GEOSPATIAL CONSERVATION

AT THE NATURE CONSERVANCY

2021
Annual Report
& Map Book

Contents

About the Cover

The Wehea-Kelay landscape, in the province of East Kalimantan, Indonesia on the island of Borneo, is an area of collaborative management for the protection of orangutan habitat and forest ecosystems. This image shows the Wehea-Kelay boundary and surrounding area including intact forest landscapes and forest cover. Intact forest landscapes (darker green) are seamless mosaics of forest and open areas with no remotely detected signs of human activity or habitat fragmentation. These forests are large enough to maintain native biological diversity and viable populations of wide-ranging species. Additionally, they are critical for stabilizing terrestrial carbon storage, regulating hydrological regimes and providing other ecosystem functions. The Nature Conservancy and partners are working to protect these landscapes and forest cover habitats (lighter green) across Kalimantan by implementing conservation actions that address the commodity-driven land use changes motivated by economic growth. In the print version of this report, the raised areas on the cover represent modeled orangutan habitat.

FOREST LANDSCAPES

Intact Forest | Forest Cover | Non-forest

DATA SOURCES: TNC, World Resources Institute, European Space Agency, Shuttle Radar Topography Mission

PHOTO: Forest near the Lesan River Orangutan Survey Site, East Kalimantan, Indonesia. © Mark Godfrey/TNC

Determining Decade

TNC'S 2030 CONSERVATION GOALS

Johanna M. Ward
Director of Conservation Programs
Chief Conservation Office

People and nature are currently facing the biggest, most complex challenges of our times. The Nature Conservancy (TNC) is meeting these challenges with a set of bold and inspiring actions to secure the future of our planet. TNC's ambitious goals for 2030 are grounded in science and guided by our mission: to conserve the lands and water on which all life depends. We commend the global commitment made as part of the Paris Climate Accord of limiting global temperature increase to 1.5°C (in this century) and the Convention on Biological Diversity proposal to protect 30% of the planet by 2030. Our 2030 goals support these commitments to address two urgent crises: climate change and biodiversity loss. We are confronting these challenges with a renewed sense of urgency, community and equity.

By 2030, we have committed to the protection and improved management of 1 million river kilometers, 30 million hectares of lakes and wetlands, 4 billion hectares of oceans and 650 million hectares of lands with 45 million people benefitted. We are tackling climate change by committing to increase sequestration or reduce emissions by 3 gigatons of CO_2 equivalent with 100 million people benefitted. These goals will guide our work in this determining decade. For example, in protecting 30% of U.S. lands and waters by 2030 (known as America the Beautiful Act), let's look at California:

In October 2020, Governor Newsom signed an executive order committing to protect 30% of California's lands and coastal waters by 2030. This bold commitment makes California a leader in containing and eventually stemming the biodiversity crisis. Contextualizing and targeting protection efforts requires the application of comprehensive, reliable geospatial data that informs these conservation actions. For example, we are calculating current percentages of land protection by analyzing geospatial data that represents the state's major habitat types to identify those that require more protection. Geospatial data analysis fills these critical knowledge gaps. By centralizing these data on the cloud, designing web tools to visualize the information and communicating the relationship between the current and future desired states of protection, TNC's geospatial community can offer compelling **conservation stories** to an array of audiences. California's scalable geo-accounting system provides a visual representation of biodiversity, identifies patterns of existing protection and provides opportunities to improve ecosystem resilience.

The 2021 Geospatial Conservation Annual Report & Map Book presents practical applications where conservation science and geospatial work is already underway and informing the actions we take to achieve our ambitious 2030 goals. These stories provide a snapshot of TNC's geospatial conservation science in action in four key geographies that are integral to achieving these goals: the U.S. Appalachians, Kalimantan in Indonesia, the Brazilian Amazon and Kenya.

We demonstrate how when leveraged well, sound geospatial science, planning and action allows practitioners to track progress and identify crucial conservation gaps. These spatially explicit conservation stories support the integral role of geospatial technology as we set our sights on accomplishing these lofty ambitions for the health of our planet and all people.

TARGETS & METRICS

CLIMATE	**3,000,000,000** TONS OF CO_2 REMOVED OR SEQUESTERED PER YEAR	• Greenhouse gas mitigation (Equivalent of getting 650 million cars off the road)
	100,000,000 PEOPLE BENEFITTED	• People most likely to be affected by climate-related emergencies such as floods, fires and droughts
OCEAN	**4,000,000,000** HECTARES CONSERVED	• Ocean protected (10% of the world's ocean area, 390 million hectares) • Ocean area with improved management (4 billion hectares) • At-risk ocean areas with avoided impact (5 million hectares)
LANDS	**650,000,000** HECTARES CONSERVED	• Land protected (an area twice the size of India, 150 million hectares) • Land area with improved management (400 million hectares) • At-risk natural areas with avoided conversion (100 million hectares)
FRESHWATER	**1,000,000** KILOMETRES OF RIVERS CONSERVED	• River systems protected (500,000 km) • River systems with improved management (550,000 km) • At-risk river systems with avoided impact (75,000 km)
	30,000,000 HECTARES OF LAKES AND WETLANDS CONSERVED	• Lakes and wetlands protected (6 million hectares) • Lakes and wetlands with improved management (20 million hectares) • At-risk lakes and wetlands with avoided impact (3 million hectares)
PEOPLE	**45,000,000** PEOPLE SUPPORTED	• Increased sustainable, place-based economic opportunity (25 million people) • Increased security of rights to territory or resources (8 million people) • Increased ability to meaningfully participate in decision-making about territory or resources (12 million people)

TNC's Trail of Geospatial Conservation

Zach Ferdaña
Director, Conservation & Geospatial Systems

Umesh Yadav
Chief Enterprise Technology Architect

"With TNC's Conservation GeoCloud, we are harnessing the power of best-in-class cloud & data technologies to advance the oldest of technologies–nature–to solve today's most pressing challenges. The GeoCloud allows our scientists to deliver relevant information to leaders in a format that is easy to understand. This streamlined data-sharing and computing experience is creating more confidence in the data and perhaps most importantly, facilitating efficient decision-making to conserve critical ecosystems."

DAVID BANKS, TNC'S CHIEF CONSERVATION OFFICER

Working across scales and spatial footprints brings with it a high degree of complexity. At its best, the orchestration of interdependent geospatial data facilitates the mapping of geographic-based accounting systems that, for TNC, report on conservation progress. To achieve this, we must leverage a cross-disciplinary approach that creates optimal data management solutions with robust documentation, organization and access protocols, cloud technology and geospatial science solutions. TNC is investing in the future of our geospatial work by supporting a scalable, nimble cloud migration strategy that will accommodate the entire organization's geospatial needs.

The documentation, organization and access to relevant information are critical components to any data strategy. Large investments are often made to procure, generate and process information that guides conservation decisions. However, without the capacity and the commitment required to manage data assets, this information can get lost or even become irrelevant after its initial procurement. TNC is assessing its current technology needs and planning a future where data can easily be shared and managed. We are evaluating and implementing a cloud strategy to leverage geospatial data for conservation. This work is allowing TNC to gain traction and understanding regarding the best ways to harness geospatial data assets and match data management practices with optimal cloud capabilities.

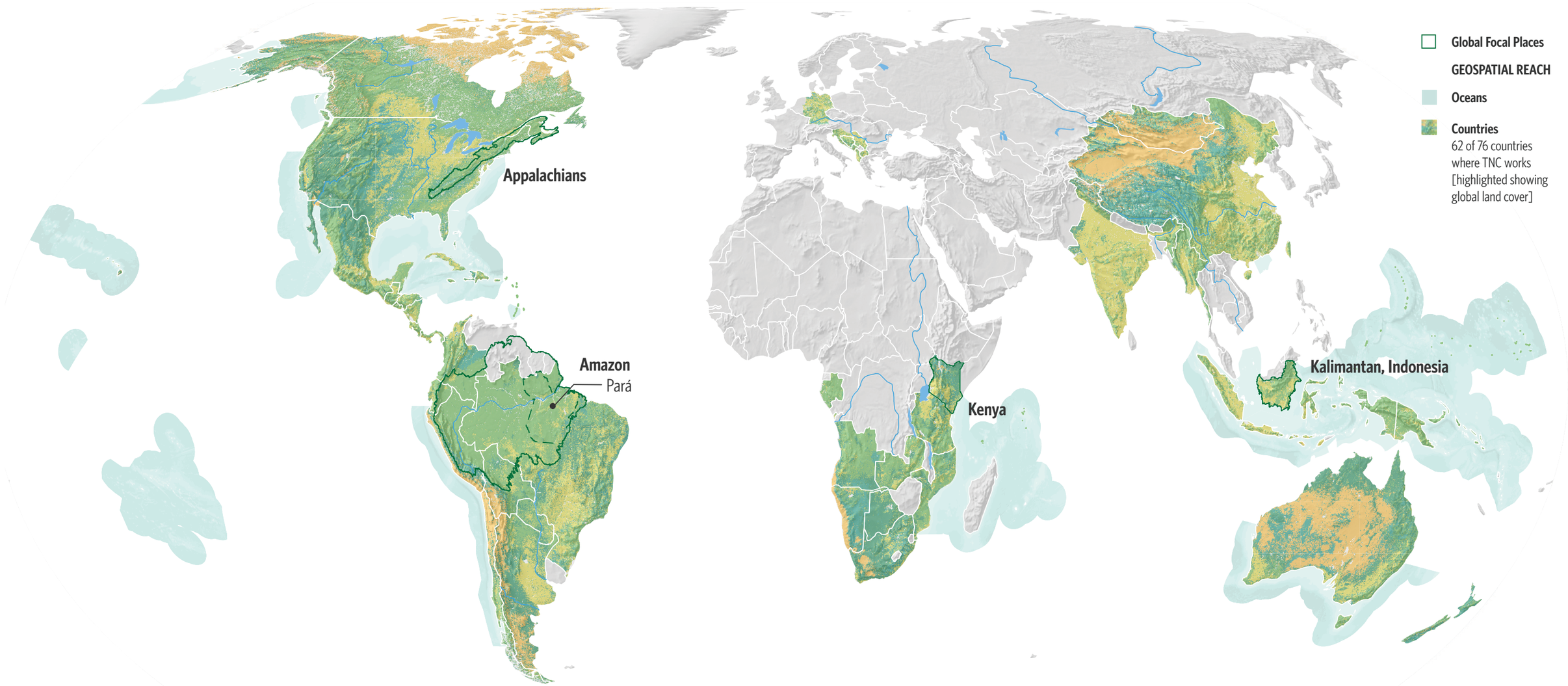
Conservation data scientists face several geospatial technology challenges. Examples include insufficient computer and storage capacities and the need to mail hard drives to colleagues for validation. Due to the time-intensive nature of collecting, analyzing and sharing data, these challenges can inhibit TNC science staff from meeting the demands of government and corporate leaders and/or delay the delivery of critical environmental analyses. These challenges adversely impact TNC's ability to produce timely results and may damage relationships with those who support and fund our conservation work.

In response, we designed TNC's Conservation GeoCloud platform to reduce the resource-intensive process of collecting, analyzing, sharing and managing data for over 1,600 staff members (including data scientists who need on-demand cloud resources). The GeoCloud is facilitating effective communication of ecological insights between scientists, planners and conservation practitioners and ultimately, decision makers. From first-kilometer design to last-kilometer conservation, our data and cloud transformation is the largest migration in TNC's history of geospatial data to the cloud and will have lasting, positive implications for every aspect of our organization.

As we migrate all geospatial data to the cloud, we are working to reduce data latency, improve overall workflow efficiencies and address the needs of conservation users with appropriate, timely and innovative technology. TNC's Conservation GeoCloud leverages Amazon Web Services (AWS) and Esri's ArcGIS Online to streamline geospatial data analysis and processing through the cloud's agility and elasticity. The GeoCloud enables conservation scientists to: ❶ Process large datasets by scaling storage and compute. ❷ Enable upload and capture real-time geospatial data. ❸ Support in-depth data mining and analysis in hours versus days. ❹ Communicate with other conservation colleagues and validate work. ❺ Generate visualizations for internal and external stakeholders. ❻ Provide leaders with insightful, timely and accurate information.

One must plan for the "last kilometer" when starting a digital transformation initiative. TNC is harnessing the power of data and cloud technology to build geospatial science solutions that measure the success of our conservation efforts and align with our 2030 goals. These geospatial tools contribute to our goal of finding solutions that address the urgent climate and biodiversity crisis to conserve the lands and waters on which all life depends.

2021 GEOSPATIAL ANNUAL REPORT & MAP BOOK



State of the Conservancy Map

The Nature Conservancy is a science-based organization. We use conservation science tools, technology and innovation in our work on land, rivers, lakes and oceans to halt catastrophic climate change and biodiversity loss. A non-profit organization with over 400 scientists active in 76 countries and territories across six continents, TNC applies conservation planning approaches to the most pressing environmental issues of our time. Many of these strategies leverage geospatial technology - the combination of Geographic Information Systems (GIS), remote sensing and machine learning. With over 1,600 geospatial-related staff and deep partnerships across the globe, we are meeting the challenges of this defining decade.

