

# [What are the grand challenges for plant conservation in the 21st century?](https://assignbuster.com/what-are-the-grand-challenges-for-plant-conservation-in-the-21st-century/)

[Health & Medicine](https://assignbuster.com/essay-subjects/health-n-medicine/)

## Introduction

Conserving plants in these turbulent and rapidly changing times is challenging, but nevertheless essential to the well-being of humans and all organisms on our planet. Plants supply our food, fiber, and medicines, regulate our climate, clean water and protect our soils, provide flood protection, underpin many cultures, and provide landscapes that restore and connect us to nature. Yet they face multiple interacting stressors and require urgent attention and decisive action that is effective, inclusive, and just.

## Foundational Data on Plant Distribution and Abundance

The effective conservation of plants is underpinned byfundamental information on plant diversity, distribution and abundance, and how this is changing over time. Some species become extinct before they are even described by science, especially in tropical areas, where more financial, human and infrastructure resources are urgently needed ( [Vorontsova et al., 2020](#B62) ). At least 571 plant species have gone extinct since the 1750s ( [Humphreys et al., 2019](#B34) ), and 40% of current plant species are at risk of extinction ( [Antonelli et al., 2020](#B4) ). Genetic diversity and ecological and evolutionary processes are just as important as species in conserving plant diversity, providing bases for plants and their communities to adapt to global environmental change and local pressures such as habitat fragmentation ( [Coates et al., 2018](#B17) , [Quiroga et al., 2019](#B45) ). Data on distribution, changes in abundance and genetic diversity can inform the prioritization of conservation funding and effort, and research aimed at advancing conservation and management of plants and the processes that maintain healthy ecosystems.

Accurate inventories of genetic diversity, populations, species, and ecosystems, are essential both in understanding the biogeographic determinants of plant distribution and abundance, and in assessing changes over time. The likely trajectories of decline and effectiveness of conservation interventions can only be assessed if there is foundational data collection that can then be monitored over time. These surveys can use the energy and expertise ofcitizen scientists, who participate in capturing information including plant and animal distributions, range extensions or contractions, phenology of migrations, and plant flowering, and the presence or absence of pollinators ( [McKinley et al., 2017](#B41) ). Most of the information recorded for the Global Biodiversity Information Facility (GBIF) and the USA National Phenology Network, for instance, comes from citizen scientists ( [Chandler et al., 2017](#B15) , [Taylor et al., 2019](#B57) ). Interfaces such as iNaturalist provide user-friendly and accessible means of connecting citizen scientists and co-ordinating data. That said, greater investment in teaching of natural historyis needed to grow our foundational knowledge and understanding of species and ecosystems ( [Greene, 2005](#B31) ). Data on distribution and abundance are required to inform *in-situ* conservation efforts such as species-focused conservation interventions and protected area planning and prioritization, as well as *inter-situ* conservation and assisted migration ( [Richardson et al., 2009](#B47) ). The resources of *ex-situ* conservation such as seed banks, arboreta and botanic gardens could complement *in-situ* conservation and play a vital role in restoration projects and conservation of genetic diversity ( [Mounce et al., 2017](#B42) , [Abeli et al., 2020](#B1) ).

## Curation and Modeling of Data

Biodiversity data need to be managed in forms that areaccessible and useful to practitioners( [Ball-Damerow et al., 2019](#B5) ), requiring collaborative efforts that integrate and co-ordinate while remaining flexible enough to accommodate the dynamics of changing knowledge and available information ( [Costello et al., 2018](#B18) ).

As spatial data and computational tools improve, moreaccurate monitoring of vegetation change and modeling of the drivers of plant distribution and abundanceat spatial and temporal scales fine enough to be relevant for conservation action are becoming possible. There are many new algorithms for continuous satellite-based monitoring of vegetation in near-real time ( [Zhu, 2017](#B67) ), and recent advances that help account for high dynamism in disturbance-prone ecosystems ( [Slingsby et al., 2020b](#B55) ). Both correlative and mechanistic approaches to modeling the distribution of species and ecosystems are advancing rapidly, and are invaluable in conservation planning and prioritization. Species Distribution Models (SDMs) can now incorporate a range of biotic and abiotic variables alongside the climate parameters, including soil type, disturbance regime, local adaptation, phenotypic plasticity and competition ( [Gavish et al., 2017](#B26) , [Benito Garzón et al., 2019](#B9) , [Magadzire et al., 2019](#B40) ). Similarly, Dynamic Global Vegetation Models (DGVMS), are increasing in sophistication and can include disturbance factors (e. g., fire) and are better able to predict responses in grass- or shrub-dominated systems ( [Hantson et al., 2016](#B33) , [Ruffault and Mouillot, 2017](#B49) ). Combined modeling offers the benefits and simplicity of correlative approaches with the biological realism of mechanistic and trait-based approaches, enabling demographic process, competition, dispersal and land-use change, for example, to be considered alongside climatic and other environmental parameters ( [Foden et al., 2019](#B24) ). The recent push for more emphasis on iterative near-term ecological forecasting is also testing our understanding of and ability to model ecological processes, and will hopefully accelerate our learning and model development ( [Dietze et al., 2018](#B20) ). These exciting developments are technically demanding and data-hungry, presenting both challenges and opportunities for the coming decades.

## Understanding Landscape History

Knowledge of thehistory of landscapes and processesthat generate the biodiversity patterns we see today is crucial to ensuring we understand the ecological character and effects of long-term human influence ( [Gillson, 2015](#B28) ). Data require context and interpretationto guide conservation and restoration efforts effectively. For example, global analyses highlight vast areas that could support trees for climate mitigation ( [Bastin et al., 2019](#B7) ), with potential benefits for biodiversity restoration in deforested landscapes, but the maps include large areas of disturbance-maintained grasslands, shrublands, and savannas, where tree-planting would have severe detrimental effects on biodiversity and human livelihoods ( [Bond et al., 2019](#B11) ).

Interdisciplinary studiesthat include long-term data from palaeoecology and other disciplines can help to identify the range of variability prior to extensive human impact, aiding understanding of ecological character and helping to define limits of acceptable change/thresholds of potential concern ( [Gell, 2010](#B27) , [Wu, 2011](#B66) ). Furthermore, integration ofcustomary management and local ecological knowledgeinto conservation practice can help maintain heterogeneous landscapes that benefit both people and biodiversity ( [Lindholm and Ekblom, 2019](#B37) ). This approach is especially powerful when combined with a willingness toadapt social-ecological systems to novel and changing conditions. Interdisciplinary teams can work together with communities to build nuanced understanding of landscape change and apply this knowledge in shaping conservation that is locally appropriate ( [Balvanera et al., 2017](#B6) , [Bennett et al., 2017](#B10) ).

## Grappling With the Complexity of Multiple Interacting Drivers

Models provide valuable tools for testing hypotheses and exploring future scenarios. Nevertheless, they do not capture thecomplexity of all interacting factorsthat determine population viability and ecosystem health. There are synergistic effects between habitat degradation, over-exploitation, disturbance, and climate change that can lead to unexpected and non-linear effects when environmental and biotic factors coincide. In western North America, for example, the warming climate has seen die-back of coniferous forests as a result of tree-killing beetles now able to over-winter more successfully and breed more rapidly ( [Lovejoy, 2019](#B38) ), and of aspen trees from increasingly frequent drought, which makes trees more susceptible to herbivory and disease ( [Anderegg et al., 2013](#B3) ).

