WHERE TO RESTORE?

USING SPATIAL DATA TO INFORM RESTORATION PRIORITIZATION FOR CLIMATE, BIODIVERSITY, AND COMMUNITY BENEFITS.

CONSERVATION INTERNATIONAL

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COVER PHOTO: CLOUD FOREST OF THE EL DORADO RESERVE IN THE SIERRA NEVADA DE SANTA MARTA, COLUMBIA

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EXECUTIVE SUMMARY

Effective forest restoration strategies are urgently needed to mitigate climate change and restore biodiversity, water, and soils. But too often, trees are planted as a go-to approach without considering the social and ecological context. Identifying where to restore – where restoration is most likely to succeed and bring the most benefits – is critical. Equally important is choosing a restoration approach that fits the local ecological and social context, project goals, and budget.

This guide describes a process for using readily available spatial data to identify restoration opportunities at national, landscape, and local scales. It also lays out a series of restoration options for restoring forests, and the ecological and social contexts that they are best suited for. Together, these help planners and practitioners decide where and how to restore forests.

SELECTING SITES FOR RESTORATION

Forest restoration can produce many outcomes, from increasing local food security and improving livelihoods to protecting biodiversity to sequestering carbon. Often goals are synergistic or compatible, but sometimes trade-offs are involved. Gathering stakeholders to set concrete goals for restoration is a critical first step to identifying restoration opportunities: goals will guide which characteristics are used and how important each is. Identifying project goals should be an iterative process involving relevant stakeholders. Goals should be concrete enough to drive action but flexible enough to accommodate the local context once sites are identified.

Using established goals, the next step is identifying what information is most important, and finding available data. Data layers are then mapped to identify priority areas for restoration. Maps can be used to engage planners, practitioners and other key stakeholders in the site selection process, and to illicit feedback. Once potential areas are identified at a courser scale, practitioners can also use maps to engage with the landscapes and locales to make sure restoration is appropriate on the ground.

CHOOSING A RESTORATION APPROACH

There are many ways to restore a forest. Practitioners and planners should choose an approach (or approaches) that best fits the landscape and local context, and the project goals. This guide provides information on different options for restoration, and this section can be used once a site has been selected using the process above, or as stand-alone guidance.

To effectively choose a restoration approach, practitioners require 1) a set of goals for restoration; 2) information on the condition of the land and its ability to naturally regenerate in forests; and 3) an in-depth understanding of the local political and social context, including livelihood strategies, land and tree tenure arrangements, and local needs for restoration. With this information, practitioners can select an approach that works with the local context to achieve project goals within projects constraints (budget, timeframe, scale).

Combined, the two sections of this guide provide an accessible, straightforward approach to identifying where the best options for restoration are, and how to make limited resources go farther by selecting the most appropriate method to meet project goals.

INTRODUCTION

TO CONFRONT THE CLIMATE CRISIS, THE WORLD NEEDS TO COLLECTIVELY PROTECT AND CONSERVE EXISTING FOREST, SUSTAINABLY MANAGE FORESTS IN USE, AND RESTORE DEFORESTED AREAS.

Forest restoration is the only shovel-ready, large-scale way to remove carbon dioxide from the atmosphere (1). Nations around the world have committed to restoring 350 million hectares – an area bigger than the size of India – by 2030 through the Bonn Challenge. Support for tree planting has also skyrocketed through virtual platforms and large-scale planting campaigns. Despite this enthusiasm, on-the-ground restoration progress has been painstakingly slow and large-scale tree planting campaigns often fail to provide their promised climate mitigation, biodiversity conservation, or livelihood benefits (2). Efforts often default to tree planting rather than choosing a restoration strategy based on project goals and context. Considering alternative options can reduce costs, increase success rates for both social and environmental outcomes, and improve efforts to scale up restoration globally.

Restoring forests to mitigate climate change can also be a win-win for communities and biodiversity. For example, forests could be restored to enhance landscape connectivity and therefore aid migration critical to species conservation in a changing environment. Biodiverse forests are often more resiliant to climate change impacts. Implementation using principles of community and stakeholder engagement, good governance, livelihood compatibility, and sustainably managing and maintaining native forests can help restored forests persist on the landscape - which is fundamental to attaining long-term goals such as carbon sequestration, benefits to communities, and biodiversity conservation. This guide provides critical information on where and how to prioritize restoration actions that will unlock efficient restoration and use a range of strategies at scale. Unlike many existing resources, it outlines how to combine social and ecological information, and it provides guidance for identifying opportunities that range from national to local scales.

This guide explains how to use spatial data to identify opportunities for restoration, and presents a wide range of alternative restoration strategies suited to different ecological and socioeconomic contexts. The goal of this guide is to help countries, projects, and organizations identify where and how to restore forests using readily available data (3). It focuses on restoration that facilitates forest succession, enhances forest resilience in the face of climate change, and complements existing forest conservation initiatives (4, 5). The restoration strategies highlighted here include assisted natural regeneration, silvopasture, agroforestry, applied nucleation, direct seeding, enrichment planting, and tree planting. Aimed at practitioners and restoration managers, we detail how to use spatial data to decide where to restore (Figure 1), and provide information on different strategies to inform restoration on the ground.


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The process described here relies on having a clear set of goals and priorities articulated through a multi-stakeholder, inclusive process. Where ecological conditions and social needs allow, it promotes using natural regeneration, and planting diverse native species of trees in areas that require more intensive intervention (6). This guide also helps identify and prioritize areas for restoration to meet specific objectives such as improved water resources, food security, and/or species-specific habitats. In all cases, the adopted strategies must be informed by traditional and scientific knowledge.

Restoration works best when it is grounded in the local ecological and socioeconomic context. It is crucial that restoration projects focused on climate mitigation and adaptation also incorporate community benefits and native biodiversity. Employing spatial and non-spatial data on existing ecological, socioeconomic, and political conditions and risks will help determine what restoration strategies are likely to be successful in a landscape (7).

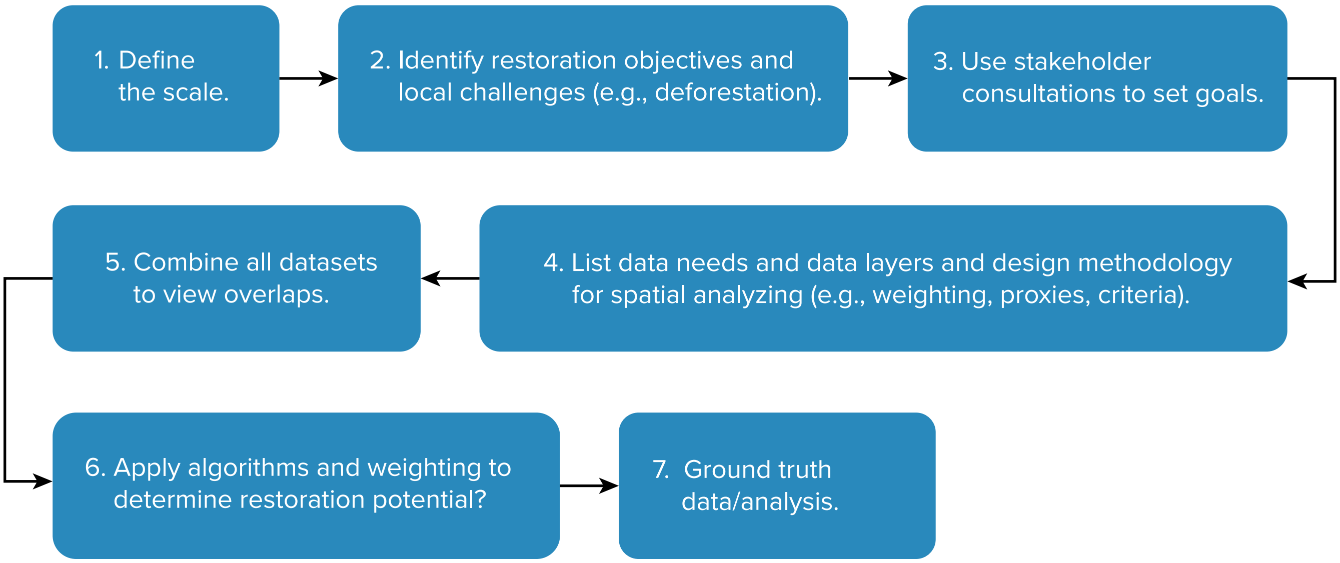
Other guidance exists for identifying restoration opportunities, especially at large scales (Box 1). This guide is intended to complement existing resources, including the Restoration Opportunities Assessment Methodology (ROAM) framework, by providing more detail on the types of spatial data available at various geographic scales. It also provides comparative information on different restoration strategies in varying ecological, political and socioeconomic contexts. This guide allows users to start big and hone in on specific regions, landscapes and communities where restoration has a high chance of success. It provides information on key data types at each level (macro, landscape or local) that will help to strategically locate restoration projects and identify cost-effective strategies suited to local context. Even if planning for restoration happens at the macro or landscape scale, all restoration occurs on parcels of land at the local level. Restoration success will depend heavily on how project planners engage community priorities and perspectives.

THE IMPORTANCE OF DATA AND SPATIAL ANALYSIS IN PLANNING RESTORATION

Incorporating spatial analysis into restoration planning can help inform project design, set baselines, facilitate monitoring, direct scarce resources and investments to areas the most in need, and justify the choice of project location to investors and other stakeholders. Relevant data can be spatial, non-spatial, or not currently spatial but transformable into a spatial representation. However, spatial products should always be ground-truthed and developed and/or used in consultation with stakeholders about what is feasible, relevant, and in the interests of the community where the restoration intervention will take place. The results of a spatial analysis should 1) target areas where restoration investments are most needed to produce results for communities, climate, and biodiversity; and 2) establish baseline information for monitoring the progress of restoration outcomes.

Some key data types used in this process are easier to obtain than others. For example, land use data is sometimes difficult to come by, but can be critical to identify land use transitions that might affect restoration; land tenure data is key for understanding the potential for adoption and restoration longevity. Restoration priorities and data choices will be location specific and will interact with each other. For example, a restoration objective of restoring biodiverse forests that are climate-resilient might require data layers on current levels of forest degradation and projected shifts in temperature or precipitation (See Section 1 on key data types). This information can then be used to identify and prioritize the most appropriate restoration strategy within the targeted area (See Section 2 on mapping). In all cases, conversations with a diverse set of stakeholders are essential (See Section 3 on prioritization). Understanding potential challenges will also help to choose what data layers to include and how to perform the analysis. This could involve assessing technical capacity, internet bandwidth of team members with key skills, staff availability, and balancing scientific rigor with practicality (See Section 4 on challenges). The case studies at the end of this document (Section 6) show how two teams from across the world, each with a unique context, were able to complete this process.

FIGURE 1: STEPS FOR USING SPATIAL ANALYSIS TO IDENTIFY RESTORATION OPPORTUNITIES.



AMAZONIA LIVE - REFORESTATION IN BRAZIL MUVUCA

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SECTION 1:

KEY DATA TYPES TO IDENTIFY RESTORAITON OPPORTUNITIES

ECOLOGICAL CONTEXT

Considering the ecological context identifies the extent and location of deforested areas, where land use trends may best support restoration, and where existing forests might facilitate restoration.

What is the historical, current, and potential forest cover? What is the proximity to forests? How accessible is the area of interest? What is the condition of those forests?

From an ecological perspective, only areas that were previously forest should be considered for forest restoration opportunities to avoid damage to other ecosystems with key importance in the landscape. It is important to understand 1) the entire area of pre-human disturbance tree cover/forest (including areas that are still forested); or if a country has been deforested for a long time, 2) areas that are thought to have been forest using forest potential maps or data combining climatic and other data to identify the conditions that may have been amenable to native forests.

Recommended weighting: Positive weighting to areas previously forested or near existing forest cover. Proximity to existing forests and more recent clearing profiles are especially important for the assisted natural regeneration and applied nucleation methods that rely on local seed rain (See Section 3, Table 2 below), although planted areas will also benefit from being close to natural forests.

Note: Both land cover and land use will be referenced throughout this guide. For the purposes of this guide, land cover is defined as the land type (i.e., forests, wetlands, urban) and land use is defined as how humans use the land (i.e., agriculture, timber, mining).

At the **macro level,** spatial data may include layers showing deforestation or degradation, time since clearing, climate, potential productivity, and forest proximity. National forest cover/land use/land cover data layers may contain some of this information. The imagery resolution should be fine enough to pick up on parcels of land that are amenable to regrowing forest cover or distinguish different forest types. Note that young forest recovery often does not show up as 'forest' in satellite imagery - this should be combined with ground data and/or interviews.

At the **landscape level,** data may include satellite imagery showing increasing or decreasing vegetation in recent years. Finer resolution data or conversations with partners at the regional level could determine the time since clearing and identify the presence of smaller forest fragments that could aid recovery but might not show up on a larger-scale analysis (i.e. land use trajectories, level of degradation, past land use; 9).

At the **local level**, partners can help to identify areas where natural regeneration has started and/or areas experiencing deforestation, degradation or that are threatened. Data sources include interviews with local partners; vegetation surveys; more detailed forest degradation and land cover maps if available, and surveys or existing studies of regional livelihoods and land/forest reliance. Field visits and baseline ecological surveys can identify remnant trees and small forest fragments on the landscape that provide significant seed sources. Large-scale forest cover analyses may miss these smaller seed sources, so collecting data at smaller scales is key to their identification.

What is the condition (intact/compact/eroded) of the soil? What is the erodibility of the soil? What does the type of soil say about restoration potential? How does topography affect suitability for restoration?

These data can identify the soil conditions and terrain type. Restoration strategies differ in their ability to promote regeneration of vegetation in certain soils. Generally, steeper areas are more complicated to restore due to increased erosion or difficult terrains to access, maintain and monitor. Depending on the place, steep areas also benefit from restoration as activities can prevent erosion and can experience reduce threats from timber harvest and/or agricultural encroachment due to the perception of marginality or low potential for other competing land uses.

Recommended weighting: Weighting of soil condition/topography/slope are considered on a case-by-case basis due to the restoration strategy of interest and objective
(See Section 3 below).

At the **macro level**, data may include national maps of soil conditions and future predictions of soil erosion (10). Digital elevation models (DEM) about the steepness of terrain should be considered, as steep areas are more difficult to be restored but also could be important areas for preventing landslides or increased erosion.

At the **landscape level**, data may include regional maps of soil conditions if they exist and regional watershed protection status, soil data layers, or sediment export data (could show areas of erosion or topsoil conservation).

Conversations with partners, field-level questionnaires, surveys, or visualizations at the **local level** could identify regional problems and priorities related to water and soil management.

Are there key species, threatened, endemic, engaged or other conservation units (Key Biodiversity Areas) that need spatial consideration within the planning process?

