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APPLICATION ARTICLE

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Conservation Action Tracker: A tool to identify and monitor conservation actions for tree species

Itxaso Quintana | **Malin Rivers** | **Katharine Davies**

Botanic Gardens Conservation International (BGCI), Descanso House, 199 Kew Road, Richmond, TW9 3BW, United Kingdom

Correspondence

Itxaso Quintana, Botanic Gardens Conservation International (BGCI), Descanso House, 199 Kew Road, Richmond, TW9 3BW, United Kingdom.
Email: itxaso.quintana@bgci.org

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Abstract

Premise: The GlobalTree Portal, hosted by Botanic Gardens Conservation International, provides access to information on the approximately 58,000 tree species worldwide. Included in the GlobalTree Portal is the Conservation Action Tracker, a dynamic and collaborative database to identify and monitor conservation actions for tree species globally.

Methods: The Conservation Action Tracker collates conservation action information at the species level, including species recovery/action plans, ex situ collections, propagation protocols, in situ management, species protection policy, and education/awareness campaigns.

Results: To date, the Conservation Action Tracker contains conservation action information for 4126 tree species, including 2161 threatened species, of which 659 are classified as Vulnerable, 783 as Endangered, and 719 as Critically Endangered. It covers conservation action information for at least one tree species in every country; however, more information is needed for 89% of Vulnerable, 87% of Endangered, and 77% of Critically Endangered tree species.

Discussion: Monitoring species conservation actions can support the prioritization and scaling up of conservation practices by sharing knowledge, increasing collaboration, enabling the identification of conservation gaps, and making the information available to be used by decision-makers. Tracking conservation actions at the species level is, therefore, essential to guide future conservation efforts. Increasing the amount of data in the Conservation Action Tracker will improve the tool's ability to guide future conservation efforts and avoid the extinction of tree species.

KEYWORDS

conservation effort, Critically Endangered, gap analysis, global database, prioritization, threatened, trees

The first global list of all known tree species and their country-level distribution was published in 2017 through Botanic Gardens Conservation International's (BGCI) GlobalTreeSearch (Beech et al., 2017; BGCI, 2023a). As of May 2023, there are 57,922 tree species worldwide reported by GlobalTreeSearch database (BGCI, 2023a), which is actively maintained and updated to incorporate the latest available information on taxonomy, distribution, and life-forms. Tree species play a keystone role in their ecosystems, supporting a multitude of other species from their position at the base of trophic pyramids in ecological networks, and providing habitat for a wide range of species (Barthlott et al., 2001; Schulze et al., 2004; Basset et al., 2012); therefore, the loss of tree species damages the foundations of ecosystems and risks a domino effect of extinctions (Rivers et al., 2023). Trees are crucial for the Earth's biogeochemical processes, regulating air temperature; influencing soil production, hydrological, nutrient, and carbon cycles; and acting as a sink for anthropogenic carbon emissions (Nadrowski et al., 2010; Pan et al., 2011; Miura et al., 2015). Moreover, they are highly valued for their economic, ecological, aesthetic, and cultural importance,

providing us with food, timber, and medicine (Seth, 2003; Rivers et al., 2023).

Despite their crucial ecological role, the landmark "State of the World's Trees" report revealed that at least 29.9% of tree species, over 17,500 tree species, are threatened with extinction at the global scale, with most of the tree diversity and proportion of threatened trees concentrated in the tropical and subtropical regions (BGCI, 2021). The report, published in 2021, shared the preliminary results from the Global Tree Assessment, a collaborative initiative to produce risk of extinction assessments for all tree species (BGCI, 2021). The number of threatened trees is therefore expected to rise as the remaining tree conservation assessments are published.

Faced with this alarming scenario, there is an urgent and pressing need to scale up the conservation of tree species. Most of the current conservation action takes a broader, landscape- and/or habitat-level approach (Butler and Laurance, 2008; Harvey et al., 2010; Hoffmann, 2022); however, while the protection of forest habitat is hugely valuable, it does not necessarily guarantee the survival of the diverse range of tree species growing within different forest ecosystems, as species can face species-specific threats (Heywood, 2019; Rivers et al., 2023). Tree planting efforts to restore degraded forest areas also often use a much narrower range of species than the original species mix (Di Sacco et al., 2021). The conservation of tree species requires biological knowledge of each species to identify and undertake appropriate management strategies; hence, adopting complementary, proactive, and species-focused approaches is necessary for the survival of many threatened trees (Lindenmayer et al., 2007; Heywood, 2017; Bolam et al., 2023).

Numerous plant conservation organizations across the globe are dedicated to safeguarding tree species via conservation initiatives. For instance, the Global Conservation Consortia (GCC) catalyzes groups of institutions and experts to collaboratively develop and implement conservation strategies for priority threatened plant groups at the taxonomic level, including tree groups such as magnolias, dipterocarps, and oaks (BGCI, 2023b; Linsky et al., 2024). Furthermore, funding provided by Fondation Franklinia to organizations such as BGCI and Fauna & Flora has facilitated multi-year tree conservation projects. These projects are carried out in partnership with in-country organizations to undertake tree conservation actions, including surveys and inventories, site protection measures, planting in situ, establishing ex situ collections, propagating target species, and raising awareness (BGCI and FFI, 2021).

