BELIZE COLLECT EARTH/OPEN FORIS LAND USE AND LAND USE CHANGE ASSESSMENT PROTOCOL

DECEMBER 30, 2019

MINISTRY OF AGRICULTURE, FISHRIES, FORESTRY, THE ENVIORNENT, SUSTAINABLE DEVELOPMENT, AND IMMIGRATION

Coalition for Rainforest Nations

openforis COLLECT EARTH

REDD+ Reduction of carbon emissions from deforestation & forest degradation BELIZE

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Contents

LIST OF ACRONYMS

AD	Activity Data
AFOLU	Agriculture, Forestry, and Other Land Uses
BFD	Belize Forest Department
CE/OF	Collect Earth/Open Foris tool
CfRN	Coalition for Rainforest Nations
ERI	Environmental Research Institute, University of Belize
ESA	European Space Agency
FAO	Food and Agriculture Organization
FMS	Forest Monitoring System
FRL	Forest Reference Level
GEE	Google Earth Engine
GHGi	Greenhouse Gas Inventory
GSMU	Geospatial Monitoring Unit, Belize Forest Department
IPCC	Inter-governmental Panel on Climate Change
LTFL	Long-Term Forest License
LULUC	Land Use and Land Use Change
MRV	Measuring, Reporting, and Verification
NASA	National Aeronautic and Space Administration
NDC	Nationally Determined Contribution
PA	Paris Agreement
QA/QC	Quality Assurance/Quality Control
REDD+	The reduction of emissions from deforestation and forest degradation and the sustainable management of forests, conservation, and the enhancement of forest carbon stock.
SFM	Sustainable Forest Management
SFMP	Sustainable Forest Management Plan (SFMP)
TACCC	Transparency, Accuracy, Consistent, Complete and Comparable
UNFCCC	United Nations Framework Convention on Climate Change

1. INTRODUCTION

In its 2016 Nationally Determined Contribution (NDC) for the Paris Agreement, Belize decided as a mitigation activity, REDD+. REDD+ is the reduction of emissions from deforestation and forest degradation and the sustainable management of forests, conservation, and the enhancement of forest carbon stock (REDD+). For Belize, REDD+ is a mitigation action-based approach that is dependent on cost-effective technology, capacity building, and adequate financial support.

Understanding REDD+ requirements – as agreed by Article 5 of The Paris Agreement (PA) – and Belize’s NDC required a careful evaluation of the best cost-effective technology alternatives Belize needed to determine its forest activity data. Belize needed to carefully analyze and rebuild its historical Land Use and Land Use Change (LULUCF) Activity Data. The technology and methodology it used also needed to meet the Intergovernmental Panel on Climate Change (IPCC) principles to prepare Green Gas House Inventories (GHGi): Transparency, Accuracy, Consistent, Complete and Comparable (TACCC). After careful evaluation, it was determined that the Collect Earth/Open Foris tool, developed by the Food and Agriculture Organization (FAO), is the most appropriate technology.

First, the Collect Earth/Open Foris tool confirmed with Belize’s national circumstances. And second, the tool complied with REDD+ requirements, especially those related to the Forest Reference Level (FRL), the Forest Monitoring System (FMS) and the Measuring, Reporting and Verification (MRV) components of Belize’s NDC.

One of the most important documents to have before undertaking data collection with the Collect Earth/Open Foris tool is a detailed protocol. The protocol not only serves as a clear and transparent guide for the participants of the LULUC assessment, but it also serves to guide decision making on issues that are unique to the national circumstances.

The collection of the Activity Data (AD) is necessary to develop the GHGi and to prepare a national FRL report. The FRL must be presented to the United Nations Framework Convention on Climate Change (UNFCCC) to participate in the results-based payment for REDD+.

To undertake the LULUC assessment, Belize's national LULUC classification system was modified to fit the 2006 IPCC Classification Guidelines for a robust GHGi and FRL. Figure 1-1 below illustrates the classifications that can be made taking into account the Land Use and Land Use Change transitions from one year to the other.

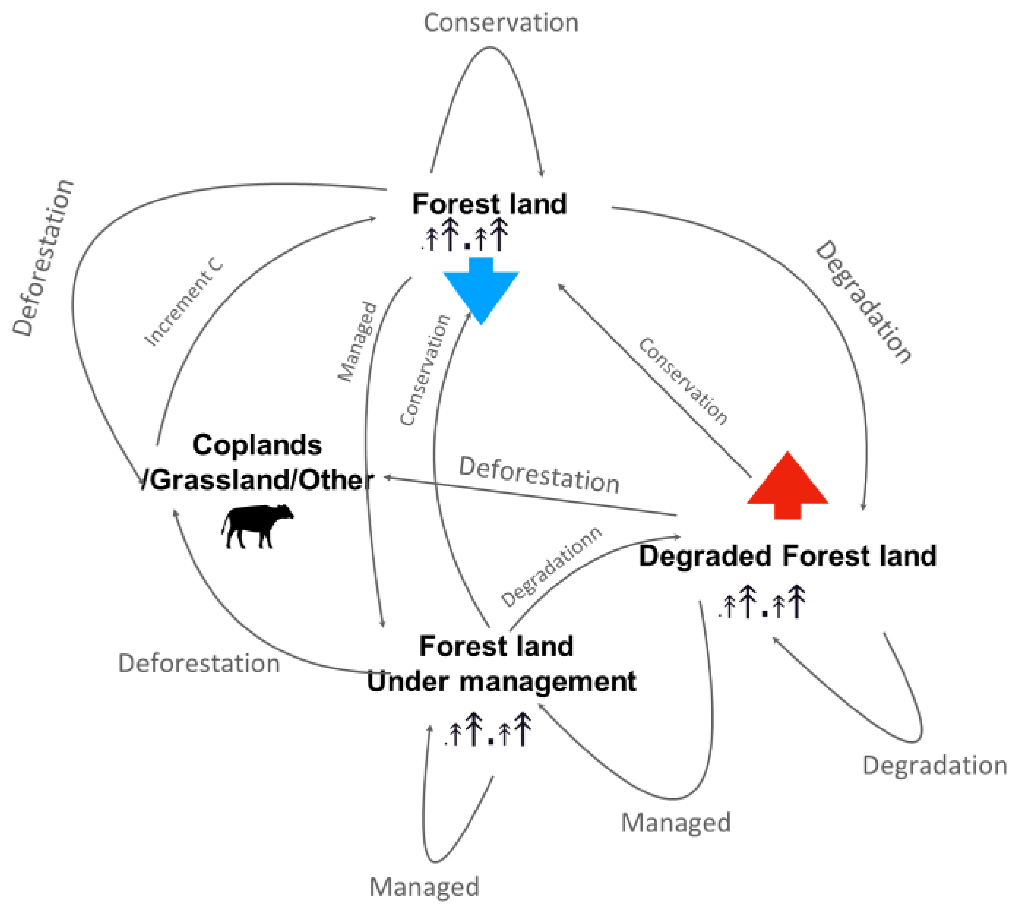


Figure 1-1. Land Use and Land Use Change transitions for REDD+.

This '*Belize Collect Earth/Open Foris Land Use and Land Use Change Assessment Protocol*', hereafter the Protocol, describes the planning, deliberation, decision-making, and considerations made for the LULUC assessment for the Agriculture, Forestry, and Other Land Use Changes of Belize. The main body of the Protocol is organized in three sections, corresponding to the three phases of the assessment: the preparation for the Collect Earth/Open Foris assessment, the implementation of the Collect Earth/Open Foris assessment, and the Validation of the Collect Earth/Open Foris assessment results.

Phase 1: The Preparation Phase. This phase is one of the most important phases for Belize. This phase includes identifying country lead individuals, training individuals to operate the CE/OF desktop tool, understanding the national circumstance, and having experts' inputs on national definition and processes. The preparation of the Collect Earth/Open Foris tool is fundamental within this phase as well. Having a clear understanding of the quality and the quantity (numbers of years) of the data that needs to be collected for Belize is also important. Having an understanding of land use classes and their natural ecological processes is necessary. Equally important is having an understanding of the non-ecological factors that influence LULUC. Furthermore, having a clear grasp of the Quality Assurance/Quality Control (QA/QC) activities to consider and conduct during the Implementation Phase and the Validation Phase. During this Preparation Phase, it was decided that the timeframe to collect activity data was from 2000 to 2018. It was also decided that the activity data should record human disturbance and natural disturbances (hurricanes and pests). For Belize, the Preparation Phase took approximately 7 months. The Preparation Phase should be clearly defined and endorsed nationally before moving onto Phase 2.

Phase 2: The Implementation Phase. The Implementation Phase is the execution of the LULUC assessment in CE/OF. This is where the equipment and venue are ready, the CE/OF tool and its elements are ready, the CE/OF operators (mapping team) assemble, and, the QA/QC processes are in place during the assessment of the LULUC. Belize had a team of 14 operators/mappers. Each had a laptop and an additional wide-screen monitor. The internet speed at the centralized location – the Forest Department Main Office - was around 60 megabits per second. The principal tasks of the Implementation Phase were: to assess the LULUC and disturbances (for forests and grasslands) of all the sample plots/data points of Belize, and, conduct QA/QC on the data collected from all of the sample plots. The CE/OF operators had at their disposition additional personnel from the Belize Forest Department with vast field experience to inquire and/or corroborate the activity data being collected. For the QA/QC, the team had available experts from the Coalition for Rainforest Nations in AFOLU assessment. The Implementation Phase took approximately 7 weeks.

Phase 3: The Validation Phase. The Validation Phase is where data collected from the sample plots during the assessment undergo most of the Quality Assurance/Quality Control. For Belize, different types and levels of QA/QC were conducted. This included the reassessment of 5% of all the sample plots by a different CE/OF operator, conducted during Phase 2. It also included a reassessment from uncertain sample plots identified with Saiku. And lastly, there was a reassessment of all Secondary Broadleaf Forest and Shrubland sample plots. After this last reassessment, an intensive review of the year-by-year data of each of the sample plots was done in Microsoft Excel. During this phase, the CE/OF operators used additional tools such as Arc Map to visualize and filter sample plots. The Validation Phase after the assessment in CE/OF lasted almost a year because of the intensive review of the sample plots.

In the following section a closer examination of Phase 1, the Preparation Phase, is presented.

2. PHASE I: PREPARATION FOR COLLECT EARTH/OPEN FORIS

The preparation phase for the Collect Earth/Open Foris assessment of land use and land-use change and disturbances (for forests and grasslands) for the Agriculture, Forestry, and Other Land Use sector of Belize started with capacity building for the Forest Department Officers. The capacity building included learning how to operate the Collect Earth/Open Foris tool, designing a sampling grid for the assessment, engaging in further technical planning, and doing the logistical arrangements for the assessment exercise. These steps are discussed further in the following section.

2.1 Technical Capacity Building of The Forest Department

The process to use the Collect Earth/Open Foris tool to assess the LULUC and disturbances (for forests and grasslands) of the AFOLU sector of Belize started with the training of four (4) Forest Department (FD) Officers in data collection with the tool. The REDD+ Project considered the usefulness of the CE/OF tool to collect the activity data for the Forest Reference Level (FRL) following the experiences of other countries, including Panama. The training was at the Food and Agriculture Organization headquarters in Rome, Italy (see Annex I).

During the training workshop, the FD Officers developed a plan for the data collection of the activity data of the AFOLU sector, referred to as the 2018 Collect Earth/Open Foris Assessment/Mapathon (see notes in Annex II). The next important step for the 2018 Assessment was to develop a Collect Earth/Open Foris Mapathon Protocol—this document. The Protocol served to guide the CE/OF operators in their assessment of the LULUC and disturbances (of forests and grasslands) of the sample plots, from 2000 to 2018. In addition, it helped guide the decision-making process for unique national circumstances.

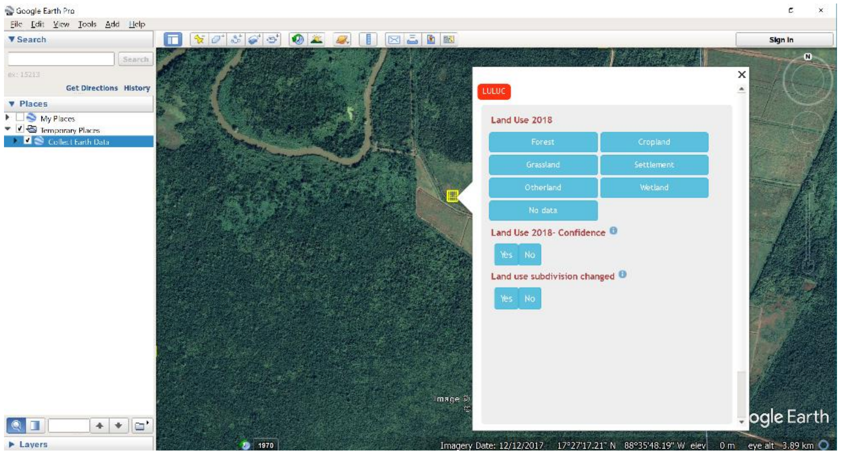
2.2 The Collect Earth/Open Foris Tool

Collect Earth/Open Foris software is a land use and land-use change activity data collection tool that utilizes satellite imagery from Google Earth, Bing Maps, Here WeGo, and Google Earth Engine. This tool is part of open-source online software called Open Foris that was developed by FAO to be used free of cost. Open Foris is used to collect, analyze, and report spatial and environmental data. This is the basis for REDD+ to track and record deforestation, forest degradation, conservation, afforestation, and sustainable forest management, accordingly to the definitions of these concepts by Belize.

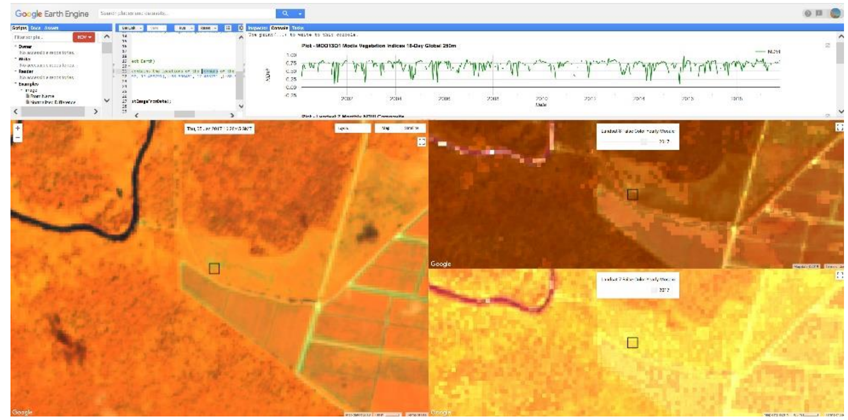
Belize decided to use the CE/OF tool to develop the reports that member countries need to submit to the United Nations Framework Convention on Climate Change (UNFCCC). Collect Earth - as well as all the tools developed within Open Foris - can be downloaded for free from the OpenForis.org website (www.openforis.org). This software is developed in Java. It uses Google Earth as its main data collection interface. It also integrates several web services that provide very high-resolution satellite images, in addition, it allows for temporal analysis using free images from the National Aeronautics and Space Administration (images available from 1984) and the European Space Agency. This interface facilitates the process of visual interpretation.

Collect Earth/Open Foris' integration with high-resolution satellite images allows for multiple images to be retrieved when a survey plot (yellow square, Figure 2-1.a) is selected in Google Earth. Figure 2-1 below illustrates the images retrieved, including Bing Maps, Here WeGo, NASA's Landsat 7 and 8, and ESA's Sentinel 2. In Google Earth Engine, images retrieved from NASA are Landsat 7 and 8 and MODIS, for the years 2000 to 2018. ESA Sentinel 2 images retrieved are from 2014 to 2018. Sentinel 2 images provided 10-meter high-resolution images. In some instances, Sentinel 2 images were available every 16 days. MODIS data were used to analyze fire occurrence with the plot visualizing. MODIS data appears in a graph, the top-right corner of Figure 2-1.b.

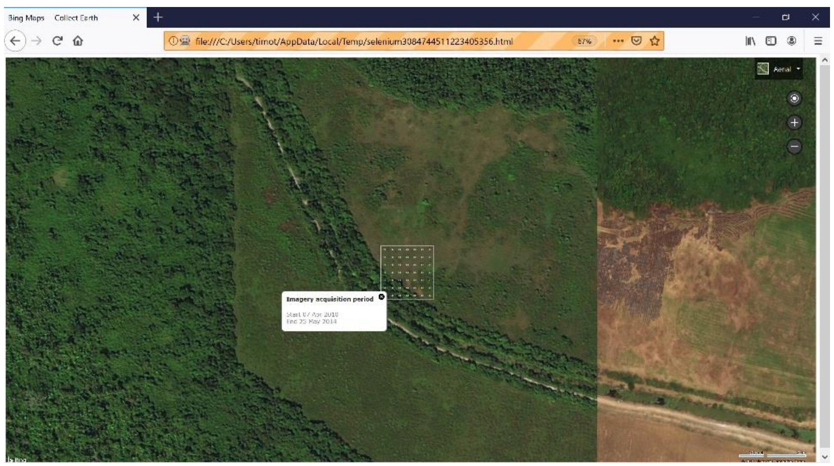
With at least seven (7) platforms that provided data and images from different dates, Collect Earth/Open Foris operators gathered land use and land-use changes for each sample plot using the survey sheet (Figure 2-1.a). Section 3.4 on 'Analysis of Land Use and Land Use Change from 2001 to 2018' describes how the visual interpretation process was conducted.



