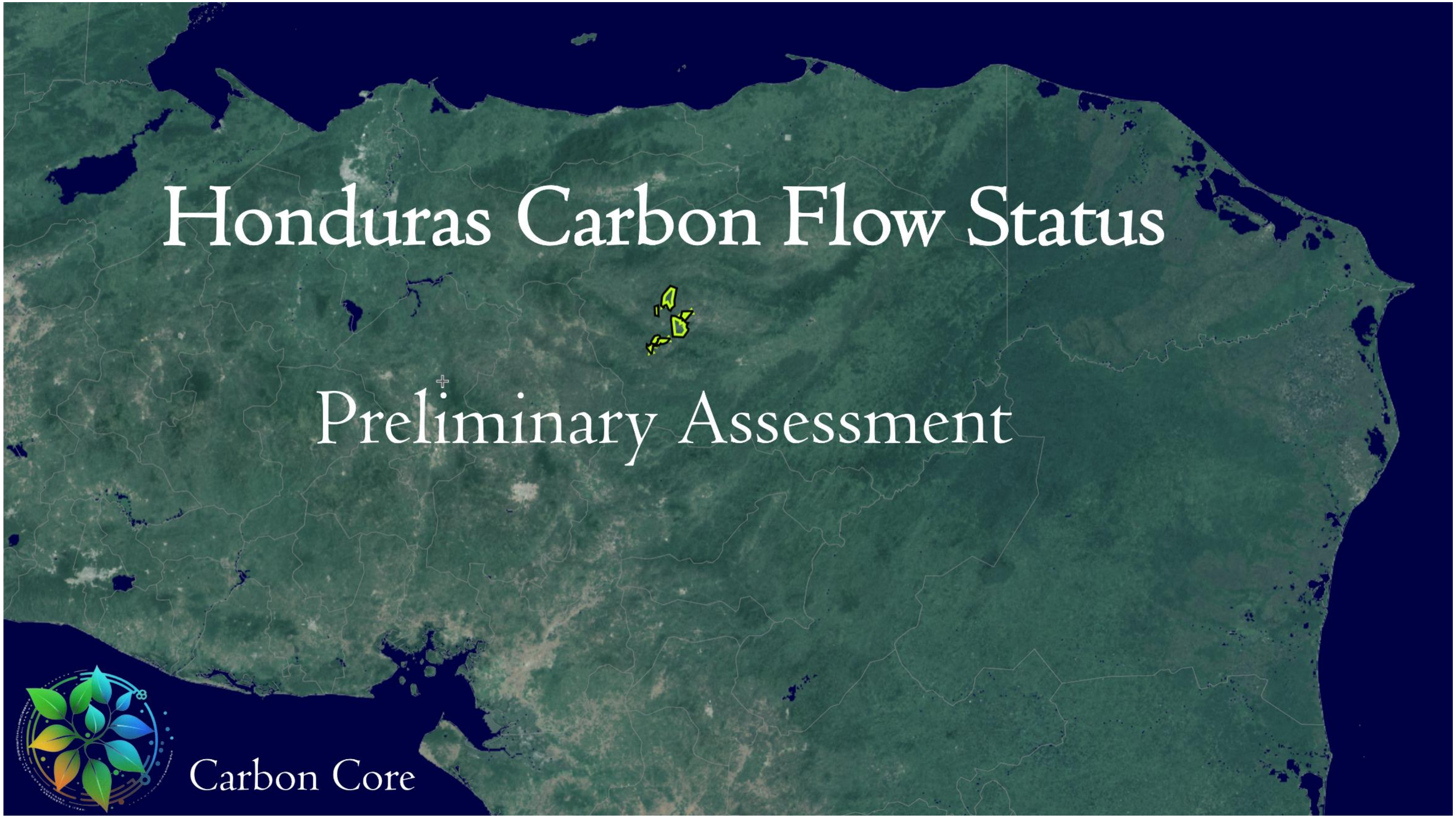
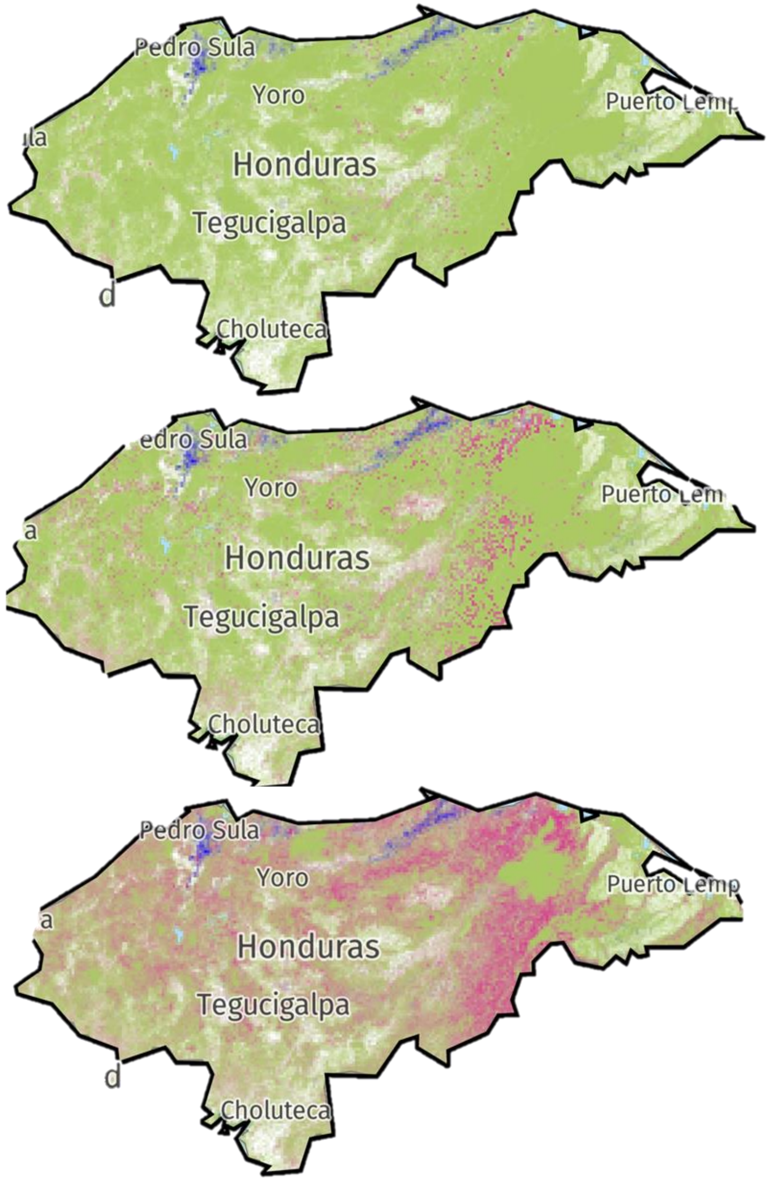
Honduras Carbon Flow Status

Preliminary Assessment



Carbon Core

Table of Contents



Abstract

This report analyzes tree cover loss, carbon emissions, and sequestration across six areas of forest in Honduras from 2001-2022. The areas range in size from 0.81 to 6.02 thousand hectares. In 2000, tree cover ranged from 21% in Agua Caliente to 98% in El Zapote. By 2022, all areas except El Zapote had suffered high deforestation, losing 7.9-19% of 2000 tree cover. This loss released over 1.5 million Mg of CO2 equivalent emissions, with annual emissions peaking in 2016 likely due to an extreme 110 hectares burnt from fires. Tree cover loss and emissions far outpaced minor reforestation efforts. Key drivers were shifting agriculture and forest fires. However, two areas remained net carbon sinks - Agua Caliente and El Zapote. For the merged 19,240 hectare region, original tree cover was 60% but 14% was lost by 2022, emitting 677 kilotons of emissions. Loss was dominated by fires rather than agriculture. Reforestation efforts helped offset some emissions, resulting in net removal of 33.1 kilotons per year. However, protection and restoration of forests are still critical climate change mitigation priorities in this ecologically important region of Honduras.

Estimations show that if deforestation could be reduced and reforestation efforts increased, substantial carbon credits could be generated. However, precise measurements and analysis of local conditions would be required to determine accurate sequestration rates and carbon credits for Honduras' specific forests. Protection of existing forests, restoration of degraded zones, and sustainable agriculture practices are recommended to maintain Honduras' carbon sink capacity while maximizing the potential value of carbon credits. Carbon credits could then provide an income source to support rural development and climate action if managed through a coordinated regional plan. Carbon credits could then provide an income source to support rural development and climate action if managed through a coordinated regional plan.

Introduction

Honduras is a country in Central America with a population of over 9 million people with a total land area of approximately 112,492 km^2, which is equivalent to 11,249,200 ha. It has 5.2 million ha of forest covering 46% of its land area. These forests are ecologically important, economically valuable, and essential for carbon sequestration. Sustainably managing these resources can support climate goals while preserving Honduras' natural heritage. The country is home to a variety of ecosystems, including tropical forests, wetlands, and agricultural lands. These ecosystems play a vital role in the global carbon cycle by absorbing and storing carbon dioxide from the atmosphere through natural processes like photosynthesis.

Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide in long-term reservoirs. This can occur naturally through photosynthesis or through human activities like reforestation. Capturing carbon this way can help mitigate climate change. Carbon credits are a way to monetize the climate benefits of carbon sequestration projects. Credits are generated when projects reduce or remove greenhouse gases. These credits can then be traded on carbon markets, enabling businesses and governments to offset their emissions.

Honduras has significant potential for carbon sequestration. The country's forests store an estimated 1.2 billion tons of carbon dioxide, equal to the annual emissions of over 250,000 cars. Carbon credits could help finance projects that enhance sequestration, like reforestation efforts. Experts estimate Honduran forests can sequester 10-15 tons of carbon dioxide per hectare annually. This means a 100 ha forest could remove 1,000-1,500 tons yearly. Carbon prices are typically USD $5-10 per ton, so a 100 ha forest could generate USD$500-1,500 in credits annually. However, sequestration rates vary based on forest type, age, and climate factors.

In 2015, Honduras launched a national carbon sequestration strategy aiming to increase sequestration by 10 million tons annually by 2030. The government is also developing a domestic carbon market to incentivize sequestration investments through the sale of credits. This market-based approach could accelerate climate action.

Factors Influencing Carbon Sequestration:

- Tree Growth Rates: Faster-growing species sequester more carbon.
- Forest Age: Older forests may sequester less carbon annually as growth slows down.
- Soil Conditions: Soils with high organic content can store significant amounts of carbon.
- Forest Management Practices: Sustainable practices can enhance CSR.

- Climatic Conditions: Temperature and precipitation patterns affect photosynthesis rates and biomass accumulation.

Data Collection:
The first step involves gathering accurate and recent data on carbon sequestration rates (CSR) for different forest types. This data can be sourced from scientific literature, databases maintained by environmental organizations, remote sensing data, and field research studies.

Carbon Sequestration Estimation:
- *Direct Measurement*: This involves measuring the increase in biomass through forest inventories and converting this increase into carbon sequestration using established conversion factors.
- *Modeling Approaches*: Models can predict CSR based on growth rates, forest type, climatic conditions, and other ecological factors.
- *Remote Sensing*: Satellite imagery can help estimate changes in forest cover and biomass at larger scales.

Carbon Credits Calculation: Once the CSR is estimated, the next step is to convert this into carbon credits. A carbon credit represents the removal of one ton of carbon dioxide equivalent (CO_2e) from the atmosphere. The CSR needs to be multiplied by the area (per hectare) and then by the global warming potential of CO_2e.

Verification, Validation and Reporting: The results should be verified through peer review or by third-party organizations specializing in carbon accounting to ensure accuracy and transparency: The final step is to compile the findings into a report that details the methodology, data sources, calculations, and assumptions.

Objectives

- ✓ This report provides a detailed analysis of the carbon credits for 6 areas in Honduras. The analysis calculates the carbon emissions and removals for each area based on the land cover and tree canopy data provided.

- ✓ The country Ecuador has Forest type Estimated area in ha Tropical moist Forests 2.5 million Tropical dry Forests 1.5 million Cloud Forests 0.5 million Mangrove Forests 0.2 million estimate the Carbon Sequestration Rate per Year per Hectare and the carbon credits per year.

Abbreviations

ktCO$_2$e/year:
Stands for kilotons of carbon dioxide equivalent per year. It's a unit of measurement used in greenhouse gas inventories to express the impact of each different greenhouse gas in terms of the amount of CO_2 that would create the same amount of warming.

Kilotons (kt):
It's a unit of mass equivalent to 1,000 metric tons. In this context, it's used to quantify the amount of greenhouse gases.

Carbon Dioxide Equivalent (CO$_2$e):
This is a standard unit for measuring carbon footprints. The idea is to express the impact of each different greenhouse gas in terms of the amount of CO_2 that would create the same amount of warming. That is, it converts the quantity of each greenhouse gas being emitted to the number of units of CO_2 that would have the same global warming potential.

Per Year (/year):
This indicates that the measurement is an annual rate.

Carbon Stock (tC/ha):
This refers to the quantity of carbon contained in a "pool", which is a reservoir or system that has the capacity to accumulate or release carbon. In the context of forests, it refers to the amount of carbon stored in the world's forest ecosystem, mainly in living biomass and soil. It's typically measured in tons of carbon per hectare (tC/ha).

Aboveground Biomass (t/ha):
This is the total amount of living organic material found above the soil surface, including stems, branches, bark, seeds, and foliage. It's usually measured in tons per hectare.

Biomass to Carbon Conversion Factor:
This is a coefficient used to convert the amount of biomass (the total mass of organisms in each area or volume) into an equivalent amount of carbon. This factor is necessary because while biomass includes all elements in a plant (carbon, hydrogen, oxygen, nitrogen, etc.), only the carbon portion is counted when calculating carbon stocks.

Annual Removals (ktCO$_2$e/year):
This refers to the reduction in greenhouse gas emissions achieved in a given year, usually through activities such as afforestation, reforestation, or improved forest management. It's typically measured in kilotons of carbon dioxide equivalent per year.

Carbon Accumulation Rate (tC/ha/yr):
This is the rate at which carbon is stored or accumulated in each area (usually a forest or other type of ecosystem) over time. It's typically measured in tons of carbon per hectare per year.

Net Carbon ($ktCO_2e$/year):
This is the difference between the amount of carbon dioxide equivalent released into the atmosphere and the amount removed from the atmosphere each year, measured in kilotons. It's a measure of a country or region's impact on global warming.

Total Emitted ($ktCO_2e$):
This refers to the total amount of greenhouse gases that have been released into the atmosphere over a certain period of time, measured in kilotons of carbon dioxide equivalent. It includes not only CO_2 but also other gases like methane (CH_4) and nitrous oxide (N2O), which have greater warming potential than CO_2.

Type of forests

Tropical moist forests:
These forests are found in the lowlands of the country and are characterized by high rainfall and warm temperatures. The trees in these forests are typically tall and evergreen, and the understory is dense with shrubs and vines.

Tropical dry forests:
These forests are found in the drier parts of the country and are characterized by lower rainfall and a shorter growing season. The trees in these forests are typically deciduous, and the understory is less dense compared to tropical moist forests.

Cloud forests:
These forests are found in the mountains of the country and are characterized by high rainfall and cool temperatures. The trees in these forests are typically short and stunted, and the understory is often covered in mosses and lichens.

Mangrove forests:
These forests are found along the coasts of the country and are characterized by their ability to grow in salty water. The trees in these forests are typically tall and stilt-rooted, and the understory is often covered in algae and seagrasses.

The forests of Honduras face several threats, including deforestation, illegal logging, and climate change. Deforestation is the main threat to the forests of Honduras, with an estimated loss of about 100,000 ha of forest each year. Illegal logging is also a major problem, with approximately 50% of the timber harvested in Honduras being done so illegally. Climate change further poses a threat to the forests as it causes them to become drier and more susceptible to fire.

The government of Honduras is actively working to protect its forests and has implemented various policies and programs to address these challenges. However, the protection of Honduras' forests remains a significant task that requires ongoing efforts. It is important to note that this list represents some of the most representative species in each forest type. There are many other species that inhabit these forests, and each forest type supports a unique ecosystem.

Carbon sequestration rate per type of forest

Tropical Moist Forests:
These are typically among the most productive ecosystems in terms of biomass accumulation. A study might find that these forests can sequester between 15 to 30 tons of CO_2 per hectare per year. For our estimation, we'll use a conservative average of 20 tons CO_2/ha/year.
- CSR: 20 tons CO_2/ha/year
- Area: 2.5 million ha
- Total Sequestration: 20 * 2.5 million = 50 million tons CO_2/year

Tropical Dry Forests: These forests usually have lower sequestration rates due to less dense vegetation and slower growth rates. The sequestration rate might range from 10 to 20 tons CO_2/ha/year. We'll use an average of 15 tons CO_2/ha/year.
- CSR: 15 tons CO_2/ha/year
- Area: 1.5 million ha
- Total Sequestration: 15 * 1.5 million = 22.5 million tons CO_2/year

Cloud Forests: These forests, due to their unique climatic conditions, can vary widely in their carbon sequestration rates. A plausible range could be 10 to 25 tons CO_2/ha/year.
We'll take an average of 18 tons CO_2/ha/year.
- CSR: 18 tons CO_2/ha/year
- Area: 0.5 million ha
- Total Sequestration: 18 * 0.5 million = 9 million tons CO_2/year

Mangrove Forests: Mangroves are highly productive and can sequester carbon at high rates, sometimes exceeding 30 tons CO_2/ha/year. We'll use an average rate of 25 tons CO_2/ha/year.
- CSR: 25 tons CO_2/ha/year
- Area: 0.2 million ha
- Total Sequestration: 25 * 0.2 million = 5 million tons CO_2/year

Carbon credits per type of forest

To convert these sequestration amounts into carbon credits, we note that one carbon credit is equivalent to one ton of CO_2 sequestered:

- Tropical Moist Forests: 50 million carbon credits/year
- Tropical Dry Forests: 22.5 million carbon credits/year
- Cloud Forests: 9 million carbon credits/year
- Mangrove Forests: 5 million carbon credits/year

Estimations of Carbon credits per forest type

Forest type	Predominant type of vegetation	Most representative species	Estimated area in ha	Estimated carbon sequestration rate	Estimated carbon credits per year
Tropical moist Forests	Tall evergreen trees	Mahogany, cedar, rosewood	2.5 million	20 tCO_2/ha/year	50 million tons CO_2/year
Tropical dry Forests	Deciduous trees	Guanacaste, oak, pine	1.5 million	15 tCO_2/ha/year	22.5 million tons CO_2/year
Cloud Forests	Short, stunted trees	Wax myrtle, alder, oak	0-5 million	18 tCO_2/ha/year	9 million tons CO_2/year
Mangrove Forests	Tall stilt- rooted trees	Red, black and white mangrove	0.2 million	25 tCO_2/ha/year	5 million tons CO_2/year

Carbon sequestration rate per area

- ✓ Estimate carbon stock per hectare:

Carbon stock (tC/ha) = Aboveground biomass (t/ha) x Biomass to carbon conversion factor

Where biomass to carbon factor is typically 0.47 to 0.51

- ✓ Emissions from tree cover loss:

Annual emissions ($ktCO_2e$/year) = Area of loss (ha) x Carbon stock per hectare (tC/ha) x 44/12

Where 44/12 converts tons of carbon to tons CO_2 equivalent.

- ✓ Removals from tree cover gain:

Annual removals ($ktCO_2e$/year) = Area of gain (ha) x Carbon accumulation rate (tC/ha/yr) x 44/12

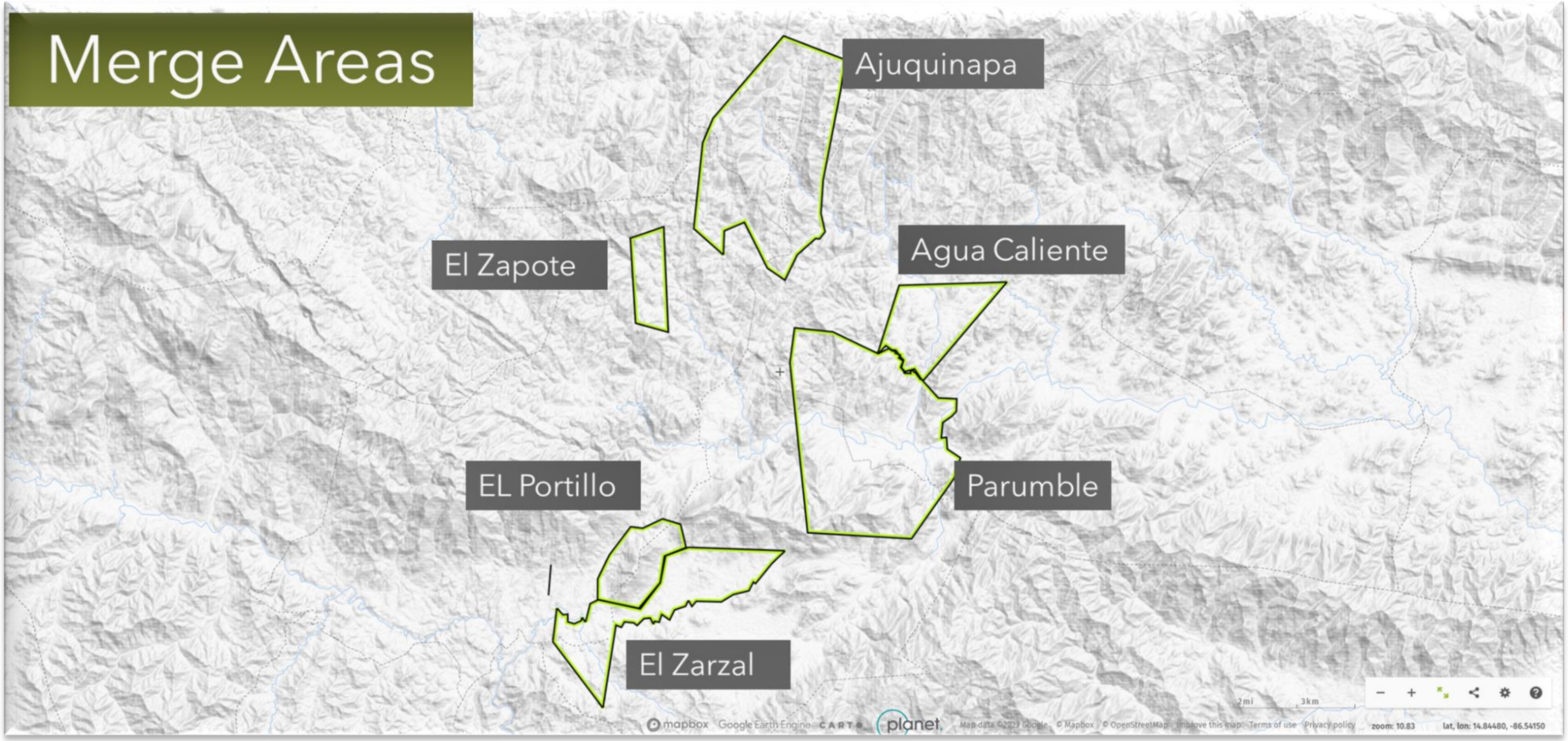
- ✓ Net carbon balance:

Net carbon ($ktCO_2e$/year) = Emissions - Removals

- ✓ Total emitted:

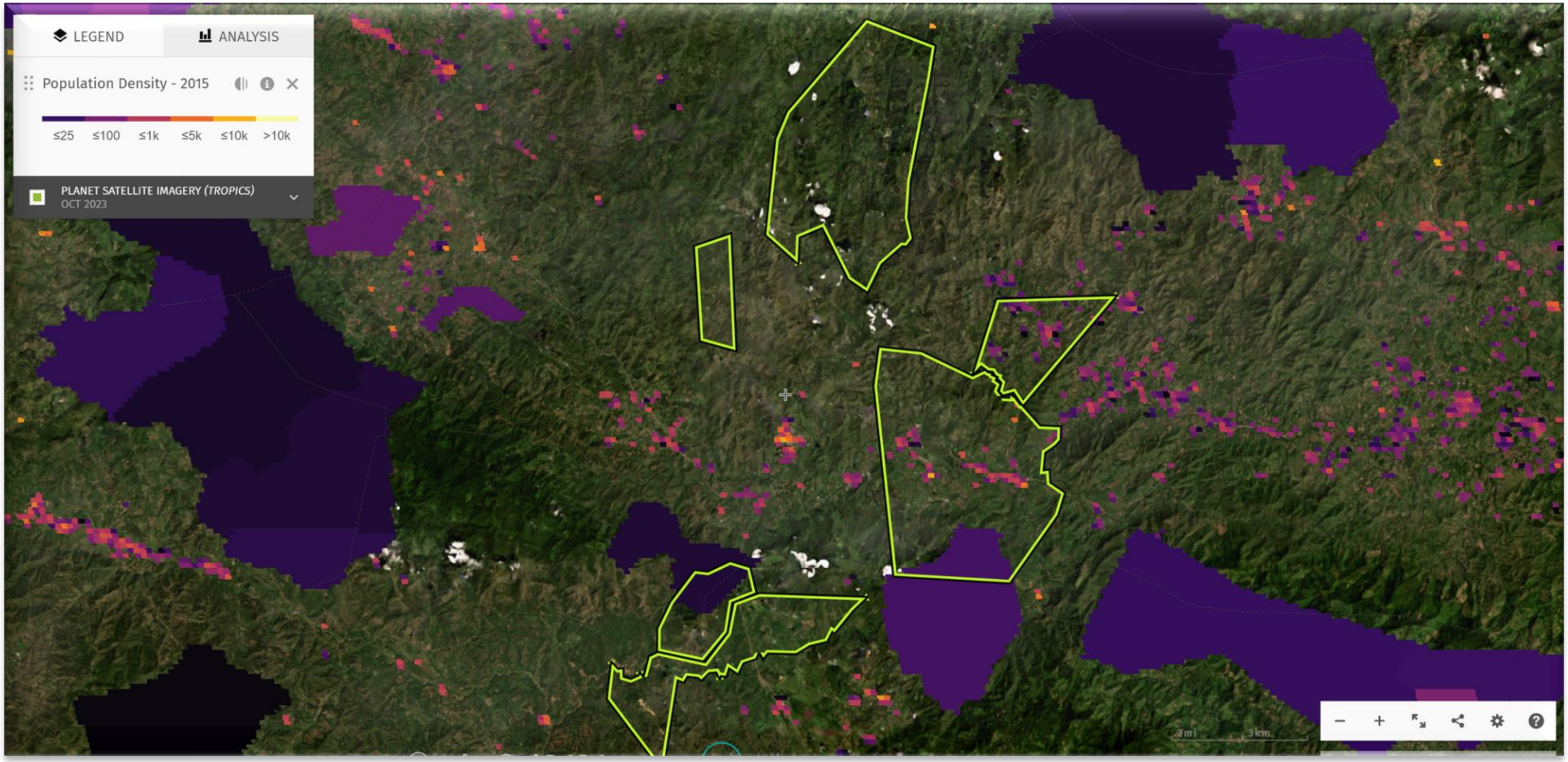
Total emitted ($ktCO_2e$) = Sum of annual emissions from 2001 to 2022

Geographical Map Layers



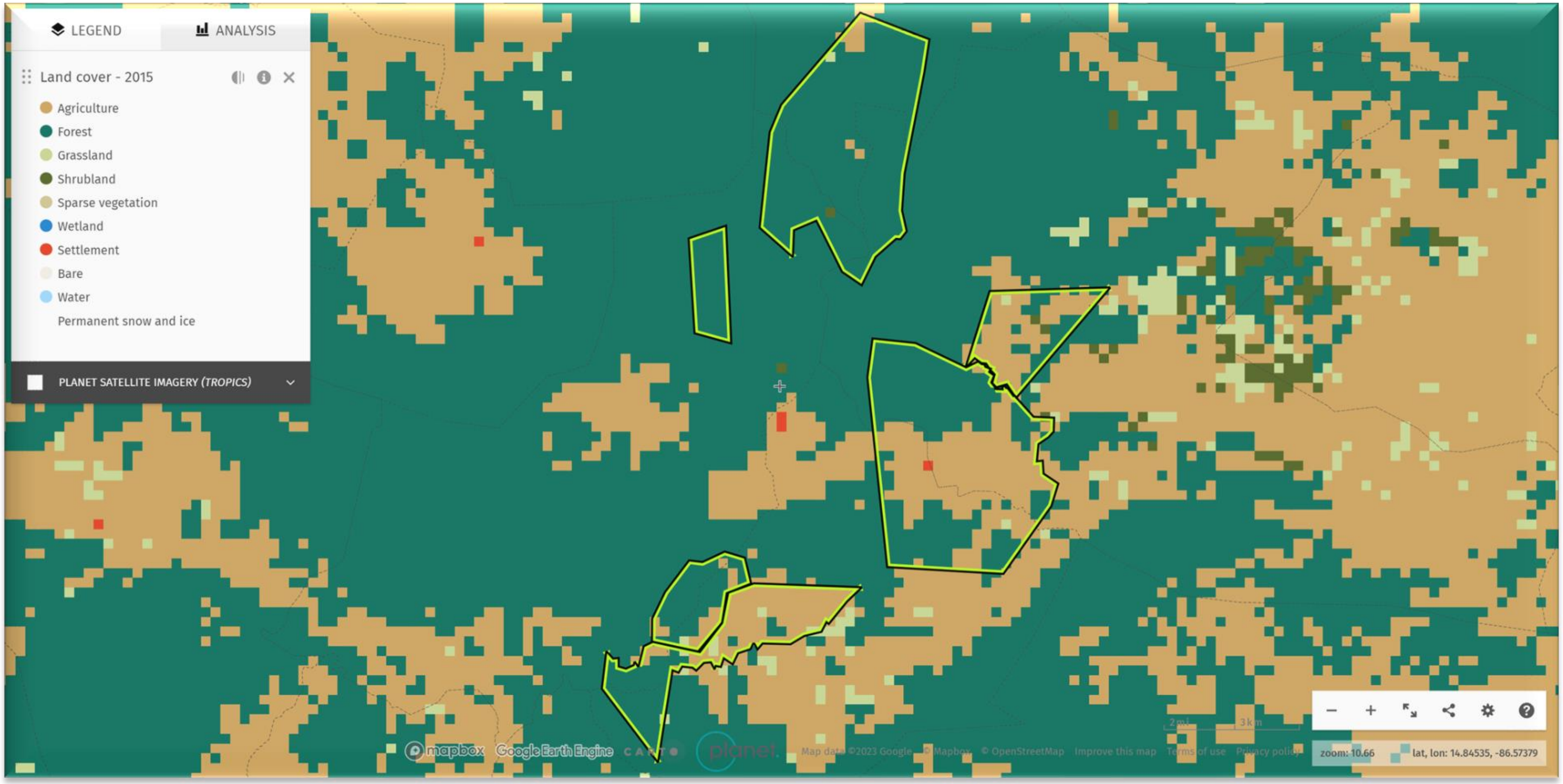
We used satellite imagery analysis to obtain region-specific data on aboveground biomass carbon stocks and accumulation rates from published sources and field measurements for relevant forest types and climate zones. Maps were based on Planet Satellite Imagery that provides a high-resolution view of the tropics, crucial for contextualizing deforestation alerts and validating land cover changes. With a 4.8 m resolution, these images are sourced from Planet-NICFI basemaps and are updated monthly from September 2020.

Global Population



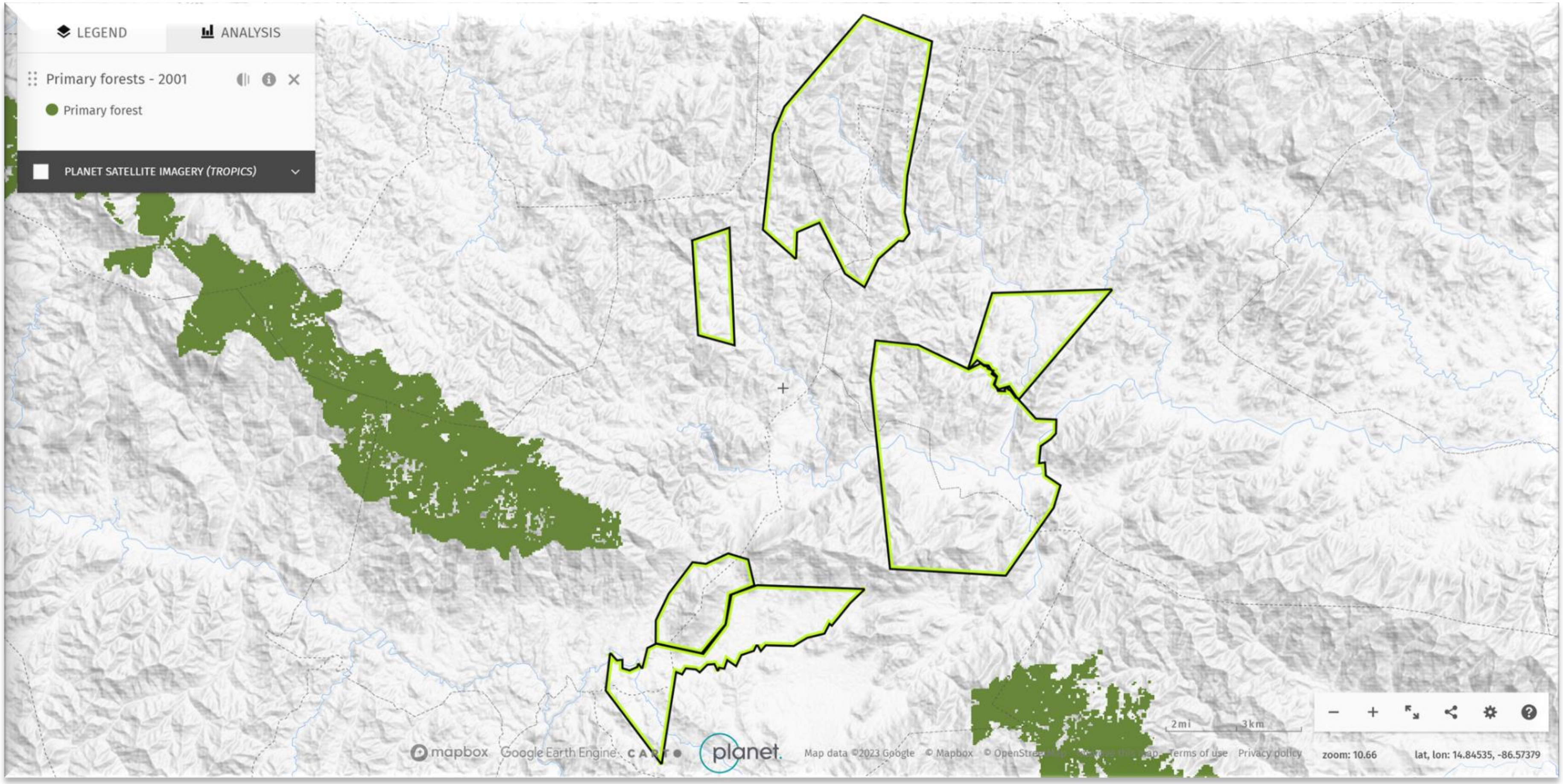
The Global Human Settlement Layer (GHSL) Population Grid is a high-resolution estimate of population density and distribution for 2015. Utilizing Landsat imagery and Gridded Population of the World data, it provides insights into built-up areas and residential population.

Land cover



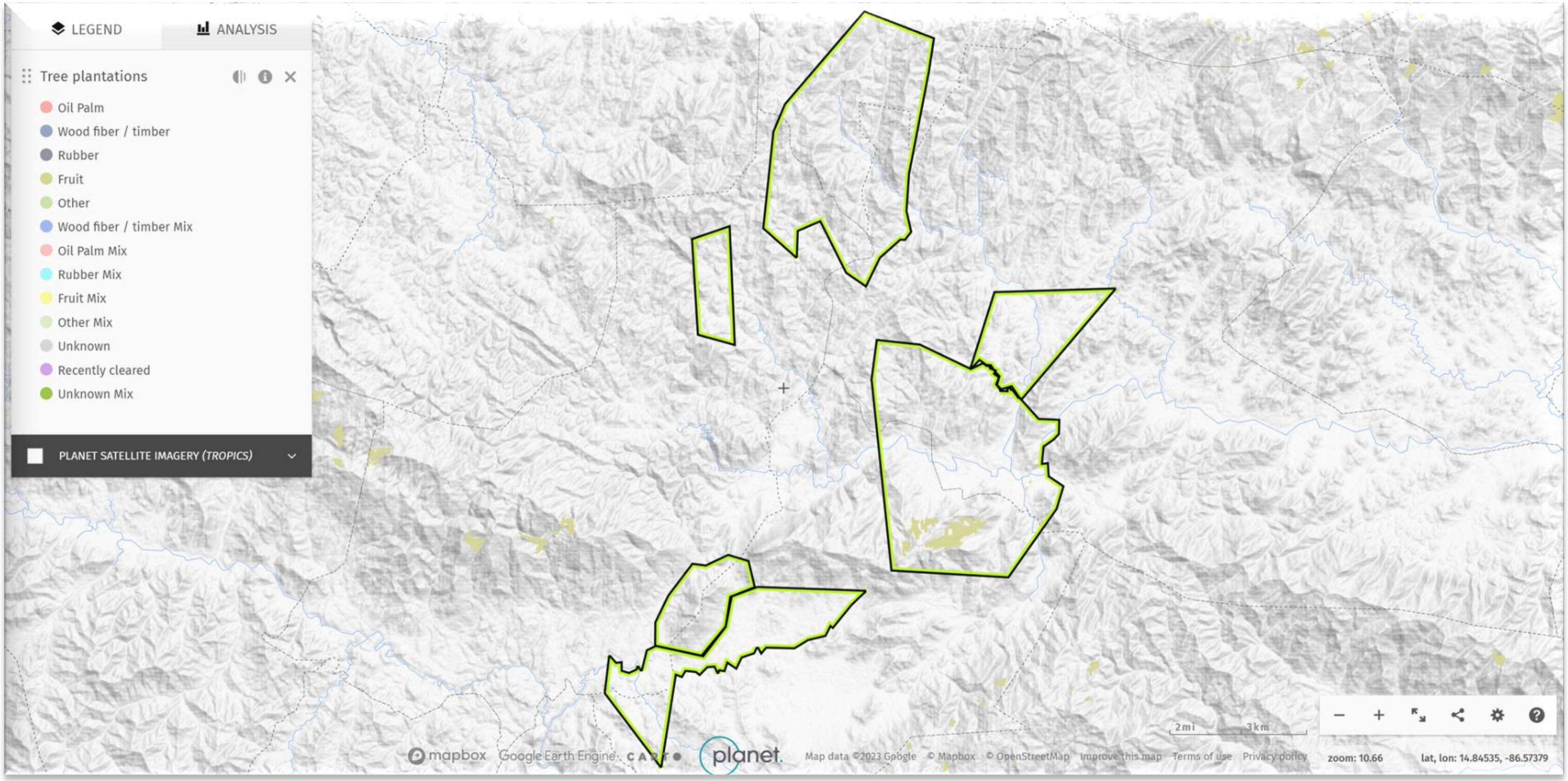
Shows global land cover in 2015 at 300 m resolution. The data was created using satellite imagery to identify 22 land cover classes.

Primary Forests



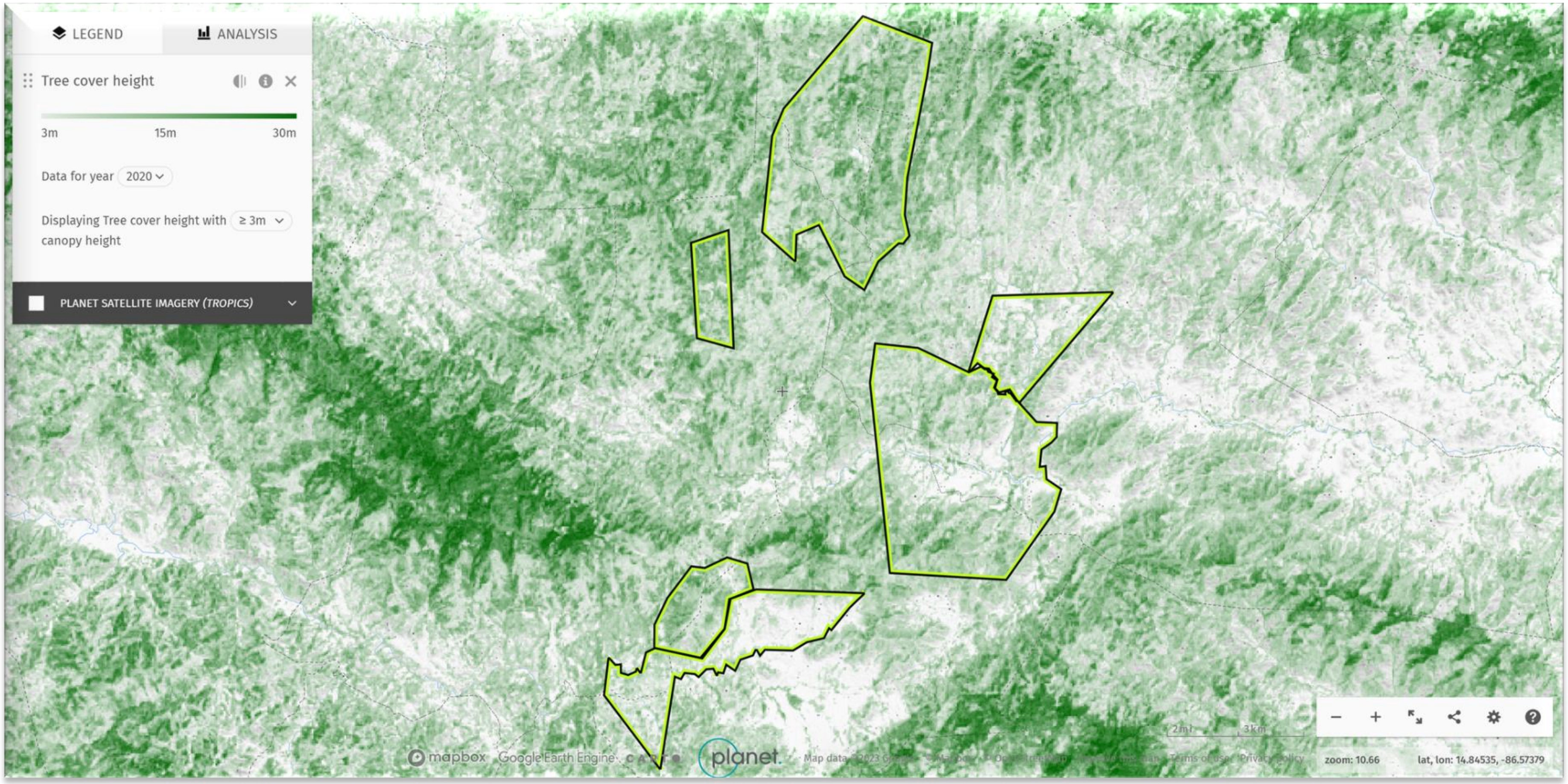
Layer with a 30 × 30 meters resolution, delineates the extent of primary forests across global pan-tropical regions in 2001. Defined as mature natural humid tropical forest cover not completely cleared and regrown recently, are critical for biodiversity and ecosystem services. Use Landsat images and specific algorithms for different regions. The dataset, crucial for national land use planning and carbon accounting, highlights ongoing primary forest loss in Brazil, the Democratic Republic of the Congo, and Indonesia.

Planted Trees



Identifies planted forests and tree crops using satellite imagery. Data is available for 2015.