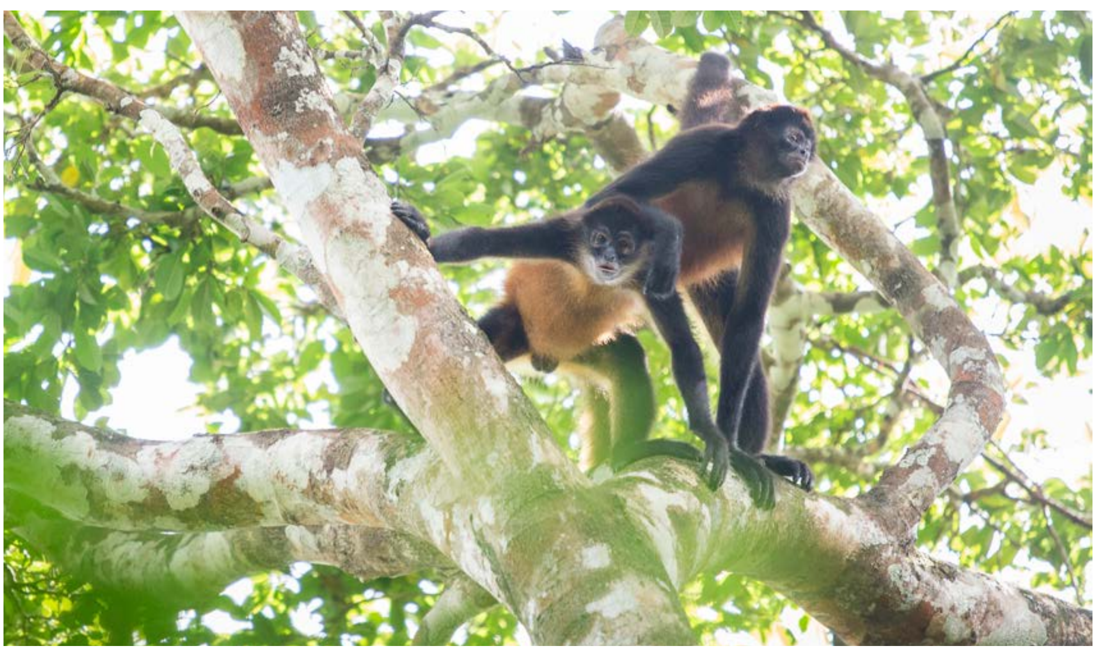
Data on key species ranges, abundance or presence can be used to identify areas of importance.

Recommended weighting: Positive weighting to key biodiverse areas or species of high importance for conservation.

At the **macro level**, spatial data include species richness and ranges, Red List Species ranges, a global database on Key Biodiversity Areas (KBAs), and the Species Threat Abatement and Restoration (STAR) metric. Data on conservation corridors and biodiversity hotspots could also help to identify priority areas for this consideration.

Landscape level data may include subnational level inventories on location and identity of key species habitats and species occurrence, and national maps on species distribution, abundance, and biodiversity.

Local level data could include expert/partner interviews and official records documenting local conserved area locations and status, as well as field level surveys on species presence, composition, and population trends; presence of pollinator insects, birds or bat, invertebrate and vertebrate seed dispersers published by governments, civil society organizations, or in the scientific literature.



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How far are the closest protected areas? Are there areas that should be protected?

Restoration in, adjacent to, or near protected areas is important for species movement and pollination. In addition, the protected area may have become degraded over time due to human activities (poor management, encroachment) and other disturbances (ie. insect outbreaks, fires). Restoration in protected areas can facilitate the regeneration of desired tree species for threatened and endangered species; enhance landscape connectivity; reconnect isolated areas to facilitate the movement of species and genes; and help to attract seed-dispersal.

Recommended weighting: Positive weighting for protected areas or areas near protected areas, especially if biodiversity conservation and/or increased landscape connectivity are included as project goals.

At the **macro and landscape level**, spatial data may be available on the location of national protected areas for terrestrial and marine systems.

At the **local level**, discussions and input with local partners and community leaders could identify areas with significant indigenous value or protection.

Where do regrowing forests have high carbon storage potential?

Data identifying areas with carbon potential or carbon stock in aboveground biomass and soils should be considered to increase carbon sequestration and storage.

Recommended weighting: Positive weighting to areas with high carbon storage potential, provided carbon storage is a goal.

At the **macro level**, spatial data may include carbon sequestration datasets (11) and IIS potential for natural regeneration. Forest biomass carbon maps and soil organic carbon maps at this level are important, and many are available in the scientific literature.

At the **landscape level**, national tree or carbon inventory data can be assessed and used to provide baseline information, historic trends, habitat fragmentation, loss of forest cover, loss of ecosystem productivity over time. If available, lidar remote sensing data can provide estimates of extant forest carbon stocks or proxy potential forest carbon stocks on reforested sites (12, 13).

Local level data depends on the local conditions such as precipitation and characteristics of the regenerating forest including species present, density of trees, plot management and soil condition, among others (14).

RISK OF DISTURBANCE

Considering the risk of disturbance identifies areas that are at risk of having regeneration interrupted by natural and/or anthropogenic disturbance. Common risks are fire, pest and/or pathogen outbreaks, flooding/landslides, deforestation, and hurricanes. These factors also identify areas where restoration could help mitigate risks.

The purpose of these data are to understand and map potential risks and risk mitigation opportunities.

Which areas have a higher frequency or density of fire based on climatic conditions, past fire incidences, or both?

In some places fire poses one of the greatest threats to regenerating forests. Protecting areas with high fire risk will require greater levels of investment. For climate change mitigation, focusing on areas where fires are not frequent will be less risky. Depending on the context, restoration can also be used to reduce fire risk by eliminating fire-prone vegetation and facilitate fire resistant tree restoration. Data related to aridity (fire-prone areas), as well as data related to evapotranspiration and rainfall is useful to assess opportunities for vegetative growth.

Recommended weighting: Negative weighting for areas prone or at risk to fire. The weighting of this variable should be considered carefully in the local context.

Macro level data may include global fire incidence mapping, and global aridity index to identify fire prone areas or future likelihood of fire.

At both the **macro and landscape level,** data on fire can come from satellite imagery and other products monitoring fires at the global and regional level. This includes past burned areas and active fires.

Local level data may be available from local fire reports or fire alerts for the area (fire severity and/or cause of fires - human or climate/external forces).

What are the recent forest clearing trends?

Data on 1) recent deforestation rates, and 2) changes in rates can be used to identify areas where deforestation in the past 1-2 decades has been relatively 1) high/rapid (e.g., >1%/year), 2) slowing/low (e.g., 0-1%/year), and 3) stopped/forest cover is increasing. When possible, the drivers of these trends should be identified to assess if clearing is likely to continue.

Recommended weighting: Positive weighting given to areas with stable or decreasing forest clearing rates.

At the **macro level,** deforested areas can be identified by comparing historical/potential forest cover to current forest cover by using databases for degraded forests depending on national priorities. Space-time cubes could be helpful for this topic.

At the **landscape and local level,** interviews and conversations/oral histories with local stakeholders, non-profits, or communities can provide detail on deforestation trends, locations, and threatened areas, as well as which areas are regenerating naturally.

Which areas are impacted or at increased risk of flooding and landslides? How often does flooding occur? Is the area experiencing greater flooding/landslides in recent decades? What is the likelihood of a landslide? Would restoration practices, lessen the likelihood of a landslide occurring?

Datasets that map areas with increased risk of flooding or potential landslides can be helpful to identify areas that may not be suitable for restoration because of the risk that restored areas might be damaged, or where restoration could help to mitigate such events.

Recommended weighting: Depends on the frequency and magnitude of coastal flooding or landslide events. If coastal flooding and landslides are mild and do not happen often, a positive weighting might be given to these areas. A negative weighting might be given if coastal flooding or landslides are too frequent and intense and compromise the survival of young trees and the success of the restoration intervention.

At the **macro level,** water risk assessments may be available that indicate potential flooding or landslide likelihood.

Landscape level data may include water stress risk and coastal flooding risk layers. Data on topography, steep slopes, and/or precipitation patterns can also indicate the exposure of a site to those hazards. Information can also be derived from national vulnerability maps or national records.

At the **local level**, identifying areas on steep slopes, in exposed coastal areas, in micro watersheds, and in riparian areas can all be identified using local maps and/or surveys.

How often do hurricanes occur in the area? What is the impact or severity of hurricanes to the land? Would restoration lessen the impacts of these hazards?

Areas more prone to acute hazards such as hurricanes could be risky restoration investments. Alternatively, restoration might be able to mitigate certain hurricane impacts.

Recommended weighting: Depends on the frequency and magnitude of natural hazards. If natural hazards are mild and do not happen often, a positive weighting might be given to these areas. A negative weighting might be given if natural hazards are too severe and frequent and compromise the survival of young trees and the success of the restoration intervention.

Macro level data may include national databases on storms or hazards such as national hurricane databases.

At the **landscape level**, regional databases, reports, or historic patterns can be referenced.

Frequency, impact, and severity of natural hazards can be accessed through surveys at the **local level.**

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POLITICAL CONTEXT

Consider the political context: Policies, governance structures, institutional plans, strategies, and priorities are key to success, equity, and sustainability of restoration. Understanding governance structures and decision making is as important as enabling policies and laws.

What arrangements exist regarding land ownership, natural resource management rights, communal lands and rights, customary tenure, and/or user-right certificates? Do landholders feel that their rights to tree and land tenure are secure?

Data on land ownership and tenure are among the most important for successful restoration programs, yet are also often the hardest to obtain spatial datasets for. Collecting data on local tenure bylaws and access rights (including related to the access, use and/or management of land, trees, and other natural resources) may be an important and necessary first step. Existing datasets, if available, may identify where state, Indigenous, communal, and private lands are generally located; as there may be overlaps between land tenure regimes.

Important to consider power dynamics and governance structures, what laws, institutions and traditional arrangements determine how power and benefit-sharing over natural resources are exercised. This data is likely more accessible at local and potentially landscape levels.

Recommended weighting: Positive weighting for protected areas, Indigenous lands, communally managed forest lands, areas where smallholders have secure land/tree tenure, and other tenure regimes suitable for reforestation projects.

At the **macro level,** datasets may include land tenure datasets identifying the type of ownership, but these are few and far between as land tenure often changes faster than it can be reliably mapped. Data should be as granular as possible, but access and coverage will vary by country. Attention to customary tenure rights are equally important to integrate.

At the **landscape level**, data may be available on indigenous or community conservation areas or lands, recognized or unrecognized local ownership. At both the **landscape and local level,** to ensure potential adverse impacts are avoided or mitigated to local communities, minorities, and marginalized groups, it is advised to map stakeholders who rely on, manage and govern restored areas.

For the **local level,** conversations and interviews with local leaders and partners can help to identify who owns the land and how secure their land and resource rights are.

Is there a national or subnational political commitment to restoration and associated spatial assessment and/or prioritization? What national restoration (or if not restoration, conservation) strategies and/or plans are in place and what areas are considered priority areas by the government for conservation/ biodiversity/ sustainable development? Can these initiatives be enhanced by adding a restoration component? What areas have the best amplification potential?

Relevant data can be used to identify areas set aside or prioritized by the governing bodies of the country, where there may be additional support for or interest in restoration.

Recommended weighting: Positive weighting for areas prioritized for restoration by national, regional or local governments.

At the **macro, landscape and local level,** data may include high priority areas identified by the government/governing body/local communities where resources are already being invested and locations with potential for restoration that can serve as a 'demonstration' or example (i.e. high profile areas, areas of high cultural and visual appeal, contain charismatic species or ecosystems, have media attention for showcase).

Some of the data on restoration priorities can be found in national commitments under Nationally Determined Contributions (NDCs), Bonn Challenge/regional targets, Land Degradation Neutrality targets and associated national reports and strategies (e.g. LDN Target Setting Profiles, NBSAPs, NAP/NAMAs, National Restoration Strategy etc.), which often include spatial data and/or prioritization. Indicate if priorities focus on or apply only to certain states/ regions, or state-level differences in forest policy.


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What is the political status or stability of the national/regional/local government? Is the country of interest in a good relationship or political standing with other countries? Is it safe or responsible to work in the country or area? Is the area experiencing conflict, civil unrest, or migration? Data on political stability or countries in conflict can help determine restoration project locations. Governance indices may also indicate the capacity of institutions to provide enabling environments and enact bylaws or other regulations that can enhance restoration success. Recommended weighting: Positive weighting for areas with stable government systems.
Spatial data from global databases on areas in peace or conflict can be useful at the **macro level.** At the **landscape level,** data from interviews with regional partners and participatory techniques for rural settings can provide information on stability. At the **local level** this data can be determined through a conflict analysis or a political economy analysis.
Does the government have legal requirements to restore landscapes and to what extent are they enforced?" Where are there regulatory mechanisms or laws that encourage or discourage restoration? Where are there financial incentives for restoration or subsidies for competing land uses? Areas required legally to be restored or conserved may be better restoration candidates as there is an additional incentive to restore. For example, financial incentives to restore could include payments for ecosystem services, and disincentives could include subsidies for cattle or alternative land uses. Laws promoting or restricting logging or land clearing for other uses (like extensive grazing) can have a big impact on restoration success. Recommended weighting: Positive weighting for areas prioritized for restoration.
At the **macro and landscape level,** there may be data on government requirements to restore specific areas or landscapes. Obligations to restore consists of legislation on forest regrowth such as extractive industries or government-imposed mandates restrictions on forest clearing and expansion. At the **local level,** interviews or focus groups with leaders or local organizations can help to understand any restoration mandates or incentives, to what degree they are implemented, and how local people adhere to or are able to access these.

SOCIOECONOMIC CONTEXT

Considering the socioeconomic context can identify where livelihoods and restoration are most compatible, areas where competing land uses are lower, and where people have the capacity to undertake restoration. Combined, these conditions can increase the likelihood that restoration will provide benefits to local people, and thus persist on the landscape.

What is the potential of the land for agriculture (current or future)?

Relevant data may include maps of agricultural lands, crop yields, types of crops/commodities, production potential land value, and accessibility (road presence/quality, distance to markets, available transport options, etc.).

Recommended weighting: Negative weighting given to areas with high opportunity costs/ high yield industrial agriculture.

At the **macro level,** agricultural and land productivity maps may include different agriculture types (industrial agriculture, industrial/large-scale commercial cattle, subsistence/smallholder farming). Data on land values from national databases or cadastral records can be used to identify agricultural areas. Information about national food security, commodity production priorities, and policies or projects linked to these topics are helpful to identify areas likely to be converted to intensive agriculture (which should be avoided as part of the restoration process to avoid future conflict).

At the **landscape level,** data on production potential, land use practices, and land value can be helpful. Data on access to water, food, and livestock can be derived from census datasets.

Field visits that include participatory mapping exercises to identify perceptions of land value, opportunity costs, and/or environmental problems impacting agriculture can be useful at the **local level.**

What priorities/investments exist for developing forest products? Are markets for forest-produced goods accessible?

