Appendix E, Attachment F – Terrestrial Ecology – Assessment of Alternatives

Environmental Statement

East-West Arterial Extension:

Section 2 (Woodland Drive – Lookout Road)

Section 3 (Lookout Road – Frank Sound Road)

Terrestrial Ecology - FINAL

Assessment of Alternatives
Grand Cayman East-West Arterial Extension

NATIONAL ROADS AUTHORITY

February 6, 2024

Table of Contents

Attachments

List of Tables

List of Figures

List of Terms

CBA	Cost-Benefit Analysis
CI$	Cayman Islands Dollar
CIR	Colour-Infrared
CMW	Central Mangrove Wetland
DoE	Department of Environment
EIA	Environmental Impact Assessment
EWA	East-West Arterial
GIS	Geographic information systems
Ha	Hectares
Km	Kilometres
LiDAR	Light Detection and Ranging
NBAP	National Biodiversity Action Plan
NCA	National Conservation Act
NDVI	Normalized Difference Vegetation Index
NIR	Near Infrared
NT	National Trust
ppt	Parts Per Thousand
R	Red
RAM	Rapid Assessment Method
ToR	Terms of Reference
UMAM	Uniform Mitigation Assessment Method
USD	U.S. Dollar
USGS	United States Geological Survey
WebTAG	UK Department for Transport’s Transport Analysis Guidance

1 Introduction

The East-West Arterial (EWA) Extension Environmental Impact Assessment (EIA) is proposed to evaluate an alternative east-west travel route on Grand Cayman. The Terms of Reference (ToR) for the proposed EWA Extension EIA was finalized on April 4, 2023. Since then, five Build alternatives (B1, B2, B3, B4, and C1), in addition to the No-Build scenario, were developed and assessed as part of the Longlist Alternatives Evaluation. A separate Longlist Alternatives Evaluation Document has been prepared to document this analysis.

As a result of the Longlist Alternatives Evaluation, four Build alternatives (B1, B2, B3, and B4) and the No-Build scenario were advanced to the shortlist evaluation. This report focuses on the assessment of terrestrial ecology resources for these shortlisted alternatives. Information from this report will be incorporated within the Shortlist Alternatives Evaluation Document and Environmental Statement.

2 Shortlist of Alternatives

This analysis evaluates the Shortlist of Alternatives and their anticipated direct impacts on terrestrial ecology. For the Shortlist Evaluation, terrestrial ecology impacts have been evaluated based on direct landcover habitat impacts and species habitat impacts. Evaluation of protected areas, including the Central Mangrove Wetland (CMW), Mastic Reserve, and Meagre Bay Pond, are included within the Cultural and Natural Heritage Assessment of Alternatives.

The Assessment of Alternatives specifically concentrates on analysing direct impacts since these impacts can be more accurately be assessed, quantified, and monetized based on the project's level of design. The potential for possible indirect and cumulative effects has been discussed, where applicable, however since these impacts are less defined due to numerous variables outside of the project's design process they have been noted and qualitatively described. Further evaluation of indirect and cumulative effects will occur as part of the analyses which will be carried out for the Preferred Alternative Evaluation.

The Shortlist of Alternatives includes the No-Build scenario and four Build alternatives (B1, B2, B3, and B4) as depicted in **Figure 1**. As shown in **Figure 1,** the four Build alternatives all share exactly the same common section beginning at the western terminus, near Woodland Drive, and continuing east to near Lookout Road. They also share the same common improvements to the local roadway network referred to as the Will T Connector. Additional details describing the Shortlist of Alternatives including full descriptions of each alternative along with typical design sections can be found in the Shortlist Evaluation Document.

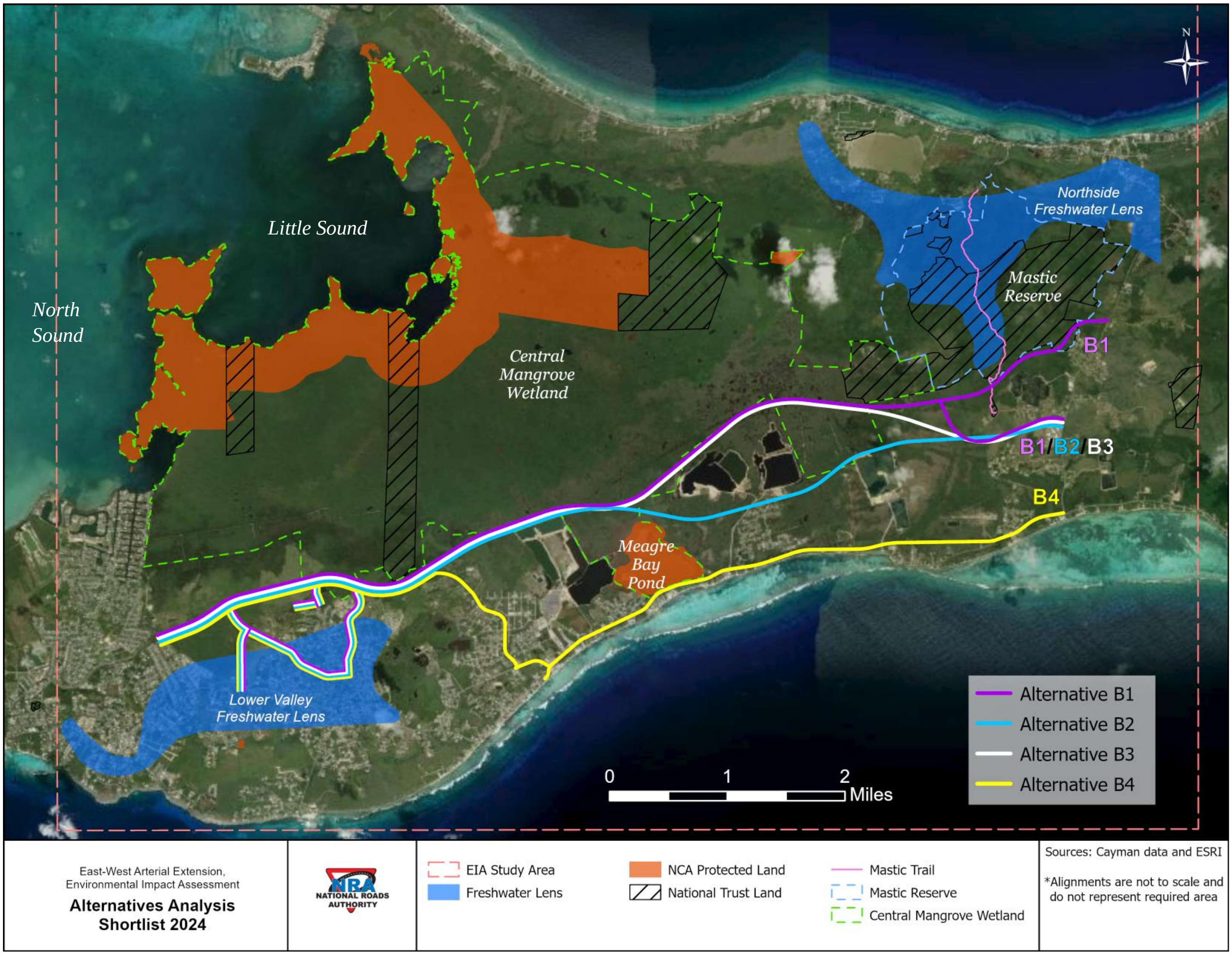


Figure 1: Shortlisted Build Alternatives

3 Baseline Conditions and Assessment Methodology

The Assessment of Alternatives included a July 2023 field review of the EIA study area and a desktop analysis using the technical reports, publications, government documents, websites, spreadsheets, and geographic information systems (GIS) datasets listed in **Section 3.1** of this document. Information derived from the field review and desktop analysis was used to establish existing conditions within, adjacent to, and in the vicinity of the proposed EWA Extension Build alternative corridors. This information was then used to identify and evaluate the potential impacts to terrestrial ecological resources for **Section 4: Anticipated Project Impacts** in this document.

