



## RESEARCH ARTICLE

## UN decade on ecosystem restoration

## Ecosystem restoration job creation potential in Brazil

Pedro H. S. Brancalion<sup>1,2</sup>  | Ludmila Pugliese de Siqueira<sup>1,2</sup> | Nino T. Amazonas<sup>3,4</sup> |  
 Mayte B. Rizek<sup>4</sup> | Alex F. Mendes<sup>1,2</sup> | Edson L. Santiami<sup>2</sup> | Ricardo Ribeiro Rodrigues<sup>5</sup> |  
 Miguel Calmon<sup>6</sup> | Rubens Benini<sup>7</sup> | Julio R. C. Tymus<sup>7</sup> | Karen D. Holl<sup>8</sup>  |  
 Rafael B. Chaves<sup>9,10,11</sup>

<sup>1</sup>Department of Forest Sciences, 'Luiz de Queiroz' College of Agriculture, University of São Paulo, Piracicaba, Brazil; <sup>2</sup>Atlantic Forest Restoration Pact, Campinas, Brazil; <sup>3</sup>Department of Botany, Biology Institute, Federal University of Rio de Janeiro, Rio de Janeiro, Brazil; <sup>4</sup>MN Socioflorestal, Rua Ana Simões de Oliveira, São Paulo, Brazil; <sup>5</sup>Department of Biological Sciences, 'Luiz de Queiroz' College of Agriculture, University of São Paulo, Piracicaba, Brazil; <sup>6</sup>World Resources Institute, Salvador, Brazil; <sup>7</sup>The Nature Conservancy, São Paulo, Brazil; <sup>8</sup>Environmental Studies Department, University of California, Santa Cruz, California, USA; <sup>9</sup>Secretariat for Infrastructure and Environment of the State of São Paulo, São Paulo, Brazil; <sup>10</sup>Brazilian Society for Ecological Restoration, Rua Fernando de Noronha, Londrina, Brazil and <sup>11</sup>Department of Ecology, Institute of Biosciences, University of São Paulo, São Paulo, Brazil

## Correspondence

Pedro H. S. Brancalion  
 Email: [pedrob@usp.br](mailto:pedrob@usp.br)

## Funding information

The Nature Conservancy; World Resources Institute

Handling Editor: Patricia Balvanera

## Abstract

1. The central motivation to restore ecosystems at a planetary scale has been to reverse degradation and provide multiple environmental benefits, but key global players like governments may be more interested in social outcomes from undertaking restoration, such as job creation. Assessing the job opportunities stemming from ongoing restoration programmes can leverage additional investments for their implementation and support their long-term maintenance.
2. Here, we aimed to understand and quantify current and potential ecosystem restoration jobs in Brazil, based on a widely distributed online survey performed in 2020 and led by the main restoration networks in the country. We explored the structure, job distribution and outputs of the national restoration supply chain.
3. At the beginning of 2020, 4713 temporary and 3510 permanent jobs were created, nearly 60% of which were generated by organizations specialized in restoration, mainly from the non-profit (48%) and private (37%) sectors.
4. Restoration jobs were concentrated in organizations working in one (58%) or two (28%) biomes, and the vast majority were in the Atlantic Forest (85%). Similarly, most restoration jobs were concentrated in the southeast region (61%), with one-third in the state of São Paulo. This geographical distribution was more strongly associated with the states' GDP than with the legal deficit of native vegetation area.
5. Nearly 20% of the restoration jobs were terminated during the COVID-19 pandemic in 2020.

This is an open access article under the terms of the [Creative Commons Attribution](https://creativecommons.org/licenses/by/4.0/) License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

© 2022 The Authors. *People and Nature* published by John Wiley & Sons Ltd on behalf of British Ecological Society.

6. We estimate that restoration activities can generate 0.42 jobs per hectare undergoing restoration, which could potentially create 1.0–2.5 million direct jobs through the implementation of Brazil's target of restoring 12 million hectares.
7. We conclude by reinforcing the value of ecosystem restoration in promoting economic development and job creation, which can be crucial to promote countries' effective engagement in the UN Decade on Ecosystem Restoration. We also highlight the critical role of grassroots organizations to maximize restoration opportunities for socioeconomic development during the post-pandemic economic recovery.

#### KEYWORDS

ecological restoration, forest restoration, green economy, green jobs, large-scale restoration, restoration economy, restoration socioeconomics, sustainable development

## 1 | INTRODUCTION

Ecosystem restoration has received unprecedented support from different sectors of society, often being considered a 'silver bullet' for myriad environmental and social problems. Restoration programmes have proliferated immensely, including pledges from over 60 countries to restore >200 million hectares of forest landscapes by 2030 as part of the Bonn Challenge, several tree planting programmes promoted by influential organizations like the World Economic Forum and the United Nations Environmental Program, and thousands of other initiatives led by varied groups such as large corporations, entrepreneurs, NGOs, local communities and celebrities (Holl & Brancalion, 2020). These initiatives include multiple restorative approaches (Gann et al., 2019), including ecological restoration, rehabilitating ecosystem functions and agroforestry, and were recently leveraged by the United Nations' Decade on Ecosystem Restoration (2021–2030), which is expected to mainstream dispersed programs as part of a unified global restoration movement (Aronson et al., 2020).

The central motivation to restore ecosystems at a planetary scale has been to reverse degradation and achieve multiple environmental benefits, including climate change mitigation and adaptation, biodiversity conservation and water security (Chazdon & Brancalion, 2019; Strassburg et al., 2020). Although most of the narrative and evidence-based practice supporting ecosystem restoration has relied on biodiversity and ecosystem services (Romanelli et al., 2021), key global players like governments may be more interested in social and economic outcomes for their constituents, such as job creation (BenDor, Livengood, et al., 2015; Mansuy & MacAfee, 2019). Unlike most restoration benefits, which often take decades to accrue (Moreno-Mateos et al., 2017) and therefore are perceived by society as long-term strategies, most restoration jobs are created at the beginning of the process. Promoting restoration is also expected to result in attractive return on investment, which varied from US\$7 to as much as US\$30 per dollar spent across over

100 projects distributed in different ecosystems and global regions (Bullock et al., 2011; De Groot et al., 2013; Ding et al., 2017).