In order to effectively guide and prioritize conservation efforts for tree species, it is crucial to track specific conservation actions at the species level. To address this, BGCI launched the GlobalTree Portal (https://www.bgci.org/resources/bgci-databases/globaltree-portal/) in September 2021 as the first portal dedicated to conservation information for the world's tree species (BGCI, 2023c). The GlobalTree Portal has a profile for every tree species, and each profile displays information on the species' country-level distribution, conservation assessment, and presence or absence from protected areas or ex situ collections.

Included in the GlobalTree Portal is the Conservation Action Tracker, an online, global resource that tracks and monitors species-specific conservation actions at the global scale. The aim of the Conservation Action Tracker is to guide and prioritize conservation actions by identifying gaps in the conservation of tree species. The identification of conservation gaps is crucial to facilitate planning future conservation actions for the world's most threatened trees. Here, we present the Conservation Action Tracker tool and provide an overview of the currently available information. Through analysis of the Conservation Action Tracker information for two case studies, one at the national and another at the taxonomic level, we demonstrate the identification of conservation gaps to prioritize species conservation efforts.

METHODS

The Conservation Action Tracker is a species-specific tool for trees, providing a set of fields to give an overview of conservation action at a tree species level, such as baseline information, conservation action plan for species, ex situ information, in situ management, policy for species protection, and education/awareness about species conservation (Table 1).

Most of the conservation action fields can be answered as Yes, No, or Unknown. There is also a conservation action text field that contains summary information about the species (Table 1). Other information provided to help understand the context and scope of the project and verify the provided data is stored internally, along with the contact information of the data providers. When conservation action information for a tree species is received, it is stored in the Conservation Action Tracker database with the date the information was provided. This makes it possible to track changes on conservation actions over time. The data displayed in the GlobalTree Portal will then be the most recently updated information.

The conservation action information presented here was downloaded on 15 December 2023. The taxonomic list of tree species informing the analysis in this paper was BGCI's GlobalTreeSearch version 1.7 (BGCI, 2023e). The list of trees was then matched to the most up-to-date International Union for Conservation of Nature (IUCN) Red List of Threatened Species assessment at the global level (IUCN, 2023a). The IUCN Red List categorizes species into various levels of extinction risk: Least Concern, Data Deficient, Near Threatened, Vulnerable, Endangered, Critically Endangered, Extinct in the Wild, and Extinct. Threatened species are included in the IUCN Red List categories Vulnerable, Endangered, and Critically Endangered. Country-level information from the GlobalTree Portal (BGCI, 2023c) was compared to the information in the Conservation Action Tracker.

TABLE 1 Details about the information within the Conservation Action Tracker, including category, field name in the GlobalTree Portal, field description and criteria, and the data type.

Category	Field name in the GlobalTree Portal	Field description and criteria	Type of answer
Basic information	Tree species	The scientific name of the species (in the format *Genus epithet*). The species name is matched to GlobalTreeSearch (BGCI, 2023a). If the action is directed to a subspecies or variety, it will be attributed to the species level and noted in the conservation action summary: "Is this species under conservation action?"	Text
Basic information	Is this species under conservation action?	A short text field summarizing the conservation actions for the specific tree species. This conservation summary field could contain information about the geographical scope, project timeline, responsible organization, and the key conservation actions.	Text
Baseline	Is there accurate baseline information for the target species?	If yes, sufficient work has been carried out to be confident that the information on population, threats, and conservation status is comprehensive enough to identify appropriate recovery actions for the target species. The accurate baseline information needs to be from the entire native range of the species. Additionally, evidence of how accurate baseline information was obtained needs to be provided; for example: the species has a recent IUCN Red List Assessment, the species has been the subject of a conservation genetics study, survey work confirmed the distribution of this species and the associated threats, etc.	Yes/No/Unknown
Recovery/ action plan	Is there a species recovery and/or action plan?	If yes, there is a species recovery or conservation action plan for the species. This refers to a document describing the current status, threats, and intended methods for mitigating threats and increasing the species' population size. The species recovery/ conservation action plan can cover the full range or a smaller part of the range, and can be at the species, habitat, or national scale.	Yes/No/Unknown
Recovery/ action plan	Is there a species recovery and/or action plan?	If present, the URL link to the species recovery plan or conservation action plan can be found at the end of the "Is there a species recovery and/or action plan?" question. It can be a website link or a link to an online document. The species recovery/action plan can be uploaded in the language of origin. More than one species recovery/action plan can be included.	URL address
Ex situ	Are there living collections of wild origin?	If yes, at least one living collection is known to be of wild origin. The living collection must have been successfully established.	Yes/No/Unknown
Ex situ	Are there seed collections of wild origin?	If yes, at least one seed collection is known to be of wild origin. The seed collection needs to be a long-term collection.	Yes/No/Unknown
Ex situ	Are there any other (not living and not seed) collections of wild origin?	If yes, this species is conserved in at least one ex situ collection, other than living and seed collections, and the material is known to be of wild origin; for example: pollen, vegetative propagules, tissue, or cell cultures.	Yes/No/Unknown
Ex situ	Is there a representative ex situ collection?	If yes, sufficient work has been undertaken to ensure that ex situ collections (including seed, living, and/or other) are sufficiently representative of the wild population throughout its entire native distribution range. Additionally, justification of why or why not the ex situ collections are representative of wild populations of the species is needed; for example: all populations were surveyed, genetic and/or geographic analyses were conducted, etc.	Yes/No/Unknown
Ex situ	Is there a propagation protocol?	If yes, there is a propagation protocol for the species. The propagation protocol can encompass any propagation method, such as: seed germination, rooting of cuttings, grafting, air layering, micropropagation, etc.	Yes/No/Unknown
Ex situ	Is there a propagation protocol?	If present, the URL link to the propagation protocol can be found at the end of the "Is there a propagation protocol?" question. It can be a website link or a link to an online document. The	URL address