Data on market opportunities can help identify areas better suited for restoration if the activity is aimed towards income generation from selling forest goods.

Recommended weighting: This variable is especially important for determining if the area is well-suited to planted and agroforestry strategies. Positive weighting for agroforestry and silvopasture strategies can be given to areas where clear market connections exist for agroforestry/tree crops and/or forest goods (for example, coffee, non-timber forest products), keeping in mind that areas with high market access may also have a higher opportunity cost.

Relevant data may be scarce at the macro level. If it exists, spatial data on national investments or priority plans for developing forest products can be used at the **macro level** to identify locations with potential markets for forest products.

At the **landscape level,** areas with existing cooperatives or that are known for certain agroforestry or forest goods (like coffee, chocolate) might be good candidates.

Interviews with local stakeholders on opportunities to sell forest products (fodder, fuelwood, medicinal, fiber, timber, nuts/fruits, spices), as well as agricultural products that could be integrated into the forest system (coffee, chocolate) are helpful data resources at the **local level.**

What are the main livelihoods in different regions? How do the local people use the forest? Are they reliant on forest products?

Data on primary livelihood strategies can help understand how forest- or nature- dependent people are and, at more local levels, their level of forest dependency. Nature-dependent people are defined as those that depend on natural sources for at least three of the four basic needs: housing materials, water, energy, livelihoods (15).

Data on nature-dependent people at the **macro level** may include data on percentage and number of nature-dependent people. Land dependency can also be used to understand how much people rely on farming/pasture versus other livelihood activities, important information if implementing silvopastoral or agroforestry systems. Percentages of households in the sub-national regions in which the head of household's occupation, dwelling materials, cooking fuel, and/or drinking water come from natural sources.

Recommended weighting: Positive weighting to areas where people use forest products for subsistence or income, where restoration can improve agriculture/production, and where native forest recover can restore water or other ecosystem services or contribute to agroforestry and silvopasture.

Existing census data including information on income sources can be helpful at the **macro level** to identify how much income comes from forest products and also from agriculture/animal rearing, but may not capture subsistence use which is often more significant**.** Proximity to existig forest has also been used as a proxy for forest dependence at the global level (16).

At the **landscape level,** use data on an analysis of regional livelihoods, including degree of reliance on the land versus non-farm wage labor/remittances, and employment rates. These data can come from census datasets.

Participatory rural appraisal and interviews with local partners at the **local level can** provide data on livelihoods, as can tools like the PEN survey (17).

Do people have a history of working together on forest-related issues?

Data on the history of collaborative multi-stakeholder processes in conducting restoration work, and/or forest work and use can help to identify areas where people have institutions/organizations in place for restoration, and/or are accustomed to working together.

Recommended weighting: Positive weighting for areas with forest restoration/conservation initiatives.

At the **macro level,** few data exist that are relevant to this scale, although identifying areas with forest conservation or restoration programs in place could be helpful.

Mapping non-profit, academic, private sector actors involved in restoration based on government data, network lists, crowdsourced maps (google maps, etc.), directories can provide helpful data at the **landscape level.**

Data gathering from working relationships with communities and stakeholder engagement can provide information at the **local level.** Also, if there is a history of social cohesion, social movements or visionary local leadership, these types of information can be useful at this level.

SOCIOECONOMIC RISKS

How might increasing population in an area increase pressure on land and forests?

Relevant data may include population density, which can identify highly populated areas with greater pressure on land, natural resources, and human capital. Data on the proportion of women can be collected to ensure equity and to facilitate gender-responsive restoration.

Recommended weighting: Depends on project goals and context. A positive weight may be given to areas where population growth/urbanization is lower, and thus less likely to increase pressure on future forest land. But if the goal of restoration is to provide local ecosystem services, including climate change adaptation & resilience, a positive weight might be given to areas with expanding populations.

Data on population growth at the **macro level** can come from national census data. There are also data on urban expansion, policies, and practices available through groups such as the United Nations.

Landscape level data can come from census data at the jurisdictional or land parcel level.

Conversations with partners, agencies, non-profits, or local governments can supply data at the **local level** and explore how population dynamic changes affect land use and forest cover.

Is there a high risk of public health crises or prevention measures impacting the ability to restore effectively in this area? How will restoration impact (positively or negatively) local public health risks?

Data collected on health risks, how restoring forest could decrease the spread of zoonotic diseases, and how high disease incidence or strict prevention measures could negatively impact restoration success can help identify priority areas.

Recommended weighting: Depends on the project objectives. Positive weighting on areas where restoration may be connected to better public health outcomes. Negative weighting on areas with high public health risk that negatively affect the ability to restore effectively.

At a **macro level,** international or national risks maps can be used to highlight places with greater level of disease and transmission.

At all levels – **macro, landscape, and local level,** data on pathogen emergence reflect dynamic interactions between people, domestic animals, and wildlife (18). The clearing and degradation of tropical forests can increase risk for emergence of infectious diseases, as the movement of people and domestic animals into these areas increases opportunities for interaction with displaced wildlife, many of which can carry pathogens capable of spilling over. Furthermore, deforestation and forest degradation can lead to loss of biodiversity, and the animals that are more likely to survive are those that can live alongside humans (e.g., bats, rodents), many of which can harbor pathogens. To the extent that restoration increases biodiversity, reduces human-wildlife interactions, or alleviates public health risk factors (for example, providing cooling shade or microclimatic benefits in heat stressed areas), it may improve public health outcomes (19).

SECTION 2:

MAPPING RESTORATION POTENTIAL: PRIORITIZING AND WEIGHTING DATA LAYERS

A key challenge for mapping restoration potential is finding existing datasets that align with restoration goals. Before deciding which of the above datasets to use, it is critical to: 1) articulate specific restoration goals, incorporating the needs of key stakeholders, and 2) decide which data layers are needed to identify restoration sites to meet these specific goals (figure 1). Note that some data layers are important regardless of the goals of restoration, for example, those related to land tenure and conflict areas.

Because many of the above-listed data layers are not publicly available or analysis-ready, teams may need to aquire data or preprocess existing data prior to mapping. After assembling the list of key layers, teams must decide how to combine the various datasets based on the relative importance of each variable (magnitude) and whether the variable contributes or detracts (direction) from your restoration goals.

A 'weighted overlay' or Analytical Hierarchical Process (AHP) assigns weights to each data layer. Weighting involves assigning numerical direction and magnitude (e.g., -1 vs 2) to each data layer. For example, a variable may be x times more important than another, or they might be weighted equally. Weighting is a subjective process, and it is critical that the needs and goals of all stakeholders are reflected. Each variable is ranked based on the level of importance to project goals, and the rank determines the given weight. Weighted variables are then mapped and overlaid to identify key project locations (20). During this process, be cautious when using global datasets as some are composite indices (not necessarily final products) with weighted variables included and changing their weights can alter the outcome of the map.

In some cases, layers may require processing before being used in the overlay (e.g., distance to road, or proximity to forests), if this is the case, the layer would not be the forest layer but would represent the outcome of the processed layer and should be weighted as such. A 'weighted overlay' analysis is sufficient when working with fewer data layers, but if the weighting system is more nuanced and/or many data layers are being used, a more systematic process that helps to assess how consistent weights are can be used, as demonstrated by the Brazilian case study below in Section 6 of this guide.

SECTION 3:

PRIORITIZATION OF RESTORATION STRATEGIES BUILDING ON RESTORATION OPPORTUNITY MAPS AND INFORMED BY SCIENCE AND LOCAL KNOWLEDGE

Once a map has been created, different restoration strategies can be chosen to best fit the local context and goals (Table 1). This section provides example questions to help decide whether a given strategy or set of strategies is right for a given context. Note that areas with greater regeneration potential tend to be better suited to assisted natural regeneration (ANR), with middling levels appropriate for applied nucleation (AN), and those that are more degraded/unable to recover naturally may need more intervention such as tree planting. Areas where local people are dependent on restoration for direct livelihood benefits or where it is important to have specific species present may also be better suited to agroforestry/silvopastoral systems and/or tree planting.

Strategies may be used alone or in combination, depending on the context and project goals. Forest and Landscape Restoration (FLR) is an approach that combines different restoration elements across a landscape to provide a broader spectrum of socioeconomic and ecological goals (Table 2)(21). A FLR approach in montane farmland, for example, might use ANR in riparian areas to protect water resources and prevent erosion, agroforestry in and around productive farm areas, silvopastoral systems in pastures, and tree planting in especially low productivity/degraded areas to restore soils and provide other ecosystem services (inspiring case examples of FLR in Ecuador and Lebanon; see case 1 and 6 (22))

TABLE 1

Key contextual factors to help identify which restoration technique is best suited to a given local context. High means that there is high potential for that strategy to be successful or the strategy if a given factor is present. For example, ANR has a high potential of success in areas that are close to existing forests and where the opportunity cost of land is low.

	Restoration technique suitability factors	Importance of proximity to Forest	Works best when land degradation is...	Importance of secure land tenure/tree rights**	Importance of external/ national priorities and/ or support***	Works best when opportunity cost of land is...	Works best when the need for direct/timely livelihood benefits is...	Importance of access to markets for agroforest/ forest goods
Strategies	ANR	High	Low-Med	High	High	Low	Low	Low
	Direct Seeding	Medium-Low	Low-Med	Medium	High	Low	Low	Low
	Agroforestry	All	Low-High	High	Medium	Medium	Med-High	Med-High
	Silvopasture	All	Low-High	High	Medium	Medium	Med-High	Med-High
	Applied Nucleation	High	Low-Med	High	Med-High	Low	Low-Med	Low-Med*
	Enrichment planting	Medium-Low	Low-High	Medium	High	Low	Med-High	Low-High*
	Tree Planting	Med-Low*	Low-High	Med-High	Med-high	Low-High (depending on type)	Med-High	Low-High*

**Forests will likely recover more quickly if there are nearby forests, but planting can work when forests are not present.*

*** Land tenure is often critical for successful restoration of all kinds. It is usually critical for ANR because regenerating areas may appear unused, and for agroforestry and silvopastoral systems because of the labour and financial investments involved. Tree planting (pure tree planting or AN) can sometimes be used to establish tenure, but also requires labor investment and so landholders are often more willing to invest when tenure is secure.*

****Tree planting and agricultural systems can provide direct economic benefits, while ANR and direct seeding are less predictable.*

*****The importance of markets depends on the goals of the project and the types of tree planted and for what purpose.*

ASSISTED NATURAL REGENERATION (ANR):

ANR and AN both require ecological conditions where forests can recover naturally to some degree, but would benefit from additional intervention. ANR is a process of actively facilitating natural forest regeneration to help them recover more quickly or persist for longer periods of time. It builds on the ecological conditions at a given location using a variety of techniques, including protecting areas from fire, clearing or grazers and/or maintaining regenerating trees. 'Assisted' implies that natural recovery processes are enhanced through active interventions and provide additionality for climate change mitigation. Examples of ANR include protecting regenerating areas to expand buffer zones around existing forests; protecting, and maintaining regenerating seedlings in degraded agricultural land to allow forests to grow back; and creating protected corridors for forest regeneration between forest patches.

Applied Nucleation (also known as tree islands) involves planting trees in 'islands' or clusters to encourage natural regeneration in and between planted islands. Like other ANR techniques it requires that forests can regenerate to some degree, but could benefit from speeding up successional processes (23).

Using ANR and/or AN as primary means of restoration can be both cost effective and ecologically robust (24) where conditions are right. But even in areas with high potential for natural forest regrowth there are likely to be people who use the land. It is vitally important to identify land users and assess how an ANR strategy might affect them, what the legal requirements or restrictions around forest restoration are, and how ANR can work with local production and livelihoods rather than be at odds. In places where specific species or more reliable income benefits are required from restoration, agroforestry or planting trees may be more suitable.

The following questions can help identify if areas are suitable for ANR (links to data sources can be found in section 5):

ECOLOGICAL CONTEXT†

Land use/forest cover:

- Are forests likely able to regenerate naturally in current ecological conditions?
  - ANR and AN both work only if the area has some capacity to recover. Strategically protecting regenerating areas and/or planting tree islands can help speed up regeneration (25, 26). AN is a more intensive intervention better suited to places where helping forests to recover more quickly is a priority, and that show some natural regeneration but could use some additional help.
  - Previously forested areas with a history of light land use or only used for shorter periods often have greater capacity for natural regeneration due to higher quality soils and seedbanks (27).
  - Areas close to high quality remnant forests are also more likely to regenerate naturally with more diverse species assemblages.
- What is the condition of the soil? Has it been impacted, eroded or compacted?
  - Areas with poor soil conditions with limited nutrients or seed banks may not be able to regenerate unassisted and might be poor candidates for ANR and AN (27, 28, 29, 30, 31). Where forests can recover, however, both strategies can improve soil conditions and help to control erosion.
- How long has it been since the last time the land was cleared?
  - Areas recently cleared or less time since the clearing occurred will provide a better chance that seeds, and stumps will be viable and lead to a more successful outcome.
- Are forests already regenerating (32)?
  - To evaluate if an area has the potential to regenerate naturally, investigating if forests are already recovering on the site is a good first step. The % grass cover, % canopy cover, and tree seedling density of young (as young as 1-2 year) forests should be measured. Canopy cover of >10% and grass cover of < 70% after 1.5 years were associated with higher recovery eight years later in Costa Rica, although other systems may have different proportions, and the type (especially size) of grass also has an impact (33).
  - If sites have not had time to begin to recover, if time permits, allowing areas to regenerate naturally for 1-2 years can provide a good indication of their ability to recover naturally (as per the measurements above) (33). Areas where succession appears to be ‘arrested’ may require higher investment, such as tree planting.
- Are remnant forests, forest patches or islands in close proximity to the area of interest for restoration?
  - ANR and AN generally require that seed dispersers are present and able to reach the site (34). Having remnant forest patches present is important for forest recovery (35, 36).

Biodiversity/conservation biodiversity

- Is the area of interest located near a desirable natural forest composition?
  - Proximity to existing forests generally means more propagule sources and better regeneration potential (37). Areas near remaining forests and forest fragments may regenerate faster than other areas (38, 39).
- What is the dominant species of the restoration area? Are invasive species abundantly present or dominant?
  - Places where invasive species are dominant or highly invasive would not be a suitable place for ANR or AN strategy, as these species can prevent native forest recovery and limit regeneration between tree islands (40).
- Does the area have high biodiversity potential?
  - ANR and AN can produce highly biodiverse forests in areas where the ecological conditions support recovery and native forests are present (41, 42, 43, 44).

Soil Condition/Topography/Slope: Ecological risks: Fire

- Is there a history of frequent fire or burning in the restoration area?
  - Intense or repeated fires can reduce the seedbank and make areas less amenable to ANR and AN. Fire is also a major threat to naturally regenerating forests in many areas. In AN, vegetation between the nuclei or tree islands may be more susceptible to forest wildfires (44).

