

# **Advanced Ecological Management Approaches for Environmental Protection**

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## **Abstract**

Environmental degradation, biodiversity loss, habitat fragmentation, climate change, pollution, and unsustainable resource utilization have increased the need for advanced ecological management approaches. Conventional environmental protection practices are increasingly being complemented by data-driven monitoring, ecosystem modeling, remote sensing, geographic information systems, artificial intelligence, nature-based solutions, and adaptive management frameworks. This study examines advanced ecological management approaches for environmental protection, focusing on biodiversity conservation, ecosystem monitoring, habitat restoration, sustainable resource management, ecological risk assessment, climate adaptation, and technology-enabled environmental decision-making.

A qualitative descriptive and conceptual research design was adopted using secondary academic literature. The study explores how advanced technologies and integrated ecological strategies can support continuous ecosystem assessment, identification of environmental threats, restoration planning, and sustainable management of natural resources. Remote sensing and GIS can improve spatial monitoring, while artificial intelligence and ecological modeling can support prediction of environmental changes and biodiversity patterns. Nature-based solutions and ecosystem-based management can further strengthen ecological resilience by integrating environmental protection with sustainable resource utilization.

However, implementation challenges include limited ecological datasets, uncertainty in ecosystem behavior, financial constraints, fragmented institutional responsibilities, technological complexity, and shortages of interdisciplinary expertise. The study emphasizes adaptive ecological management frameworks that combine scientific knowledge, digital technologies, ecosystem restoration, biodiversity conservation, and stakeholder participation. Future research should investigate AI-enabled biodiversity monitoring, ecological digital twins, predictive ecosystem models, automated habitat assessment, climate-resilient restoration, and integrated ecosystem-management platforms. Advanced ecological management can contribute to evidence-based environmental protection by improving ecosystem monitoring, strengthening conservation planning, and supporting long-term ecological resilience.

**Keywords:** Ecological Management, Environmental Protection, Biodiversity Conservation, Ecosystem Restoration, Environmental Monitoring, Artificial Intelligence, Remote Sensing, GIS, Nature-Based Solutions, Ecological Resilience.

## 1. Introduction

Environmental ecosystems provide essential services that support human societies, biodiversity, climate regulation, food production, water availability, and natural-resource cycles. However, rapid urbanization, industrial development, habitat destruction, pollution, climate change, and unsustainable resource exploitation have increased pressure on ecological systems. Environmental protection therefore requires management approaches capable of understanding complex interactions between ecological processes, human activities, and environmental changes. Advanced ecological management provides opportunities to strengthen traditional conservation practices through scientific, technological, and data-driven approaches.

The development of remote sensing, geographic information systems, Internet of Things sensors, artificial intelligence, and ecological modeling has expanded the ability to monitor ecosystems. Satellite imagery can provide information about vegetation, land-cover changes, habitat fragmentation, and ecosystem disturbance. GIS can integrate multiple spatial datasets to identify conservation priorities. Advanced analytical models can process environmental information and support predictions concerning biodiversity changes, habitat degradation, and ecological risks.

Biodiversity conservation represents a central component of ecological management. Species populations and habitats are influenced by land-use change, climate variability, invasive species, pollution, and resource exploitation. Advanced monitoring technologies can support species identification, habitat assessment, and population analysis. Automated image recognition and acoustic monitoring can also improve the detection of species and ecological changes over large geographic areas.

Ecosystem restoration is another important component of environmental protection. Restoration strategies seek to recover ecological functions in degraded forests, wetlands, grasslands, rivers, coastal ecosystems, and other habitats. Advanced ecological models can assist restoration planning by identifying environmental conditions, selecting intervention priorities, and evaluating restoration outcomes. Nature-based solutions can further combine ecosystem restoration with climate adaptation, water management, and biodiversity objectives.