Plants are also affected bychanges in the major disturbance regimes and their drivers, such as alteration of fire regimes ( [Slingsby et al., 2020a](#B54) ), the loss of megafauna, or trophic cascades through the loss of apex predators and other keystone species from terrestrial and aquatic environments. This can affect processes at the level of biome or even Earth system, with potentially serious impacts on ecosystem structure and function, ecosystem services, and biogeochemical cycles ( [Bowman et al., 2009](#B12) , [Norris et al., 2020](#B43) ). Loss of carnivores, for example, can propagate through multiple trophic levels, ultimately affecting plant assemblages; such cascading effects have been observed in terrestrial, freshwater, and marine ecosystems ( [Estes et al., 2011](#B22) , [Galetti and Dirzo, 2013](#B25) ). Rewildingof landscapes provides exciting opportunities to re-integrate plant and animal conservation, restore trophic interactions as well as to revive landscapes that inspire a fascination and care of nature, though of course requiring caution when functional equivalents are used to replace extinct species ( [Lundgren et al., 2018](#B39) ; [Wolf and Ripple, 2018](#B64) ; [Perino et al., 2019](#B44) ; [Svenning et al., 2019](#B56) ).

## Dealing With Extremes—the New Normal

As the devastating recent fires in Australia and California illustrate, the combination of changing climate, and the legacy of past and present fire management and suppression have led to fires that exceed the historical range of variability, in extent, intensity and duration. For example, Australia, although used to fire, experienced the most intense and widespread fires yet seen in the 2019–2020 austral summer, certainly the largest in Eastern Australia since European occupation ( [Wintle et al., 2020](#B63) ). The fires were so ferocious that they burnt through areas that ordinarily would serve as fire-free refuges. Almost half of the most impacted plant species lost over 80% of their range, and rehabilitation may be next to impossible given that the areas burnt are so large and that the distances that recolonizing mutualists will need to cover may be too great ( [Wintle et al., 2020](#B63) ). The relief effort for fire control was understandably focused on human safety, with only few pre-emptive responses aimed at reducing loss of biodiversity, although one example was saving the critically endangered Wollemi pine ( *Wollemia nobilis* ) ( [Wintle et al., 2020](#B63) ). A more future-focused effort to fire management could focus on restoring heterogeneity and building resilience ( [Gillson et al., 2019](#B29) ).

Temporary policies that are triggered duringstates of emergencycan over-ride longer-term goals that safeguard the environment and conservation ( [Seymour et al., 2020](#B52) ). Therefore, as we acknowledge the likelihood that extreme events will become both more frequent and more severe, the time is right to take actions thatbolster green infrastructureand integrate biodiversity conservation into climate change adaptation and disaster management, as well as to train a cohort of policy makers who can think strategically and plan for long-term resilience using sound underlying ecological principles ( [Ha, 2019](#B32) ).

## Balancing Biodiversity Conservation With Other Pressing Needs

As we grapple withmultiple interacting drivers of biodiversity loss, the planet has other urgent concerns that compete for capacity and resources. For example, the recent drive to plant trees and increase carbon storage and contribute to climate regulation can come at a cost when non-native species replace native vegetation, compromising biodiversity and other ecosystem services. In Madagascar, for example, many afforestation projects use *Eucalyptus* spp. to provide wood for construction and fuel; these alien species, which evolved in very different systems, alter soil properties and water quality and alter fire regimes ( [Rakotondrasoa et al., 2012](#B46) , [Kull et al., 2019](#B36) ). Improving carbon storage while maintaining ecosystem integrityrequires accurate understanding of carbon storage potential of native ecosystems and a thorough understanding of landscape history ( [Veldman et al., 2019](#B60) ).

With our minds understandably preoccupied with the current COVID-19 pandemic, there is no better time to consider thelinks between human health and ecosystem health. The transmission of zoonotic diseases to humans underlines the interconnectedness of living things and could inspire us to grapple with the complexity and uncertainty involved in doing conservation effectively, and building social ecological systems that are both resilient and adaptable. Land degradation is extensivein many countries, brought about by heavy grazing, invasion by non-native plants, and unsustainable agricultural and forestry practices. Habitat degradation and fragmentation shrink the resilience of ecosystems, reducing population sizes, and restricting gene flow. But there are other far-reaching consequences, including erosion, and damage to water quality and quantity and freshwater and often, marine ecosystems. Furthermore, many emerging infectious diseases arise from human encroachment into wildlife habitats. Human activities, particularly agricultural expansion and intensification and bushmeat harvesting make the transmission of diseases from animal populations to humans more likely ( [Allen et al., 2017](#B2) , [Rohr et al., 2019](#B48) ). Furthermore, the use of Genetically Modified (GM) crops with inbuilt herbicide tolerance ( [Woodbury et al., 2017](#B65) ), leads to increased herbicide use and associated loss of weeds that support pollinator species ( [Benbrook, 2012](#B8) ). Wildlife-friendly, locally appropriate means of securing food and diversifying livelihoodsare needed, that support human and ecological health at the same time as conserving the genetic heritage that is in danger of being lost due to agricultural intensification and homogenization ( [Isbell et al., 2017](#B35) ).

In the past, fortress approaches to conservation have led to loss of livelihoods and cultural connections to landscapes, fuelling tension between conservation and development aims. However, more-inclusive approaches to conservation integrate customary protection of biodiversity like sacred groves into the protected area network, as occurred in Madagascar ( [Virah-Sawmy et al., 2014](#B61) ). Integrating poverty alleviation and food security with climate action and biodiversity conservation highlights the need for intersectional thinking, as articulated in the Sustainable Development Goals ( [United Nations, 2015](#B58) ).

## Fostering Connections Among Plants, People, and Place

Creative solutions are needed that integrate ecological and societal benefits. For example, controlling non-native invasive species can be costly and time-consuming, but in South Africa, the “ Working for Water” programme, aimed at clearing such plant species, provides social upliftment as well as environmental benefits. Clearing these species benefits biodiversity and ecosystem services, improving water quality and quantity and helping in fire management and regulation. It also provides much-needed training and employment opportunities and spin-off opportunities that make use of the wood ( [van Wilgen and Wannenburgh, 2016](#B59) ).

Projects that have both social and ecological benefits are especially advantageous when they areco-created with stakeholder communities and are rooted in local ecological knowledge. An example of this is the West Arnhem Land Fire Abatement (WALFA) program in northern Australia, which reintroduces traditional management of fire with benefits for carbon storage and biodiversity, providing cultural, natural resource, and biodiversity benefits at local levels, while addressing climate-change issues at the global level ( [Russell-Smith et al., 2013](#B50) ). Such initiatives help build resilience that will be crucial to adapting to the increasingly drier and fire-prone environments in the coming decades ( [Bowman and Murphy, 2011](#B13) ).

Cultural landscapes such as those in West Arnhem Land depend on human intervention for their maintenance and loss of management can lead to homogenisation of landscapes and associated loss of biodiversity ( [Gil-Romera et al., 2010](#B30) ; [Lindholm and Ekblom, 2019](#B37) ). Yet, younger generations often do not want to participate in traditional agriculture and land management, instead preferring to seek employment in urban and coastal areas, leading to rural depopulation and loss of local ecological knowledge, as has happened in parts of Europe ( [Dax and Fischer, 2018](#B19) ). As more people dwell in urban areas, there are fewer opportunities to engage with nature. This extinction of experience can erode concern for nature ( [Seymour et al., 2020](#B52) ). To remedy this will require genuine efforts toreconnect people with the landscapes and ecosystemsthat they depend on, while recognizing our 21st Century context and the aspirations of young people and rural communities ( [Fischer et al., 2012](#B23) ). Stewardship and certification schemes, and access to global markets for high-value artisan products, can provide means of diversifying livelihoods and engaging with customary management that is locally appropriate and culturally rooted ( [Chapin et al., 2010](#B16) , [Lindholm and Ekblom, 2019](#B37) ). Furthermore, there are exciting opportunities for citizen science that enable individuals to contribute to our knowledge of species' distributions and abundance ( [McKinley et al., 2017](#B41) ).