The persistent knowledge gap concerning restoration socioeconomics is a central barrier to effective restoration design and efficient implementation (Aronson et al., 2010; Fernández-Manjarrés et al., 2018; Martin, 2017). In spite of the potential environmental benefits of large-scale restoration, there are important uncertainties related to the local social impacts, which highlight the value of understanding the contribution of restoration as a source of jobs. For instance, the implementation of global restoration commitments could displace local people and compromise local agro-pastoral production, in such a way that environmental benefits desired by developed countries (e.g. carbon sequestration) come at the expense of local economies and livelihoods in developing countries (Brancalion & Holl, 2020). It is critical that restoration initiatives are based on the free and informed consent of local communities and stakeholders. Timing, societal support and economic benefits are crucial for government decisions, so the creation of jobs is expected to be a key restoration outcome and to become part of the agenda of several countries in the near future, as clearly expressed by global leaders in the Climate Summit 2021. The global recession resulting from the COVID-19 pandemic has further magnified the appeal of restoration as an emerging source of green jobs (Hanna et al., 2020; Mansuy, 2020).

Past and current initiatives, such as the Civilian Conservation Corps in the United States (Maher, 2007), the Green Belt Movement in Kenya (Maathai, 2004), the Working for Water in South Africa (Bek et al., 2017) and the Grain for Green in China (Dang et al., 2020), are emblematic of the enormous potential of restoration activities to generate green jobs. In particular, these initiatives have favoured rural communities marginalized from the modern economy and contributed to economic recovery following the shocks resulting from natural resources depletion and economic recessions. The limited information available in the literature on job creation by restoration provides promising estimates, including the generation of

0.016–0.033 jobs per US\$1000 spent on restoration in the United States (BenDor, Lester, et al., 2015; Nielsen-Pincus & Moseley, 2013), and ~0.2 jobs per hectare restored in Brazil (Brasil, 2017; Calmon et al., 2011; Costa, 2016), yet the numbers for Brazil are rough estimates not based on surveys or with specific details.

More than establishing a general number of jobs potentially generated per hectare restored or dollar spent, it is critical to understand how jobs are distributed among restoration activities, geographical regions and other factors, so as to guide market and policy interventions to foster jobs creation. Ecosystem restoration relies on an integrated supply chain of products (e.g. seeds and seedlings), knowledge (e.g. understanding of site-specific socio-ecological features, ecological processes), familiarity with best practices on varying restoration activities and services (e.g. implementation, maintenance and monitoring) to be efficient. Bottlenecks in the supply chain, such as the lack of seedlings (Nevill et al., 2018; Silva et al., 2017) or specialized labour for different restoration activities, may constrain projects development, limit the amount and quality of restoration and prevent achieving both social and ecological benefits.

Here, we aimed to understand and quantify the current and potential ecosystem restoration jobs in Brazil. Based on an online survey led by the main restoration networks in the country, we explored the structure, job distribution and outputs of the national restoration supply chain. We estimated the number of jobs that could be created through Brazil's target to restore and reforest 12 million hectares of degraded land and ecosystems by 2030. Our overarching objective was to identify bottlenecks for upscaling ecosystem restoration and identify opportunities for policy interventions to transform restoration into an effective, vibrant economic activity with the potential to deliver critical benefits to people and nature during the UN Decade on Ecosystem Restoration. To our knowledge, this is one of the largest assessments of the ecological restoration job creation potential ever made, including the six Brazilian biomes and a variety of ecosystem types. Previous reviews have broadly addressed the importance of restoration for providing income and improving livelihoods (Adams et al., 2016; Erbaugh & Oldekop, 2018), yet have not quantified restoration jobs.

The first step to evaluating restoration outcomes is to clearly understand the regional motivations for restoration and the project-specific goals (Brancaion & Holl, 2020). Currently, in Brazil, restoration projects are mostly established to comply with a national legislation—the 2012 Native Vegetation Protection Law (Brancaion et al., 2016). To comply with this law, landowners must restore native vegetation (e.g. forests, savannas, grasslands) in environmentally fragile areas that were converted in the past, particularly around water bodies and along riparian buffers, and to achieve a percentage of the landholding covered by native vegetation (80% in the Amazon Forest and 20% in other biomes; Guidotti et al., 2020), which represent a pioneering and ambitious requirement for ecosystem restoration in the global context. Restoration has been mostly financed by the landowner, who can be fined or not receive environmental certification for exporting agricultural commodities if targeted areas are not restored. Quite often, NGOs provide financial support to

such compliance-led restoration in small to medium landholdings through payments for ecosystem services schemes and conservation programmes. This primary goal of legal compliance can be complemented by myriad other objectives (e.g. conservation of a targeted species, watershed protection, carbon stocking funded by international organizations) depending on the motivations and requirements of stakeholders financing restoration interventions. Therefore, ecosystem restoration in Brazil is mostly a private entrepreneurship, and the jobs created by demand from landowners responding to a technocratic obligation (Clewell & Aronson, 2013), with important financial risks and consequences imposed on them.

## 2 | METHODS

### 2.1 | The survey

A questionnaire (Appendix S1) was prepared and disseminated online from 11 August to 30 September 2020 through an outreach and engagement campaign led by the Brazilian Society for Ecological Restoration (584 associates), The Brazilian Coalition on Climate, Forests and Agriculture (281 organizations), The Alliance for Restoration of the Amazon (80 organizations) and The Atlantic Forest Restoration Pact (298 organizations) (Appendix S2), plus the valuable collaboration of several other formal and informal networks. This survey also resulted in the creation of an online platform to offer restoration products and services and serve as a hub for restoration organizations and individuals ('Restoration Glassdoor' or *Vitrine da Restauração*, in Portuguese). A total of 356 organizations responded to the survey, each of them represented by a single questionnaire. Some organizations did not answer all questions, so the sample size is not the same for every question. Our survey included organizations from 24 of the 26 Brazilian states and Brasília (the Federal District), missing only organizations from the states of Piauí and Tocantins, and covered many different ecosystem types (wetlands, temperate grasslands, tropical savannas, shrublands, dry and wet tropical and subtropical forests).

**Research ethics:** This research was carried out by the NGOs Atlantic Forest Restoration Pact, The Nature Conservancy, and World Resources Institute, which have internal ethical procedure that this survey was signed off against. Participants of the online survey signed an electronic consent term of participation.