Tree Cover Height

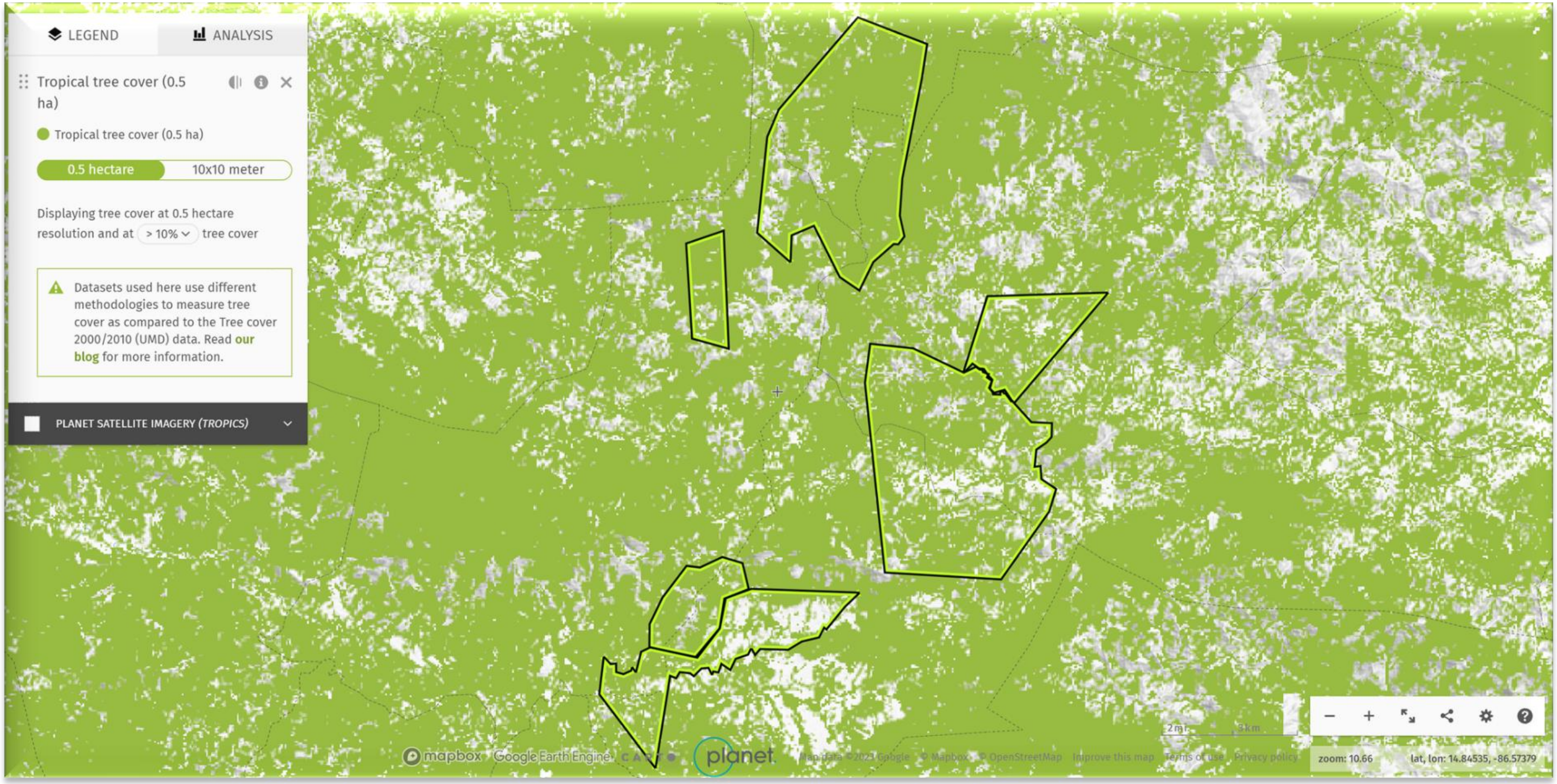


Shows global forest canopy height in 2000 and 2020 at 30 m resolution. The data was created by integrating lidar and satellite imagery.

Tree Cover

Tree Cover: is defined as the presence of all vegetation over 5 m tall, which can be natural forests or plantations with varying canopy densities. It was generated using multispectral satellite imagery from the Landsat 7 ETM+ sensor and analyzed via Google Earth Engine with a supervised learning algorithm to determine tree cover per pixel. Tree cover it refers to the biophysical presence of trees rather than specifically indicating forested regions.

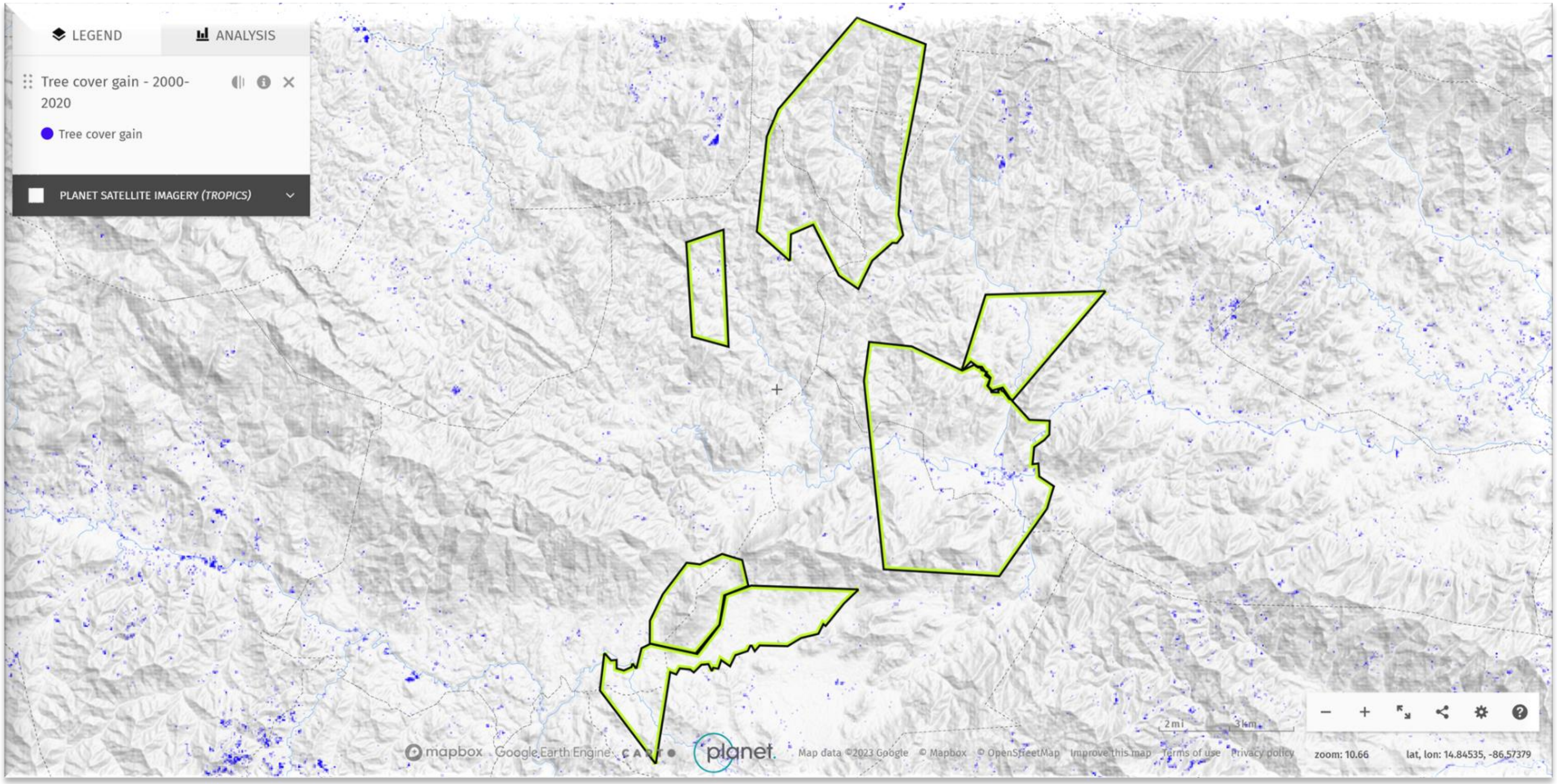
Aboveground Live Woody Biomass Density



Layer, at 30m resolution, globally visualizes woody biomass density. This map utilizes LiDAR and Landsat imagery to estimate biomass density at a pixel resolution of approximately 30 meters for the year 2000.

**Difference between Forest loss in natural forest and Tree cover loss: Forest loss in natural forest: This refers to the year-by-year tree cover loss specifically within natural forests. It includes the loss of vegetation within natural forest areas, excluding tree plantations. Loss within tree plantations can be considered as plantation harvesting, while loss outside of plantations is generally associated with natural forest loss. The data for this category is sourced from the Global Forest Watch and provides information on the extent of tree cover loss within natural forests.

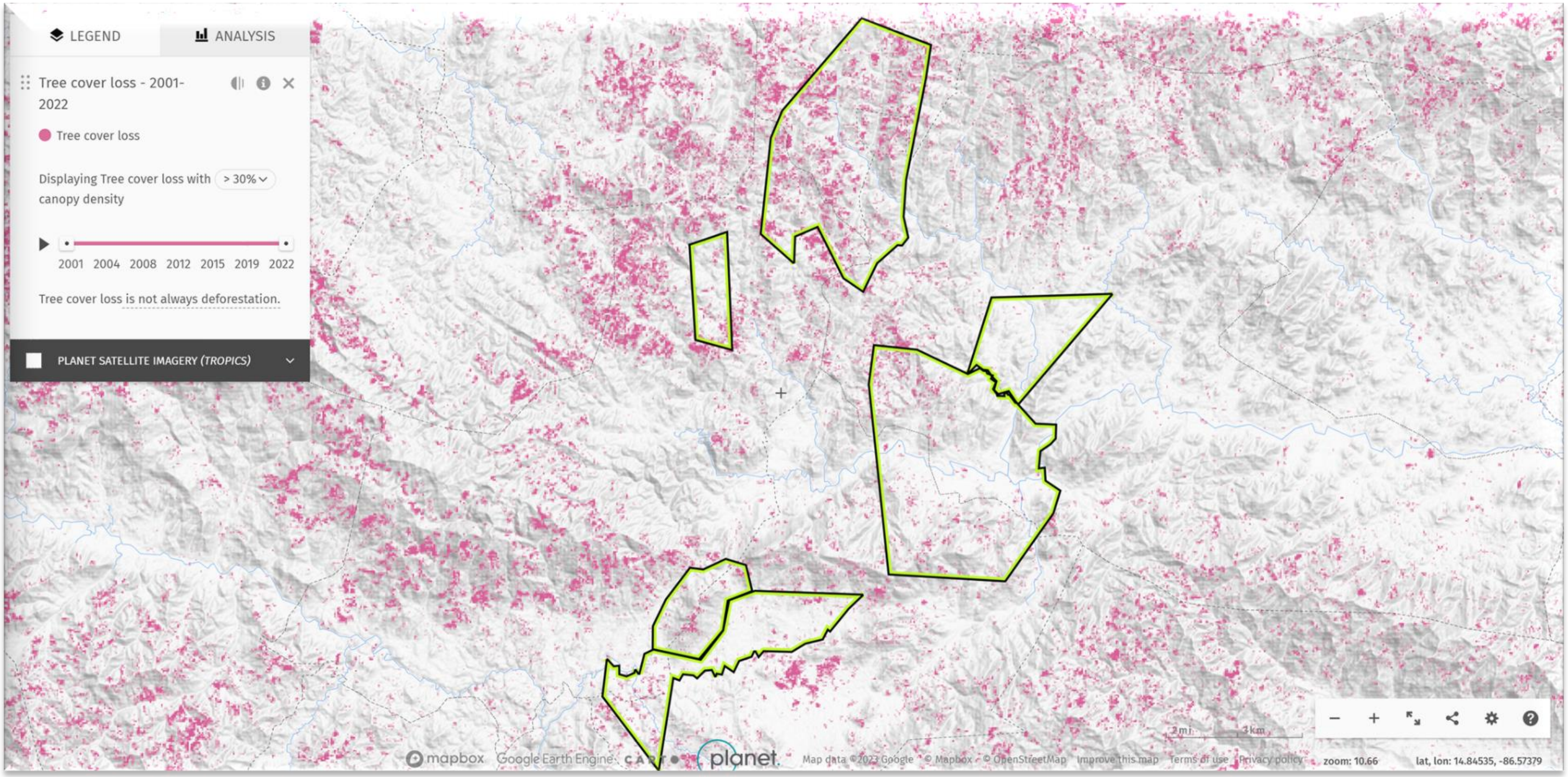
Tree Cover Gain



12

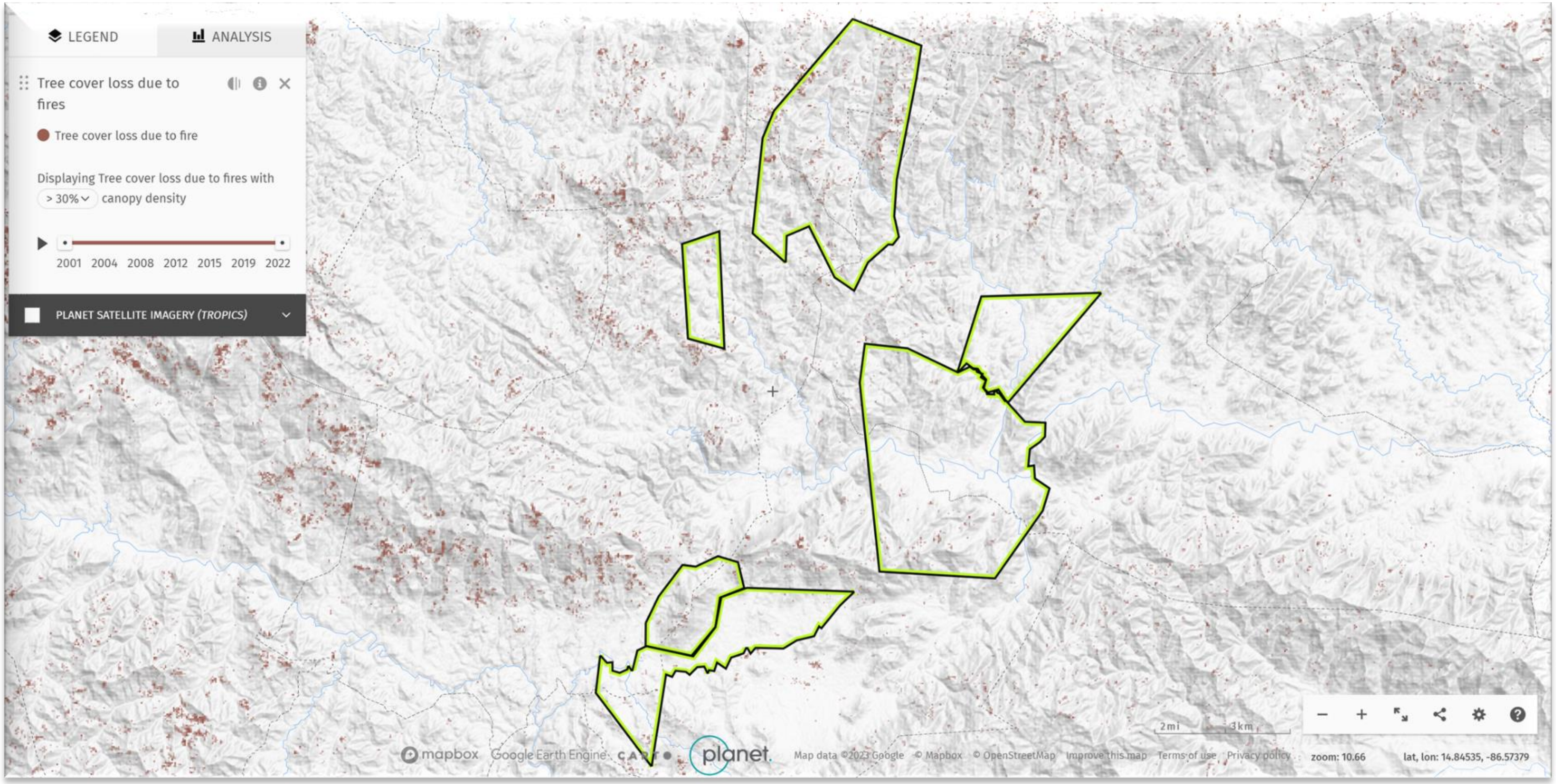
Layer with a 30m resolution, identifies areas of increased tree cover from 2000 to 2020. This 20-year cumulative layer integrates tree height information from GEDI lidar forest structure measurements and Landsat analysis-ready data time-series and with 99.3% accuracy, offers insights into forest dynamics. Pixel shading indicates gain concentration, with darker shades representing higher concentrations. Tree cover gain may indicate natural forest growth or tree plantations.

Tree Cover Loss



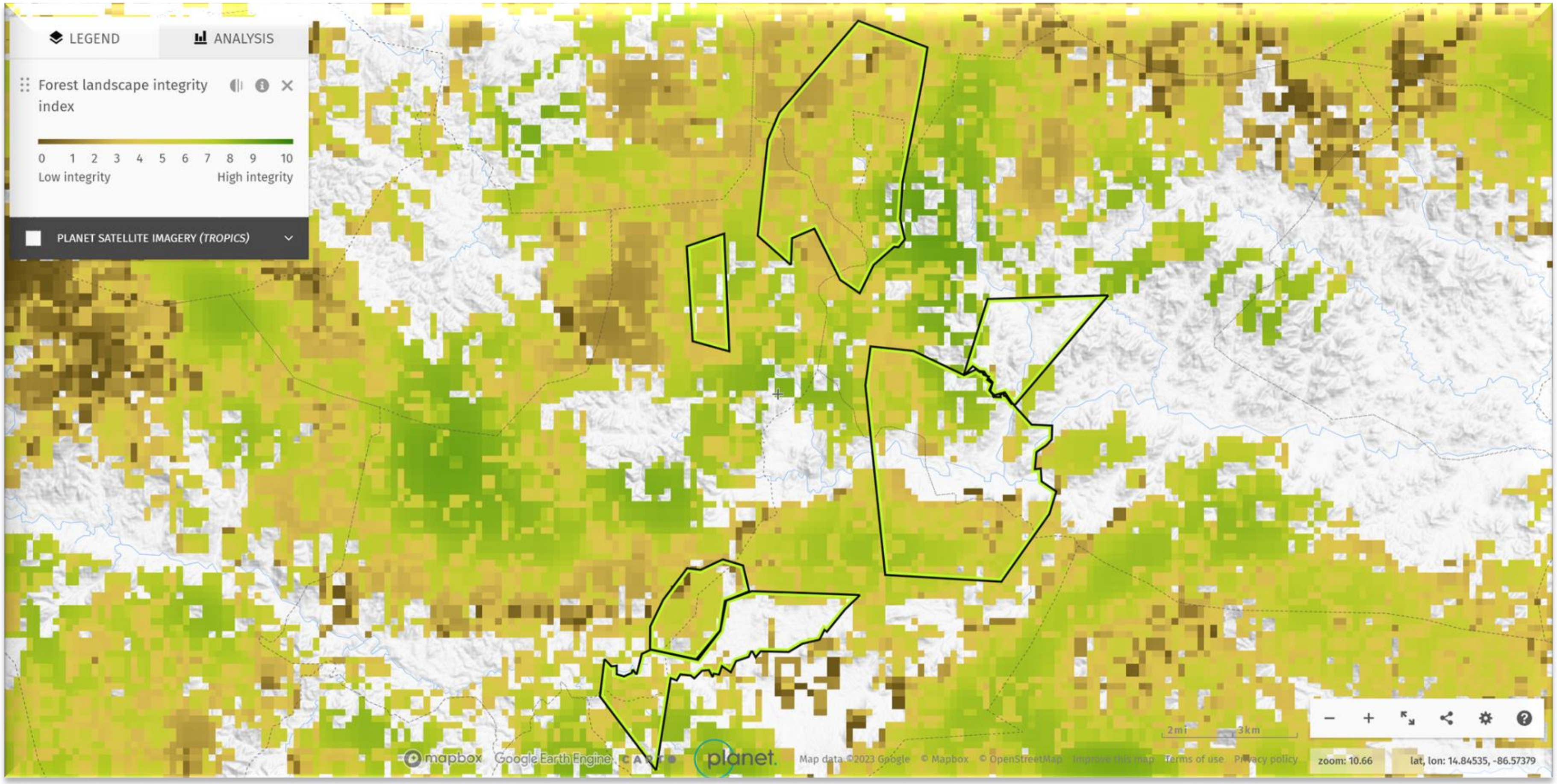
Layer with an annual 30m resolution, identifies areas of gross tree cover loss from 2001 to 2022. Defined as vegetation taller than 5 meters, "loss" indicates the removal or mortality of tree cover due to various factors, including harvesting, fire, disease, or storms.

Tree Cover Loss Due to Fire



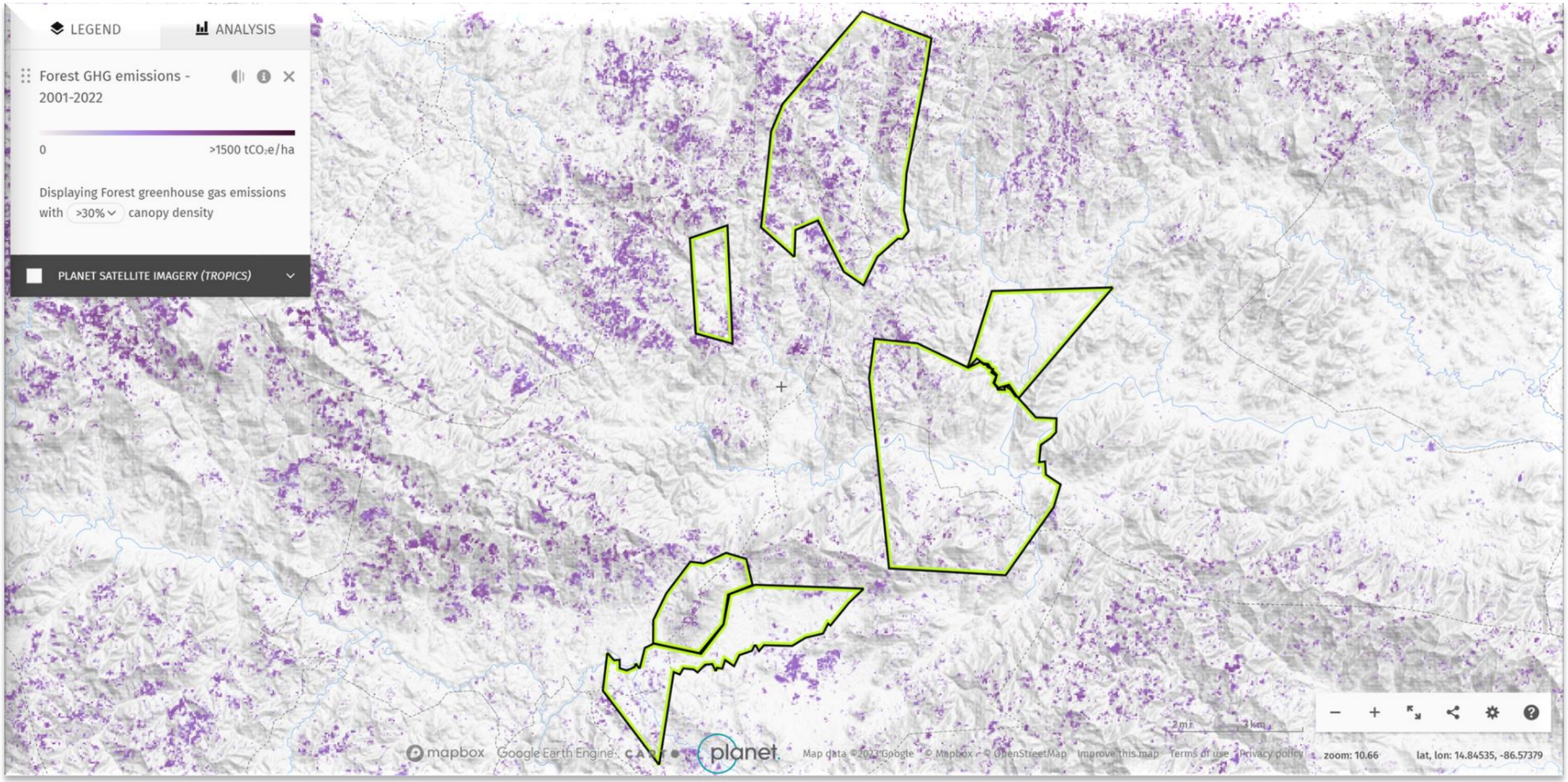
This layer is a critical resource for understanding and monitoring areas affected by tree cover loss specifically due to fires in comparison to other drivers. This annual assessment, conducted at a high resolution of 30 × 30 meters.