## Concluding Remarks

As the current COVID-19 pandemic has shown, in times of emergency we turn to our neighbors, communities and local environment to meet material, social and emotional needs. At the same time, the unpredictability of our increasingly volatile Earth systems requires us to be adaptable and think at global scales. Policy frameworks, platforms and assessments such as the Sustainable Development Goals, Convention on Biodiversity and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) ( [Brondizio et al., 2019](#B14) , [Secretariat of the Convention on Biological Diversity, 2020](#B51) ; [Sharrock, 2020](#B53) ) need to be translated into national and local interventions that are place-based, locally rooted and culturally appropriate. Our approach to plant conservation must remain responsive, flexible, and alert to new directions and opportunities, including the possibility that novel emerging ecosystems, better adapted to our no-analog future, might provide unexpected benefits. Action needs to take place at all scales from local to global, underpinned by a willingness to overhaul radically our approach to consumption and production, and incorporating interdisciplinary research, and co-learning and transparent communication between scientists and practitioners ( [Norris et al., 2020](#B43) ). Perhaps above all, as we grapple with issues at the intersection of social and environmental justice, we must seek to be equitable and inclusive. Citizen science and knowledge co-production achieve another vital goal, of helping to educate and enthuse. In the words of Baba Dioum, “ In the end we will conserve only what we love, we will love only what we understand” ( [Dioum, 1968](#B21) ).

## Author Contributions

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

## Funding

LG was funded by the National Research Foundation, African Origins Platform, SASSCAL (Grant numbers 118538, 117666, and 118589) and the Vice Chancellor's Future Leaders Fund. JS was supported by the National Research Foundation of South Africa, Grant no. 118593. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

## Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Acknowledgments

We thank the reviewer for helpful comments.

## References

Abeli, T., Dalrymple, S., Godefroid, S., Mondoni, A., Müller, J. V., Rossi, G., et al. (2020). *Ex situ* collections and their potential for the restoration of extinct plants. *Conserv. Biol.* 34, 303–313. doi: 10. 1111/cobi. 13391

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/31329316) | [CrossRef Full Text](https://doi.org/10.1111/cobi.13391) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=T.+Abeli&author=S.+Dalrymple&author=S.+Godefroid&author=A.+Mondoni&author=J.+V.+Müller&author=G.+Rossi+&publication_year=2020&title=Ex+situ+collections+and+their+potential+for+the+restoration+of+extinct+plants&journal=Conserv.+Biol.&volume=34&pages=303-313)

Allen, T., Murray, K. A., Zambrana-Torrelio, C., Morse, S. S., Rondinini, C., Di Marco, M., et al. (2017). Global hotspots and correlates of emerging zoonotic diseases. *Nat. Commun.* 8, 1–10. doi: 10. 1038/s41467-017-00923-8

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/29066781) | [CrossRef Full Text](https://doi.org/10.1038/s41467-017-00923-8) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=T.+Allen&author=K.+A.+Murray&author=C.+Zambrana-Torrelio&author=S.+S.+Morse&author=C.+Rondinini&author=M.+Di+Marco+&publication_year=2017&title=Global+hotspots+and+correlates+of+emerging+zoonotic+diseases&journal=Nat.+Commun.&volume=8&pages=1-10)

Anderegg, L. D., Anderegg, W. R., Abatzoglou, J., Hausladen, A. M., and Berry, J. A. (2013). Drought characteristics' role in widespread aspen forest mortality across Colorado, USA. *Glob. Chang. Biol.* 19, 1526–1537. doi: 10. 1111/gcb. 12146

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/23504823) | [CrossRef Full Text](https://doi.org/10.1111/gcb.12146) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=L.+D.+Anderegg&author=W.+R.+Anderegg&author=J.+Abatzoglou&author=A.+M.+Hausladen&author=J.+A.+Berry+&publication_year=2013&title=Drought+characteristics'+role+in+widespread+aspen+forest+mortality+across+Colorado,+USA&journal=Glob.+Chang.+Biol.&volume=19&pages=1526-1537)

Antonelli, A., Fry, C., Smith, R. J., Simmonds, M. S. J., Kersey, P. J., Pritchard, H. W., et al. (2020). *State of the World's Plants and Fungi 2020.* Kew: Royal Botanic Gardens.

[Google Scholar](http://scholar.google.com/scholar_lookup?author=A.+Antonelli&author=C.+Fry&author=R.+J.+Smith&author=M.+S.+J.+Simmonds&author=P.+J.+Kersey&author=H.+W.+Pritchard+&publication_year=2020&title=State+of+the+World's+Plants+and+Fungi+2020.)

Ball-Damerow, J. E., Brenskelle, L., Barve, N., Soltis, P. S., Sierwald, P., Bieler, R., et al. (2019). Research applications of primary biodiversity databases in the digital age. *PLoS ONE* 14: e0215794. doi: 10. 1371/journal. pone. 0215794

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/31509534) | [CrossRef Full Text](https://doi.org/10.1371/journal.pone.0215794) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=J.+E.+Ball-Damerow&author=L.+Brenskelle&author=N.+Barve&author=P.+S.+Soltis&author=P.+Sierwald&author=R.+Bieler+&publication_year=2019&title=Research+applications+of+primary+biodiversity+databases+in+the+digital+age&journal=PLoS+ONE&volume=14&pages=e0215794)

Balvanera, P., Calderón-Contreras, R., Castro, A. J., Felipe-Lucia, M. R., Geijzendorffer, I. R., Jacobs, S., et al. (2017). Interconnected place-based social–ecological research can inform global sustainability. *Curr. Opin. Environ. Sustain.* 29, 1–7. doi: 10. 1016/j. cosust. 2017. 09. 005

[CrossRef Full Text](https://doi.org/10.1016/j.cosust.2017.09.005) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=P.+Balvanera&author=R.+Calderón-Contreras&author=A.+J.+Castro&author=M.+R.+Felipe-Lucia&author=I.+R.+Geijzendorffer&author=S.+Jacobs+&publication_year=2017&title=Interconnected+place-based+social–ecological+research+can+inform+global+sustainability&journal=Curr.+Opin.+Environ.+Sustain.&volume=29&pages=1-7)

Bastin, J.-F., Finegold, Y., Garcia, C., Mollicone, D., Rezende, M., Routh, D., et al. (2019). The global tree restoration potential. *Science* 365, 76–79. doi: 10. 1126/science. aax0848

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/31273120) | [CrossRef Full Text](https://doi.org/10.1126/science.aax0848) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=J.+-F.+Bastin&author=Y.+Finegold&author=C.+Garcia&author=D.+Mollicone&author=M.+Rezende&author=D.+Routh+&publication_year=2019&title=The+global+tree+restoration+potential&journal=Science&volume=365&pages=76-79)

Benbrook, C. M. (2012). Impacts of genetically engineered crops on pesticide use in the US–the first sixteen years. *Environ. Sci. Eur.* 24: 24. doi: 10. 1186/2190-4715-24-24