### 2.2 | Data analysis

We focused our analysis on the number of jobs to better represent the participation and level of influence of organizations in restoration activities. We classified jobs as 'temporary' (i.e. seasonal jobs, in which people are only hired for part of the year) and permanent (i.e. jobs in which people become part of the ongoing staff of a given organization). We note that restoration supply chain is more complex than a simple flow of goods and services, and that our survey did not

assess it comprehensively. Rather, we focused on some important activities and stakeholder groups that partially constitute restoration supply chain and explored the geographical distribution of restoration jobs, based on the following classes:

- *types of activity*: seed collection, seedling production, implementation and maintenance, technical services (e.g. consultancy, project preparation, monitoring), others;
- *stakeholder groups*:
  - non-profit sector: cooperatives, associations and seed networks, which were further classified as local/municipal, state/regional and national/international;
  - private companies: classified according to their gross annual revenue, in Brazilian real (BRL)—large: revenue >R\$300M, medium: R\$4.8 M < revenue <R\$300M, small: R\$0.36 M < revenue < R\$4.8 M, and micro companies: revenue <R\$0.36 M (US\$1 = ~R\$5.0);
  - individual micro-entrepreneur;
  - farmers;
  - governments: classified as federal, state and municipal;
  - watershed committees;
- *biomes*: Pampas, Atlantic Forest, Cerrado, Pantanal, Caatinga and Amazon;
- *regions*: South, North, Northeast, Southeast and Central West (Figure S1);
- *states*: 26 states + the federal district (Figure S1).

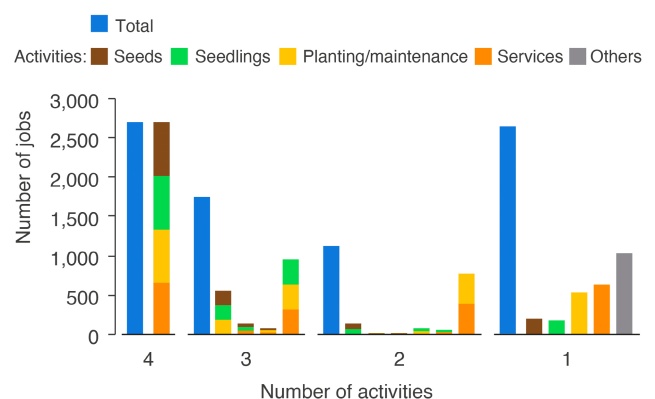
We further collected information on state gross primary product (GDP) and legal deficit of native vegetation in riparian areas (areas buffering water bodies and springs) according to the 2012 Native Vegetation Protection Law (Soares et al., 2014), and evaluated through linear regressions whether the number of jobs was more associated with the GDP of states or with their legal deficit of native vegetation. We excluded São Paulo data in this analysis because it was an outlier. For the analyses, we used information reported in 2019 (the most recent year before the pandemic) and GDP data from 2018. We also asked in the questionnaires how many jobs were terminated due to the COVID-19 pandemic.

We then estimated the number of jobs that could be created by the implementation of Brazil's target to restore and reforest 12 million hectares of degraded lands and forests, which is associated with the National Plan for Native Vegetation Recovery, the national pledge to the Bonn Challenge and the Nationally Determined Contribution to the Paris Climate Agreement. We based our estimates on the following assumptions: (i) the survey accurately represented the various elements of the restoration supply chain in Brazil and (ii) all reported activities and jobs (8223 jobs) are associated with the total restoration implementation area covered by the survey (19,426 ha). It is not possible to define the proportion of areas to be restored through passive and active restoration in Brazil's target

(i.e. broadly through natural regeneration and restoration plantings), so we considered the scenarios established by Brazil's National Plan for Native Vegetation Recovery (20%, 30%, 40% and 50% of active restoration; Brasil, 2017). We recognize that the survey may be biased towards active restoration and failed to estimate the number of jobs created by passive restoration, as reported by Brancalion et al. (2019). Although this national target is based on both ecological restoration and reforestation, without a specific target area for each activity, our analyses are based on the assumption that the whole target would be achieved through ecological restoration.

### 3 | RESULTS

The organizations that reported production data (325 out of 352) produced 93.6 t of seeds (49 questionnaires) and 19.6 million seedlings (97), planted 4.6 million seedlings (40), implemented 19,426 ha of restoration (72) and maintained 27,440 ha (67) during 2019. A total of 8223 restoration jobs were created, 57.3% of which were temporary and 42.7% were permanent. When organizations were asked to select one or more activities in which they were involved in (i.e. seed collection, seedling production, implementation and maintenance, and technical services), nearly one-third of these jobs were generated by that specialized in one particular restoration activity, mainly planting/maintenance and services in general; the rest were distributed across organizations performing multiple restoration activities (Figure 1). Jobs from seed and seedling production were mostly supplied by multitask restoration organizations (Figure 1). Most of the jobs were in organizations (e.g. local NGOs, companies specialized in restoration services) that focus on ecosystem restoration (28.3% and 21.1% of jobs in organizations for which restoration is their exclusive or main activity, respectively), whereas a lower proportion of restoration jobs were offered by organizations for which restoration was not a central activity (e.g. forest nurseries that primarily produce commercial tree species, consultant offices that mostly provide environmental



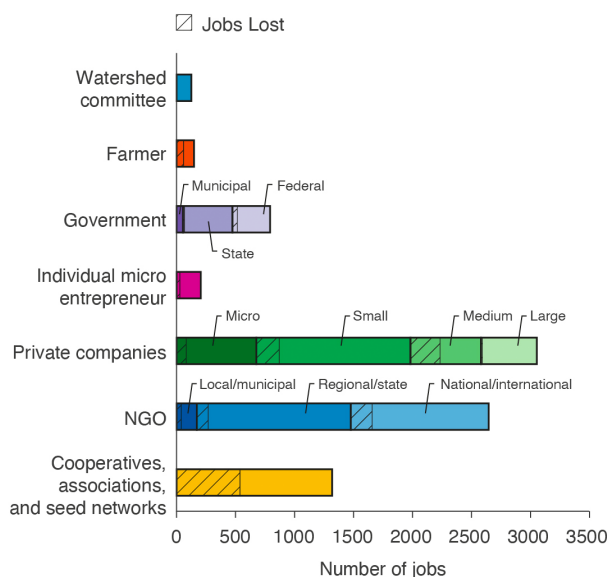
**FIGURE 1** Distribution of restoration jobs according to the number of activities performed by organizations. The colour(s) of the bars (except for the blue bar—Total) represent the composition of activities.

licensing services); 13.7% and 19.2% had restoration as a secondary and marginal activity, respectively.