(Continues)

TABLE 1 (Continued)

Category	Field name in the GlobalTree Portal	Field description and criteria	Type of answer
		propagation protocol can be uploaded in the language of origin. More than one propagation protocol can be included.	
In situ	Is there active protection and/or management in situ?	If yes, active protection and/or management of the species in the wild is in place, indicating dedicated efforts to monitor, manage, and/or protect the species in its natural habitat. The in situ protection/management does not need to cover the entire distribution range of the species. Additionally, the specific geographic area or portion of the species' distribution range where active protection and management measures are implemented must be specified.	Yes/No/Unknown
In situ	Is there planting in situ?	If yes, the species is being planted within its natural habitat and within its native range. Planting in the wild refers to population augmentation, reintroduction, and/or translocation.	Yes/No/Unknown
Policy	Is there policy and/or legislation in place?	If yes, there exists national or international policy or legislation aimed at protecting this species. The policy/legislation can refer to a specific species (e.g., CITES) or address the protection of an area or habitat that includes the tree species.	Yes/No/Unknown
Education	Is there a public awareness and/or education program in place?	If yes, public workshops, awareness, and/or education programs have been conducted for this species. The education/awareness programs should be directed to the broader public, including schools and local communities; for example: workshops designed to involve the public in conservation efforts for the species.	Yes/No/Unknown
Additional information	For more information on conservation action for this species, click on the following links:	Useful URL links that provide additional information about the conservation actions in place.	URL address

Note: CITES = Convention on International Trade in Endangered Species of Wild Fauna and Flora.

The data for the Conservation Action Tracker are collated from various sources stated below, including species experts, researchers, botanic gardens, seed banks, and organizations conserving trees around the world. To date, the main data contributors to the Conservation Action Tracker are:

A. **Global Conservation Consortia:** The GCC is a coordinated network of institutions and experts with the objective of identifying species of greatest conservation concern to prioritize and execute effective in situ and ex situ conservation actions, build capacity, increase public awareness, and collaboratively fundraise to scale up conservation action for highly threatened taxonomic groups, including those that are technically challenging to manage (BGCI, 2023b; Linsky et al., 2024). Currently, 11 GCC are in place, and each GCC is managed by a lead institution and coordinated by an expert. The Conservation Action Tracker contains conservation action information for the following plant groups: *Acer*, dipterocarps, magnolias, *Nothofagus*, oaks, and rhododendrons.

   Baseline conservation action information for magnolias and oaks was gathered from the conservation gap analysis published for magnolias (Linsky et al., 2022) and native U.S. oaks (Beckman et al., 2019). For the taxonomic groups that have not published a conservation gap analysis, the baseline conservation action information was collated by the respective GCC coordinator. Each GCC coordinator is responsible for gathering and updating conservation action information for the target taxonomic groups every year.

B. **BGCI's Tree Conservation Programme:** BGCI provides support to in-country partners to carry out practical tree conservation programs aimed at securing populations of the world's most threatened tree species. BGCI's Tree Conservation Programme builds on past work of the Global Trees Campaign, a partnership between BGCI and Fauna & Flora that was in place from 1999 until 2023. Information on conservation actions is provided by the in-country project partners and is collated and added into the Conservation Action Tracker every year. The duration of species conservation projects is three years or more; therefore, the progress of tree conservation projects can be tracked on a yearly basis.

C. **Conservation planning for tree species:** At the national scale, BGCI has coordinated some of the first multi-species tree conservation planning workshops. For Kenya (Harvey-Brown and Shaw, 2020) and Ghana (Harvey-Brown, 2023), these have resulted in reports including baseline information on conservation actions and recommendations. This information

has been entered into the Conservation Action Tracker database, and workshop participants will be surveyed every few years to update the information.

D. **Contacting specialized organizations:** Conservation organizations and species specialists that are based in countries with a high proportion of threatened tree species and have previously contributed to the assessment of tree species coordinated by the Global Tree Assessment initiative were also contacted. Information was provided from organizations such as: Fondation Franklinia, Fauna & Flora, Sociedade Chauá (Brazil), Energy Development Corporation (the Philippines), Tropical Rainforest Conservation & Research Center (Malaysia), Bogor Botanic Gardens (Indonesia), the Instituto de Ecología (INECOL) (Mexico), and the IUCN Species Survival Commission (SSC) Colombia Species Specialist Group (Colombia).

E. **Online form:** An online form (https://www.bgci.org/resources/bgci-databases/globaltree-portal/conservation-action-tracker/) containing the set of questions established by the Conservation Action Tracker (Table 1) is accessible through each species page on the GlobalTree Portal (BGCI, 2023d). Species experts such as conservationists and researchers provide conservation action information for specific tree species by completing the form. Once submitted, the form is reviewed to ensure its completeness and coherence of information. If any doubts arise regarding the provided data, the person responsible for the submission is contacted for clarification before the information is uploaded to the Conservation Action Tracker database.