[CrossRef Full Text](https://doi.org/10.1186/2190-4715-24-24) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=C.+M.+Benbrook+&publication_year=2012&title=Impacts+of+genetically+engineered+crops+on+pesticide+use+in+the+US–the+first+sixteen+years&journal=Environ.+Sci.+Eur.&volume=24&pages=24)

Benito Garzón, M., Robson, T. M., and Hampe, A. (2019). ΔTrait SDMs: species distribution models that account for local adaptation and phenotypic plasticity. *New Phytol.* 222, 1757–1765. doi: 10. 1111/nph. 15716

[CrossRef Full Text](https://doi.org/10.1111/nph.15716) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=M.+Benito+Garzón&author=T.+M.+Robson&author=A.+Hampe+&publication_year=2019&title=ΔTrait+SDMs%3A+species+distribution+models+that+account+for+local+adaptation+and+phenotypic+plasticity&journal=New+Phytol.&volume=222&pages=1757-1765)

Bennett, N. J., Roth, R., Klain, S. C., Chan, K. M., Clark, D. A., Cullman, G., et al. (2017). Mainstreaming the social sciences in conservation. *Conserv. Biol.* 31, 56–66. doi: 10. 1111/cobi. 12788

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/27334309) | [CrossRef Full Text](https://doi.org/10.1111/cobi.12788) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=N.+J.+Bennett&author=R.+Roth&author=S.+C.+Klain&author=K.+M.+Chan&author=D.+A.+Clark&author=G.+Cullman+&publication_year=2017&title=Mainstreaming+the+social+sciences+in+conservation&journal=Conserv.+Biol.&volume=31&pages=56-66)

Bond, W. J., Stevens, N., Midgley, G. F., and Lehmann, C. E. (2019). The trouble with trees: afforestation plans for Africa. *Trends Ecol. Evol.* 34, 963–965. doi: 10. 1016/j. tree. 2019. 08. 003

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/31515117) | [CrossRef Full Text](https://doi.org/10.1016/j.tree.2019.08.003) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=W.+J.+Bond&author=N.+Stevens&author=G.+F.+Midgley&author=C.+E.+Lehmann+&publication_year=2019&title=The+trouble+with+trees%3A+afforestation+plans+for+Africa&journal=Trends+Ecol.+Evol.&volume=34&pages=963-965)

Bowman, D. M., Balch, J. K., Artaxo, P., Bond, W. J., Carlson, J. M., Cochrane, M. A., et al. (2009). Fire in the Earth system. *Science* 324, 481–484. doi: 10. 1126/science. 1163886

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/19390038) | [CrossRef Full Text](https://doi.org/10.1126/science.1163886) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=D.+M.+Bowman&author=J.+K.+Balch&author=P.+Artaxo&author=W.+J.+Bond&author=J.+M.+Carlson&author=M.+A.+Cochrane+&publication_year=2009&title=Fire+in+the+Earth+system&journal=Science&volume=324&pages=481-484)

Bowman, D. M., and Murphy, B. P. (2011). Australia-a model system for the development of pyrogeography. *Fire Ecol.* 7, 5–12. doi: 10. 4996/fireecology. 0701005

[CrossRef Full Text](https://doi.org/10.4996/fireecology.0701005) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=D.+M.+Bowman&author=B.+P.+Murphy+&publication_year=2011&title=Australia-a+model+system+for+the+development+of+pyrogeography&journal=Fire+Ecol.&volume=7&pages=5-12)

Brondizio, E., Settele, J., and Díaz, S. (2019). *IPBES 2019 Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services* . Bonn: Germany.

[Google Scholar](http://scholar.google.com/scholar_lookup?author=E.+Brondizio&author=J.+Settele&author=S.+Díaz+&publication_year=2019&title=IPBES+2019+Global+Assessment+Report+on+Biodiversity+and+Ecosystem+Services+of+the+Intergovernmental+Science-Policy+Platform+on+Biodiversity+and+Ecosystem+Services)

Chandler, M., See, L., Copas, K., Bonde, A. M., López, B. C., Danielsen, F., et al. (2017). Contribution of citizen science towards international biodiversity monitoring. *Biol. Conserv.* 213, 280–294. doi: 10. 1016/j. biocon. 2016. 09. 004

[CrossRef Full Text](https://doi.org/10.1016/j.biocon.2016.09.004) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=M.+Chandler&author=L.+See&author=K.+Copas&author=A.+M.+Bonde&author=B.+C.+López&author=F.+Danielsen+&publication_year=2017&title=Contribution+of+citizen+science+towards+international+biodiversity+monitoring&journal=Biol.+Conserv.&volume=213&pages=280-294)

Chapin, F. S., Carpenter, S. R., Kofinas, G. P., Folke, C., Abel, N., Clark, W. C., et al. (2010). Ecosystem stewardship: sustainability strategies for a rapidly changing planet. *Trends Ecol. Evol.* 25, 241–249. doi: 10. 1016/j. tree. 2009. 10. 008

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/19923035) | [CrossRef Full Text](https://doi.org/10.1016/j.tree.2009.10.008) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=F.+S.+Chapin&author=S.+R.+Carpenter&author=G.+P.+Kofinas&author=C.+Folke&author=N.+Abel&author=W.+C.+Clark+&publication_year=2010&title=Ecosystem+stewardship%3A+sustainability+strategies+for+a+rapidly+changing+planet&journal=Trends+Ecol.+Evol.&volume=25&pages=241-249)

Coates, D. J., Byrne, M., and Moritz, C. (2018). Genetic diversity and conservation units: dealing with the species-population continuum in the age of genomics. *Front. Ecol. Evol.* 6: 165. doi: 10. 3389/fevo. 2018. 00165

[CrossRef Full Text](https://doi.org/10.3389/fevo.2018.00165) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=D.+J.+Coates&author=M.+Byrne&author=C.+Moritz+&publication_year=2018&title=Genetic+diversity+and+conservation+units%3A+dealing+with+the+species-population+continuum+in+the+age+of+genomics&journal=Front.+Ecol.+Evol.&volume=6&pages=165)

Costello, M. J., Horton, T., and Kroh, A. (2018). Sustainable biodiversity databasing: international, collaborative, dynamic, centralised. *Trends Ecol. Evol.* 33, 803–805. doi: 10. 1016/j. tree. 2018. 08. 006

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/30213659) | [CrossRef Full Text](https://doi.org/10.1016/j.tree.2018.08.006) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=M.+J.+Costello&author=T.+Horton&author=A.+Kroh+&publication_year=2018&title=Sustainable+biodiversity+databasing%3A+international,+collaborative,+dynamic,+centralised&journal=Trends+Ecol.+Evol.&volume=33&pages=803-805)

Dax, T., and Fischer, M. (2018). An alternative policy approach to rural development in regions facing population decline. *Eur. Plann. Stud.* 26, 297–315. doi: 10. 1080/09654313. 2017. 1361596

[CrossRef Full Text](https://doi.org/10.1080/09654313.2017.1361596) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=T.+Dax&author=M.+Fischer+&publication_year=2018&title=An+alternative+policy+approach+to+rural+development+in+regions+facing+population+decline&journal=Eur.+Plann.+Stud.&volume=26&pages=297-315)

Dietze, M. C., Fox, A., Beck-Johnson, L. M., Betancourt, J. L., Hooten, M. B., Jarnevich, C. S., et al. (2018). Iterative near-term ecological forecasting: Needs, opportunities, and challenges. *Proc. Natl. Acad. Sci. U. S. A.* 115, 1424–1432. doi: 10. 1073/pnas. 1710231115

[CrossRef Full Text](https://doi.org/10.1073/pnas.1710231115) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=M.+C.+Dietze&author=A.+Fox&author=L.+M.+Beck-Johnson&author=J.+L.+Betancourt&author=M.+B.+Hooten&author=C.+S.+Jarnevich+&publication_year=2018&title=Iterative+near-term+ecological+forecasting%3A+Needs,+opportunities,+and+challenges&journal=Proc.+Natl.+Acad.+Sci.+U.S.A.&volume=115&pages=1424-1432)

Dioum, B. (1968). *Speech Presented at the International Union for Conservation of Nature* . IUCN, New Delhi.