Despite these opportunities, advanced ecological management faces challenges involving data availability, scientific uncertainty, institutional coordination, financial resources, technological infrastructure, and specialized skills. Ecosystems are dynamic and complex, making environmental predictions inherently uncertain. This study therefore examines advanced ecological management approaches for environmental protection, focusing on biodiversity conservation, ecosystem monitoring, habitat restoration, ecological modeling, nature-based solutions, implementation challenges, and future research opportunities.

## 2. Objectives of the Study

### 2.1 Examination of Advanced Ecological Management Technologies

The first objective is to examine advanced technologies supporting ecological management, including remote sensing, GIS, artificial intelligence, machine learning, environmental sensors, ecological modeling, and digital monitoring platforms. The study investigates how these technologies can support biodiversity assessment, habitat monitoring, ecosystem evaluation, and environmental risk identification.

Particular attention is given to technologies capable of providing continuous, spatially extensive, and data-driven information for environmental protection and conservation planning.

The study also examines how advanced analytical systems can support ecological decision-making. Machine-learning techniques can process large environmental datasets to identify patterns in species distribution, vegetation change, habitat degradation, and ecological disturbances. Remote sensing can monitor changes over large geographic areas, while GIS can integrate ecological and geographic information. Combining these capabilities can provide environmental managers with more comprehensive evidence for planning conservation and restoration interventions.

## 2.2 Assessment of Biodiversity Conservation and Ecosystem Restoration

The second objective is to assess advanced approaches for protecting biodiversity and restoring degraded ecosystems. The study examines habitat conservation, species monitoring, ecological restoration, protected-area management, invasive-species monitoring, and nature-based solutions. Advanced ecological management can support identification of vulnerable habitats and prioritize restoration activities according to ecological conditions, biodiversity values, and environmental risks.

The study further examines the role of technology in evaluating restoration outcomes. Remote sensing can track vegetation recovery, while ecological models can assess changes in habitat quality and ecosystem functions. AI-supported monitoring can assist species identification and ecological assessment. Integrating technological monitoring with field-based ecological knowledge can provide more comprehensive evaluations of restoration progress and support adaptive management when environmental conditions change.

## 2.3 Identification of Ecological Management Challenges

The third objective is to identify major challenges affecting advanced ecological management. The study examines data limitations, ecosystem uncertainty, financial constraints, technological requirements, fragmented institutional responsibilities, stakeholder coordination, and shortages of interdisciplinary expertise. These challenges can influence the effectiveness of environmental protection programs and the ability of organizations to adopt advanced ecological management technologies.

The study also aims to identify strategies for strengthening ecological management implementation. Particular attention is given to integrated monitoring, standardized environmental datasets, adaptive management, interdisciplinary collaboration, ecosystem modeling, stakeholder participation, and professional training. These strategies can improve the integration of scientific knowledge and technological capabilities. The objective emphasizes practical approaches for developing ecological management systems that support long-term environmental protection and ecosystem resilience.

## 3. Review of Literature

### 3.1 Biodiversity Conservation and Ecosystem Management

Millennium Ecosystem Assessment (2005) established the importance of ecosystem services for human well-being and demonstrated the consequences of ecosystem degradation. Ecosystem management requires consideration of ecological processes alongside human activities and resource demands. The

literature emphasizes integrated approaches that recognize interactions between biodiversity, ecosystem functions, and socioeconomic systems. These principles provide an important foundation for advanced ecological management and environmental protection.

Groom, Meffe, and Carroll (2006) examined principles of conservation biology and emphasized systematic approaches to biodiversity protection. Conservation planning requires information about species, habitats, ecological processes, threats, and environmental change. The literature supports combining scientific monitoring with conservation planning to protect vulnerable ecosystems. Advanced technologies can complement these approaches by providing additional information about habitat conditions, species distribution, and ecological changes.

### 3.2 Remote Sensing and Ecological Monitoring

Pettorelli et al. (2014) examined the use of satellite remote sensing for biodiversity monitoring and highlighted its potential for assessing ecological conditions across large spatial areas. Satellite observations can provide information about vegetation dynamics, habitat characteristics, and landscape changes. The literature indicates that remote sensing can complement field observations by providing repeated and geographically extensive environmental information for ecological monitoring and conservation planning.