A future where people and nature thrive is within reach. The Paris Climate Agreement, the United Nations Convention on Biological Diversity and its Sustainable Development Goals all point to a collective discourse on addressing the climate and biodiversity crisis. As stated in the Foreword, TNC has adopted these measures for a healthier planet and outlined our own conservation goals to be reached by 2030. Our ambitious plan to secure a thriving planet leverages geospatial data and web technology to measure and track these goals. Grounded in place, we have selected four initial focal geographies highlighted on the map to measure our conservation gains by 2030. These are featured in the Focal Applications section.

GEOSPATIAL REACH: TNC's conservation science, planning and action methods rely heavily on mapping within the countries where we work as well as in ocean Exclusive Economic Zones (EEZ) illustrated on this map. This is shown here as TNC's "geospatial reach," or the application of geospatial technology in support of conservation. Maps are central to TNC's mission, leveraging critical ecosystem, climate and human activity data as decision support and measuring our conservation goals.

Annual Survey

GEOSPATIAL TRENDS

The Nature Conservancy conducted a third annual survey in May 2021 to assess the status and needs of our geospatial community across GIS, Remote Sensing and data science disciplines. We asked respondents about their use of the cloud in terms of platforms, storage and compute needs, training, software usage and their specific geospatial areas of expertise and technology support. With this information we have begun to track trends since 2019 in an effort to build an effective enterprise geospatial system that supports practitioners and elevates our geospatial work to a higher level of excellence.

Note: Like all surveys, results are only as accurate as the response rate. Therefore, results do not necessarily reflect the status of the entire TNC geospatial community.

1,511
STAFF INVITED TO PARTICIPATE IN THE SURVEY

417
RESPONDENTS [88% COMPLETED THE ENTIRE SURVEY]

Defining TNC's Geospatial Community

1,650 GEOSPATIAL COMMUNITY MEMBERS

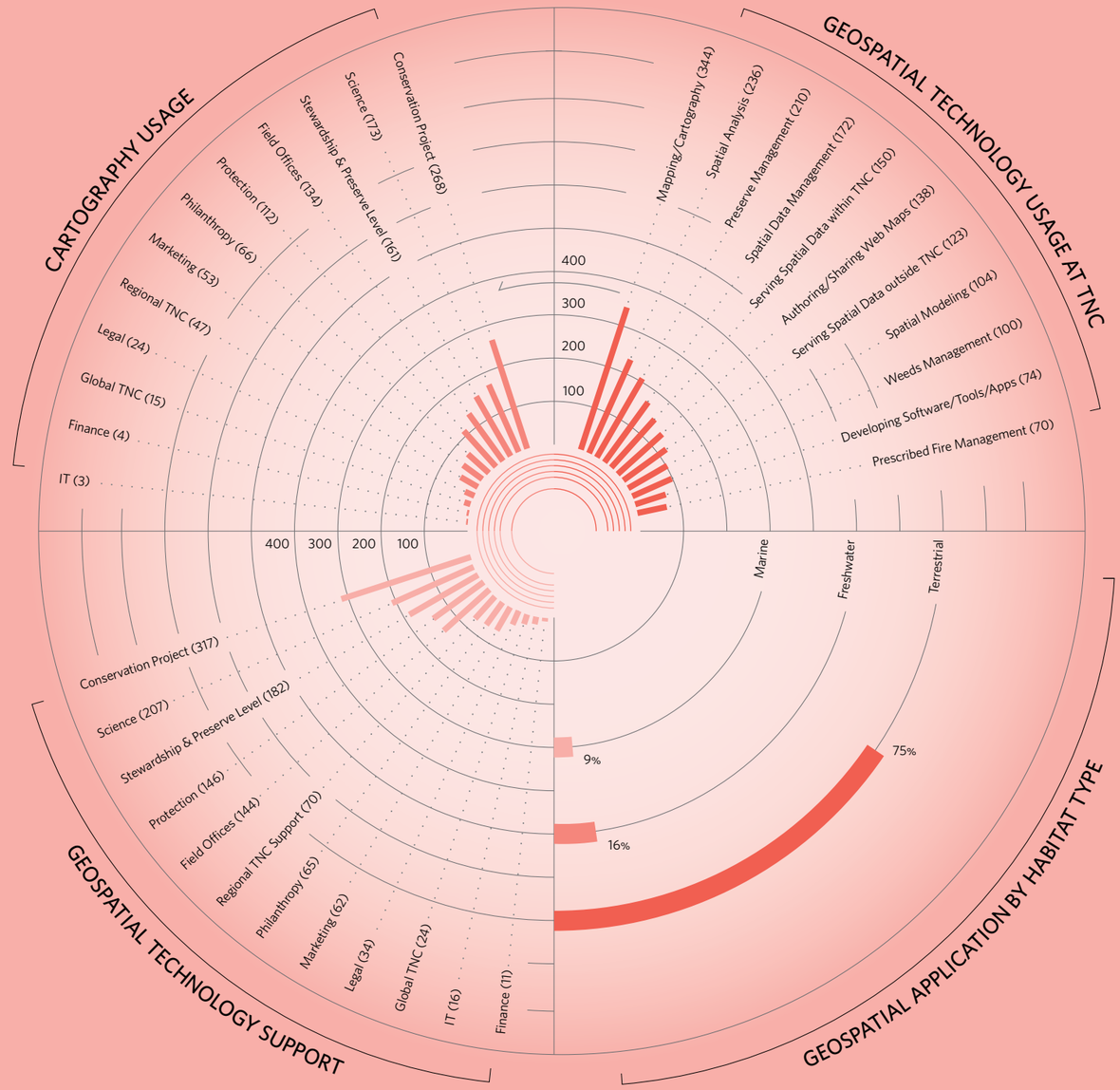
1,450 TNC STAFF USING GEOSPATIAL COMMUNITY MICROSOFT TEAMS

1,480 ACTIVE MEMBERS ON ARCGIS ONLINE

325 USERS ON CONSERVATION GEOCLOUD

48 EXTERNAL PARTNER ORGANIZATIONS SUPPORTED (BY EXTENSION)

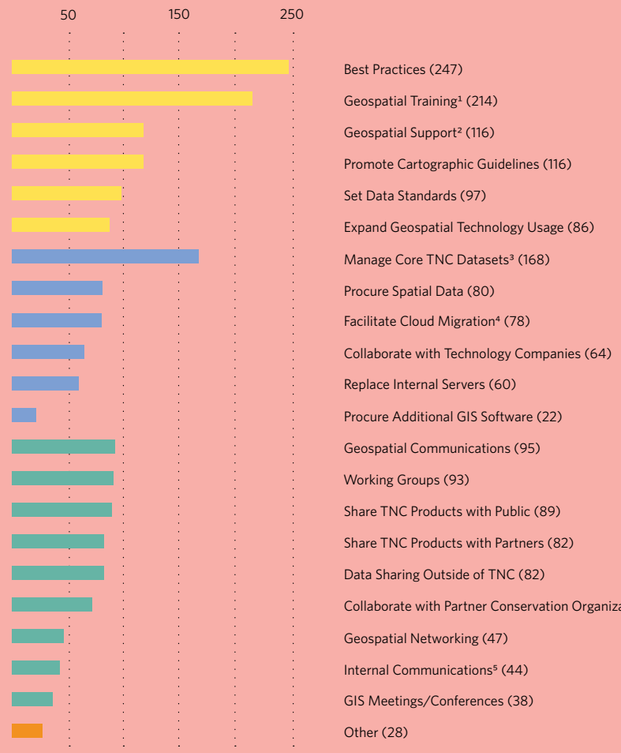
Geospatial Use at TNC



The vast majority of maps that are created at TNC support conservation projects, science and stewardship work (upper-left quadrant). Map creation (cartography) and spatial analysis represent the greatest usage of geospatial technology, while preserve management and spatial data management are also very common (upper-right quadrant). The lower-right quadrant of the chart shows the majority of geospatial technology is applied to terrestrial work, and the lower-left quadrant demonstrates how TNC's geospatial community supports nearly every part of the organization.

Priorities of Geospatial Community

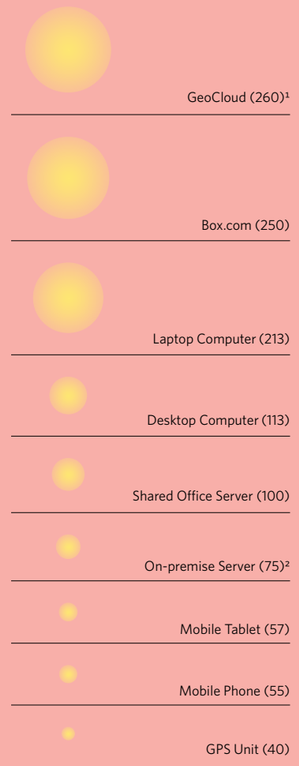
We asked respondents to identify the top priorities that the Geospatial Systems IT team should focus on to make the biggest impact on the community's work.



[1] Esri courses, other vendors, etc.
[2] Help Desk
[3] Organize, manage and centralize
[4] Azure, Amazon Web Services etc.
[5] TNC Intranet

Storing Spatial Data

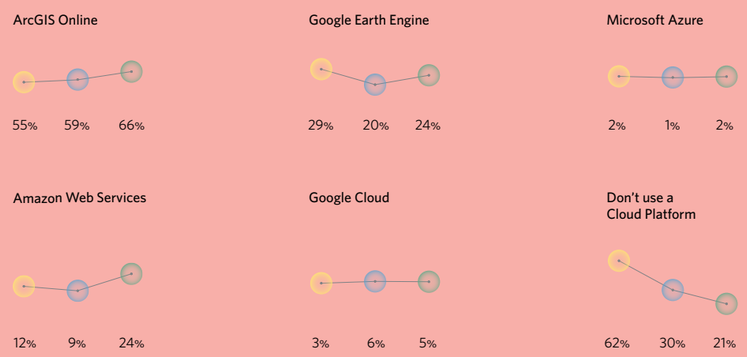
Most respondents now use TNC's Conservation GeoCloud to store their spatial data. While Box.com, laptop and desktop computers are also widely used to store spatial data. The usage of shared office servers and on-premise servers declined in 2021.



[1] AWS, Azure, ArcGIS Online, Google Cloud, etc.
[2] NYADKSSPATIAL, CAROSPATIAL, MAGEOPROC, etc.

Cloud Platform Usage

In the past three surveys, we have seen increased reported usages of cloud platforms, principally ArcGIS Online and Amazon Web Services. Our Geospatial Operations team has also migrated spatial data from outdated on-premise servers to the GeoCloud. Usage of Google Cloud and Microsoft Azure have remained consistent with data science projects.

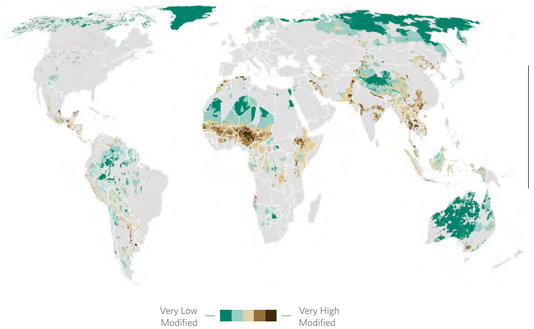


Indigenous Lands at Risk

Indigenous Peoples comprise less than 5% of the global population, yet they own or manage at least a quarter of the world's terrestrial, freshwater and coastal landscapes. Their stewardship conserves global biodiversity, mitigates climate change and provides essential benefits for society. The work featured on the following pages emphasizes the important role that Indigenous Peoples play in protecting critical conservation landscapes, which are under threat by industrial development pressures. Notably, this is the first global analysis to summarize development threats to Indigenous lands from the expansion of renewable energy, oil and gas, mining, commercial agriculture and urbanization. This work is meant to increase awareness and identify opportunities for conservation partnerships that support self-determined development alternatives aligned with Indigenous Peoples' values and visions for the future, and their continued stewardship.

PHOTO: Samburu herder with cattle in Sara Conservancy, Northern Kenya. © Ami Vitale

Ecological Condition of Indigenous Lands

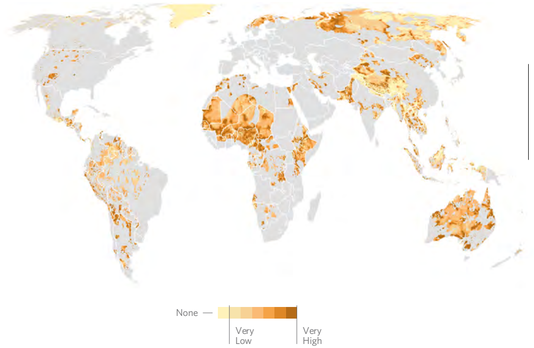


39%

of the world's least modified and most ecologically intact lands are stewarded by Indigenous Peoples, underscoring the critical importance of conservation partnerships.