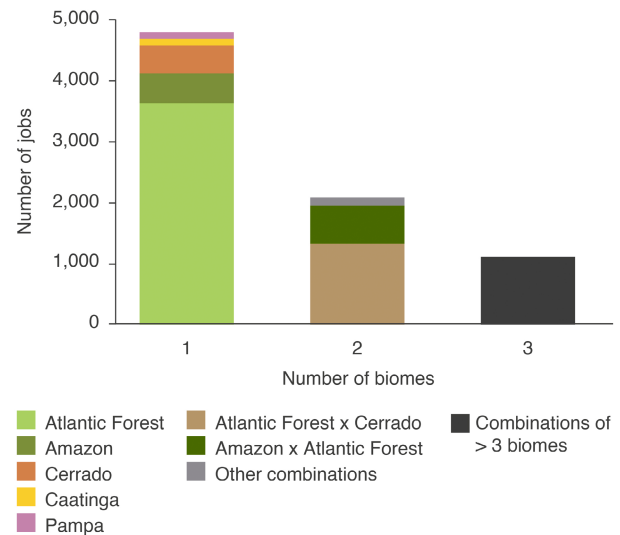
Most jobs were created by organizations from the non-profit (48%) and private (37%) sectors (Figure 2). In particular, (i) cooperatives, associations and seed networks; (ii) regional/state NGOs; (iii) national/international NGOs; and (iv) small private companies were the main sources of jobs, each of them accounting for nearly 15% of jobs (Figure 2). During the COVID-19 pandemic in 2020, nearly 20% of these jobs (512 permanent and 1043 temporary) were terminated; the jobs generated by farmers, medium-sized private companies and local/municipal NGOs were the most negatively impacted (Figure 2).

Most organizations worked in one (58%) or two (28%) biomes (Figure 3) and most restoration jobs were supplied by those restoring the Atlantic Forest exclusively (44%) and the Atlantic Forest and Cerrado together (16%; Figure 3). Only 15% of the restoration jobs reported in this survey did not involve any activity in the Atlantic Forest. Similarly, most restoration jobs were concentrated in the southeast region (61%; Figure 4), with nearly three-quarters concentrated in five states (33.7% in São Paulo state, 13.5% in Minas Gerais, 10.0% in Rio de Janeiro, 8.6% in Bahia and 6.6% in Paraná; Figure S1). This geographical concentration was more strongly associated with the states' GDP than with the legal deficit of native vegetation (Figure 5); these results not related to the state area ( $R^2 = 0.01$ ) or population ( $R^2 = 0.003$ ). Moreover, state area and population were not significantly correlated with the number of restoration jobs.

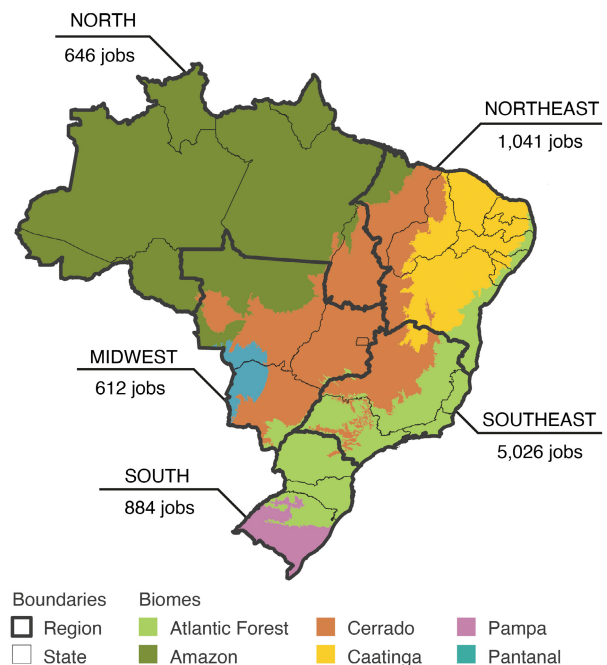
We estimated that restoration activities can generate 0.42 jobs per hectare (19,426 ha of restoration implementation created 8223 jobs), which could potentially create 1.0–2.5 million jobs based on the scenarios of 20%–50% of Brazil's restoration target, respectively, being implemented through active restoration.



**FIGURE 2** Distribution of restoration jobs according to stakeholder groups and number of jobs terminated during the COVID-19 pandemic in 2020.



**FIGURE 3** Distribution of restoration jobs across the Brazilian biomes. Bars represent the number of jobs generated by organizations that work (i) exclusively in one biome (colours represent the number of jobs per biome type), (ii) in two biomes (colour classes represent the number of jobs per different combinations of biomes) and (iii) three or more biomes.

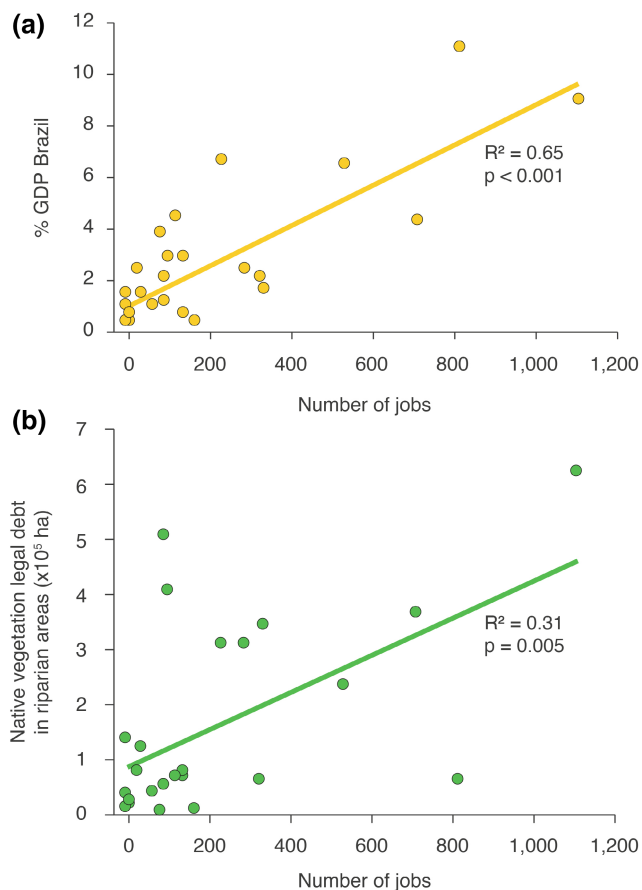


**FIGURE 4** Distribution of restoration jobs across Brazilian regions (see Figure S1 for distribution among states).

## 4 | DISCUSSION

Our assessment of ecosystem restoration jobs in Brazil illustrates that restoration is a complex, multistakeholder activity with marked geographical differences.