Forest Landscape Integrity Index (FLII)



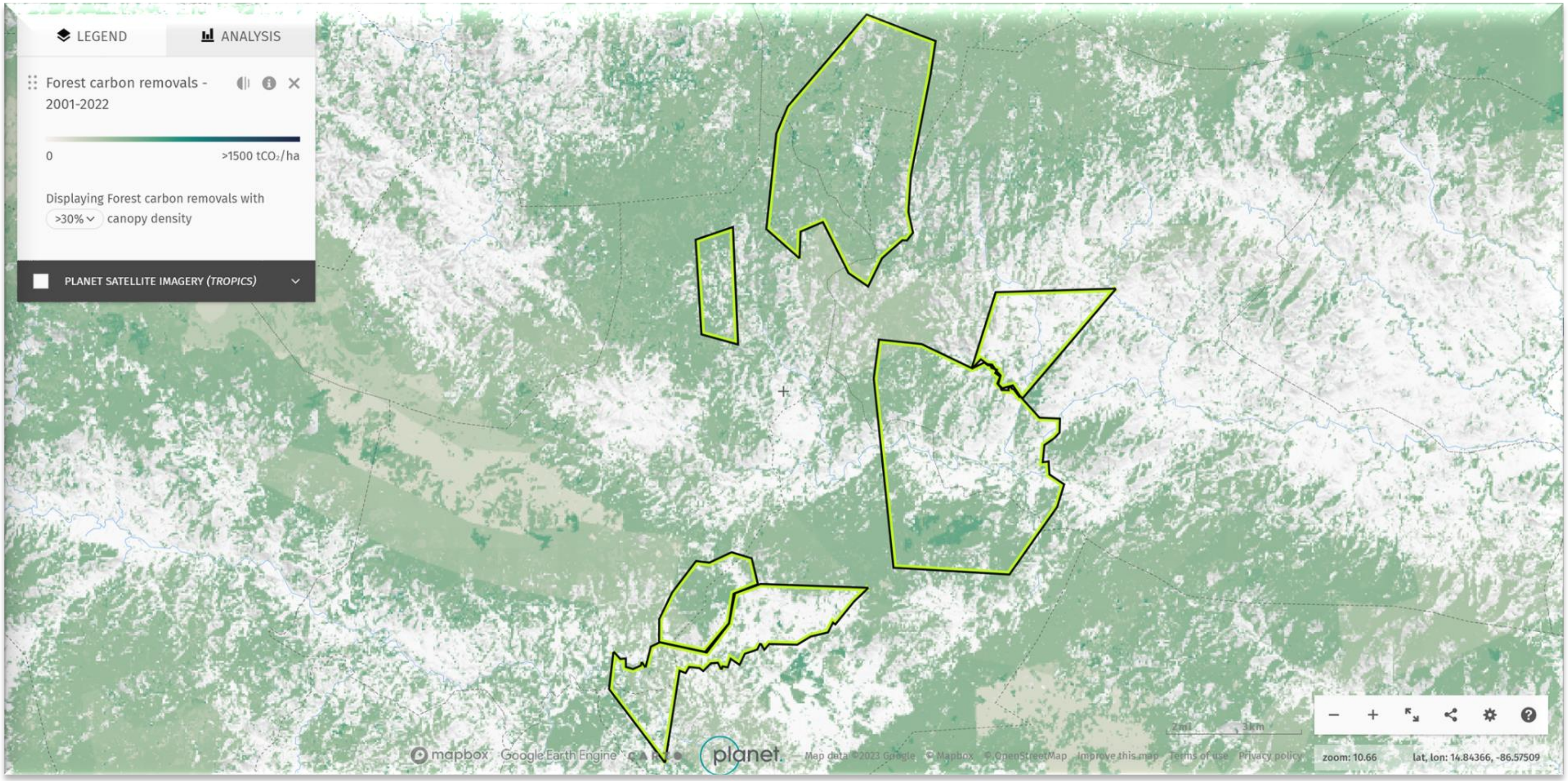
This layer provides a continuous assessment of global forest condition based on anthropogenic modification. Utilizing a 300 x 300m resolution, it combines data on forest extent, observed pressure from human activities, inferred pressure from edge effects, and changes in forest connectivity. The index categorizes forest integrity into high, medium, and low classes.

Forest Carbon Emissions



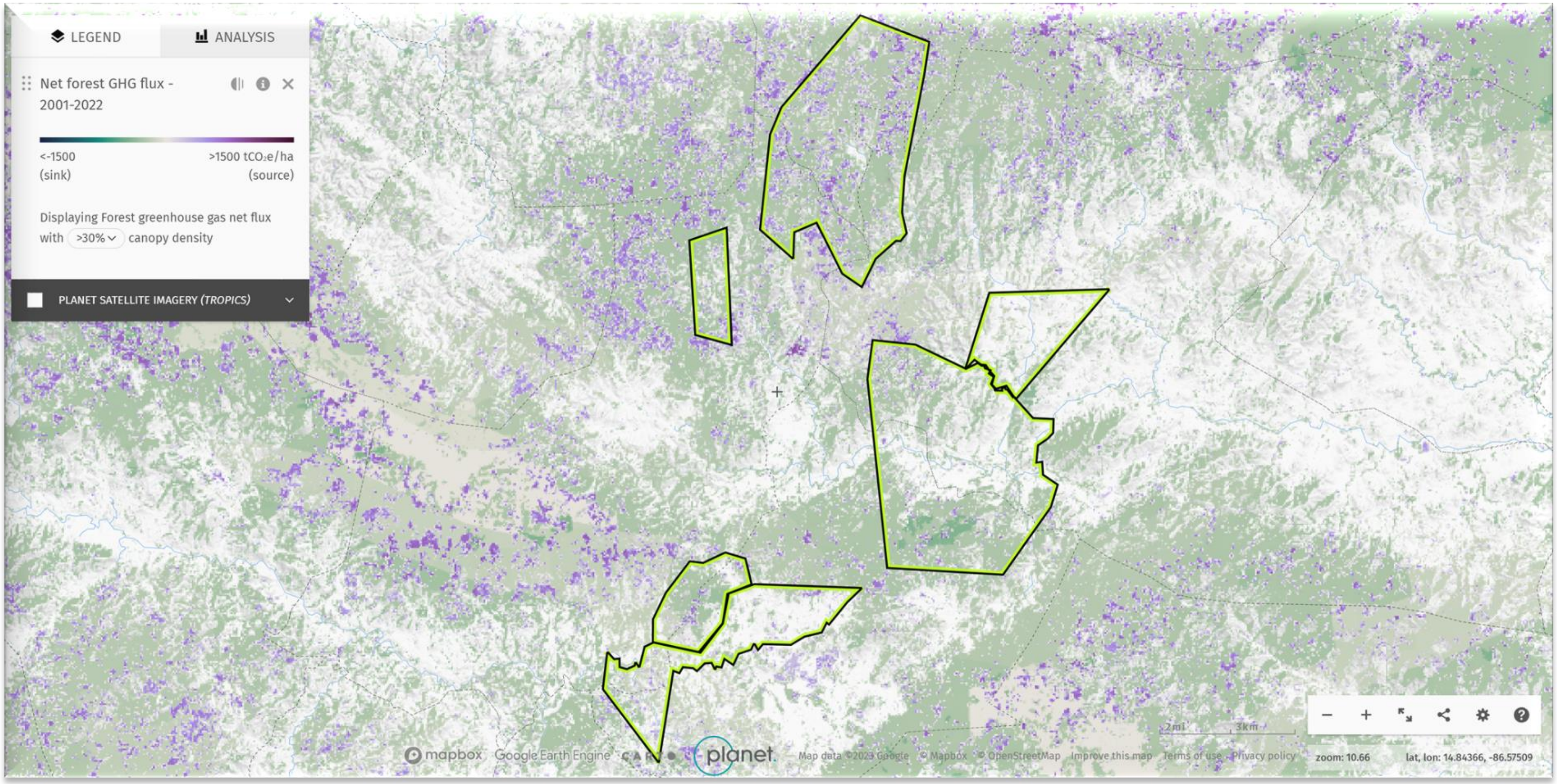
Layer, at a 30m resolution, portrays greenhouse gas emissions from stand-replacing disturbances in forests. It provides a gross estimate of carbon emissions (megagrams CO_2 emissions/ha) from such disturbances occurring between 2001 and 2022. It includes all relevant ecosystem carbon pools (aboveground biomass, belowground biomass, dead wood, litter, soil) and greenhouse gases (CO_2, CH_4, N_{20}).

Forest Carbon Removals



Layer at 30m resolution, reveals forest carbon removals by forest sinks. It portrays the cumulative carbon sequestration (megagrams CO_2/ha) by established and regrowing forests from 2001 to 2022. It incorporates both aboveground and belowground live tree biomass.

Net Forest Carbon Flux



Displays the net loss of forest carbon from 2001 to 2022 at 30 m resolution. Negative values indicate forests were net sinks of carbon.

Agua Caliente

Agua Caliente is a small area spanning just 1.74 thousand hectares across lowland and mountainous terrain. Originally in 2000 it contained moderately valuable forest coverage of 21% tree canopy. Encouragingly, only 1.7% of this original 2000 tree cover has been lost as of 2020, signifying admirably low deforestation rates with responsible preservation of most former forests. Simultaneously, Agua Caliente has also seen effective reforestation efforts, managing to gain 2.2% new tree cover over the period to regenerate vegetation and wildlife habitat. Consequently, Agua Caliente stands out as a carbon sink with net negative emissions of -1,543,000 tons CO2, meaning it sequesters more carbon than it emits. These details paint an ecologically promising picture. Suggested conservation actions are to fully protect all remaining intact forests while considering additional reforestation programs to further boost carbon removal. With its moderate yet meaningful initial tree cover, tiny deforestation impacts, demonstrated reforestation success and robust carbon absorption, Agua Caliente retains very high environmental preservation potential.

Ajuquinapa

Is a large area spanning 6,020 ha located in mountainous terrain. Back in 2000, it had a very high tree cover of 86%, indicating heavily forested land. However, Ajuquinapa experienced major deforestation, with a concerning 19% loss of its 2000 tree cover by 2022. This resulted in very high CO_2 emissions of 20.5 kt per year, with total emissions from 2001-2022 reaching an extremely high 451 ktCO_2e. The minimal reforestation gain was not enough to offset these substantial emissions. Stronger conservation measures are critically needed to halt further deforestation in Ajuquinapa. Reforestation efforts should also be greatly expanded to begin absorbing some of the CO_2 released. Sustainable agriculture practices should be promoted to prevent additional forest clearing. The initially heavy forest coverage makes Ajuquinapa an ecologically important area, but the severe deforestation here has been environmentally disastrous. Urgent action must be taken to protect and restore Ajuquinapa's remaining forests.

Parumble

Is a moderately sized area spanning 6,880 ha. In 2000, it had relatively high forest coverage with 55% tree canopy. From 2000 to 2022, Parumble lost 7.9% of its original 2000 tree cover to deforestation. Though less severe than some other areas, this still resulted in substantial emissions of 5.56 ktCO_2e per year and 122 ktCO_2e total during 2001-2022. However, Parumble's higher rate of reforestation gain helped increase carbon removals to 22.5 ktCO_2e per year, partially offsetting the emissions. Recommended strategies for Parumble are protection of remaining forests combined with expanded reforestation efforts and sustainable agriculture practices. The moderate initial tree cover, less intensive deforestation, and increased removals through reforestation make Parumble an area of ecological importance with potential for further preservation and restoration.

Portillo

Is a small area spanning 1,200 ha located in mountainous terrain. Back in 2000, it had a high tree canopy cover of 64%, revealing extensive initial forest area. From 2000 to 2022, El Portillo experienced heavy deforestation, with a 9.8% loss of its original 2000 tree cover. This resulted in carbon emissions of 1.46 ktCO_2e per year, totaling 32 ktCO_2e from 2001-2022. Negligible reforestation gains and moderate emissions demonstrate insufficient recovery of tree cover and concerning carbon release. Given its high ecological value from the initial expansive forests, deforestation here has been environmentally damaging for El Portillo. More focus on conservation of remaining forests is essential, along with expanded reforestation efforts to help absorb additional CO_2.

El Zapote

Is a very small area spanning just 813 ha in mountainous terrain. Back in 2000, it had an exceptionally high 98% tree canopy cover, denoting this area was almost completely forested initially. From 2000 to 2022, exemplary forest protection occurred with just 0.26% loss of tree cover, signifying minimal deforestation. El Zapote also gained a bit of new tree cover and maintains high CO_2 removals of 3.23 ktCO_2e per year. Its total emissions from 2001-2022 were negligible at 1.26 ktCO_2e. These results are optimal, with slight tree cover gain and high negative net carbon absorption. El Zapote is the most ecologically valuable area due to its near pristine initial forest and minimal deforestation. Maintaining this intact forest and carbon sink status through full protection is critical for El Zapote.

El Zarzal

Is a moderately sized area spanning 2,670 ha in mountainous terrain. In 2000, it had 38% tree canopy cover, indicating moderate forest area initially. From 2000 to 2022, El Zarzal experienced significant deforestation, with a 13% loss of its original 2000 tree cover. This resulted in carbon emissions of 2.1 ktCO_2e per year, totaling 46.1 ktCO_2e from 2001-2022. The small gain in new tree cover and moderate emissions signify insufficient reforestation success and substantial carbon impacts. Though El Zarzal had moderate ecological importance initially, the deforestation here has degraded its environmental condition. Recommended actions are preventing further deforestation and restoration programs to reforest degraded lands, which could improve El Zarzal's ecology.

Merged Areas

A region spanning 19,240 ha across mountainous terrain. Back in 2000, the Merged Areas had relatively good forest coverage with 60% tree canopy. From 2000 to 2022, deforestation occurred, with a 14% loss of the original 2000 tree cover. This resulted in substantial carbon emissions totaling 677 ktCO_2e from 2001-2022. However, reforestation efforts also expanded, increasing removals to 63.9 ktCO_2e per year which helped offset some emissions.

Between 2001 and 2022, a total of 1,357 hectares of tree cover was lost across the merged areas. Of this total loss, 181 hectares or 13% was attributable to fires. The vast majority of tree cover loss was caused by other drivers, mainly shifting agriculture. The year 2016 saw an extreme spike in fire-related loss, with 110 out of 644 total hectares lost due to fires that year. This was 17% of loss for 2016. In most other years, the proportion of loss from fires ranged from 0-16 hectares, representing under 10% of total loss in most years.

Total tree cover loss from fires from 2001-2022 is 181 hectares. This accounts for 13% of the total tree cover loss of 1,357 hectares. Loss from fires ranges from 0 hectares (no loss in 2004) to 110 hectares lost in 2016. The average annual fire loss is about 9 hectares. 2016 saw an extreme spike of 110 hectares lost to fires, over 10 times higher than the average. Most years saw relatively low loss from fires of 10 hectares or less. Other than 2016, no year exceeded 16 hectares lost to fires. Fires contribute a consistent but relatively small portion to total tree cover loss each year. The exception was 2016, when over half of total loss was due to fires burning 110 hectares. This indicates that overall, most loss is driven by shifting agriculture rather than fires. Reducing agricultural encroachment into forests would likely have a greater impact on conservation. However, during periods of drought or climate variability, fires may spike - so fire prevention and management strategies are still important components. Targeting shifting agriculture and similar practices would likely have the greatest impact on reducing total tree cover loss.

El Zapote originally contained the highest tree canopy coverage at 98% in the baseline year 2000, while Agua Caliente exhibited the lowest initial forest density at 21% . Through 2020, effective conservation in El Zapote and Agua Caliente has maintained 98% and 19.3% of 2000 tree cover respectively. However, substantial degradation has occurred in Ajuquinapa and El Zarzal, with over 13-19% loss of initial tree cover, indicating severe ecological impacts from unmitigated deforestation. Regarding reforestation programs, Parumble shows the greatest re-establishment of forest area, while gains were negligible in Ajuquinapa and El Portillo. Analyzing net carbon balances, El Zapote and Agua Caliente again perform optimally as carbon sinks, with the highest levels of negative net emissions as post-2000 carbon sequestration surpasses emission volumes. Contrastingly, Ajuquinapa exhibits the most severe climate impacts, with emissions levels exceeding sequestration by far. In conclusion, initial forest preservation has been most successful in El Zapote and Agua Caliente, reforestation efforts are most extensive in Parumble, and net carbon removal is highest in El Zapote and Agua Caliente. Targeted conservation and restoration interventions tailored to each region's unique ecological contexts remain essential moving forward.

Carbon credit calculations

Emissions ($ktCO_2e$/year) = Area of tree cover loss x emission factor

Removals ($ktCO_2e$/year) = Area of tree cover gain x removal factor

Net carbon ($ktCO_2e$/year) = Emissions - Removals

Total released ($ktCO_2e$) = Emissions x number of years

The emission and removal factors were derived from IPCC guidelines for the relevant forest types and climate zones.

Greenhouse gas fluxes*	Emitted	Removed	Net Carbon	Total released
	($ktCO_2e$/year)			(kt of CO_2e)*
Merge Areas	30.8	-63.9	-33.1	677
Ajuquinapa	20.5	-27.7	-7.2	451
Parumble	5.6	-22.5	-16.9	122
El Zarzal	2.1	-4.9	-2.8	46
EL Portillo	1.5	-4.2	-2.8	32
El Zapote	1.3	-3.2	-2.0	28
Agua Caliente	0.1	-1.8	-1.7	2

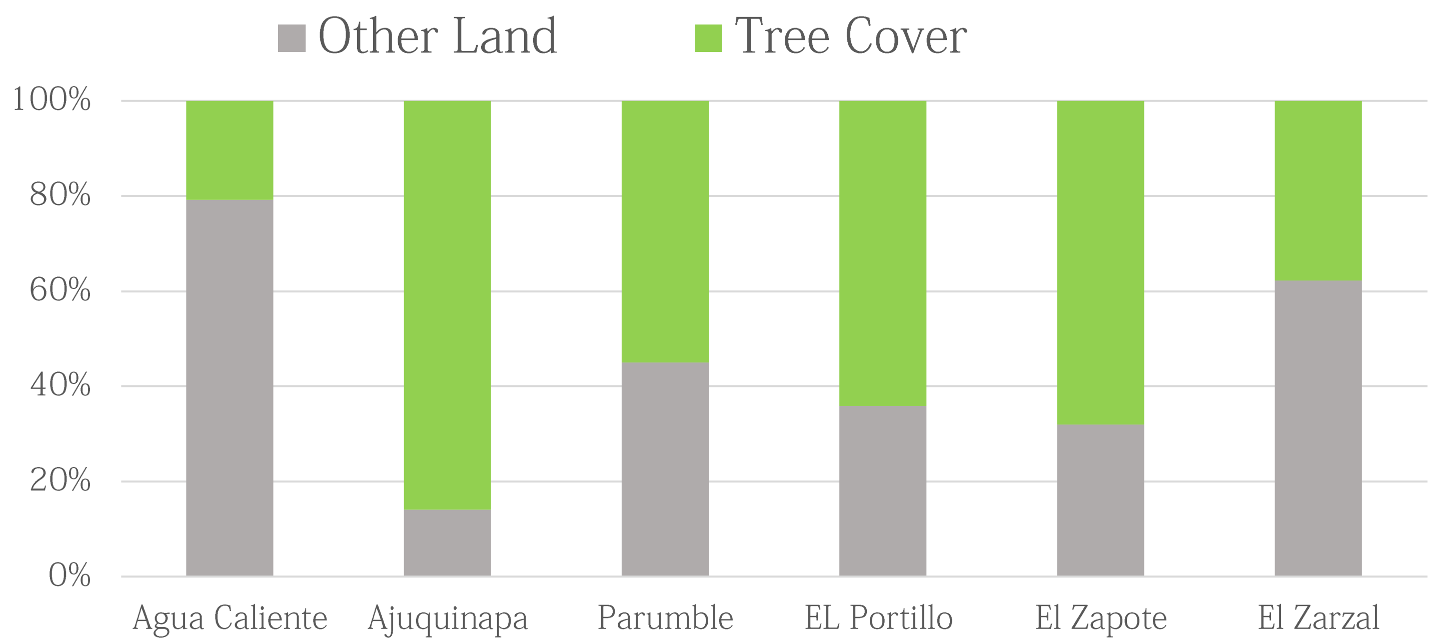
*Greater than 30% tree canopy and tree cover gain.

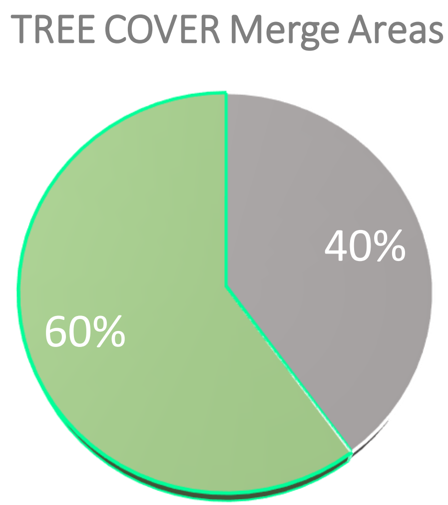
Between 2001 and 2022, the average annual release of kilotons (kt) of CO_2e into the atmosphere because of tree cover loss.

Total CO_2e emissions in kilotons (kt) from 2001 to 2022.