Carbon benefits

- Has forest clearing ceased or slowed?
  - Existing/mature forests provide higher amounts of carbon sequestration over time and biodiversity than young ones, and regenerating forests are more likely to be cleared if deforestation


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is active in the area. Areas where deforestation is slowing or stopped thus provide better candidates for ANR and AN. (Note that areas with slower deforestation rates may also be areas that are farther from remnants and with more time since clearing, so there may be a trade-off here).

Topography

- Are there steep/rocky/otherwise marginal lands?
    - Steeper areas may be better suited for ANR as the topography is less conducive for agriculture thus will protect the forest from agricultural expansion. This type of land may have a have lower opportunity costs and produce more local benefits when forested (45, 46). They might also work for AN, but note that tree planting becomes more challenging on steep slopes.

POLITICAL CONTEXT:

Land tenure:

- Are land tenure arrangements secure and amenable to restoration (including zoning regulations?)
    - Secure or continuous land tenure is very important for ANR, as regenerating areas can appear abandoned or unused and be at greater risk of clearing (47). Tenure arrangements with shared communal or indigenous lands with shared use could be good candidates for restoration as some portion may be allocated to restoration with reduced risk to anyone landholder (48). Land tenure can be secured without formal rights to land, so the absence of formal tenure should not necessarily rule out an area otherwise well suited to restoration (49). However, in areas where formal tenure does not exist, additional emphasis should be placed in the planning process on understanding how and ensuring that tenure over-restored land will be secure in the long term.
- What do the landowners understand about restoration strategies?
    - Some landowners find the natural regeneration process occurring on fields or between the tree islands "messy" (50, 51) This perception could result in a lack of support, intrusions on the land, or not seeing the forest as being active or productive. Engaging (and educating) local landowners in the restoration process by demonstrating the benefits and cost-effective purposes of using natural regeneration can be one way to solve this. The AN strategy can also strategically use the active tree planting component to solve this– trees can be planted along property lines, for example, and can demonstrate use (50, 51).

National priorities for restoration (and conservation)

- Does the national government have obligations or set priorities for forest restoration?
    - ANR can be a useful strategy to implement in prioritized areas because it is cost-effective and requires less labor to restore forest at scale.

Legal limitations or obligations to restore

- Does the government recognize ANR (or AN) as an effective restoration strategy
    - ANR is not well understood as a restoration strategy, and AN even less so. Education about the benefits of both strategies may be necessary before implementation.

- Is there potential for the restoration to serve as a 'demonstration plot' or example to the rest of the country, e.g., high profile areas or areas of high cultural importance.
  - Demonstration plots could help to show the promise of both ANR and AN. ANR requires little investment but has a potentially high impact.

POLITICAL CONTEXT/GOVERNANCE:

- Are social conditions relatively stable? Are culturally appropriate systems in place for conflict resolution and rule enforcement?
  - Areas that are politically unstable may be more subject to conditions that could detract from restoration (including corruption, lower prioritization of restoration compared to other issues, volatility around land rights and tenure, etc.). Systems for resolving disputes around shared benefits, land, or tree rights, and so on are important for collaborative efforts (52, 53).

SOCIOECONOMIC CONTEXT

Opportunity costs:

- What is the opportunity cost of land?
  - ANR is especially well suited to areas where opportunity costs are low. Because the results are not always predictable, income and other benefits are not certain and it is likely unable to compete with agriculture, etc., in areas with higher opportunity costs to land.

Livelihoods:

- Is the area looking for cost-effective strategies for restoration?
  - If budget is limited, ANR is generally less expensive than tree planting. AN can also be used to make tree planting efforts go further.
- Are people experiencing the effects of past forest clearing and degradation?
  - Where livelihoods and wellbeing have been negatively impacted by the

effects of past deforestation/forest degradation, if people recognize these impacts, they may be more likely to engage with restoration practices (54, 55).

- Does the local community support and accept restoration efforts?
    - Applied nucleation is more successful when the practices are supported, encouraged and accepted by the local communities. It is important to understand how the local communities view, use and value the forests.

Communities:

- Are there communities with a good track record of social forestry or strong land-use oriented cooperatives (agricultural etc.)?
    - Good governance practices take time to implement and processes for consultation, inclusion, identifying who is impacted, and capacity building is often costly. Working with communities and organizations that have these processes in place can save time and effort.
- Are there processes for stakeholder engagement in place? Are there communities present with a history of working across levels of government and other sectors?
    - Stakeholder engagement is key to restoration success but can be time-consuming to develop such processes from scratch (56). Consider working in places where the networks and precedence for these already exist or where organizations are present to facilitate this (57).
- Are there visionary leaders (individuals, or potentially organizations) available/ interested to engage with restoration (58, 59)?
    - Visionary leaders with the ability to bring people on board can be important for embracing restoration into the culture of a local area and building the support needed for lasting stewardship of restored areas (60, 61). This is important but often not considered in restoration planning, and can be especially important for introducing new techniques that are not familiar.

Technical capacity and labor availability:

- Are there organizations, agencies, and people with the skills required to do necessary work, and to train others? If not present already, are there people willing to receive training to train others?
    - Both ANR and AN require some specialized training, but often government agencies are trained only to plant trees. Ensuring that there are organizations on the ground who can do this is essential.
    - Areas where communities have a history of restoration or other similar work, and/or with existing social/family/ community forestry programs could be good candidates.

AGROFORESTRY AND SILVOPASTORAL STRATEGIES:

Agroforestry involves integrating trees and forests into farming systems to improve ecological conditions, increase and/or diversify production, and make farmlands more resilient. Trees may be planted or intentionally allowed to regrow. Implementing an agroforestry strategy involves working with farmers, landholders, or other stakeholders in areas where large-scale forest restoration might not be feasible, but the potential exists to improve carbon sequestration in farmlands. When successful, agroforestry improves the economic opportunities, lives, and livelihoods of people in these areas, provides ecosystem services and other incentives, and can build a culture of stewardship towards trees and forests (62). This should be done in a way that is culturally and gender appropriate and considers gender issues in the local context.

Silvopasture involves intentionally mixing and cultivating woody perennial species (trees, shrubs, bamboos) on pastureland where tree cover was absent in a way that improves the productivity and ecological function of the area for continued use as pasture (For a large-scale case example of silvopastoral systems in Colombia, see citation (63).

Farmer-managed natural regeneration (FMNR) is a technique in which farmers tend to regenerating stumps and trees on site to improve farm productivity, provide tree products (like firewood) and improve local environmental conditions. The technique has been widely implemented in Niger and other countries in Africa and sits between ANR and agroforestry; however, farmers generally participate to improve farming conditions and so the motivations are similar to agroforestry (64).

The following questions can help identify If areas are suitable for agroforestry:

ECOLOGICAL CONTEXT:

Land use/forest cover:

- Is there a potential for forest ecosystem services? Are there areas that are especially well suited for forests to deliver key benefits?
  - Landscapes where forests could be incorporated into active farmland to deliver local benefits such as reducing erosion, protecting water resources, etc. while increasing carbon storage may be good candidates for agroforestry.
- Is the land currently an open-pasture or have a history of pastoralism?
  - Incorporating trees into an open-pasture or grassland can provide nutritious grazing opportunities (seed pods, acorns) for livestock (65).
- Are there existing trees/tree stock on the site?
  - For FMNR to work, there need to be some regenerating trees on-site (66). Other agroforestry and silvopastoral techniques can use tree planting on both degraded land and land with regeneration potential.

Biodiversity/conservation biodiversity:

- What is the biodiversity potential of the area? Does the area have diversity that could be enhanced through restoration?
  - Agroforestry can increase biodiversity (over traditional agriculture) by establishing habitat and connecting forest fragments.
  - Silvopastoral areas tend to have greater biodiversity of plants, birds, insects and other groups, but lower diversity than secondary forest areas. If rebuilding the species diversity is a key component of the restoration activities, agroforestry and silvopasture may not result in the greatest increase of species diversity or richness (67).

Soil Condition/Topography/Slope:

- What is the topography of the area? Are there steep slopes or soil erosion?
  - Agroforestry benefits may be especially well suited to steep areas where opportunity costs tend to be lower, but benefits from reintroducing forests (like flooding, erosion control, and other water benefits) have the potential to be greater and can improve agriculture in these regions.
  - Silvopastoral systems can help to rebuild soil fertility and structure in compacted or depleted soils.
- Is an interest or goal of the restoration project to increase carbon sequestration?
  - Agroforestry systems can increase carbon sequestration rates over traditional or monoculture agriculture, although carbon outcomes vary (68, 69).
  - Sites using a silvopasture strategy have higher aboveground biomass than open-grasslands or prairies and overall have greater carbon storage than monoculture- grasses (70, 71). Similarly, soil organic carbon is greater in silvopasture systems than open-pasture (72, 73).

POLITICAL CONTEXT

Land tenure:

- Are there formal or informal land tenure agreements in the area of interest?
  - The perception of secure land tenure/ tree rights is generally important for restoration success in agricultural lands (74, 75, 76, 77). Tenure arrangements with shared communal or indigenous lands could be good candidates for restoration as some portion may be allocated to restoration with reduced risk to anyone landholder (78).
- What is the stability of the social and political framework of the place? Are there systems for handling conflict resolution or legal enforcement?
  - For restoration to be successful, places considered politically stable have a greater chance of longevity for restoration and will experience the lasting impacts. For these efforts to be collaborative, it is important for systems to be in place when conflicts (land rights and tenure) do arise (79, 80).

SOCIOECONOMIC CONTEXT

Opportunity costs:

- What is opportunity cost of restoring the land?
  - In places where alternative land use does not outweigh the benefits from combining forests and agriculture, agroforestry is a good candidate. agroforestry is a good candidate.

Communities:

  - Do agroforestry and/or silvopasture have the potential to fit with regional land use practices? Are local communities/peoples actively using the land? And if so, is it for agriculture? Who are these users (e.g., small-scale subsistence farmers, absentee landholders, large commercial operations)?
  - If agriculture is an industry in the area, the local people may be more inclined to introduce agroforestry into their already existing industry. The ecological benefits that can be gained from integrating these practices can have greater returns for the industry while re-establishing forest cover.
- If agriculture exist, are the local crops vulnerable to climate change? How is it effecting the economic conditions?
  - Agroforestry can assist in economic restoration opportunities for vulnerable crops. For example, Arabica coffee may show greater vulnerability climate change but could mitigate with shade trees to support a more suitable micro-climate, while sequestering carbon and providing adaptation co-benefits.
- Potential for forest ecosystem services: Are there areas that are especially well suited for forests to deliver key benefits?
  - Watershed regions serving downstream populations: Note that reforestation can result in reduced short-term annual water yield downstream but can also have 'positive' benefits in terms of reduced downstream flooding and local soil water infiltration. Reduction in sedimentation and potentially nutrient pollution to streams can be meaningful (81, 82, 83).

Organizational support, technical capacity and labor availability:

- Are processes for stakeholder engagement in place? Are there communities present with a history of working across levels of government and other sectors? Or, do extension staff and organizations exist with the capacity to do this effectively?
  - Engaging with stakeholders for the agroforestry strategy is key to its success and can take time to develop a cohesive relationship (84). Implementing agroforestry into places where supportive networks exist will be helpful in establishing the agroforestry strategy (85).
- Are there existing, strong farmer/landholder associations who could bring landholders together around restoration?
  - Agroforestry and/or silvopastoral systems require both labor and technical expertise needed ensure the success of both the crops and the trees. Areas with existing agricultural associations or local NGOs may have more resources to provide training and technical support.
- Agroforestry and silvopastoral strategies will benefit from having local or regional partners who are well acquainted with the local people in targeted areas. They do not need to be restoration experts but having agricultural experience will be helpful in this strategy.
  - Does the area have a sufficient labor force to do the work required (or has outmigration limited the availability of workers).
  - Market-based restoration is often labor-intensive, especially in the implementation phase. In places where outmigration is high local labor shortages could impede restoration efforts.

Market-based considerations:

- Are markets for forest/agroforestry products accessible, economically attractive, and culturally relevant? Do communities/organizations in the region have a history of local production through cooperatives or other means (i.e., are there existing mechanisms of working together on coordinating and marketing production?
  - For agroforestry to be successful, the conditions listed above especially market access, must be in place and accessible (86). These conditions will likely make implementation easier, especially if the region relies heavily on marketable goods. If they are absent, resources will have to be allocated to develop them.

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DIRECT SEEDING:

Also known as seed dispersal, direct seeding is the active dispersal of seeds (preferably ecologically diverse, native seed mixes) that will allow for natural regeneration to occur, provided the area is protected from disturbances. This may be done by humans or drones and implies active collection and dispersal, not natural dispersal by natural seed dispersers that are part of natural regeneration processes. This is different from planting young trees, which would be more associated with tree planting.

The following questions can help identify if areas are suitable for direct seeding:

ECOLOGICAL CONTEXT

Forest Cover/Land Use:

- Is the area surrounded by forests that have desirable species compositions?
    - Seeds distributed through direct seeding are in competition with seeds from elsewhere on the landscape, and may be outcompeted by invasives if present on the landscape. These areas might require more intensive restoration methods, like invasive species removal and intensive tree planting.

Soil:

- Are the soils favorable to tree growth (e.g., not compacted, depleted, or eroded?)
    - Direct seeding will be more successful where soils are less degraded/ compacted. Areas with very poor soils may require more intensive intervention.

Ecological risks: Fire and floods

- Are areas prone to specific risks such as fire, flooding, etc?
    - Direct seeding allows for the implementor to choose seeds that are tolerant, resistant, or favorable to disasters such as fire or flood. However, frequent disturbances will likely limit forest recovery.

POLITICAL CONTEXT

Land Tenure

- Are the land rights and tenure acknowledged or identified in the area?
    - Like ANR, direct seeding may not demonstrate use to the same degree as tree planting. With planting strategies such as direct seeding, it is critical to work with the landowners and understand the status of the tenure (87).

SOCIOECONOMIC CONTEXT

Communities:

- Are there members of the local community or indigenous groups who are interested in restoration efforts?
    - Direct seeding will be successful when the local community is engaged and involved in the restoration process and projects. It is important to incorporate local ecological knowledge and labor when using this strategy (88).

Technical capacity and labor availability:

- Are there skilled workers in the area of interest? Are there training programs or local professionals?
    - This strategy may require manual labor to plant the seeds in the area of interest – in this case, it is important to involve the local people in the initial planting. Depending on resources, direct seeding may also use other types of methods to disperse seeds including natural regeneration. Long-term maintenance and monitoring will also require trained people to be present, regardless of the planting mechanism.