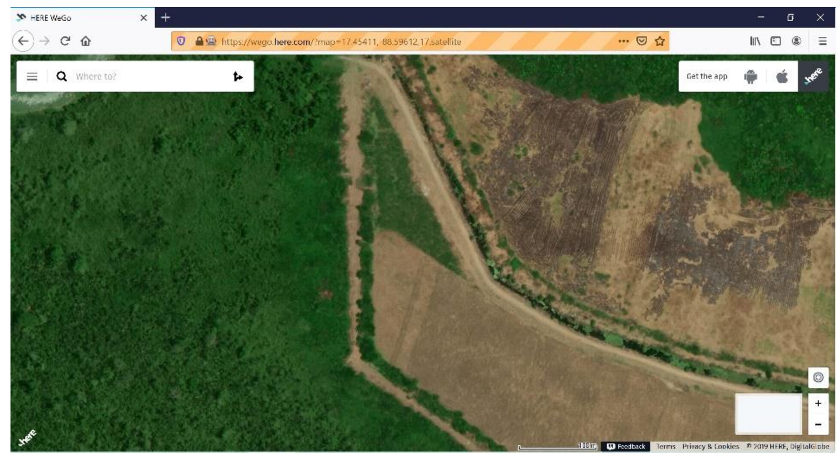
(a) BEL16922 Google Earth Survey Sheet.



(b) BEL16922 Earth Engine (clockwise: MODIS, top right; Landsat 8; Landsat 7, bottom right; Sentinel 2, bottom left).



(c) BEL16922 Bing maps composite image from April 2010 to May 2014.



(d) BEL16922 Here WeGo composite image (no date).

Figure 2-1. Belize Collect Earth/Open Foris visual interface.

2.3 Collect Earth/Open Foris Grid Design

To define a grid for sample plots for Belize, it was necessary to establish the total land area of Belize. This was calculated with Arc Map using the country district shapefiles obtained from the Lands Information Center of Belize. The result of the geometric calculation was an area of 22,110 square kilometers. After a systematic selection done in Google Earth Engine using the grid design parameters, a total of 21,991 sample plots were created. Figure 2-2 below provides an illustration.

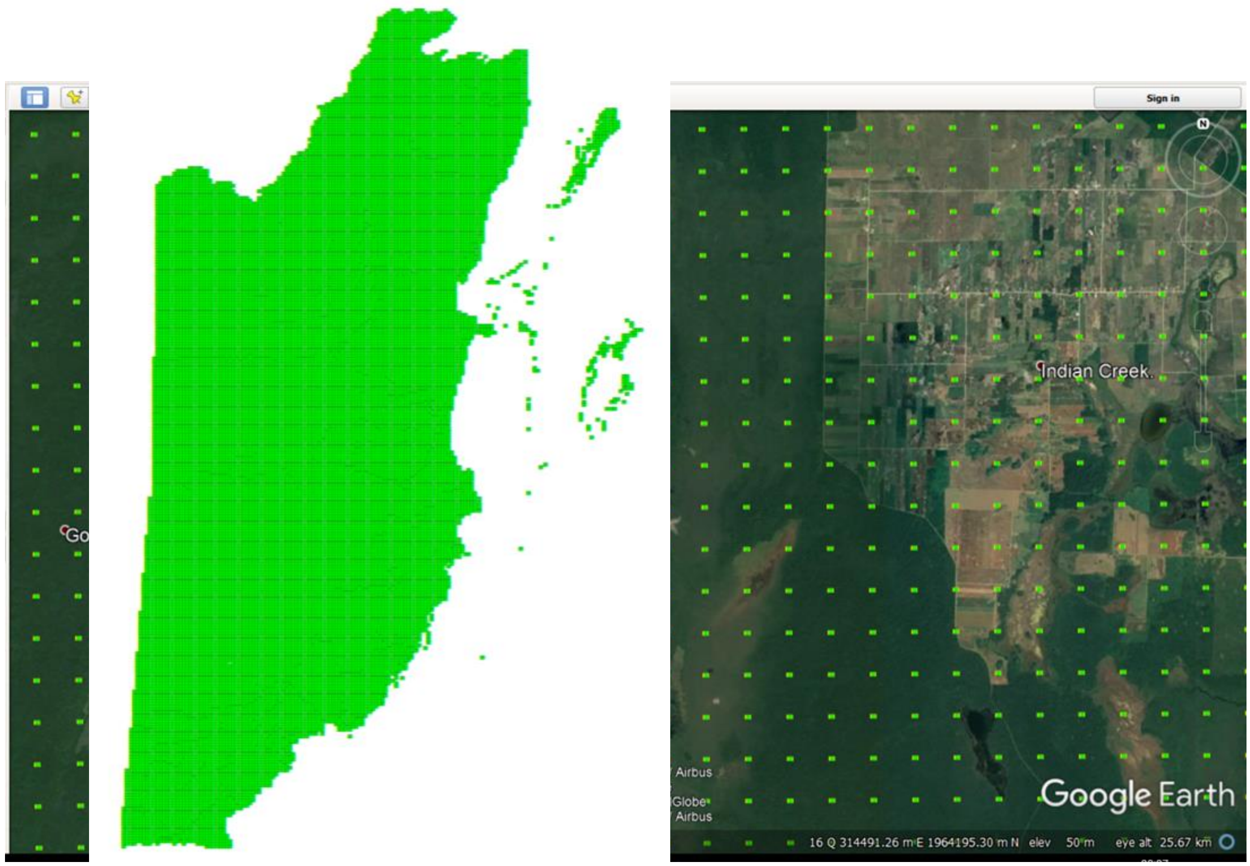


Figure 2-2. Grid design for the Belize Collect Earth/Open Foris tool.

For Belize, a plot size of 0.5 hectares with 1 kilometer between sample plots was defined for the 2018 Assessment, depicted in Figure 2-3. Half-a-hectare plot (0.5 ha) was also determined to be the country definition for the forest for Belize (see Section 2.6.a). Figure 2-1 above illustrates how a plot was visualized in each of the platforms integrated with the Collect Earth/Open Foris tool.

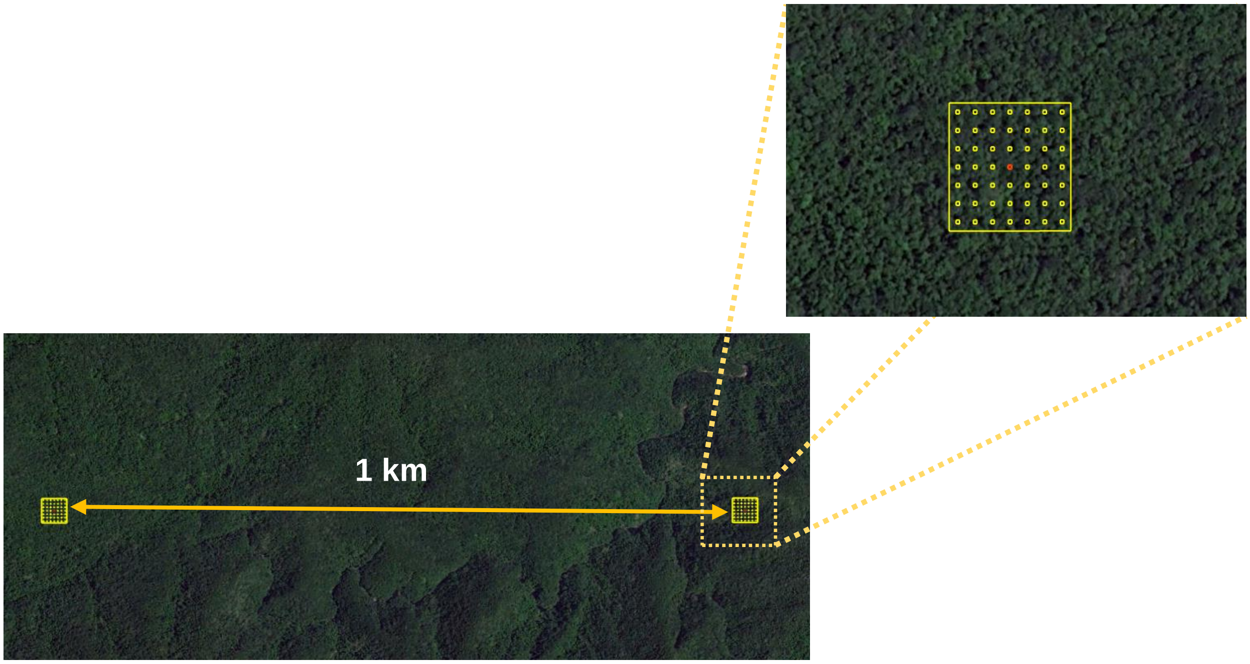


Figure 2-3. Distance between sample plots and illustration of 0.5-hectare plot in Google Earth Pro.

2.4 Collect Earth/Open Foris Survey Design

The survey sheet was designed to capture land use and land-use change and disturbances (for forest and grassland) for each sample plot. The data collected for each sample plot by the survey sheet included:

- The IPCC land use category in 2018;
- Land-use change from 2000 to 2018 (category and year of change);
- Percentage of coverage (e.g. trees, grassland, roads, et cetera);
- Accessibility of sample plot from the closest road;
- Disturbance for forest and grassland (main disturbance and year/s of disturbance); and,
- Availability of Very High-Resolution satellite imagery.

The final report by Alfonso Sánchez-Paus Días, the Lead Coordinator for the 2018 Assessment, contains a full description of the development of the survey sheets (see pages 11 – 15).

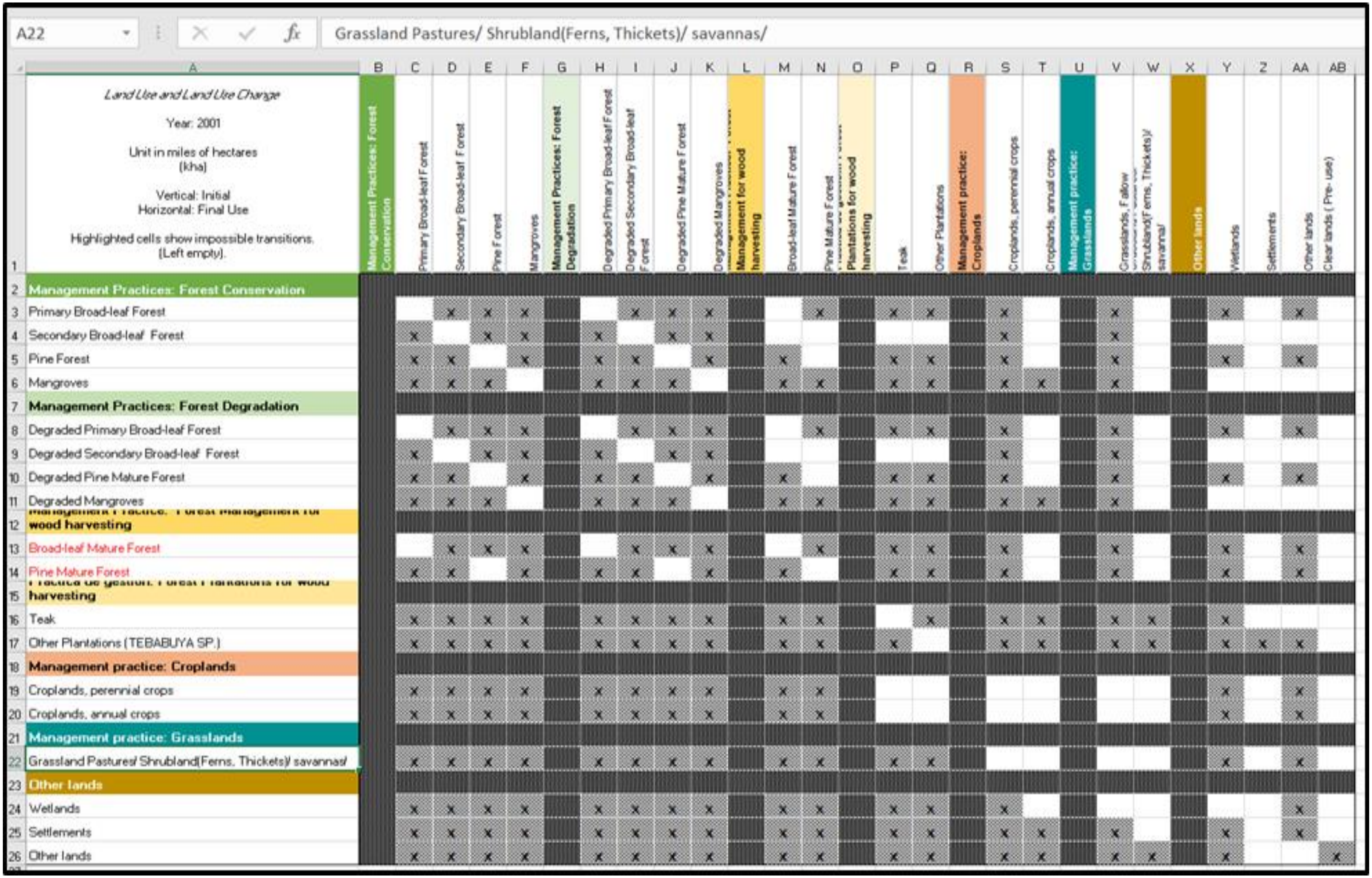
2.5 Planning for Implementation of the Collect Earth/Open Foris Assessment

After the training of the four (4) Forest Department Officers, there was a need for an in-country discussion with key stakeholders to outline the various technical considerations before commencing the CE/OF Assessment. Technical considerations for Belize included existing definitions for forests, land use classes, land-use change, forest cover, and ecosystem mapping and methods. Multiple discussions included national experts from the Belize Forest Department, the Lands and Survey Department, the University of Belize, the National Climate Change Office, private sector consultants, non-governmental organizations, and the Coalition for Rainforest Nations. Most of the discussions were led by the Chief Executive Officer from the Ministry of Agriculture, Fisheries, Forestry, the Environment, Sustainable Development, and Immigration.

Figure 2-4. Technical discussion during the Planning Phase with experts from Belize.

2.5.a Possible land-use transitions

During the technical discussions, it was necessary to understand national circumstances including definitions by law and natural dynamics that are specific to Belize. This was fundamental in determining possible land-use changes as well as impossible transitions between land-use changes in Belize (see Figure 2-5 below). This is very important since Belize has the commitment to conduct a year-by-year time series analysis, from 2000 to 2018, with the purpose of reporting the greenhouse gas emissions and removals annually. Having clear criteria allowed the time series analysis of possible land-use transitions to be transparent, accurate, consistent, complete, and comparable. This was key and would come into effect when doing QA/QC of the data collected.



A22 | Grassland Pastures/ Shrubland(Ferns, Thickets)/ savannas/

Land Use and Land Use Change

Year: 2001

Unit in miles of hectares (kha)

Vertical: Initial
Horizontal: Final Use

Highlighted cells show impossible transitions. (Left empty).

	Management Practices: Forest Conservation	Primary Broad-leaf Forest	Secondary Broad-leaf Forest	Pine Forest	Mangroves	Management Practices: Forest Degradation	Degraded Primary Broad-leaf Forest	Degraded Secondary Broad-leaf Forest	Degraded Pine Mature Forest	Degraded Mangroves	Management for wood harvesting	Broad-leaf Mature Forest	Pine Mature Forest	Plantations for wood harvesting	Teak	Other Plantations	Management practice: Croplands	Croplands, perennial crops	Croplands, annual crops	Management practice: Grasslands	Grasslands, Fallow	Shrubland(Ferns, Thickets)/ savanna/	Other lands	Wetlands	Settlements	Other lands	Clear lands (Pre-use)
Management Practices: Forest Conservation																											
Primary Broad-leaf Forest			x	x	x			x	x	x			x		x	x		x			x			x		x	
Secondary Broad-leaf Forest		x		x	x		x		x	x								x			x						
Pine Forest		x	x		x		x	x		x		x			x	x		x			x			x		x	
Mangroves		x	x	x			x	x	x			x	x		x	x		x	x		x						
Management Practices: Forest Degradation																											
Degraded Primary Broad-leaf Forest			x	x	x			x	x	x			x		x	x		x			x			x		x	
Degraded Secondary Broad-leaf Forest		x		x	x		x		x	x								x			x						
Degraded Pine Mature Forest		x	x		x		x	x		x		x			x	x		x			x			x		x	
Degraded Mangroves		x	x	x			x	x	x			x	x		x	x		x	x		x						
Management Practice: Forest Management for wood harvesting																											
Broad-leaf Mature Forest			x	x	x			x	x	x			x		x	x		x			x			x		x	
Pine Mature Forest		x	x		x		x	x		x		x			x	x		x			x			x		x	
Práctica de gestión: Forest Plantations for wood harvesting																											
Teak		x	x	x	x		x	x	x	x		x	x			x		x	x		x	x		x			
Other Plantations (TEBABUYA SP.)		x	x	x	x		x	x	x	x		x	x		x			x	x		x	x		x	x	x	
Management practice: Croplands																											
Croplands, perennial crops		x	x	x	x		x	x	x	x		x	x											x		x	
Croplands, annual crops		x	x	x	x		x	x	x	x		x	x											x		x	
Management practice: Grasslands																											
Grassland Pastures/ Shrubland(Ferns, Thickets)/ savannas/		x	x	x	x		x	x	x	x		x	x		x	x								x		x	
Other lands																											
Wetlands		x	x	x	x		x	x	x	x		x	x		x	x		x								x	
Settlements		x	x	x	x		x	x	x	x		x	x		x	x		x	x		x			x		x	
Other lands		x	x	x	x		x	x	x	x		x	x		x	x		x	x		x	x		x			x

Figure 2-5. Possible land use transitions in Belize for the 2018 CE/OF Assessment.

The ‘possible land-use changes’ for Belize was provided to the programmer of the CE/OF to design the survey sheets (Figure 2-1.a). This gave the Assessment additional QA/QC since the CE/OF operators would not erroneously enter impossible transitions.

2.5.b Hierarchy of land use classification

Another crucial discussion was the national definition of forest. The experts were cognizant that the sample plot to be visually assessed in the CE/OF is 0.5 hectare; focused on land-use changes and disturbances for forests and grasslands. Canopy cover percentage, thus, was fundamental to determine its land use. This led to the establishment of a hierarchy for the land use categories (Figure 2-6) for the visual interpretation during the CE/OF Assessment.