RESULTS

The Conservation Action Tracker for tree species is available on the GlobalTree Portal (https://www.bgci.org/resources/bgci-databases/globaltree-portal/), where a summary of the conservation actions for each specific tree species is presented. Further details about the project or specific conservation actions are available via external links located at the bottom of the Conservation Action Tracker (Figure 1). Additionally, links to the shared species recovery/action plans and propagation protocols are available after the respective questions (see the example of *Magnolia pallescens* Urb. & Ekman in Figure 1).

To date, the Conservation Action Tracker database covers conservation action information for 4126 tree species; 2161 of these species are threatened, of which 659 are Vulnerable, 783 are Endangered, and 719 are Critically Endangered trees (Table 2). The Conservation Action Tracker covers conservation action information for at least one tree species in every country (Figure 2A). As the Conservation Action Tracker is not yet fully populated for all tree species, the geographic distribution of the data is currently skewed toward countries where species with recorded conservation projects are found. Tree species with conservation action information are primarily found in East and Southeast Asia and Eastern African countries, as well as in Mexico and Colombia (Figure 2A). China has the most tree species (581 spp.) with conservation action information, followed by Colombia (559 spp.) and Mexico (528 spp.) (Table 3). When examining the threatened tree species with available conservation action information, a similar pattern is observed (Figure 2B). Of the countries with the highest number of species with conservation action information, none have conservation action information for more than 50% of their threatened species (Table 3). However, noteworthy exceptions exist, exemplified by countries such as Kenya, the United Kingdom, Laos, and Cambodia; for these countries, conservation action data are available for over 50% of their threatened tree species.

According to the GlobalTree Portal, the top three countries with the most native tree species assessed as Critically Endangered are Madagascar, the Philippines, and Brazil (Figure 3). Of the top 10 countries, Mexico has the highest proportion of Critically Endangered trees (81%) with conservation action information, followed by Sri Lanka (39%) and the United States (36%) (Figure 3). For the remaining top 10 countries, the number of Critically Endangered tree species with conservation action information is less than 25% (Figure 3).

Case study at the country level: Kenya (National Planning)

Kenya is home to 1117 native tree species, of which 142 are threatened, including eight that are Critically Endangered at the global level (BGCI, 2023c). The Conservation Action Tracker holds information on 237 of Kenya's native tree species, including 118 threatened and all eight Critically Endangered tree species.

By examining the information within the Conservation Action Tracker at the country level, we are able to identify the gaps in conservation actions for these threatened tree species. In Kenya, 17% of the threatened trees (24 species) do not have any documented conservation action in place. Conservation action information is available for 83% of Kenya's threatened tree species (118 species), but most of these species are not known to have an established ex situ collection (90 species) or a propagation protocol in place (111 species). Of Kenya's 142 threatened tree species, 86 have a conservation action plan in place. However, for 71 of these species, there are not species-specific conservation actions defined; instead a multi-species conservation plan at the national level is in place for the protection and restoration of Kenya's forest (Harvey-Brown and Shaw, 2020). Active in situ management or protection is in place for 49 threatened species, but in situ planting has only been reported for seven threatened species. Only two of Kenya's threatened species have a policy in place for their protection.