TREE PLANTING

Planting trees for restoration involves planting seedlings to establish forest cover and accelerate succession. When used for the purposes of restoration a mix of species, mainly native, should be used, although exotic species can also help forests to establish and promote natural regeneration in some cases.

The following questions can help identify if areas are suitable for tree planting:

ECOLOGICAL CONTEXT

Land use/forest cover:

- Does the restoration project include producing timber or other wood products?
  - Tree planting allows forests to be managed in a more predictable way to produce forest products, timber or NTFP.
- Is the restoration area distant from remnant native forests?
  - In areas where the area of interest is far from native forests, tree planting can be effective in restoring tree cover with planted native species.
- Does the area have a history of logging or is the land heavily degraded?
  - Under heavily degraded conditions or a history of logging, traditional tree planting techniques are often most successful in restoration efforts.

- Without intervention, is the land unable to regenerate naturally or are invasive species dominate in natural regeneration?
    - Tree planting is needed when the forest is unable to naturally regenerate or when invasive species are abundant during natural regeneration (89, 90, 91). These areas which are slow to recover need more assistance, such as tree planting, to regenerate the forest.

Soil Condition/Topography/Slope:

- What is the condition of the soil? Is it heavily eroded, compacted or degraded?
    - Tree planting is a useful strategy for areas with poor soil conditions due to the implementors' ability to plant species that tolerate these conditions. The use of nitrogen fixers or enrichment of soil may be necessary during the planting.

Biodiversity/conservation biodiversity:

- Is biodiversity lacking or in decline in the restoration area of interest?
    - Tree planting allows implementors to choose a variety of native species to plant, which can help restore a diverse composition of species.

POLITICAL CONTEXT

National priorities for restoration (and conservation):

- Are there goals or areas designated for restoration within the national, landscape or local level from the government?
    - Tree planting is a common method of restoration – results are immediately visible and more 'orderly' than techniques that reply on natural regeneration, for example. Because tree planting is familiar, and many practitioners are trained to plant trees, in some places tree planting may be an easier 'sell' because of its familiarity and relative predictability.

Land tenure:

- Does tree planting help to establish land tenure?
    - Tree planting can demonstrate use, and planting trees in some areas may be an important tool for landholders to demonstrate forest ownership.

SOCIOECONOMIC CONTEXT

Livelihoods:

- Does the community rely on forest products as a source of income? Is timber production a main source of income for the local community?
    - In areas where the community relies on income from the land, traditional tree planting can provide sustainable livelihood opportunities (91).
- Is the goal to produce trees as crops (i.e. plant and harvest on a regular cycle)?
    - Traditional tree planting will allow for implementors to restore on regular cycles.

Communities:

- Does the local community support restoration and tree-planting efforts?
    - To be successful, the local community must be involved and supportive of the restoration efforts (92).

Market-based considerations:

- Does the area have access to markets for forest products?
    - Tree planting allows practitioners to select species with economic value. Have access to markets for forest species can help motive people to restore for this purpose.

Technical training and skills required:

- Is there trained/skilled work force available? Does the capacity for and interest in training exist?
    - Maintenance, protection, and labor are necessary for successful traditional tree-planting efforts (92).

ENRICHMENT PLANTING:

Enrichment planting is the strategic reestablishment of key tree species of ecological, economic, or cultural importance in a forest that is ecologically degraded or has not recovered a full suite of species following restoration. Enrichment planting can be used alone, or in combination with and of the other restoration strategies above.

The following questions can help identify if areas are suitable for enrichment planting:

ECOLOGICAL CONTEXT

Land use/Forest cover:

- How much of the area is under forest cover? Is the landscape fragmented?
  - In areas where the forest is in fragments or experiencing low forest cover, enrichment planting strategy is useful to reconnect the fragmented landscapes or for reintroducing species back into the landscape (93, 94, 95).
- Are there invasive species abundant and present in the area of interest?
  - Using enrichment planting could help outcompete undesired species. Since this strategy is introducing key species, trees with the ability to outcompete invasive species or restore the area to a natural state.

Biodiversity/conservation biodiversity:

- What is the current status of biodiversity in the area? Is the area devoid of biodiversity or is there some diversity present?

- Unlike monoculture plantations, enrichment planting can be mixed-species and lead to greater biodiversity in the areas if at least some biodiversity is already present (96). Enrichment planting can also increase biodiversity by planting specific or endangered species.

Soil Condition/Topography/Slope:

- What is the condition of the soil? Is it heavily eroded, compacted or degraded?
  - Enrichment planting is a useful strategy for areas with poor soil conditions due to the implementors ability to plant species tolerate to these conditions.

Carbon:

- Is carbon sequestration a goal of the restoration project?
  - The amount of carbon sequestered in forests using an enrichment planting strategy can result in key tree species that are beneficial for storing carbon or implementing high-value native species to use when implementing small-scale carbon projects (96).
- Are the landowners looking to use carbon for financial gains?
  - Using an enrichment planting strategy can provide additional short-term income benefits through carbon sequestration payments (97).

Ecological risks: Fire

- Is the area susceptible or prone to fire?
  - Fire can be a hazard to enrichment planting and risk the goals of the project (i.e. carbon sequestration) (98). While this strategy requires more initial investment and therefore could be riskier to use in fire-prone areas, implementors could choose specific species to plant which could be more resistant to fire.

POLITICAL CONTEXT

Land Tenure:

- What is the status and acknowledgement of land rights and tenure in the area?
  - Formal or informal land tenure must be considered when implementing a restoration strategy. Due to the nature of enrichment planting, in many cases, the saplings must physically be planted on the land. Working with the landowner and understanding the rights on the land is critical when using this strategy. Often, factors such as land

tenure are not included in the data collection for identifying restoration locations, but play a vital role in the longevity of a project (99).

Political context/governance:

- Is the political and social system considered stable? Are there programs in place to deal with conflict and avoid corruption?
    - Corruption is a key deterrent for restoration success as funds can be misused or abused (100). Enrichment planting involves more investment as planting of key species are used in this type of restoration. Consider the stability of the region when implementing enrichment planting to ensure the financial resources are going to be properly allocated.

SOCIOECONOMIC CONTEXT

Livelihoods:

- Are there small-scale farmers looking to transition their land away from traditional agriculture or cattle to forestry?
    - Small-scale farmers should consider enrichment planting over other strategies because of the minimal land preparation necessary before planting occurs, maximizing the economic opportunities for a planting cycle (101, 102).
- Has the area been harvested before or is there an interest in active forest management as part of the restoration strategy?
    - Enrichment planting has shown to increase the wood volume and economic gains from harvesting in secondary forest (103, 104). Enrichment planting can also include short-term and long-term gains through intermediate harvesting or through non-timber products (105).

Communities:

- Are there local or indigenous communities nearby with an interest in alternative livelihood opportunities?
    - For enrichment planting to be successful, engagement from the local community is necessary to monitor and manage the forest (106).

Technical capacity and labor availability:

- Is there skilled or trained workforce available in the area for the management of the forest?
    - Trained practitioners are necessary for the management of enrichment planting forest stands (106).

SECTION 4:

CHALLENGES WITH COLLECTING, ORGANIZING AND ANALYZING DATA AND HOW TO OVERCOME THEM

Organizing datasets: Each step in the site selection process involves multiple data layers, which will need to be organized and prioritized. The use of a spreadsheet is helpful to keep track of the data required for each step. In some cases, multiple datasets may be available for the same variable. Below, we provide general guidance for selecting and organizing datasets.

1. **Keep things simple to start and have clarity on what the restoration aims to achieve**. Additional data layers can always be added later, but it's best to begin with a set of data that covers the "essential" components first for a given context.

2. **Select the best data for each topic** (rather than including multiple layers with similar data). Consider the scale at which the dataset was produced (global or local) as well as what you trying to prioritize (eg. within a country or within a landscape). In many cases, global datasets produced through statistical or numerical modeling are highly inaccurate or inappropriate for use at local scales.

    a. When possible, use national datasets. These can be important for both engaging national governments and may be higher resolution than global datasets.

    b. Use datasets that either have the same time stamp, are from the same time period, or that have more recent data and imagery.

    c. Consider the spatial resolution that is necessary. There are times when coarser resolution is better, such as when they better reflect confidence in the accuracy of the data. For imagery, higher resolution is generally better but not necessarily for modeled raster data.

3. Ensure that data comes from a reliable source. Each dataset (which may contain multiple file extensions) should also have associated metadata, which can help in understanding the context in which a dataset was created, key data features, and where to go for more information about the data. **Have a principled approach for combining raster layers of different spatial resolutions, or for combining vector and raster datasets.** Raster layers range in spatial resolution from meters to tens of kilometers. It is best to work with someone who has experience in geographic information systems to decide the best way to align spatial resolutions, but generally speaking, one should upsample finer resolutions (e.g., average 30 m data to produce 1 km data). Downsampling coarse resolution rasters to finer scales tends to suggest a finer degree of precision in the data than is warranted. Spatial overlays of vector data on raster layers are useful for visualization, but converting vector layers to raster layers (via rasterization) must be done judiciously.

4. **Think about whether the data layers are still valid** for the variables you are concerned with after changing the ecology of the region. For example, the ecosystem services that exist in a region before and after a reforestation project are likely to be very different.

5. **Consider the accuracy of modeled data** – at the pixel scale, rarely is a model going to be accurate; however, they can show patterns and relative trends across a landscape.

6. **Generally, the most important variables for restoration success are the most difficult ones to access** or translate into spatial layers (e.g., land tenure, land use, rights to land). However, if these data are available, choose datasets that are easily accessible and available in standard formats to ease the process and create reproducible methods.

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SECTION 5:

RESOURCES BY DATA TOPIC

This guide seeks to serve as a resource for those interested in developing a comprehensive spatially informed and data-driven prioritization and identification process for potential restoration areas. For more information on additional spatial analysis resources for restoration siting, see Box 1.

Table 3: Data sources for ecological, political and social context topic areas.

TOPIC	TOOLS/DATA SOURCES AND NOTES
Ecological Context	
Land Use/Forest Cover	1. Rules of thumb for predicting tropical forest recovery. (Identify areas that are close to existing forests. Remnant forests in the landscape generally means more propagule sources and better regeneration potential 2. Applied Nucleation Guide (conservation.org) gives guidance on best practices, methodology and case studies on how to use this restoration strategy. This guide should be considered when using ANR as a restoration strategy. 3. ESA 300 m annual global land cover time series from 1992 to 2015 - 24 global land cover maps and additional resources. 4. Protected Planet - World Database of Protected Areas (PA), a database of terrestrial and marine protected areas that is updated monthly. Has data on number of areas, percentage coverage, governance types, IUCN management categories, and specific protected area designations by country. Public and downloadable data 5. Global Forest Change (30m resolution), also provides short-term historical context as it goes back to 2000-present 6. LANDSAT 8 at a 30 meter resolution provides a fine resolution for land and forest cover
Soil Condition/Topography/Slope	1. Areas more prone to landslides in the past 5-10 years (from EM-DAT): Areas with high inclination (topographic position index) and top of hills (topographic position index) 2. Global digital elevation models from the SRTM at 30m resolution provides high-quality mapping with digital elevation models (DEMs) for the entire globe. Data can be downloaded for free in 5 deg x 5 deg tiles in GeoTIFF or Esri ASCII format. 3. Soil erodibility study provides information on soil erodibility mapping and the correlations to soil properties.
Protected Areas	1. Protected Planet provides databases on the following topics: the World Database on Protected Areas (WDPA), World Database on OECMs, and Global Database on Protected Area Management Effectiveness (GD-PAME)

Biodiversity	1. IUCN Red List Species Richness and Range Rarity Data include raster for species richness and range-size rarity for amphibians, birds, and mammals. Species richness reflects the number of species ranges overlapping at each pixel. Range-size rarity also includes weighting based on the proportion of each species' range in each pixel. Please note that the ranges have not been refined based on land cover and elevation (eg. area of habitat), and raw ranges may include unsuitable habitats. However, by including unsuitable – but potential – habitat, these raw ranges may be more suitable for restoration analyses. 2. The World Database of Key Biodiversity Areas is a global database on KBAs: contains a searchable map of Key Biodiversity Areas (KBAs), Potential ranges of species diversity of key taxa, or of endemic species and/or threatened species would all be good candidate metrics. The goal would be to give an indication of the relative conservation potential of different species. Some of the features and data of the official IBA website are not available through the free plan. 3. Towards a global understanding of drivers of marine and terrestrial biodiversity has compiled data from around the world to model species richness and the state and vulnerability of climate. 4. IUCN RedList provides data on a number of vertebrate species ranges, rarity, and richness present in a given pixel. 5. Spatial Planning for Area Conservation in Response to Climate Change (SPARC) provides information that can support planners in considering the effects of climate change more effectively. SPARC mapped conservation priorities by modeling over 100,000+ plant and animal species under both current and future projected climates. Data layers are available for download on the SPARC website (linked above) or for view on the Resilience Atlas. 6. The Species Threat Abatement and Restoration Metric (STAR) uses data from the IUCN Red List of Threatened Species to evaluate the potential to benefit threatened species with threat abatement and habitat restoration. Planners can use the restoration score (STARR) to quantify the potential contributions that restoration activities offer toward reducing extinction risk globally. Threat abatement (START) and restoration (STARR) data layers are available in Mair et al., 2021 Supplementary Information.

Biodiversity	7. PADDD - Protected Area Downgrading, Downsizing, and Degazettement) is a database of efforts to scale back protections of national parks or protected areas. Raw data is not easily accessible from the map view, but can be downloaded for free from the 'Download Data' section. 8. IUCN's Biodiversity guidelines for forest landscape restoration opportunities assessments. 9. Bird Distribution data is provided by BirdLife International through the DataZone containing information on species and case study examples. 10. Alliance for zero extinction mapped critical areas for protection to ensure the survival of the world's threatened species. The map is searchable by country, taxonomic group, selected polygons, or downloadable data. 11. Mapping of Invasive species can be found through Invasive Species Specialist Group on the Global Invasive Species Database (GISD) or Turbelin et al., 2016 Mapping of the global state of invasive alien species. 12. Secretariat of the Convention on Biological Diversity's Sourcebook to Remote Sensing and Biodiversity Indicators has data on national maps on species distribution, abundance, biodiversity assessments and threats. 13. Critical Ecosystem Partnership Fund (CEPF) conservation corridors and biodiversity hotspot data is aiming at protecting the world's hotspots and biodiverse rich places.
Carbon	1. CMS: Estimated Deforested Area Biomass, Tropical America, Africa, and Asia, 2000. -This dataset estimates pre-deforestation aboveground live woody biomass in tropical regions for the year 2000. The data is for areas that were deforested from 2000-2012 and the biomass estimates can be used to calculate carbon emissions. Dataset is downloadable. 2. Global carbon dioxide removal rates from forest landscape restoration activities developed biomass accumulation rates for forest landscape restoration projects. 3. Effect of species richness and vegetation structure on carbon storage in agroforestry systems in southern Amazon of Bolivia I Revista de Biología Tropical; I Revista de Biología Tropical 4. Rate of carbon accumulation from natural regeneration, Cook-Patton et al., 2021. Resolution: 1km 5. IIS Potential for Natural Regeneration provides a proportion of 1km tile with potential for natural regeneration.