Categories	% Minimum
Forest	➢ 30
Cropland	➢ 20
Grassland	➢ 20
Wetland	➢ 20
Settelment	➢ 20
Other Land	➢ 80

Figure 2-6. Hierarchy of land use classification for Belize for the visual interpretation in the 2018 CE/OF Assessment.

According to the ‘hierarchy of land use classification’, if a sample plot in the CE/OF tool has 30% or more forest canopy, its land use will be classified as "forest". If a sample plot has 70% or more of a non-forest IPCC category, a determination is made to classify the sample plot according to the hierarchy. For example, if a plot only has 10 % forest, 20 % of grassland, 20 % of cropland, and 50 % of other lands, according to the hierarchy, the classification is cropland.

2.5.c Forest degradation

After defining forests for Belize, it became important to define forest degradation. The decision was made to use Meerman and Sabido (2010) Ecosystem Classification for forest degradation. For these authors and the CE/OF Assessment, the mature degraded forest is one that remains as a forest with a somewhat open canopy or closed canopy (65% to 90% of canopy). The degraded secondary broadleaf forest has a canopy percentage of 65% to 90% of the Forest Definition. Figure 2-7 provides guidance for the CE/OF operators.

- Closed Canopy: 95% to 100%. Broad leaf Mature Forest
- Closed or somewhat open canopy: 65% to 90%. Broad leaf Mature Forest degraded
- Closed or some what open canopy: 65% to 95%. Pine dominated evergreen regeneration.
- Some what Canopy: 65% to 95% Broad leaf Mature Plantation
- Semi Open Canopy: 65% to 95%, Broad-leaf dominated semi-deciduous / semi-evergreen secondary forest.

Figure 2-7: Degraded forest definition for Belize for the 2018 CE/OF Assessment.

2.5.d Ground truthing

One of the activities Forest Department Officers did before the CE/OF Assessment was capturing images of the IPCC land use categories along with their global positioning system coordinates. These globally positioned images in the CE/OF tool allowed the operators to familiarize themselves with how the IPPC land use category looked in a photograph and how they appear in the various satellite images as pixels. These images and GPS points were used to develop a visual guide of the IPPC land use categories for the CE/OF operators to use during the Assessment.

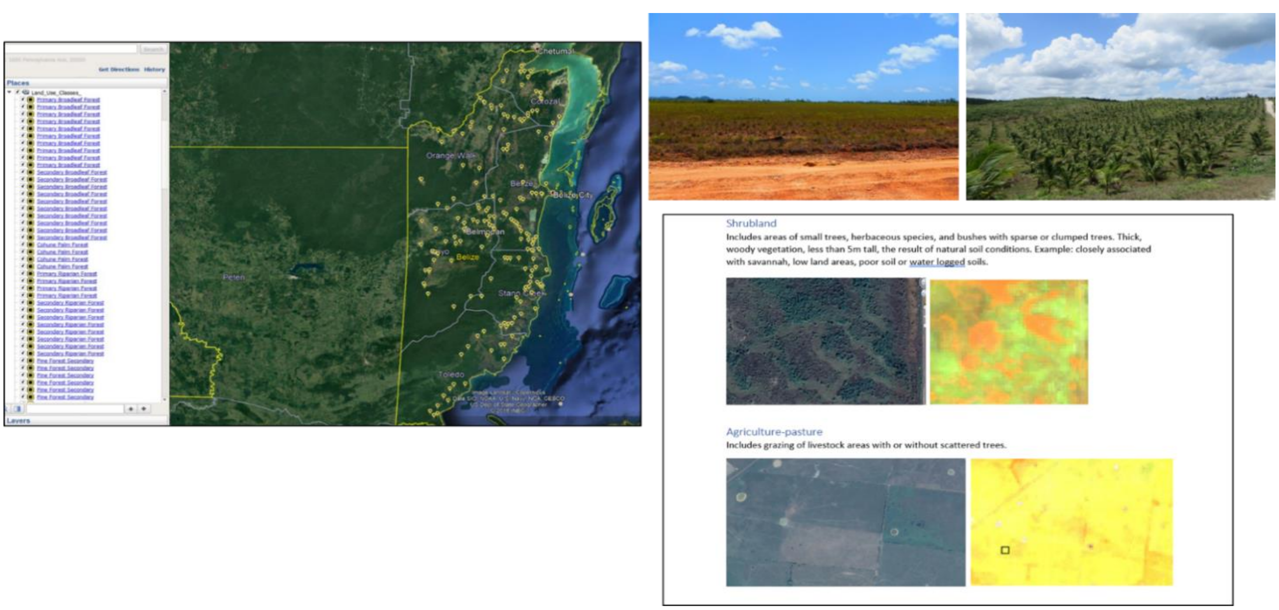


Figure 2-8. IPCC land use categories for the Belize 2018 CE/OF Assessment: GPS positions, images, and except from the guide.

In addition, the national geospatial file was sent to the Belize CE/OF Assessment tool developers. The file included shapefiles of:

- Ecosystem classification
- Protected Areas of Belize
- Administrative district shapefile
- Hurricane path (2000 to 2018)
- District shapefile

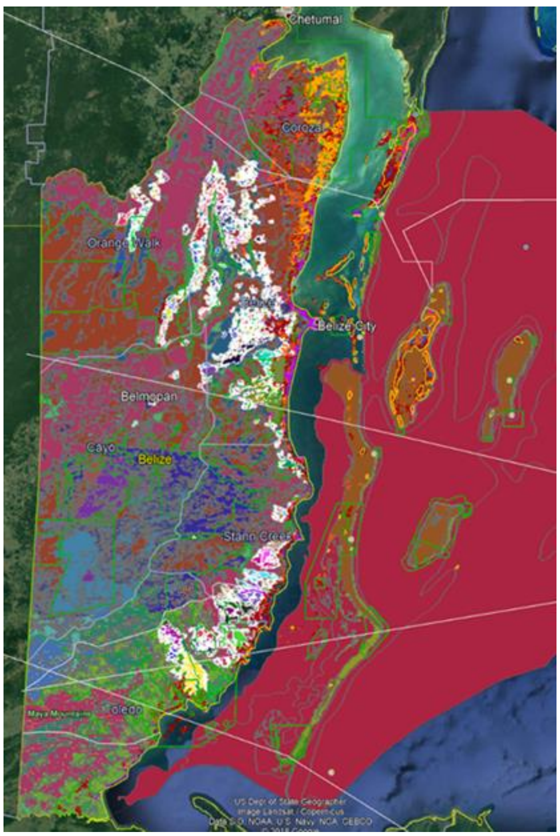


Figure 2-9. Belize geospatial layers used for the 2018 CE/OF Assessment.

During the planning session, decisions made for Belize were land use definitions, time frame for the assessment (2000 to 2018), CE/OF grid design, sample plot size, information to be collected with the CE/OF survey, land use transition matrix, hierarchy of land use classification, definition for forests and other IPPC categories, and a definition for degraded forest. Throughout the Preparation Phase, the Lead Expert from the Belize Forest Department was in constant communication with the developers of the CE/OF tool to ensure that all the decisions made were incorporated in the design.

2.6 Definitions for REDD+

Definitions for the assessment of the AFOLU sector required defining key REDD+ terminologies within the Belize national context. This saw the participation of experts from the Belize Forest Department, the Lands and Survey Department, the University of Belize, the National Climate Change Office, private sector consultants, non-governmental organizations, and the Coalition for Rainforest Nations. The process also considered the existing definitions from the Forest Department. The definitions for forest and the five (5) REDD+ activities considered the definitions of the United Nations Framework Convention on Climate Change.

2.6.a Forest

For Belize, the forest is a plot of land with an area of 0.5 hectares or more, with trees 5 meters or higher, and a canopy cover of 30% or higher. This definition also includes forest plantation. In addition, it includes an ecosystem that due to biotic conditions (terrain, soil type, rainfall, et cetera), the trees cannot grow higher than 5 meters.

Belize divided its ‘forest category’ into five subcategories/subdivisions. These are mature broad-leaf forest, secondary broad-leaf forest, pine forest, mangrove forest, forest plantation and regenerating forest (this is disturbed forest).

2.6.b Deforestation

Deforestation is when a forest is converted to another IPCC land use category (cropland, grassland, settlement, wetland, and other lands). Conversion can be caused by humans or natural causes (pest and hurricane).

For the visual interpretation in the CE/OF tool, within the 0.5-hectare sample plot, deforestation required that less than 30% of the forest canopy remained after the human or natural intervention.

2.6.c Forest degradation

Forest degradation is the process where a forest is disturbed but continues to remain as a forest. Forest disturbance can be caused by humans or natural causes. Natural forest disturbances are pests and hurricanes. Human disturbances are illegal logging, fire, shifting cultivation, infrastructure, and (livestock) grazing.

For degraded forest, within the 0.5 hectares visually interpreted in the CE/OF tool, 30 % to 90 % of the canopy need to have remained after the human or natural disturbance.

2.6.d Sustainable forest management

Sustainable forest management is the sustainable use and extraction of timber and non-timber forest resources. In Belize, SFM is allowed in three areas: state forest reserves, private forest reserves, and in community forests. Sustainable forest management is defined by a sustainable forest management plan (SFMP) that governs the sustainable use and extraction of forest resources. An SFMP is developed for areas that have long term forest licenses, granted by the Forest Department.[1]

In Collect Earth/Open Foris, the predominant sustainable forest practice was sustainable logging and its associated activities such as the construction of barquediers and logging trails. Logging in these areas was not considered as a forest disturbance (forest degradation) (illegal logging) since it is a lawful operation. Shapefiles of state and private protected areas were overlain to identify sustainably managed forests.

2.6.e Conservation

Conservation is the non-extractive use and enjoyment of natural resources from the protected areas of Belize.[2] The protected area categories in conservation are national parks, nature reserves, wildlife sanctuaries, and natural monuments.

In Collect Earth/Open Foris, shapefiles were overlain to identify terrestrial conservation areas.

2.6.f Enhancement of forest carbon stock

The enhancement of forest carbon stock is the creation or restoration of forest carbon pools through human intervention. This includes restoration of degraded lands,

[1] The Forest Department grants long term forest licenses for the sustainable forest management of the timber and non-timber forest products. These are governed by a sustainable forest management plan which is submitted periodically. SFMPs are monitored by the Sustainable Forest Management Program of the Forest Department.

[2] The use and enjoyment of the national parks of Belize is governed by the National Protected Areas System Act, Ch 215 of 2015. For details on prohibitions and exceptions, see Part VIII of the cited Act.

reforestation, afforestation and the use of agroforestry practices that enhance forest pools (e.g. agroforestry, silvopasture, intercropping, et cetera).

For the Collect Earth/Open Foris Assessment, however, forest plantations classified as forests after they met the forest definition of 30% or more of the canopy, 5 meters or more in height, and 0.5 hectares or more in area.

These concepts 'from REDD+' determined the land use and land-use change definitions for the Agriculture, Forestry, and Other Land Use (AFOLU) sector of Belize. The AFOLU sector, using the IPCC categories, was further defined taking into consideration the national circumstances of Belize. The following section provides the definitions.

2.7 IPCC Definitions for the AFOLU sector

The Intergovernmental Panel on Climate Change has the following six (6) categories for the Agriculture, Forestry, and Other Land Use (AFOLU) sector. These are forest, cropland, grassland, wetland, settlement, and other lands. Each IPPC category has further subcategories and specific classes. Table 2-1 below illustrates the classification and codes developed for Belize. The following section provides a definition of the IPCC category, subcategory, and specific class for the AFOLU sector of Belize.

2.7.a Forest (F)

Forest is a plot of land with an area of 0.5 hectares or more, with trees of heights of 5 meters or higher, and a canopy cover of 30% or higher. This definition also includes forest plantation. In addition, it includes an ecosystem that due to biotic conditions (terrain, soil type, rainfall, et cetera) the trees cannot grow higher than 5 meters.

Mature Broadleaf Forest (MBL)
Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **closed canopy cover** of 30% or higher. These forests include all classes of mixed-species broadleaf trees – including intermittent palms – on all types of soil at all elevations.

Mature Riparian Forest (MBLR)
Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **closed canopy cover** of 30% or higher. These forests are generally located on alluvial plains along

watercourses or in gullies in mountainous areas. The defining characteristic is that a mature riparian forest is found **within 66 feet (20 m) from a water source**.

Mature Swamp Forest (MSWAMP)
Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a closed canopy cover of 30% or higher. These forests are characterized by being **inundated seasonally or permanently**.

Other Mature Broadleaf Forest (MBLO)
Other Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **closed canopy cover** of 30% or higher. These forests include all classes of mixed-species broadleaf trees – including intermittent palms – on all types of soil at all elevations. If the specific class was not Riparian or Swamp MBL, then MBLO was used.

Secondary Broadleaf Forest (SBL)
Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **semi-open canopy** cover of 30% or higher. These forests include all classes of mixed-species broadleaf trees – including intermittent palms – on all types of soil at all elevations.

These are forests **regenerating** largely through natural processes **after significant human and/or natural disturbance land-use change** (with more than **70% mortality**) of the original forest vegetation at a single point in time or over an extended period. These forests also display a major difference in forest structure and/or canopy species composition with respect to nearby mature forest on similar sites.

Secondary Riparian Forest (SBLR)
Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **semi-open canopy** cover of 30% or higher. These forests include all classes of mixed-species broadleaf trees – including intermittent palms – on all types of soil at all elevations.

These are forests **regenerating** largely through natural processes **after significant human and/or natural disturbance land use change** (with more than **70% mortality**) of the original forest vegetation at a single point in time or over an extended period. These forests also display a major difference in forest structure and/or canopy species composition with respect to nearby mature forest on similar sites.

The defining characteristic is that secondary riparian forest is found **within 66 feet (20 m) from a water source**.

These are forests **regenerating** largely through natural processes **after significant human and/or natural disturbance land use change** (with more than **70% mortality**) of the original forest vegetation at a single point in time or over an extended period. These forests also display a major difference in forest structure and/or canopy species composition with respect to nearby mature forest on similar sites. If the specific forest class was not Riparian or Swamp, then SBLO was used.

Secondary Swamp Forest (SBLSWAMP)
Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **semi-open canopy** cover of 30% or higher. These forests include all classes of mixed-species broadleaf trees – including intermittent palms – on all types of soil at all elevations.

These are forests **regenerating** largely through natural processes **after significant human and/or natural disturbance** land use change (with more than **70% mortality**) of the original forest vegetation at a single point in time or over an extended period. These forests also display a major difference in forest structure and/or canopy species composition with respect to nearby mature forest on similar sites.

Other Secondary Broadleaf Forest (SBLO)

Other Broadleaf dominated semi-deciduous/semi-evergreen mature forest that is 0.5 hectare, with trees of a height of 5 meters or higher, and a **semi-open canopy** cover of 30% or higher. These forests include all classes of mixed-species broadleaf trees – including intermittent palms – on all types of soil at all elevations. The defining characteristic of the secondary swamp forests is that these are **inundated seasonally or permanently**.

Pine Forest (PINE)

Mature Pine Forest (PINEM)
A plot of land that is 0.5 hectares or more, with pine-dominated evergreen mature trees with a height of 5 meters or higher. Pine forests have some intermittent mixing of broadleaf tree species (oak, craboo). The defining characteristic is an **open canopy** that is dominated by pine trees with some intermittent small gaps of low broadleaf tree species, grass, or shrubs.

Secondary Pine Forest (PINES)
A plot of land that is 0.5 hectares or more, with pine-dominated evergreen mature trees with a height of 5 meters or higher. Pine forests have some intermittent mixing of broadleaf tree species (oak, craboo). The defining characteristic is an **open low canopy** that is dominated by pine saplings with some intermittent small gaps of low shrubby vegetation, grass or small broadleaf trees.

These are pine forests **regenerating** largely through natural processes **after significant human and/or natural disturbance** land use change (with more than **<u>70% mortality</u>**) of the original forest vegetation at a single point in time or over an extended period.

Mangrove (MAN)

Mangrove and Littoral (MANLIT)
Comprised of a monoculture of mangrove trees 5 meters or taller. Also includes mixed-species forests over 5 meters tall in brackish to saline conditions. Littoral mangroves are mostly found along the coastline and on cayes.

Dwarf Mangrove Forest (MAND)
Composed of mangrove species lower than 5 m tall. Also includes mixed-species forests lower than 5 meters tall in brackish to saline conditions. Dwarf mangroves are mostly found along the coastline and on cayes.

Forest Plantation (PLANTF)
Planted monoculture stands of broadleaf tree species. The main defining characteristic here is a stand of trees planted in rows with a **somewhat open canopy.** Common species planted include teak, mahogany, cedar, melina, and acacia.

Regenerating Forest (REGFOR)
A forest that was highly disturbed by either hurricane, fire, or pests, and is left to regrow. The distinguishing characteristic is significant loss in canopy cover without having a land use change by anthropogenic causes.

2.7.b Cropland (C)

Agricultural activity is 0.5 hectare of land that has a 20% cover with crops in the sample plot/point. Land that was once used for swidden agriculture and has been abandoned and is 'regenerating toward a secondary forest' is also considered cropland under specific class fallow land.

Swidden Farming (SHIFTAGR) [3]

[3] Definitions of Cropland were provided by the Coordinator for the Research & Innovation Program at the Department of Agriculture. Annual crops are crops that complete their life cycle from seed germination to seed production in one year (e.g. beans, corn, lettuce, sweet pepper, et cetera). Perennial crops are a crops that live year round, producing several crops or harvests during its life time (e.g. fruit trees).

A system of cultivation where land is cleared (and oftentimes burned) for the production of staple food-crop for a short period of time (1 to 3 years), followed by a long fallow period. Only annual crops are planted in swidden farming. Swidden farming is also referred to as milpa farming or slash-and-burn farming.