We showed several idiosyncrasies of restoration as an economic activity that must be addressed to evaluate the economic impact of



**FIGURE 5** Association between the number of restoration jobs and state GDP and the legal debt of native vegetation in riparian areas. Lines represent linear regressions without São Paulo state data, an outlier.

restoration. Our estimates that each hectare of restoration creates 0.42 jobs is nearly double the previous estimates of restoration jobs in Brazil (e.g. Brasil, 2017; Calmon et al., 2011; Costa, 2016), and indicates the potential to create 1.0–2.5 million direct jobs through the implementation of the national restoration target of 12 million hectares. Considering the estimate of BenDor, Lester, et al. (2015) for the United States that each direct restoration job was associated with 0.76 indirect jobs, the total number of jobs created by restoration in Brazil could reach 1.76–4.40 million.

Previous studies have demonstrated that restoration activities can be important for job creation in the United States (Edwards et al., 2013), South Africa (van Wilgen & Wannenburg, 2016) and the United Kingdom (GreenAlliance, 2021), and particularly for sectors of society with high unemployment. However, these studies were based on different methodologies and contexts, and for the most part did not conduct detailed analyses by region and restoration activity, so it is challenging to compare their results with ours. Despite the uniqueness of our study, we draw some general lessons that could potentially be extrapolated to other contexts and improve future surveys.

#### 4.1 | Profile of restoration jobs

We found a predominance of temporary, seasonal jobs in the restoration supply chain, with work concentrated in periods of peaking demand

(i.e. during the rainy season in Brazil) and reduced offers for stable, longer term job opportunities. Indeed, the seasonal nature of restoration jobs is a concern for growing the global restoration economy (Baker & Quinn-Davidson, 2011; BenDor, Lester, et al., 2015). Our results show that many restoration organizations focus on one or two primary activities, whereas diversifying the restoration activities that organizations perform can be a valuable strategy to increase the permanence of restoration jobs, since seed collection, seedling production, some maintenance activities, and project planning and monitoring require labour throughout the year. The quantity and quality of restoration jobs could then be expanded, and the chances of restoration failure reduced, if the maintenance period is increased and monitoring and adaptive management become integral components of projects (Holl, 2020). At the same time, diversification may enhance the overall management of restoration projects, it may reduce the efficiency of individual restoration activities as compared to specialization.

#### 4.2 | Restoration employers

The high proportion of non-specialized, multitask restoration organizations may also reflect the high level of instability of the restoration market. The lack of stable and predictable demand for restoration inputs and services over time may force restoration organizations to diversify their activities into different directions, either to activities not directly associated with restoration or different types of restoration activities within the supply chain. For instance, 71% of the nurseries in Brazil that produce native tree seedlings also commercialize exotic species as a way to diversify their income and be financially viable (Silva et al., 2017). Conversely, this result may suggest that organizations not previously dedicated to restoration are progressively including it as part of their portfolio of products and services, and can expand their participation in this sector if supportive market and policy instruments are established (Brancaion et al., 2017).

The prominent role that non-profit and private sectors play in restoration shows that it is a growing entrepreneurial activity. Although government regulations and policy interventions play a central role in restoration, and EMBRAPA (the [Brazilian Agricultural Research Corporation](#), a federal government agency) has contributed to the creation of restoration jobs in different Brazilian regions, our findings suggest that more jobs could be created if the market demand for restoration inputs and services increased. In the case of Brazil and other countries with specific legislation mandating restoration in private lands, the enforcement of legal compliance, combined with marked incentives, could boost the demand for restoration inputs and services, and therefore stimulate the creation of new jobs. In parallel, research and education centres would need to create specific programmes to meet the growing demand for well-trained professionals and novel technologies.

Conversely, many jobs can be terminated abruptly if market demand is reduced and environmental policies are weakened (BenDor, Livengood, et al., 2015), as occurred during the COVID-19 pandemic when nearly 20% of restoration jobs were terminated. The restoration sectors with higher proportion of terminated jobs during the

COVID-19 pandemic were those with lower levels of capital and higher dependency from external financial support, as farmers (46% of restoration jobs terminated); medium-sized private companies (42%); cooperatives, associations and seed networks (41%); and local/municipal NGOs (28%).

Cooperatives, seed networks, NGOs operating at the regional/state level and small private companies provide nearly half of all jobs, and were also some of the most impacted organizations by the COVID-19 pandemic, so these local, grassroots organizations require special financial aid to recover after the pandemic. In addition to providing a larger share of restoration jobs, local and community-based organizations can maximize the social benefits of those jobs and opportunities, improving local livelihoods while involving indigenous participation and promoting environmental justice throughout targeted territories (Urzedo et al., 2021). Brazil, like a number of Latin American countries, has been going through a long and intense process of rural outmigration, followed by a concentration of jobs in urban centres and reduction of jobs in the rural area due to agriculture mechanization (Aide & Grau, 2004; Baptista & Rudel, 2006; García-Barrios et al., 2009). Ecosystem restoration can become a powerful alternative to generate green jobs in rural areas, contributing to economic development and alleviating social problems in urban centres, as well as providing environmental benefits to society and the planet (GreenAlliance, 2021; Mansuy, 2020).

### 4.3 | Spatial distribution of restoration jobs

The high concentration of restoration jobs and overall investment in restoration in Brazil (Brancaion et al., 2019) in the southeastern region and in the Atlantic Forest biome is a result of multiple, intertwined factors that are difficult to disentangle. First, it likely reflects the economic inequalities among Brazilian states and suggests that restoration has been a 'luxury' environmental intervention promoted for those who can pay for it. Rather than concentrating restoration where it is most needed in terms of legal compliance, restoration jobs have been mostly promoted where the GDP is higher and organizations can afford to pay for it (Figure 5). Conversely, given that more than 40% and 60% of Brazil's population lives within the Southeast region and the Atlantic Forest biome, one could argue that restoration jobs are concentrated where they have the potential to supply ecosystem services to the most people, and potentially where environmental agencies and policies are more efficient.