3.1 Data Sources Evaluated

The following information (i.e. spreadsheets and GIS datasets) was provided by the Cayman Islands Department of Environment (DoE):

- Provided November 2022;
    - Grand Cayman Landcover and Habitat (2018);
    - Dry Forest above 20-ft Elevation;
    - Lands protected under the National Conservation Act (NCA) of 2013 (*.shp shapefile);
    - Lands owned by the National Trust (NT) (*.shp shapefile); and
    - Habitats of important species (*.shp shapefiles):
        - Plants
            - *Aegiphilia caymanensis*
            - Inkberry (*Scaevola Plumieri*)
            - *Pisonia margaratae*
            - Tea banker (*Pectis caymanensis*)
        - Reptiles
            - Marine Turtle Critical Habitat through 2018
            - Marine Turtle Nesting Beaches through 2018
        - Mammals
            - Northern lower valley forest Cuban white-shouldered bat (*Phyllops falcatus*) habitat
        - Birds
            - Grand Cayman Parrot (*Amazona leucocephala caymanensis*) density
            - White Tailed Tropicbird *(Phaethon lepturus*);
        - Insects
            - Pygmy Blue Butterfly (*Brephidium exilis thompsoni*)
- Provided July 2023;
    - Central Mangrove Wetland (CMW) (*.shp shapefile); and
    - Mastic Reserve and Mastic Trail (*.shp shapefile)
- Provided September 2023;
    - 2021 Natural Capital Account Spreadsheets for Natural Capital Account Report 2020; and
    - South Key Parrot Nesting Habitat (*.shp shapefile)
        - Referred to as “parrot nesting habitat” throughout this document.

The following information (i.e. geospatial datasets) was provided by the Cayman Islands Government and other sources:

- Provided by the Cayman Islands Land and Survey on August 4, 2023;
    - Light detection and ranging (LiDAR) LAS geospatial data; and
    - 2013 Colour-Infrared (CIR) imagery;
- CIR and Normalized Difference Vegetation Index (NDVI) imagery from EOS Data Analytics, dated January 25, 2023;
- Satellite imagery from Google Earth Pro, dated between June 5, 2023, and September 15, 2023.

The following legislation and relevant Cayman guidance materials were also reviewed as part of the ecological studies:

- Cayman Islands National Biodiversity Action Plan (NBAP) (2009);
- National Trust Law (2010 Revision);
- National Conservation Act (2013);
- National Conservation (General) Regulations (2016);
- The Mangrove Conservation Plan (2020);
- National Conservation (General) (Amendment) Regulations (2021);
- Development and Planning Act (2021 Revision);
- Development and Planning Regulations (2022 Revision);
- 2020 Cayman Islands Ecosystem Accounting (**Attachment E**);
- Childs, C., MacDonald, M.A., Bradbury, R.B. (2015). *Ecosystem services provided by two potential protected areas in the Cayman Islands.* National Trust for the Cayman Islands.; and
- UK Department for Transport's Transport Analysis Guidance (WebTAG) Unit A3: Environmental Impact Appraisal
- Chartered Institute of Ecology and Environmental Management's (CIEEM) *Guidelines for Ecological Impact Assessment in the UK and Ireland: Terrestrial, Freshwater, Coastal and Marine* (Updated April 2022)

The following Multi-lateral Environmental Conventions were reviewed as part of the ecological studies:

- Convention on Biological Diversity;
- Convention on Wetlands of International Importance (Ramsar Convention); and
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

3.2 Existing Conditions

A number of habitats, outlined in the 2009 National Biodiversity Action Plan, comprise the ecosystems on Grand Cayman. The island houses coastal, wetland, and upland ecosystems which all play an important role in providing ecosystem services and supporting native wildlife. The ecosystems are interconnected hydrologically and often share in the species that depend on them. Major ecosystems that are relatively untouched by human activity include wetland ecosystems and upland ecosystems.

Wetland Ecosystems

Mangrove wetlands provide Grand Cayman myriad ecosystem services, like protecting the coast from storms, waves, and floods; inhibiting coastal erosion; carbon sequestration; water filtration; and providing important habitat to many species like the Grand Cayman parrot. The CMW and Meagre Bay Pond (**Figure 1**) are both part of the mangrove wetland ecosystem on the island. The CMW is one of the largest contiguous wetland in the Caribbean.

Ideal conditions for mangroves include low wave energy, brackish water, fine soil sediment, and waterlogged soil. On Grand Cayman, mangrove typically grow on peat, laid down by mangroves themselves. The unique root systems of the red mangrove (*Rhizophora mangle*; buttressed roots) and black mangrove (*Avicennia germinans*; pneumatophores) slow the flow of the tides and encourage mud and silt deposition. Water salinity and hydroperiod (i.e., the depth, duration, and frequency of tides) affect the composition of mangroves in wetlands like the CMW. Any major disturbance to one or more of these factors is likely to alter the species composition, since red, black, and white mangroves (*Laguncularia racemose*) each prefer different depths of inundation and water salinity levels. Hurricane events can also strongly influence mangrove communities on Grand Cayman.

The CMW is an integral part of the water flow system on Grand Cayman. Water migrates, primarily as sheet flow, from the southern coast, across the CMW, and into the North Sound (**Figure 1**). The mangrove system filters the surface water and shallow ground water that flow through it, adding nutrients which are essential to the North Sound food chain. In addition, the CMW has an important role in the evapotranspiration/precipitation cycle of Grand Cayman. An estimated 40% of the rainfall in western districts of the island is believed to be due to evapotranspiration in the CMW (Bradley et al, 2004).

Meagre Bay Pond is part of the flow pattern between the southern shore of the island, the CMW, and North Sound. Meagre Bay Pond has a buffer of mangroves around it and provides habitat for over 104 different species of migratory birds and plenty of other wildlife (www.eBird.org). In times of heavy rain, the pond contributes to the south-to-north sheet flow through the CMW. Quarry and residential development adjacent to the pond threaten the pond's hydrology and its connection to the CMW sheet flow system.

Upland Ecosystems

The Mastic Reserve (**Figure 1**) is the oldest ecosystem on Grand Cayman. Comprised of subtropical, semi-deciduous dry forest, this part of the island is home to many endemic flora and fauna. The Mastic Reserve is recognized as an Important Bird Area, and provides habitat to numerous endemic species, including ten plant species, four reptile species, and five butterfly species (Bradley et al., 2004).

The Reserve is connected to the other ecosystems on Grand Cayman in many ways, both by providing habitat to some of the same species and via hydrological connection. The Reserve absorbs rainfall and slowly releases it, helping to regulate the water flow on the island. Some of that water soaks into the soil and recharges the groundwater, making it an essential part of supplying the island with freshwater. It also includes some pools and seasonal ponds, which support aquatic life.

3.3 Existing Developed Conditions and Trends

Five districts make up Grand Cayman: West Bay, George Town, Bodden Town, North Side, and East End. With Owen Roberts International Airport and the George Town Port located in George Town, both George Town and West Bay are the primary locations for commercial and retail businesses such as hotels and restaurants, with a mix of residential uses. Farther east, Bodden Town, North Side, and East End are primarily residential with some minor retail and community facilities interspersed along the existing roadways. Bodden Town is currently the fastest growing district, almost tripling in population size since the turn of the 21st century, while North Side and East End remain relatively sparsely populated. The EIA study area (**Figure 1**) encompasses both the Bodden Town and North Side Districts with the area required for the shortlisted Build alternatives (B1, B2, B3 and B4) being primarily located within the Bodden Town District. (Economic and Statistics Office, 2022).

The overall EIA study area consists of residential, commercial, agricultural, and industrial sites. Portions of the CMW (**Figure 1**) also extend into the EIA study area. Several active mine quarries sit within the EIA study area. Recent aerial photographs, as well as NDVI and CIR data derived from satellite imagery, provide a general overview of existing vegetative conditions within the EIA study area. The CMW and developed areas within the EIA study area are visually apparent. A distinct area marked by low density mangrove vegetation occurs along the southern boundary of the CMW, from Bodden Town to North Side as shown in **Figures 2**, **3**, and **4** This low density vegetation area appears to be comprised of a mix of mangroves, open water, bare ground (peat), and man-modified areas. **Figure 2** depicts the 2023 True Colour Aerial with an example area of low density mangrove habitat. Review of the aerial imagery shows cleared access paths/roads and canals extending through this area. Vegetation density also appears to be lower throughout this area when compared to the CMW areas farther north.