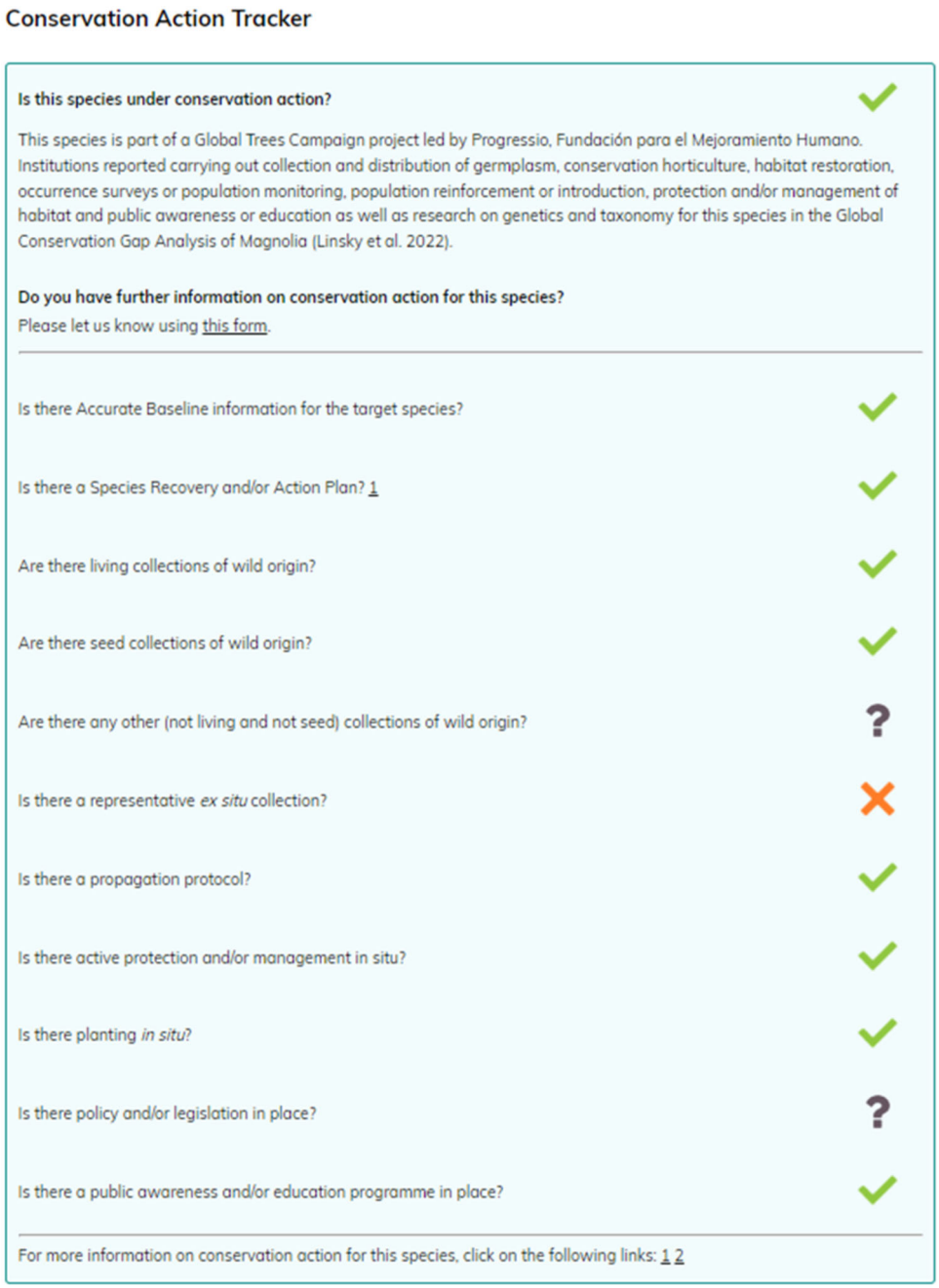

FIGURE 1 Conservation Action Tracker example for *Magnolia pallescens*. This information is available in the GlobalTree Portal under Species Search (BGCI, 2023g). The green checkmark indicates this conservation action has taken place for this species. The orange cross indicates this conservation action has not occurred for this species. The question mark indicates there is not known information that this conservation action has taken place for this species. *Magnolia pallescens* has a species recovery/action plan available, which is accessible through the link (1) following the corresponding question.

Case study at the taxonomic level: Oaks (GCC)

The *Quercus* genus, commonly known as oaks, comprises 415 tree species (BGCI, 2023e), of which 108 are threatened with extinction, including 31 that are Critically Endangered at the global level. The Conservation Action Tracker holds conservation action information for 402 oak tree species (97% of all *Quercus* tree species), including 105 threatened species and 29 Critically Endangered oak trees.

The information available in the Conservation Action Tracker allows us to detect that 65% of threatened oak trees (70 species) are not under any conservation action, including 81% of Critically Endangered oak trees (25 species). More than 80% of the threatened oak trees are lacking at least one of the following conservation actions: species recovery/action plan, established ex situ living collection, propagation protocol, policy for the protection of species, and awareness/education for promoting the conservation of the species (Figure 4). Over 50% of threatened oak species are conserved in situ (Figure 4). This

TABLE 2 Number and percentage of tree species with information in the Conservation Action Tracker for all trees and each threat category (IUCN, 2023a).

Category	Tree species in the Conservation Action Tracker	% relative to total tree species in each category
All tree species	4126	7%
Threatened	2161	14%
Vulnerable	659	11%
Endangered	783	13%
Critically Endangered	719	23%

includes 12 species being actively managed or protected in situ, 13 species being planted in situ, and 10 with both activities in place.

DISCUSSION

The Conservation Action Tracker aims to gather conservation action information for all threatened tree species to enable the identification of conservation gaps and facilitate the prioritization of future tree conservation actions. The value of making these data available is demonstrated by the Kenya and oak case studies. Although the Conservation Action Tracker is still in the early stages, information has