Tree Cover by Type

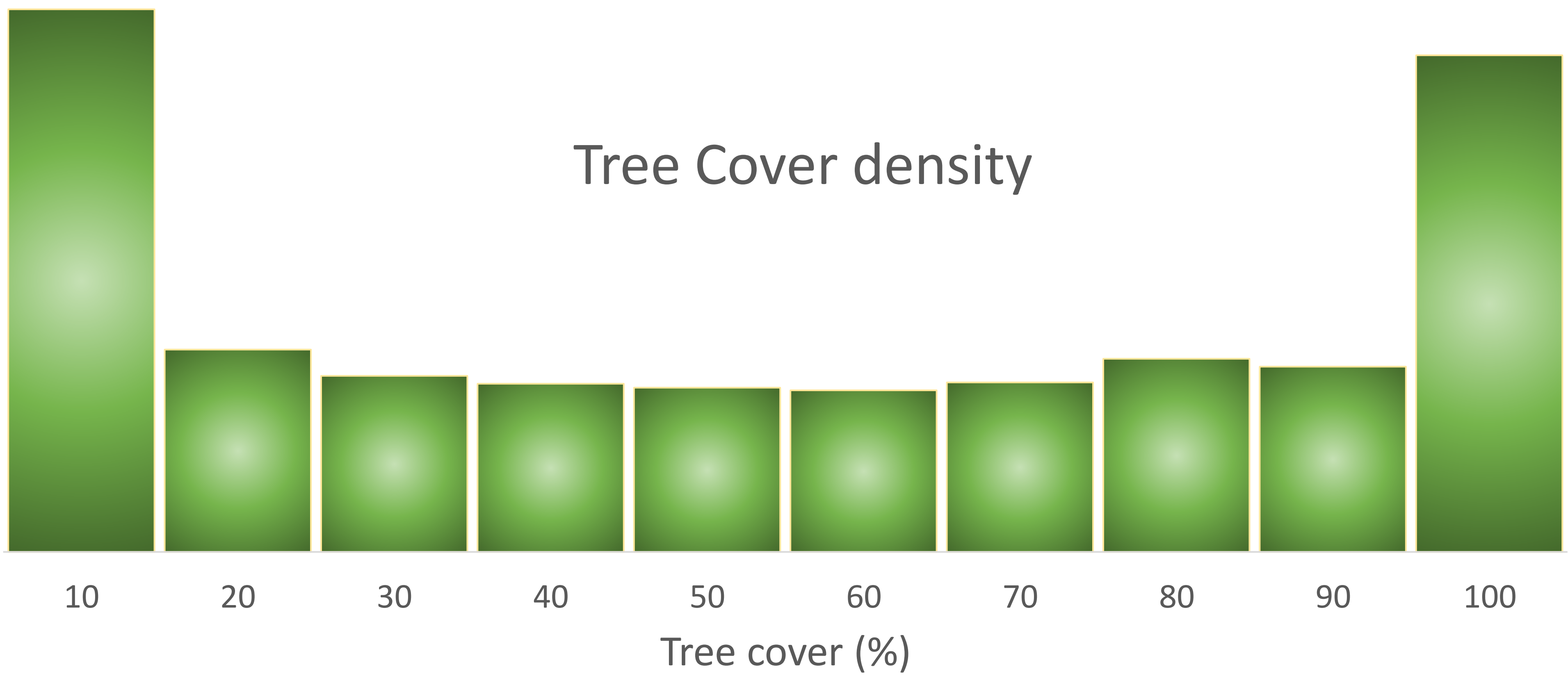
As of 2000, 60% of Merge Areas land cover was >30% tree cover. Natural Forest 11.6 kha Plantations 0.00 ha Other Land Cover 7.69 kha
*2000 tree cover extent | >30% tree canopy





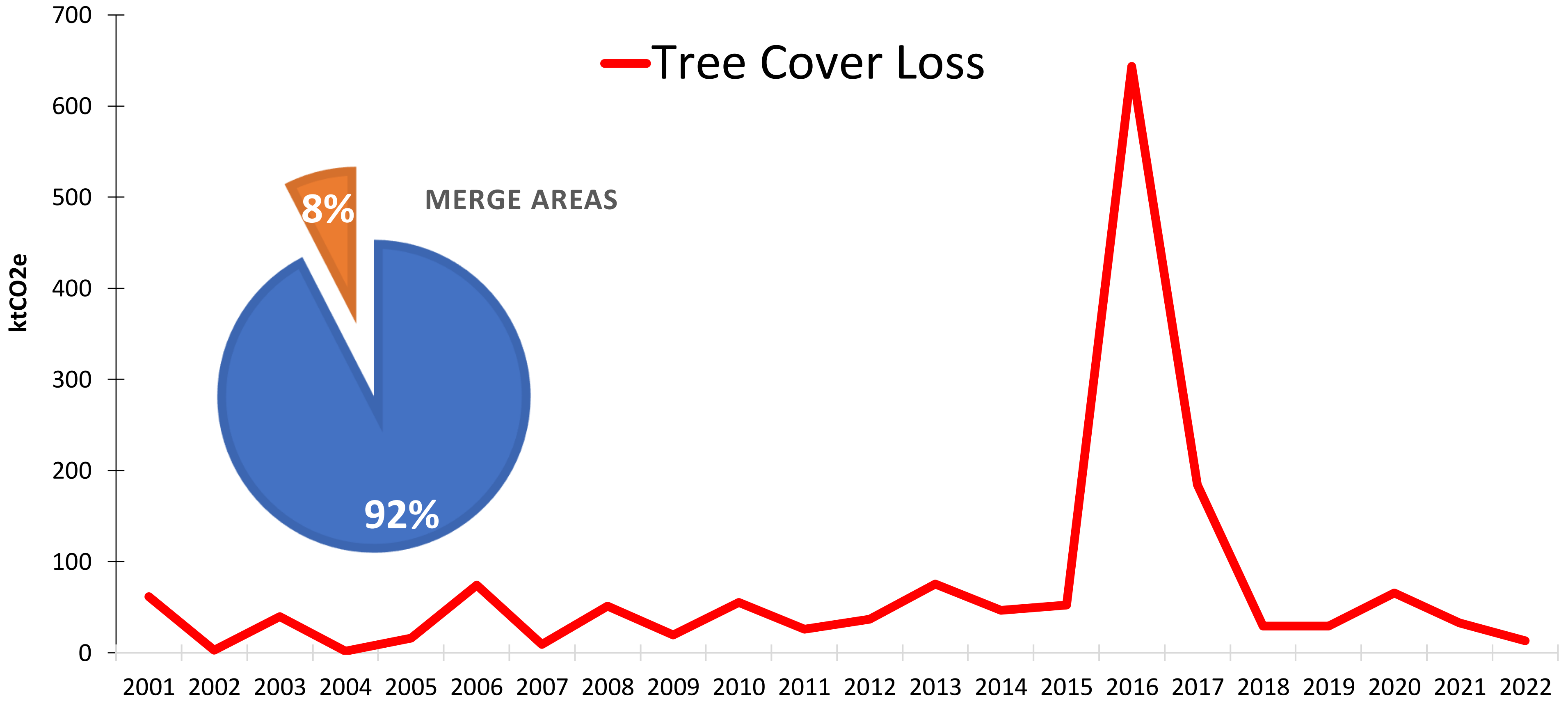
Tree Cover Density

In 2020, Merge Areas had 15.1 kha of land above 10% tree cover, extending over 78.5% of its land area. *2020 tropical tree cover extent



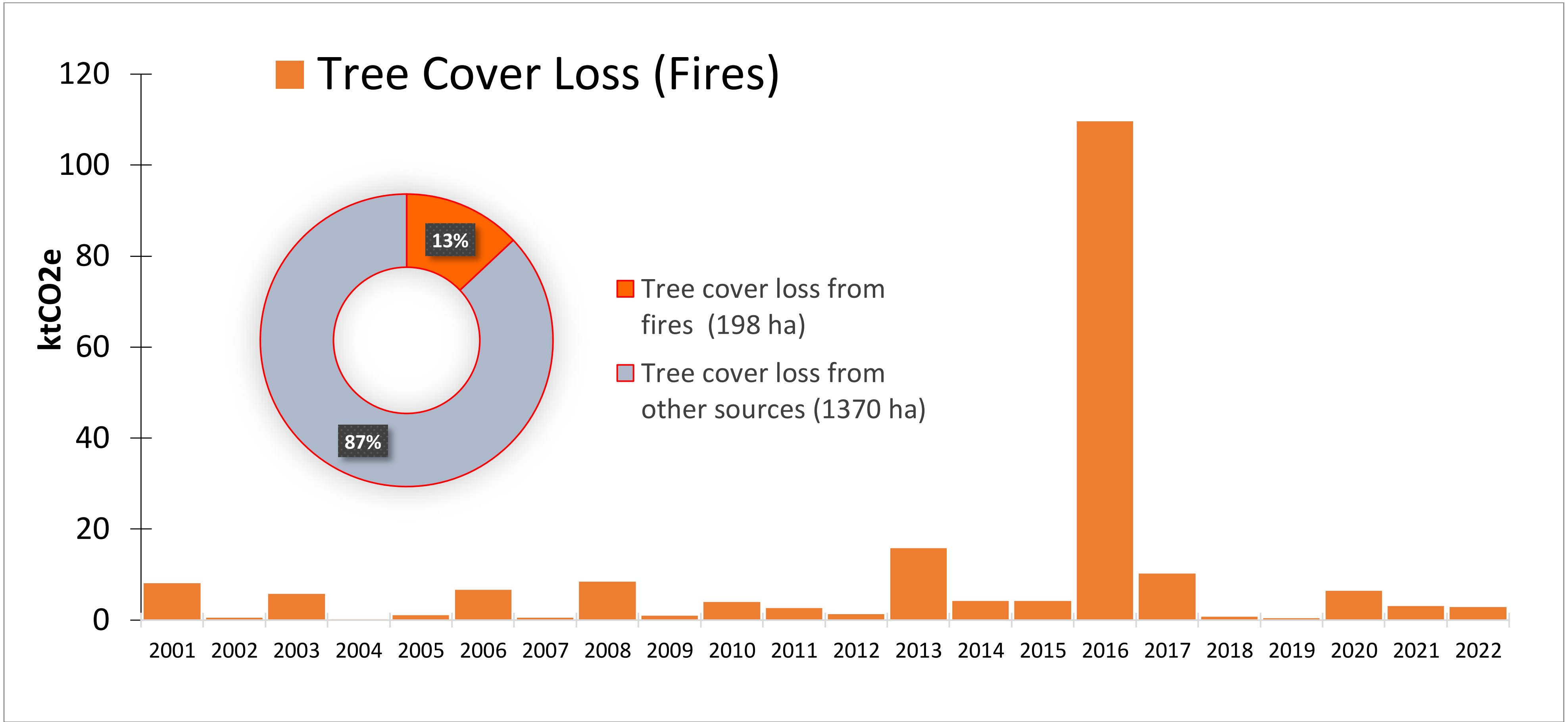
Tree Cover Loss

From 2001 to 2022, Merge Areas lost 1.57 kha of tree cover, equivalent to a 14% decrease in tree cover since 2000.
2000 tree cover extent | >30% tree canopy | these estimates do not take tree cover gain into account.



Tree Cover Loss due to Fires

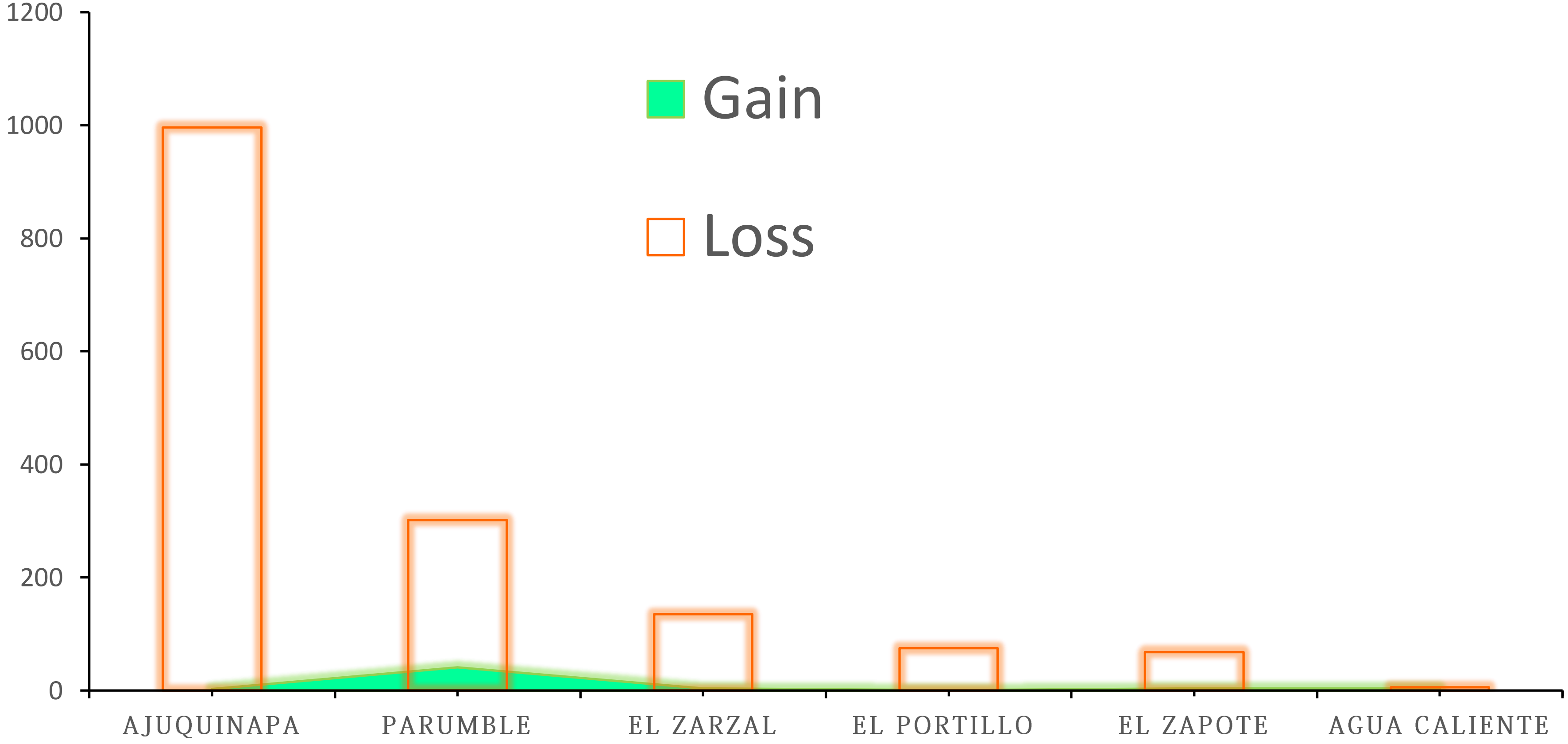
From 2001 to 2022, Merge Areas lost 198 ha of tree cover from fires and 1.37 kha from all other drivers of loss. The year with the most tree cover loss due to fires during this period was 2016 with 110 ha lost to fires — 17% of all tree cover loss for that year. >30% tree canopy Fires were responsible for 13% of tree cover loss in Merge Areas between 2001 and 2022. Tree cover loss from other sources 1.37 kha. Tree cover loss from fires 198 ha



Tree Cover Gain

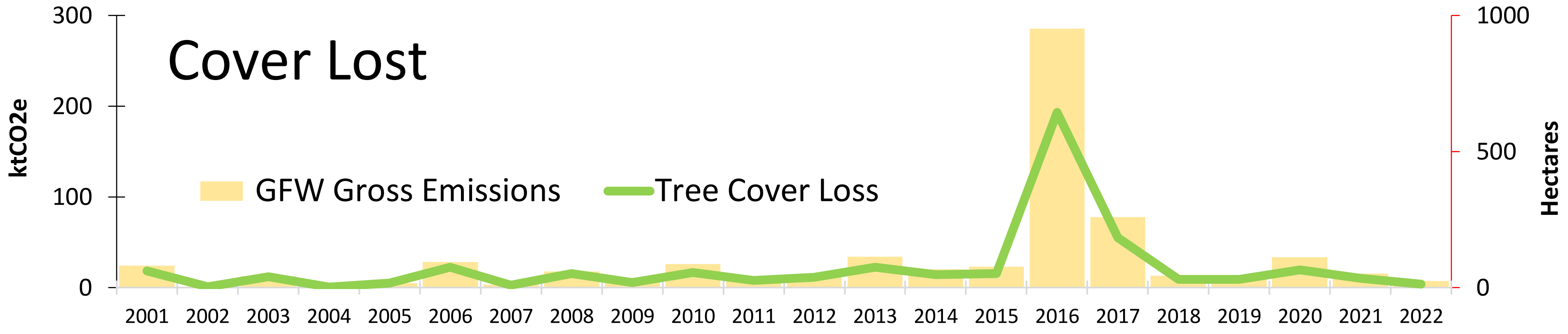
From 2000 to 2020, Merge Areas gained 55 ha of tree cover equal to 0.28% is its total extent.

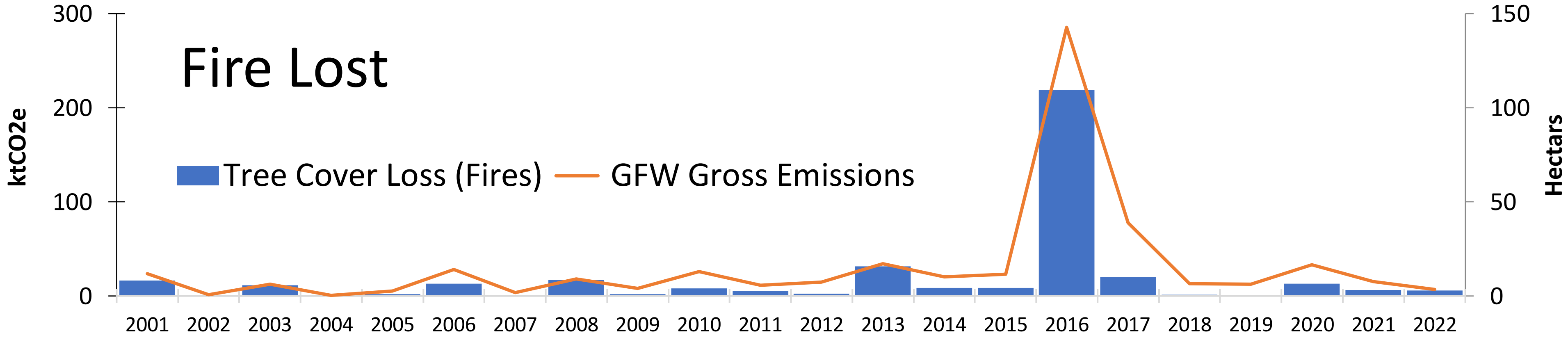
Tree cover gain 55 ha



Forest-Related Greenhouse Gas Emissions

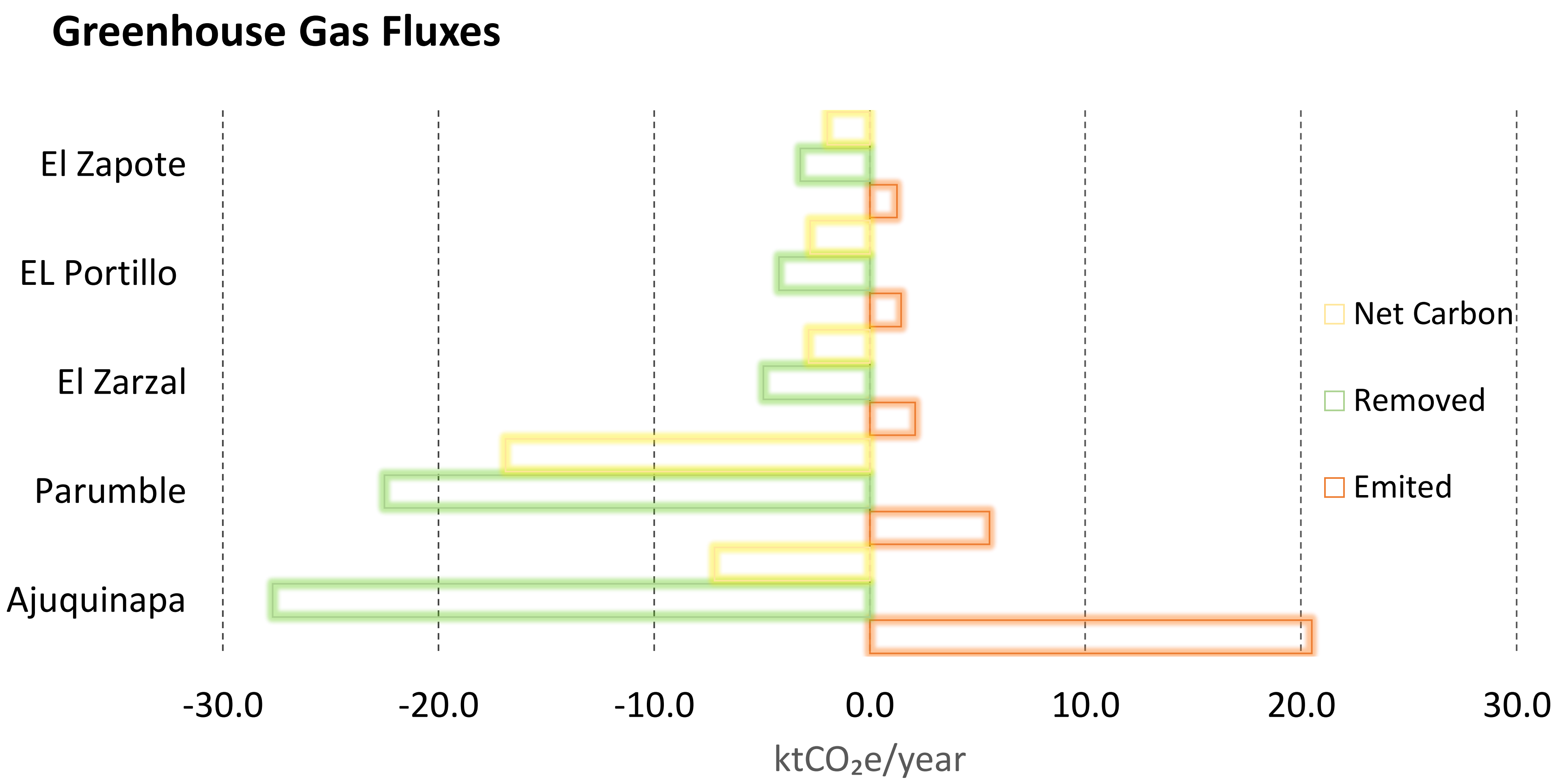
Between 2001 and 2022, an average of 30.8 kt per year w.as released into the atmosphere as a result of tree cover loss in Merge Areas. In total, 677 kt of CO_2e was emitted in this period. >30% tree canopy and tree cover gain