Second, this geographical pattern of restoration may reflect historical legacies, as the restoration movement in Brazil originated in the Atlantic Forest (Rodrigues et al., 2009) and currently restoration research is concentrated in this region (Guerra et al., 2020). More funding needs to be invested in restoration of other biomes in Brazil. This geographical bias may be progressively reduced over time as the implementation of the 2012 Native Vegetation Protection Law advances (Brancaion et al., 2016). This revised law established a more efficient governance system than the previous 1965 Forest Code, including the creation of a national system for registering the

legal native vegetation deficit, a programme to foster legal compliance, economic incentives for restoration and a national policy for native vegetation recovery (Brancaion et al., 2016). Once this programme is fully operational, the number of jobs should increase substantially and be more equitably distributed across the country. However, there is a great deal of uncertainty regarding the impact of this law, as initial studies have not found clear evidence that the national registry has changed landowners' willingness to protect and restore native ecosystems (Jung et al., 2017; Rasmussen et al., 2016), and the current presidential administration has promoted a massive deregulation of environmental policies (Vale et al., 2021).

### 4.4 | Survey limitations

We acknowledge a slight geographical bias of our survey responses, as most of the leaders of the survey work in the Atlantic Forest are based in the southeast region, despite the fact that it was an online, national survey and we received responses from nearly all states. Furthermore, online surveys may underrepresent important restoration stakeholder groups, such as indigenous and traditional communities, small farmers and local NGOs and companies, who have less access to Internet and may prefer to be contacted through in-person meetings. We recommend that future surveys census restoration jobs in targeted regions, which could yield estimates less biased by sampling, and try to more thoroughly evaluate the entire restoration supply chain. Finally, we note that the assumptions we used to estimate job creation by achieving Brazil's restoration plan are simplistic and necessarily subject to the uncertainty regarding the extent of its implementation.

## 5 | CONCLUSION

We and other (e.g. BenDor, Lester, et al., 2015; GreenAlliance, 2021; van Wilgen & Wannenburg, 2016) demonstrate that ecosystem restoration is an emerging economic activity with relevant potential to generate jobs, especially through local organizations. In Brazil, this potential mostly has been leveraged by the financial capacity of states to pay for restoration activities, which highlight the critical role of financial incentives, appropriate policies, and the development of markets for restoration goods and services to create new jobs, especially in less economically developed regions. We conclude by underscoring the potential value of ecosystem restoration to promote economic development and the creation of jobs, which can be crucial for the effective engagement of countries in the U.N. Decade on Ecosystem Restoration (Aronson et al., 2020; Edwards et al., 2021), and highlighting the critical role of grassroots organizations to maximize restoration opportunities for the socioeconomic development in times of post-pandemic economic recovery.

Restoration jobs are one of the most efficient options to address prosperity not only with social inclusiveness, the

predominant focus across many U.N. Sustainable Development Goals, but also adding ecological inclusiveness (Gupta & Vegelin, 2016). However, to realize these potential outcomes requires that successful restoration have a funding commitment longer than 1–2 years (Iftekhar et al., 2017), and that restoration funding, particularly from national and international players, should be expanded and more equitably distributed across regions and biomes (Brancalion & Holl, 2020). Our study is the first countrywide study of job restoration creation potential and we strongly recommend that other countries evaluate restoration jobs and multiple aspects of the restoration supply chain which will be invaluable in stimulating momentum for and investment in ecosystem at the societal level.

#### AUTHORS' CONTRIBUTIONS

P.H.S.B., L.P.d.S., A.F.M., E.L.S., R.R.R., M.C., R.B., J.R.C.T. and R.B.C. conceived the idea and designed the study; N.T.A. and M.B.R. conducted the surveys; N.T.A., M.B.R. and P.H.S.B. analysed the data; P.H.S.B. and K.D.H. led the writing. All authors contributed to the writing and gave final approval for publication.

#### ACKNOWLEDGEMENT

The Nature Conservancy and World Resources Institute are acknowledged for financial support.

#### CONFLICT OF INTEREST

Dr. Pedro H. S. Brancalion and Dr. Ricardo R. Rodrigues are co-founders of Re.green company and member of its scientific advisory board. Dr. Pedro H. S. Brancalion receives research funding from the Suzano Company that pays for student scholarships and fieldwork costs. Dr. Karen Holl does unpaid advising for a few organizations involved in tree growing, including Conservational International, Reforest'Action and Milkywire.

#### DATA AVAILABILITY STATEMENT

The dataset for this study is available from the Data available via Zenodo Repository <https://doi.org/10.5281/zenodo.6574824> (Brancalion et al., 2022).