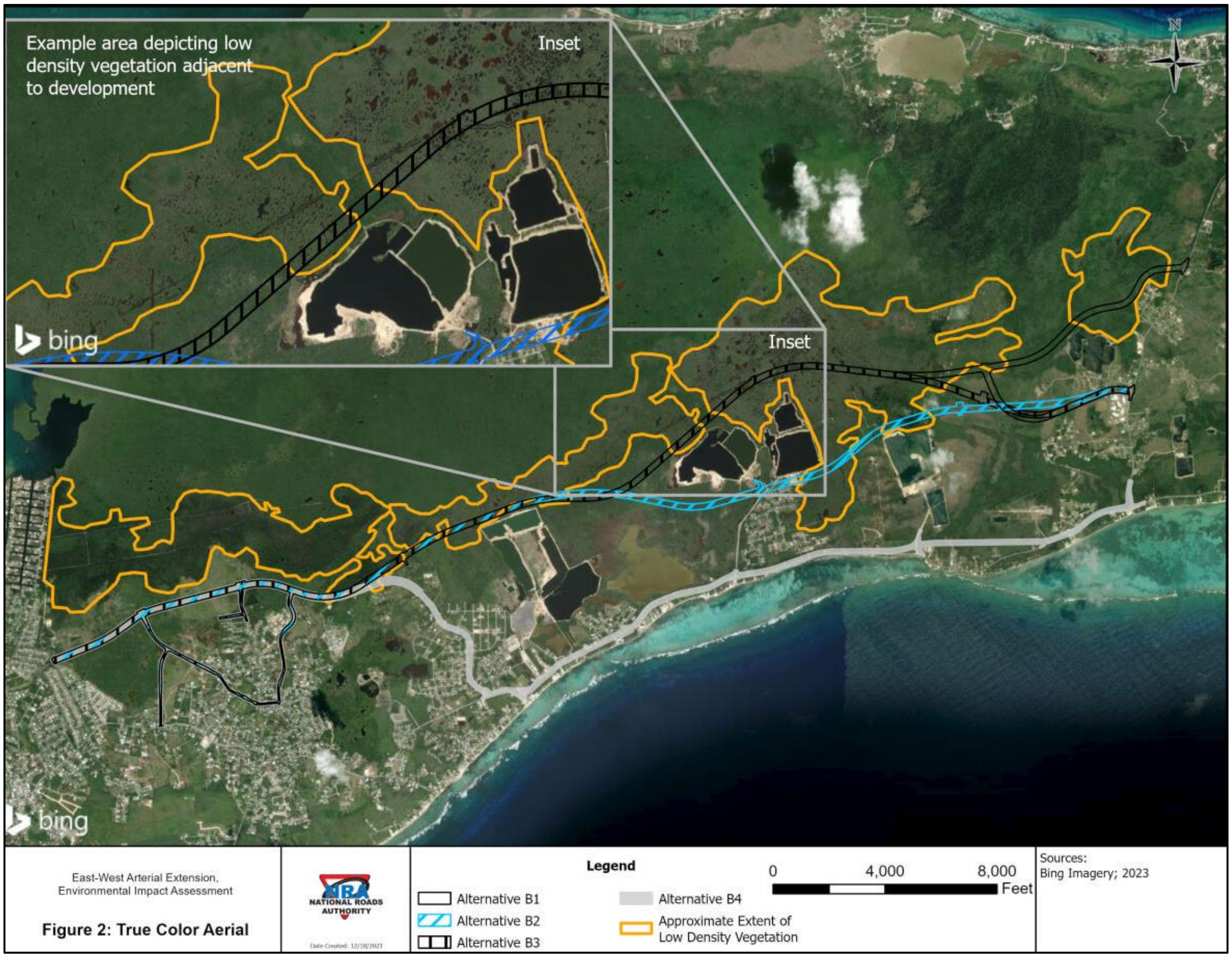


Figure 2: True Colour Aerial of EWA EIA Study Area

Figure 3 and **Figure 4** depict the January 25, 2023 NDVI and CIR imagery with an example area of the low density mangrove habitat. Imagery from this time of year was selected to support this analysis due to low cloud coverage. NDVI mapping is used to quantify vegetation greenness (based on the presence of chlorophyll) and is useful in understanding vegetation density and assessing changes in plant health. NDVI is calculated as a ratio between the red (R) and near infrared (NIR) values and is the most common index used in scholarly study of mangroves (Tran *et al.*, 2022). Greenness is based on several factors: the number and type of plants, how leafy they are, and how healthy they are. In places where foliage is dense and plants are growing quickly, the index is high, represented in dark green. Areas where vegetation density is low are depicted as yellow or orange. Areas where NDVI values indicate low density vegetation may be due to the presence of naturally occurring open water features such as mangrove lagoons and ponds, or areas where mangroves have been uprooted due to severe weather events. Additionally, accuracy of reflectance values can vary based on mangrove species due to a variety of factors. Therefore, field verification of vegetative conditions will need to be performed.

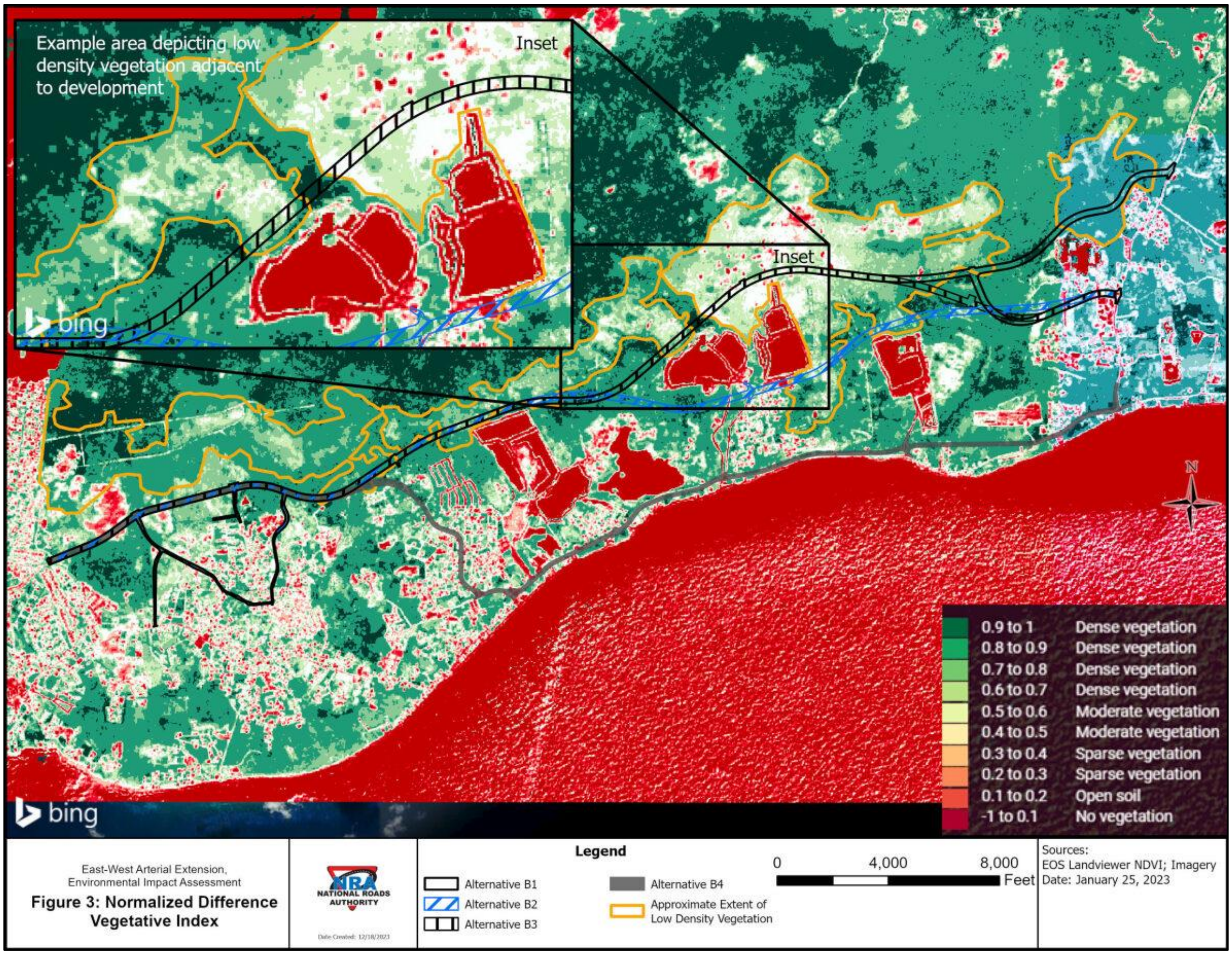


Figure 3: NDVI of EWA EIA Study Area
Source: EOS Data Analytics (Jan 25, 2023)

Similarly, CIR imagery is widely used for interpretation of vegetation health. CIR imagery shows healthy vegetation in hues of red; intense reds indicate densely growing vegetation, while lighter shades of red and pink indicate sparsely growing vegetation. Various shades of greens and tans may also indicate areas of lower vegetative growth. Bare soils appear as shades of white, blue, or green. (USGS, n.d.)