Estes, J. A., Terborgh, J., Brashares, J. S., Power, M. E., Berger, J., Bond, W. J., et al. (2011). Trophic downgrading of planet Earth. *Science* 333, 301–306. doi: 10. 1126/science. 1205106

[CrossRef Full Text](https://doi.org/10.1126/science.1205106) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=J.+A.+Estes&author=J.+Terborgh&author=J.+S.+Brashares&author=M.+E.+Power&author=J.+Berger&author=W.+J.+Bond+&publication_year=2011&title=Trophic+downgrading+of+planet+Earth&journal=Science&volume=333&pages=301-306)

Fischer, J., Hartel, T., and Kuemmerle, T. (2012). Conservation policy in traditional farming landscapes. *Conserv. Lett.* 5, 167–175. doi: 10. 1111/j. 1755-263X. 2012. 00227. x

[CrossRef Full Text](https://doi.org/10.1111/j.1755-263X.2012.00227.x) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=J.+Fischer&author=T.+Hartel&author=T.+Kuemmerle+&publication_year=2012&title=Conservation+policy+in+traditional+farming+landscapes&journal=Conserv.+Lett.&volume=5&pages=167-175)

Foden, W. B., Young, B. E., Akçakaya, H. R., Garcia, R. A., Hoffmann, A. A., Stein, B. A., et al. (2019). Climate change vulnerability assessment of species. *Wiley Interdiscip. Rev.* 10: e551. doi: 10. 1002/wcc. 551

[CrossRef Full Text](https://doi.org/10.1002/wcc.551) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=W.+B.+Foden&author=B.+E.+Young&author=H.+R.+Akçakaya&author=R.+A.+Garcia&author=A.+A.+Hoffmann&author=B.+A.+Stein+&publication_year=2019&title=Climate+change+vulnerability+assessment+of+species&journal=Wiley+Interdiscip.+Rev.&volume=10&pages=e551)

Galetti, M., and Dirzo, R. (2013). Ecological and evolutionary consequences of living in a defaunated world. *Biol. Conserv.* 163, 1–6. doi: 10. 1016/j. biocon. 2013. 04. 020

[CrossRef Full Text](https://doi.org/10.1016/j.biocon.2013.04.020) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=M.+Galetti&author=R.+Dirzo+&publication_year=2013&title=Ecological+and+evolutionary+consequences+of+living+in+a+defaunated+world&journal=Biol.+Conserv.&volume=163&pages=1-6)

Gavish, Y., Marsh, C. J., Kuemmerlen, M., Stoll, S., Haase, P., and Kunin, W. E. (2017). Accounting for biotic interactions through alpha-diversity constraints in stacked species distribution models. *Methods Ecol. Evol.* 8, 1092–1102. doi: 10. 1111/2041-210X. 12731

[CrossRef Full Text](https://doi.org/10.1111/2041-210X.12731) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=Y.+Gavish&author=C.+J.+Marsh&author=M.+Kuemmerlen&author=S.+Stoll&author=P.+Haase&author=W.+E.+Kunin+&publication_year=2017&title=Accounting+for+biotic+interactions+through+alpha-diversity+constraints+in+stacked+species+distribution+models&journal=Methods+Ecol.+Evol.&volume=8&pages=1092-1102)

Gell, P. (2010). “ With the benefit of hindsight: the utility of palaeoecology in wetland condition assessment and identification of restoration targets,” in *Ecology of Industrial Pollution* , eds. L. C. Batty and K. B. Hallberg (Cambridge, UK: Cambridge University Press), 162-188.

[Google Scholar](http://scholar.google.com/scholar_lookup?author=P.+Gell+&publication_year=2010&title=“ With+the+benefit+of+hindsight%3A+the+utility+of+palaeoecology+in+wetland+condition+assessment+and+identification+of+restoration+targets,”&journal=Ecology+of+Industrial+Pollution&pages=162-188)

Gillson, L. (2015). *Biodiversity Conservation and Environmental Change: Using palaeoecology to Manage Dynamic Landscapes in the Anthropocene.* Oxford: Oxford University Press.

[Google Scholar](http://scholar.google.com/scholar_lookup?author=L.+Gillson+&publication_year=2015&title=Biodiversity+Conservation+and+Environmental+Change%3A+Using+palaeoecology+to+Manage+Dynamic+Landscapes+in+the+Anthropocene.)

Gillson, L., Whitlock, C., and Humphrey, G. (2019). Resilience and fire management in the Anthropocene. *Ecol. Soc.* 24: 14. doi: 10. 5751/ES-11022-240314

[CrossRef Full Text](https://doi.org/10.5751/ES-11022-240314) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=L.+Gillson&author=C.+Whitlock&author=G.+Humphrey+&publication_year=2019&title=Resilience+and+fire+management+in+the+Anthropocene&journal=Ecol.+Soc.&volume=24&pages=14)

Gil-Romera, G., López-Merino, L., Carrión, J. S., González-Sampériz, P., Martín-Puertas, C., López Sáez, J. A., et al. (2010). Interpreting resilience through long-term ecology: potential insights in western Mediterranean landscapes. *Open Ecol. J.* 3, 43–53. doi: 10. 2174/1874213001003020043

[CrossRef Full Text](https://doi.org/10.2174/1874213001003020043) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=G.+Gil-Romera&author=L.+López-Merino&author=J.+S.+Carrión&author=P.+González-Sampériz&author=C.+Martín-Puertas&author=J.+A.+López+Sáez+&publication_year=2010&title=Interpreting+resilience+through+long-term+ecology%3A+potential+insights+in+western+Mediterranean+landscapes&journal=Open+Ecol.+J.&volume=3&pages=43-53)

Greene, H. W. (2005). Organisms in nature as a central focus for biology. *Trends Ecol. Evol.* 20, 23–27. doi: 10. 1016/j. tree. 2004. 11. 005

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/16701336) | [CrossRef Full Text](https://doi.org/10.1016/j.tree.2004.11.005) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=H.+W.+Greene+&publication_year=2005&title=Organisms+in+nature+as+a+central+focus+for+biology&journal=Trends+Ecol.+Evol.&volume=20&pages=23-27)

Ha, K.-M. (2019). Evaluating ecosystem-based natural disaster management. *Hum. Ecol. Risk Assess.* 26, 1896–1906. doi: 10. 1080/10807039. 2019. 1619069

[CrossRef Full Text](https://doi.org/10.1080/10807039.2019.1619069) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=K.+-M.+Ha+&publication_year=2019&title=Evaluating+ecosystem-based+natural+disaster+management&journal=Hum.+Ecol.+Risk+Assess.&volume=26&pages=1896-1906)

Hantson, S., Arneth, A., Harrison, S. P., Kelley, D. I., Prentice, I. C., Rabin, S. S., et al. (2016). The status and challenge of global fire modelling. *Biogeosciences* 13, 3359–3375. doi: 10. 5194/bg-13-3359-2016