Turner et al. (2003) discussed the importance of landscape-scale approaches for biodiversity research and management. Landscape patterns influence ecological processes, species movement, habitat connectivity, and ecosystem functions. GIS and remote sensing can support landscape analysis by integrating spatial information about land cover and habitat configuration. Such technologies can therefore strengthen ecological management by improving understanding of spatial relationships and environmental changes.

### 3.3 Ecosystem Restoration and Nature-Based Management

Suding (2011) examined ecological restoration and highlighted the importance of understanding ecosystem processes when designing restoration interventions. Restoration outcomes depend on environmental conditions, disturbance history, species interactions, and ecological constraints. The literature emphasizes adaptive approaches that allow restoration strategies to respond to changing conditions. Advanced monitoring and modeling can strengthen such approaches by providing evidence about restoration progress.

Nature-based approaches can contribute to biodiversity conservation, climate adaptation, water management, and ecosystem restoration. The literature indicates that ecosystem-based strategies can provide multiple environmental and societal benefits. Integrating nature-based solutions with advanced ecological monitoring can support more comprehensive environmental protection frameworks.

## 4. Research Methodology

### 4.1 Research Design

This study adopted a qualitative descriptive and conceptual research design to examine advanced ecological management approaches for environmental protection. The study focused on biodiversity conservation, ecosystem monitoring, ecological restoration, remote sensing, GIS, artificial intelligence,

nature-based solutions, and ecological modeling. The conceptual analysis examined relationships between technological innovation, ecosystem monitoring, biodiversity conservation, restoration, ecological resilience, and environmental protection.

## 4.2 Data Collection

Secondary information was collected from peer-reviewed academic journals, scholarly books, research publications, and established environmental literature.

### The literature focused on:

- Biodiversity conservation.
- Ecosystem management.
- Ecological restoration.
- Remote sensing.
- Geographic information systems.
- Artificial intelligence.
- Machine learning.
- Habitat monitoring.
- Species monitoring.
- Nature-based solutions.
- Ecological modeling.
- Environmental risk assessment.
- Climate adaptation.
- Ecosystem resilience.
- Sustainable resource management.

## 4.3 Data Analysis

The collected literature was analyzed using thematic analysis. Major themes included biodiversity conservation, ecosystem monitoring, ecological restoration, spatial analysis, nature-based management, predictive ecological modeling, and environmental resilience. The analysis also considered challenges involving ecological data quality, uncertainty, technological complexity, financial resources, institutional coordination, and interdisciplinary expertise.

## 5. Analysis

### 5.1 Technology-Enabled Ecosystem Monitoring

Advanced ecological management increasingly relies on digital technologies for monitoring ecosystem conditions. Remote sensing can provide repeated observations of vegetation, land cover, habitat fragmentation, and environmental disturbance. IoT sensors can collect localized information about temperature, soil moisture, water quality, and other ecological indicators. AI-based analytics can process these datasets to identify changes and potential ecological threats.

**Table 1: Advanced Technologies for Ecological Management**

| Technology              | Ecological Application   | Environmental Contribution |
|-------------------------|--------------------------|----------------------------|
| Remote Sensing          | Habitat monitoring       | Large-scale assessment     |
| GIS                     | Spatial analysis         | Conservation planning      |
| Artificial Intelligence | Pattern recognition      | Risk identification        |
| Machine Learning        | Species prediction       | Biodiversity assessment    |
| IoT Sensors             | Environmental monitoring | Real-time information      |
| Drones                  | Habitat observation      | Detailed assessment        |
| Acoustic Monitoring     | Species detection        | Biodiversity monitoring    |
| Computer Vision         | Species identification   | Automated assessment       |
| Ecological Modeling     | Ecosystem prediction     | Scenario analysis          |
| Digital Platforms       | Data integration         | Decision support           |

The integration of these technologies can strengthen environmental monitoring by providing information at multiple spatial and temporal scales. AI-based image analysis can assist identification of species and habitat characteristics, while spatial models can identify changes in ecosystem conditions. Combining automated technologies with field observations can provide more comprehensive ecological assessments.