#### ORCID

Pedro H. S. Brancalion  <https://orcid.org/0000-0001-8245-4062>

Karen D. Holl  <https://orcid.org/0000-0003-2893-6161>

#### REFERENCES

- Adams, C., Rodrigues, S. T., Calmon, M., & Kumar, C. (2016). Impacts of large-scale forest restoration on socioeconomic status and local livelihoods: What we know and do not know. *Biotropica*, 48, 731–744.
- Aide, T. M., & Grau, H. R. (2004). Globalization, migration, and Latin American ecosystems. *Science*, 305, 1915–1916.
- Aronson, J., Blignaut, J. N., Milton, S. J., Le Maitre, D., Esler, K. J., Limouzin, A., Fontaine, C., De Wit, M. P., Mugido, W., Prinsloo, P., Van Der Elst, L., & Lederer, N. (2010). Are socioeconomic benefits of restoration adequately quantified? A meta-analysis of recent papers (2000–2008) in restoration ecology and 12 other Scientific Journals. *Restoration Ecology*, 18, 143–154.
- Aronson, J., Goodwin, N., Orlando, L., Eisenberg, C., & Cross, A. T. (2020). A world of possibilities: Six restoration strategies to support the united Nation's decade on ecosystem restoration. *Restoration Ecology*, 28, 730–736.
- Baker, J. M., & Quinn-Davidson, L. N. (2011). Jobs and community in Humboldt County, California. In D. Egan, E. E. Hjerpe, & J. Abrams (Eds.), *Human dimensions of ecological restoration: Integrating science, nature, and culture* (pp. 221–237). Island Press/Center for Resource Economics.
- Baptista, S. R., & Rudel, T. K. (2006). A re-emerging Atlantic forest? Urbanization, industrialization and the forest transition in Santa Catarina, southern Brazil. *Environmental Conservation*, 33, 195–202.
- Bek, D., Nel, E., & Binns, T. (2017). Jobs, water or conservation? Deconstructing the green economy in South Africa's working for water Programme. *Environmental Development*, 24, 136–145.
- BenDor, T., Lester, T. W., Livengood, A., Davis, A., & Yonavjak, L. (2015). Estimating the size and impact of the ecological restoration economy. *PLoS ONE*, 10, e0128339.
- BenDor, T. K., Livengood, A., Lester, T. W., Davis, A., & Yonavjak, L. (2015). Defining and evaluating the ecological restoration economy. *Restoration Ecology*, 23, 209–219.
- Brancalion, P. H. S., Garcia, L. C., Loyola, R., Rodrigues, R. R., Pillar, V. D., & Lewinsohn, T. M. (2016). A critical analysis of the native vegetation protection law of Brazil (2012): Updates and ongoing initiatives. *Natureza & Conservacao*, 14, 1–15.
- Brancalion, P. H. S., & Holl, K. D. (2020). Guidance for successful tree planting initiatives. *Journal of Applied Ecology*, 57, 2349–2361.
- Brancalion, P. H. S., Lamb, D., Ceccon, E., Boucher, D., Herbohn, J., Strassburg, B., & Edwards, D. P. (2017). Using markets to leverage investment in forest and landscape restoration in the tropics. *Forest Policy and Economics*, 85, 103–113.
- Brancalion, P. H. S., Meli, P., Tymus, J. R. C., Lenti, F. E. B., Benini, R. M., Silva, A. P. M., Isernhagen, I., & Holl, K. D. (2019). What makes ecosystem restoration expensive? A systematic cost assessment of projects in Brazil. *Biological Conservation*, 240, 108274.
- Brancalion, P., Siqueira, L., Amazonas, N., Rizek, M., Mendes, A., Santiami, E., Rodrigues, R., Calmon, M., Benini, R., Tymus, J., Holl, K., & Chaves, R. (2022). Data for "Ecosystem restoration job creation potential in Brazil".
- Brasil. (2017) Plano Nacional de Recuperação da Vegetação Nativa (PLANAVEG). (ed. Ministry of Environment), pp. 73. Ministry of Environment, Brasilia.
- Bullock, J. M., Aronson, J., Newton, A. C., Pywell, R. F., & Rey-Benayas, J. M. (2011). Restoration of ecosystem services and biodiversity: Conflicts and opportunities. *Trends in Ecology & Evolution*, 26, 541–549.
- Calmon, M., Brancalion, P. H. S., Paese, A., Aronson, J., Castro, P., da Silva, S. C., & Rodrigues, R. R. (2011). Emerging threats and opportunities for large-scale ecological restoration in the Atlantic Forest of Brazil. *Restoration Ecology*, 19, 154–158.
- Chazdon, R., & Brancalion, P. (2019). Restoring forests as a means to many ends. *Science*, 365, 24–25.
- Clewell, A. F., & Aronson, J. (2013). *Ecological restoration: Principles, values, and structure of an emerging profession*. Island Press.
- Costa, M. M. (2016). Financiamento para a Restauração Ecológica no Brasil. In A. P. M. Silva, H. R. Marques, & R. H. R. Sambuichi (Eds.), *Mudanças no código florestal brasileiro: Desafios para a implementação da nova lei* (pp. 235–260). IPEA.
- Dang, X., Gao, S., Tao, R., Liu, G., Xia, Z., Fan, L., & Bi, W. (2020). Do environmental conservation programs contribute to sustainable livelihoods? Evidence from China's grain-for-green program in northern Shaanxi province. *Science of the Total Environment*, 719, 137436.
- De Groot, R. S., Blignaut, J., Ploeg, S., Aronson, J., Elmqvist, T., & Farley, J. (2013). Benefits of investing in ecosystem restoration. *Conservation Biology*, 27, 1286–1293.