DATA SOURCES:
GADM: Garnett et al. 2018; Kennedy et al. 2018

Development Pressure on Indigenous Lands

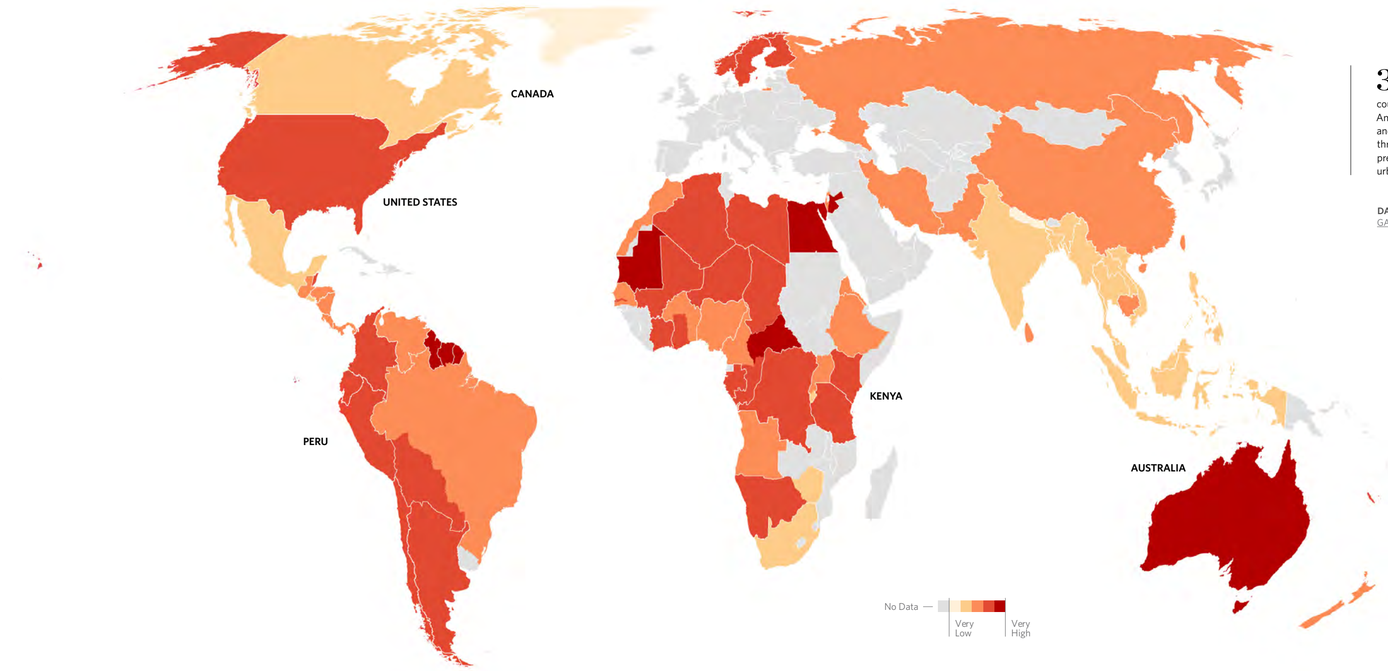


22%

of Indigenous lands face high development pressure from energy, oil and gas, mining, commercial agriculture and urban sectors.

DATA SOURCES:
GADM: Garnett et al. 2018; Oakleaf et al. 2020; Zhou et al. 2019

National-Level Threats to Indigenous Lands



37

countries (primarily in Africa, South America, Oceania, North America, and Northern Europe) have highly-threatened Indigenous lands facing pressures from extractive, industrial and urban sectors.

DATA SOURCES:
GADM: Kennedy & Fariss et al. 2022

KENYA	
IP Lands Total	372,005 km²
Major Drivers	Renewables, commodity agriculture and oil/gas
	37% of IP lands threatened

UNITED STATES	
IP Lands Total	583,281 km²
Major Drivers	Renewables, mining and oil/gas
	35% of IP lands threatened

PERU	
IP Lands Total	415,917 km²
Major Drivers	Mining, renewables and oil/gas
	33% of IP lands threatened

AUSTRALIA	
IP Lands Total	4,074,597 km²
Major Drivers	Renewables, commodity agriculture and mining
	30% of IP lands threatened

CANADA	
IP Lands Total	716,344 km²
Major Drivers	Mining, renewables and oil/gas
	7% of IP lands threatened

Authority-Capacity-Support (ACS) Index

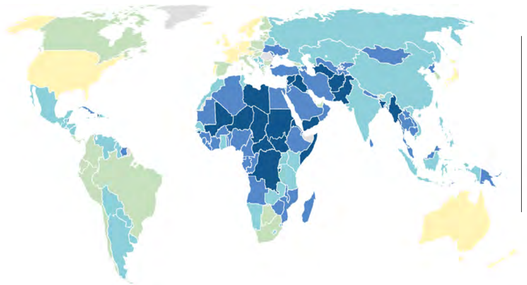
These global maps include the **ecological conditions** of **Indigenous lands**, the threats they confront from various **extractive, industrial, and urban development sectors** and a novel, national-level Authority-Capacity-Support (ACS) index. The ACS index allows us to assess the risk to Indigenous lands by highlighting national contexts less favorable to their stewardship given the following:

A **AUTHORITY:**
Challenges to Indigenous land rights and decision-making authority

C **CAPACITY:**
Barriers to the capacity for engagement and representation of Indigenous Peoples in decision-making processes

S **SUPPORT:**
Inadequate capital and financial support for sustainable development

Lower — — Higher



None — Very Low — Very High

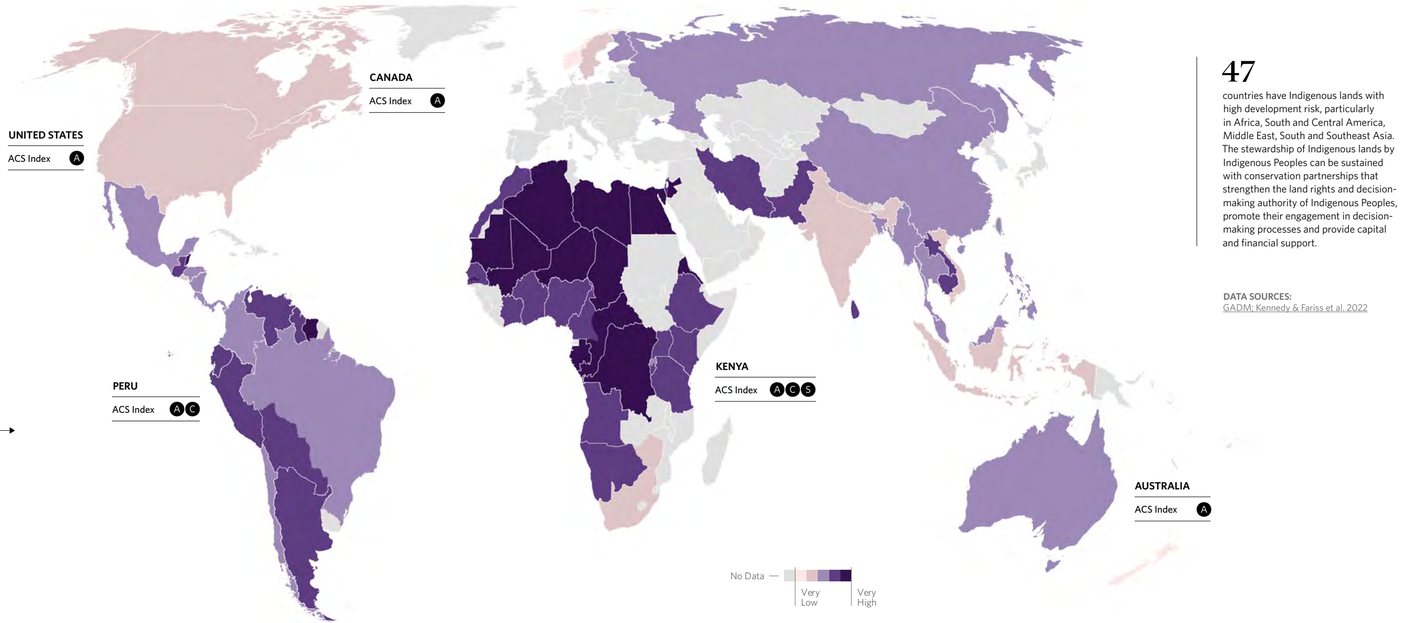
21
countries have contexts that challenge Indigenous land rights and decision-making authority, present barriers to the capacity for engagement and equitable representation of Indigenous Peoples in decision-making processes or offer inadequate capital and financial support for sustainable development.

DATA SOURCES:
GADM; ACS Index: Authority Indicators, Capacity Indicators, Support Indicators; Kennedy & Fariss et al. 2022

National-Level Development Risk for Indigenous Lands

National-Level Threats to Indigenous Lands (from previous page)

ACS Index



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countries have Indigenous lands with high development risk, particularly in Africa, South and Central America, Middle East, South and Southeast Asia. The stewardship of Indigenous lands by Indigenous Peoples can be sustained with conservation partnerships that strengthen the land rights and decision-making authority of Indigenous Peoples, promote their engagement in decision-making processes and provide capital and financial support.

DATA SOURCES:
GADM; Kennedy & Fariss et al. 2022

UNITED STATES & CANADA

To ensure the continued stewardship of critical conservation landscapes in the U.S. and Canada, TNC has launched a new North America strategy to elevate the importance and impact of working with tribal nations. Supporting Indigenous Peoples in conservation and natural resource management is critical for a future of healthy lands, waters and communities. From Maine to Hawai'i and from the Northwest Territories to Texas, TNC is accelerating its work in Indian Country with a human rights-based approach to conservation, standing with Indigenous Peoples as they protect and exercise their rights.

PERU

TNC is leading a participatory planning process with the Indigenous organization FECONARIN of the Marañón River basin. The goal is to strengthen its capacity for engagement and representation in regional planning processes through the creation of Quality of Life Plans that communicate community values and visions and facilitate resource mapping and zoning activities. This effort compliments a petition to the Peruvian government for the creation of an Indigenous Territorial Reserve, "AJUTAP" which aims to safeguard natural resources and provide for future generations.

KENYA

TNC is tackling complex challenges in Kenya by supporting 39 Indigenous communities across 10 million hectares to map and register communal lands, strengthen capacity for leadership and natural resource governance and increase access to new economic opportunities and revenue streams. Through innovative projects like BeadWORKS, TNC is supporting the development of human, social and financial capital—connecting local artisans to global online markets and empowering women in the process.

AUSTRALIA

TNC is partnering with communities in the Kimberley and Cape York regions to support community-led development. This spatial planning methodology enables communities to make informed decisions about future developments and strengthens their authority to negotiate outcomes that promote conservation and protect social and cultural values.

Focal Applications

This is the decade to deliver on our 2030 goals. TNC has a long history of developing conservation planning methodologies informed by geospatial data and tools that assist the organization in identifying conservation priorities. With the recent advancement of conservation mapping through predictive modeling, prioritization (asset & threat mapping and spatial action mapping) and monitoring & evaluation, we are grounding our strategies in these priority places. This decision support is leading to meaningful conservation actions that maximize our ability to effect change for nature and the people who rely on it. In this section, we identified four priority geographies that are using geospatial technology to track significant contributions to our goals. The programs and projects within these geographies illustrate the range with which this technology is being used, from cloud-based systems to community mapping across the organization and the globe.

PHOTO: Anti-poaching rangers on a training ride in the Loisaba Wilderness, Laikipia, Kenya. © Ami Vitale

The Pará State

SECURING THE CONSERVATION AND BIODIVERSITY OF THE BRAZILIAN AMAZON

The Nature Conservancy has been working in the Amazon for decades and has recently identified the Pará State as an iconic place due to the presence of large free-flowing rivers, extensive tracts of native forests, high diversity of terrestrial and aquatic fauna and significant conservation opportunities. The Pará State is one of the most threatened regions in the Amazon. TNC's efforts here aim to increase sustainable, place-based, low-carbon economic opportunities, improve land tenure security and expand community access and participation in decision-making processes.