Carbon	6. Areas of recent mangrove lost 7. FAO's Soil Organic Carbon mapping of soil carbon loss and soil carbon sequestration potential. 8. Harmonized global maps of above and belowground biomass carbon density in the year 2010 created comprehensive, 300-m resolution maps of biomass carbon densities across a variety of vegetation types (Spawn et al., 2020).
Ecological Risks	
Deforestation	1. Global database on Land Degradation: Resilience Atlas - Summarized data from 60 resilience-related datasets with layers for livelihoods, ecosystems, production systems (agriculture and fisheries), stressors and shocks, and factors influencing vulnerability. Degradation layer showing degradation, improvement, or stability based on changes in primary productivity, land cover, and carbon stocks. Data should distinguish between deforestation/forest degradation drivers: fire, industrial agriculture, pasture, small scale/rotational agriculture, logged or partially logged areas, urbanization, etc. Local information would be ideal. 2. See the process described in: https://science.sciencemag.org/content/361/6407/1108 3. Global dataset at 1km resolution: New 1 km Resolution Datasets of Global and Regional Risks of Tree Cover Loss 4. Global Restoration Opportunities in Tropical Rainforest Landscapes, (44). - This source includes a 'restoration feasibility' calculation for lowland tropical forests (the relative rate of recent tree cover loss, which represents the chances that restored forests persist over time without reconversion to alternative land uses and also serve as a proxy of investment risks). 5. Trends.earth - Map degraded/deforested areas. Use in combination with Hansen Global Forest change 6. Hewson Deforestation risk to identify risk of conversion from forested to non-forested state in the period 2014-2029 7. Space-time cubes - a spatial and temporal time-series analysis tool.
Fire	1. Global Forest Watch: Fire and Logging data, and/or underlying data sources: Forest Monitoring, Land Use & Deforestation Trends I Global Forest Watch 2. Firecast (past trends in fires) tracks ecosystem disturbances such as fires or deforestation via satellite and alerts and provides decision-makers in the area with timely information. An Active Fire Live Map shows fires globally while regional summary maps on forest fires from 2002 to 2013 are available and downloadable for Peru, Bolivia, Madagascar, and the Philippines.

Fire	3. The human dimension of fire regimes on Earth, (Bowman et al. 2011) discusses the link between human occupation and fire risk in a mesic tropical forest. 4. MODIS global burned area data can be used to see past trends of fire in the region of interest. 5. VIIRS: NASA active fire product 6. Observed historical fire occurrence as a proxy of fire risk (USGS/NASA 2020) 7. The Global aridity index identifies fire-prone areas or areas with greater likelihood of fire in the future. 8. EM-DAT is the International Disaster Database at the national and subnational scale.
Inland and Coastal Flooding	1. NOAA Coastal Management Database
Hurricane	1. Resource Watch: United States Hurricane Tracker 2. NOAA Hurricane Center and Central Pacific Hurricane Center
Political Context	
Land Tenure: including indigenous lands, protected areas, and traditional regimes when possible/appropriate as well as private lands	1. CI Indigenous Peoples and Local Communities spatial data. 2. Coming soon: the Conservation Atlas Initiative is collecting data on land tenure. 3. Legal records of land disputes on file may provide information about whether and how land tenure has been disputed in the past. 4. Coming soon: Data on IPLC land tenure based on the bundle of rights framework available for 43 countries. 5. Spatial data on legally recognized collective lands with tenure information on access, use, management, exclusion and alienation rights. Tenure considered “stronger” where IPLCs have rights in the bundle of rights or when they own the land. Data will be available after IPLC-tenure paper publication in FY-21, but some data for selective countries may be available from Sushma Shrestha (sshrestha@conservation.org). 6. Garnett et. al. 2018 - This data is available for CI’s use but has specific use criteria that needs to be followed when using it. See use-criteria for CI here. Reach out to Stephen Garnett (stephen.garnett@cdu.edu.au) to request data access. 7. Landmark - Includes both traditional and formal regimes. Database of lands collectively used and held by Indigenous Peoples or local communities presented in maps. Data downloadable directly off the website.

Land Tenure: including indigenous lands, protected areas, and traditional regimes when possible/appropriate as well as private lands	8. ICCA Registry. The ICCA Registry - Global database on ICCAs (indigenous peoples' and community conserved territories and areas). Voluntary, online collection of information on areas and territories conserved by indigenous peoples and communities. Case studies submitted by indigenous peoples are available online and to the public but further data collected by the Registry is not accessible. 9. Native lands provides data on indigenous and community conservation areas or indigenous and community lands. 10. IUCN Natural Resource Governance Framework provides guidance on effective and equitable conservation. 11. Toward a Tenure-Responsive Approach to Forest Landscape Restoration: A Proposed Tenure Diagnostic for Assessing Restoration Opportunities (McLain et al., 2018) looks at the ROAM tools use of land tenure and provides suggestions for improvement.
Political context/governance	1. Conservation Beyond Protected Areas - CI's social science team has been collecting spatial data on all area-based conservation governance systems globally 2. World bank governance indicators: - The Worldwide Governance Indicators project aggregates data from over 30 sources to report governance indicators on: voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption. After choosing the indicator/s, the year/s, and the country or collection of countries, the interactive data access tool displays the data in different formats such as graph, table, or time series view, making it possible to compare statistics. 3. International Institute of Peace - This organization works to address any violence that takes place in the world, mainly in areas of high population. 4. USAID Political Economic Analysis (PEA) 5. UKAID Political Economic Analysis (PEA)
Legal limitations or obligations to restore	1. National plans, priorities, and land tenure arrangements - Collect plans from relevant agencies on restoration commitments. GIS layers on national targets from SDGs, NDCs
Demographics	1. WorldPop is an archive of demographic and distributional data for the world population. Data is open access and downloadable for many measures, such as births, pregnancies, urban change, and more for individual countries and is displayed on a map as well.

Political Risks	
Unstable Land Tenure	1. PADDD (protected area downgrading, downsizing and degazettement) can provide information on legal rollbacks to protected areas
Socioeconomic Context	
Agricultural productivity	1. Naidoo and Iwamura, 2007 - Global-scale mapping of economic benefits from agricultural lands: Implications for conservation priorities. 2. Mapping agricultural land and land types, including a distinction between industrial agriculture, industrial/large-scale commercial cattle, and subsistence/smallholder farming (minimum level of analysis).
Opportunity costs of land	1. Global Restoration Opportunities in Tropical Rainforest Landscapes, (44) - For restoration feasibility this paper includes three variables: land opportunity costs, landscape variation in forest restoration success, and restoration persistence chance 2. MCODE (Modelo para cálculo do custo de oportunidade do uso da terra) - This tool computes the opportunity cost of a given piece of land based on the land use around it. It is slightly out of date but still a good option at the global scale.
Market-based considerations Land use, forest product markets and agriculture	1. ESA CCI land cover time series annual maps 1992-2018 at 300m: Agricultural areas, the type of agriculture present, and major trends in the agricultural sector. 2. Mapping the Global Distribution of Livestock: Maps of livestock, indicating the need to check for pasture grass. 3. World agroforestry: Provides information on ecological agricultural restoration systems and how to reconcile conservation with production. 4. Revista de Biología Tropical: Effect of species richness and vegetation structure on carbon storage in agroforestry systems in southern Amazon of Bolivia 5. There are many excellent guides written on where and how to implement agroforestry for conservation and carbon sequestration.

Communities	1. TNC's Water Funds Toolbox: Water Funds are organizations that unite community stakeholders to take collective action to improve water security. The Toolbox site includes a map and list of existing Water Funds as well as regional example stories. 2. Coastal flood risk - Database of risk that can be minimized by mangrove restoration 3. Nature Dependent People - Layer of the nature dependent people who are dependent on nature for basic needs (i.e. where people highly depend on wood for energy) 4. Indigenous lands – indigenous and community conservation areas or areas of indigenous people and local communities. Or Native Lands.
Livelihoods	1. A Guide to the Restoration Opportunities Assessment Methodology (ROAM): Assessing forest landscape restoration opportunities at the national or subnational Level. IUCN: International Union for Conservation of Nature & WRI: World Resources Institute, 2014. (see pages 58 to 63 for the Stakeholder Prioritization of Restoration Interventions tool and other relevant information). 2. Peace Corps Participatory Analysis for Community Action (PACA) Training Manual. Peace Corp, 2007. Oriented towards use at the community level-mapping. 3. Good Practices in Participatory Mapping: A review prepared for the International Fund for Agricultural Development (IFAD). IFAD, 2009. Oriented towards community level-mapping. 4. Rapid Rural Appraisal and Participatory Rural Appraisal: A manual for CRS field workers and partners. Freudenberger, K. S., CRS: Catholic Relief Services, 2008. Oriented towards community level-mapping.
Technical capacity and labor availability specialized for restoration	1. AidData is a research lab at William & Mary and in partnership with CI.
Socioeconomic Risks	
Population growth and urban expansion	1. WorldPop develops peer-reviewed, open-source, spatial data focused on low-medium income populations and demographics. 2. UN-Habitat works across the globe to promote positive change, policies and practices in the urban landscape through setting standards, monitoring set policies and global practices and partnering with organizations and governments. 3. Trends.Earth urban mapper can be used to calculate urban expansion.
Public Health Risks: (COVID-19)	International and national datasets on risks https://ourworldindata.org/coronavirus - Database of COVID-19 related information

BRAZIL DATA SOURCES	
Ecological Context	
Forest cover/Land use	1. Map biomass is initiative that maps historic land use and cover change in Brazil via a collaboration between various experts and data types. Maps, statistics, and infographics are available for download or the interactive map contains layers on land cover, transition from 1985 to 2018, deforestation (beta), and regeneration (beta). 2. DETER and DEGRAD - Coordenação-Geral de Observação da terra for the Amazon. 3. ImazonGeo is a map with a variety of spatial layers for the Amazon region. 4. TerraClass is INPE Centro Regional da Amazônia de Pesquisas Espaciais. 5. SAD Alerta 6. Terrbrasilis – Geographic Data Platform
Carbon	1. Atlas Agropecuário - Interactive map with layers on land tenure, land use, and carbon 2. Carbono Vivo - carbon sequestration tool
Ecological Risks: Fire	1. INMET – Instituto Nacional de Meteorologia is the ministry of agriculture, livestock and supply database.
Political Context	
	1. Atlas of Brazil Agriculture - Land tenure, land use, Carbon and Forest spatial data 2. RAISG is an ArcGIS Online spatial map of the Amazon region with a variety of layers included.
Socioeconomic Context	
Technical capacity and labor availability specialized for restoration	1. Alianca Amazonia is Brazil's organizational mapping throughout the Amazon (page 9)

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BOX 1. EXISTING TOOLS AND GUIDANCE DOCUMENTS THAT CAN INFORM SPATIAL ANALYSIS FOR RESTORATION

- ROAM: https://portals.iucn.org/library/sites/library/files/documents/2014-030.pdf
- ITTO: https://www.itto.int/direct/topics/topics_pdf_download/topics_id=6511&no=1&disp=inline
- FAO: http://www.fao.org/3/ca4191en/CA4191EN.pdf
- WRI Guide: The Road to Restoration
- SER Standards - https://www.ser.org/page/SERStandards/International-Standards-for-the-Practice-of-Ecological-Restoration.htm
- Kew Guide: https://shop.kew.org/restoring-tropical-forests-a-practical-guide#tab-label-description-title
- IUFRO Guide
- ROOT - https://www.naturalcapitalproject.org/software/#root-software
- (InVEST) – http://www.naturalcapitalproject.org
- Carbon Balance Tool for Agriculture and Forestry Sector - http://www.fao.org/tc/exact/carbon-balance-tool-ex-act/en/
- Restoration Ecosystem Service Tool Selector (RESTS) - https://forestecosyst.springeropen.com/articles/10.1186/s40663-016-0062-y
- Africa Tree Finder app - http://www.vegetationmap4africa.org/Species/Africa_treefinder.html
- Mobile phone map of Vegetation and Climate Change in East Africa (VECEA) - http://www.worldagroforestry.org/project/vegetation-and-climate-change-eastern-africa
- Qualitative method: the Forest-Poverty Toolkit - http://www.profor.info/content/poverty-forests-linkages-toolkit-1
- GLADIS - http://www.fao.org/nr/lada/gladis/gladis/
- Map SPAM - https://www.mapspam.info/


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SECTION 6:

CASE EXAMPLES

CASE EXAMPLE 1:

BRAZILIAN AMAZON

Authors: Bruno Henriques Coutinho, Maria Isabel Martinez Garcia, Laís Sarlo, Luís Barbosa an Danielle Celentano

High level summary: A spatial analysis was conducted for by Conservation International - Brazil (CI-Brazil) to identify potential sites for restoration for areas over 100,000 ha, suitable for assisted natural regeneration (ANR) and in the Brazilion Amazon. There was ample data available for the ecological (land use/deforestation/carbon), political (land tenure/priority areas), and socio-economic (opportunity costs of land) contexts to produce six maps prioritizing restoration sites.

Context: Brazil is a large country with a wide range of forest types, and its conservation and restoration efforts are at the center of the global stage. Its forests are among the most biodiverse in the world and store vast amounts of carbon. Both deforestation and reforestation processes are occurring rapidly.

The political context is mixed with respect to restoration. Major Brazilian banks are making commitments against illegal deforestation, and past national administrations have passed proactive policies towards conserving and restoring forests. However, when a national administration makes elements of restoration bureaucratic or challenging, working on restoration initiatives with state-level governments can be more feasible.

Data on forests and forest cover change is abundant and of high quality, and spans a number of years. CI-Brazil's analysis focused on the Brazilian Amazon, a key biodiversity and deforestation hotspot in which there are many different restoration initiatives taking place.

Goals and desired outcomes of the pilot

The main goal of participating in the mapping exercise was to locate larger scale areas (ideally of more than 100,000ha) with good potential for assisted natural regeneration (ANR) in the Brazilion Amazon. A joint focus on carbon sequestration and co-benefits (especially biodiversity and human wellbeing) was key. The map would be used to prioritize CI's actions and increase efficiency in both planning and implementation. Specifically, findings would help the team design a national strategy for restoration with more precisely defined geographic details than previous strategies, and could also serve to connect and coordinate efforts occurring in the same region. Results of the mapping process will also be published in the academic literature.

Data collection and data sources

Brazil has a wealth of publicly available data, and the team was able to collect data on key topic areas outlined in the guide. Data on nearly all variables was collected from the websites of public institutions, including the National Institute of Space Research which has readily accessible data that has been used in analyses before.