Per **Figure 3** above, areas of low density mangroves demonstrate lower values on the NDVI scale (0.4 to 0.6) when compared with northern sections of the CMW (0.7 to 1.0). Per **Figure 4** below, the low density mangroves are interspersed with areas of dark tan and green indicating lower vegetative growth, ponds, and bare ground, specifically peat.

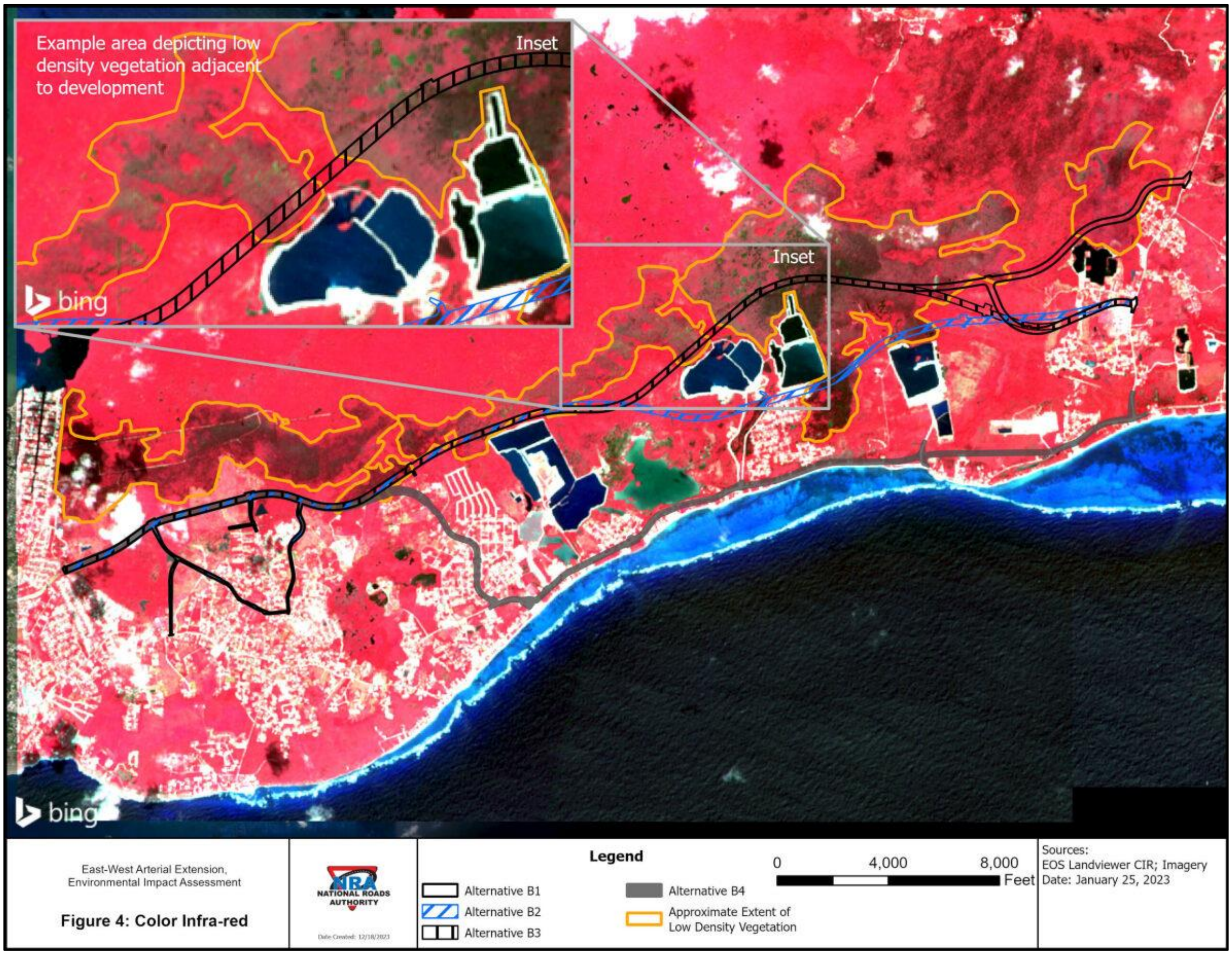


Figure 4: CIR of EWA EIA Study Area
Source: EOS Data Analytics (Jan 25, 2023)

There are various reasons that may influence why mangrove habitat in this area appears to be lower density, including elevation, salinity, urban impacts on water quality (e.g., nutrient build-up), adjacent urbanization, and hurricanes:

Elevation: A high water table plus low elevation may result in pooling water, which can affect the type and density of mangrove species growing in those areas along with the density of open ponds.

Salinity: Salinity is another factor that could affect the density and growth of mangroves. Red mangroves survive best in waters with salinities at 35 parts per thousand (ppt) or below with minimal fluctuation, though they can grow in salinities almost twice that (Biber, 2006; Florida Museum, n.d.). Black mangrove seedlings prefer salinities between 15 and 45 ppt for establishment and growth. When salinities exceed 60 ppt, it can cause black mangrove growth difficulties and seedling mortality (Matto *et al.*, 2023).

Nutrient Runoff: Nutrient runoff from agricultural and urban activity has a documented negative effect on mangroves. Excess nutrients result in an overproduction of shoots relative to roots. The increased shoot to root ratio leaves the mangroves more susceptible to increased salinity and drought which negatively affects the health of the plant resulting in chlorosis and mortality. (Lovelock *et al*, 2009)

Urbanization: As depicted in **Figures 2** through **4**, the low density vegetation area is adjacent to urban development along the southern edge of the island, and adjacent to quarries in the southwest. This low density area may represent an ecotone between developed land and undeveloped CMW. The proximity to urban development and quarry activity could be affecting the density of the vegetation through degradation.

Hurricanes: Hurricanes, along with other tropical storms, can have a significant impact on mangrove habitat. High-velocity winds and storm surge can impact both the vegetative community and underlying soils (peat). Mangrove habitats which have been fragmented, are adjacent to development, or have been previously channelized are especially vulnerable (2009 NBAP). Dependent of the severity of the storm, this can result in either relatively short-term impacts or result in long-term changes or elimination of the vegetative communities. Vegetative communities recovering from a storm event may result in lower density than undisturbed communities.

During the July 2023 field evaluation, mangrove habitat in the "low density" area displayed characteristics indicating stressed vegetation (stunted growth, chlorosis of the leaves, and fungal growth), impacted water quality (discoloration, debris), and an overall decrease in vegetative cover/density. The low density mangrove area will be investigated further during the Preferred Alternative.

3.4 Pre-Field Evaluation Desktop Review

Prior to the field evaluation, a comprehensive desktop review was conducted using geospatial files provided by the DoE (see **Section 3.1**). The purpose of this desktop review was to identify existing ecological features within the EIA study area. These features included NT parcels, protected habitats and other lands, and areas known to have occurrences of listed sensitive species.

The geospatial file that was the most relevant to the desktop and later field review was the 2018 Grand Cayman Landcover and Habitat because it provided the most comprehensive baseline for the existing landcover and habitat types in the EIA study area (**Figure 5**). A 500-foot buffer was established around each Build alternative and the No-Build scenario to identify the primary habitats that could experience direct and indirect impacts from the project. Using the Grand Cayman Landcover and Habitat file, habitats within the 500-foot buffer were identified. These habitats were later verified through field evaluation.

A total of 55 field verification points were proposed to sample each of the habitats in the Grand Cayman Landcover and Habitat file. A total of three habitat points were selected for each habitat in the 500-foot buffer. The habitat in the northern portion of the EIA study area was more uniform than those in the southern portion, which contained a larger diversity of more fragmented habitats. Therefore, more field verification points were required in the south than the north. Additionally, some habitats only appeared once in the 500-foot buffer areas, therefore, additional verification points were added outside the buffer areas to ensure multiple data points were collected for each habitat type.

