Aszalós, R., Brazaitis, G., Cutini, A., D'Andrea, E., Doerfler, I., … Ódor, P. (2021). Handbook of field sampling for multi-taxon biodiversity studies in European forests. *Ecological Indicators*, *132*, 108266. https://doi.org/10.1016/j.ecolind.2021.108266

Burrascano, S., Chojnacki, L., Balducci, L., Boch, S., Chianucci, F., Haeler, E., … Odor, P., Under Review. Basic and Applied Ecology.

Chianucci, F., Napoleone , F., Ricotta, C., Ferrara, C., Fusaro, L., Balducci, L., Trentanovi, G., … , Burrascano, S., Under Review. Journal of Applied Ecology.

Paillet, Y., Zapponi, L., & Schall, P. (Under review). One to rule them all? Assessing the performance of Forest Europe's biodiversity indicators against multi-taxonomic data. *Conservation Biology*. https://www.biorxiv.org/content/10.1101/2024.02.12.579875v1

Tinya, F., Doerfler, I., de Groot, M., Heilman-Clausen, J., Kovács, B., Mårell, A., Nordén, B., Aszalós, R., Bässler, C., Brazaitis, G., Burrascano, S., Camprodon, J., Chudomelová, M., Čížek, L., D'Andrea, E., Gossner, M., Halme, P., Hédl, R., Korboulewsky, N., … Ódor, P. (2023). A synthesis of multi-taxa management experiments to guide forest biodiversity conservation in Europe. *Global Ecology and Conservation*, *46*, e02553. https://doi.org/10.1016/j.gecco.2023.e02553

Trentanovi, G., Campagnaro, T., Sitzia, T., Chianucci, F., Vacchiano, G., Ammer, C., Ciach, M., Nagel, T. A., del Río, M., Paillet, Y., Munzi, S., Vandekerkhove, K., Bravo-Oviedo, A., Cutini, A., D'Andrea, E., De Smedt, P., Doerfler, I., Fotakis, D., Heilmann-Clausen, J., … Burrascano, S. (2023). Words apart: Standardizing forestry terms and definitions across European biodiversity studies. *Forest Ecosystems*, *10*, 100128. https://doi.org/10.1016/j.fecs.2023.100128