PHOTO: Red and Green Macaw, Brazil © Mats Brynolf/Getty Images

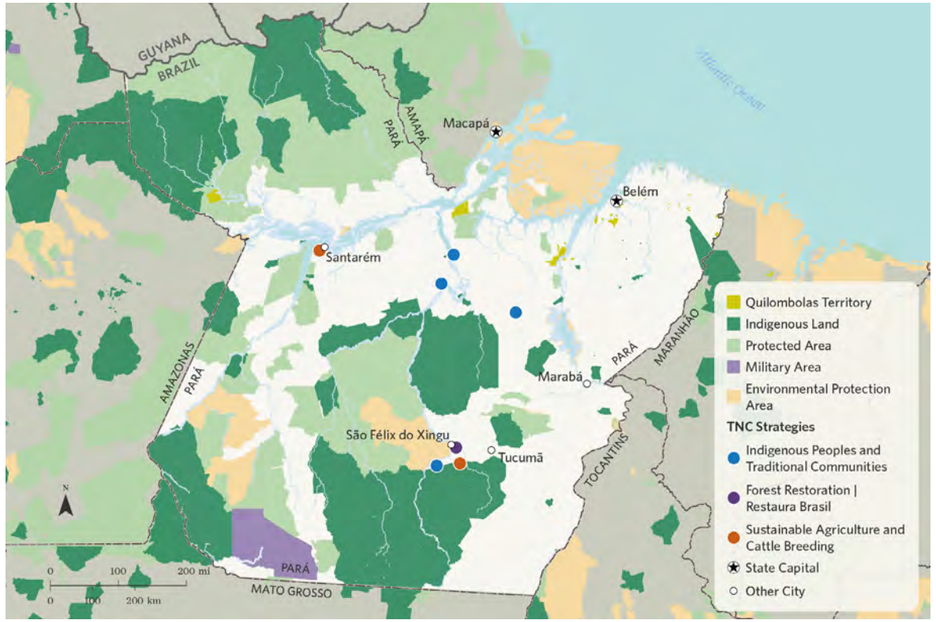
CHALLENGE

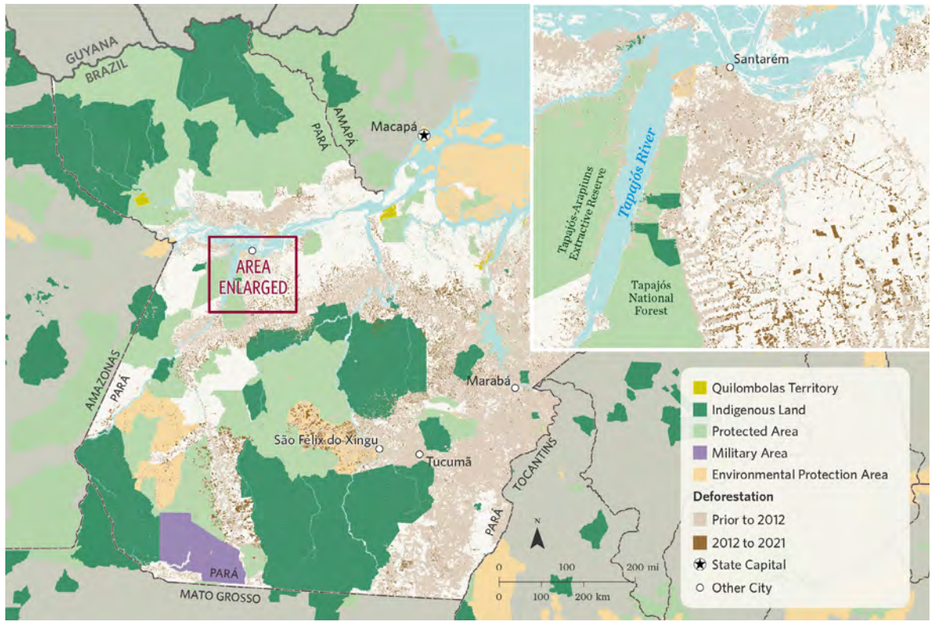
At 6.3 million km², the Amazon River Basin is the largest basin in the world. The Amazon Basin is home to Indigenous and local communities with deep social, cultural and economic connections to the complex network of forest and freshwater ecosystems. Approximately 2.7 million people (9% of the total population) are part of one of the roughly 350 Indigenous ethnic groups. These communities are at the frontline of protecting and conserving natural resources in the face of significant land use pressures. Between 2000 and 2018 agricultural land in the Amazon River Basin tripled in size from 7.5M hectares to 20.4M hectares. In addition, illegal mining inside conservation units and on Indigenous lands increased dramatically. From 2020 to 2021, deforestation increased 22%–representing 13,235 km² of forest lost and the highest deforestation rate since 2006. Most notably in 2021, 40% of the Amazon Basin deforestation took place in Pará State. Such forest loss elevated the priority to focus our conservation efforts on Pará to help the state avoid the biome's tipping point.

SOLUTION

TNC's neutral status as a non-confrontational conservation partner is facilitating dialogue between stakeholders to mediate conflicts and maximize the results of conservation initiatives. TNC is guiding and coordinating actions and interventions at the speed and scale necessary to address deforestation. Reducing and avoiding deforestation in Pará will have multiple impacts for the biome. Our geospatial data and analyses provide the necessary context to detect deforestation trends using a territorial intelligence approach, assess potential restoration on degraded and deforested areas, identify areas of high value for bioeconomy and evaluate land use changes in freshwater ecosystems. These assessments account for the spatial relationships with nearby watersheds, protected areas, local communities, property sizes and the legal status of neighboring land. This information supports new social, environmental and economic development models (low carbon) and promotes efficient land use, conservation and inclusive income generation. The evidence is built by exploring the spatial expansion of deforested lands (especially within riparian areas), mining, infrastructure and degraded pastures to name a few. This analysis identifies the conservation potential of terrestrial and aquatic ecosystems while prioritizing areas in critical need of action. Some specific actions TNC and partners are now taking to reduce land conversion include: mitigating social and environmental impacts from mining, increasing the value of standing forest through Payment for Ecosystem Services (PES) and Reducing Emissions from Deforestation

MAP: This map of the Amazon River Basin is an example of the geospatial context required to assess and identify potential restoration opportunities that will contribute to terrestrial and freshwater conservation metrics.





TOP: Protected areas in Pará and where TNC is supporting social, environmental and economic development models (low carbon) and promoting efficient land use, conservation and inclusive income generation. These assessments account for the spatial relationships with nearby watersheds, local communities, property sizes and the legal status of neighboring land.

BOTTOM: Tapajós Region, one of the regions where TNC operates in the Pará state. Social and environmental tensions have resulted in habitat loss, threats to protected areas and the subjection of Indigenous communities to increased vulnerabilities such as deforestation. Geospatial analysis aims to understand the potential for TNC's work to improve outcomes related to deforestation and degraded pastures that directly impact freshwater ecological condition and biodiversity.

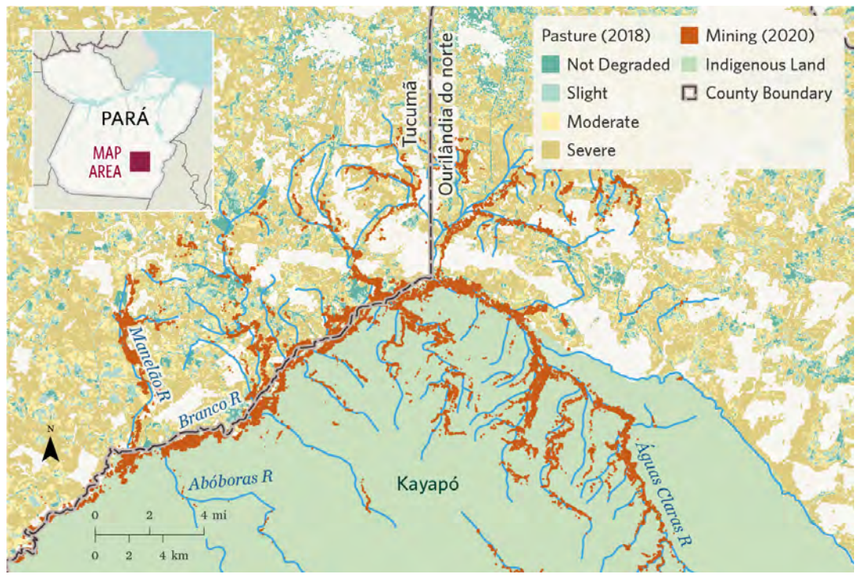
and Degradation (REDD+) in non-designated areas, increasing carbon sequestration and reducing deforestation through the implementation of agroforestry (SAF) in degraded pastures, avoiding the expansion of pasture in IPLC (Indigenous People and local communities) lands and reducing the need for new productive areas through sustainable intensification and best management practices. Leveraging spatial data analyses will help our partners appropriately site and prioritize conservation work, maximizing the costs and benefits of restoration and preservation of vital ecosystem services.

2030 GOALS

Land conservation, restoration and avoided conversion in the Amazon River Basin contribute to TNC's Iconic Landscapes Campaign in Latin America, which includes other relevant ecosystems and biodiversity hotspots, such as the Cerrado-Savanna, and the Atlantic Forest in Brazil. These efforts are linked to the Voice, Choice and Action (VCA) structure and the organization's Shared Conservation Agenda commitment of working with Indigenous Peoples and local communities to ensure resource management is based on inclusion, engagement and leadership from these communities. Specifically, our geospatial analyses aim to explore the potential for systematic change and how TNC can address deforestation and degraded pastures that affect freshwater ecological condition and biodiversity. Potential conservation areas are becoming partner commitments, for example, in the selection of areas for cocoa agroforestry with small farmers or restoration in riparian areas that directly contribute to water quality improvements.

PHOTO: TNC project coordinator Benito Guerrero with tree seedlings, Santarem, Para, Brazil. © Steve Niedorf

DATA SOURCES: IBGE (Brazilian Institute of Geography and Statistics), Mapbiomes (land use collection 6, deforestation collection 6), MMA (Environmental Ministry), FUNAI (National Indian Foundation), EMBRAPA (pasture condition), TNC



MAP: Geospatial analysis informs us about deforestation profiles, degraded pasture conditions, restoration opportunities and how these areas are connected to freshwater ecosystems. In 2020, we identified illegal mining areas around Indigenous lands that impacted approximately 122 km of river on land owned by the Kayapó people. We select and prioritize areas in critical need of restoration and where we (or our partners) have established relationships with local municipalities.

From Forests to Mangroves

A COMPREHENSIVE LAND AND SEA CONSERVATION STRATEGY IN INDONESIA

Borneo is the third largest island on Earth, encompassing parts of three countries: Malaysia, Indonesia and Brunei. Three-quarters of the island is part of the archipelago nation of Indonesia. Borneo is located at the western extent of the Pacific Ocean's Coral Triangle, a global center of marine diversity. Although Indonesian Borneo (also known as Kalimantan) represents only 1% of the world's lands, it is estimated to be home to over 6% of the world's terrestrial and freshwater biodiversity. Indonesia is home to the world's richest and most diverse tropical marine ecosystems, including 76% of the total mangroves in Southeast Asia, amounting to 23% of all mangrove areas in the world.

PHOTO: Young orangutan, East Kalimantan, Indonesia. © Jez O'Hare

Yayasan Konservasi Alam Nusantara (YKAN), TNC's affiliate organization in Indonesia, has recently been active in the East and North Kalimantan landscapes. YKAN's work engages a local coalition of communities, companies and governments with the goal of conserving large, intact forest ecosystems and carbon-rich peatlands, improving fisheries and encouraging community-centered approaches to sustainable forest management. Globally, the UN Climate Paris agreement has set targets to reduce carbon dioxide (CO_2e) in the atmosphere. YKAN is applying **Natural Climate Solutions (NCS)** as a proven way to reduce carbon emissions and store them in the world's forests, grasslands and wetlands. Conservation actions such as avoided forest and peatland conversion and improved forest management could help Indonesia meet nearly 40% of their NCS mitigation goal of absorbing 1.4 Gigatons of CO_2e from the atmosphere.

CHALLENGE

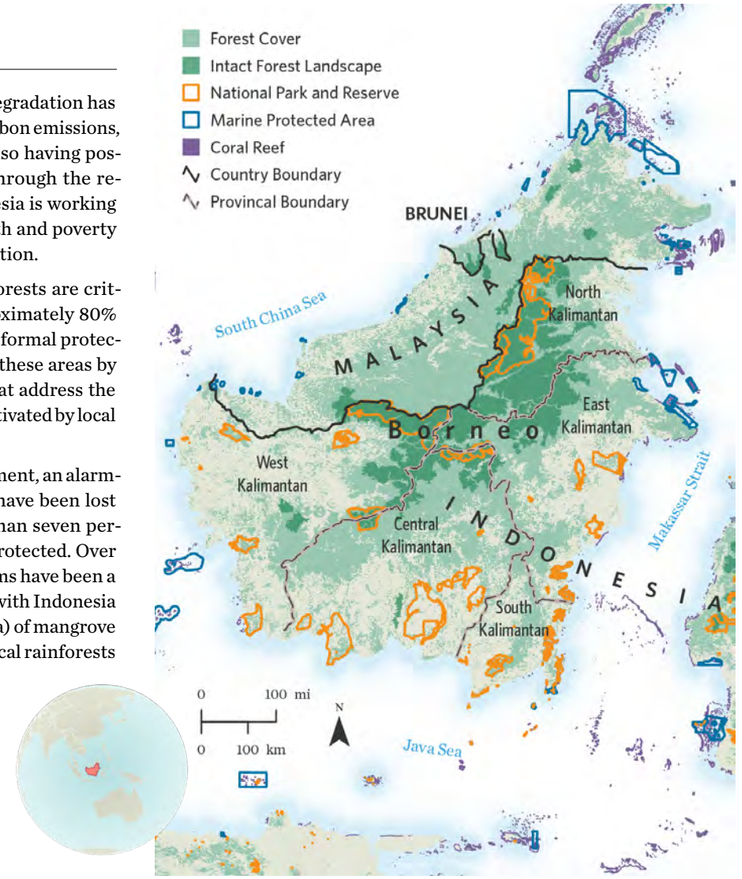
Ongoing deforestation and forest degradation has made Indonesia a top contributor to carbon emissions, yet these development activities are also having positive impacts on local communities through the reduction of poverty. As a nation, Indonesia is working to balance sustainable economic growth and poverty reduction with natural resource protection.

High Conservation Value (HCV) forests are critical for retaining CO_2. However, approximately 80% of the HCV areas in the region lack any formal protection. TNC and partners are protecting these areas by implementing conservation actions that address the commodity-driven land use changes motivated by local economic growth.