Intensive Agriculture (INTAGR)
A production system characterized by having high output per unit of lands as a result of increase in the use of technological inputs (e.g improved seed, irrigation, fertilizer application, pesticides, mechanization and capital). Intensive agriculture can be small scale or large scale. It can also be annual crops (eg. Corn, beans, etc.) or perennial crops (citrus, coconut, etc.)

Fallow Land (FALL)
Regeneration immediately after abandonment of agricultural activity. Fallow land that was monocrop takes eighteen (18) years to transition to secondary broad lead forest. During the initial eight (8) years of growth, fallow land has bushes. Consequently, for the next ten (10) years, fallow land is dominated by broadleaf pioneer tree species such as bay cedar, trumpet tree, pole wood, et cetera. At this stage, the defining characteristic of fallow land is an open canopy, with intermittent large trees, low vegetation, and high vine coverage. The canopy is generally lower than 5 meters. Fallow land is referred to as *wamil*.

2.7.c Grassland (G)

Grassland is 0.5 hectare of land that has a 20% cover of savannah, grass, shrubs, ferns, and tickets in the sample plot/point.[4] Cattle pasture is considered grassland.

Lowland Savannah (SAVG)
Savannah is dominated by graminoids (grasses and sedges) with scattered tree species. The dominant species is pine.

- Savannah with scattered trees: Dominated by graminoids (grasses and sedges) scattered with various tree species such as Oak, Palmetto Palms, Pines, and Calabash.

- Savannah with Scattered Shrubs: Dominated by graminoids (grasses and sedges) scattered with various shrub species.

- Open Savannah: Large expanse of areas covered by graminoids (grasses and sedges) only.

Shrubland (SHRUB)

[4] Definition for Grassland relied on the ‘Classification system for the forest and land cover map of Belize 2012/014 based on RapidEye imagery’ of 2016, published by the Forest Department.

Includes areas of small trees, herbaceous species, and with bushes with sparse and clumped trees. These thick and woody vegetation are less than 5 meters in height because of natural soil conditions, for example, savannah soil, low land areas, poor soils, and waterlogged soils.

Pasture (PAST)
This includes areas covered with grass and small plants or scattered trees. This includes livestock grazing areas and backyards/lawns, especially backyards in farming communities (e.g. Mennonite communities). The defining characteristic of pasture is that are established by humans.

Ferns/Thickets (FTG)
Large patches covered by tiger ferns (bracken) and other fern species. These are generally found in areas of higher elevation. Ferns generally occur after a disturbance such as fire. In the Columbia Forest Reserve, ferns and thickets appeared after hurricane disturbance in forests.

Regenerating Shrubs & Bushes (REGBUSH)

- Areas disturbed by natural causes (hurricane and fires) or human disturbance (abandoned pasture) that are left to regrow into a natural transition. Grassland areas that remain as regenerating bushes and shrubs because of continuous disturbance (natural and human) that does not allow them to transition to another category. However, regenerating bushes, e.g. abandoned pastures, can eventually transition to another category such as secondary forest.

- Regenerating Shrubs & Bushes (Mountain Pine Ridge) (REGBUSHP)

  In the **Mountain Pine Ridge Forest Reserve**: pine forests destroyed by a combination of pests and fire disturbances that was unable to recover to pine forest or in the process of recovery (see section 'Analysis of LULUC from 2001 to 2018' for explanation).

2.7.d Wetland (W)

Wetland (WET)
Wetland is an area that is 0.5 hectare or more that has a 20% permanent or seasonal floods, dominated by herbaceous/graminoid vegetation. Wetlands can have trees such as calabash (*Cresentia cujete*) or no trees.

Inland Water Bodies (IWB)
Area that is 0.5 hectare or more that has 20% of rivers, streams, inland lagoons, lakes, cenotes, and reservoirs that may have aquatic vegetation.

2.7.e Settlement (S

Settlements is an area that is 0.5 hectare or more that has 20% of urban construction that fall within the following subcategories:

City (SET)
Plots that fall within either Belize City or Belmopan City.

Town (SET)
Plots that fall within Corozal, Dangriga, Orange Walk, Punta Gorda, San Ignacio, Benque Viejo, San Pedro, or Santa Elena town.

Village (SET)
Settlement that is smaller than a town, having homes and related urban infrastructure.

Road (SET)
Paved or unpaved permanently transited roadways.

Mining (SET)
Areas generally quarried for construction material (white mall for road construction).

Aquaculture (SET)
Areas that are generally shrimp farms/ponds.

Other Settlement (SET)
Urban constructions that do not fall within any of the above (e.g. telephone antennas, etc.).

2.7.f Other lands (O)

Other lands is an area that is 0.5 hectare or more that has 80% of soils that fall in the following subcategories:

Bare Soil (BARS)
Area that has no vegetation, are not rocks and is not beach.

Bare Soil Rocks (BARS)
Area that is bare and are rocks.

Bare Soil Beach (BARS)
Area that fall on beaches having no vegetation.

Table 2-1. AFOLU sector categories for Belize, using IPCC categories.

Category	Code	Subcategory	Code	Specific class	Code
Forest					
Forest	F	Mature Broadleaf Forest	MBL		
Forest	F	Mature Broadleaf Forest	MBL	Riparian	MBLRIP
Forest	F	Mature Broadleaf Forest	MBL	Swamp Forest	MBLSWAMP
Forest	F	Mature Broadleaf Forest	MBL	Other	MBLO
Forest	F	Secondary Broadleaf Forest	MBL		
Forest	F	Secondary Broadleaf Forest	SBL	Riparian	SBLRIP
Forest	F	Secondary Broadleaf Forest	SBL	Swamp Forest	SBLSWAMP
Forest	F	Secondary Broadleaf Forest	SBL	Other	SBLO
Forest	F	Pine Forest	PINE		
Forest	F	Pine Forest	PINE	Mature	PINEM
Forest	F	Pine Forest	PINE	Secondary	PINES
Forest	F	Pine Forest	PINE	Unknown	PINUNK
Forest	F	Mangrove	MAN		
Forest	F	Mangrove	MAN	Mangrove & Littoral	MANLIT
Forest	F	Mangrove	MAN	Dwarf Mangrove	MAND
Forest	F	Mangrove	MAN	Unknown	MANUNK
Forest	F	Forest Plantations	PLANTF		
Forest	F	Forest Plantations	PLANTF	Teak	PLANTE
Forest	F	Forest Plantations	PLANTF	Other Plantations	PLANOT
Forest	F	Forest Plantations	PLANTF	Unknown	PLANUNK
Forest	F	Regenerating Forest	REGFOR		
Cropland					
Cropland	C	Swidden farming	SHIFTAGR		
Cropland	C	Intensive Agriculture	INTAGR		
Cropland	C	Intensive Agriculture	INTAGR	Corn	CORN
Cropland	C	Intensive Agriculture	INTAGR	Rice	RICE
Cropland	C	Intensive Agriculture	INTAGR	Sugar Cane	SUGCANE
Cropland	C	Intensive Agriculture	INTAGR	Beans	BEANS
Cropland	C	Intensive Agriculture	INTAGR	Banana	BANANA
Cropland	C	Intensive Agriculture	INTAGR	Coffee	COFFEE
Cropland	C	Intensive Agriculture	INTAGR	Citrus	CITRUS
Cropland	C	Intensive Agriculture	INTAGR	Coconut	COCONUT
Cropland	C	Intensive Agriculture	INTAGR	Shifting Crops	SHCROP
Cropland	C	Intensive Agriculture	INTAGR	Other Crops	OTCROP
Cropland	C	Intensive Agriculture	INTAGR	Unknown	AGRUNK
Cropland	C	Fallow land	FALL		

…cont'd

Category	Code	Subcategory	Code	Specific class	Code
Grassland					
Grassland	G	Lowland Savannah	SAVG		
Grassland	G	Lowland Savannah	SAVG	Savannah with scattered trees	SAVTREE
Grassland	G	Lowland Savannah	SAVG	Savannah with scattered shrubs	SAVSHRUB
Grassland	G	Lowland Savannah	SAVG	Open Savannah	SAVOPEN
Grassland	G	Shrubland	SHRUB		
Grassland	G	Pasture	PAST		
Grassland	G	Ferns/Thickets	FTG		
Grassland	G	Regenerating Shrubs/Bushes	REGBUSH		
Grassland	G	Regenerating Shrubs/Bushes (Pine)	REGBUSHP		
Wetland					
Wetland	W	Wetland	WL		
Wetland	W	Inland Water Bodies	IWB		
Settlement					
Settlement	S	City	CS		
Settlement	S	Town	TOWN		
Settlement	S	Village	VS		
Settlement	S	Other Settlement	OS		
Settlement	S	Road	RS		
Settlement	S	Mining	MS		
Settlement	S	Aquaculture	AQC		
Settlement	S	Other infrastructure	IS		
Other land					
Other land	O	Bare Soil	BARS		
Other land	O	Bare Soil	BARS	Rocks	ROCKS
Other land	O	Bare Soil	BARS	Beaches/Sand dunes	BEACH

After developing the definitions for REDD+ activities, definitions for the IPCC categories and subcategories, defined codes for the categories and subcategories, having the visual guide for the CE/OF operators, and having taken care of the equipment and logistical arrangements, the Implementation Phase was next. The next section describes that phase.

3. PHASE II: IMPLEMENTATION OF COLLECT EARTH/OPEN FORIS

Prior to the CE/OF Assessment, a three-day training was done with all the selected operators. Operators required some GIS knowledge and some level of satellite image interpretation skills. The training was on the uses of the Collect Earth/Open Foris tool. It focused on the operation of the CE/OF tool. The three (3) elements discussed at length were the input of data in CE/OF, development of forms in CE/OF, and the analysis of data collected from CE/OF. After the theoretical session, operators were given a two-day introduction on the Collect Earth/Open Foris tool. This part of the training focused on process. It also provided practical knowledge of visual interpretation in the CE/OF tool.

Operators had already installed the CE/OF, Google Earth Engine, Google Earth Pro, and Mozilla Firefox software on their laptops. All operators had to use their Google accounts or create one. Operators practiced how to launch the CE/OF tool, how to input and launch CSV files, fill the CE/OF surveys, and save the data collected. Collectively, the CE/OF operators assessed sample plots, using the visual guide. The visual guide and the IPCC category definitions gave operators clear guidance on how to assess and classify the sample plots. In addition, it provided guidance to document the disturbances in forests and grasslands.

Operators saw how a sample plot looks on Google Earth, Bing Maps, Here WeGo Maps, and Google Earth Engine. In addition, operators saw the land use history of a sample plot through the high-resolution images and the satellite images available for that plot. For the visual interpretation, operators could not rely on Google Earth images since these were not consistently up to date, and, the time series were too far in between. Herein the value of the Google Earth Engine interface since it provided NASA Landsat 7 and 8 images and ESA Sentinel 2, with 30-meter resolution and 10-meter resolution, respectively. of GEE provided us with Sentinel 2 and Landsat 7 imagery, through sentinel we could observe satellite imagery of 10m resolution for 2015-2018. Sentinel 2 images were available from 2015 to 2018, in some instances every 16 days.

After the three-day training workshop and the two-day practice on the operation of the CE/OF, the sample plots were distributed among the operators and the Belize 2018 CE/OF Assessment began.

3.1 Distribution of Sampling Area

The 21,991 sample plots were divided by each of the six districts. Each of the district's sample plots were further randomly divided into three data sets. This ensured that each operator had a separate data set to assess. Table 3-1 below illustrates how district's sample plots were distributed to the CE/OF operators.

Table 3-1. First distribution of sample area among mappers.

	Corozal	Orange Walk	Belize	Cayo	Stann Creek	Toledo
German Lopez	1					
Luis Balan	0, 2					
Mercedes Carcamo		1				
Florencia Guerra		2				
Edalmi Grijalva		0				
Koreen Sanchez			1			2
Kareem Reynolds			0.2		2	
Sumeet Betancourt				2		
Alex Escalante				0		
Jorge Nabet				1		
Timoteo Mesh					1	
Marcial Arias					0	
Edgar Correa						0
Brittany Meighan						1

After two weeks of CE/OF assessment, unassessed sample plots were further divided and distributed to some CE/OF operators that had completed their initial sample plots. Table 3-2 demonstrates the distribution.

Table 3-2. Second distribution of sample area among mappers.

	Corozal	Orange Walk	Belize	Cayo	Stann Creek	Toledo
German Lopez						
Luis Balan	0					
Mercedes Carcamo		1				
Florencia Guerra	1					
Edalmi Grijalva		0				
Koreen Sanchez						0
Kareem Reynolds			0,1		1	
Sumeet Betancourt				0		
Alex Escalante						
Jorge Nabet				1		
Timoteo Mesh						
Marcial Arias					0	
Edgar Correa						1
Brittany Meighan						

3.2 Analysis of Land Use and Land Use Change from 2000 to 2018

As discussed above, land use and land use change assessment and forests and grasslands disturbance assessment were conducted through visual interpretation. In the example below in Figure 3-1, the sample plot is a mature broadleaf forest in 2018. If it is a mature broadleaf forest in 2018 it is almost certain that the sample plot was a forest in 2000. It is important to note that if a sample plot is within a protected area, the plot generally has limited access. In addition, if a sample plot did not undergo any disturbance, it would not lead to forest/grassland degradation. Hence, for each sample plot, a historical review by the CE/OF operator is important.

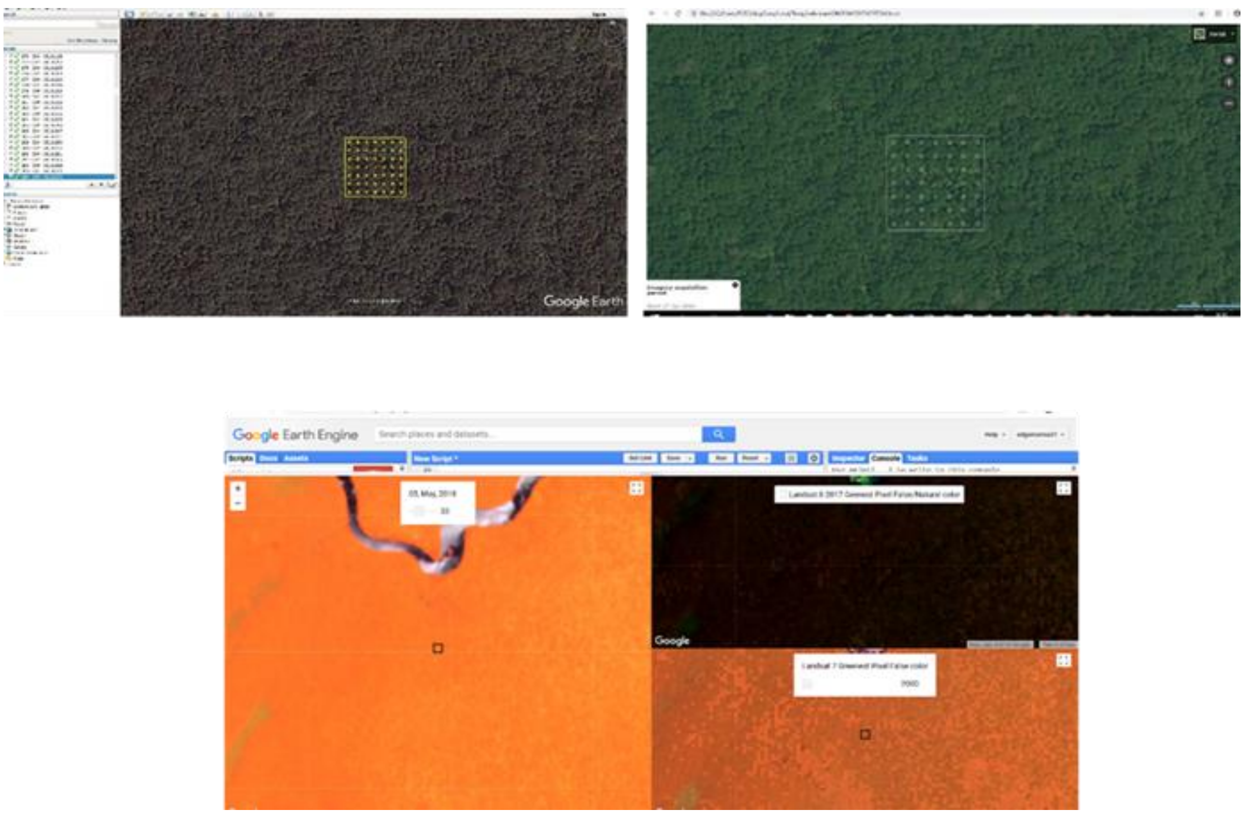
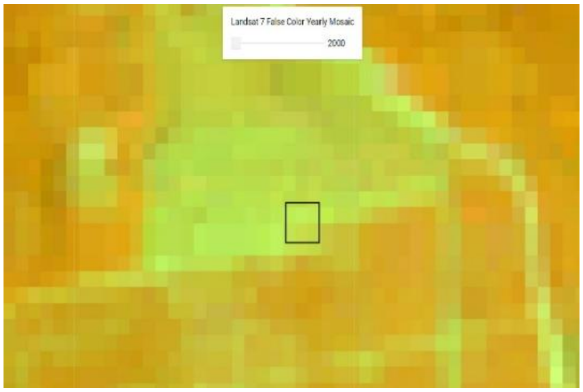


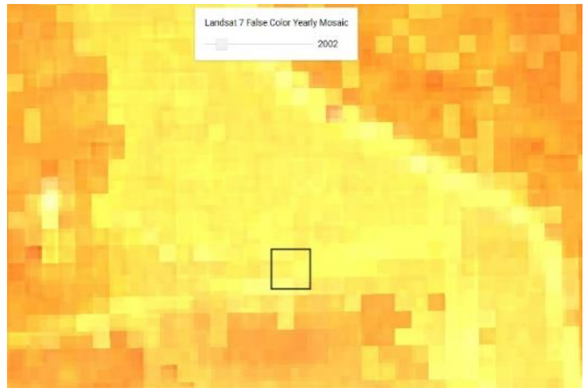
Figure 3-1. Sample plot with a 100% mature broadleaf forest in 2018.