[CrossRef Full Text](https://doi.org/10.5194/bg-13-3359-2016) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=S.+Hantson&author=A.+Arneth&author=S.+P.+Harrison&author=D.+I.+Kelley&author=I.+C.+Prentice&author=S.+S.+Rabin+&publication_year=2016&title=The+status+and+challenge+of+global+fire+modelling&journal=Biogeosciences&volume=13&pages=3359-3375)

Humphreys, A. M., Govaerts, R., Ficinski, S. Z., Lughadha, E. N., and Vorontsova, M. S. (2019). Global dataset shows geography and life form predict modern plant extinction and rediscovery. *Nat. Ecol. Evol.* 3, 1043–1047. doi: 10. 1038/s41559-019-0906-2

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/31182811) | [CrossRef Full Text](https://doi.org/10.1038/s41559-019-0906-2) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=A.+M.+Humphreys&author=R.+Govaerts&author=S.+Z.+Ficinski&author=E.+N.+Lughadha&author=M.+S.+Vorontsova+&publication_year=2019&title=Global+dataset+shows+geography+and+life+form+predict+modern+plant+extinction+and+rediscovery&journal=Nat.+Ecol.+Evol.&volume=3&pages=1043-1047)

Isbell, F., Adler, P. R., Eisenhauer, N., Fornara, D., Kimmel, K., Kremen, C., et al. (2017). Benefits of increasing plant diversity in sustainable agroecosystems. *J. Ecol.* 105, 871–879. doi: 10. 1111/1365-2745. 12789

[CrossRef Full Text](https://doi.org/10.1111/1365-2745.12789) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=F.+Isbell&author=P.+R.+Adler&author=N.+Eisenhauer&author=D.+Fornara&author=K.+Kimmel&author=C.+Kremen+&publication_year=2017&title=Benefits+of+increasing+plant+diversity+in+sustainable+agroecosystems&journal=J.+Ecol.&volume=105&pages=871-879)

Kull, C. A., Harimanana, S. L., Andrianoro, A. R., and Rajoelison, L. G. (2019). Divergent perceptions of the ‘ neo-Australian'forests of lowland eastern Madagascar: invasions, transitions, and livelihoods. *J. Environ. Manage* 229, 48–56. doi: 10. 1016/j. jenvman. 2018. 06. 004

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/30041841) | [CrossRef Full Text](https://doi.org/10.1016/j.jenvman.2018.06.004) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=C.+A.+Kull&author=S.+L.+Harimanana&author=A.+R.+Andrianoro&author=L.+G.+Rajoelison+&publication_year=2019&title=Divergent+perceptions+of+the+‘ neo-Australian'forests+of+lowland+eastern+Madagascar%3A+invasions,+transitions,+and+livelihoods&journal=J.+Environ.+Manage&volume=229&pages=48-56)

Lindholm, K.-J., and Ekblom, A. (2019). A framework for exploring and managing biocultural heritage. *Anthropocene* 25: 100195. doi: 10. 1016/j. ancene. 2019. 100195

[CrossRef Full Text](https://doi.org/10.1016/j.ancene.2019.100195) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=K.+-J.+Lindholm&author=A.+Ekblom+&publication_year=2019&title=A+framework+for+exploring+and+managing+biocultural+heritage&journal=Anthropocene&volume=25&pages=100195)

Lovejoy, T. E. (2019). Look back lest you fail to mark the path ahead. *Plants People Planet* 1, 71–76. doi: 10. 1002/ppp3. 19

[CrossRef Full Text](https://doi.org/10.1002/ppp3.19) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=T.+E.+Lovejoy+&publication_year=2019&title=Look+back+lest+you+fail+to+mark+the+path+ahead&journal=Plants+People+Planet&volume=1&pages=71-76)

Lundgren, E. J., Ramp, D., Ripple, W. J., and Wallach, A. D. (2018). Introduced megafauna are rewilding the anthropocene. *Ecography* 41, 857–866. doi: 10. 1111/ecog. 03430

[CrossRef Full Text](https://doi.org/10.1111/ecog.03430) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=E.+J.+Lundgren&author=D.+Ramp&author=W.+J.+Ripple&author=A.+D.+Wallach+&publication_year=2018&title=Introduced+megafauna+are+rewilding+the+anthropocene&journal=Ecography&volume=41&pages=857-866)

Magadzire, N., De Klerk, H. M., Esler, K. J., and Slingsby, J. A. (2019). Fire and life history affect the distribution of plant species in a biodiversity hotspot. *Divers. Distrib* . 25, 1012–1023. doi: 10. 1111/ddi. 12921

[CrossRef Full Text](https://doi.org/10.1111/ddi.12921) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=N.+Magadzire&author=H.+M.+De+Klerk&author=K.+J.+Esler&author=J.+A.+Slingsby+&publication_year=2019&title=Fire+and+life+history+affect+the+distribution+of+plant+species+in+a+biodiversity+hotspot&journal=Divers.+Distrib&volume=25&pages=1012-1023)

McKinley, D. C., Miller-Rushing, A. J., Ballard, H. L., Bonney, R., Brown, H., Cook-Patton, S. C., et al. (2017). Citizen science can improve conservation science, natural resource management, environmental protection. *Biol. Conserv.* 208, 15–28. doi: 10. 1016/j. biocon. 2016. 05. 015

[CrossRef Full Text](https://doi.org/10.1016/j.biocon.2016.05.015) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=D.+C.+McKinley&author=A.+J.+Miller-Rushing&author=H.+L.+Ballard&author=R.+Bonney&author=H.+Brown&author=S.+C.+Cook-Patton+&publication_year=2017&title=Citizen+science+can+improve+conservation+science,+natural+resource+management,+environmental+protection&journal=Biol.+Conserv.&volume=208&pages=15-28)

Mounce, R., Smith, P., and Brockington, S. (2017). *Ex situ* conservation of plant diversity in the world's botanic gardens. *Nat. Plants* 3, 795–802. doi: 10. 1038/s41477-017-0019-3

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/28947807) | [CrossRef Full Text](https://doi.org/10.1038/s41477-017-0019-3) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=R.+Mounce&author=P.+Smith&author=S.+Brockington+&publication_year=2017&title=Ex+situ+conservation+of+plant+diversity+in+the+world's+botanic+gardens&journal=Nat.+Plants&volume=3&pages=795-802)

Norris, K., Terry, A., Hansford, J. P., and Turvey, S. T. (2020). Biodiversity conservation and the earth system: mind the gap. *Trends Ecol. Evol* . 35, 919–926. doi: 10. 1016/j. tree. 2020. 06. 010

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/32650985) | [CrossRef Full Text](https://doi.org/10.1016/j.tree.2020.06.010) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=K.+Norris&author=A.+Terry&author=J.+P.+Hansford&author=S.+T.+Turvey+&publication_year=2020&title=Biodiversity+conservation+and+the+earth+system%3A+mind+the+gap&journal=Trends+Ecol.+Evol&volume=35&pages=919-926)

Perino, A., Pereira, H. M., Navarro, L. M., Fernández, N., Bullock, J. M., Ceau? u, S., et al. (2019). Rewilding complex ecosystems. *Science* 364: eaav5570. doi: 10. 1126/science. aav5570