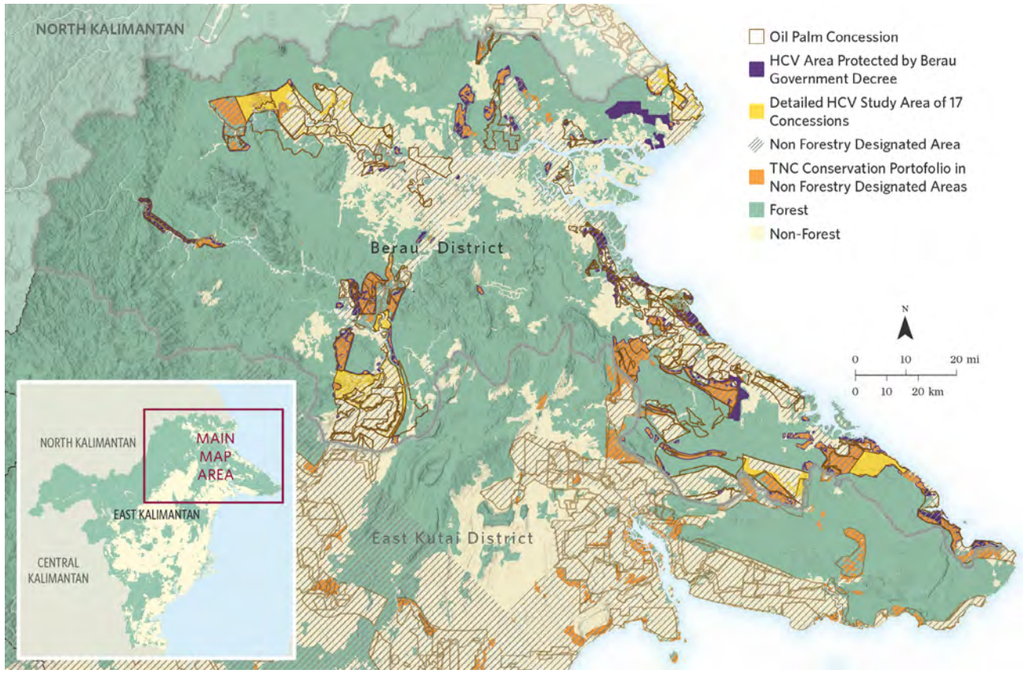
Within Indonesia's marine environment, an alarming 30-50% of the world's mangroves have been lost (over the past half century) and less than seven percent of the remaining mangroves are protected. Over the last 10 years, expanding shrimp farms have been a key driver in the decline of mangroves–with Indonesia losing approximately 6,000 hectares (ha) of mangrove forests per year–a rate faster than tropical rainforests and coral reefs. Currently, over 600,000 ha of mangroves are in critical condition and another 700,000 ha are likely to disappear in Kalimantan without additional protections. In this region, shrimp ponds now cover more than 11,000 ha, further replacing mangrove forests as global shrimp demand increases. Pollution and forest fires also threaten the remaining forests, especially along the mangrove-peatland border areas.

Expansive shrimp ponds and mangrove degradation also contributes to a decline in shrimp farming productivity. In recent years production has declined to less ¼ of the usual yield. Intensive shrimp production in previously forested areas has reduced the ability of the ecosystem to support shrimp farming, having a negative impact on coastal villages in Berau District. Reductions in farming productivity and a lack of knowledge about sustainable aquaculture pose a significant risk to remaining mangroves.

Geospatial analyses have been used to identify and inform conservation actions to protect mangrove forests adjacent to existing shrimp ponds as farmers are likely to expand their ponds to compensate for



MAP: Mapping existing assets is essential to TNC's work toward conserving forest and marine ecosystems. We are working with local coalitions to conserve intact forests and expand protection of marine resources in Borneo, particularly in the Indonesian provinces of North Kalimantan and East Kalimantan.



TOP: Working with partners, we developed conservation portfolio maps for East Kalimantan Province using a Development by Design approach. Using these data, YKAN worked with the Berau District government on a decree protecting the remaining forests in areas designated for agriculture (83,000 ha). We worked with the government and oil palm companies to map areas of HCV in oil palm plantation concessions to ensure their protection.

BOTTOM: YKAN, TNC's affiliate organization in Indonesia, uses a spatially explicit, landscape-level approach of mapping HCV areas in North Kalimantan that facilitates decision-making and reconciles the competing goals of improving provincial, district and village-level livelihoods. In collaboration with the provincial government, we identified Essential Ecosystem management areas for protection or improved management of endangered species, karst and mangrove ecosystems and areas that provide critical ecosystem services.

PHOTO: Forest patrol member, Wehea, East Kalimantan, Indonesia. © Nick Hall

reduced yields. Within Berau District, East Kalimantan Province, over 80,000 ha of mangrove forests remain, representing the largest intact mangrove in Indonesia outside of Papua. TNC is working with stakeholders to protect these remaining mangroves by sharing knowledge on sustainable fishing and aquaculture practices, one community at a time.

SOLUTION

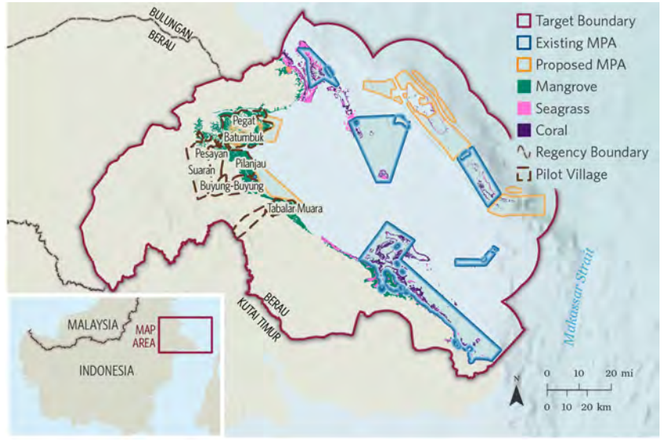
YKAN uses a spatially explicit, landscape-level approach of mapping HCV areas in North Kalimantan to improve decision-making and reconcile the competing goals of improving provincial, district and village-level livelihoods. The geospatial component requires the delineation of critical HCV areas using remotely sensed imagery to map the status and trends of current land cover types, model habitat areas for sensitive species and map conflicts with current and projected development plans. YKAN and partners are using province-wide, spatial land use data to identify places to protect and chip away at these ambitious ecological and community objectives.

The recent success of collaborative landscape management in the Wehea-Kelay Orangutan habitat spurred YKAN and the provincial government to identify an additional twelve HCV areas. They were designated as Essential Ecosystem management areas and will be managed for protection or improved management through Governor Decrees: five areas for endangered species protection (Orangutan, Sumatran Rhino, Irrawaddy Dolphin, White-shouldered Ibis, Siamese Crocodile), three karst and four mangrove ecosystem areas and two areas that provide critical ecosystem services.

Our work compliments the HCV conservation goals to restore mangrove ecosystems while supporting the implementation of the Shrimp-carbon aquaculture (SECURE) approach. These efforts reduce the expansion of shrimp aquaculture into mangrove areas and will improve converted areas through hydrological restoration. Mangrove species that are rare, threatened and endemic/native to the area will be used for both natural and assisted restoration actions to increase conservation impact and sustainability. Policy recommendations at the national level include guidance on how to mitigate greenhouse gas emissions through an aquaculture improvement plan and the establishment of a government taskforce for mangrove management. These projects serve as a model to shape and inform mangrove protection and restoration in other locations in East Kalimantan Province.

2030 GOALS

YKAN's improved forest management goal for Indonesia is 15.7 million ha by 2030 and approximately 4.7 million ha in 2022. Improved forest management will be accomplished through logging concessions. We also have a goal for avoiding deforestation across approximately 1.5 million ha by 2030 with 83,000 ha avoided in 2022. Avoided deforestation will be accomplished using pulp and paper concessions. The terrestrial program is targeted to protect 1.75 million ha by 2030 and 329,000 ha in 2022. Total potential emission reduction will be approximately 96 Mt CO_2e/year as a result of these terrestrial program actions. The SECURE program will enhance shrimp pond productivity and restore a large part of the ponds (50-80%) back to mangroves. The effort provides economic and ecological benefit as well as potential income for farmers from carbon financing and shrimp certification.



MAP: Mangroves, seagrasses and coral reefs represent important marine habitats in Kalimantan and while some marine protected areas (MPA) have been established, mangrove forests remain highly threatened. Strong geospatial data has informed Berau District's marine conservation goals of protecting 50,000 hectares of intact mangroves, restoring 5,000 hectares of active and degraded ponds to mangroves and the allocation of 2,000 hectares of active ponds for community livelihoods with improved aquaculture practices.

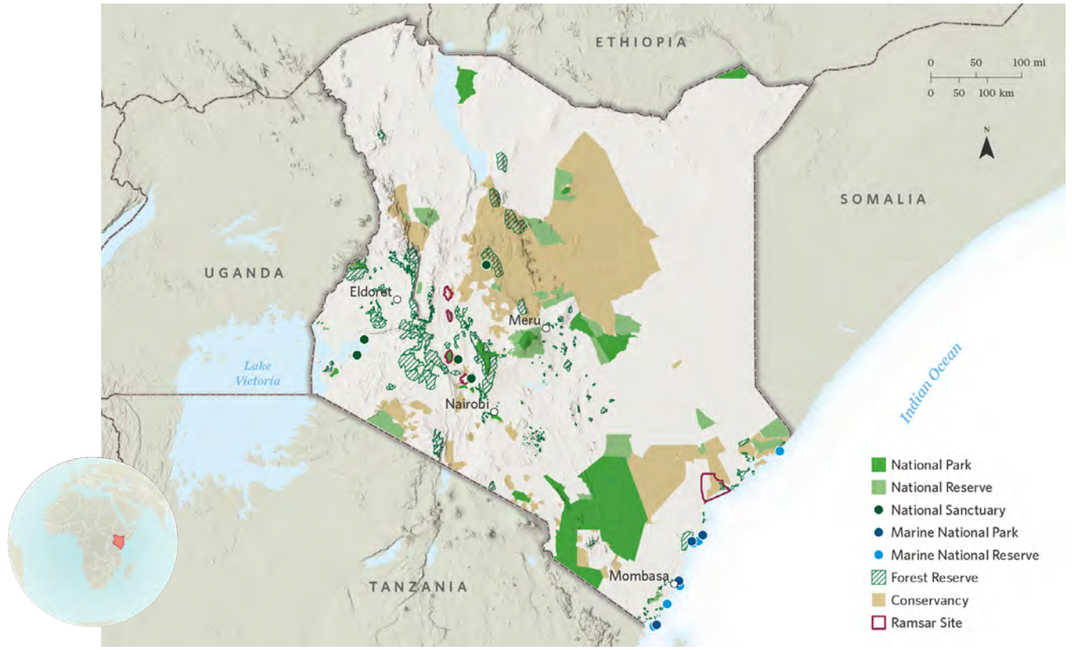
DATA SOURCES: ESA Climate Change Initiative, World Resources Institute, Indonesia Ministry of Environment and Forestry, Indicative map of Essential Ecosystems in East Kalimantan Province (East Kalimantan Governor's Decree No 522.5/K.672/2020), Spatial Planning Regulation Dataset of East Kalimantan, Berau Regent decree, Allen Coral Atlas, Ministry of Marine Affairs and Fisheries, TNC/YKAN

Community-led Conservation

SECURING A PROSPEROUS FUTURE FOR PEOPLE & WILDLIFE OF KENYA

Kenya is home to an incredibly rich and unique flora and fauna that contributes to the well-being of the Kenyan people and attracts millions of visitors to the country. Despite the heavy reliance on its natural resources for economic development, the government has a strong commitment to conservation and the sustainable use of its natural resources. Kenya's wildlife are considered an asset tied to peace, jobs and money for education, water projects and clinics. Across the rangelands, private and community conservancies have forged beneficial partnerships. Private and community lands provide breeding grounds for wildlife, jobs in tourism and resource management and nutrient dense grass for livestock during droughts. In turn, the peace and stability that community conservancies foster make private lands more secure. At the coast, community conservancies are also making progress, managing fisheries, reefs and mangroves for a more sustainable future.

PHOTO: Flamingos over Lake Magadi, Kenya © Hao Jiang/TNC Photo Contest 2019



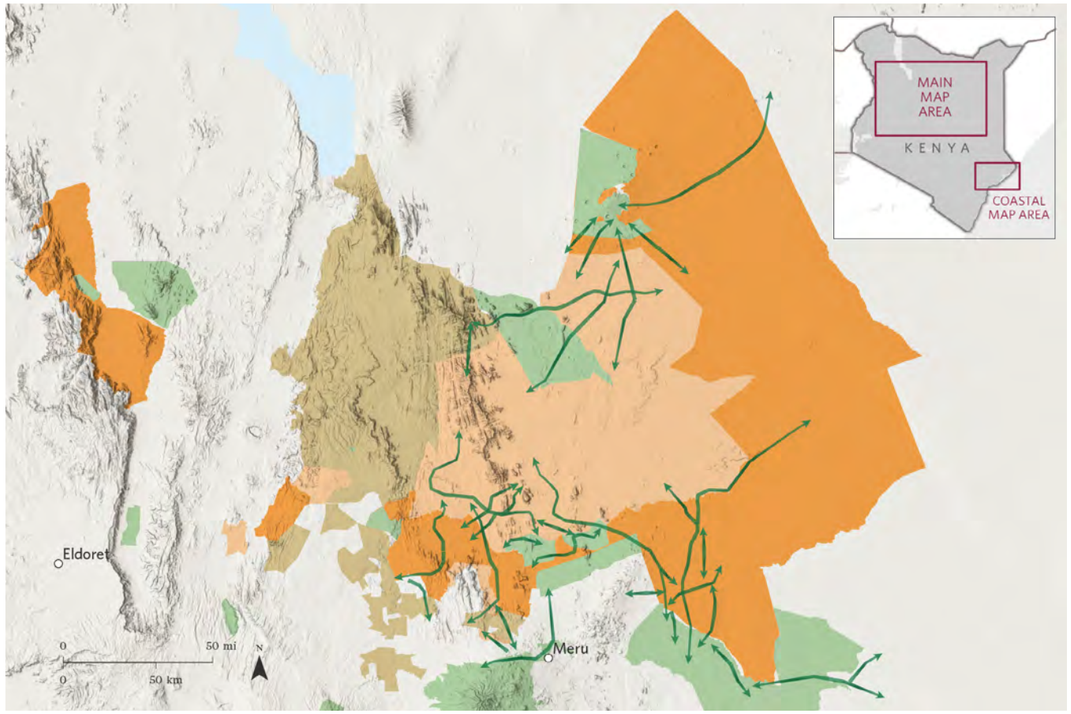
CHALLENGE

Kenya has a long history of establishing protected and community conservation areas. However, wildlife declines occur both inside and outside protected areas and have been attributed to rapid human population growth, land use and cover changes, habitat fragmentation, infrastructure development, poaching for trophy and bushmeat, weak law enforcement, competition with livestock for space, water and pasture, poverty and inequality. These challenges facing Kenya threaten its rich legacy—and its future. Rangelands are overgrazed, fisheries are declining, jobs are scarce and healthcare is often inaccessible. To address these concerns, TNC is contributing to solutions in the country by integrating the Conservation Connectivity Frameworks (CCF) with geospatial technologies to advance conservation efforts throughout Kenya.