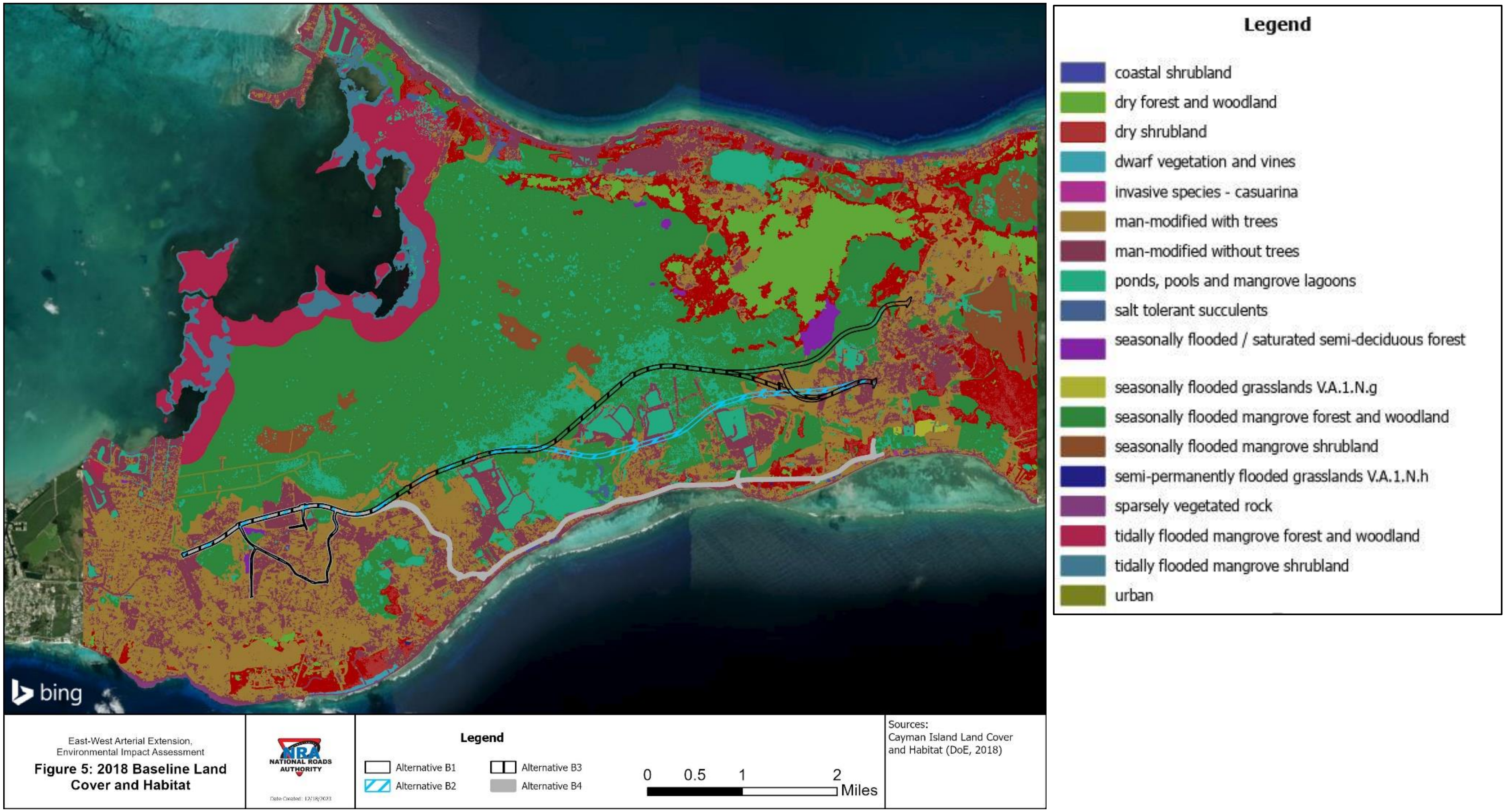


Figure 5: 2018 Baseline Landcover and Habitat of EWA EIA Study Area

3.5 Field Evaluation

The terrestrial ecology team conducted an on-site field evaluation of the habitats in the EIA study area from July 24th – July 28th, 2023. During this field evaluation, ecologists observed and noted existing conditions, habitat types and condition, vegetative species, and wildlife. Supplemental data was collected based on the habitat type for each field verification point such as litter, salinity, and canopy height for water and forested communities respectively.

During the field evaluation, 21 of the 55 preselected field verification points were inaccessible. In these cases, additional field verification points were sampled to replace the inaccessible points. A total of 25 alternative field verification points were sampled. Based on the field conditions, 59 field verification points were sampled (34 originally chosen points and 25 alternative points). **Figure 6** shows the 34 original field verification points that were sampled in green, the 25 alternative field verification points in yellow, and the 21 original, unsampled field verification points in red.

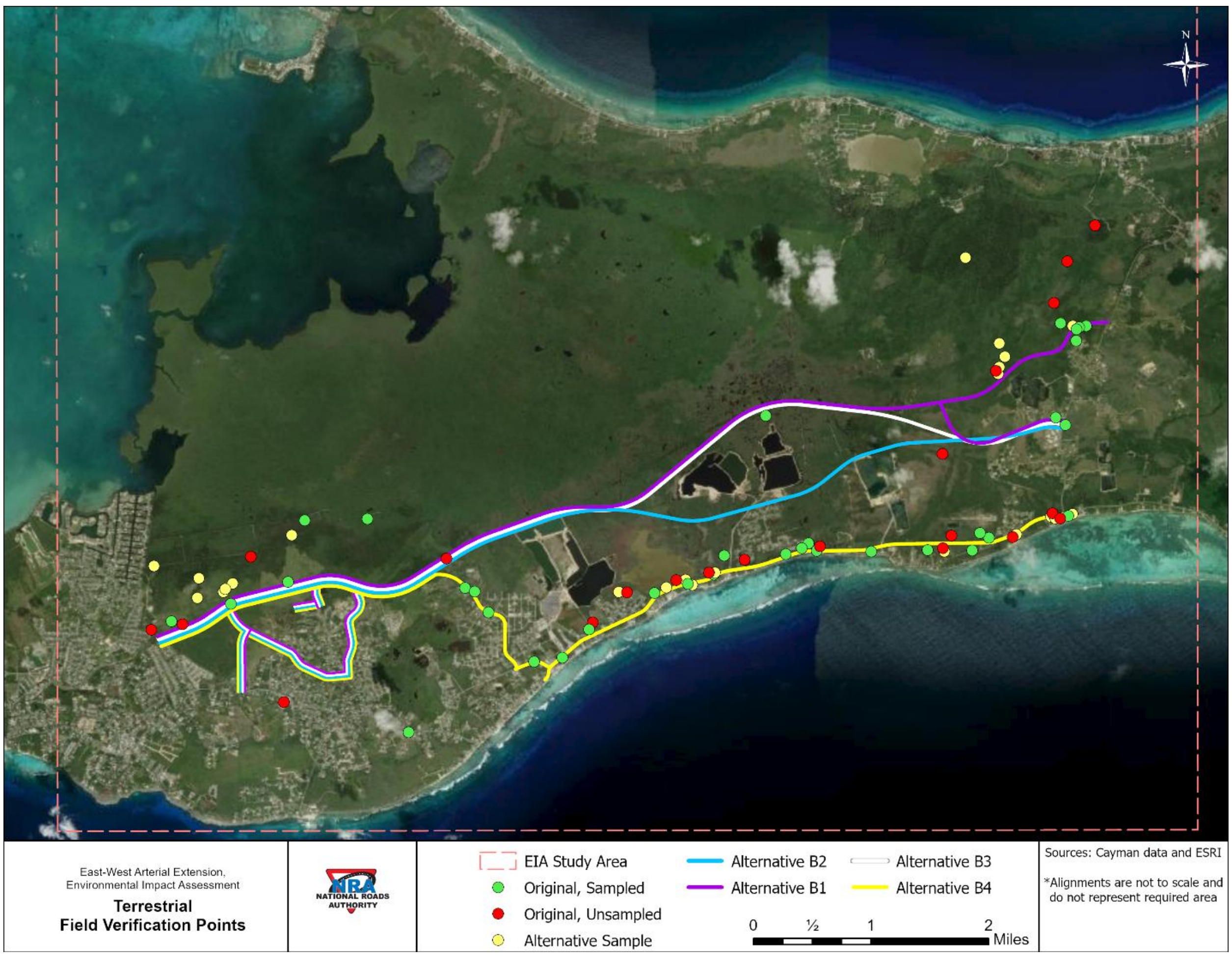


Figure 6: Terrestrial Field Verification Points, July 2023

3.6 Post-Field Evaluation Desktop Evaluation

The purpose of the desktop evaluation was to establish existing habitat conditions within the area of the Build alternatives. This evaluation was performed using the 2018 Grand Cayman Landcover and Habitat data layer as a baseline of existing landcovers. The 2018 data layer was then refined based on an overlay analysis using data collected during the field review and information derived from recent aerial imagery and other remotely sensed data (LiDAR, CIR, and NDVI) to reflect existing habitat conditions. The 2018 Grand Cayman Landcover and Habitat data layer was reclassified to:

- Reflect new development or habitat conversion.
- Divide man-modified features into subcategories, such as residential, commercial, agricultural development, etc.
- Update habitat features based on proximity to developed areas, such as those areas adjacent to industrial, commercial, and residential developments.
    - These areas were reviewed in relation to possible indirect secondary impacts that may occur because of the adjacent development, including changes in hydrology and drainage patterns, sedimentation, and habitat fragmentation.
- Reflect habitat types based on field observations.

The updated habitat mapping within the area of each of the shortlisted Build alternatives can be found in **Attachment A – Attachment D**. This habitat mapping incorporates revisions to the 2018 Grand Cayman Landcover and Habitat based on the field evaluation and desktop reviews described. Descriptions of habitats are provided in **Section 3.7** below.

3.7 Existing Habitat

Habitat classifications and descriptions are based on the Vegetation Classification for the Cayman Islands (Burton, 2007). Based on the desktop and field evaluations previously discussed, additional subclassifications were also included. The broad classifications encountered, and additional subclassifications are detailed as follows:

3.7.1 Man-Modified

This habitat classification includes any land which has been altered or disturbed due to a variety of human activities including habitat conversion for use as residential, commercial, or industrial activities. These areas may also include activities managed for agricultural purposes, or those that come under the influence of agricultural practices, specifically, the growing of fruits, crops or the keeping of livestock.

3.7.1.1 Man-modified Without Trees

This habitat subclassification is defined as any land without trees which has been modified. Although these areas are classified as man-modified, they still may contain a vegetative component suitable for providing functional habitat to important species. Per Burton (2008b), this would include seasonally flooded grasslands, medium or short tropical/subtropical grassland with broad-leaved evergreen or semi-evergreen shrubs, or saturated tropical/subtropical perennial forb vegetation.

Plant species noted during the field evaluation included: buttonwood (*Conocarpus erectus*), sea-purselane (*Sesuvium portulacastrum*), seaside heliotrope (*Heliotropium curassavicum*), queen of the night (*Selenicereus grandifloras*), white button (*Spilanthes urens*), beach naupaka (*Scaevola* *taccada*), bay vine (*Ipomoea pes-caprae*), chick weed (*Chamaesyce/Euphorbia hypericifolia*), prostrate sandmat (*Euphorbia prostrata*), cutleaf groundcherry (*Physalis angulata*), Australian pine (*Casuarina equisetifolia*), buff coat (*Waltheria indica*), seaside mahoe (*Thespesia populnea*), Euphorbia (*Chamaesyce/ Euphorbia bruntii*), goose grass (*Eleusine indica*), Alamo vine (*Merremia dissecta*), coconut palm (*Cocos nucifera*), logwood/bloodwood (*Haematoxylum campechianum*), tan-tan (*Leucaena leucocephala*), red mombin (*Spondias purpurea*), banana (*Musa paradisiacal*), weeping fig (*Ficus benjamina*), gumbo limbo (*Bursera simaruba*), royal poinciana (*Delonix regia*), wild coffee (*Psychotria nervosa*), guinea grass (*Panicum maximum/ Megathyrsus maximus*) and ackee fruit (*Blighia sapida*).

Field biologists also observed butterflies, Greater Antillean grackle (*Quiscalus niger caymanensis*), black-necked stilt (*Himantopus mexicanus*), black-crowned night heron (*Nycticorax nycticorax*), glossy ibis (*Plegadis falcinellus*), Grand Cayman parrot, western cattle egret (*Bubulcus ibis*), yellow warbler (*Setophaga petechia*), tri-colored heron (*Egretta tricolor*), green heron (*Butorides virescens*), northern mockingbird (*Mimus polyglottos*), dragonflies, anoles, and smooth-billed ani (*Crotophaga ani*).

Figure 7: Man-Modified Without Trees (July 2023 Field Evaluation)

3.7.1.2 Man-modified With Trees

This habitat subclassification is defined as any land with trees which has been modified. Although these areas are classified as man-modified, they still may contain a vegetative component suitable for providing functional habitat to important species. This habitat subclassification would include any man-modified areas which have established a dominance of woody vegetation, including broad-leaved evergreen or semi-evergreen trees.

Plant species noted during the field evaluation included: saltwort (*Batis maritima*), samphire (*Blutaparon vermiculare*), sea-purselane (*Sesuvium portulacastrum*), white button (*Spilanthes urens*), buttonwood, logwood (*Haematoxylum campechianum*), and yellow root (*Morinda royoc*). Field biologists also observed Greater Antillean grackle.

Figure 8: Man-Modified With Trees (July 2023 Field Evaluation)

3.7.1.3 Agricultural

This habitat subclassification includes areas containing the presence of row crops, groves, or a cultivated tree plantation.

Figure 9: Agricultural (July 2023 Field Evaluation)

3.7.1.4 Commercial

This habitat subclassification includes areas that have been developed for commercial use and contain minimal vegetation or vegetation is present but is maintained. These areas consist of hotels, automotive facilities, retail developments, and other businesses.

3.7.1.5 Disturbed Land

This habitat subclassification consists of areas that have been changed/disturbed primarily due to human activities.

3.7.1.6 Institutional

This habitat subclassification includes areas that have been developed for institutional use and contain minimal vegetation or vegetation is present but is maintained. These areas include schools, parks, and municipal areas.

3.7.1.7 Mining

This habitat subclassification includes areas that encompass both surface and subsurface mining operations. There are several quarry areas between Bodden Town and East End.

Figure 10: Mining (July 2023 Field Evaluation)

3.7.1.8 Pasture

This habitat subclassification includes pastureland used for livestock grazing.

Figure 11: Cattle Pasture (July 2023 Field Evaluation)

3.7.1.9 Residential

This habitat subclassification consists of residential land use ranging from low to medium density single family homes, to multiple dwelling units. These areas contain minimal vegetation or vegetation is present but is controlled.

Figure 12: Residential (July 2023 Field Evaluation)

3.7.1.10 Roads

This habitat subclassification includes paved roads extending through residential and commercial areas, as well as unpaved access roads through rural or agricultural areas.

Figure 13: Roads (July 2023 Field Evaluation)

3.7.1.11 Man-Made Ponds

This habitat subclassification includes man-made (artificial) ponds.

Figure 14: Man-made excavated pond (July 2023 Field Evaluation)

3.7.2 Coastal

3.7.2.1 Coastal Shrubland

This habitat is defined as a class of vegetation dominated by flora, which ranges in height between 0.5 metre and 5 metres. Shrubs tend to grow as separate individuals or clumps of individuals. In shrubland, the canopy cover of shrubs constitutes greater than 25% of the total canopy cover. Larger trees may be present in shrubland; however, tree canopy cover should constitute less than 25% of the total cover to distinguish the area from woodland. Coastal shrublands of Grand Cayman may be dominated by hemi-sclerophyllous evergreen shrubland, sclerophyllous evergreen shrubland, mixed evergreen/drought-deciduous dwarf-shrubland, or low tropical/subtropical perennial forb vegetation. This category represents a wide variety of vegetative species found in the coastal zone.

Plant species observed during the July 2023 field effort were parrot berry (*Bourreria venosa*), seagrape (*Coccoloba uvifera*), Cayman agave (*Agave caymanensis*), coconut palm, silver palm (*Coccothrinax proctorii*), gumbo limbo, and cocoplum (*Chrysobalanus icaco*), with minimal invasive species coverage consisting of leadtree (*Leucaena leucocephala*), Egyptian crowfoot (*Dactyloctenium aegyptium*), beach naupaka (*Scaevola taccada*), grey nickel (*Guilandina bonduc*) and Australian pine (*Casuarina equisetifolia*).