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/31023897) | [CrossRef Full Text](https://doi.org/10.1126/science.aav5570) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=A.+Perino&author=H.+M.+Pereira&author=L.+M.+Navarro&author=N.+Fernández&author=J.+M.+Bullock&author=S.+Ceau?u+&publication_year=2019&title=Rewilding+complex+ecosystems&journal=Science&volume=364&pages=eaav5570)

Quiroga, M. P., Castello, L., Quipildor, V., and Premoli, A. C. (2019). Biogeographically significant units in conservation: a new integrative concept for conserving ecological and evolutionary processes. *Environ. Conserv.* 46, 293–301. doi: 10. 1017/S0376892919000286

[CrossRef Full Text](https://doi.org/10.1017/S0376892919000286) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=M.+P.+Quiroga&author=L.+Castello&author=V.+Quipildor&author=A.+C.+Premoli+&publication_year=2019&title=Biogeographically+significant+units+in+conservation%3A+a+new+integrative+concept+for+conserving+ecological+and+evolutionary+processes&journal=Environ.+Conserv.&volume=46&pages=293-301)

Rakotondrasoa, O. L., Malaisse, F., Rajoelison, G. L., Razafimanantsoa, T. M., Rabearisoa, M. R., Ramamonjisoa, B. S., et al. (2012). Tapia forest, endemic ecosystem to Madagascar: ecology, functions, causes of degradation and transformation: a review. *Biotechnol. Agron. Soc. Envir.* 16, 541–552.

[Google Scholar](http://scholar.google.com/scholar_lookup?author=O.+L.+Rakotondrasoa&author=F.+Malaisse&author=G.+L.+Rajoelison&author=T.+M.+Razafimanantsoa&author=M.+R.+Rabearisoa&author=B.+S.+Ramamonjisoa+&publication_year=2012&title=Tapia+forest,+endemic+ecosystem+to+Madagascar%3A+ecology,+functions,+causes+of+degradation+and+transformation%3A+a+review&journal=Biotechnol.+Agron.+Soc.+Envir.&volume=16&pages=541-552)

Richardson, D. M., Hellmann, J. J., McLachlan, J. S., Sax, D. F., Schwartz, M. W., Gonzalez, P., et al. (2009). Multidimensional evaluation of managed relocation. *Proc. Natl. Acad. Sci. U. S. A.* 106, 9721–9724. doi: 10. 1073/pnas. 0902327106

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/19509337) | [CrossRef Full Text](https://doi.org/10.1073/pnas.0902327106) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=D.+M.+Richardson&author=J.+J.+Hellmann&author=J.+S.+McLachlan&author=D.+F.+Sax&author=M.+W.+Schwartz&author=P.+Gonzalez+&publication_year=2009&title=Multidimensional+evaluation+of+managed+relocation&journal=Proc.+Natl.+Acad.+Sci.+U.S.A.&volume=106&pages=9721-9724)

Rohr, J. R., Barrett, C. B., Civitello, D. J., Craft, M. E., Delius, B., DeLeo, G. A., et al. (2019). Emerging human infectious diseases and the links to global food production. *Nat. Sust.* 2, 445–456. doi: 10. 1038/s41893-019-0293-3

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/32219187) | [CrossRef Full Text](https://doi.org/10.1038/s41893-019-0293-3) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=J.+R.+Rohr&author=C.+B.+Barrett&author=D.+J.+Civitello&author=M.+E.+Craft&author=B.+Delius&author=G.+A.+DeLeo+&publication_year=2019&title=Emerging+human+infectious+diseases+and+the+links+to+global+food+production&journal=Nat.+Sust.&volume=2&pages=445-456)

Ruffault, J., and Mouillot, F. (2017). Contribution of human and biophysical factors to the spatial distribution of forest fire ignitions and large wildfires in a French Mediterranean region. *Int. J* . Wildland Fire 26, 498–508. doi: 10. 1071/WF16181

[CrossRef Full Text](https://doi.org/10.1071/WF16181) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=J.+Ruffault&author=F.+Mouillot+&publication_year=2017&title=Contribution+of+human+and+biophysical+factors+to+the+spatial+distribution+of+forest+fire+ignitions+and+large+wildfires+in+a+French+Mediterranean+region&journal=Int.+J&volume=26&pages=498-508)

Russell-Smith, J., Monagle, C., Jacobsohn, M., Beatty, R. L., Bilbao, B., Millán, A., et al. (2013). Can savanna burning projects deliver measurable greenhouse emissions reductions and sustainable livelihood opportunities in fire-prone settings? *Clim. Change* 140, 47–61. doi: 10. 1007/s10584-013-0910-5

[CrossRef Full Text](https://doi.org/10.1007/s10584-013-0910-5)

Secretariat of the Convention on Biological Diversity (2020). Global Biodiversity Outlook 5 - Summary for Policy Makers. Montreal, QC: Secretariat of the Convention on Biological Diversity.

Seymour, C. L., Gillson, L., Child, M. F., Tolley, K. A., Curie, J. C., da Silva, J. M., et al. (2020). Horizon scanning for South African biodiversity: a need for social engagement as well as science. *Ambio* 49, 1211–1221. doi: 10. 1007/s13280-019-01252-4

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/31564051) | [CrossRef Full Text](https://doi.org/10.1007/s13280-019-01252-4) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=C.+L.+Seymour&author=L.+Gillson&author=M.+F.+Child&author=K.+A.+Tolley&author=J.+C.+Curie&author=J.+M.+da+Silva+&publication_year=2020&title=Horizon+scanning+for+South+African+biodiversity%3A+a+need+for+social+engagement+as+well+as+science&journal=Ambio&volume=49&pages=1211-1221)

Sharrock, S. (2020). *Plant Conservation Report 2020: A review of progress in implementation of the Global Strategy for Plant Conservation 2011-2020* . Richmond, UK: Secretariat of the Convention on Biological Diversity, Montréal, Canada and Botanic Gardens Conservation International.

Slingsby, J. A., Moncrieff, G. R., Rogers, A. J., and February, E. C. (2020a). Altered ignition catchments threaten a hyperdiverse fire-dependent ecosystem. *Glob. Chang. Biol.* 26, 616–628. doi: 10. 1111/gcb. 14861

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/31587449) | [CrossRef Full Text](https://doi.org/10.1111/gcb.14861) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=J.+A.+Slingsby&author=G.+R.+Moncrieff&author=A.+J.+Rogers&author=E.+C.+February+&publication_year=2020a&title=Altered+ignition+catchments+threaten+a+hyperdiverse+fire-dependent+ecosystem&journal=Glob.+Chang.+Biol.&volume=26&pages=616-628)

Slingsby, J. A., Moncrieff, G. R., and Wilson, A. M. (2020b). Near-real time forecasting and change detection for an open ecosystem with complex natural dynamics. *ISPRS J. Photogramm. Remote Sens.* 166, 15–25. doi: 10. 1016/j. isprsjprs. 2020. 05. 017

[CrossRef Full Text](https://doi.org/10.1016/j.isprsjprs.2020.05.017) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=J.+A.+Slingsby&author=G.+R.+Moncrieff&author=A.+M.+Wilson+&publication_year=2020b&title=Near-real+time+forecasting+and+change+detection+for+an+open+ecosystem+with+complex+natural+dynamics&journal=ISPRS+J.+Photogramm.+Remote+Sens.&volume=166&pages=15-25)

Svenning, J.-C., Munk, M., and Schweiger, A. (2019). Trophic rewilding–ecological restoration of top-down trophic interactions to promote self-regulating biodiverse ecosystems. *Rewilding* 73–89. doi: 10. 1017/9781108560962. 005