SOLUTION

Kenya's Constitution (2010), Vision 2030 and Sustainable Development Goals (SDG) all recognize the importance of sustainable resource use, reducing biodiversity loss and maintaining ecosystem processes. In the Vision 2030, under the strategic conservation thrust, securing wildlife dispersal areas and migratory corridors is one of the economic and social pillars of the country. TNC has been working with a suite of local and regional partner organizations, including the community-led Northern Rangelands Trust (NRT) since 2008 to tackle Kenya's interconnected environmental and social challenges—first in the grasslands and the coast. Using an award-winning approach to community-led conservation that's based on local resource rights, we are supporting efforts to design and deliver a prosperous future that also honors the region's natural and cultural heritage. Our partnership is improving governance, increasing leadership and livelihood opportunities for women and linking economic and community benefits to sound habitat and wildlife management. Geospatial tools have advanced local and regional knowledge about key wildlife dispersal zones, migratory corridors and areas vulnerable to wildlife-livestock conflicts. We are engaging with stakeholders to identify wildlife cor-

MAP: Accurate and timely geospatial analysis is one of the critical catalysts that will advance conservation work in Kenya. Geospatial analyses establish a baseline of current conservation under both formal protection and other effective conservation management strategies that will help Kenya reach the target of 30% protection by 2030. This map represents the current protection efforts in Kenya to date, where 26.6% of the land and water overlaps with Kenya's Conservation Network.



Designation	Number of Sites	Area (km²)	% Kenya
National Park	23	29,139.7	5%
National Reserve	29	17,803.8	3%
National Sanctuary	6	37.7	0.01%
Marine National Park	4	60.1	
Marine National Reserve	6	718.7	
Forest Reserve	307	15,153.9	2.6%
Community Conservancy	131	81,861.8	14%
Private Conservancy	9	1,617.1	0.3%
County Conservancy	5	8,853.7	1.9%
Ramsar Wetland	4	1,979.4	0.3%
	Percent Conservation Land Area		27.1%

MAP: Between 2008 and 2021, the Northern Rangelands Trust (NRT) Conservancy expanded its footprint from 20,234 km² to 60,702 km². Geospatial tools advanced local and regional knowledge about key wildlife dispersal zones and migratory corridors. This information is critical as NRT and other community-led conservancies work to maintain, protect and expand these important corridors.

DATA SOURCES: KWS (2018), Kenya Forest Service (2021), KWCA (2016), NRT (2021), Mara Conservancies (2019), Private Conservancies (2021), Kenya Vision 2030, TNC

ridors and dispersal areas in Kenya (e.g., intact terrestrial and freshwater ecosystems, carbon storage and critical wildlife habitat) that can (and should) be maintained for the benefit of wildlife and people alike. The process of integrating mapped wildlife dispersal areas and migratory corridors facilitates an inclusive and collaborative strategy for securing and managing the wildlife space that exists in human-and livestock-dominated landscapes. The identification and mapping of these areas will improve the country's spatial planning and guide the process of securing natural resources that are threatened by human activities.

Most of the wildlife in the country is located outside protected areas on land that is either communally owned, or on land that has been privatized and subdivided into clan, family or individual properties. The participation of these landowners is critical to the success of wildlife conservation, as most of this land is subject to multiple-use status, some of which are incompatible with wildlife conservation. While there remains an urgent need to secure wildlife dispersal areas, protect migratory routes/corridors and secure space available to wildlife outside the protected areas, TNC recognizes a need for wider consultation and buy-in from local communities. A concerted effort is critical on the part of landowners, stakeholders, wildlife agencies and federal government officials. Perhaps most importantly, it requires political goodwill and the implementation of policies and legislation on integrated land-use planning, wildlife conservation management and the application of economic and legal instruments. TNC supports the creation of informative visualizations and maps when consulting with the variety of stakeholders described above. Solid geospatial data provides critical context when connecting conservation challenges with conservation solutions.

2030 GOALS

National Protected Wildlife Areas, which cover 11% of Kenya's land area, include 29 national parks, 36 national reserves, seven sanctuaries, 203 forest reserves, four marine national parks and six marine national reserves. Additional land protection provided by community-based conservancies are estimated at 14% of Kenya's total land area. Among the 43 community conservancies that govern 63,333 km², more than 512,000 people benefit from these lands. In addition, more than 47,753 ha are protected via private land deals.

For the first time, an increase in wildlife numbers has been recorded in the census of 2021. An indicator of the value of conservancies is the amount of habitat restoration occurring across the country. TNC is contributing to the formation of three new community conservancies spanning 180,490 ha, as well as 21,651 ha of additional private lands permanently protected. Rangeland health will be measured annually.

PHOTO: Endangered Black Rhinoceros, Lewa Conservancy, Kenya.
© Suzi Eszterhas

Enterprises within community-based conservancies are meeting peace, governance, and resource management standards that generated US $916,000 for families and $630,000 for conservancies in 2020. One of these investments has launched the world's first large-scale grassland soil carbon business. Overall, these enterprises generate $5 million per year for families and $5 million per year for community-based conservancies.

More locally, the Proportion of Illegally Killed Elephants (PIKE) on the Northern Rangelands Trust (NRT) lands fell from 77% in 2012 to 36% in 2020. NRT's goal is maintaining <35% PIKE annually as per the organization's wildlife strategy. This is important because any PIKE >50% means that the illegal killing will have a negative impact on the population if not checked. Helping to stabilize the elephant population, NRT's community conservancy footprint grew from 20,234 km² to 60,702 km² from 2008 to 2021.

In other conservancies, the population of critically endangered hirola antelope increased 180% since Ishaqbini sanctuary formed in 2012, and in the first community-run rhino sanctuary in East Africa at Sera Conservancy, 18 rhinoceroses are thriving. Black rhino will also be reintroduced on Loisaba Conservancy, returning this species for the first time in 50 years.

The Appalachian Opportunity

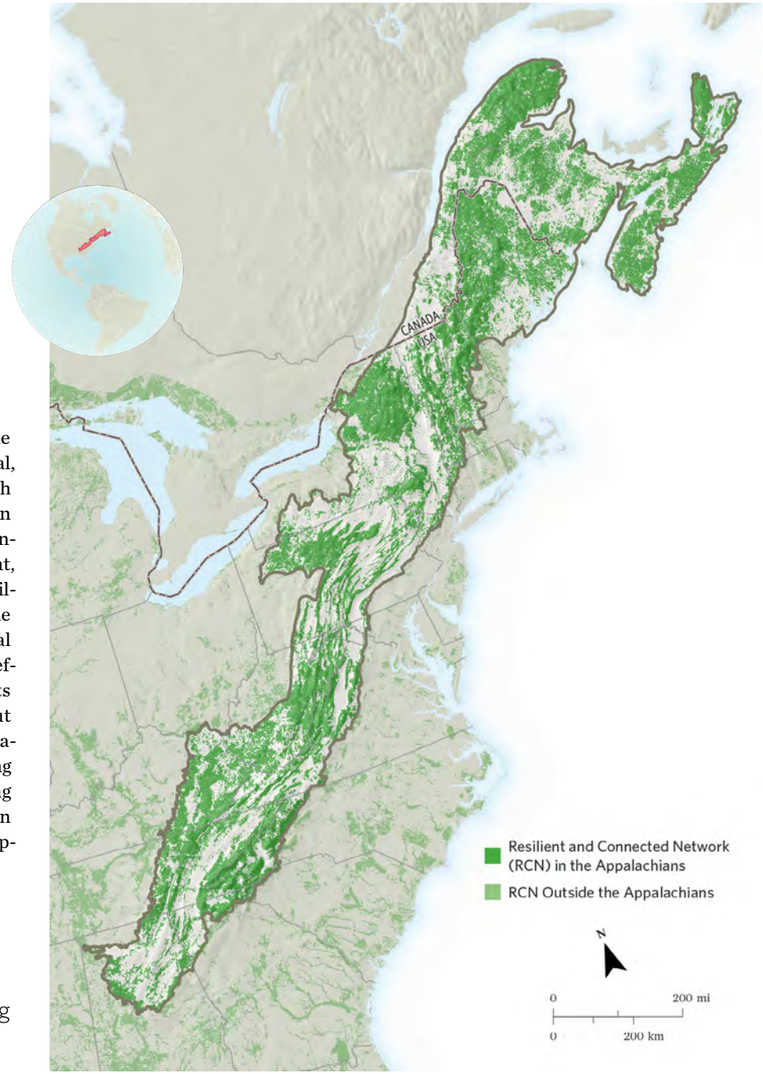
LANDSCAPE-SCALE CONNECTIVITY, FLOODPLAIN AND FOREST RESTORATION, CROSS-BOUNDARY LAND PROTECTION

Stretching roughly 2,000 miles from Alabama to Canada is one of the most resilient, diverse and carbon-rich landscapes in the world—the Appalachians. Originally occupied and stewarded by many Indigenous nations and communities, this ancient landscape forms a vast, nearly unbroken chain of forested mountains, valleys, wetlands and rivers. Today, 22 million people call this region home, and millions more depend on it for their health, livelihoods and overall well-being. As the world mobilizes to confront the dual crises of accelerated species loss and climate instability, science shows that the Appalachians are an irreplaceable safe harbor for nature and people as the landscape changes.

As the climate evolves, animals and plants will need to safely migrate to and between resilient strongholds to survive. The Nature Conservancy's Resilient and Connected Network (RCN) program used geospatial science methodologies to identify the lands that are resilient to climate change, rich in biodiversity and well connected. This research offers a roadmap for preserving the Appalachians' wildlife, natural landscapes and the more than 93 million acres of RCN in this region. When used as a guide, these mapped priority resilient landscapes can help TNC and our partners focus on the most critical places to conserve now, and into the future.

PHOTO: Mountains and fog, Campbell County, Tennessee © Cameron Davidson

MAP: The Appalachians stretch from the southeastern U.S. to eastern Canada. The RCN was developed using cutting-edge science and geospatial analysis to identify a conservation network of climate resilient sites designed to sustain biodiversity and ecological function in a changing climate. A wealth of publicly available spatial data (over 70 datasets) informed this analysis to capture attributes such as geophysical setting, landscape diversity, local connectedness and climate flow across the study area. Circuitscape software was used to model climate flow. Circuitscape is an innovative tool that models species and population movements as if they were electric currents flowing through a landscape of variable resistance.



We highlight the three regions of the Appalachian territory: Northern, Central, Southern and discuss threats facing each region. From the waterway restoration hydrologist to the wildlife biologist identifying key passages for animal movement, to the professionals doing important philanthropical work, we recognize the value of using thoughtful, accurate, geospatial science in our science communication efforts. None of the conservation projects outlined below can be achieved without targeted, accurate and accessible geospatial data. Geospatial technologies are aiding our current and future efforts at improving conservation in each Appalachian region while highlighting opportunities that support TNC's ambitious 2030 goals.

Northern Appalachians:

Enhancing the Resilient & Connected Network and Accelerating Floodplain Restoration

The Northern Appalachians is a globally significant, spatially diverse landscape. As the climate warms, maintaining the connectivity of lands and waters becomes even more essential for the diversity of terrestrial and aquatic species. Healthy connected floodplain forests and wetlands also benefit people: by slowing and absorbing water, floodplains help to protect downstream communities from flooding during large rain events.

CHALLENGE

The Upper Connecticut River Valley is part of the Northern Forest and Headwaters Focal Landscape which spans portions of Vermont, New Hampshire and Maine. This focal landscape includes a rich diversity of ecosystems, however only 20% of it is currently protected. The Upper Connecticut River Valley is critical for ecological connectivity, yet it remains vulnerable to pressures from development due to residential and commercial development, agriculture, motorized recreational use, industrial forest management, and transportation infrastructure. Human

development and the network of major dams along the river has reduced floodplain habitat abundance and condition, and threatened the species that rely on them. These floodplains provide habitat for more than 35 species of migratory birds, bald eagles, bear, moose, marten and other wildlife and they often serve as the only remaining intact habitat through which wildlife can move through this developed landscape.