Forest Plantation remaining as forest plantation

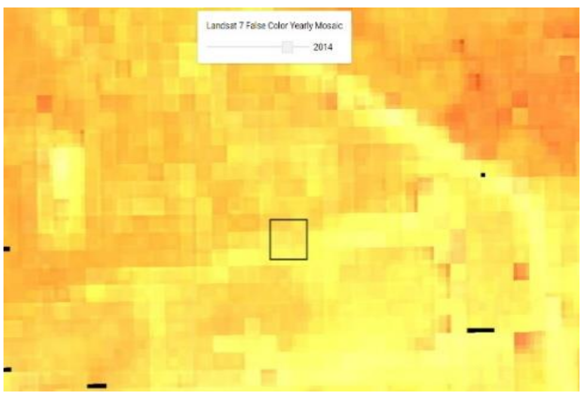
CSV: Cayo_O.CSV
ID: BEL14676



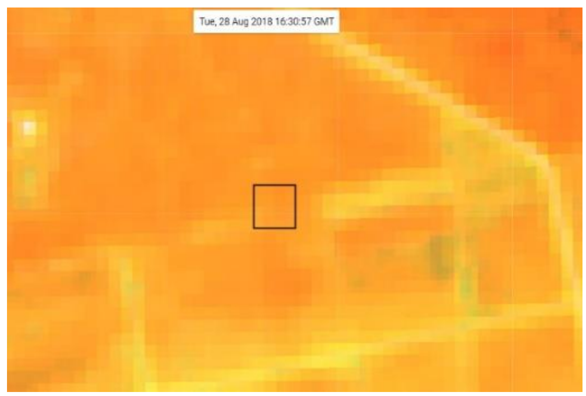
2000 (Landsat7 Image)



2002 (Landsat7 Image)

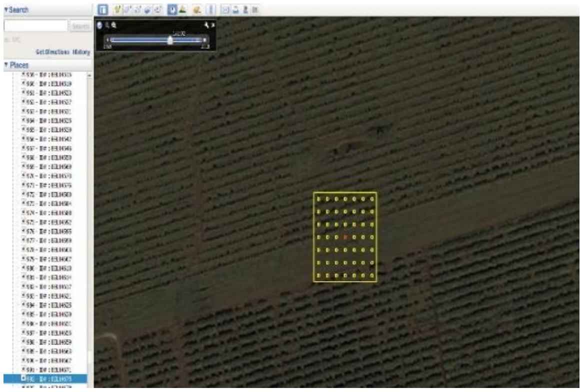


2014 (Landsat7 Image)



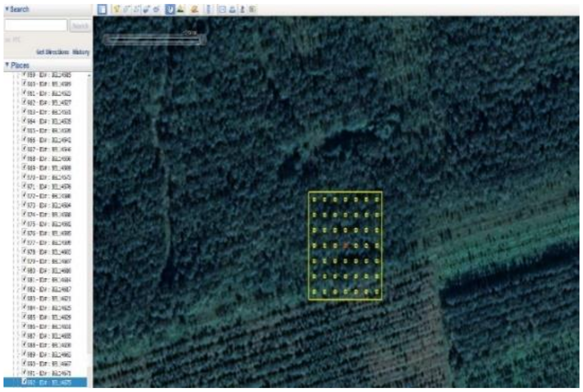
2018 (Sentinel-2 Image)

Figure 13 a: Plantations viewed with Landsat images



2002 (Google Earth Image)

2014 (Google Earth Image)



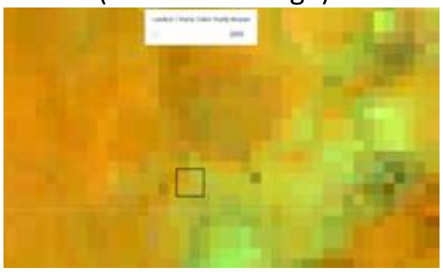
2018 (Google Earth Image)

Figure 13 b: Plantations viewed with Google Earth Images

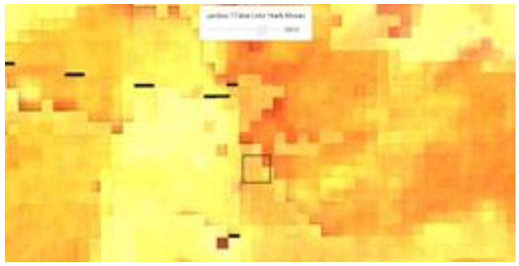
This sample plot is classified as Forest remaining Forest with a disturbance of grazing from the year 2000 to 2018

CSV: Cayo_1.csv
ID: BEL14737

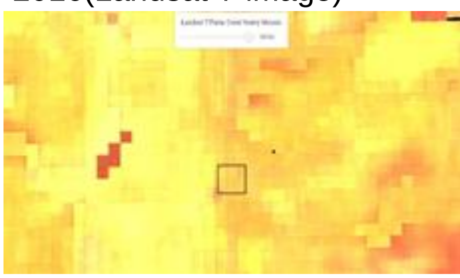
2000(Landsat-7 image)



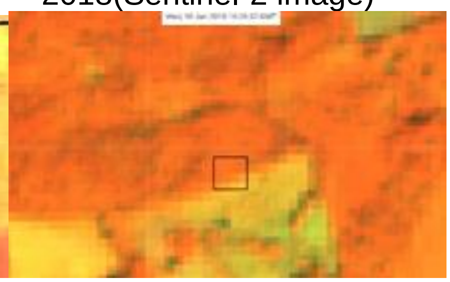
2013(landsat-7 image)



2016(Landsat-7 image)



2018(Sentinel-2 image)



2013(Google Earth Image)

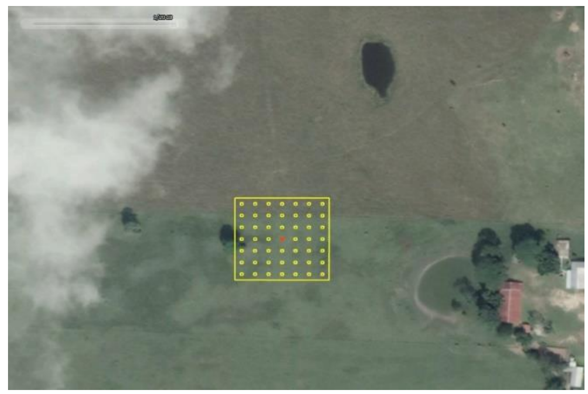
2016(Google Earth image)

2018(Google Earth image)

2018 (Sentinel-2 Image)

Figure 3-7.a. Satellite images showing grazing disturbance in a sample plot (___________ District, Belize).

2011 (Google Earth Image)



2018 (Google Earth Image)

Figure 3-7.b. Very high-resolution images showing grazing disturbance in a sample plot (___________ District, Belize).

3.2.a Transitions to mature broadleaf forest in Belize

As it pertains to transitions from other IPCC land use categories to the IPCC category of mature broadleaf forests in Belize, the following timeline was developed as a guideline to assist with the visual interpretation (see Figure 3-1). As it pertains to land use categories with little to no regeneration present, such as bare soil, pasture (grassland) and croplands, these require eighteen (18) years of no disturbance and natural transition/growth, for these to transition and be classified as secondary broadleaf forests. These secondary broadleaf forests, however, need to meet the definition of forest to be classified as such (Section 2.7.a). For land use categories with some regeneration present, such as fallow land and regenerating bushes and shrubs, the transition/growth time needed is ten (10) years, with no disturbance, for these to be classified as secondary broadleaf forests. Like in the previous instance, these need to meet the definition of forest (Section 2.7.a). The timeline for a secondary broadleaf forest to have the characteristics of a mature broadleaf forests would be dependent on environmental characteristics but could be anywhere from 20-50 years.

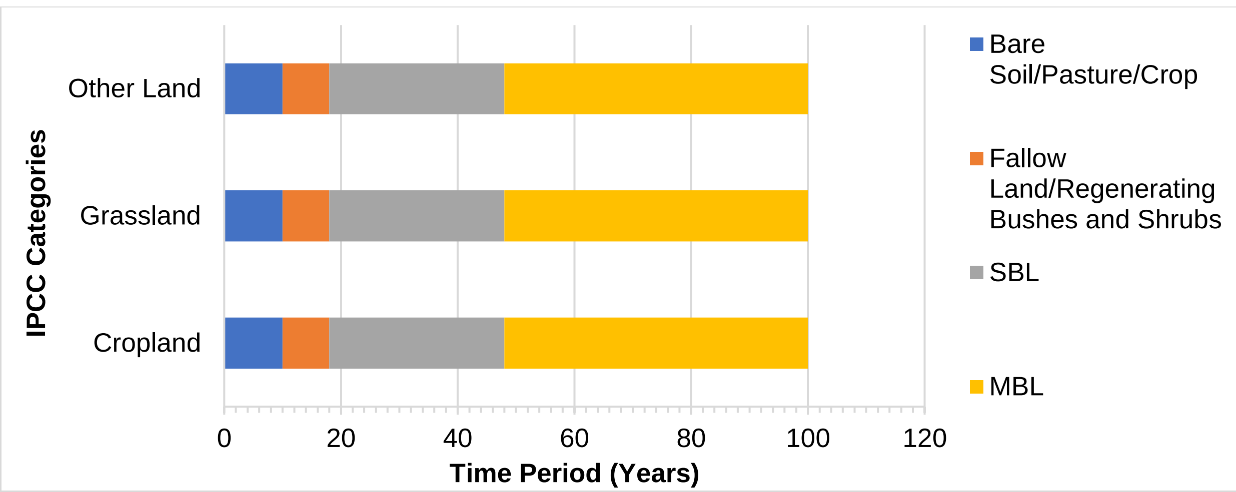


Figure 3-2. Natural transition toward mature broadleaf forests for Cropland, Grassland, and Other Lands.

While these are indicative timelines to transition toward mature broadleaf forest, there are biotic and abiotic factors that influence the transition. For example, during extended years of long and severe drought, it can take more than 18 years for a cropland to transition to secondary broadleaf forest.

3.3 Disturbance in forests and grasslands in Belize

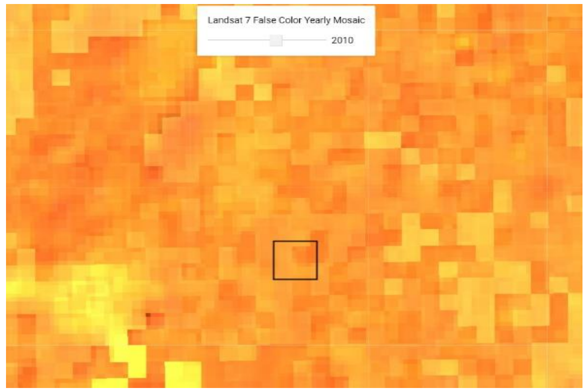
The disturbance was seen while doing the classification of the plot. The CE platform provided MODIS data graph to see the occurrence of fire within and around the plot, over the years. Hurricane paths were available as a kml layer in Google Earth and damages of plots could be seen in the high-resolution image over the time frame. Logging disturbance was noted in the area due to the best expert knowledge of logging roads and baquerdillas. Pest disturbance was noted from the area within the Mountain Pine Ridge and the best expert knowledge. Furthermore, changes in the canopy were noted within high-resolution imagery. Infrastructure and Mining disturbances could be seen within the high-resolution imagery over the time frame. Other human Impacts were noted from constant disturbances within an area of best expert knowledge. These areas we along the roadside, buffer zones of Protected Areas, Electrical Boundary Lines, constant maintenance of the property and around urban and rural areas. Below are some examples of disturbances. Overall, disturbances were noted as high and low accordingly to the plot damaged.

3.3.a Hurricane disturbance

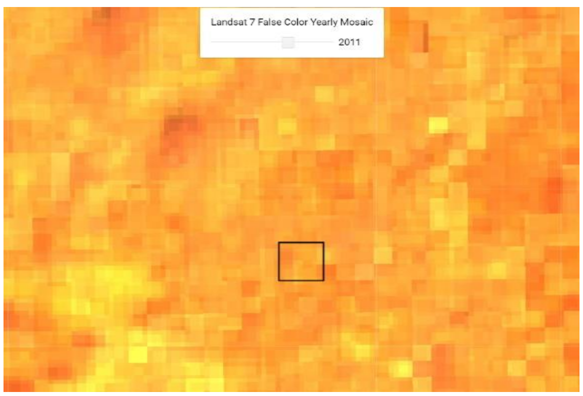
Hurricane Richard affected this sample plot in October 2010. Its effect can be seen in the collage of images from 2011.

CSV: Cayo_O.CSV
ID: BEL14851

2000 (Landsat7 Image)



2010 (Landsat7 Image)



2011 (Landsat7 Image)

Figure 3-3.a. Satellite images showing hurricane disturbance in a sample plot (Cayo District, Belize).

2010 (Google Earth Image)

2010-2014 (Bing Map Image)

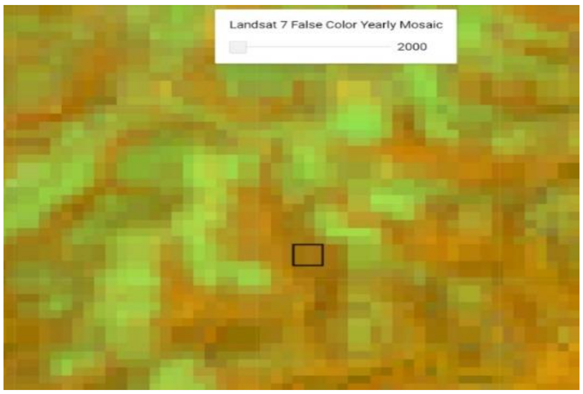
2018 (Google Earth Image)

Figure 3-3.b. Very high-resolution images showing hurricane disturbance in a sample plot (Cayo District, Belize).

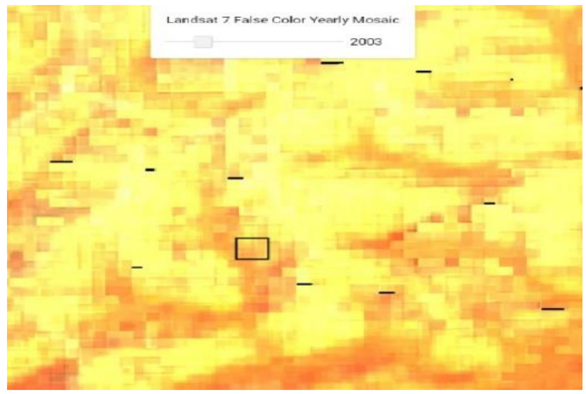
3.3.b Pest disturbance

This sample plot located in the Mountain Pine Ridge area was highly affected by an outbreak of bark beetle infestation in the late 1990's and early 2000's. Its effect (and recovery) can be seen in the collage of images below.

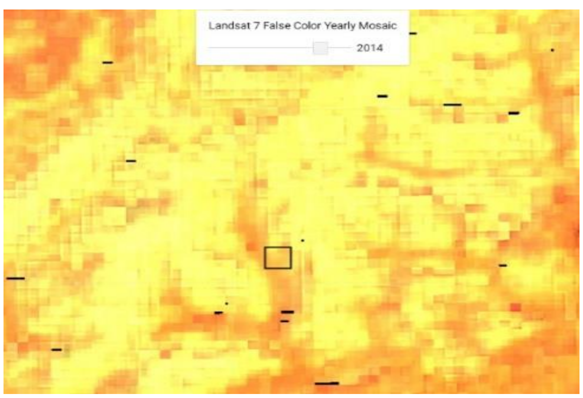
CSV: Cayo_O.CSV
ID: BEL05797



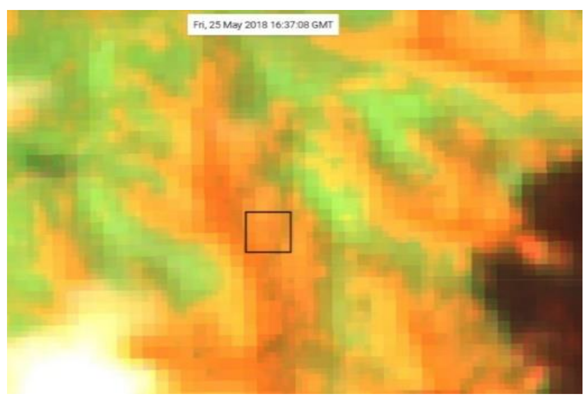
2000 (Landsat7 Image)



2003 (Landsat7 Image)



2014 (Landsat7 Image)



2018 (Sentinel-2 Image)

Figure 3-4.a. Satellite images showing pest disturbance (bark beetle) in a sample plot (Cayo District, Belize).

2003 (Google Earth Image)

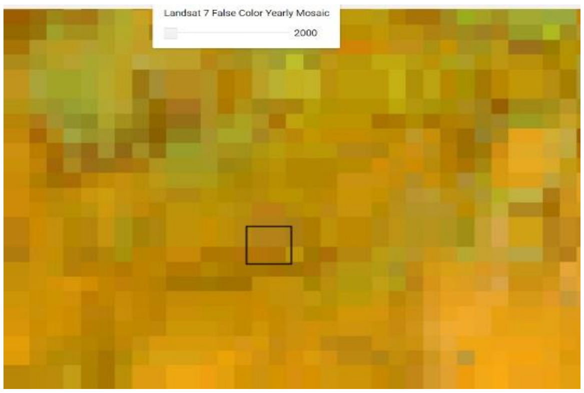
2014 (Google Earth Image)

Figure 3-4.b. Very high-resolution images showing pest disturbance (bark beetle) in a sample plot (Cayo District, Belize).