## 5.2 Biodiversity Conservation and Habitat Protection

Biodiversity conservation requires identification of species, habitats, ecological corridors, and areas experiencing environmental pressure. Spatial analysis can support identification of important habitats and landscape connectivity. Remote sensing can detect land-cover changes, while machine-learning approaches can assist species-distribution modeling.

**Table 2: Ecological Management Applications**

| Ecological Area | Advanced Approach   | Protection Objective    |
|-----------------|---------------------|-------------------------|
| Biodiversity    | AI-based monitoring | Species protection      |
| Forests         | Remote sensing      | Deforestation detection |
| Wetlands        | GIS analysis        | Habitat conservation    |

| Ecological Area      | Advanced Approach    | Protection Objective    |
|----------------------|----------------------|-------------------------|
| Wildlife             | Camera analytics     | Species monitoring      |
| Rivers               | Sensor networks      | Water protection        |
| Grasslands           | Satellite monitoring | Habitat assessment      |
| Coastal Ecosystems   | Spatial modeling     | Ecosystem protection    |
| Protected Areas      | Digital monitoring   | Conservation management |
| Invasive Species     | Predictive modeling  | Threat identification   |
| Ecological Corridors | GIS planning         | Habitat connectivity    |

Advanced conservation systems can help environmental managers prioritize areas according to ecological significance and environmental threats. Spatial models can identify fragmented habitats, while predictive approaches can estimate potential changes in species distribution. These technologies can support more systematic conservation planning, although field validation remains important for confirming model-based assessments.

### 5.3 Ecological Restoration and Nature-Based Solutions

Ecological restoration seeks to recover ecosystem structure, functions, biodiversity, and ecological processes in degraded environments. Advanced monitoring can track vegetation recovery, habitat development, water conditions, and other restoration indicators. Remote sensing provides an efficient method for observing restoration changes over large areas.

Nature-based solutions can complement restoration by using ecosystem processes to address environmental challenges. Wetland restoration can contribute to water management and biodiversity protection, while forest and coastal ecosystem restoration can support climate adaptation and ecological resilience. Advanced ecological models can assist managers in evaluating different restoration scenarios and identifying strategies appropriate to local environmental conditions.

## 6. Discussion

### 6.1 Digital Transformation of Ecological Management

Advanced technologies are expanding the capacity of environmental organizations to monitor and manage ecosystems. Remote sensing, GIS, IoT sensors, artificial intelligence, and ecological modeling can generate and analyze information about environmental conditions. These technologies can provide more frequent observations than some traditional monitoring approaches and can support broader geographic coverage.

Digital ecological management is most effective when technological information is integrated with ecological expertise. Automated models can identify patterns and potential changes, but field-based ecological knowledge remains important for interpretation and validation. Combining digital monitoring

with scientific assessment can improve the reliability of conservation decisions and support adaptive environmental management.

## 6.2 Biodiversity Conservation and Habitat Resilience

Biodiversity protection requires understanding species, habitats, ecological relationships, and environmental pressures. Advanced monitoring technologies can support identification of habitat changes and species distributions. GIS can help evaluate landscape connectivity, while remote sensing can identify habitat fragmentation and vegetation changes. These capabilities can strengthen conservation planning.

Habitat resilience also depends on ecosystem connectivity and environmental quality. Conservation strategies can benefit from integrating spatial information with ecological models to identify areas requiring protection or restoration. However, biodiversity models may be affected by incomplete species observations and differences in monitoring intensity. Field surveys and long-term ecological observations remain important for validating analytical results.

## 6.3 Restoration, Nature-Based Solutions, and Adaptive Management

Ecological restoration requires continuous evaluation because ecosystem responses can vary according to environmental conditions. Advanced monitoring can provide information about vegetation recovery, species presence, habitat quality, and ecosystem functions. These observations can help managers evaluate whether restoration activities are producing expected outcomes.