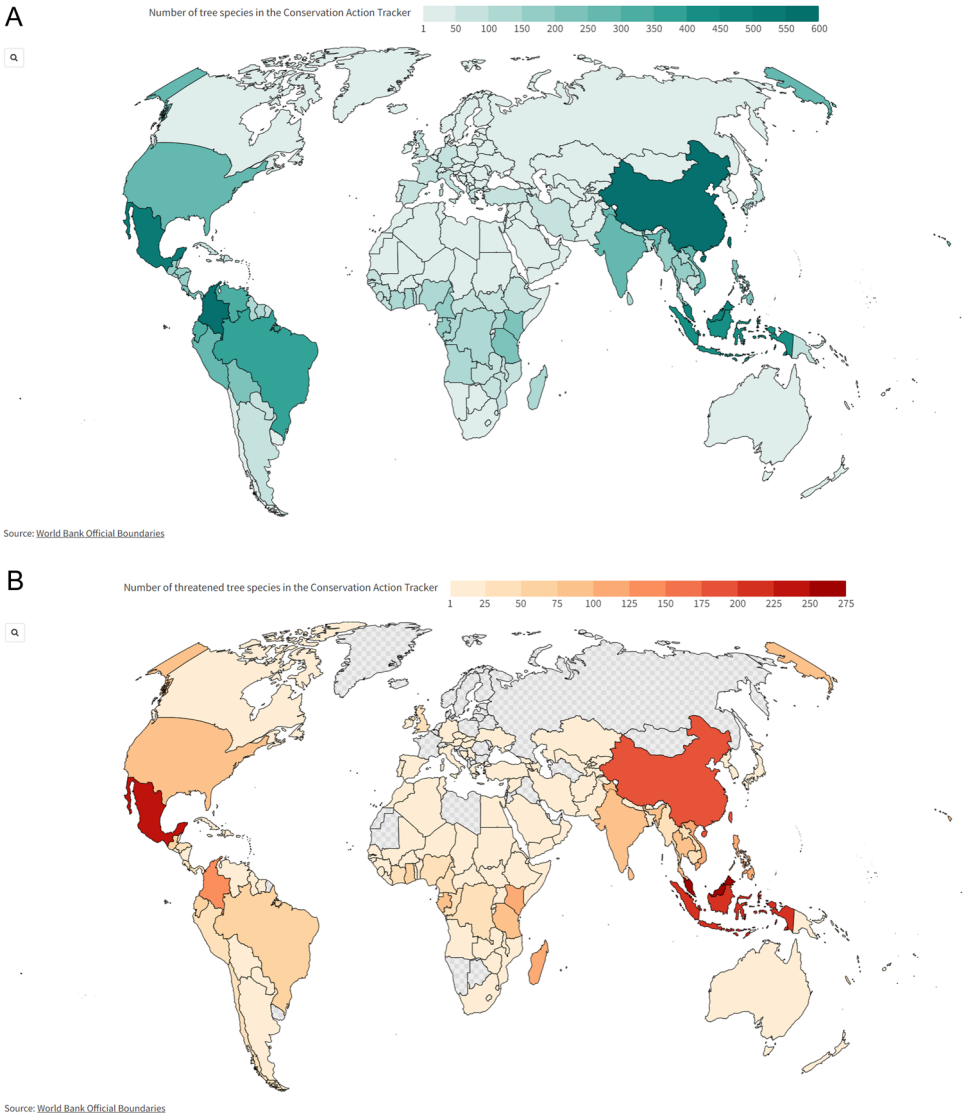

FIGURE 2 World map showing the number of (A) tree species and (B) threatened tree species by country with conservation action information in the Conservation Action Tracker. Maps were created using Flourish (https://flourish.studio).

already been recorded for 2161 threatened tree species, including 719 Critically Endangered species. Critically Endangered species are the main priority for conservation actions due to the imminent and severe extinction risk they face. However, information is currently unavailable in the Conservation Action Tracker for 77% of the Critically Endangered tree species, and as illustrated in Figure 3, information is not available from most of the countries with a high number of Critically Endangered species. BGCI is actively seeking contributions from individuals and organizations working on the conservation of tree species.

TABLE 3 The top 10 countries with the highest number of species with conservation action information in the Conservation Action Tracker. For each country, the total number of tree species with conservation action information, the percentage relative to the total number of native species, the number of threatened species with conservation action information, and the percentage relative to the total number of threatened native species is shown.

Country	Species in the Conservation Action Tracker	% relative to total native species	Threatened species in the Conservation Action Tracker	% relative to total threatened native species
China	581	13%	176	44%
Colombia	559	9%	142	25%
Mexico	528	14%	246	20%
Malaysia	482	9%	259	22%
Indonesia	439	7%	211	21%
Brazil	360	4%	74	7%
Ecuador	309	8%	61	12%
Venezuela	302	6%	22	5%
India	274	11%	95	25%
Peru	274	6%	36	8%

Information on conservation action has not previously been systematically collected and made publicly available at the species level. There are multiple platforms promoting the sharing of site-based conservation, for example, Restor (Crowther et al., 2022) or the IUCN Contributions for Nature Platform (IUCN, 2023b). However, these platforms focus on the particular site where conservation activities take place rather than focusing on individual species and the species-specific conservation actions. If conservation is only considered at the habitat level, the survival of tree species (which often require species-specific actions) is not guaranteed (Bolam et al., 2023). Although the IUCN Red List includes species-specific information and provides recommendations for conservation action, species-specific actions already taking place are not consistently provided. There is also a lack of plant-specific conservation information such as propagation protocols. In addition, the IUCN Red List assessments are updated every 10 years (IUCN, 2016), whereas the GlobalTree Portal is updated at least once a year, allowing more up-to-date information to be made available.

Knowledge on existing conservation actions for tree species included in the Conservation Action Tracker enables the prioritization and scaling up of tree species conservation practices by (1) providing a portal to share crucial resources in the conservation of species, such as species recovery/action plans and propagation protocols; (2) increasing international, national, and regional

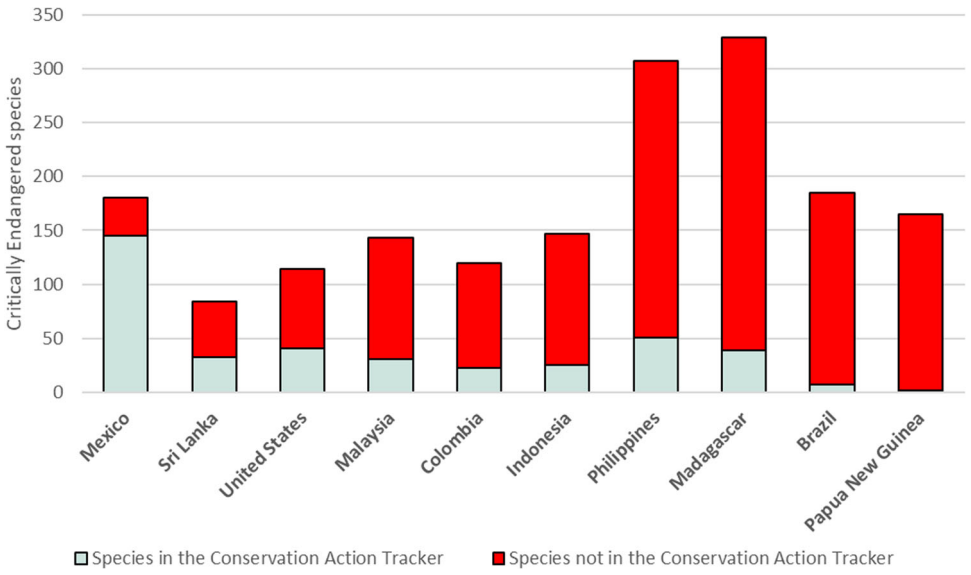

FIGURE 3 Number of tree species assessed as Critically Endangered within the top 10 countries with the highest number of Critically Endangered trees. The blue bars denote the number of Critically Endangered species with information in the Conservation Action Tracker. The red bars denote the number of Critically Endangered species lacking conservation action information.