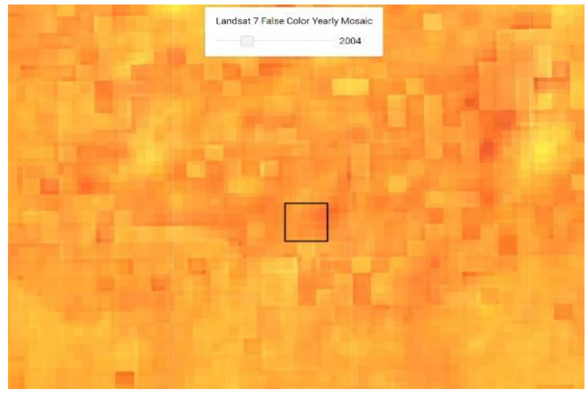
3.3.c Fire disturbance

This sample plot is a forest that remained as forest, with a fire disturbance in 2017. Its effect can be seen in the collage of images below.

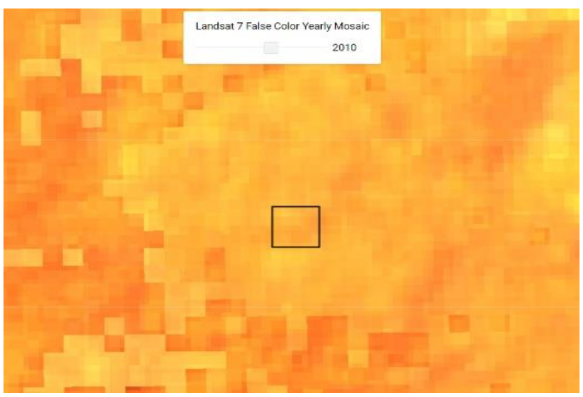
CSV: Cayo_2.CSV **ID:** BEL14849



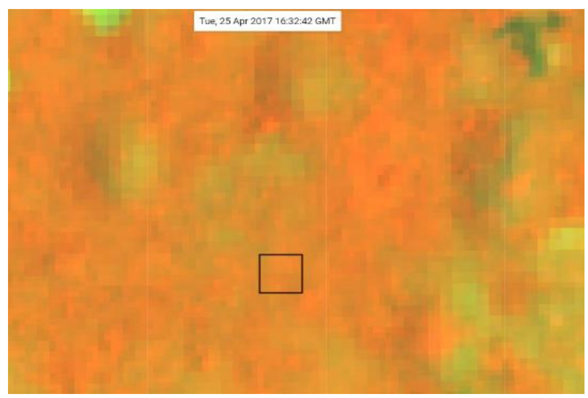
2000(Landsat7 Image)



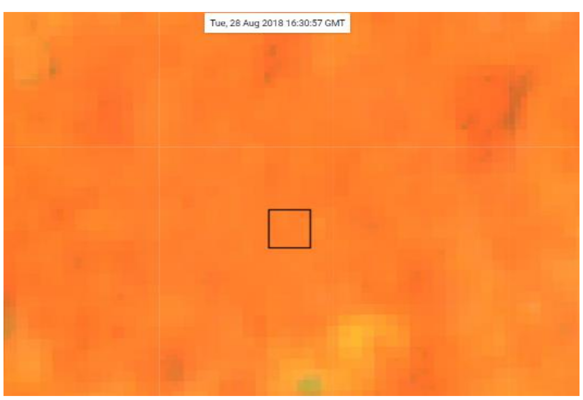
2004(Landsat7 Image)



2010 (Landsat7 Image)



2017 (Sentinel-2 Image)



2018 (Sentinel-2 Image)

Figure 3-5.a. Satellite images showing fire disturbance in a sample plot (Cayo District, Belize).

2003 (Google Earth Image)

2010 (Google Earth Image)

2017 (Google Earth Image)

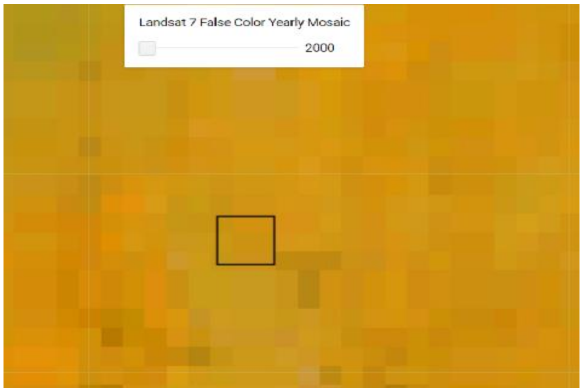
2018 (Google Earth Image)

Figure 3-5.a. Very high-resolution images showing fire disturbance in a sample plot (Cayo District, Belize).

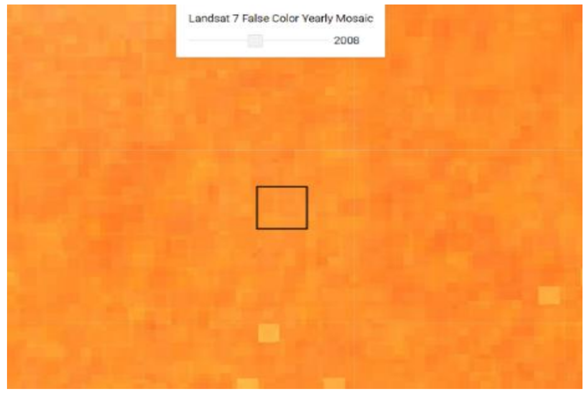
3.3.d Logging disturbance

This sample plot is a forest that remained as forest, with a logging disturbance in 2017. Its effect can be seen in the collage of images below.

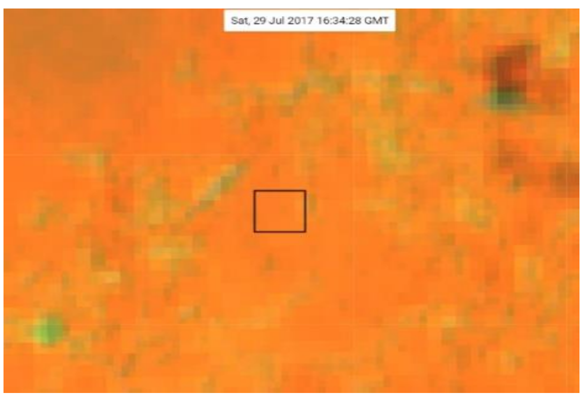
CSV: Orange Walk_1.CSV
ID: BEL08952



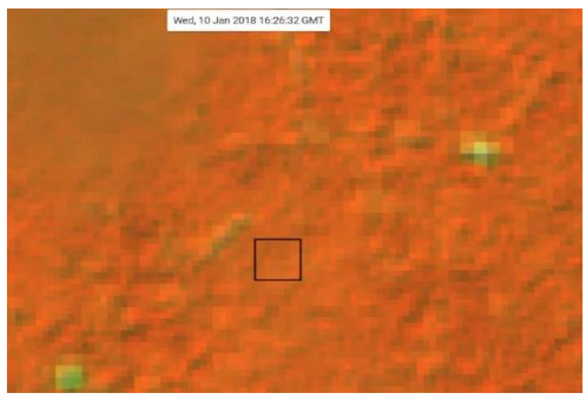
2000 (Landsat7 Image)



2008 (Landsat7 Image)



2017 (Landsat7 Image)



2018 (Sentinel-2 Image)

Figure 3-6.a. Satellite images showing logging disturbance in a sample plot (Orange Walk District, Belize).

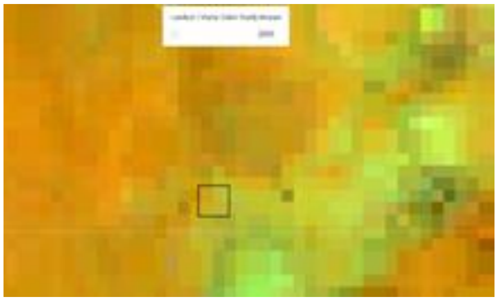
2014 (Google Earth Image)

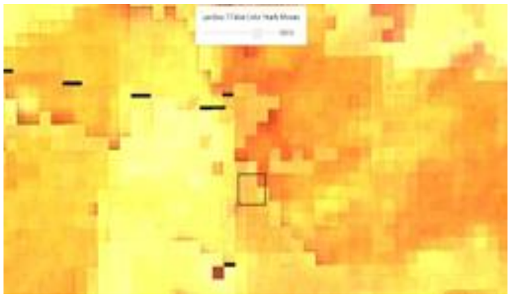
2017 (Google Earth Image)

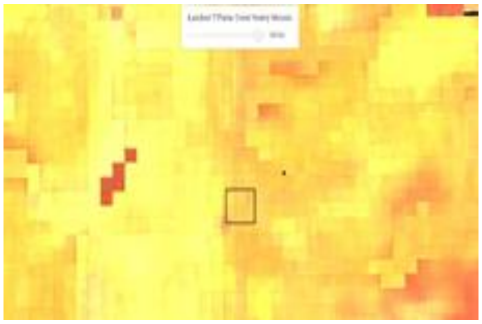
Figure 3-6.b. Very high-resolution images showing logging disturbance in a sample plot (Orange Walk District, Belize).

3.3.e Grazing disturbance
This sample plot is classified as pasture from the year 2000 to 2018 with a disturbance of grazing throughout the eighteen years.

CSV: Cayo_1.csv
ID: BEL14737


2000(Landsat-7 image)


2013(Landsat-7 image)


2016(Landsat-7 image)

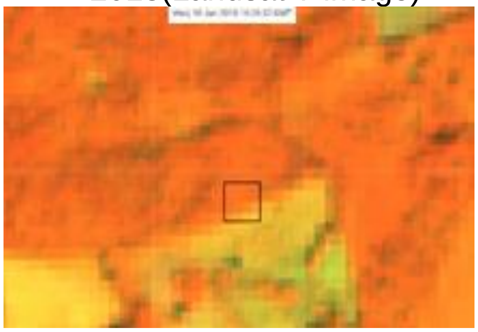
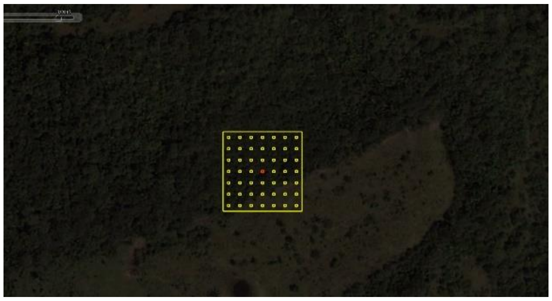
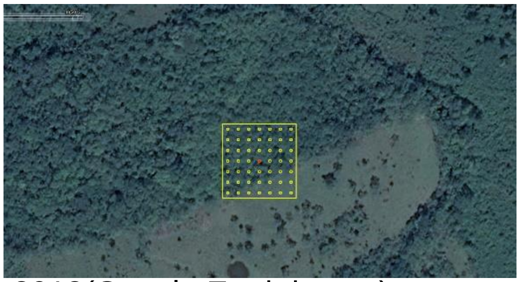

2018(Sentinel-2 image)

Figure 3-7.a. Satellite images showing Grazing disturbance in a sample plot (Cayo District, Belize).


2013(Google Earth image)


2016(Google Earth image)

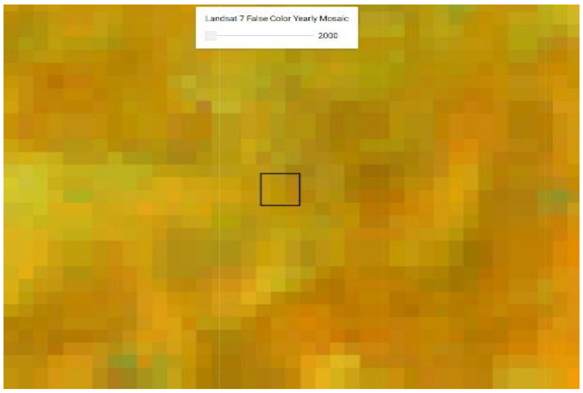


2018(Google Earth image)

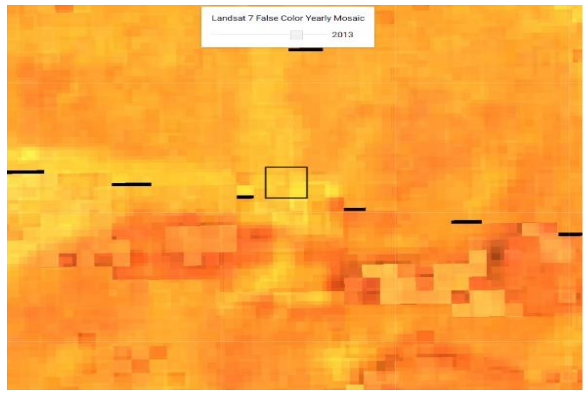
3.3.f Shifting cultivation disturbance

This sample plot is a forest that remained as forest, with a shifting cultivation disturbance in 2013. Its effect can be seen in the collage of images below.

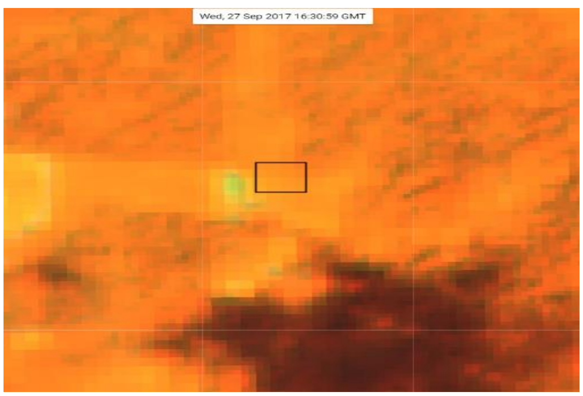
CSV: Cayo_1.CSV
ID: BEL13696



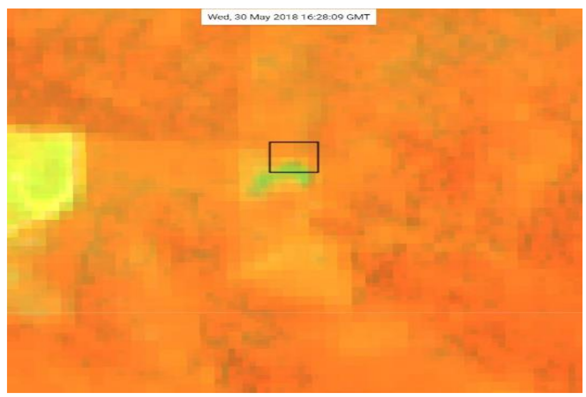
2000 (Landsat7 Image)



2013 (Landsat7 Image)



2017 (Sentinel-2 Image)



2018 (Sentinel-2 Image)

Figure 3-8.a. Satellite images showing shifting cultivation disturbance in a sample plot (Cayo District, Belize).

2013 (Google Earth Image)

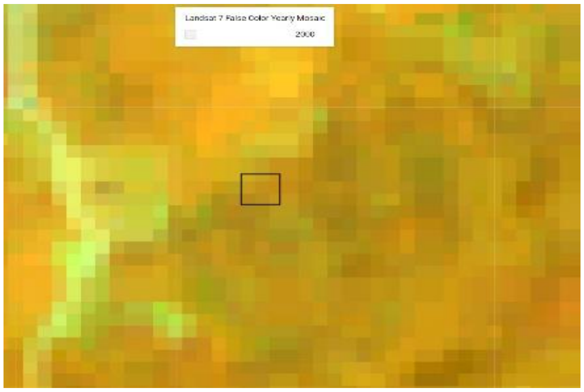
2017 (Google Earth Image)

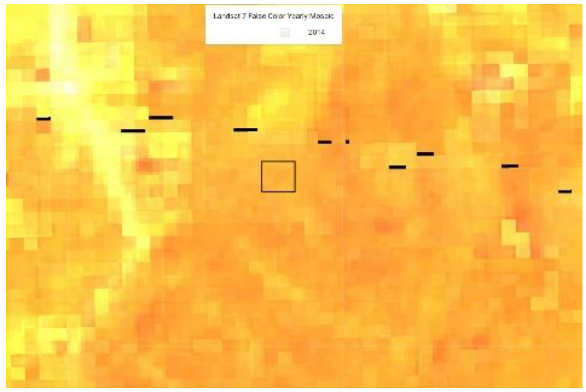
2018 (Google Earth Image)

3.3.g Infrastructure disturbance

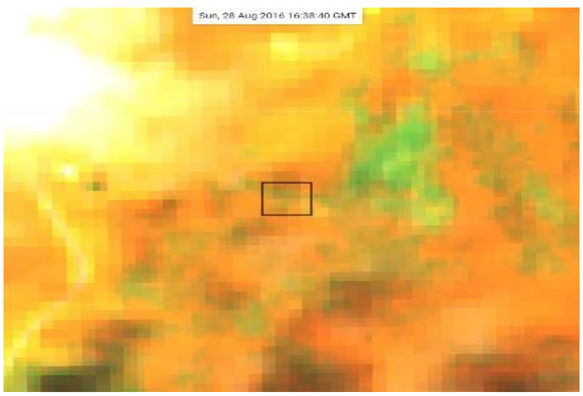
This sample plot is a forest that remained as forest, with a infrastructure disturbance in 2016. A road was opened through the forest in 2016 and continued to be open in 2018. This is seen in the collage of images below.

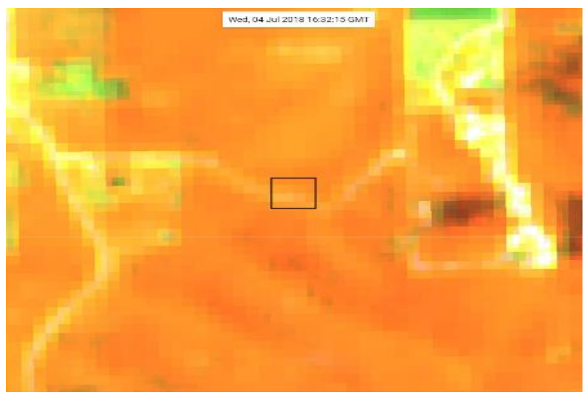
CSV: Cayo_0.CSV
ID: BEL14023





2000 (Landsat7 Image) **2014** (Landsat7
Image)





2016 (Sentinel-2image) **2018**
(Sentinel-2 Image)

Figure 3-9.a. Satellite images showing infrastructure disturbance in a sample plot (Cayo District, Belize).