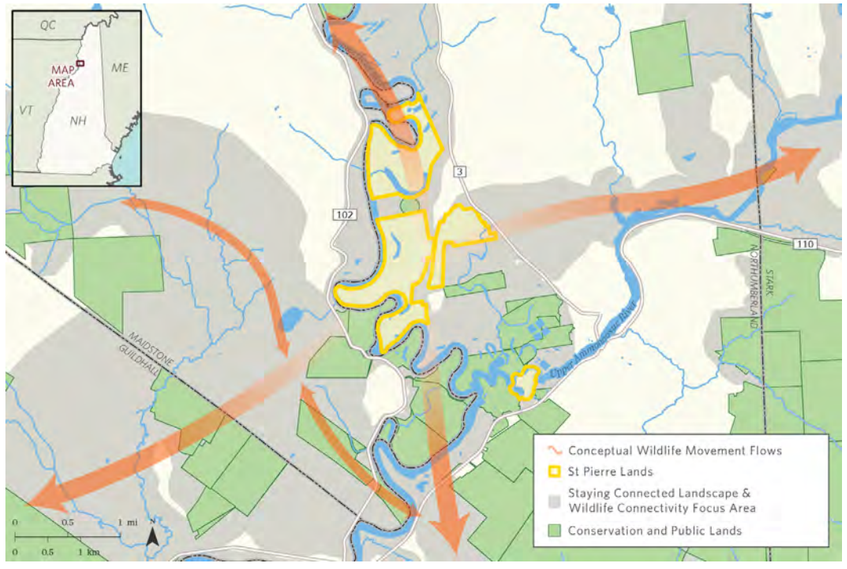
SOLUTION

Since 2009, TNC in New Hampshire and Vermont have been working to protect important floodplain habitat and agricultural lands within the reach of the Upper Connecticut. The St Pierre lands provides a unique opportunity to restore and protect floodplain and riverfront in this region while boosting connectivity. This 750-acre farm is nestled alongside the Connecticut River in the town of Northumberland, New Hampshire. The property comprises a unique mix of farmland, woods and wetlands on the Connecticut River, Upper Ammonoosuc River and tributary streams. Its expansive floodplains filter water and provide irreplaceable wildlife habitat. The St Pierre lands will become part of TNC's Maidstone Bends Preserve, and we will initiate the largest active floodplain restoration project in the history of New England. This will include purchasing and protecting the farm, conserving over 550 acres of floodplain forest and wetlands, restoring approximately 200 acres of floodplain forest with native trees and shrubs, linking over 4,500 acres of continuous lands in NH and VT and permanent protection of six miles of river frontage on the Connecticut and Ammonoosuc Rivers and major tributaries. Geospatial technologies helped us prioritize the best areas for conservation while visualizing the best restoration approach for each ecosystem. Specifically, we conducted "least cost corridor mapping" and were able to identify the St Pierre Lands as a wildlife corridor priority.

The floodplain forests and wetlands will be restored to increase wildlife connectivity, climate resilience and carbon storage. By acquiring and conserving this farm, this project will benefit people through flood attenuation, stabilization of eroding riverbanks and protection of drinking water resources. Terrain models created from Light Detection and Ranging (LiDAR) data helped to identify low-lying areas on the property that may be more frequently flooded in the future as climate change continues to alter the landscape. Because of this, we will focus our restoration on these most vulnerable portions of the active floodplain. Thanks to the precision of LiDAR data, we can identify the optimal locations for different species based on predicted flood frequency both today and into the future.

2030 GOALS

The metrics for protecting and restoring floodplains and rivers include acres protected (both land and floodplain), stream miles protected and land area with improved management. This floodplain restoration will reduce downstream flooding and improve climate adaptation.



MAP: The Staying Connected Initiative is a multi-state, bi-national partnership with the goal of maintaining and enhancing landscape connections for wide-ranging wildlife species across the Northern Appalachian Region. Geospatial analysis known as "least cost corridor mapping" identified St Pierre Lands and other wildlife connectivity focal areas as priorities for protection and floodplain habitat restoration. Data analysis and mapping continue to be important throughout the floodplain restoration process by using technologies such as LiDAR data analysis to map subtle elevation gradients.

PHOTO: Wetlands near the Connecticut River, Lyme, Connecticut. © Jerry and Marcy Monkman

Central Appalachians:

Focused Land Protection to Achieve an Ambitious Vision

The Central Appalachians Program encompasses more than 50 million acres of lands and waters spanning seven states (New Jersey, Pennsylvania, Maryland, West Virginia, Virginia, Kentucky and Tennessee). This mountainous expanse is home to one of the largest and most intact remaining temperate, mixed forests on Earth that serves as a critical, living carbon reserve. Unfortunately, the current state of this forest reflects a legacy of poor forest management and natural resource extraction. This positions the Central Appalachian forests as an excellent location for bold and ambitious forest restoration and carbon sequestration initiatives. Resilient forest management and Natural Climate Solutions could provide a valuable pathway for the sequestration of additional carbon and enhanced forest resilience.

CHALLENGE

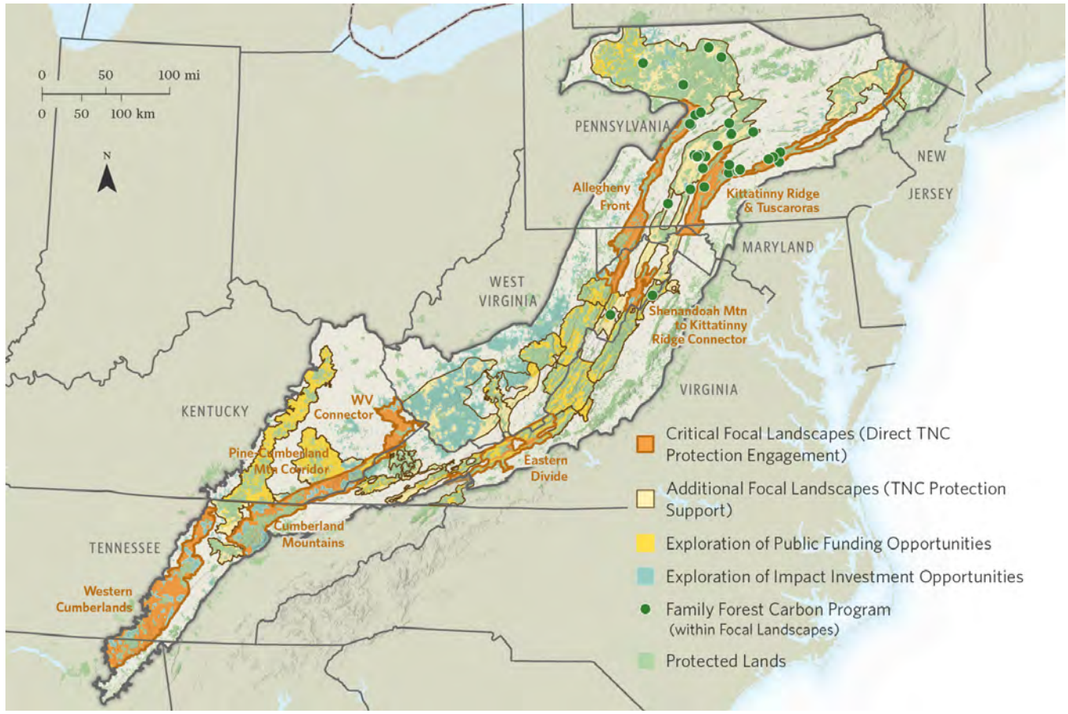
Twenty-one million acres (42% of the program area) of the Central Appalachian region have been identified as climate resilient. The Central Appalachians Program is deploying three landscape-scale conservation strategies focused in 36 focal landscapes to protect and restore a healthy Central Appalachians Resilient and Connected Network (RCN).

SOLUTION

Mapping our protection priorities, including the foundational spatial evaluation of assets, vulnerabilities and opportunities has been critical to setting a collaborative vision and focused objectives for protecting resilient areas of the Central Appalachians. We leveraged geospatial technologies to create a land protection strategy with a spatially explicit set of near-term conservation priorities within the RCN, including many continentally significant areas where TNC could conserve vast areas with significant carbon stocks. Opportunities of this magnitude and impact are found in few (if any) other places in the U.S. Our work on cross-boundary collaborations has laid the groundwork to deliver impactful conservation projects in the region. Specifically, our work with the American Forest Foundation to enroll priority landowners in the Family Forest Carbon Program (FFCP) can enable long-term protection outcomes on small forest properties through landowner incentive payments for sustainable forestry practices.

We used geospatial technologies to inform our planning, analyses and collaboration as we mapped the most critical places to implement protection actions. We identified 14 priority land ownerships (1.3 million acres) in the coal fields region (i.e., 10,000-250,000+ acre ownerships; totaling 1.3 million acres) where protection could secure strongholds in unprotected gaps of the RCN. We identified eight Critical Focal Landscapes (CFLs) of our 36 focal landscapes totaling 6.2 million acres, for which TNC's land protection efforts can secure key connectivity corridors in the RCN. In addition, we are identifying lands in three focal areas where investments in restoration are likely to provide both terrestrial and aquatic habitat connectivity. Rather than relying only on a static map of current habitat distribution to infer connectivity and climate change resilience benefits in the RCN, we developed a first-of-its-kind connectivity analysis using Circuitscape to model the improvements to connectivity if areas were restored. Leveraging key geospatial data, we identified small parcels within important climate corridors that when linked together, can have a significant impact in maintaining regional connectivity.

PHOTO: Bobcat, Monongahela National Forest, West Virginia. © Kent Mason



2030 GOALS

The Central Appalachian region has an annual goal of protecting 50,000+ acres of RCN and a 5-year goal of 3 million+ acres of RCN. These protection mechanisms enable contributions to the metrics of land area with improved management and at risk natural areas with avoided conversion.

Southern Appalachians:

Building 3-D Maps to Target Forest Restoration

The Blue Ridge Mountains of Western North Carolina look different than they did centuries ago. Stands of mature oak and hickory are reaching the end of their lives and will eventually be replaced by maples and poplars that dominate today's midstory. Over the past 40 years, temperatures in the region have been increasing at a rate of 0.5°C per decade. Oak, hickory and yellow pine store more carbon and use up to four times less water than maple and poplar, making forests dominated by these species more resilient to impacts from a changing climate. Oaks and hickory also provide important habitat for a host of more than 100 vertebrates from mice to black bear. Removing these trees will have negative consequences for forest biodiversity and the species that rely on them.

CHALLENGE

For 11,000 years, Indigenous People used fire to actively manage ecosystems in North America. Carbon dating demonstrates how fire frequency increased when Indigenous People moved into the region. Their burning practices improved forest health and created a mosaic on the landscape, described by early Europeans as an open forest with dappled sunlight and savannas. In the last century, fire was removed from the forest and the result is the closed canopy of today.

MAP: We used extensive geospatial analyses in the Central Appalachians to identify 36 focal landscapes (including eight critical focal landscapes) as places where TNC's land protection efforts can secure key connectivity corridors in the RCN. Further analysis identified opportunities for impact investments, public land expansion and the potential to work with private owners of small forest properties.

SOLUTION

TNC and our partners are restoring forests by returning prescribed fire to the Blue Ridge Mountains. We are leveraging geospatial technologies and using LiDAR techniques to generate 3-D models of the Earth's surface to model current forest conditions across 1.5 million acres in North Carolina. This analysis has required more than 15 terabytes of data and taken 46 days of computer processing time. The use of LiDAR technology provides a more complete picture of the forest and allows practitioners to make comprehensive management decisions about where to conduct prescribed burns. This work builds off earlier modeling that determined which ecozones in the forest were fire-adapted, meaning they required fire to thrive.

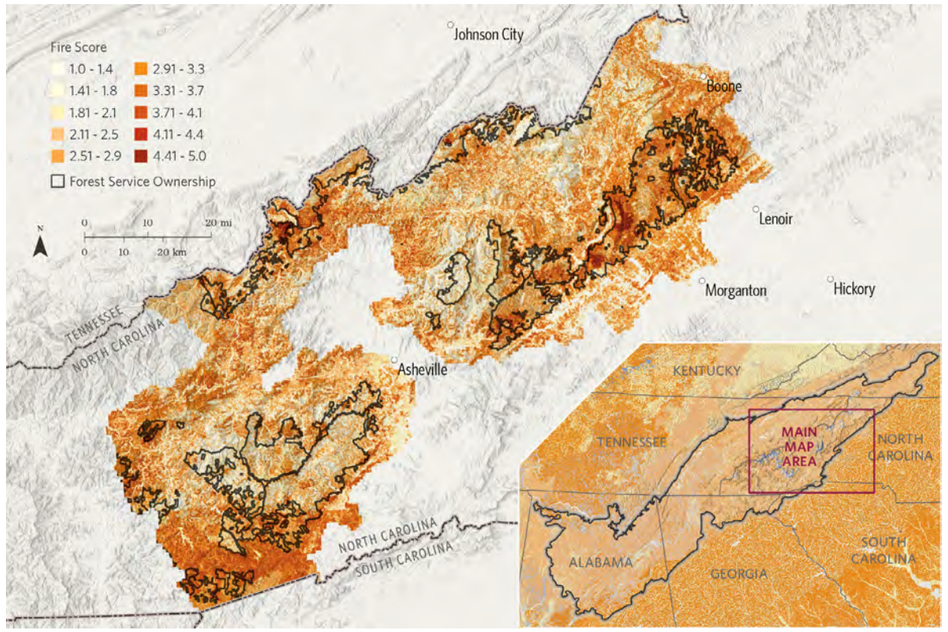
By identifying fire-adapted zones adjacent to development, TNC can pinpoint the areas where prescribed fire can have the greatest impact on biodiversity and most positive outcomes for people. Communicating this spatially explicit information requires access to current, accurate geospatial data, especially when interacting with communities living adjacent to fire-adapted forests. By returning fire to fire-adapted forests, practitioners can reduce fuel loads, improve forest health and mitigate risk to nearby communities. To further pinpoint the best locations for restoration, practitioners consider two other elements, heavy fuel loads and past wildfire history. Increased fuel loads increase the likelihood of a catastrophic wildfire making these places a priority for controlled burns and areas that have experienced wildfire in the past are more likely to burn again in the future. These qualifying factors help TNC identify the best places to prioritize restoration with controlled burning. The use of prescribed fire will increase the forests' resilience to climate change and improve biodiversity in the region.