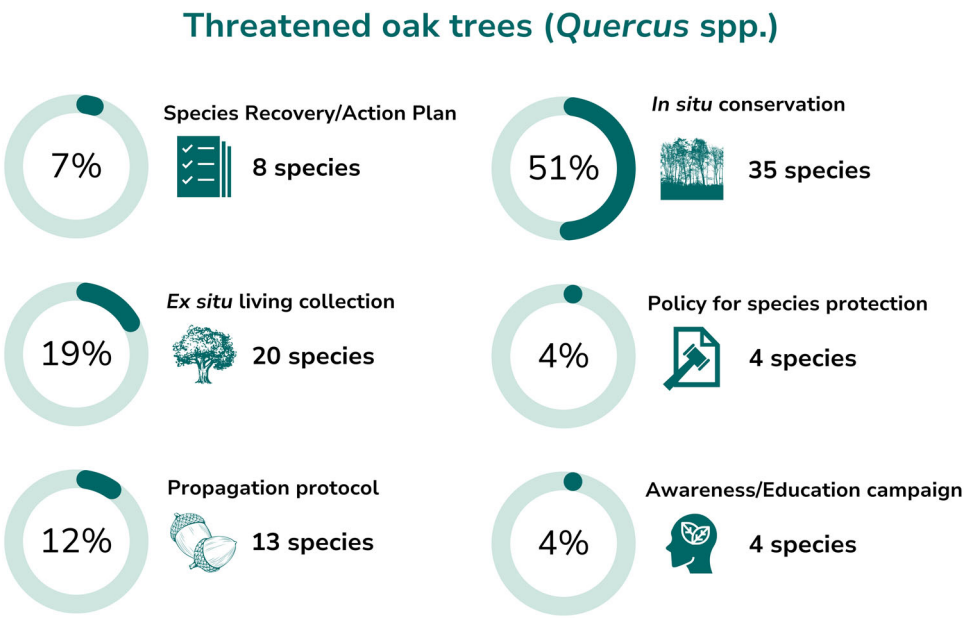

FIGURE 4 The percentage and number of threatened oak tree species with specific conservation actions added into the Conservation Action Tracker. In total, 108 threatened oak tree species are known.

collaboration and thereby avoiding effort duplication; (3) enabling the identification of gaps in the conservation of tree species worldwide; and (4) making the information available for use by conservationists, scientists, and decision-makers.

Sharing knowledge and enhancing collaboration

For species conservation, the species recovery/action plan and propagation protocol are essential. The species recovery/action plan acts as a roadmap for the recovery of threatened species by outlining what needs to be done and how best to achieve it (Boersma et al., 2001; Heywood et al., 2018). In addition, ex situ collections and the propagation protocol play a vital role in the restoration and recovery of plant species, as they enable the production of healthy plants that can be planted to bolster natural populations (Cochrane et al., 2007; Abeli et al., 2020). In the Conservation Action Tracker, these documents are made accessible for conservation practitioners, researchers, and educators. The sharing of these documents, and of conservation action information in general, enhances collaboration as it allows conservationists to identify ongoing projects and activities related to the same species or areas, work together more efficiently, and learn from one another. Additionally, this helps to prevent the duplication of efforts and allows resources to be directed to sectors where they are needed most. The propagation of threatened tree species can be challenging, often requiring specific treatments and conditions. Consequently, sharing established propagation protocols can significantly aid the process by conserving time and resources that would otherwise be spent on experimental trials, or guiding targeted experiments aimed at refining and improving propagation methods.

We recognize the importance of tailoring species recovery/action plans and propagation protocols to specific habitat, ecological, and climatic conditions (Boersma et al., 2001; Seglias et al., 2018). As a result, Conservation Action Tracker allows multiple species recovery/action plans and propagation protocols to be displayed for each species to ensure that conservation efforts can be adapted to diverse environmental contexts. In addition, although the information in the Conservation Action Tracker is at the species level, it may also be useful when planning conservation activities for a closely related taxon or specific geographic areas. For instance, closely related species often share similar propagation needs (Burns and Strauss, 2011; Seglias et al., 2018). Hence, sharing conservation action information is essential for effective and coordinated conservation efforts, ensuring that limited resources are used efficiently and knowledge is disseminated.