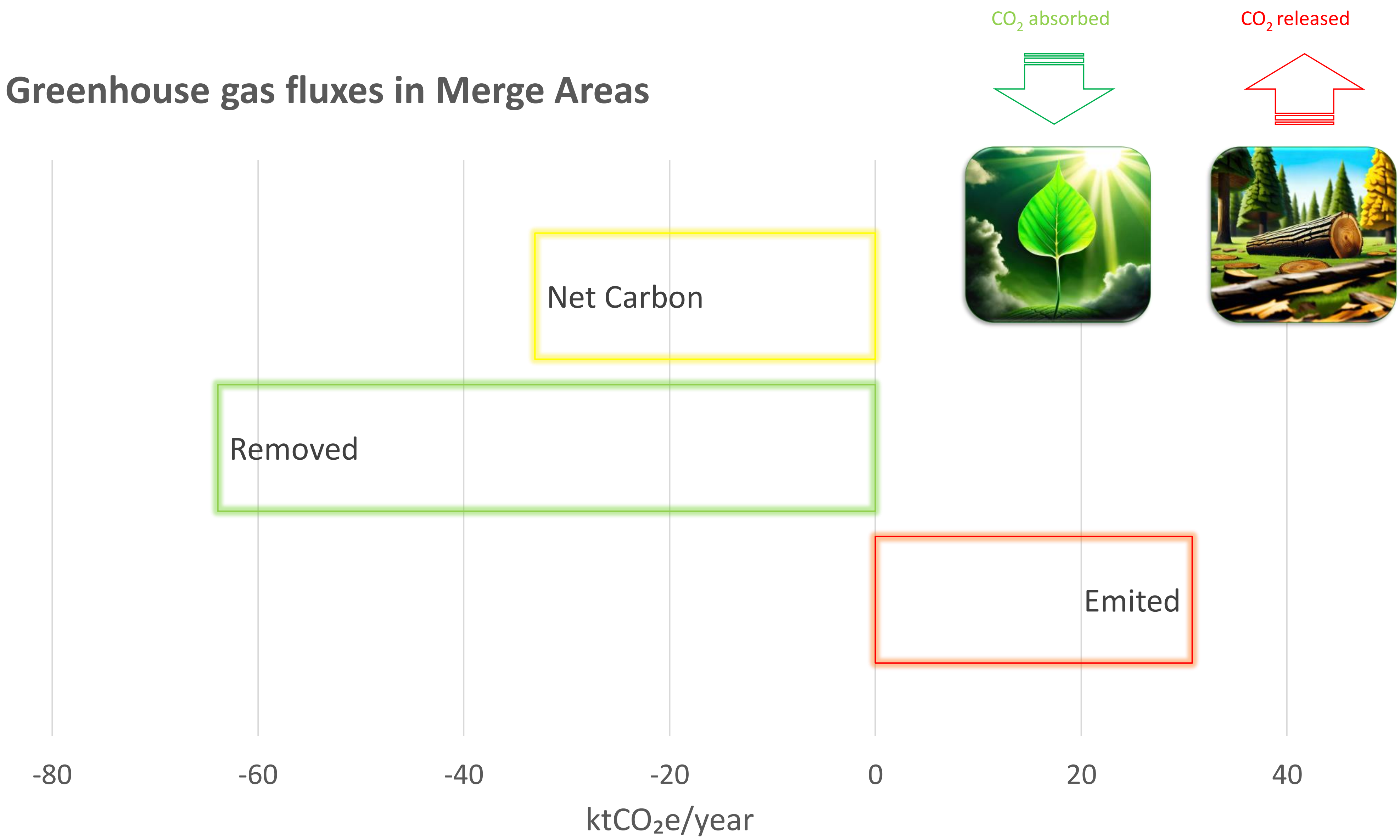




Forest-Related Greenhouse Gas Fluxes

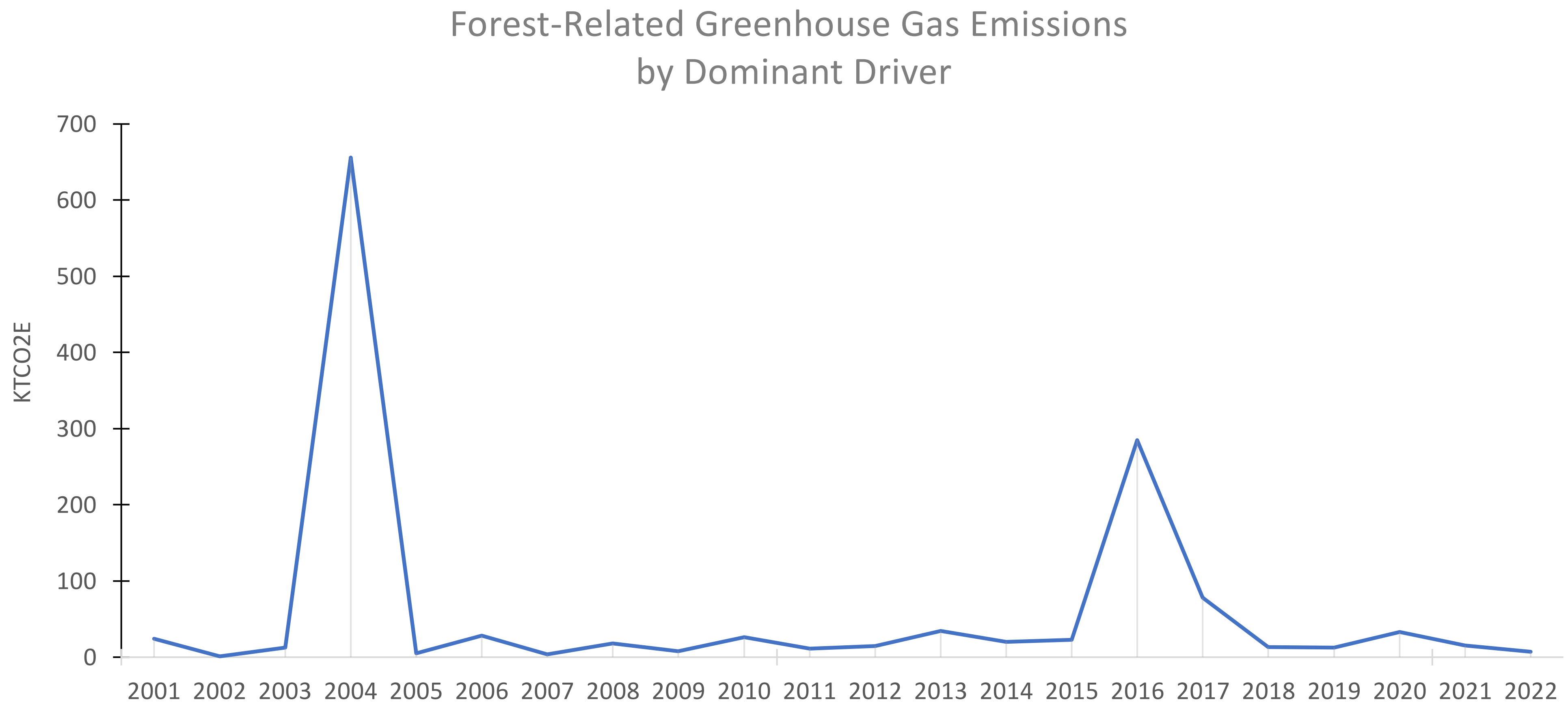
Between 2001 and 2022, forests in Merge Areas emitted 30.8 $ktCO_2e$/year, and removed -63.9 $ktCO_2e$/year. This represents a net carbon sink of -33.1 $ktCO_2e$/year. *>30% tree canopy and tree cover gain




Greenhouse gas fluxes in Merge Areas
CO2 absorbed
CO2 released
Net Carbon
Removed
Emited
-80
-60
-40
-20
0
20
40
ktCO2e/year

Forest-Related Greenhouse Gas Emissions by Dominant Driver

In Merge Areas from 2001 to 2022, dominant drivers shifting to agriculture resulted in deforestation. >30% tree canopy and tree cover gain



Summary results

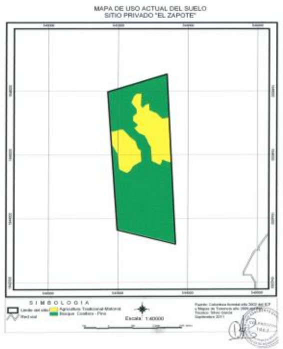
Parameter	Agua Caliente	Ajuquinapa	Parumble	El Portillo	El Zapote	El Zarzal	Merge Areas
Area (kha)	1.74	6.02	6.92	1.2	0.813	2.67	19.24
Tree cover (>30% tree canopy) (kha)	0.36	5.19	3.79	0.77	1.2	1.01	11.6
Other land cover (kha)	1.38	0.85	3.11	0.43	0.07	1.66	7.69
Land covered by tree cover (>30% tree canopy) in 2000 (%)	21	86	55	64	98	38	60
Tree Cover >30 loss since 2000 to 2022 (ha)	6	996	301	75	0.554	135	1570
Decrease in tree cover (>30% tree canopy) since 2000 (%)	1.7	19	7.9	9.8	0.261	13	14
Tree Cover (>30% tree canopy) Gain since 2000 to 2022 (ha)	4	3	41	< 0.1	4	4	55
Tree Cover (>30% tree canopy) Gain respectively to total extent (%)	0.23	< 0.1	0.59	< 0.1	0.43	0.13	0.28
Tree cover (>10% tree canopy) in 2020 (kha)	0.77	5.27	3.74	0.98	0.71	1.77	15.1
Tree cover (>10% tree canopy) of land area in 2020 (%)	44	87	54	81	89	66	78
Emitted (ktCO_2e/year)	0.09	20.5	5.56	1.46	1.26	2.1	30.8
Removed (ktCO_2e/year)	-1.77	-27.7	-22.5	-4.22	-3.23	-4.94	-63.9
Net carbon (ktCO_2e/year)	-1.67	-7.21	-16.9	-2.77	-1.97	-2.84	-33.1
Total released (kt of CO_2e)	2.03	451	122	32	27.8	46.1	677
Carbon credits (ktCO_2e)	1.67	7.21	16.9	2.77	1.97	2.84	33.1

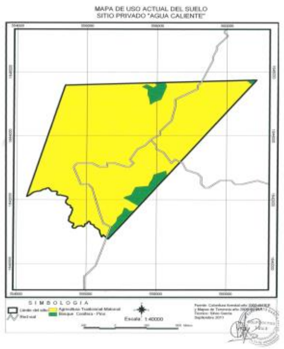
Summary results

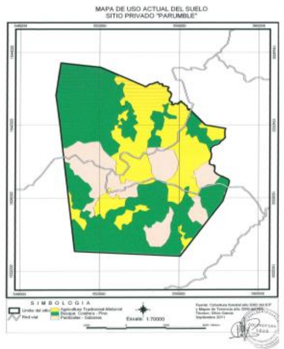
Year	Tree cover loss (ha)	Gross emissions CO_2e all gases mg	Emissions CO_2e no CO_2 g	Gross emissions CO_2e CO_2 only mg	Forest cover loss (ha)	Gross emissions CO_2e all gases mg	Tree cover loss from fires (ha)
2001	62	23923	262	23660	0.5	211	8
2002	3	1092	16	1076			1
2003	40	12770	140	12630	0.2	99	6
2004	2	656	5	651			0
2005	16	5110	27	5083			1
2006	74	28319	191	28128	0.1	49	7
2007	9	3442	15	3426			1
2008	51	17850	226	17624	0.1	40	8
2009	19	7799	32	7766	1.0	484	1
2010	55	26056	145	25910			4
2011	26	11480	91	11389			3
2012	37	14704	40	14664	0.1	45	1
2013	76	34189	571	33618	0.4	139	16
2014	47	20255	148	20107			4
2015	52	22864	154	22710	1.0	544	4
2016	644	285446	3832	281613	4.5	2005	110
2017	184	77769	305	77464	2.2	1200	10
2018	29	13220	28	13192			1
2019	29	12433	12	12421			0
2020	66	33331	256	33075	3.1	1780	6
2021	33	15530	116	15414	0.5	340	3
2022	13	7198	134	7064	4.1	2687	3

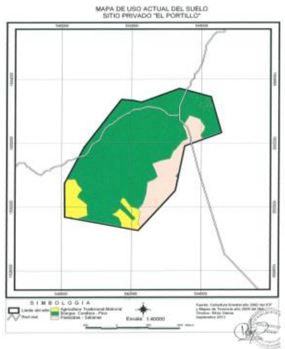
Pine conifer Forest

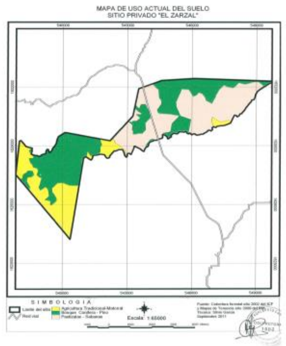
Analysis of tropical forest canopy density reveals substantial variation in carbon removal capacities. Considering areas with over 30% canopy cover, Ajuquinapa exhibits the highest annual sequestration potential at 447 tons carbon due to its expansive qualifying forest. Meanwhile Agua Caliente, El Portillo, El Zapote and El Zarzal show more modest potential between 75-274 tons carbon yearly. Collectively across the regions, forests with over 30% canopy could remove 1,239 tons carbon per annum. As thresholds increase to 40% and 50% canopy cover, qualifying area and corresponding sequestration decline sharply - to just 101 tons carbon per year combined at the 50% level. Finally, forests with 75%+ canopy are extremely scarce and concentrated in Parumble, with estimated 50 tons annual merged sequestration. These estimates reveal an acute need for reforestation and canopy restoration to expand carbon storage capabilities across the jurisdictions. Specific initiatives can be tailored to ecological conditions in each locale. Ongoing monitoring of forest density and carbon mitigation outcomes is also essential.

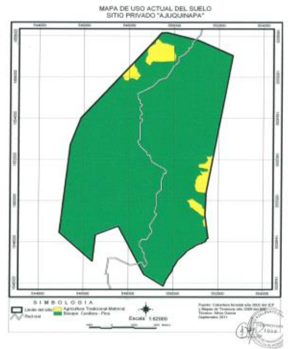


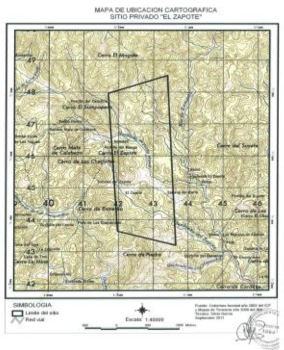


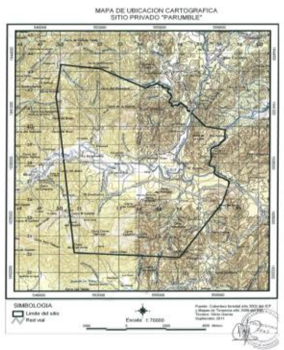


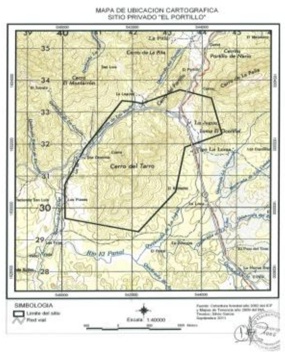


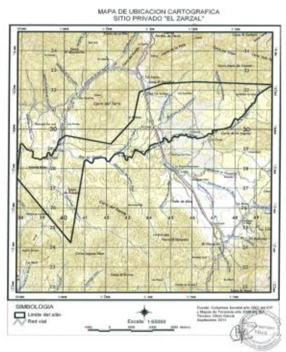


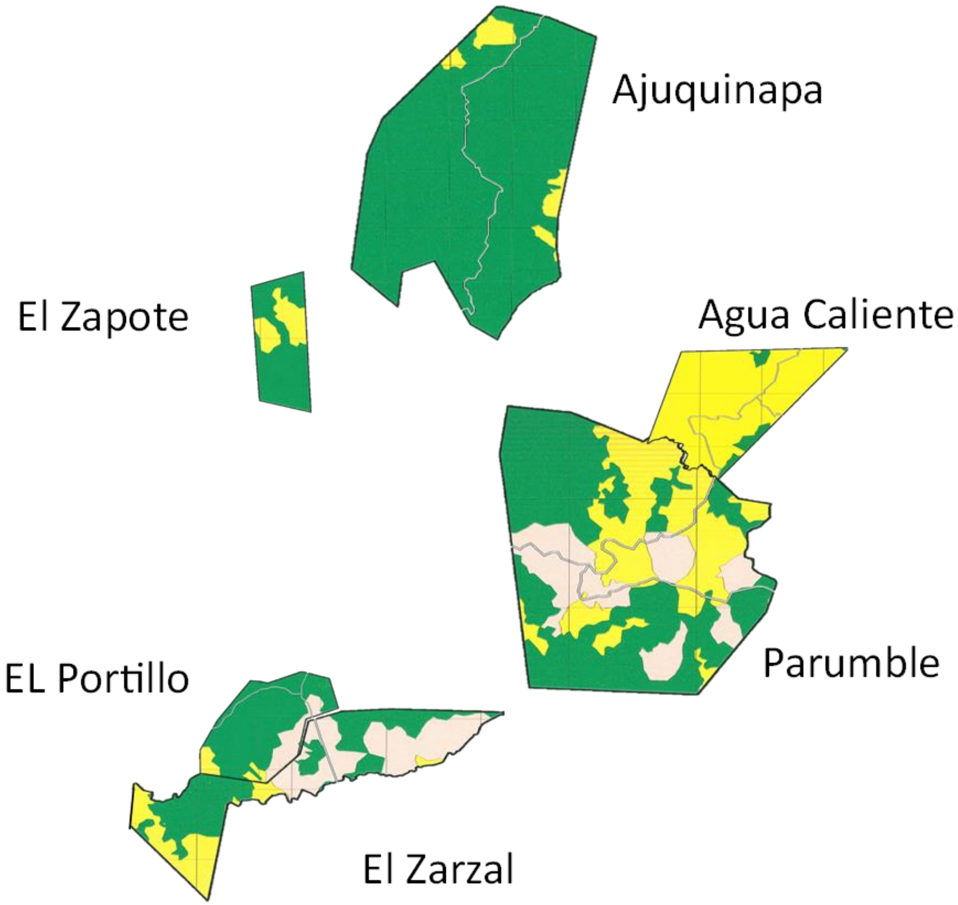












Assumptions:

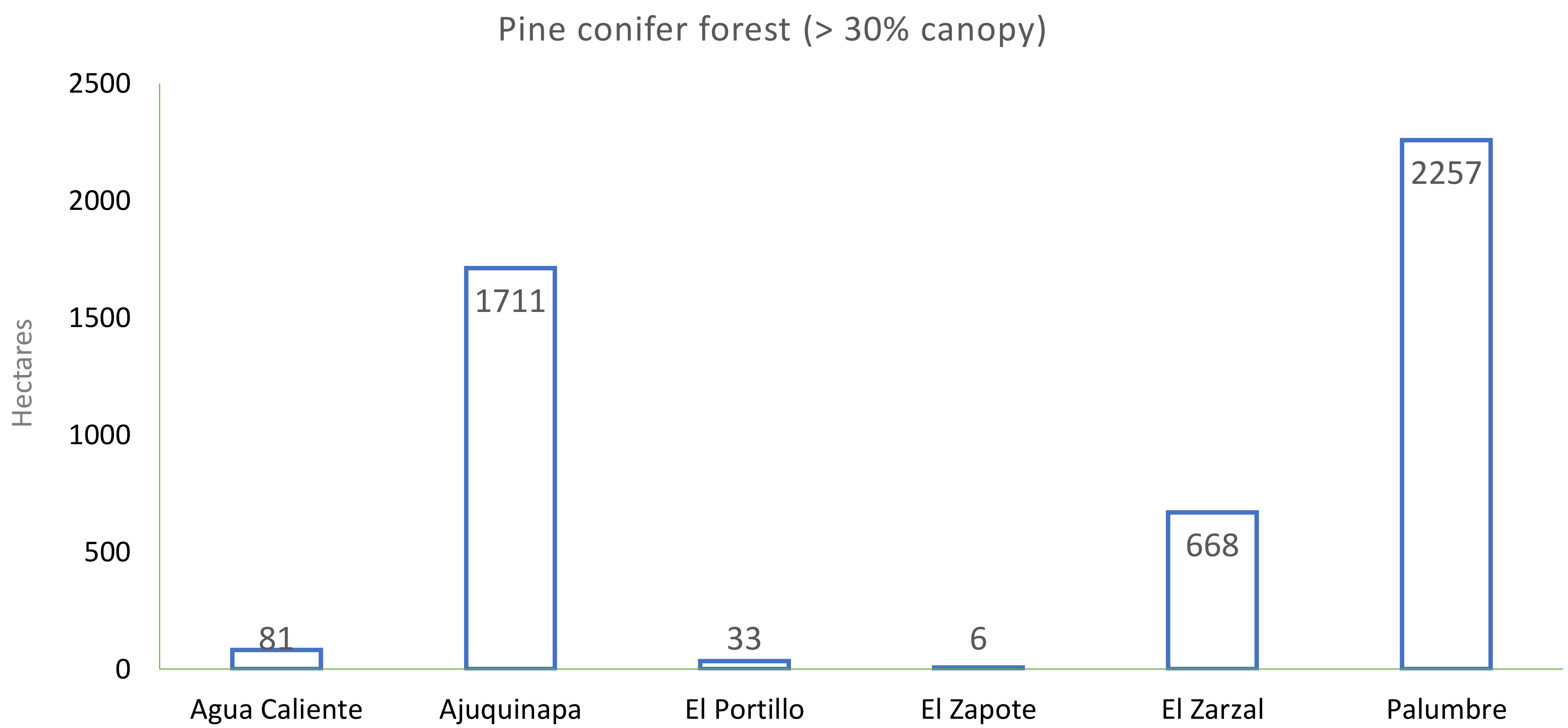
Carbon credit price of USD $10 per ton of carbon.