In many cases, the team had multiple data sources for a given variable. The abundance of readily available data required that the authors develop methods and criteria for choosing between different sources and formats of available data, as follows:

1. They excluded variables that could be auto-correlated. Rather than use statistical analyses, this was done based on an understanding of the source of information, and by mapping the data and removing variables if redundancies seemed apparent.
2. They also chose between multiple options for similar data by preferentially selecting 1) official data sources; 2) datasets that were most up to date; and 3) datasets that were most accurate in terms of scale.

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Table 1: Data and data sources used for each step in the Restoration Protocol.

TOPIC	DATA SOURCES AND NOTES
Ecological Context	
Land Use/Forest Cover	Phytophysiognomies - IBGE, 2019 Distance from Forest Remnants - PRODES, 2019 Forest Connectivity - CI/Aliança pela Restauração na Amazônia, 2020
Biodiversity	Plant Diversity Prediction to Year 2070 (SPARC) – CI, 2020 Climate Change Prediction to Year 2070 (SPARC) – CI, 2020 Fresh water ecosystem services - MENC2/ CI, 2015 Weighted Endemism - MENC2/ CI, 2015 Priority Areas for Conservation (Biological Importance) - MMA, 2019 World Database of Key Biodiversity Areas (KBAs) – IUCN, 2020 Potential for natural regeneration –IIS, 2019
Carbon	Carbon accumulated in secondary forest biomass -Celso H. L. Silva Junior, 2020
Ecological Risk	
Land Degradation and Deforestation	Amount of secondary forest's deforestation in the same area (2008-2018) - Celso H. L. Silva Junior, 2020
Fire	Number of fires occurring in the same area during the period (2001-2019) - USGS/ NASA, 2020 Recent fire risk (2005-2019) - USGS/ NASA, 2020 PADDD (2010-2019) - CI, 2020
Political Context	
Land tenure	Macro ZEE Legal Amazon – MMA, 2009 Land Tenure - IMAFLORA, 2019
Political context/governance	Definition of Scope Area in Amazon Biome - MMA, 2019; IBGE, 2019; and DETER/INPE, 2020
Legal limitations or obligations to restore	Priority Areas for Conservation, Sustainable Use and Sharing of Biodiversity Benefits - Restoration Actions – MMA, 2019
Socioeconomic Context	
Opportunity costs of land	Opportunity cost of land use - Naidoo e Iwamura, 2007

Despite having relatively easy access to data, the team found that the effort required to compile and analyze the data was substantial. They estimated that a dedicated, full-time person would have been able to do this in 2-3 weeks, and recommend that teams consider hiring a full-time consultant for that time period to collect data, run the modeling, and create maps.

Stakeholder engagement/workshops:

The Brazil team ran stakeholder engagement workshops with the goal of coming to a group decision about the importance of different variables, legitimizing the process, and bringing people on board. Specific goals included: 1) presenting the initiative, 2) gathering feedback, 3) engaging partners and 4) conducting a participatory variable 'weighting' process to inform the maps. In addition to 10 staff members from the Brazil CI office, external participants included a researcher from the Brazilian National Institute for Space Research (INPE), and representatives from the NGO Imazon. Two workshops were held totaling 9 hours in collaboration time.

Workshops began with a presentation of the goals and the overall process of site selection, and then a more detailed explanation of the variable weighting process, data layers, and classification. Participants provided abundant feedback and contributed to an exercise using cards with various geospatial data layers which they organized in order of importance.

CI-Brazil felt that the workshop process was important to bring legitimacy to the process via the inclusion of other experts and partners, and also because they had so many variables to work with. In other regions with less data, the process would likely be less time consuming and complex. They recommend that workshops include at least two academic professionals, two specialists from government, plus other NGO partners as appropriate.

Mapping Methodology

The results from each step in the guide were combined into a single map for that step with multiple layers. These layers were weighted (using a normalized 0-1 classification). For all layers, the file sources and metadata were recorded in an excel file for future reference. Approximately 20 shapefiles were used to run the model. The outcome was five separate maps that were combined to produce the final map.

First, the team determined our area of interest using polygons and eliminated forest, hydrograph, or urban areas. Additional details for the methodology are provided below.

STEP 1: Under the political context, the team mapped national plans, priorities, and land tenure arrangements. The team integrated data on restoration actions in the Amazon biome, and from IMAFLORA into this stage of mapping (see graphic below). Note: This stage has not included CI internal goals or existing work.

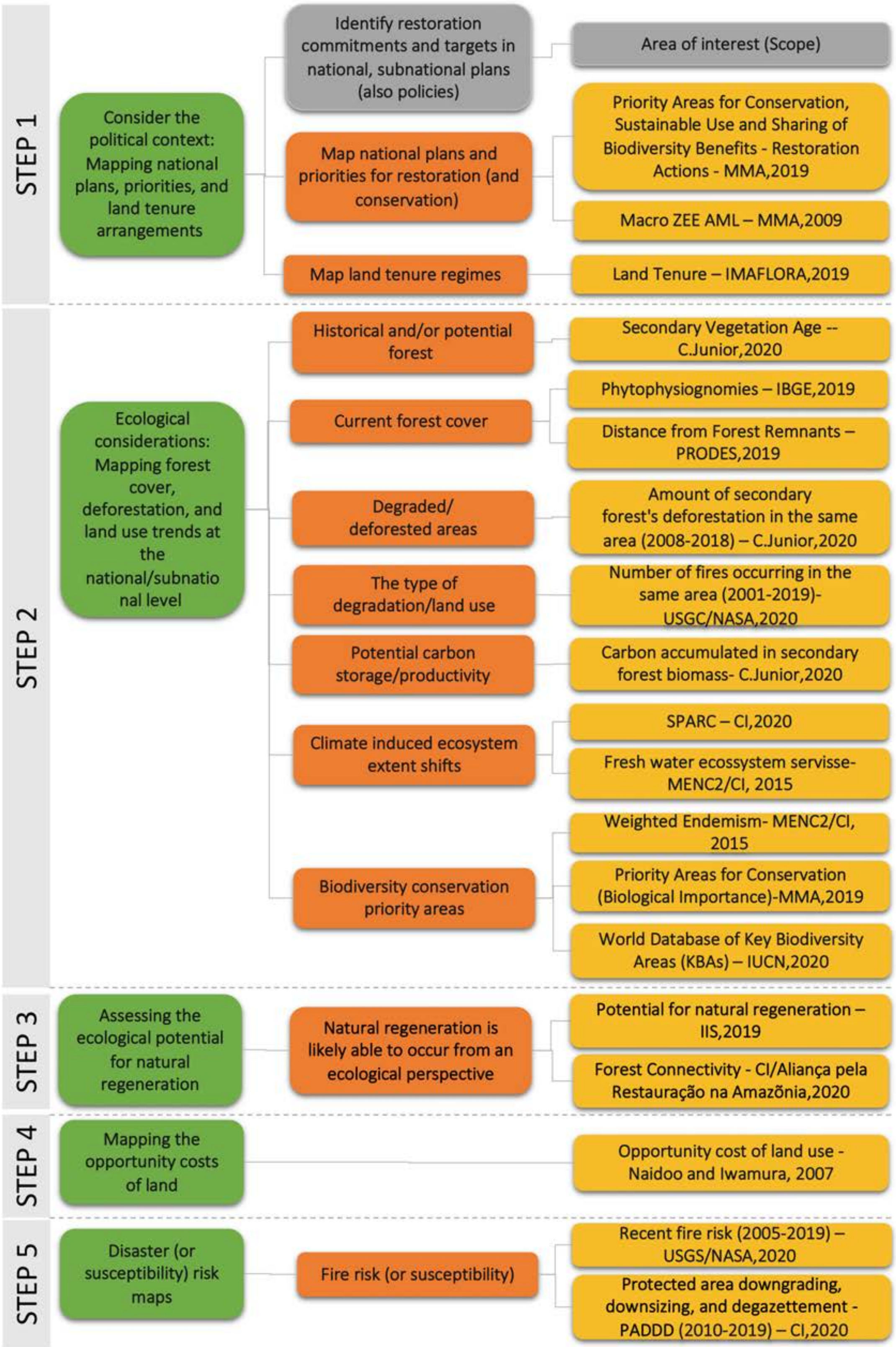
STEP 2: Data collection and processing for the ecological context proved to be the most challenging step due to the numerous data sources (including climate, forest extent, ecology, and biodiversity). The selection of data were chosen based on restoration criteria and combined with the remaining data to perform a weighted overlay. The team found this process extremely time-consuming. At each step, from blue, to green, to yellow, many layers and classes within the layers are combined and weighted to use for the ecological context.

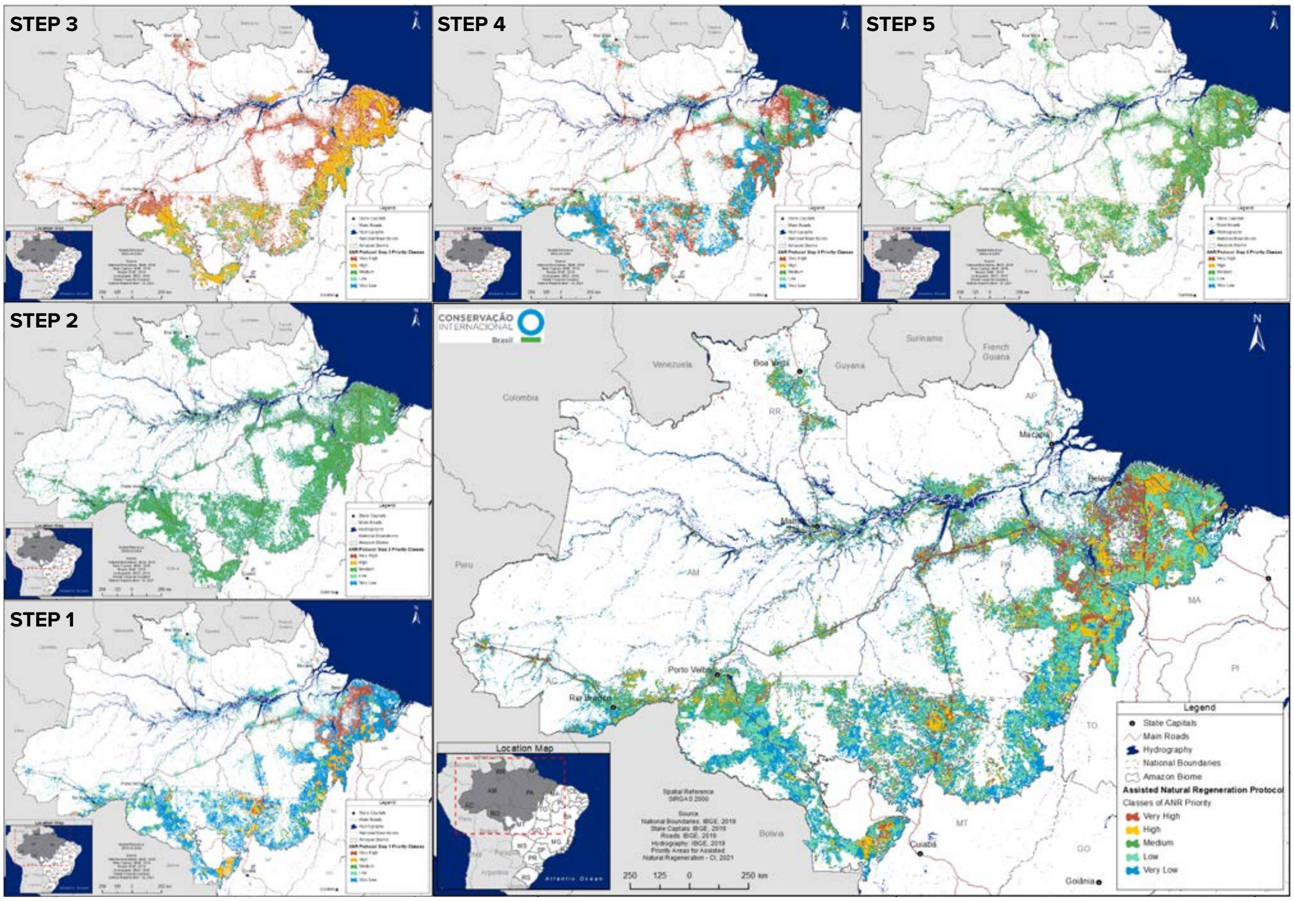
STEP 3: To access the viability of using ANR as the restoration strategy, the team examined the forest connectivity to the area of interest.

STEP 4: The opportunity cost of land was mapped from a single data source . The areas in the map below represent higher opportunity cost.

STEP 5: The disaster/susceptibility to risk maps incorporated historical burned area data (2001-2019) and data from PADDD records (2010-2019) showing where protected areas have been downgraded, degazetted, or downsized.

Final Result: This is the final map combining all of the previous layers shown above, with very high class areas shown by size class.




STEP 3
STEP 4
STEP 5
STEP 2
STEP 1
CONSERVAÇÃO INTERNACIONAL
Brasil
Venezuela
Colombia
Suriname
French Guiana
Guyana
Boa Vista
RR
AP
Macapá
Belém
Manaus
AM
PA
MA
PI
Peru
Porto Velho
Rio Branco
TO
MT
Cuiabá
GO
Goiânia
Bolivia
Location Map
Atlantic Ocean
Spatial Reference
SIRGAS 2000
Source
National Boundaries: IBGE, 2019
State Capitals: IBGE, 2019
Roads: IBGE, 2019
Hydrography: IBGE, 2019
Priority Areas for Assisted Natural Regeneration - CI, 2021
250 125 0 250 km
Legend
State Capitals
Main Roads
Hydrography
National Boundaries
Amazon Biome
Assisted Natural Regeneration Protocol
Classes of ANR Priority
Very High
High
Medium
Low
Very Low

Outcomes of the mapping process

The map produced through the analysis (more than 60 GB in size) involves more than 20 layers. Through this analysis, the team separated the area into 5 priority classes, ranging from very low to very high for assisted natural regeneration. Within the very high class, there is 12 million ha of priority areas for assisted natural regeneration. The states with the greatest total area for restoration are Pará (6.6M ha), Mato Grosso (2 M ha), Amazonas (1 M ha), and 6 other states with hectares below a million. These very high regions were crossed with the land tenure and determined the majority of the land the majority of the land consists of rural settlements, private properties and untitled public areas. This map provides a realistic representation of the target areas for ANR in Brazil.

Key challenges and lessons learned

1. The cost and specifications of the equipment used for a weighted spatial analysis was quite advanced. In cases where organizations do not have access to this type of equipment, partnerships between groups with access to this technology is necessary.

2. The data can be unwieldy because of the size and diversity of layers, and the technology required to do the analysis can be slow in its processing. Processing high spatial resolution geodata on a regional scale can be an arduous task if it is not performed on high-performance computers.