2014 (Google Earth Image

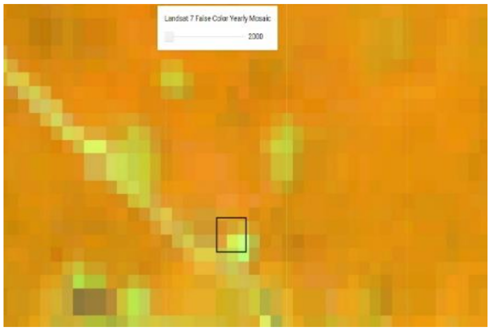
2016 (Google Earth Image)

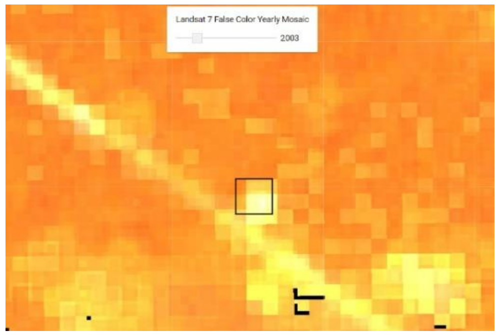
2018 (Google Earth Image)

3.3.h Mining disturbance

Images of mining disturbance should be placed in this section. There are 2 plots (FF) in Belize with this disturbance: BEL12787 and BEL13403. Both are in Stann Creek District.

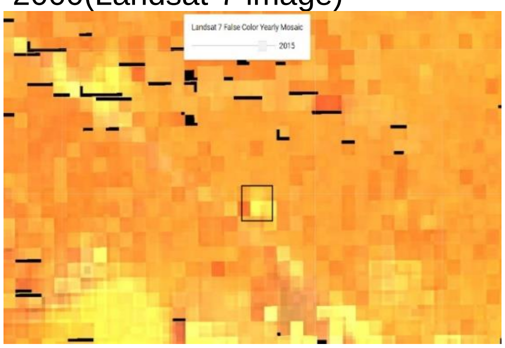
CSV: Corozal_0.csv
ID: BEL10555

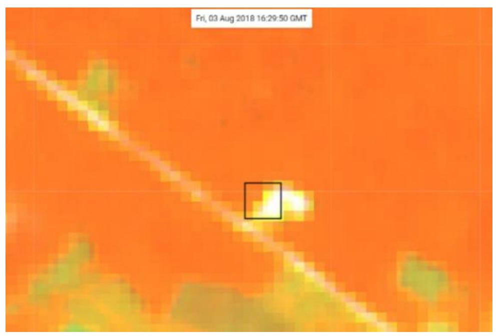




2000(Landsat-7 image)

2003(Landsat-7 image)

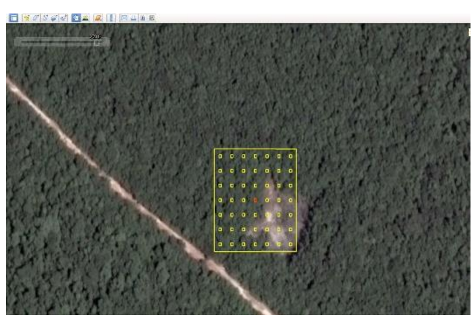




2015(Landsat-7 image)

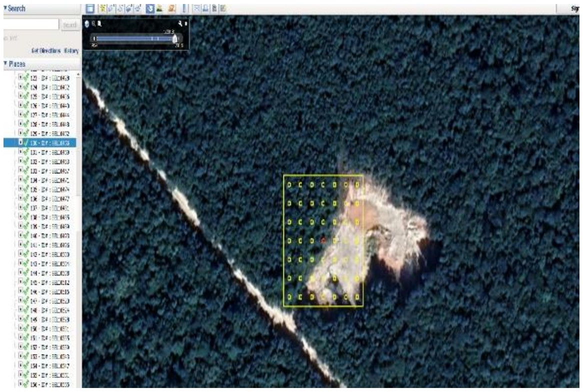
2018(Landsat-7 image)

Figure 3-10.a Satellite images showing mining disturbance in a sample plot (Corozal District, Belize).



2003(Google Earth image)

2015(Google Earth image)

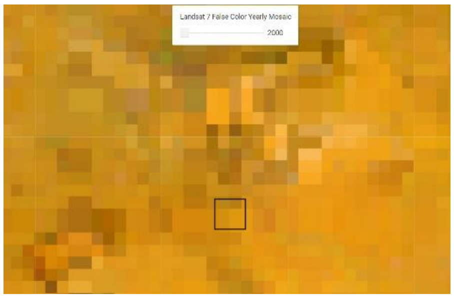


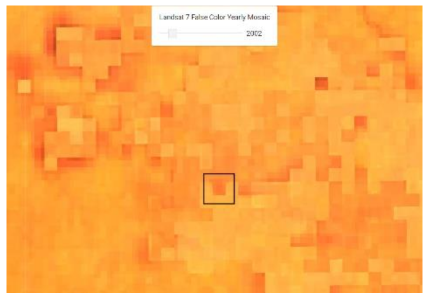
2018(Google Earth image)

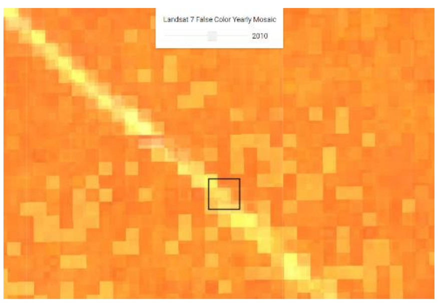
3.3.i Other human impact disturbance

This sample plot is a forest that remained as forest, with other human impact disturbance from 2000 to 2018. Its effect can be seen in the collage of images below.

CSV: Cayo_1.csv
ID: BEL16333


2000(Landsat-7 image)


2002(Landsat-7 image)


2010(Landsat-7 image)

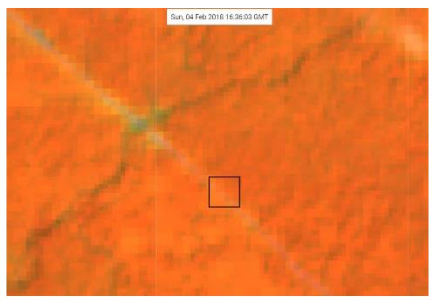

2018(Sentinel-2 image)

Figure 3-11.a Satellite images showing other human impact disturbance in a sample plot (Cayo District, Belize).


2002(Google Earth image)


2010(Google Earth image)


2019(Google Earth image)

4. PHASE III: VALIDATION OF COLLECT EARTH/OPEN FORIS RESULTS

4.1 Quality Control/Quality Assurance During the CE/OF Assessment (August 2018)

The main Quality Assurance/Quality Control activity conducted during the CE/OF Assessment was to have a second operator reassess five (5) % of all the sample plots of Belize. These sample plots were randomly selected and ensured that the same operators were not ‘reassessing themselves’. A detailed methodology and the results of that QA/QC activity can be found in the final report of Alfonso Sánchez-Paus Díaz, the CE/OF Lead Expert (see Section ‘Interpretation error’, pages 36 – 38). We note the coincidence level between the first assessment and the second assessment for forests was above 95%.

After the CE/OF Assessment was completed, a one-week ‘Collect Earth Post-Mapathon’ workshop was conducted in Belize by the CE/OF Lead Expert (see Annex V for an agenda). The workshop included learning how to operate Saiku for data analysis. Saiku is a business intelligence tool that is linked with Collect Earth for the data analysis. Saiku has a multispectral approach, allowing user to create tables or graphs from the data collected with the CE/OF tool.

During this ‘CE Post-Mapathon’ workshop, we conducted another validation using Saiku. We filtered sample plots by developing queries that identified plots that needed additional review. Figure 4-1 below illustrate some of the queries that were developed and the results. Approximately 3000 sample plots were identified for review after the workshop. The sample plots identification number were sent to the Lead CE/OF Expert so the sample plots could be imported into CE/OF and consequently reassessed by the CE/OF operators in Belize.

Plots with NO CONFIDENCE for LAND USE CHANGE	304
Plots with NO CONFIDENCE for LAND USE Subdivision	527
Plots where the LU change year was not specified	18
Plots that where there was a change of use of less than 10 years and became forest	18
Forest plots where the tree cover was set to Not Applicable (NA)	331
Intensive agriculture plots where the crop cover is set to Not Applicabe (NA)	81
Mangrove plots that are located above 15 meters of elevation	20
Plots that are still not finished (in yellow) so there is some attribute left to fill	156
Plots with more than 30% crop cover that are classified as Forest, Grassland, Otherland or Wetland	63
Plots with more than 30% tree cover that are classified as Grassland, Otherland or Wetland	126
Plots with more than 30% of roads that are not classified as Settlement	11
Plots with more than 30% of Built-Up that are not classified as Settlement	4
Plots with mulitple land uses that are classified as Forest with a tree cover under 30%	49
Plots with mulitple land uses that are classified as Cropland with a crop cover under 30%	34
Plots where there is no land cover information at all (all elements set as NA)	507
Review plots inside protected areas with a recorded Land Use change	215
Review plots with one cange where there was not a specification if there was a second land use change	101
Review plots where there is a transition to Forest from intensive agriculture	11
Review plots that have changed from Pine to shrubs or Lowland Savannah	11

Figure 4-1.Sample of queries in Saiku that identified sample plots for reassessment.

Following this reassessment of the approximately 3000 plots, the activity data (AD) for all the 21,991 plots were forwarded to the Coalition for Rainforest Nations to draft the Greenhouse Gas Inventory tool. The AD was necessary for CfRN to generate preliminary results for Belize's Forest Reference Level Report. During this Validation Phase of the CE/OF Assessment, the Geospatial Monitoring Unit of the Belize Forest Department created maps to visualize the activity data of Belize, from 2001 to 2018.

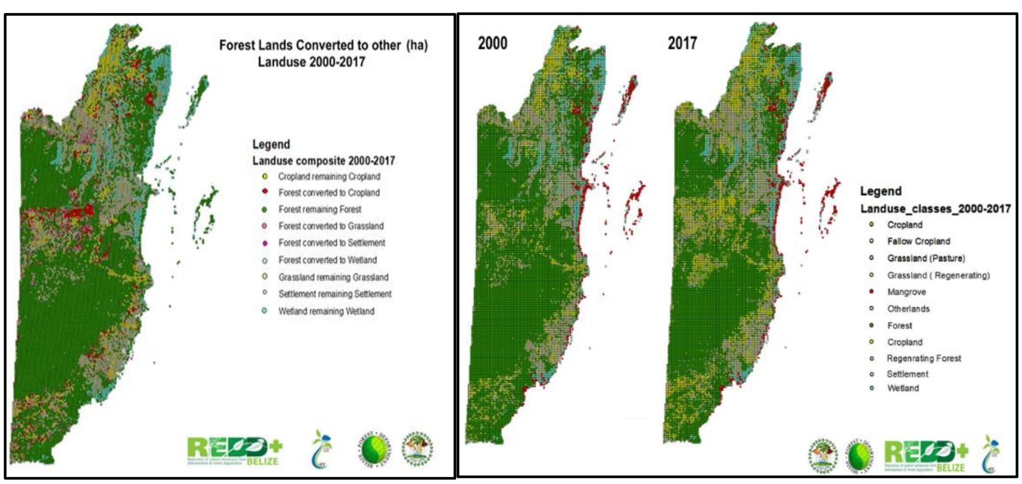
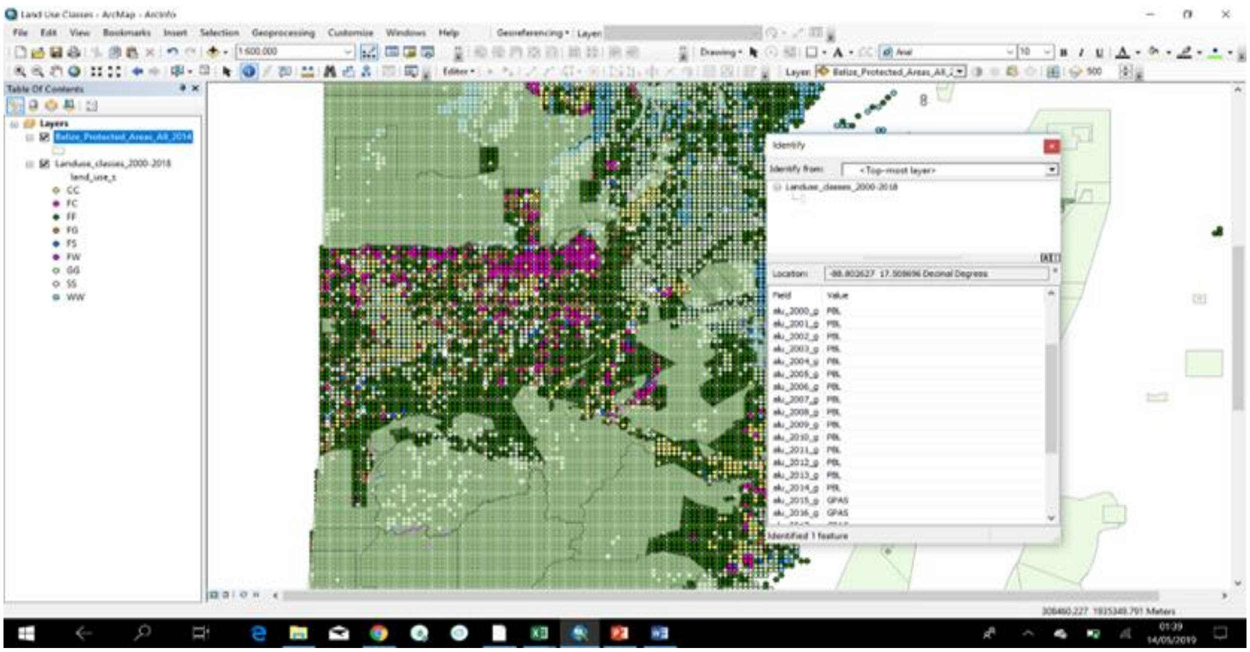


Figure 4-2. GIS maps showing CE/OF activity data for Belize.

Having the activity data in GIS allowed the Geospatial Monitoring Unit to visualize and further analyze the information by overlaying other geospatial layers, as illustrated below.



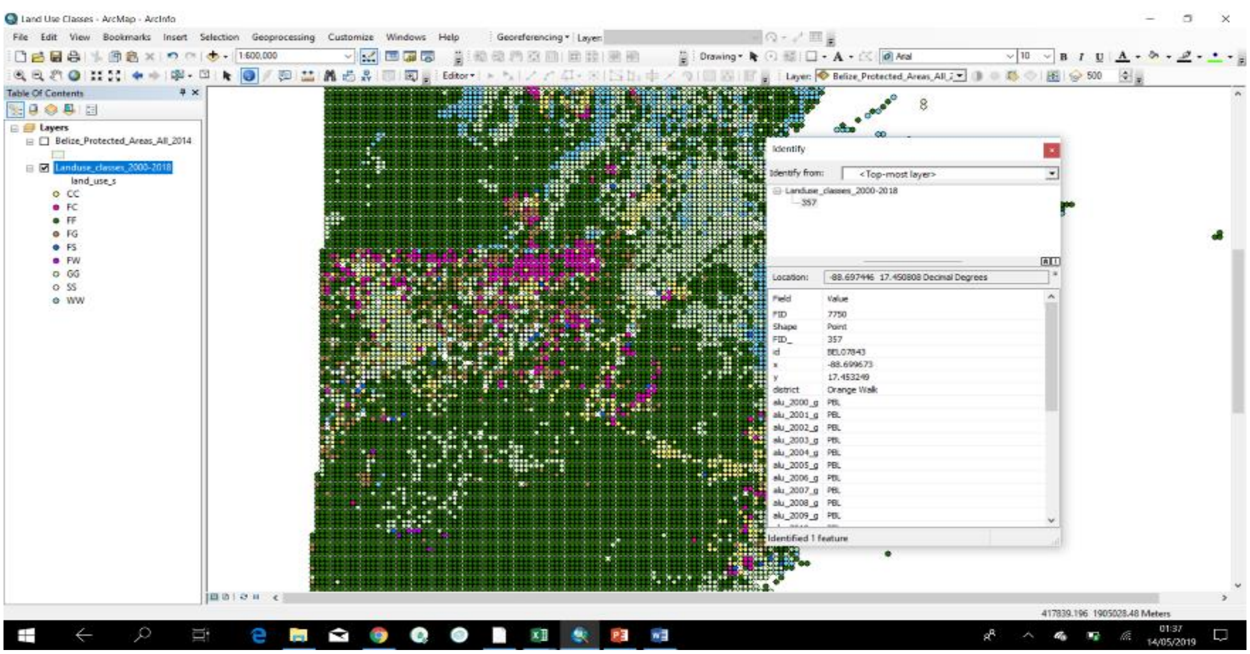


Figure 4-3. Overlaid protected areas on Belize's activity data.

4.3 Quality Control/Quality Assurance of Activity Data (October 2019)

With the use of the activity data by Geospatial Monitoring Unit and the Forest Department in general, it became evident that some of the sample plots needed review. It was noted that some of the sample plots that were classified as secondary broadleaf forests were indeed mature broadleaf forests. Visualizing the activity data in Arc Gis was the key reason why this observation was made. In addition, it was also noted that there were uncertainties with the classification of shrublands and these were reassessed as well.