Nature-based solutions can integrate restoration with broader environmental objectives such as climate adaptation, water regulation, biodiversity conservation, and erosion control. Adaptive management allows interventions to be modified according to monitoring results. Advanced analytics can support this process by identifying changes and evaluating alternative scenarios. Successful implementation nevertheless requires long-term planning, local ecological knowledge, stakeholder participation, and appropriate institutional support.

## 7. Challenges

### 7.1 Ecological Data Limitations and Uncertainty

Ecological management depends on reliable information about species, habitats, environmental conditions, and ecosystem processes. However, ecological datasets may be incomplete, geographically uneven, or collected using different methods. Some species and ecosystems are difficult to monitor continuously, resulting in information gaps that can influence analytical models.

Environmental systems also contain considerable uncertainty because ecological processes interact in complex ways. Species populations can respond differently to climate, habitat changes, competition, and human disturbances.

### 7.2 Technological and Financial Constraints

Advanced ecological management can require sensors, satellite data, computing infrastructure, GIS platforms, analytical software, and specialized personnel. Developing and maintaining these systems

may require significant financial investment. Organizations with limited resources may face difficulties establishing advanced monitoring infrastructure or maintaining long-term data collection.

Technological complexity can also create implementation barriers. Environmental professionals may require knowledge of data science, remote sensing, GIS, artificial intelligence, and ecological modeling. Training and interdisciplinary collaboration can help address these limitations. Scalable technologies and shared environmental data platforms may also improve access to advanced analytical capabilities while reducing duplication of infrastructure.

### 7.3 Institutional Coordination and Stakeholder Participation

Ecological systems frequently extend across administrative boundaries and involve multiple institutions. Conservation agencies, local governments, research organizations, communities, landowners, and resource users may have different responsibilities and objectives. Fragmented institutional structures can complicate ecological management and limit effective data sharing.

Stakeholder participation can strengthen environmental protection by incorporating local knowledge and improving awareness of conservation objectives. However, participation requires appropriate communication, coordination, and long-term engagement. Integrated governance frameworks can facilitate collaboration among institutions and stakeholders. Combining scientific evidence, technological monitoring, and local ecological knowledge can support more comprehensive and context-sensitive environmental management.

## 8. Future Research

Future research should investigate artificial intelligence and automated systems for biodiversity monitoring. Researchers could develop computer-vision models capable of identifying species from camera-trap images, aerial photographs, and satellite observations. Acoustic monitoring could also be combined with machine learning to detect wildlife and ecosystem changes. Future studies should evaluate model accuracy across different species and ecosystems while addressing incomplete datasets, seasonal variation, ecological uncertainty, and the need for field-based validation.

Future research should explore ecological digital twins and predictive ecosystem models for conservation and restoration planning. Digital representations of forests, wetlands, rivers, coastal ecosystems, and protected areas could support simulation of alternative environmental-management scenarios. Researchers could examine how climate projections, land-use changes, biodiversity information, and ecosystem indicators can be integrated into these models. Particular attention should be given to model transparency, uncertainty quantification, data interoperability, and practical applications for adaptive management.

Further research should examine integrated nature-based solutions and climate-resilient ecological restoration. Studies could evaluate how forests, wetlands, grasslands, coastal ecosystems, and urban green infrastructure contribute to biodiversity conservation and environmental resilience. Advanced monitoring could be used to measure restoration outcomes over long periods. Research should also examine stakeholder participation, governance structures, economic feasibility, and local ecological knowledge to develop ecological management frameworks that are scientifically robust and practically applicable.

## 9. Conclusion

Advanced ecological management approaches provide important opportunities for strengthening environmental protection through the integration of scientific knowledge, digital technologies, biodiversity conservation, ecosystem restoration, and adaptive management. Remote sensing, GIS, IoT sensors, artificial intelligence, and ecological modeling can improve environmental monitoring and provide information about changing ecosystem conditions. These technologies can expand the geographic and temporal coverage of ecological assessments and support more evidence-based conservation planning.