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/26504218) | [CrossRef Full Text](https://doi.org/10.1017/9781108560962.005) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=J.+-C.+Svenning&author=M.+Munk&author=A.+Schweiger+&publication_year=2019&title=Trophic+rewilding–ecological+restoration+of+top-down+trophic+interactions+to+promote+self-regulating+biodiverse+ecosystems&journal=Rewilding&pages=73-89)

Taylor, S. D., Meiners, J. M., Riemer, K., Orr, M. C., and White, E. P. (2019). Comparison of large-scale citizen science data and long-term study data for phenology modeling. *Ecology* 100: e02568. doi: 10. 1002/ecy. 2568

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/30499218) | [CrossRef Full Text](https://doi.org/10.1002/ecy.2568) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=S.+D.+Taylor&author=J.+M.+Meiners&author=K.+Riemer&author=M.+C.+Orr&author=E.+P.+White+&publication_year=2019&title=Comparison+of+large-scale+citizen+science+data+and+long-term+study+data+for+phenology+modeling&journal=Ecology&volume=100&pages=e02568)

United Nations (2015). *Sustainable Development 17 Goals to transform our world* . Available online at: [https://www. un. org/sustainabledevelopment/sustainable-development-goals/](https://www.un.org/sustainabledevelopment/sustainable-development-goals/)

[Google Scholar](http://scholar.google.com/scholar_lookup?publication_year=2015&title=Sustainable+Development+17+Goals+to+transform+our+world)

van Wilgen, B. W., and Wannenburgh, A. (2016). Co-facilitating invasive species control, water conservation and poverty relief: achievements and challenges in South Africa's Working for Water programme. *Curr. Opin. Environ. Sust.* 19, 7–17. doi: 10. 1016/j. cosust. 2015. 08. 012

[CrossRef Full Text](https://doi.org/10.1016/j.cosust.2015.08.012) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=B.+W.+van+Wilgen&author=A.+Wannenburgh+&publication_year=2016&title=Co-facilitating+invasive+species+control,+water+conservation+and+poverty+relief%3A+achievements+and+challenges+in+South+Africa's+Working+for+Water+programme&journal=Curr.+Opin.+Environ.+Sust.&volume=19&pages=7-17)

Veldman, J. W., Aleman, J. C., Alvarado, S. T., Anderson, T. M., Archibald, S., Bond, W. J., et al. (2019). Comment on “ The global tree restoration potential”. *Science* 366: eaay7976. doi: 10. 1126/science. aaz0111

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/31624182) | [CrossRef Full Text](https://doi.org/10.1126/science.aaz0111) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=J.+W.+Veldman&author=J.+C.+Aleman&author=S.+T.+Alvarado&author=T.+M.+Anderson&author=S.+Archibald&author=W.+J.+Bond+&publication_year=2019&title=Comment+on+“ The+global+tree+restoration+potential”&journal=Science&volume=366&pages=eaay7976)

Virah-Sawmy, M., Gardner, C., and Ratsifandrihamanana, A. (2014). “ The Durban vision in practice, experiences in the participatory governance of Madagascar's new protected areas,” in *Conservation and Environmental Management in Madagascar* , ed I. Scales (Routledge), 216–251. doi: 10. 4324/9780203118313

[CrossRef Full Text](https://doi.org/10.4324/9780203118313) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=M.+Virah-Sawmy&author=C.+Gardner&author=A.+Ratsifandrihamanana+&publication_year=2014&title=“ The+Durban+vision+in+practice,+experiences+in+the+participatory+governance+of+Madagascar's+new+protected+areas,”&journal=Conservation+and+Environmental+Management+in+Madagascar&pages=216-251)

Vorontsova, M. S., Lowry, P. P., Andriambololonera, S. R., Wilmé, L, Rasolohery, A., Govaerts, R., et al. (2020). Inequality in plant diversity knowledge and unrecorded plant extinctions: an example from the grasses of Madagascar. *Plants People Planet.* 1–16. doi: 10. 1002/ppp3. 10123

[CrossRef Full Text](https://doi.org/10.1002/ppp3.10123) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=M.+S.+Vorontsova&author=P.+P.+Lowry&author=S.+R.+Andriambololonera&author=L+Wilmé&author=A.+Rasolohery&author=R.+Govaerts+&publication_year=2020&title=Inequality+in+plant+diversity+knowledge+and+unrecorded+plant+extinctions%3A+an+example+from+the+grasses+of+Madagascar&journal=Plants+People+Planet.&pages=1-16)

Wintle, B. A., Legge, S., and Woinarski, J. C. (2020). After the megafires: what next for Australian wildlife? *Trends Ecol. Evol.* 35, 753–757. doi: 10. 1016/j. tree. 2020. 06. 009

[PubMed Abstract](https://pubmed.ncbi.nlm.nih.gov/32680597) | [CrossRef Full Text](https://doi.org/10.1016/j.tree.2020.06.009) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=B.+A.+Wintle&author=S.+Legge&author=J.+C.+Woinarski+&publication_year=2020&title=After+the+megafires%3A+what+next+for+Australian+wildlife%3F&journal=Trends+Ecol.+Evol.&volume=35&pages=753-757)

Wolf, C., and Ripple, W. J. (2018). Rewilding the world's large carnivores. *R. Soc. Open Sci.* 5: 172235. doi: 10. 1098/rsos. 172235

[CrossRef Full Text](https://doi.org/10.1098/rsos.172235) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=C.+Wolf&author=W.+J.+Ripple+&publication_year=2018&title=Rewilding+the+world's+large+carnivores&journal=R.+Soc.+Open+Sci.&volume=5&pages=172235)

Woodbury, P. B., DiTommaso, A., Thies, J., Ryan, M, and Losey, J. (2017). “ Effects of transgenic crops on the environment,” in *Environmental Pest Management: Challenges for Agronomists, Ecologists, Economists and Policymakers* , eds M. Coll, E. Wajnberg (Hoboken: Wiley), 131–150.

[Google Scholar](http://scholar.google.com/scholar_lookup?author=P.+B.+Woodbury&author=A.+DiTommaso&author=J.+Thies&author=M+Ryan&author=J.+Losey+&publication_year=2017&title=“ Effects+of+transgenic+crops+on+the+environment,”&journal=Environmental+Pest+Management%3A+Challenges+for+Agronomists,+Ecologists,+Economists+and+Policymakers&pages=131-150)

Wu, J. (2011). “ Integrating nature and culture in landscape ecology,” in *Landscape Ecology in Asian Cultures* , ed Y. Iwasa (Japan: Springer), 1–321.

[Google Scholar](http://scholar.google.com/scholar_lookup?author=J.+Wu+&publication_year=2011&title=“ Integrating+nature+and+culture+in+landscape+ecology,”&journal=Landscape+Ecology+in+Asian+Cultures&pages=1-321)

Zhu, Z. (2017). Change detection using landsat time series: a review of frequencies, preprocessing, algorithms, and applications. *ISPRS J. Photogramm. Remote Sens.* 130, 370–384. doi: 10. 1016/j. isprsjprs. 2017. 06. 013

[CrossRef Full Text](https://doi.org/10.1016/j.isprsjprs.2017.06.013) | [Google Scholar](http://scholar.google.com/scholar_lookup?author=Z.+Zhu+&publication_year=2017&title=Change+detection+using+landsat+time+series%3A+a+review+of+frequencies,+preprocessing,+algorithms,+and+applications&journal=ISPRS+J.+Photogramm.+Remote+Sens.&volume=130&pages=370-384)