Identifying tree conservation gaps

Identifying gaps in species conservation facilitates the prioritization of conservation actions. This involves determining which species need the most urgent action, which conservation actions are required for each species, and what are the priority areas to concentrate future conservation efforts. This is particularly important as financial and human resources available for conservation efforts are limited. The identification of gaps can be done at the species level, and at the national or taxonomic levels, as

shown in the case studies for Kenya and oaks. For instance, although there is an ex situ collection for *Magnolia pallescens*, it is not representative of its wild distribution (Figure 1). Representative ex situ collections are needed, as they encapsulate the genetic diversity vital for the species' long-term survival and resilience (Guerrant et al., 2004). Based on the data in the Conservation Action Tracker, further steps should be taken to improve the ex situ collections of *M. pallescens* to ensure it represents the entire wild population of the species. For Kenyan trees, 135 threatened species are lacking a propagation protocol. From our results, we suggest prioritizing the development and sharing of propagation protocols, particularly for those species that are challenging to propagate. Furthermore, the conservation of oak trees going forward should prioritize the establishment of ex situ collections of wild origin, given that 81% of threatened oak trees are lacking such collections (Figure 4). The Conservation Action Tracker can be used to support conservation planning workshops (e.g., Harvey-Brown and Shaw, 2020; Harvey-Brown, 2023) and gap analyses (e.g., Beckman et al., 2019; Linsky et al., 2022) by providing data to help identify gaps and to make recommendations for future conservation actions. The resulting conservation actions will then be tracked using the Conservation Action Tracker.

While the information collated in the Conservation Action Tracker is useful for identifying conservation gaps, users should be careful in the conclusions they draw. The information presented here is based on the information currently available in the Conservation Action Tracker; therefore, the conservation gaps identified in the case studies might underestimate the conservation efforts already in place if these efforts are not documented there. Although our case studies on Kenyan trees and oaks were comprehensive analyses, we cannot yet have the same certainty for other groups. Hence, the absence of present conservation actions (shown as an orange cross in the Conservation Action Tracker) is also valuable information, as it highlights conservation gaps. Similarly, missing data—shown as a question mark in the Conservation Action Tracker—highlights a knowledge gap. Therefore, increasing the amount of data included in the Conservation Action Tracker will allow for more accurate identification of conservation action gaps and improved development of conservation recommendations.

Making conservation information available

The online nature of the data within the Conservation Action Tracker ensures that information is readily available to conservation practitioners, plant conservation organizations, scientists, and decision-makers, making it a valuable resource for guiding decision-making processes. The prioritization of plant species has often focused on the existence of ex situ collections, such as seed banking, or the presence of species within protected areas (Maxted et al., 2008; Nduche et al., 2023), as these are more easily measurable (e.g., via PlantSearch [BGCI, 2023f] and Protected Planet [UNEP-WCMC and IUCN, 2022]). However, seed banking is not applicable to exceptional species, which cannot be preserved this way (Pence et al., 2022), and being inside a protected area does not necessarily ensure that the species is effectively protected in the wild (Geldmann et al., 2019; Heywood, 2019). The Conservation Action Tracker provides information on other important conservation activities at the species level, enabling conservationists to go beyond basic analysis. These data empower decision-makers to make more informed choices about resource allocation, species and habitat prioritization, and the development of targeted conservation efforts.

Challenges and future directions

Conservation action information has not previously been collated on a global scale for tree species. Addressing this challenge demands collaboration and widespread networking to gather and consolidate data from around the world. We believe that BGCI has an advantageous position for gathering global conservation action information at the species level, thanks to its extensive network of botanic gardens, established taxonomic networks (e.g., GCC), and global participation in tree conservation activities, such as the Global Tree Assessment and BGCI's Tree Conservation Programme.

From the experience of collecting data, we have found the collection of data on the taxonomic (e.g., oaks) and country levels to be the most effective ways to gather conservation action information comprehensively. To gather conservation action data on a taxonomic level, we will continue to update GCC information annually and include information from conservation gap analyses that will be generated by the GCC network. For country-level information, we worked with in-country partners who have gathered information through surveys in the local language. In the future, we will continue to work with partners and seek additional funding to collate conservation action information for tree species around the world, particularly in megadiverse countries and countries with a high proportion of threatened tree species.

Conclusions

The Conservation Action Tracker can be used to aid better conservation practices. Most of the conservation action information that it contains is not found elsewhere, and collating the information into a single platform makes the Conservation Action Tracker the primary source for an overview on tree species conservation. Shared documents (e.g., propagation protocols and species recovery/action plans) can help disseminate knowledge, scale up conservation practices, and avoid duplication of effort. The information made available in the Conservation Action Tracker can increase collaboration and link international, regional, and

national efforts. By tracking global conservation actions over time, the Conservation Action Tracker enables the identification of conservation gaps and guides future conservation actions. Ultimately, this tool helps prioritize tree species in need of conservation by informing decision-makers to ensure resources and expertise are allocated more effectively in order to prevent the extinction of tree species. The Conservation Action Tracker's potential to support conservation will be greatly enhanced with the addition of more data, hence we make a call to tree conservation practitioners to join this effort and contribute information for the species they are working on.

AUTHOR CONTRIBUTIONS

Manuscript preparation was carried out by I.Q. and K.D. I.Q. performed data analysis and created figures and maps. M.R. assisted with proofreading and editing the manuscript. All authors approved the final version of the manuscript.

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DATA AVAILABILITY STATEMENT

The data are available on the GlobalTree Portal online at: https://www.bgci.org/resources/bgci-databases/globaltree-portal/. This information is available to be used in accordance with our data policies: https://www.bgci.org/terms-and-conditions/.

ORCID

Itxaso Quintana http://orcid.org/0000-0002-4650-2693
Malin Rivers http://orcid.org/0000-0001-9690-1353
Katharine Davies http://orcid.org/0000-0002-0938-0631

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