Pollinators, multiple bird species, including Grand Cayman parrot, and anoles were also observed in coastal shrubland habitats.

Figure 15: Grand Cayman parrot (left) and parrot berry (right) (July 2023 Field Evaluation)

3.7.3 Upland

3.7.3.1 Dry Forest and Woodland

Dry forest is defined as a class of vegetation characterized by a closed tree canopy, with interlocking crowns generally providing 60-100% cover. Woodland, by comparison, is characterised by an open canopy, with tree crowns constituting just 25-60% cover. The canopy height of forest and woodland ranges from 16 metres down to 4.5 metres in height, below which shrubland species dominate. Per Burton (2008b), vegetative communities included in this habitat are lowland semi-deciduous forest, seasonally flooded/saturated semi-deciduous forest, xeromorphic semi-deciduous forest, lowland/submontane drought-deciduous forest woodland, and tropical/subtropical semi-deciduous woodland.

During the field evaluation, biologists identified the following plant species in this habitat: pink trumpet tree (*Tabebuia heterophylla*), devil head (*Morisonia ferruginea*), lead tree, queen of the night, bloody head (*Capparis flexuosa*), shamrock (*Tecoma stans*), silver palm, west indian almond (*Terminalia catappa*), gumbo limbo, wild olive (*Bontia daphnoides*), tan-tan, Asian leatherleaf (*Colubrina asiatica*), butterfly orchid tree (*Bauhinia divaricata*), seaside mahoe (*Thespesia populnea*), Australian pine, grey nickel, Cayman agave, and frangipani (*Plumeria obtussa*). Insects observed included honeybees (*Apis* sp.), and Julia butterfly (*Dryas iulia*).

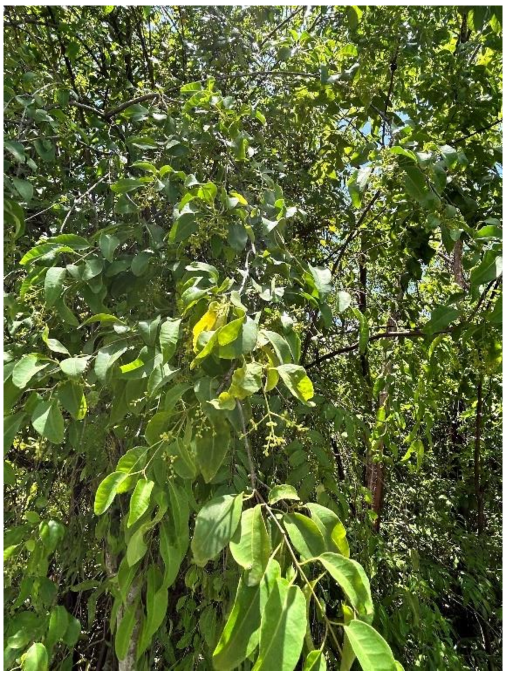


Figure 16: Dry Forest and Woodland (July 2023 Field Evaluation)

3.7.3.2 Dry Shrubland

This habitat is defined as areas dominated by woody and herbaceous species ranging in height between 0.5 metre and 5 metres tall. The canopy cover of shrubs averages over 25% of the total canopy cover, with larger trees that may be present with less than 25% total coverage. Dry shrubland is typically dominated by tropical/subtropical broad-leaved evergreen shrubland or mixed evergreen deciduous shrubland. Succulents and black candlewood (*Erithalis fruticosa*) may be present as well.

During the field evaluation, biologists identified the following plant species in this habitat: silver palm, logwood/bloodwood, Balbis' airplant (*Tillandsia baldbisiana*), Simpson's stopper (*Myrcianthes fragrans*), gumbo limbo, strangler fig (*Ficus aurea*), mangrove fern (*Acrostichum aureum*), pink trumpet tree (*Tabebuia heterophylla*), Cayman agave, wild olive, black mastic

(*Terminalia eriostachya*), foliage flower (*Phyllanthus angustifolius*), tan-tan, papaya (*Carica papaya*), shamrock, dildo cactus (*Pilosocereus royenii*), butterfly orchid tree, Spanish moss (*Tillandsia usnoides*), frangipani, giant air plant (*Tillandsia utriculate*), mangrove fern (*Acrostichum aureum*), queen of the night, buttonwood, black candlewood, twisted sister (*Tillandsia flexuosa*), seaside mahoe, shamrock, seagrape, and west indian almond.

Field observations also recorded the presence of birds, rat holes, Grand Cayman parrot, and butterflies.

Figure 17: Dry Shrubland (July 2023 Field Evaluation)

3.7.3.3 Invasive Species – Casuarina

This habitat is defined as invasive, or monoculture habitats dominated by invasive woody species (primarily *Casuarina*). Invasive plant species observed were Australian pine, beach naupaka, seaside mahoe, scaevola (*Scaevola taccada*), Asian leatherleaf, seagrape, tan-tan, parrot berry, orange geiger (*Cordia sebestena*), gumbo limbo, lavender (*Tournefortia gnaphalodes*), and *Cenchrus tribuloides*.

Field observations also recorded domestic chicken (*Gallus domesticus*), butterflies, and small birds.

Figure 18: Australian Pine (*Casuarina equisetifolia*) (July 2023 Field Evaluation)

3.7.3.4 Palm Hammock

This habitat consists of forest community composed of predominantly palms and is found on sandy type soils. Observed woody species were coconut palm, silver palm, match head (*Phyla nodiflora*), logwood/bloodwood, northern needle-leaf (*Tillandsia balbisiana*), yellow root, prickly pear (*Opuntia dillenii*), wire wiss (*Smilax habanensis*), and queen of the night. Field observations consisted of green iguana (*Iguana iguana*), northern flicker (*Colaptes auratus gundlachi*), termite mounds, and wasps.

Figure 19: Palm Hammock (July 2023 Field Evaluation)

3.7.4 Wetland Habitats

3.7.4.1 Ponds, Pools, Mangrove Lagoons

This habitat is defined as natural and man-modified areas of standing permanent and temporary water and associated vegetation. This habitat category consists of semi-permanently flooded grasslands, aquatic vegetation, tidal tropical/sub-tropical forb vegetation, mangrove pools/ponds/lagoons, man-made ditches and ponds, pools, and flooded marl pits.

During the field evaluation, biologists documented the following plant species in this habitat: black mangrove, buttonwood, mangrove fern, white mangrove, seaside mahoe (*Thespesia populnea*), Australian pine (*Casuarina equisetifolia*), seagrape, red mangrove, and sea-purselane.

Field observations also included Greater Antillean grackle, black-necked stilt, tri-colored heron, magnificent frigatebird (*Fregata magnificens*), northern flicker, smooth-billed ani, yellow warbler, minnows, green heron, dragonflies, butterflies, cattle, honeybees, mosquitoes, and mud crabs.

Figure 20: Ponds, Pools, and Mangrove Lagoons (July 2023 Field Evaluation)

3.7.4.2 Seasonally Flooded Mangrove Forest and Woodland

This habitat consists of forests of mangroves and mangrove associates, mostly growing on deep autochthonous peat with the surface 0 to 50 centimetres above mean high spring tide and located far enough inland to be free of tidal inundation under all conditions. Summer rainfall stratifies freshwater flooding over the more saline groundwater, with buttonwood, black mangrove, and mangrove rubber vine (*Rhabdadenia biflora)* all producing opportunistic rootlets to exploit the transient freshwater layer. (Burton, 2007).

During the field evaluation, biologists observed rat holes, mosquitos, termites, ants, common gallinule (*Gallinula galeata*), yellow warbler, damsel fly, geckos, butterflies, snowy egret (*Egretta thula*), common ground dove (*Columbina passerina*), northern flicker, West Indian woodpecker (*Melanerpes superciliaris caymanensis*), yellow-bellied sapsucker (*Sphyrapicus varius*), Greater Antillean grackle, and green heron in this habitat.