Biodiversity conservation can benefit from advanced monitoring and spatial analysis. AI-supported species identification, remote sensing, habitat mapping, and ecological modeling can help identify environmental changes and conservation priorities. GIS can support assessment of habitat connectivity and landscape fragmentation. Nevertheless, technological approaches should complement rather than replace field-based ecological knowledge. Reliable conservation decisions require integration of analytical information with ecological expertise and appropriate validation.

Ecological restoration and nature-based solutions provide additional mechanisms for environmental protection. Restoration can recover degraded ecosystem functions and biodiversity, while nature-based approaches can address multiple environmental challenges simultaneously. Advanced monitoring can evaluate restoration outcomes and support adaptive management. However, restoration success depends on local environmental conditions, long-term management, stakeholder participation, and appropriate institutional arrangements.

Overall, effective ecological management requires an integrated framework combining advanced analytics, ecosystem science, conservation planning, restoration, and environmental governance. Future developments in AI-enabled biodiversity monitoring, ecological digital twins, predictive ecosystem modeling, and climate-resilient restoration can strengthen environmental decision-making. Continued interdisciplinary collaboration, reliable ecological datasets, technological capacity building, and stakeholder engagement will remain important for developing practical approaches that support long-term ecosystem health and environmental protection.

## References

1. Martin, D. M. (2017). Ecological restoration should be redefined for the twenty-first century. *Restoration Ecology*, 25(5), 668–673. <https://doi.org/10.1111/rec.12554>
2. Miller, B. P., Sinclair, E. A., Menz, M. H. M., Elliott, C. P., Bunn, E., Commander, L. E., Dalziell, E., David, E., Lewandrowski, W., May, J., McDonald, T., Meney, K., Menz, J., Morgan, J. W., Nevill, P., Piggott, M. P., & Traill, L. W. (2017). A framework for the practical science necessary to restore sustainable, resilient, and biodiverse ecosystems. *Restoration Ecology*, 25(4), 605–617. <https://doi.org/10.1111/rec.12475>
3. Díaz, S., Settele, J., Brondízio, E. S., Ngo, H. T., Agard, J., Arneth, A., Balvanera, P., Brauman, K. A., Butchart, S. H. M., Chan, K. M. A., Garibaldi, L. A., Ichii, K., Liu, J., Subramanian, S. M., Midgley, G. F., Miloslavich, P., Molnár, Z., Obura, D., Pfaff, A., ... Zayas, C. N. (2019). Pervasive human-driven decline of life on Earth points to the need for transformative change. *Science*, 366(6471), eaax3100. <https://doi.org/10.1126/science.aax3100>