3. Skills in GIS, mapping, modelling, etc. are required for this type of analysis. Smaller teams may need to engage with consultants or volunteers to fill in the skill sets needed to conduct this level of analysis.

Next steps

One of the goals of the analysis was to identify large-scale areas, and in this initial analysis the team identified small-scale areas which can be filtered out in a future analyses based on organizational priorities. However, in the initial steps this general analysis helped identify patterns for restoration in the landscape. This analysis resulted in a useful map of the Amazon region, but the ultimate goal is to use this process to identify large areas for restoration and potential partners on the ground to further restoration efforts.

CASE EXAMPLE 2:

FIJI

Authors: Isaac Rounds, David Hunt

High level summary: A spatial analysis conducted for Fiji identified potential sites suitable for restoration activities. Ecological (land use/deforestation/biodiversity) and political (land tenure) data were used to determine priority areas for restoration through a weighted overlay. This analysis resulted in a restoration prioritization layer with pixels ranging from 1 – 5, with 5 representing the highest priority locations and 1 representing the lowest priority, yet still suitable, locations for restoration. This analysis also accounted for government priority areas and the socio-economic context of the region given the amount of communally owned or managed land in Fiji suitable for restoration.

Context

Fiji is an archipelago of 300+ small islands in the South Pacific, with a total land area of 18,270 km^2 and population of just over 900,000 (107). The site selection mapping analysis encompassed Viti Levu, Vanua Levu, and Taveuni, but particularly focused on drier areas on the Viti Levu (the main island which is also the most populated).

Biophysical and land use history context

Fiji has a long history of agricultural expansion. This has mainly centered around sugarcane plantations, but due to market demand, agriculture has been diversifying in recent years. This agricultural development has come with environmental costs, such as soil erosion, agrochemical usage impacts, and water pollution (108). Tropical dry forests, one of the most threatened tropical ecosystems, exist in Fiji in small remnant patches. Fire is a major threat to these forests as it is used in both traditional agricultural systems to clear land, and more recently for managing land converted to commercial crops (mainly sugarcane and pine plantations;109). From 2001 to 2019, forest area decreased by about 42 kha - a 2.7% decrease in forest cover since 2000 (110).

Social context

Approximately 90% of the land in Fiji is owned and managed by indigenous Fijians (*iTaukei*) (111). iTaukei lands are communally owned and cannot be bought or sold except to the government; however, some areas can be leased for up to 99 years. The iTaukei Land Trust Board (TLTB) administers the land and is responsible for identifying the land needed for indigenous communities and leasing the remainder (110). Historically, indigenous people have practiced swidden agriculture and today these practices still occur at the subsistence level.

Goals and desired outcomes

The main goal of the analysis was to engage and inform the government on priority areas for restoration and identify areas that are suitable for assisted natural regeneration (ANR). The national government has goals to restore over 800,000 ha of degraded lands, but have yet to determine where restoration should take place. This analysis will be used to work with the government to inform restoration action on the main island of Viti Levu and Vanua Levu.

Stakeholder engagement

Stakeholders were not formally engaged in the mapping process, but staff leading the analysis held informal meetings with key people involved in restoration.

Data collection and sources:

Data was obtained from government sources. CI Fiji generally focuses on national government priorities and has a close working relationship with them. Data sharing is part of an formal and informal agreement in which CI uses government data to undertake analyses with the understanding that this data will be used to inform and guide government plans and actions on the ground.

Table 1: Data and data sources used for each step in the Restoration Protocol.

TOPIC	DATA SOURCES AND NOTES
Ecological Context	
Land Use/Forest Cover	Fiji Forest Cover Map - Ministry of Forest 2016 Forest Cover Map – Ministry of Forest
Biodiversity	World Database of Key Biodiversity Areas (KBAs)
Carbon	N/A
Ecological Risk	
Land Degradation and Deforestation	2007-2017 Forest Cover change maps – Ministry of Forest
Fire	Number of fires occurring in the same area during the period (2001-2019) - USGS/ NASA, 2020 Recent fire risk (2005-2019) - USGS/ NASA, 2020
Political Context	
Land tenure	Native Land Commission Land Tenure – Fiji Government
Political context/governance	N/A
Legal limitations or obligations to restore	Fiji Emission Reduction Plan Accounting Areas Targets – Fiji Government 2019 Priority Sites for Conservation – Fiji Government 2016
Socioeconomic Context	
Opportunity costs of land	N/A

Data processing

Data was compiled by the project lead, who has experience with the datasets used but does not work specifically on mapping and spatial analysis, and analyzed by the spatial coordination team at CI's Betty and Gordon Moore Center for Science.

Weighting variables

Because of the limited number of datasets (an issue likely common to many small island countries) there was no formal process for weighting variables in this analysis. Instead, the lead analyst used in-depth personal experience and knowledge of the local context as well as informal input from colleagues to decide which variables are most critical for ANR. Distance to nearest forest or forest patches distance to nearest village, and other factors that determine the opportunity cost of the land were given more weight. In addition, distance to nearest protected area or proposed protected area was also given more weight. Areas where there is a high incidence of fire were excluded completely as fire is one of the major threats to ANR. Maps of the critical steps in the analysis are shown below.

STEP 1: The change between the 2007 and 2017 forest products was analyzed to determine areas that would be suitable for ANR. Any area that had not experienced deforestation during this time period was removed from the analysis. While a longer time period would be ideal, we only had comparable forest products for each year dating back to 2007.

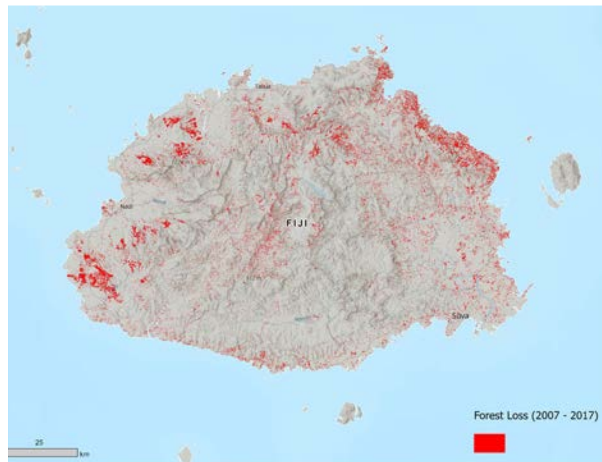


Figure 1. Initial map of areas suitable for ANR in Viti Levu based on historical deforestation

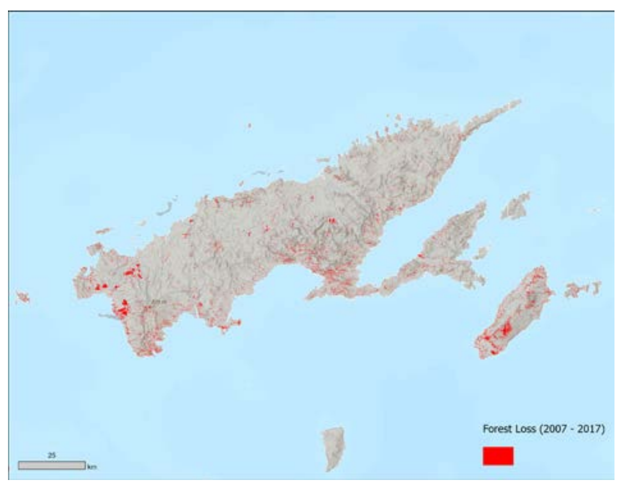


Figure 2. Initial map of areas suitable for ANR in Vanua Levu based on historical deforestation

STEP 2: The next step of the analysis was to remove areas from the analysis that were not suitable for ANR. These areas included variables such as proximity to villages and cities, presence of timber plantations, presence of sugar cane farms, a high historical fire density, and an elevation over 700m.

Outcomes of the mapping process

Below are the final ANR priority maps for Fiji. This involved combining the layers above to produce a final map of areas that were suitable for ANR. We then prioritized these suitable pixels using variables including proximity to protected areas and key biodiversity areas, and proximity to roads.

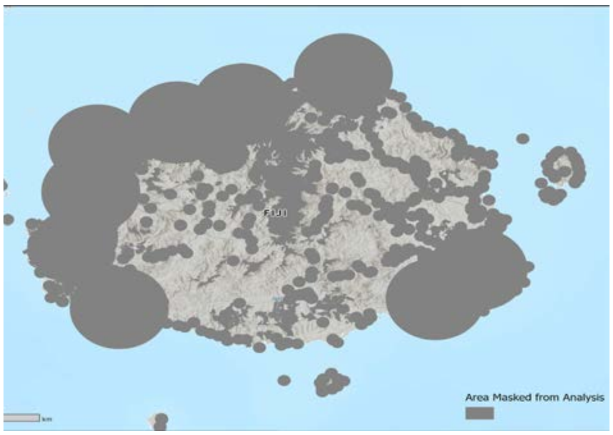


Figure 3. Areas masked out of the analysis in Viti Levu

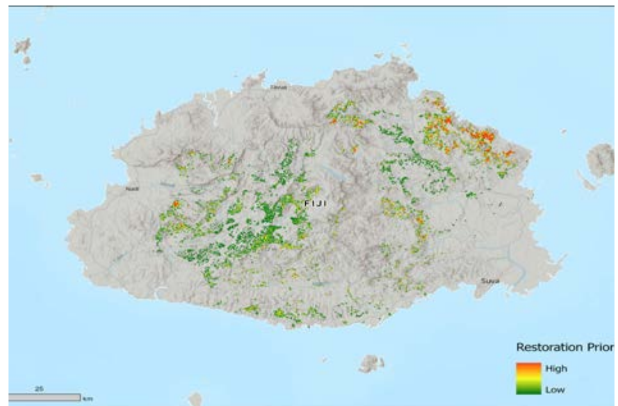


Figure 1. Final Map of ANR Potential in Viti Levu, after the process of weighting different layers

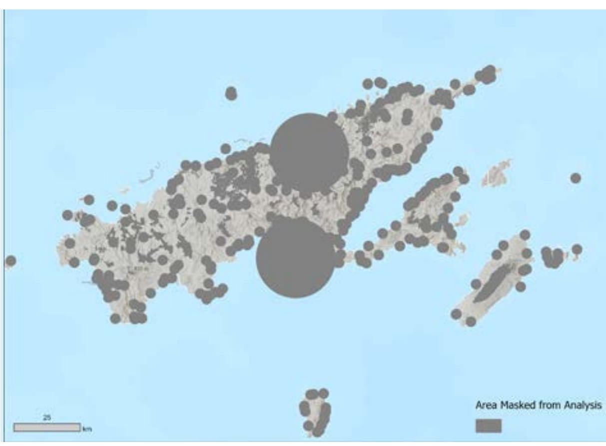


Figure 4. Areas masked out of the analysis in Vanua Levu

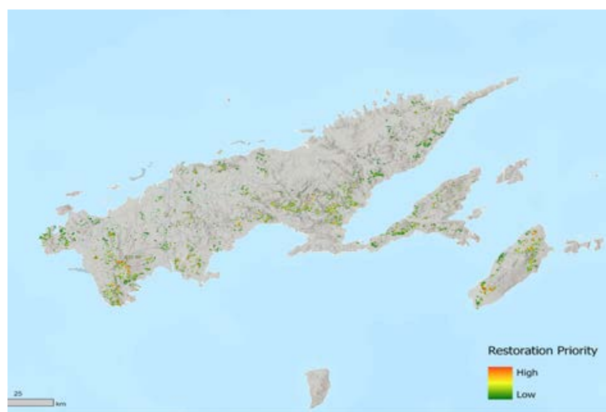


Figure 2. Final Map of ANR Potential in Vanua Levu, after the process of weighting different layers

Key challenges and lessons learned

1. The basic data categories were available for Fiji, but the team did not have to choose between multiple datasets as there were few available for each step.
2. Satellite data is intermittent, sporadic and often of low resolution as satellites do not often fly over the Fiji region, and if they do, image quality can be poor because of cloud cover/haze.

Context is important when choosing and weighting variables. In Fiji, given that most of this work was to take place on communal lands, understanding the socio-economic context of communities and matching needs with outcomes is key. As the project lead put it: "What can the project do for the people and what do they really want/need?" Understanding local livelihoods is addressed at the regional level and at the local level, but these steps were not integrated into this pilot case. There is also a need to clearly articulate the locally-relevant benefits from ANR. For example, biodiversity conservation may not be as interesting as water management issues to local communities in Fiji. For more information on ANR and its benefits and challenges, see CI's ANR guide (111).

Timelines and effort required

Compiling and organizing the data took only 2-3 days, mainly because the team had worked with much of this data before.

Data processing and weighting steps

- We established an initial area of interest by overlaying areas deforested between 2007-2017 (forest cover product produced by Fiji Ministry of Forestry) and classes VII and VIII from the Fiji land-use capability product
- We removed both hardwood (mahogany) and softwood (pine) plantations from these potential restoration areas
- We removed areas with a calculated fire density over 1 fire per square kilometer
- We removed any sugar cane farms from the potential restoration sites
- We created a buffer of 2km around all villages and a buffer of 15km around all towns/cities and removed these areas from potential restoration sites
- Using a DEM, we removed all areas with an elevation over 700m because the areas are too cold and regeneration would occur too slowly
- We merged protected areas and key biodiversity areas together and calculated a Euclidean distance raster from these sites. This distance raster was reclassified using the scheme below:

NoData - > 10000m
1 - 10000-5000m
2 - 5000-2000m
3 - 2000-1000m
4 - 1000-0m
5 – 0m

- We also calculated a Euclidean distance raster from all major roads. This distance raster was reclassified using the scheme below:

NoData - <500m
1 - 500-1000m
2 - 1000-1500m
3 - 1500-2000m
4- 2000m<

- We then multiplied the priority restoration areas with all of the masks applied, the reclassified PA/KBA distance raster, and the reclassified major road distance raster. This produced a product ranging from 1-20 with higher values representing more optimal locations for restoration. **This product was reclassified to values ranging from 1-5 to simplify this scheme. 5 represents the best areas for potential restoration activity, while 1 represents the worst, but still potentially feasible, areas for restoration.**
- Both mining and logging areas were not included in this analysis. Mining leases are large areas and do not necessarily represent activity on the ground. Harvesting areas that cannot be restored were already excluded when the pine and mahogany plantations were masked.

Next Steps

The final map will greatly assist the CI Fiji Program and the various organizations conducting restoration in Fiji to prioritize places to restore and where to restore. There are various restoration work currently underway in the country, 30 million trees in 15 years by the Ministry of Forests, United States Pacific Restoration Initiative and the REDD+ Emission Reduction Program. All these schemes will benefit greatly from this restoration prioritization exercise. In addition, more geospatial data are currently being collated and processed by partners that will be used to improve the initial map developed through this exercise.

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FOR MORE INFORMATION ON HOW TO
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