- Ding, H., Altamirano, J. C., Anchondo, A., Faruqi, S., Verdone, M., Wu, A., Zamora, R., Chazdon, R., & Vergara, W. (2017). *Roots of prosperity: The economics and finance of restoring land*. World Resources Institute.
- Edwards, D. P., Cerullo, G. R., Chomba, S., Worthington, T. A., Balmford, A. P., Chazdon, R. L., & Harrison, R. D. (2021). Upscaling tropical restoration to deliver environmental benefits and socially equitable outcomes. *Current Biology*, *31*, R1326–R1341.
- Edwards, P. E. T., Sutton-Grier, A. E., & Coyle, G. E. (2013). Investing in nature: Restoring coastal habitat blue infrastructure and green job creation. *Marine Policy*, *38*, 65–71.
- Erbaugh, J. T., & Oldekop, J. A. (2018). Forest landscape restoration for livelihoods and well-being. *Current Opinion in Environmental Sustainability*, *32*, 76–83.
- Fernández-Manjarrés, J. F., Roturier, S., & Bilhaut, A. (2018). The emergence of the social-ecological restoration concept. *Restoration Ecology*, *26*, 404–410.
- Gann, G. D., McDonald, T., Walder, B., Aronson, J., Nelson, C. R., Jonson, J., Hallett, J. G., Eisenberg, C., Guariguata, M. R., Liu, J., Hua, F., Echeverría, C., Gonzales, E., Shaw, N., Decler, K., & Dixon, K. W. (2019). International principles and standards for the practice of ecological restoration. Second edition. *Restoration Ecology*, *27*, S1–S46.
- García-Barrios, L., Galván-Miyoshi, Y. M., Valsieso-Pérez, I. A., Masera, O. R., Bocco, G., & Vandermeer, J. (2009). Neotropical Forest conservation, agricultural intensification, and rural out-migration: The Mexican experience. *Bioscience*, *59*, 863–873.
- GreenAlliance. (2021). *Jobs for a green recovery: Levelling up through nature*. Green Alliance.
- Guerra, A., Reis, L. K., Borges, F. L. G., Ojeda, P. T. A., Pineda, D. A. M., Miranda, C. O., de Lima Maidana, D. P. F., dos Santos, T. M. R., Shibuya, P. S., Marques, M. C. M., Laurance, S. G. W., Garcia, L. C., & Garcia, L. C. (2020). Ecological restoration in Brazilian biomes: Identifying advances and gaps. *Forest Ecology and Management*, *458*, 117802.
- Guidotti, V., Ferraz, S. F. D. B., Pinto, L. F. G., Sparovek, G., Taniwaki, R. H., Garcia, L. G., & Brancalion, P. H. S. (2020). Changes in Brazil's Forest code can erode the potential of riparian buffers to supply watershed services. *Land Use Policy*, *94*, 104511.
- Gupta, J., & Vegelin, C. (2016). Sustainable development goals and inclusive development. *International Environmental Agreements: Politics, Law and Economics*, *16*, 433–448.
- Hanna, R., Xu, Y., & Victor, D. G. (2020). After COVID-19, green investment must deliver jobs to get political traction. *Nature*, *582*, 178–180.
- Holl, K. D. (2020). *Primer of ecological restoration*. Island Press.
- Holl, K. D., & Brancalion, P. H. S. (2020). Tree planting is not a simple solution. *Science*, *368*, 580–581.
- Iftexhar, M. S., Polyakov, M., Ansell, D., Gibson, F., & Kay, G. M. (2017). How economics can further the success of ecological restoration. *Conservation Biology*, *31*, 261–268.
- Jung, S., Rasmussen, L. V., Watkins, C., Newton, P., & Agrawal, A. (2017). Brazil's National Environmental Registry of rural properties: Implications for livelihoods. *Ecological Economics*, *136*, 53–61.
- Maathai, W. (2004). *The Green Belt movement: Sharing the approach and the experience*. Lantern Books.
- Maher, N. M. (2007). *Nature's new Deal: The civilian conservation corps and the roots of the American environmental movement*. Oxford University Press.
- Mansuy, N. (2020). Stimulating post-COVID-19 green recovery by investing in ecological restoration. *Restoration Ecology*, *28*, 1343–1347.
- Mansuy, N., & MacAfee, K. (2019). More than planting trees: Career opportunities in ecological restoration. *Frontiers in Ecology and the Environment*, *17*, 355–356.
- Martin, D. M. (2017). Ecological restoration should be redefined for the twenty-first century. *Restoration Ecology*, *25*, 668–673.
- Moreno-Mateos, D., Barbier, E. B., Jones, P. C., Jones, H. P., Aronson, J., Lopez-Lopez, J. A., McCrackin, M. L., Meli, P., Montoya, D., & Benayas, J. M. R. (2017). Anthropogenic ecosystem disturbance and the recovery debt. *Nature Communications*, *8*, 14163.
- Nevill, P. G., Cross, A. T., & Dixon, K. W. (2018). Ethical seed sourcing is a key issue in meeting global restoration targets. *Current Biology*, *28*, R1378–R1379.
- Nielsen-Pincus, M., & Moseley, C. (2013). The economic and employment impacts of Forest and watershed restoration. *Restoration Ecology*, *21*, 207–214.
- Rasmussen, L. V., Jung, S., Brites, A. D., Watkins, C., & Agrawal, A. (2016). Understanding smallholders' intended deforestation behavior in the Brazilian Cerrado following environmental registry. *Environmental Research Letters*, *12*, 094001.
- Rodrigues, R. R., Lima, R. A. F., Gandolfi, S., & Nave, A. G. (2009). On the restoration of high diversity forests: 30 years of experience in the Brazilian Atlantic Forest. *Biological Conservation*, *142*, 1242–1251.
- Romanelli, J. P., Meli, P., Naves, R. P., Alves, M. C., & Rodrigues, R. R. (2021). Reliability of evidence-review methods in restoration ecology. *Conservation Biology*, *35*, 142–154.
- Silva, A. P. M., Schweizer, D., Rodrigues Marques, H., Cordeiro Teixeira, A. M., Nascente dos Santos, T. V. M., Sambuichi, R. H. R., Badari, C., Gaudare, U., & Brancalion, P. H. S. (2017). Can current native tree seedling production and infrastructure meet an increasing forest restoration demand in Brazil? *Restoration Ecology*, *25*, 509–515.
- Soares, B., Rajao, R., Macedo, M., Carneiro, A., Costa, W., Coe, M., Rodrigues, H., & Alencar, A. (2014). Cracking Brazil's forest code. *Science*, *344*, 363–364.
- Strassburg, B. B. N., Iribarrem, A., Beyer, H. L., Cordeiro, C. L., Crouzeilles, R., Jakovac, C. C., Junqueira, A. B., Lacerda, E., Latawiec, A. E., Balmford, A., Brooks, T. M., Butchart, S. H. M., Chazdon, R. L., Erb, K.-H., Brancalion, P., Buchanan, G., Cooper, D., Diaz, S., Donald, P. F., ... Visconti, P. (2020). Global priority areas for ecosystem restoration. *Nature*, *586*, 724–729.
- Urzedo, D., Pedrini, S., Vieira, D. L. M., Sampaio, A. B., Souza, B. D. F., Campos-Filho, E. M., Piña-Rodrigues, F. C. M., Schmidt, I. B., Junqueira, R. G. P., & Dixon, K. (2021). Indigenous and local communities can boost seed supply in the UN decade on ecosystem restoration. *Ambio*, *51*, 557–568.
- Vale, M. M., Berenguer, E., Argollo de Menezes, M., Viveiros de Castro, E. B., Pugliese de Siqueira, L., & Portela, R. D. C. Q. (2021). The COVID-19 pandemic as an opportunity to weaken environmental protection in Brazil. *Biological Conservation*, *255*, 108994.
- van Wilgen, B. W., & Wannenburg, A. (2016). Co-facilitating invasive species control, water conservation and poverty relief: Achievements and challenges in South Africa's working for water programme. *Current Opinion in Environmental Sustainability*, *19*, 7–17.

## SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

**How to cite this article:** Brancalion, P. H. S., de Siqueira, L. P., Amazonas, N. T., Rizek, M. B., Mendes, A. F., Santiami, E. L., Rodrigues, R. R., Calmon, M., Benini, R., Tymus, J. R. C., Holl, K. D., & Chaves, R. B. (2022). Ecosystem restoration job creation potential in Brazil. *People and Nature*, *00*, 1–9. <https://doi.org/10.1002/pan3.10370>