The National Forest Monitoring System Working Group, therefore, decided to conduct one last reassessment of secondary broadleaf forests and shrublands of the 2018 CE/OF Assessment. The Working Group is composed of the Belize Forest Department and the National Climate Change Office personnel. The decision to conduct a final reassessment was guided by the Chief Executive Officer of MAFFESDI, Dr. Percival Cho. Dr. Cho is an expert on the forest dynamics of Belize.

Figure 4-4. Belize National Forest Monitoring System Working Group session.

In October 2019, the last reassessment of the CE/OF Assessment saw the review of more than 11% of all the sample plots. This included 2,505 secondary broadleaf

(SBL) sample plots and 1,416 shrubland sample plots. The filtering and splitting of the sample plots were done in Microsoft Excel. Shrubland and SBL sample plots were reviewed separately. Both lists of sample plots were split by districts, distributed among CE/OF operators. This last reassessment was conducted by the same CE/OF operators as in August 2018. Operators used the CE/OF tool to retrieve satellite and very-high-resolution images for each of the sample plots. Activity data and disturbances, however, were manually recorded in a Microsoft Excel spreadsheet (see Figure 4-5).

5	ID	District	2000	2001	2002	2017	2018	Time 1 (Initial LU)	Time 2 (Final LU)	IPCC Category	Year of Conversion	Main disturbance	Year of Main Disturbance
6	BEL00001	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF			
7	BEL00002	Toledo	SHIFTAGR	SHIFTAGR	SHIFTAGR	SHIFTAGR	SHIFTAGR	CANNUAL		CC			
8	BEL00003	Toledo	REGBUSH	REGBUSH	REGBUSH	SBL	SBL	GREG	FSBL	GF	2011	fire	2007
9	BEL00004	Toledo	REGBUSH	REGBUSH	REGBUSH	SBL	SBL	GREG	FSBL	GF	2011	other_human_impact	2016
10	BEL00005	Toledo	MBL	MBL	MBL	REGBUSH	REGBUSH	FMBL	GREGBUSH	FG	2011		
11	BEL00007	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF			
12	BEL00008	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF			
13	BEL00009	Toledo	MBL	MBL	MBL	FALL	FALL	FMBL	CFALL	FC	2014		
14	BEL00011	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF			
15	BEL00012	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF			
16	BEL00013	Toledo	MBL	MBL	MBL	REGBUSH	REGBUSH	FMBL	GREGBUSH	FG	2016		
17	BEL00014	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF			
18	BEL00015	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF			
19	BEL00016	Toledo	MBL	MBL	MBL	REGBUSH	REGBUSH	FMBL	GREGBUSH	FG	2002	other_human_impact	2002
20	BEL00017	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF		other_human_impact	2000
21	BEL00018	Toledo	REGBUSH	REGBUSH	REGBUSH	SBL	SBL	GREG	FSBL	GF	2011		
22	BEL00019	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF			
23	BEL00020	Toledo	REGBUSH	REGBUSH	REGBUSH	SBL	SBL	GREG	FSBL	GF	2011	shifting_cultivation	2000
24	BEL00021	Toledo	REGBUSH	REGBUSH	REGBUSH	SBL	SBL	GREG	FSBL	GF	2011		
25	BEL00022	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF			
26	BEL00023	Toledo	REGBUSH	REGBUSH	REGBUSH	SBL	SBL	GREG	FSBL	GF	2011	other_human_impact	2001
27	BEL00024	Toledo	PAST	PAST	PAST	PAST	PAST	GGRASS		GG			
28	BEL00025	Toledo	SBL	SBL	SBL	REGBUSH	REGBUSH	FSBL	GREGBUSH	FG	2015		
29	BEL00026	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF			
30	BEL00027	Toledo	MBL	MBL	MBL	SHIFTAGR	SHIFTAGR	FMBL	CANNUAL	FC	2015		
31	BEL00028	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF			
32	BEL00029	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF		logging	2015
33	BEL00030	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF			
34	BEL00031	Toledo	SHIFTAGR	SHIFTAGR	SHIFTAGR	SHIFTAGR	SHIFTAGR	CANNUAL		CC			
35	BEL00032	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF		other_human_impact	2008
36	BEL00033	Toledo	MBL	MBL	MBL	SHIFTAGR	SHIFTAGR	FMBL	CANNUAL	FC	2013		
37	BEL00034	Toledo	REGBUSH	REGBUSH	REGBUSH	SBL	SBL	GREG	FSBL	GF	2011		
38	BEL00035	Toledo	REGBUSH	REGBUSH	REGBUSH	REGBUSH	REGBUSH	GREG		GG		other_human_impact	2000
39	BEL00036	Toledo	MBL	MBL	MBL	MBL	MBL	FMBL		FF		hurricane	2001

Figure 4-5. Sample of Microsoft Excel spreadsheet used to collect secondary broadleaf forests and shrubland activity data and disturbance.

After this final reassessment, all the 21,991 sample plots were merged together in the Microsoft Excel spreadsheet, according to their plot identification number (column 1 in Figure 4-5). The CE/OF operators proceeded with another QA/QC activity. In Microsoft Excel, all 21,991 sample plots were split by the 6 districts. As in the past, sample plots were randomly assigned to CE/OF operators for a plot-by-plot review. Each sample plot's year-by-year activity data were revised, ensuring that the transitions were possible (Figure 2-5). After the plot-by-plot review by districts, the files were re-merged in a single database.

A final Quality Assurance/Quality Control activity was conducted with the data set that contained the 21,991 sample plots for Belize. This undertaking was conducted by three key experts - the lead author and editors – who are highly knowledgeable of the possible LULUC transitions (Figure 2-5), transition phases by IPCC category (Figure 3-2), and disturbances in forests and shrublands. Using Microsoft Excel, all 21,991 sample plots were carefully reviewed by filtering for transitions, disturbances, timeframe for transitions. These three queries/filters were made by IPPC category.

Where discrepancies were difficult to assess, these reviewers returned to the CE/OF tool to use the satellite and very-high-resolution to arrive at a determination for the sample plot in the review. Throughout this final QA/QC process, this small team of reviewers was in contact with Dr. Percival Cho, the forest dynamics expert, Eduardo Reyes, REDD+ expert, and the forest reference level team of experts from the Coalition for Rainforest Nations. This QA/QC process took five full days. After the process was satisfactorily completed, the database with the activity data and disturbances for forests and shrubland was imported into the Greenhouse Gas tool of Belize.

Figure 4-6. Final Quality Assurance/Quality Control conducted on the Belize activity data and disturbance database.

A south-south exchange of experiences between countries with rainforest was headed by the Coalition for Rainforest Nations (CfRN) in St. Lucia in December 2019. During this valuable exchange, the Belize GHG tool was updated to reflect the final reassessment of the CE/OF Assessment. At this phase, another QA/QC was conducted by the CfRN team of experts on the database. Including this database into the GHG tool demonstrated to the team of CE/OF operators the value of having a database that is transparent, accurate, consistent, complete and comparable. Having a database that fully considered the principles of TACCC will ensure a robust Forest Reference Level Report for Belize.

Figure 4-7. South-south exchanges on assessing AFOLU sector for the development of Forest Reference Levels.

5. CONCLUSION

The Collect Earth/Open Forest Assessment of the AFOLU sector of Belize, from the Preparation Phase to the Validation Phase, involved the effort of national and international experts. It took approximately two (2) years of discussion, continuous assessment, and key decision-making to develop an activity database that meets the principles of transparency, accuracy, consistency, completeness, and comparability. This database is the foundation to have a robust national forest reference level. With the imminent technological improvements in this field and with stronger collaboration with national and international partners, Belize can meet its national and international reporting commitments.

The success of the CE/OF Assessment is credited to the sound guidance provided to the process by its advisors, the generous support of numerous collaborators, and the steadfast commitment provided by the team of CE/OF operators/mappers. The strategy to build national capacity with the CE/OF Assessment paid off immensely. Belize now has a team of national experts that can continue to assess the LULUC of the AFOLU sector, the principal element of the measuring, reporting, and verification process for REDD+ results-based payment. The two-year meticulous process has converted Belize into an international leader in this field.

6. ANNEX

Annex I. Forest Department Officers Pre-Collect Earth/Open Foris Training Workshop Agenda, Rome

Open Foris Workshop Agenda
FAO HQ Rome (Canada Room A-357)
12 – 16 February 2018

Day 1 Monday, February 12th	• Introduction of the workshop hosts and participants • Introduction to the Open Foris Initiative and its tools • Review of methodology for using Collect Earth to assess LULUCF • Discussion regarding the national land use classification system and the IPCC land use assessment framework • Overview of Collect Earth functionality and its supporting software (Google Earth, Bing Maps, Google Earth Engine, Saiku, etc)
Day 2 Tuesday, February 13th	• Application of Collect Earth to the national land use classification and monitoring goals • Review of current Belize national Land Use classification • Hands-on training on Collect Earth + Bing Maps + Google Earth Engine • Assess several sample plots collectively
Day 3 Wednesday, February 14th	• Saiku Analysis and data handling • Database management and best practices • Grid generation through Google Earth Engine • Survey Design – concepts on Open Foris Collect
Day 4 Thursday, February 15th	• Survey Design – creation of a small Collect Earth survey • Review Collect Earth data export, import, and backup procedures • Hands-on training on data analysis with Saiku • Planning a Mapathon: practical issues
Day 5 Friday, February 16th	• Review of Collect Mobile • Creation of a Collect Mobile survey • Data cleansing • Data visualization in Fusion Tables and Collect • Discuss and review results • Workshop conclusion and discussion on further steps

List of Participants

Name	Organization
Edgar Correa	Belize Forest Department
German Lopez	Belize Forest Department
Jorge Nabet	Belize Forest Department
Koren Sanchez	Belize Forest Department
Javier Fernandez	Coalition for Rainforest Nations

Annex II. Collect Earth/Open Foris 2018 Mapathon Planning Notes

Human Resources

- 1 officer from Agriculture department to aid on crop identification
- 1 officer from Land Information Center, to verify Land Tenure and settlements
- 1 officer from the Department of the Environment in charge of development
- 4 Forestry Department staff trained in Rome
- 4 Forest Department staff with background in Arc GIS
- 1 Natural Resources student, who has a great interests and knowledge of Arc GIS software
- 2 officers from the Belize Climate Change Office
- Assistance of Collect Earth/Open Foris mapathon expert (Marcial Arias) throughout the mapping exercise
- Assistance of Collect Earth/Open Foris software expert (Alfonso Sanchez) during the first week of the mapping exercise.

Equipment

- At least 11 desktop & 4 laptops and additional screens per station.
- Mouse for laptops
- Router
- Separate Internet connection: agree with CITO/BTL for improved connection
- Projector/Big screens for the training and shared assessment.
- Tables/Furniture for the working stations
- Stationary for taking notes

Venue/catering/logistics

- GIS Unit Forest Department
- Coffee Breaks/Snacks/lunch

Mapathon Timeframe

- 1 person = 165 plots/day (first three days < 200 sample plots in total)
- 14 people—approximately 22,000 sample plots in two working weeks.
- One-week training a test run on collect earth process
- Two-week mapathon to ensure full presence of participants and good coverage of the country

Quality control

- Add 5% of repeat-assessment sample plots to get statistics on interpretation error
- Review quality control sample plots at the end of the day/week to standardize interpretation
- Reference map of Belize for point validation
- Test within 1-week training of Collect Earth.

Data storage and visualization

- Google Drive and server backup at the Central location

Printing

- IPCC Hierarchies
- FRA classification scheme
- Training visualization guidelines

Annex III. Collect Earth/Open Foris Requirements

Step 1: All members must have a google account and sign up to Google Earth Engine

Step 2: All computer being used for Collect Earth must download google earth pro, chrome, and Firefox.

Step 3: Download of Collect Earth and Collect (http://www.openforis.org/)

Step 4: Installation Collect Earth, setting up of collect earth and setting up of google earth. (http://www.openforis.org/tools/collect-earth/tutorials/installation.html)

Annex IV. Mapathon 2018 Training Agenda

Before the mapathon commences a one-week training will be conducted. Three days will be focused on the Collect Earth/Open Foris assessment process and two days will be on data collection pilot test sample plots classification. One Forest Officer will be assigned in leading the group with the assistance of Collect Earth/Open Foris experts. The Forest Officer will be responsible to guide the group and ensure that all data collected is backed up and is safely stored. Listed below is the one-week training agenda on Collect Earth/Open Foris assessment developed during the Food and Agriculture Training in Rome.

Day 1

- Land Use classification and IPCC classes
- Landsat and Sentinel 2 imagery and NDVI graphs
- Google Earth features
- General integration of all tools of Collect Earth
- Group assessment of selected sample plots (add training_plots.csv to the survey)

Day 2

- Kahoot for Belize land uses (Online Test)
- Follow group assessment of few sample plots
- Individual assessment of sample plots
- Export/Import process for collected sample plots
- Group review through Saiku and correction of sample plots

Day 3

- Kahoot on Satellite imagery and historical analysis (Online Test)
- Cleaning databases (id using SQLite version) and start from scratch
- Data collection
- Review validation rules of the survey

Day 4 & 5

- Distribution of sample plots
- Pilot Test Run Data Collection
- Data export
- Review of quality control points

Mapathon 2 weeks

- Start day by reviewing a plot with low land use confidence from the day before
- Data Collection

- Finalize day with data export
- Review of quality control points

Annex V. Collect Earth Post-Mapathon Workshop Agenda

Orchid Bay Resort – Chunox, Corozal, Belize
24 to 28 September 2018

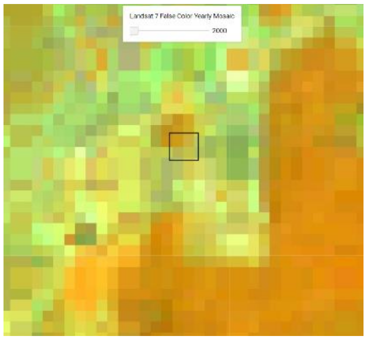
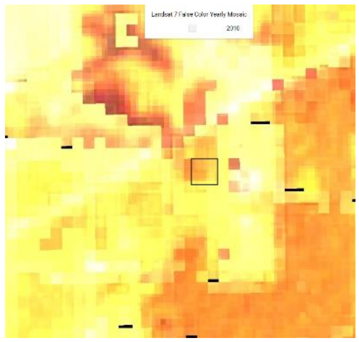
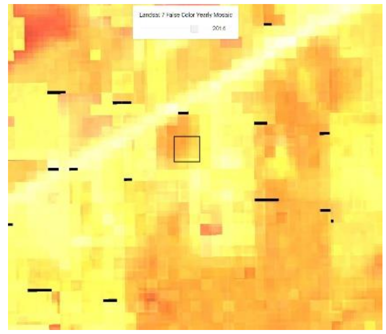
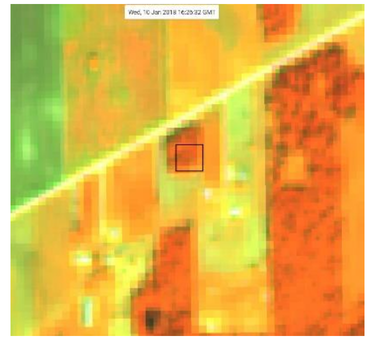
Day 1 Monday, September 24th	• Introduction of the workshop hosts and participants • Review of Collect Earth Mapathon (overview of the process and discussion regarding challenges and possible improvements) • Overview of Saiku and the data collected • Exercises with Saiku tool on data analysis with Mapathon data • Data management (exporting, importing, updating and sharing)
Day 2 Tuesday, September 25th	• Mining FREL data with Saiku • Generation and update of Saiku stand-alone tool • Advanced functionality of Saiku • Visualization and sharing of data through Fusion Tables
Day 3 Wednesday, September 26th	• Survey Design – creation of a small Collect Earth survey. Focus on protected areas • Survey Design – importing and adapting surveys • Survey Design – exporting and understanding CSV plot files
Day 4 Thursday, September 27th	• Grid generation through Google Earth Engine (recommended to bring shapefiles with areas of interest of the participants) • Grid generation – adding ancillary data and adapting the survey accordingly • Adding new data after Mapathon • Area calculations – calculation of plot expansion factor?
Day 5 Friday, September 28th	• Review of Collect Mobile • Earth Map – using climatic data for the GHGi and FREL • Earth Map – visualizing data collected for transparency • Producing maps through Mapathon data (simplified Google Earth Engine scripts for multi-temporal map generation) • Workshop conclusion and discussion on next steps for the FREL preparation

List of Participants

Name	Organization
Angela Jiménez Rosales	Panama Ministry of Environment
Javier Martínez Cedeño	Panama Ministry of Environment
Marcial Arias Medina	Panama Ministry of Environment
Eduani Muñoz	Corozal Sustainable Future Initiative
Koren Sanchez	Belize Forest Department
Edgar Correa	Belize Forest Department
George Nabet	Belize Forest Department
Alex Escalante	Belize Forest Department
German Lopez	Belize Forest Department
Edalmi Grijalva	Belize REDD+ Coordination Unit
Mercedes Carcamo	Belize REDD+ Coordination Unit
Luis Balan	Belize REDD+ Coordination Unit
Kareem Reynolds	Belize REDD+ Coordination Unit
Sumeet Betancourt	Belize REDD+ Coordination Unit
Timoteo Mesh, Ph.D.	Belize REDD+ Coordination Unit
Eduardo Reyes	Belize REDD+ Coordination Unit
Alfonso Sánchez-Paus Díaz	Food and Agriculture Organization

The interpreter classified this sample plot as forest remaining forest, based on the forest definition that was establish in the protocol for the purpose of the exercise.

2000(Landsat7) **2010**(Landsat7) **2014**(Landsat7) **2018**(Landsat7)

2010(Google



Earth Image) **2014** Google Earth Image) **2018(**Google Earth Image)