30% Canopy (1,239 tons C/yr total)

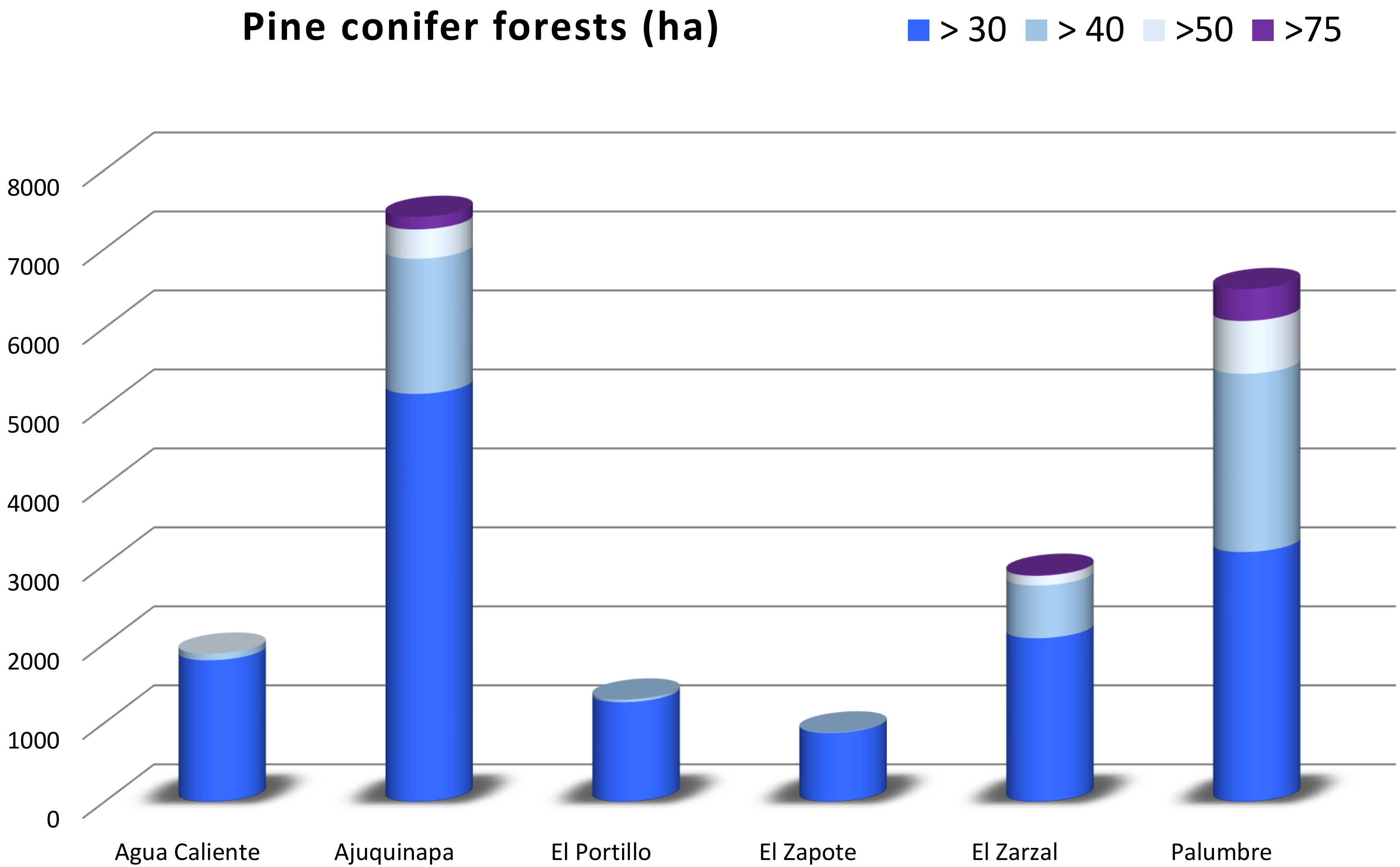
Area	Annual Carbon Credits (USD)a	
Agua Caliente	$1	$540
Ajuquinapa	$4	$470
El Portillo	$1	$90
El Zapote	$7	$50
El Zarzal	$2	$740
Parumble	$1	$790
Merged Areas	**$12**	**$390**

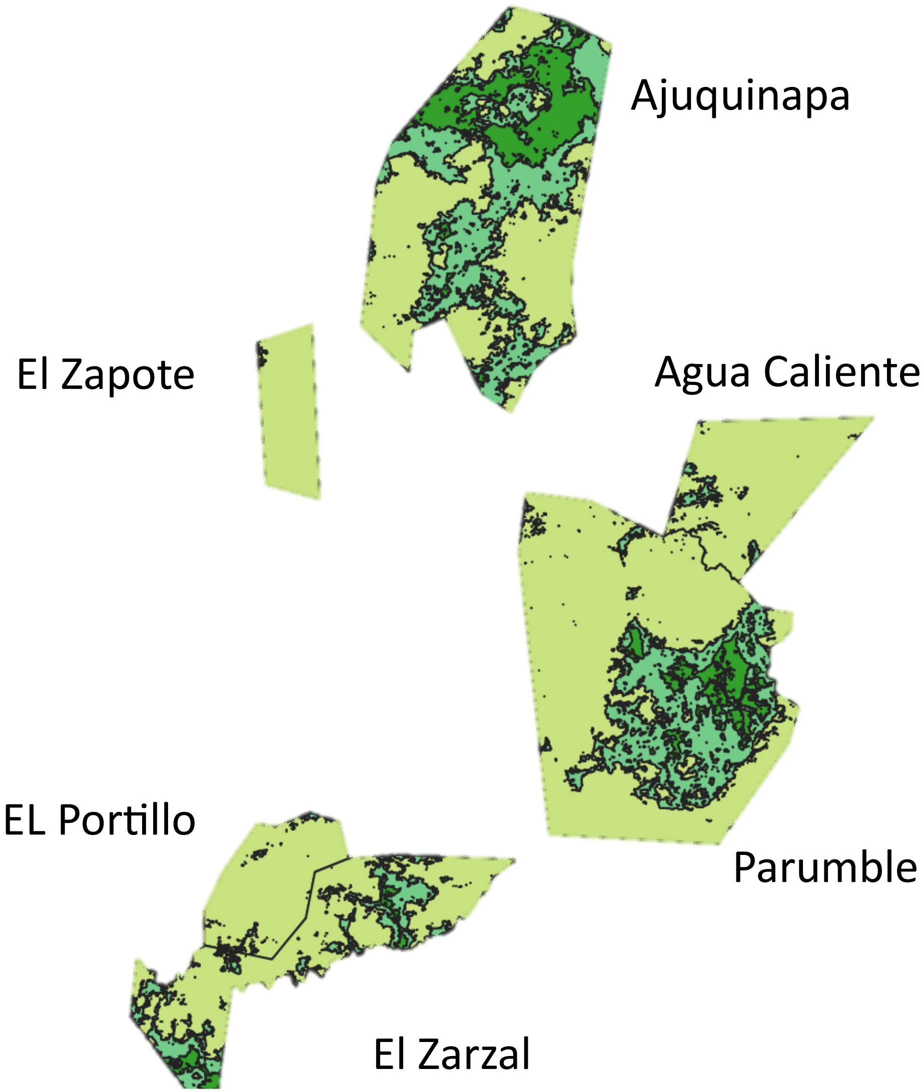
Canopy Density	Annual Carbon Sequestration
40% Canopy	412 tons C/yr total
50% Canopy	101 tons C/yr total
75% Canopy	50 tons C/yr total

Carbon credit potential drops rapidly with higher density canopy cover. Total potential credits for merged areas >30% canopy is greatest at USD $12,390 per year. Prioritizing reforestation for 30% canopy cover will maximize credit potential. Income can support forest protection and local communities.



Pine conifer forest (> 30% canopy)
Hectares
2500
2000
1500
1000
500
0
81
1711
33
6
668
2257
Agua Caliente
Ajuquinapa
El Portillo
El Zapote
El Zarzal
Palumbre


Pine conifer forests (ha)
> 30
> 40
>50
>75
8000
7000
6000
5000
4000
3000
2000
1000
0
Agua Caliente
Ajuquinapa
El Portillo
El Zapote
El Zarzal
Palumbre

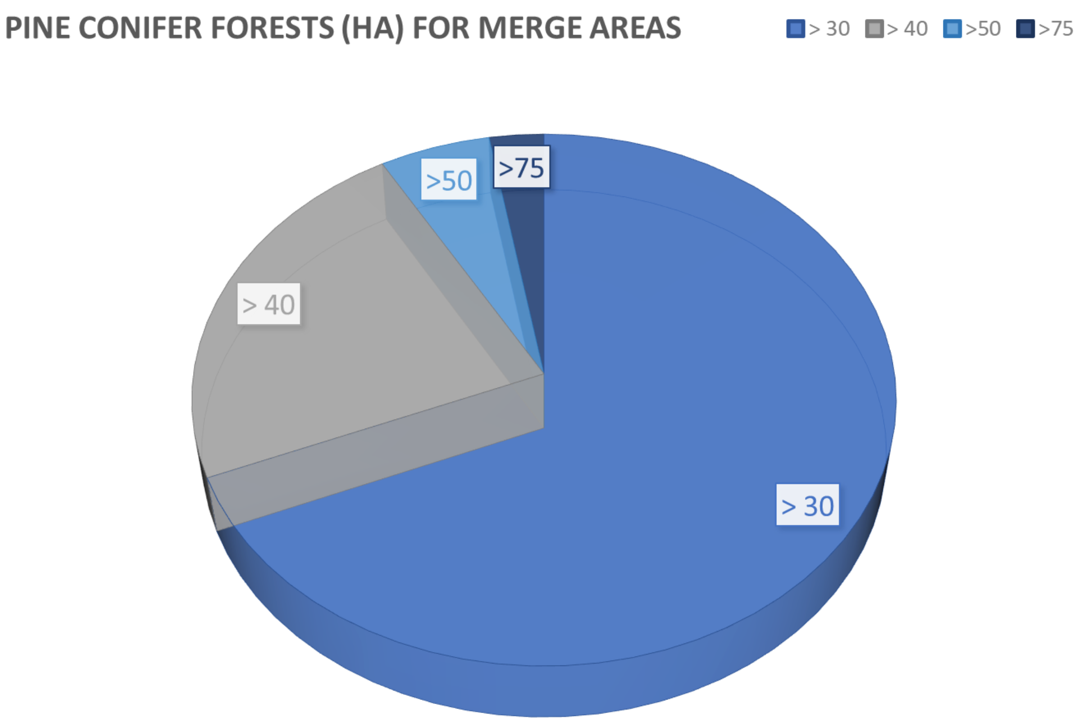


The merged areas encompass a total region of 19,240 hectares across mountainous terrain. The habitat consists of Central American pine-oak and dry forests, with no intact forests remaining. The climate is predominantly warm and temperate, with high humidity and summer heat. It is part of the Tropical/Subtropical Coniferous and Dry Broadleaf Forest biomes. Back in 2000, the merged areas had relatively strong tree canopy coverage of 60%.

However, from 2001 to 2022 there was considerable deforestation, with the loss of 14% of the original 2000 tree cover. This tree cover loss resulted in substantial carbon dioxide emissions totaling 677 kilotons over the 22 year period, equivalent to average emissions of 30.8 kilotons per year. At the same time, reforestation efforts led to an average of 63.9 kilotons of carbon removal per year, helping offset some of the emissions. So while the merged areas had the highest total emissions due to its large size, it remained a net carbon sink during the period, absorbing more than it emitted, to the tune of 33.1 kilotons of carbon per year.

The total area across the merged regions is 20,808 hectares. Of this, pine and conifer forests occupy 23% or 4,756 hectares. The remaining 69% or 14,314 hectares is classified as other land cover types.

On an individual basis, El Zarzal has the highest percentage of pine/conifer forests at 35% or 2,257 out of 6,490 total hectares. Ajuquinapa and El Zapote have a similar forest composition percentage at 23%. However Ajuquinapa has the largest absolute forest area at 1,711 hectares compared to 668 in El Zapote.



Agua Caliente, Parumble, and El Portillo have very little remaining pine/conifer forest cover, at just 4%, 3%, and 1% respectively. Almost their entire area is classified as other land cover. For example, Agua Caliente is 96% other land while El Portillo is 99% other land.

While 23% of the total merged area remains as pine and conifer forest, the condition is better in El Zarzal and worse in the southernmost areas of Agua Caliente, Parumble and El Portillo. A coordinated regional effort is needed to protect remaining forests in the north while restoring degraded habitats in the south. Reforestation efforts should focus on Agua Caliente, Parumble and El Portillo to assist forest regeneration.

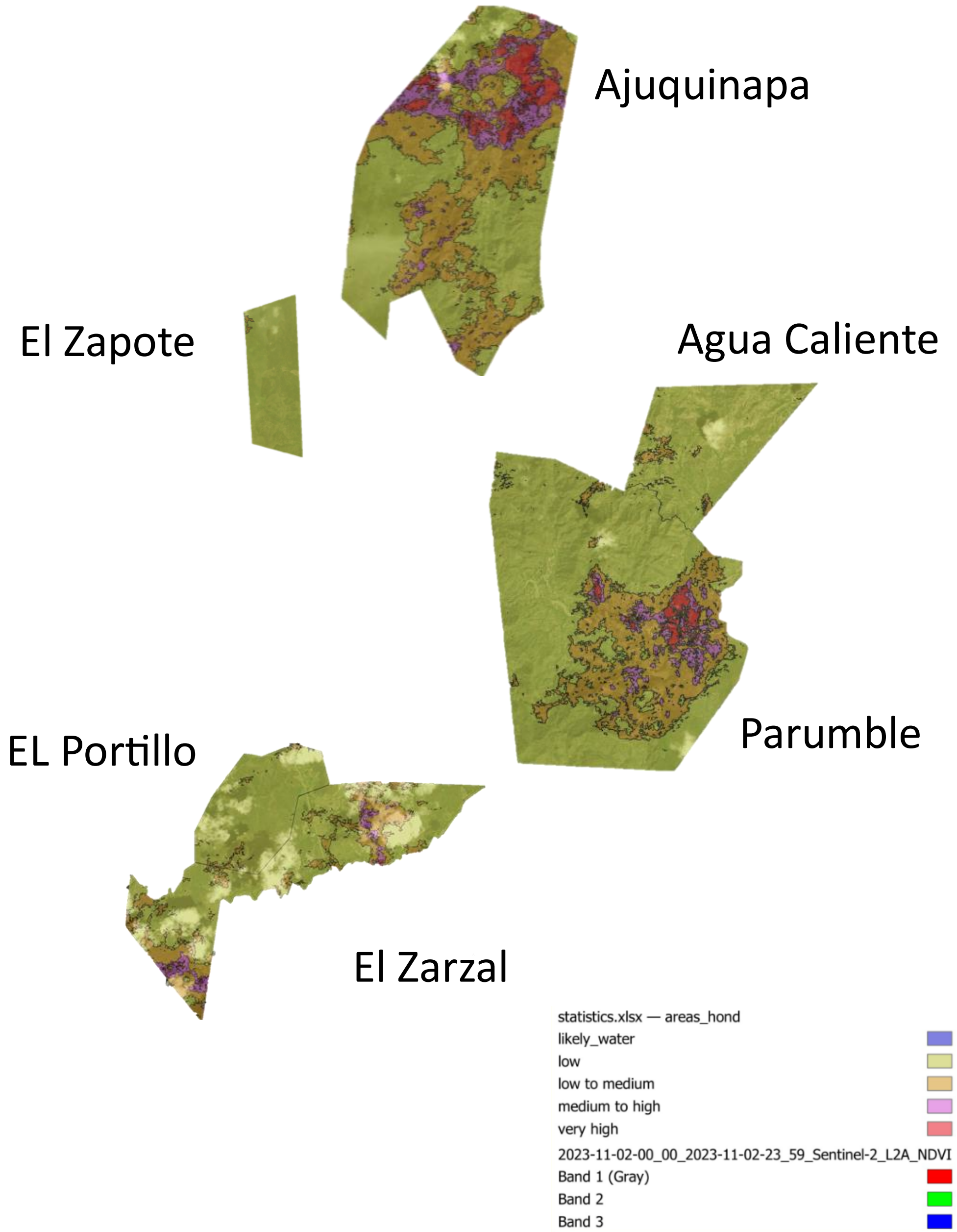
Looking at canopy cover greater than 50%, the merged areas have just 0.1% or 1,165 ha meeting this level. Individually, Parumble has the greatest coverage at 0.1% (669 ha) in this highest canopy class. For canopy cover above 75%, the totals are even lower - just 0.1% (573 ha) across merged areas. Parumble again has the highest percentage at 0.1% (403 ha). Moving to the >40% canopy threshold, totals increase, with the merged areas at 0.2% (4,756 ha).

However, most of this area is concentrated in El Zarzal and Parumble, at 0.2% and 0.4% respectively. Finally, at the >30% canopy level, coverage across the regions increases to 0.7% (14,314 ha). But when viewed individually, El Portillo, El Zapote, and Agua Caliente are all nearly completely classified as other land cover (<30% canopy), at 99-96%. Only Parumble and El Zarzal meet the 30% level on half or more of land area.

Higher density mature forest canopy cover is severely lacking across the regions and concentrated in just a few higher altitude areas like Parumble and El Zarzal. Lower elevation areas need significant reforestation efforts to restore canopy coverage, especially in southern zones like Agua Caliente, El Portillo and El Zapote which have degraded dry forests.

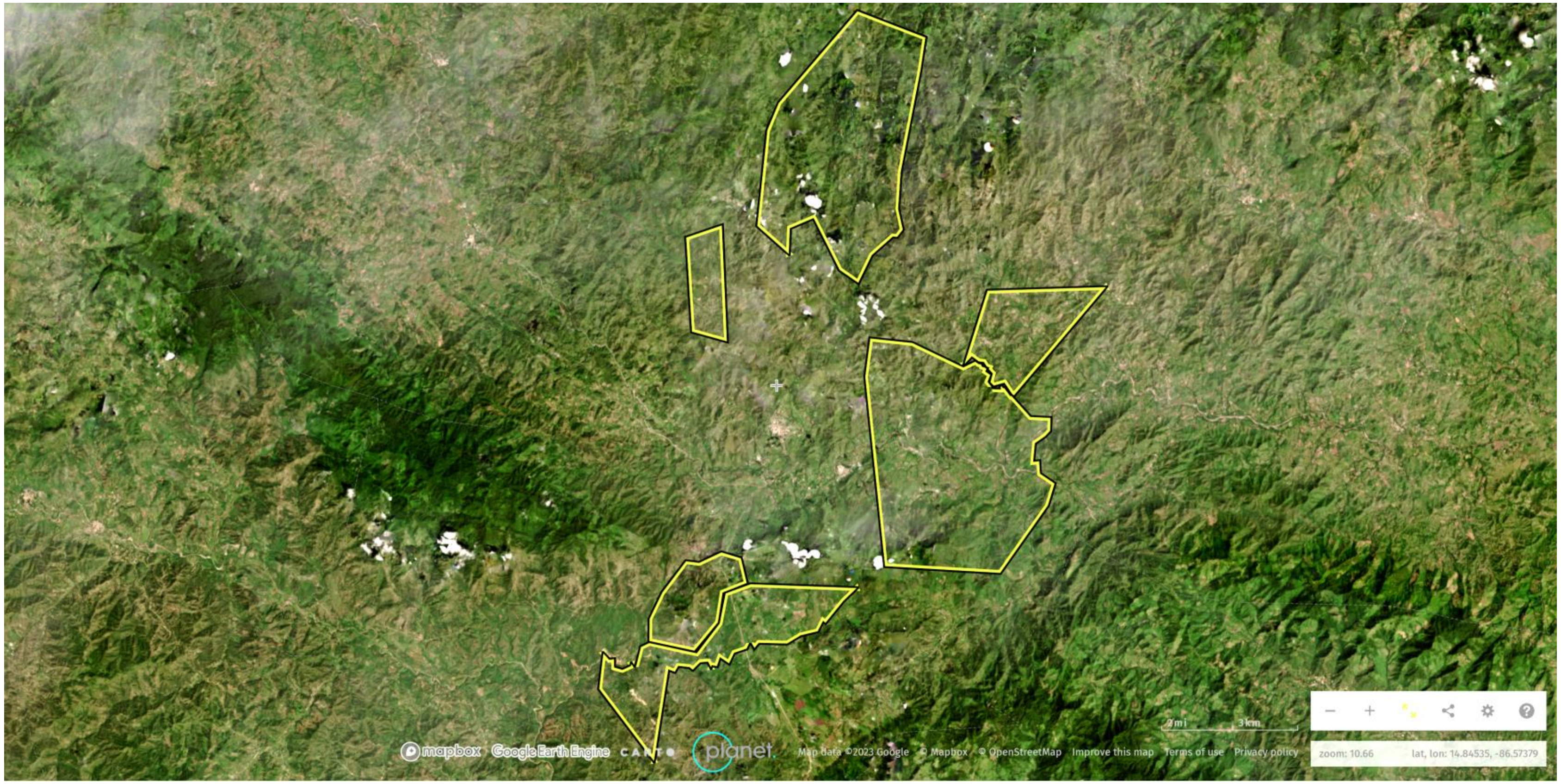
	Area	Other land	Tree Cover		Tropical Tree		Pine conifer forest	
	(ha)	(ha)	(ha)	(%)	(ha)	(%)	(ha)	(%)
Agua Caliente	1,742	1,380	362	21	1,340	27	87	5
Ajuquinapa	6,036	846	5,190	86	5,270	87	5,795	96
Parumble	6,900	3,110	3,790	55	5,130	75	3,381	49
EL Portillo	1,203	432	771	64	976	81	938	78
El Zapote	813	261	554	68	719	88	610	75
El Zarzal	2,670	1,660	1,010	38	1,770	66	1,255	47
Merge Areas	19,240	7,690	11,550	60	15,100	79	12,314	64

Areas	Total area	Other land		Pine conifer forests	
Agua Caliente	1742 ha	1380 ha	21 %	87 ha	5 %
Ajuquinapa	6036 ha	846 ha	86 %	5795 ha	96 %
Parumble	6900 ha	3110 ha	55 %	3381 ha	49 %
EL Portillo	1203 ha	432 ha	64 %	938 ha	78 %
El Zapote	813 ha	261 ha	68 %	610 ha	75 %
El Zarzal	2670 ha	1660 ha	38 %	1255 ha	47 %
Merge Areas	19240 ha	7690 ha	60 %	12065 ha	64 %



	Canopy area (ha)	Canopy area (%)
>75	1145	0.1
Ajuquinapa	157	0.0
El Zarzal	12	0.0
Palumbre	403	0.1
Merge Areas	573	0.0
>50	2330	0.3
Agua Caliente	2	0.0
Ajuquinapa	372	0.1
El Zarzal	122	0.0
Palumbre	669	0.1
Merge Areas	1165	0.1
> 40	9512	1.1
Agua Caliente	81	0.0
Ajuquinapa	1711	0.2
El Portillo	33	0.0
El Zapote	6	0.0
El Zarzal	668	0.2
Palumbre	2257	0.4
Merge Areas	4756	0.2
> 30	28628	5.5
Agua Caliente	1791	1.0
Ajuquinapa	5163	0.7
El Portillo	1260	1.0
El Zapote	870	1.0
El Zarzal	2069	0.7
Palumbre	3161	0.5
Merge Areas	14314	0.7

Natural Forest



Alberto and Elvir (2008), estimated the carbon accumulation and fixation in aerial biomass of *Pinus oocarpa*, the most frequent tree in Honduras, in natural forests. The average annual carbon dioxide sequestration per hectare in the dense pine forest *P. oocarpa* is 4.17 tons per hectare.

The carbon credits were estimated assuming the tree cover in each area was dense pine forest *P. oocarpa*, which sequesters CO_2 at a rate of 4,170 metric tons per km^2 per year. Under this assumption, the 0.37 m2 of tree cover above 10% canopy in Agua Caliente would sequester 1,543 metric tons of CO_2 annually.

Using the conversion factor of metric tons CO_2 to metric tons CO_2 equivalent for carbon credits, this equates to 5,677 metric tons CO_2 equivalent credits per year. However, these pine forest-based estimates are 3-4 times higher than the actual reported carbon credit data for each area. This suggests the vegetation is less dense or productive than a pure pine stand.

Parumble likely has the highest actual credits due to having the greatest remaining tree cover. Meanwhile Ajuquinapa shows the largest overestimation, indicating its present vegetation differs substantially from dense pine forest.