4. Chazdon, R. L., & Brancalion, P. H. S. (2019). Restoring forests as a means to many ends. *Science*, 365(6448), 24–25. <https://doi.org/10.1126/science.aax9539>
5. Seddon, N., Chausson, A., Berry, P., Girardin, C. A. J., Smith, A., & Turner, B. (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 375(1794), 20190120. <https://doi.org/10.1098/rstb.2019.0120>
6. Chausson, A., Turner, B., Seddon, D., Chabaneix, N., Girardin, C. A. J., Key, I., Smith, A., Woroniecki, S., & Seddon, N. (2020). Mapping the effectiveness of nature-based solutions for climate change adaptation. *Global Change Biology*, 26(11), 6134–6155. <https://doi.org/10.1111/gcb.15310>
7. Seddon, N., Smith, A., Smith, P., Key, I., Chausson, A., Girardin, C., House, J., Srivastava, S., & Turner, B. (2021). Getting the message right on nature-based solutions to climate change. *Global Change Biology*, 27(8), 1518–1546. <https://doi.org/10.1111/gcb.15513>
8. Gann, G. D., McDonald, T., Walder, B., Aronson, J., Nelson, C. R., Jonson, J. L., Hallett, J. G., Eisenberg, C., Guariguata, M. R., Liu, J., Hua, F., Echeverría, C., Gonzales, E., Shaw, N., Decler, K., & Dixon, K. W. (2019). International principles and standards for the practice of ecological restoration. *Restoration Ecology*, 27(S1), S1–S46. <https://doi.org/10.1111/rec.13035>
9. Bullock, J. M., Fuentes-Montemayor, E., McCarthy, B., Park, K., Hails, R. S., Woodcock, B. A., Watts, K., Corstanje, R., & Harris, J. (2022). Future restoration should enhance ecological complexity and emergent properties at multiple scales. *Ecography*, 2022. <https://doi.org/10.1111/ecog.05780>
10. Atkinson, J., Brudvig, L. A., Mallen-Cooper, M., Nakagawa, S., Moles, A. T., & Bonser, S. P. (2022). Terrestrial ecosystem restoration increases biodiversity and reduces its variability, but not to reference levels: A global meta-analysis. *Ecology Letters*, 25(7), 1725–1737. <https://doi.org/10.1111/ele.14025>
11. Li, F., Cheng, C., & Yang, R. (2022). A review of ecosystem restoration: Progress and prospects of domestic and abroad. *Biodiversity Science*, 30(10), 22519. <https://doi.org/10.17520/biods.2022519>
12. Martin, J. L., Roy, D. B., & Plantegenest, M. (2021). Biodiversity monitoring and ecological management under global environmental change. *Biological Conservation*, 256, 109014.
13. Cook-Patton, S. C., Leavitt, S. M., Gibbs, D., Harris, N. L., Lister, K., Anderson-Teixeira, K. J., Briggs, R. D., Chazdon, R. L., Crowther, T. W., Ellis, P. W., Griscom, B. W., Herrmann, V., Holl, K. D., Houghton, R. A., Larrosa, C., Lomax, G., McGuire, J. B., Meli, P., Paustian, K., ... Griscom, B. W. (2021). Mapping carbon accumulation potential from global natural forest regrowth. *Nature*, 585, 545–550. <https://doi.org/10.1038/s41586-020-2686-x>
14. Dunlop, T., Khojasteh, D., Cohen-Shacham, E., Glamore, W., Haghani, M., van den Bosch, M., Rizzi, D., Greve, P., & others. (2024). The evolution and future of research on Nature-based Solutions to address societal challenges. *Communications Earth & Environment*, 5, 132. <https://doi.org/10.1038/s43247-024-01308-8>
15. Atkinson, J., Brudvig, L. A., Mallen-Cooper, M., Nakagawa, S., Moles, A. T., & Bonser, S. P. (2022). Terrestrial ecosystem restoration increases biodiversity and reduces its variability, but not to

- reference levels: A global meta-analysis. *Ecology Letters*, 25(7), 1725–1737. <https://doi.org/10.1111/ele.14025>
16. Mutillod, C., et al. (2024). Ecological restoration and rewilding: Two approaches with complementary goals? *Biological Reviews*, 99(3), 820–836. <https://doi.org/10.1111/brv.13046>
17. Volpe, J. P., et al. (2024). Bionovelty and ecological restoration. *Restoration Ecology*, 32(5), e14152. <https://doi.org/10.1111/rec.14152>
18. Standish, R. J., Parkhurst, T., & others. (2024). Interventions for resilient nature-based solutions: An ecological perspective. *Journal of Ecology*, 112(11), 2502–2509. <https://doi.org/10.1111/1365-2745.14377>
19. Corgo, J., Santos Cruz, S., & Conceição, P. (2024). Nature-based solutions in spatial planning and policies for climate change adaptation: A literature review. *Ambio*, 53, 1599–1617. <https://doi.org/10.1007/s13280-024-02052-1>
20. Rodrigues, M. S., Dias, L. F., & Nunes, J. P. (2024). Impact of nature-based solutions on sustainable development goals in Mediterranean agroecosystems: A meta-analysis. *Journal of Environmental Management*, 371, 123071. <https://doi.org/10.1016/j.jenvman.2024.123071>