2030 GOALS

Improved management of 1.5 million acres of land in the Southern Appalachian region through the targeted use of prescribed fire contributes to the preservation of ecosystem benefits (clean air and water) that flow directly from the forest to the 1.4 million people that call the region home.

DATA SOURCES: NH GIS Clearinghouse, Esri, American Forest Foundation, Ecological Zones in the Southern Appalachians (Simon et al.), NC One Map, US Forest Service, LANDFIRE, TNC. Additional sources for the Resilient and Connected Network include bedrock geology, soils, elevation, landforms, land cover and distribution of species and wetlands. For more information see **maps.tnc.org/resilientland**

MAP: This map identifies the places where prescribed fire and fuels reduction treatments will have the greatest ecological and human benefits. The analysis incorporates data from past wildfires, fire-adapted ecological zones, current land-use, LiDAR-derived vegetation density and an approximation of the wildland-urban-interface. A fire score of 5 represents areas that have the highest need for restoring fire to the landscape coupled with strong co-benefits for nearby communities. The locator map shows data on historic fire return interval from the LANDFIRE program.



Map Spotlight

ESTIMATING THE WARMING IMPACT OF METHANE EMISSIONS FROM RICE WITH GWP*

Ali Surdoval
Agriculture & Climate Scientist
Provide Food & Water Sustainably Team

Agriculture is responsible for 64-70% of anthropogenic methane (CH_4) emissions, almost all from livestock and rice cultivation **(UNEP & CCAC 2021)**. Future land use projections show continued intensity of rice cultivation in Asia **(Chen et al. 2020)**. We use GWP-star (denoted GWP*)–a global warming potential metric that more accurately approximates the warming effect of CH_4 by accounting for its shorter lifespan **(Costa Jr. et al 2021, Smith et al. 2021)**–to estimate the mitigation opportunities of adoption scenarios of alternate wetting drying (AWD), an intermittent rice irrigation practice with demonstrated reductions in methane emissions.

This analysis helps TNC refine our work on **Foodscapes**, spatial representations of the world food system to highlight the transitions required if we are to meet this century's most pressing challenges: climate change, biodiversity loss and an "increased demand on the integrity of the global food system" **(Bossio et al. 2021)**.

TNC's **Foodscapes** work leverages nature-based solutions: managing food production systems that restore and rebuild natural systems rather than exhaust them. Geospatial data and the ability to visualize the context surrounding food system challenges provides a framework for thoughtfully considering the interplay between socioeconomic and cultural variables, food system production, agricultural sustainability and the health of the planet. Readers should reference the Foodscapes report to learn more about the many factors impacting global food systems. Using GWP* to better characterize the warming impact of methane from agriculture can direct TNC's climate mitigation efforts by identifying key geographies and practices with high mitigation potential.

WHY GWP*?

The most common metric of global warming potential is GWP100, which estimates warming impacts by aggregating the effects of greenhouse gases (GHG) over a 100-year period. This 100-year metric is not well suited for methane (CH_4) because CH_4 only stays in the atmosphere for 10 years before being converted to CO_2. GWP* more accurately approximates the warming effect of CH_4 by accounting for its shorter lifespan and equating CH_4 emissions rates to pulse emissions of longer-lived GHGs, like CO_2 and nitrous oxide **(Costa Jr. et al 2021, Smith et al. 2021)**.

Ali Surdoval (she/her/hers) contributes to science efforts on the climate mitigation potential of agriculture and supports TNC's regenerative food systems strategy. Throughout her work, Ali strives to incorporate principles of diversity, equity, justice and inclusion. Ali has a MSc in Environmental Justice from the University of Michigan School for Environment and Sustainability. She was also a GIS Analyst Intern with TNC's Alaska chapter in 2017. Ali is based in Ann Arbor, Michigan.

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MAP: Our analysis highlights the high potential of rice cultivation mitigation efforts to contribute to net neutral warming, or no additional temperature increases, from methane. Importantly, recommendations to adopt climate-mitigating agricultural practices such as AWD must account for the many nuances surrounding the cultural, socioeconomic and scientific factors impacting the role of rice cultivation in the region and worldwide.

DATA SOURCES: Chen et al. 2020, EDGAR v6.0 2021, FAO 2018, IPCC 2019

Looking Ahead: 2022

WHERE IS TNC WORKING TO ACHIEVE ITS 2030 CONSERVATION GOALS FOR HEALTHY ECOSYSTEMS, CLIMATE AND PEOPLE?

CONSERVATION ACCOUNTING

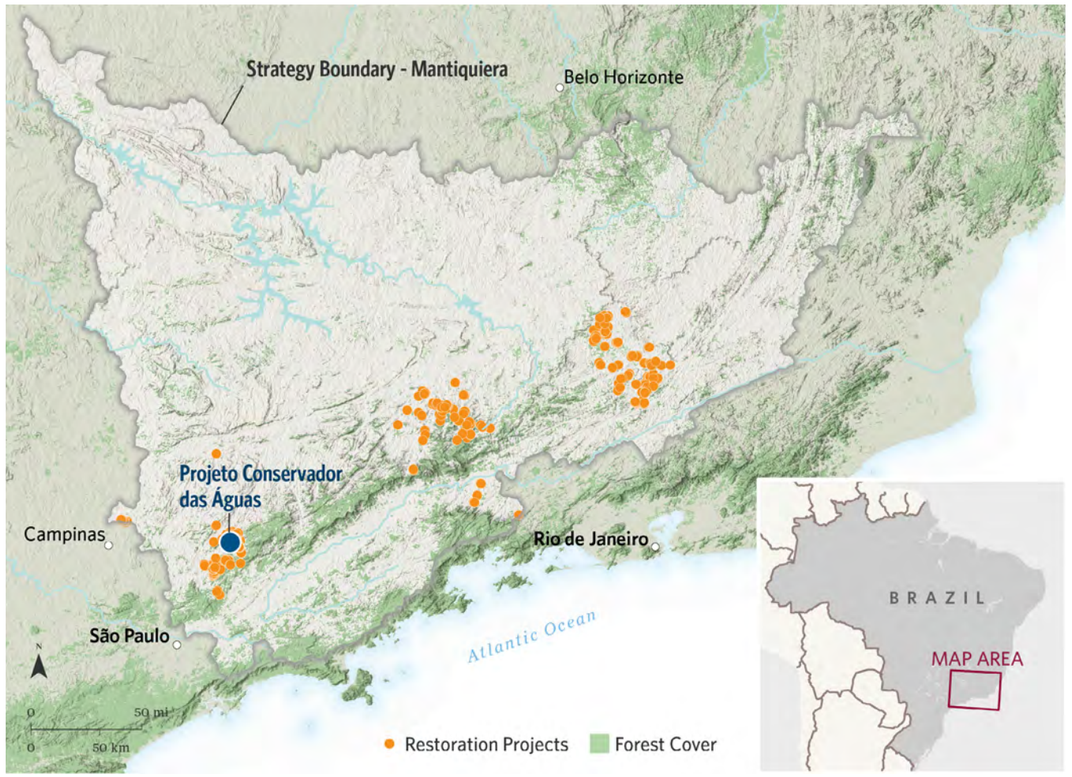
TNC's Conservation Hub is an organization-wide, internal conservation accounting system that allows leaders and teams to make informed decisions to maximize the organization's achievements towards our 2030 goals. The Hub is designed to track our conservation progress and assess the financial health of our work. The organization can access the Hub to explore specific components of each strategy and project and get a comprehensive perspective on our conservation portfolio. New features are prioritized and implemented using an agile methodology to ensure its capabilities meet best-in-class application development and performance standards. Continual improvements to the application are driven by usability, accessibility and adaptability based on decision support needs. Through interactive dashboards and custom views, TNC decision-makers can see relevant conservation data necessary for assessing and allocating resources in order to scale opportunities and meet our 2030 goals.

Application developments in 2022 include the integration of geospatial information into the conservation accounting system, adding an important visual aid and emphasizing the importance of place-based strategies. The inclusion of geospatial data will amplify conservation accounting towards our organizational goals and effectively track and measure our outcomes. This work will streamline and integrate "how" we are doing the work with the Hub, with "where" we are doing the work leveraging the Conservation GeoCloud. This will create a more comprehensive approach to conservation decision-making. In coordination with this exploratory stage, we have tested the development of a global spatial database of freshwater-focused projects to survey how we are working and where we expect to make gains toward our 2030 freshwater conservation goals. Integrating the Hub with geospatial data and analyses is an exciting step toward advancing our conservation and geospatial systems.

GEOSPATIAL REPORTING

A new geospatial reporting effort is leveraging TNC's deep geospatial expertise and mapping culture by exploring how we might gather foundational spatial data to achieve our 2030 goals. Staff from four TNC business units, including Brazil, Global Science, IT and the Chief Conservation Office, have joined forces to explore how a coordinated effort to manage geospatial data might create a more transparent and efficient approach to understanding where we are working and achieving results. The team prototyped this approach with local knowledge and spatial data from a project in Brazil's Atlantic Forest where landowners are compensated in exchange for forest restoration in the Mantiqueira mountains. By July 2022, the Brazil team aims to expand payments to 2,700 hectares. Successful forest restoration would contribute to Brazil's 2030 goals related to healthy lands and freshwater, climate mitigation and people. This pilot is among several concurrent, local and regional efforts in TNC to manage spatial data in a similar fashion related to the organization's goals.

Through this initial proof of concept in Brazil and engagement with multiple regions, TNC is learning how a scalable, geospatial reporting system could integrate with the Hub's conservation accounting system. Based on these findings, TNC will begin assessing how to create a dynamic "where we work" map. One important test of the value of geospatial reporting in 2022 will be how well it helps staff and managers understand our progress and make effective decisions that support our goals.



2007

2017

Projeto Conservador das Águas

MAP: Restoration of pasture lands to forests in the Mantiqueira Mountains of the Atlantic Forest is prioritized in over 400 municipalities within the Strategy Boundary. Payments to landowners to fence lands and remove cattle occur in project extents throughout this prioritized region.

DATA SOURCES: TNC, European Space Agency, Esri

PHOTOS: © City Hall of Extrema

Acknowledgements

This third edition Geospatial Conservation Annual Report & Map Book has been guided by TNC's Geospatial Leadership Council, a group of 26 geospatial professionals representing every region where the organization works. These Council members have reached out to their own teams to contribute to this report, totaling well over one hundred TNC and partner contributors. A core team of individuals from IT's Geospatial Systems and Marketing's Creative Design teams played a significant role in organizing and designing the report. In particular, a big thanks goes to Mrinal Joshi, Jan Slaats, Jay Sullivan and Grace McMurry for design, printing and keeping us on track. A special thanks goes to Megan Dettenmaier for her co-editing and Chris Bruce serving as Lead Cartographer for most of the map production. Additional cartography was done by Thaciane da Silva, Yusuf Fajariyanto, Anna Ormiston, Alie Syopyan and Ghufran Zulqisthi. The maps in this report make extensive use of **Natural Earth** data. Gratitude also goes to our Focal Applications teams in Brazil, Indonesia, Kenya and the United States for their critical contributions that framed this edition, as well as to Brandie Fariss, Christina Kennedy and the Indigenous Peoples team for their review and guidance of Indigenous Lands at Risk. New geospatial employee, Alison Surdoval, highlighted her work on the Warming Impact of Methane Emissions in our first ever map spotlight that features a new geospatial employee and their successful adoption of our cartographic guidelines. With additional support from our Chief Conservation Office coming from Sheila Reddy, Teresa Chapman and Dave Patrick, this report articulates important geospatial work on the horizon. Thanks to all these folks for their important contributions. We also extend appreciation to TNC's global leadership in IT and Conservation Science, most notably Umesh Yadav, Dick Cameron and Joni Ward, as well as to TNC's Marketing leadership–specifically Samir Singh, Christopher Johnson and Benay Brotman–for approving this project and championing the work of TNC's dynamic geospatial community. Finally, we couldn't have produced this great geospatial conservation work without deep collaborations principally with Esri, Amazon Web Services and Microsoft. We are truly grateful for your support!

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