Annual CO_2 Sequestration (Tm/ha)
= Total CO_2 Sequestration (Tm) Total Area of Study (ha)

Total Carbon Accumulation (Tm)
= Total Biomass (Tm) x Carbon Fraction in Aerial Biomass

Annual CO Sequestration (Tm)
= Annual CO Sequestration (Tm/ha) x Total Area of Study (ha)

Agua Caliente
Tree cover in 2020: 0.37 kha

Annual CO_2 sequestration: 0.37 kha x 4.17 tons/ha x 1000 kg/ton
= 1,542,900 kg CO_2 = 1,543 metric tons CO_2

Carbon credits: 1,543 metric tons CO_2 x (44/12)
= 5,677 metric tons CO_2 equivalent

Ajuquinapa
Tree cover in 2020: 1.14 kha

Annual CO_2 sequestration: 1.14 kha x 4.17 tons/ha x 1000 kg/ton
= 4,753,800 kg CO_2 = 4,754 metric tons CO_2

Carbon credits: 4,754 metric tons CO_2 x (44/12)
= 17,578 metric tons CO_2 equivalent

Parumble
Tree cover in 2020: 3.81 kha

Annual CO_2 sequestration: 3.81 kha x 4.17 tons/ha x 1000 kg/ton
= 15,897,700 kg CO_2 = 15,898 metric tons CO_2

Carbon credits: 15,898 metric tons CO_2 x (44/12)
= 58,724 metric tons CO_2 equivalent

El Portillo
Tree cover in 2020: 0.77 kha

Annual CO_2 sequestration: 0.77 kha x 4.17 tons/ha x 1000 kg/ton
= 3,210,900 kg CO_2 = 3,211 metric tons CO_2

Carbon credits: 3,211 metric tons CO_2 x (44/12)
= 11,860 metric tons CO_2 equivalent

El Zapote
Tree cover in 2020: 0.80 kha

Annual CO_2 sequestration: 0.80 kha x 4.17 tons/ha x 1000 kg/ton
= 3,336,000 kg CO_2 = 3,336 metric tons CO_2

Carbon credits: 3,336 metric tons CO_2 x (44/12)
= 12,321 metric tons CO_2 equivalent

El Zarzal
Tree cover in 2020: 1.02 kha

Annual CO_2 sequestration: 1.02 kha x 4.17 tons/ha x 1000 kg/ton
= 4,253,400 kg CO_2 = 4,253 metric tons CO_2

Carbon credits: 4,253 metric tons CO_2 x (44/12)
= 15,705 metric tons CO_2 equivalent

Parameter	Value
Forest Type	*Pino oocarpa*
Total Area of Study	18,640 ha
Annual CO_2 Sequestration (Tm/ha)	1.74
Total Carbon Accumulation (Tm)	913,925
Annual CO_2 Sequestration (Tm)	105,989
Carbon Fraction in Aerial Biomass	51.8%
Carbon Accumulation in Cabañas	4,700.04 Tm
Carbon Accumulation in Opatoro	3,852.94 Tm
Carbon Accumulation in Santa Ana	2,500.55 Tm
Biomass Accumulation in Cabañas	9,029 Tm/año
Biomass Accumulation in Opatoro	7,459 Tm/año
Biomass Accumulation in Santa Ana	6,000 Tm/año

NEOTROPICAL ECOREGION

The combined area of the Neotropical ecoregion NT0303 corresponding to Honduras, including the designated protected areas such as Celaque National Park and Pico Pijol National Park, is approximately 384 km2. The two main protected areas within this ecoregion in Honduras are: Celaque National Park - IUCN category II with an area of 270 km2 and Pico Pijol National Park - IUCN category II with an area of 114 km2.

Together, these two national parks cover 384 km2, which represents the portion of the overall 112,000 km2 Neotropical ecoregion NT0303 that lies within Honduras. While the ecoregion spans Honduras, El Salvador and Guatemala, this figure of 384 km2 refers specifically to the area within Honduras, consisting of Celaque and Pico Pijol National Parks.

Neotropical ecoregion carbon sequestration rate

The aboveground biomass carbon stock of the forest is 250 tons of carbon per hectare (250 t C/ha), based on allometric measurements. This means the total biomass carbon stock for the entire 38,400-hectare area is: 250 t C/ha * 38,400 ha = 9,600,000 tons of carbon

An annual increment or growth rate of 1.5% for the forest, based on published growth rates for the tree species. We apply this 1.5% to the initial biomass carbon stock to estimate the annual increment: 1.5% of 9,600,000 t C = 144,000 t C. The key factors are the biomass carbon stock per hectare, the total forest area, and the annual growth rate of the forest.

Neotropical ecoregion Carbon credits

144,000 tons of sequestered carbon per year x 44/12 (conversion factor from carbon to CO_2) = 529,333 tons of CO_2 sequestered per year

Since carbon credits are typically measured in kilotons (kt) of CO_2 equivalent (CO_2e), we can express this as: 529 ktCO_2e per year

144,000 tons of carbon sequestered per year

Conversion factor from C to CO_2 is 44/12 = 3.67

144,000 t C x 3.67 = 529,333 t CO_2

529,333 t CO_2 = 529 ktCO_2e

Neotropical ecoregion could generate an estimated 529 kilotons of carbon credits per year. This represents the amount of CO_2 that is sequestered annually by the forest through carbon uptake and storage in biomass.

Conclusions

From 2001 to 2022, Honduras has experienced a total tree cover loss of 1,357 hectares, with an average annual loss of 64 hectares. The year 2016 marked the highest loss, primarily due to fires. The total CO_2e emissions from all greenhouse gases during this period were 1.5 million Mg, with an average annual emission of 72,000 Mg CO_2e. Shifting agriculture emerges as the main driver of this loss, underscoring the need for sustainable alternatives.

The tree cover loss resulted in over 1.5 million tons of CO_2 equivalent emissions, drastically reducing the climate mitigation potential of these forests. While two areas remain carbon sinks, and minor reforestation has occurred, the scale pales compared to total loss. Fires, while contributing a smaller fraction to total tree cover loss, can lead to significant damage in specific years, as seen in 2016. This reinforces the importance of fire management strategies alongside efforts to curb agricultural encroachment.

The estimation of carbon credits based on the assumption that tree cover is dense pine forest suggests that actual vegetation may be less dense or productive. This discrepancy underscores the importance of utilizing accurate vegetation data for realistic carbon credit estimation.

Recommendations

- ✓ Reforestation: Implement reforestation programs prioritizing native species to bolster tree cover and carbon sequestration.
- ✓ Sustainable Practices: Promote agroforestry and sustainable agriculture to maintain tree cover while supporting local economies.
- ✓ Policy Development: Formulate policies and incentives aimed at curtailing deforestation linked to agricultural expansion.
- ✓ Community Engagement: Encourage community forest management programs to provide sustainable alternatives to deforestation.
- ✓ Fire Management: Strengthen forest fire prevention and management to mitigate the risk and impact of fires.
- ✓ Public Awareness: Increase public awareness regarding the critical role of forests in climate change mitigation.
- ✓ Agua Caliente: Despite its small size, this area has high remaining tree cover and low deforestation rates, resulting in net negative carbon emissions. Continued protection and potential reforestation are advised.
- ✓ Ajuquinapa: Having experienced significant deforestation, this area requires urgent measures to halt further loss and initiatives to restore degraded lands, including sustainable fruit plantation practices.
- ✓ Parumble: Moderate deforestation rates call for a balance between forest protection and sustainable agriculture, complemented by reforestation efforts.
- ✓ El Portillo: Conservation efforts should focus on the existing high tree cover, alongside reforestation strategies.
- ✓ El Zapote: An exemplary carbon sink with minimal deforestation, this area should be fully protected.
- ✓ El Zarzal: With moderate tree cover and deforestation rates, efforts should aim at preventing further loss and restoring degraded lands.

Projections

5-Year Projection (2028)

- ✓ Conservation Efforts: With the recommended conservation strategies in place, we project a reduction in annual tree cover loss by at least 30%, lowering it from an average of 64 hectares to approximately 45 hectares per year.

- ✓ Reforestation: Assuming a reforestation program is initiated, with an annual planting of 20,000 trees, we could expect an increase in forest cover. By the fifth year, these trees would start to mature and contribute to the carbon sink.

- ✓ Policy and Community Engagement: The implementation of policies to curb shifting agriculture and the successful engagement of local communities in sustainable practices could result in a stabilization or even an increase in tree cover in previously vulnerable areas.

- ✓ Fire Management: Improved fire management could reduce the average hectares lost to fires by 50%, potentially bringing it down to 4-5 hectares per year.

Carbon Credits: As forest protection and reforestation efforts mature, the value and volume of carbon credits generated could increase, incentivizing further conservation actions.

10-Year Projection (2033)

- ✓ Mature Conservation Programs: By the tenth year, conservation programs would be well-established. With continuous enforcement and community adoption, tree cover loss could be reduced by up to 50% from current levels.

- ✓ Forest Regeneration: Reforested areas would have a decade of growth, significantly increasing carbon sequestration. Natural forest regeneration would also contribute to this increase if conservation efforts are successful.

- ✓ Sustainable Agriculture: The shift to sustainable agricultural practices would be expected to have taken hold, reducing the pressure on forests for land conversion and thus decreasing the rate of tree cover loss.

- ✓ Policy Impact: Long-term policies implemented in the first five years would have taken effect, potentially providing economic alternatives to deforestation and resulting in lower emissions from land-use changes.

- ✓ Carbon Market Integration: With global carbon markets evolving, the site could be fully integrated into international carbon trading platforms, providing a steady revenue stream for continued conservation efforts.

Quality Control and Data Validation

Our approach to quality control and data validation will be comprehensive, ensuring the highest degree of accuracy and credibility in our carbon credit evaluation.

1. Quality Control Process: We will implement a robust quality control process to identify and rectify any errors or inconsistencies in our measurements. This will involve rigorous data validation checks for consistency and accuracy, identifying outliers or discrepancies that may indicate measurement errors.

2. Independent Auditing: To enhance credibility, we will engage independent third-party auditors to review and validate our measurement and carbon sequestration calculations.

3. Transparency and Documentation: We will maintain transparent and comprehensive documentation of all measurement processes, data sources, methodologies, and any updates or revisions. This documentation will include:

- Project Design Document
- Measurement Process Documentation
- Data Source Documentation
- Methodology Documentation
- Updates or Revisions Documentation
- Validation Report
- Verification Report
- Monitoring Reports
- Stakeholder Consultation Report
- Environmental Impact Assessment (if applicable)
- Sustainability Report
- Registration Documentation
- Gold Standard Issued Verified Emissions Reductions (if applicable)
- Compliance Documentation
- Carbon Credit Quality Assessment

4. Training and Expertise: All personnel involved in the measurement and calculation process will be well-trained and have expertise in forestry, environmental science, and data analysis. They will also be proficient in using measurement equipment and software.

5. Continuous Improvement: We will periodically assess and refine our measurement and calculation processes to incorporate the latest technology and best practices in forest measurement and carbon sequestration estimation.

6. Stakeholder Engagement: We will actively involve stakeholders, including local communities and environmental organizations, in the

measurement process. Their local knowledge will be invaluable for validation and enhancing measurement accuracy.

For carbon sequestration calculation, we will gather species-specific data, use established tree growth models, continuously monitor the forested area, and employ accepted methods for estimating the carbon stock of trees.

Our self-certification process will involve developing standardized methodologies, ensuring we have qualified personnel, documenting all procedures, implementing rigorous data collection and analysis processes, conducting regular internal audits, implementing a review process, maintaining transparency by publicly reporting, adopting open data principles, avoiding conflicts of interest, seeking input from external stakeholders, conducting periodic independent reviews, defining accountability measures, providing regular reports on our activities, and ensuring that our process aligns with the compliance requirements of COP and UNFCCC.

We adhere to international verification standards such as Verified Carbon Standard (VCS), Clean Development Mechanism (CDM), Gold Standard, Plan Vivo Standard, Social Carbon Standard, ISO 14064-2 (Greenhouse Gas Verification and Validation), Climate, Community & Biodiversity (CCB) Standards, American Carbon Registry (ACR), Climate Action Reserve (CAR), and Climate, Investment, and Impact (CII).

TEAM

P. Olof Olsson

Director of Fujairah Genetics Center

Dr. Olof Olsson has served as a lead researcher at the UAE BRC, Abu Dhabi Biotech Research Foundation and Sooam Biotech Research Foundation in South Korea on various preservation and species restoration projects. He received his PhD on Laboratory Medicine in Lund University and has continued to research on an extensive range of subjects such as Cancer, Animal Reproduction, Molecular and Cellular Biology and Agriculture. He has also applied his expertise to establish different enterprises and institutions where he finds a balance in scientific advancement and financial yields. Currently Dr. Olsson is focused on efforts for the systemization and standardization of carbon sequestration in organic matter.

David “Hyunduk” Kim

Researcher in Fujairah Genetics Center

Dr. David Kim has worked in various research institutions in Korea on projects related to drug development, animal cloning and biotechnology. He is a researcher with a background in Molecular and Cellular Biology as well as Immunology who has experience in managing large scale and long-term projects. He has extensive experience in project management and data analysis as well as in stakeholder engagement for forging strong, long-lasting relationships with clients and collaborators alike.

Sebastian Hylander

Sebastian Hylander is a GIS specialist with over 10 years of experience in construction, consulting and academia. He has a Masters in Engineering from the same Lund University and possesses a diverse set of skills that enable him to manage complex geospatial projects. His extensive experiences with various projects where he leverages his expertise in geographic information systems, remote sensing and data analysis allows him to deliver high-quality and customized spatial analysis. Sebastian Hylander is highly qualified to provide decision-making tools for clients across a variety of sectors and specialties.

Serge Belets

Founder of Smart State Cybersecurity

Serge Belets has more than 30 years of experience in managing high-tech projects. He has served as the COO of a startup with a evaluation of more than $2B where he has demonstrated proficient abilities in crypto, in which he has been a major player since 2015. He has also played an important role in various crypto projects in Hedera Hashgraph, DQN, and CrypterBills. He is the founder of Smart State Cybersecurity company, Unilayer blockchain and more.

Magnus Olson

Magnus Olson has lived and worked in the organic and restorative agricultural industry where he has experience in optimizing agricultural practices. His expertise in horticultural practices coupled with seasoned agricultural and industrial skills make him an invaluable asset to our team. He has also worked with and managed multiple cross-cultural teams to increase sustainable systems, focusing on the balancing of ecologies and the reduction of deleterious environmental effects all while maximizing productivity in agriculture, industry and other cross-disciplinary fields.

Aren Semenchunk

Aren Semenchunk has extensive experience in the Solution Services of the Carbon Credit and Offset industry for the past decade. He has worked closely with the aboriginal people of Canada and American northern regions on various oil and gas projects to maximize the output while minimizing any detrimental impact to the environment.

Juan Diego Urriago Suarez PhD

Dr. Juan Diego has nearly 2 decades of experience in marine research. He specializes in costal habitat and ecology, especially in regards to corals, mangroves and other related ecological systems. His work and research have taken him to the coasts of Hong Kong, Chile, and UAE where he has undertaken various projects for habitat and species conservation. His knowledge and expertise on data acquisition and analysis have played a significant role in the implementation of our carbon sequestration analysis in the costal ecosystem and can be applied to various other ecological systems.

Dr. Juan Diego GAITÁN-ESPITIA
Assistant professor,
University of Hong Kong

Marine Ecologist
Expertise in Blue carbon research

Dr. Juan Carlos ASTUDILLO
Assistant professor,
Hong Kong Metropolitan University

Marine Ecologist
Expertise in ecological engineering

Rainbow Wing Sum LEUNG
PhD student,
University of Hong Kong

Marine Ecologist
Expertise in Interdisciplinary
and stakeholder engagement

References

Alberto, D. M., & Elvir, J. A. (2008). Carbon accumulation and fixation in aerial biomass of Pinus oocarpa in natural forests in Honduras. Forest Systems, 17(1), 67-78. https://doi.org/10.5424/srf/2008171-01024.

Brandt, J., Ertel, J., Spore, J., & Stolle, F. (2023). Wall-to-wall mapping of tree extent in the tropics with sentinel-1 and sentinel-2. Remote Sensing of Environment, 292, 113574. https://doi.org/10.1016/j.rse.2023.11357.

Busch, J., Engelmann, J., Cook-Patton, S.C., Griscom, B.W., Kroeger, T., Possingham, H., and Shyamsundar, P. (2019). Potential for low-cost carbon dioxide removal through tropical reforestation. Nature Climate Change, 9(6), pp.463-466.

Carbon Sequestration in Forests. United States Environmental Protection Agency. United States Environmental Protection Agency, 2019.

Curtis, P.G., C.M. Slay, N.L. Harris, A. Tyukavina, and M.C. Hansen. (2018). Classifying Drivers of Global Forest Loss. Science.

ESA Climate Change Initiative, Land Cover - led by UCLouvain. (2015). 2015 global land cover.

European Commission, Joint Research Centre (JRC); Columbia University, Center for International Earth Science Information Network - CIESIN. (2015). GHS population grid, derived from GPW4, multitemporal (1975, 1990, 2000, 2015). European Commission, Joint Research Centre (JRC) Dataset.

Forests and Climate Change: A Guide for Policymakers. World Bank. The World Bank, 2018.

Forests and Climate Change: A Synthesis of Scientific Knowledge. Intergovernmental Panel on Climate Change. Intergovernmental Panel on Climate Change, 2014.

Forests of Honduras. The World Bank. The World Bank, 2019.

Grantham, H. S. et al. (2020). Anthropogenic modification of forests means only 40% of remaining forests have high ecosystem integrity. Nature communications, 11(1), 1-10.

Harris, N., Cook-Patton, S., Gibbs, D., and Lister, K. (2020). Young forests capture carbon quicker than previously thought. https://www.nature.org/.

Harris, N., E. Goldman, and S. Gibbes. (Spatial Database of Planted Trees (SDPT) Version 1.0.

Heinrich, V.H., Vancutsem, C., Dalagnol, R., Rosan, T.M., Fawcett, D., Silva-Junior, C.H., Cassol, H.L., Achard, F., Jucker, T., Silva, C.A., and House, J. (2023). The carbon sink of secondary and degraded humid tropical forests. Nature, 615(7952), pp.436-442.

Honduras. Forests of the World. Food and Agriculture Organization of the United Nations, 2019.

Honduras: Forests and Climate Change. World Wildlife Fund. World Wildlife Fund, 2019.

Image© 2023 Planet Labs Inc.

ISRIC: de Sousa, L. M., Poggio, L., Batjes, N. H., Heuvelink, G. B. M., Kempen, B., Riberio, E., and Rossiter, D. (2020). SoilGrids 2.0: producing quality-assessed soil information for the globe. SOIL Discuss. [preprint], https://doi.org/10.5194/soil-2020-65, in review, 2020.

Paniagua-Ramirez, A., Krupinska, O., Jagdeo, V., and Cooper, W.J. (2021). Carbon storage estimation in a secondary tropical forest at CIEE Sustainability Center, Monteverde, Costa Rica. Scientific reports, 11(1), p.23464.

The Economics of Forests and Climate Change. World Bank. The World Bank, 2018.

The Economics of Forests and Climate Change: A Review of the Literature. World Bank. The World Bank, 2018.

The Role of Forests in Mitigating Climate Change. The Nature Conservancy. The Nature Conservancy, 2019.

The State of the World's Forests 2020. Food and Agriculture Organization of the United Nations. Food and Agriculture Organization of the United Nations, 2020.

Accessed through Global Forest Watch. www.globalforestwatch.org

Cook-Patton et al. (2020). Carbon accumulation potential from natural forest regrowth in potentially reforestable areas.

Grantham, H. S. et al. (2020). "Forest Landscape Integrity Index".

Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. (2013). High-Resolution Global Maps of 21st-Century Forest Cover Change. Science, 342(15 November), 850 – 53.

Hansen/UMD/Google/USGS/NASA. Administrative boundaries: Global Administrative Areas database (GADM), version 3.6.

Harris et al. (2021). Global maps of 21st century forest carbon fluxes. Harris, N., E. Goldman, and S. Gibbes. Spatial Database of Planted Trees (SDPT) Version 1.0.

Harris, N.L., D.A. Gibbs, A. Baccini, R.A. Birdsey, S. de Bruin, M. Farina, L. Fatoyinbo, M.C. Hansen, M. Herold, R.A. Houghton, P.V. Potapov, D. Requena Suarez, R.M. Roman-Cuesta, S.S. Saatchi, C.M. Slay, S.A. Turubanova, A. Tyukavina. (2021). Global maps of twenty-first century forest carbon fluxes. Nature Climate Change. https://doi.org/10.1038/s41558-020-00976-6.

IUCN and UNEP-WCMC (2022). The World Database on Protected Areas (WDPA) [On-line], Cambridge, UK: UNEP-WCMC. Available at: www.protectedplanet.net.

Lefebvre, D., Williams, A.G., Kirk, G.J., Paul, Burgess, J., Meersmans, J., Silman, M.R., Rom á n-Dañobeytia, F., Farfan, J., and Smith, P. (2021). Assessing the carbon capture potential of a reforestation project. Scientific reports, 11(1), p.19907.

Potapov, P., et al. (2017). "The last frontiers of wilderness: Tracking loss of intact forest landscapes from 2000 to 2013." Science Advances, 3, e1600821.

Potapov, P., Hansen, M.C., Pickens, A., Hernandez-Serna, A., Tyukavina, A., Turubanova, S., Zalles, V., Li, X., Khan, A., Stolle, F., Harris, N., Song, X-P., Baggett, A., Kommareddy, I., and Kommareddy, A. (2022). The Global 2000-2020 Land Cover and Land Use Change Dataset Derived From the Landsat Archive: First Results. Frontiers in Remote Sensing, 13, April 2022. https://doi.org/10.3389/frsen.2022.856903.

Potapov, P., Li, X., Hernandez-Serna, A., Tyukavina, A., Hansen, M.C., Kommareddy, A., Pickens, A., Turubanova, S., Tang, H., Silva, C.E., and Armston, J. (2021). Mapping global forest canopy height through integration of GEDI and Landsat data. Remote Sensing of Environment, 253, p.112165. https://doi.org/10.1016/j.rse.2020.112165.

Turubanova, S., Potapov, P.V., Tyukavina, A., and Hansen, M.C. (2018). Ongoing primary forest loss in Brazil, Democratic Republic of the Congo, and Indonesia. Environmental Research Letters, 13(7), p.074028.

Tyukavina, A., Potapov, P., Hansen, M.C., Pickens, A., Stehman, S., Turubanova, S., Parker, D., Zalles, A., Lima, A., Kommareddy, I., Song, X-P, Wang, L, and Harris, N. (2022). Global trends of forest loss due to fire, 2001-2019. Frontiers in Remote Sensing. https://doi.org/10.3389/frsen.2022.825190.