Plant species observed consisted of kapok tree (*Ceiba sp*.), black mangrove, red mangrove, white mangrove, mangrove fern, buttonwood, flat-leaf flat sedge (*Cyperus planifolius*), pine fern (*Amenia adiantifolia*), bermuda grass (*Cynodon dactylon*), Balbis' airplant, Simpson's stopper, coconut palm, lancewood (*Ocotea coriacea*), sea-purslane, tan-tan, lucy Julia (*Stylosanthes hamata*), coat button (*Tridax procumbens*), *Spermacoce tetraquetra*, parrot berry, grey nickel, gumbo limbo, slender false buttonwood (*Spermacoce verticillate*), Australian pine, *Chiococca parviflora*, beach naupaka, seaside mahoe, and round-leaf sage (*Lantana involucrata*).

Figure 21: Buttonwood (left) and Black Mangrove (right) (July 2023 Field Evaluation)

Figure 22: White Mangrove (left) and Red Mangrove (right) (July 2023 Field Evaluation)

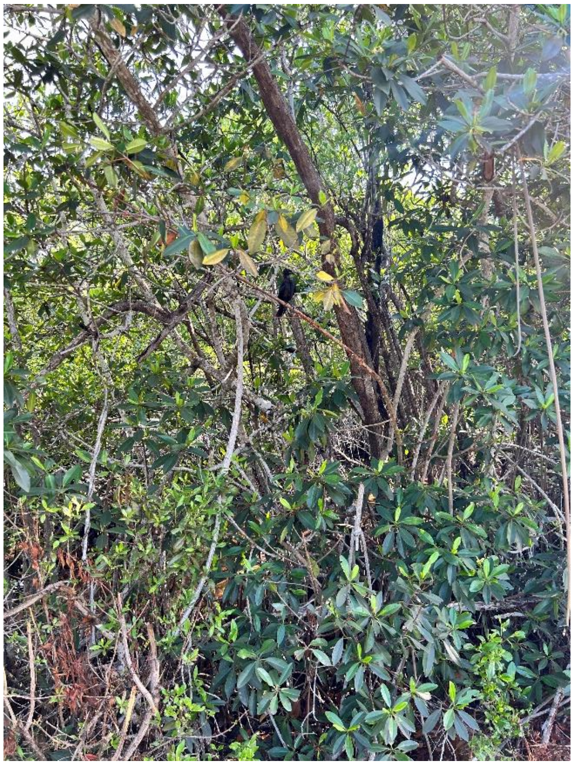


Figure 23: Seasonally Flooded Mangrove Forest and Woodland (July 2023 Field Evaluation)

3.7.4.3 Seasonally Flooded Mangrove Shrubland

This habitat consists of seasonally flooded and saturated evergreen shrubland and saturated sclerophyllous evergreen shrubland.

Field observations of floral species included black mangrove, white mangrove, red mangrove (*Rhizophora mangle*), tan-tan, gumbo limbo, cocoplum, Australian pine, beach naupaka, seaside mahoe, logwood/bloodwood, buttonwood, pink trumpet tree, yaupon holly (*Ilex vomitoria*), bull thatch (*Thrinax radiata*), bamboo (*Lasiacis divaricata*), and saltgrass (*Distichlis spicata*).

Faunal species observed included various butterflies, Grand Cayman parrot, common gallinule, purple gallinule (*Porphyrio martinicus*) and green iguana.

Figure 24: Seasonally Flooded Mangrove Shrubland (July 2023 Field Evaluation)

3.7.4.4 Seasonally Flooded/Saturated Semi-deciduous Forest

This habitat consists of areas at the intersection between lowland semi-deciduous forest and seasonally flooded mangrove. It generally consists of forests of flood-tolerant trees in shallow peat over saturated oxisol soil (Burton, 2007).

During the field evaluation, biologists documented the following plant species in this habitat: gumbo limbo, mangrove fern, silver palm, pink trumpet tree, Cayman agave, wild olive, mangrove rubber vine, bamboo, bastard mahogany (*Trichilia glabra*), duppy bush (*Phyllanthus angustifolius*), snowberry (*Chiococca alba*), and wire wiss.

Field observations also included green iguana, Cuban tree frog (*Osteopilus septentrionalis*), and Caribbean dove (*Leptotila jamaicensis*).

Figure 25: Seasonally Flooded/Saturated Semi-deciduous Forest (July 2023 Field Evaluation)

3.7.4.5 Seasonally Flooded Mangrove Forest (Low Density)

This habitat consists of mangrove forest of similar characteristics to Seasonally Flooded Mangrove Forest and Woodland, however displaying lower vegetative density. In general, mangrove forests in these habitats exhibit characteristics indicating stressed vegetation (stunted growth, chlorosis of the leaves, and fungal growth), impacted water quality (discoloration, debris), and an overall decrease in vegetative cover/density based on the GIS and field evaluations completed. The low density mangrove area will be investigated further during the Preferred Alternative.

Figure 26: Seasonally Flooded Low Density Mangrove Forest (July 2023 Field Evaluation)

3.8 Important Species Habitat

Geospatial data provided by the DoE regarding important species habitat included: Cayman parrot nesting habitat, Cuban white-shouldered bat, tea banker, Cayman pygmy blue butterfly, marine turtle nesting habitat (sea turtles on Grand Cayman include *Caretta caretta*, *Chelonia mydas*, *Dermochelys coriacea*, *Eretmochelys imbricata*, and *Lepidochelys kempii*), marine turtle critical habitat (includes same as previous), white tailed tropicbird, *Pisonia margaratae* (an endemic woody shrub), and mint. Additional data on 2014 parrot density was provided by DoE.

The geospatial data provided represents the only habitat data formally delineated, but other species are also present and will be evaluated, where applicable, as part of the Preferred Alternative. Only the important species habitats within the direct area required for the shortlisted Build alternatives (B1, B2, B3 and B4) were evaluated as part of this assessment. Further evaluation of impacts and possible mitigation measures will occur as part of the Preferred Alternative.

A summary of each species habitat is as follows, per the Cayman NBAP (2009):

- *Parrot nesting habitat* – On Grand Cayman parrots breed in cavities in black mangroves, as well as in cavities in dry forest tree species. Breeding season for birds on Grand Cayman is identified as April through late June (Cayman Turtle Centre, 2021).

- *White-shouldered bat* – The white shouldered bat uses the mature dry forest habitat on Grand Cayman.
- *Tea banker* – This coastal perennial herb typically grows close to the coast, in sand and gravel. It may also be found in beachside cemeteries and is subject to habitat fragmentation due to human activity (NBAP, 2009)
- *Pygmy blue butterfly* – The butterfly depends on habitats of salt-tolerant succulents during all life-cycle phases. It is also found in pools, ponds, and mangrove lagoons. Some of its habitats have been reduced to areas of a few square metres.
- *Marine turtle nesting habitat and marine turtle critical habitat* – These habitats refer to the terrestrial areas used during the portion of the sea turtle lifecycle spent on and near land. Female sea turtles create nests on shore, and many species use feeding grounds near shore (seagrass beds and coral reefs) (NBAP, 2009).
- *White tailed tropicbird* – This bird uses cliff and cave habitats during breeding season, laying just one egg in a rock crevice. These birds have been observed on the coastal bluff east of Bodden Town in Grand Cayman.
- *Pisonia margaratae* – This woody shrub found in terrestrial habitats, typically the understory of forest and woodlands, though it is also known to be found adjacent to roads (NBAP, 2009)
- *Mint* – This endemic plant species is a woody vine that grows in the canopy of forest and woodland habitats.

Additionally, the parrot density data is based on parrot sightings and is not limited to solely nesting habitat. Parrots may forage outside of their nesting habitat, accounting for observed parrots outside of the delineated nesting habitat. Generally, parrot habitat contains mangrove, coastal shrubland, dry shrubland, dry forest, farm and grassland, and urban and man-modified areas. The density data received from DoE covers areas of no parrot sightings to areas of up to three parrot sightings per hectare. The estimated number of parrots on Grand Cayman may be as low as 1,400 and as abundant as 7,500 or more, as estimates vary by source and time frame. According to "Important Bird Areas in the Caribbean – Cayman Islands", Grand Cayman was home to between approximately 1,408-1,935 parrots in 1995. Per Haakonsson et al. (2017), Grand Cayman had an estimated parrot population size of 6,395 (+/- 1,202) parrots in 2014. The provided parrot density data is from 2014, therefore it is estimated to be based on a parrot population size of approximately 6,395 per Haakonsson et al. (2017).

4 Anticipated Project Impacts

Proposed direct impacts in relation to terrestrial habitat and important species habitat have been assessed for each of the shortlisted Build alternatives (B1, B2, B3 and B4) and are summarized in the subsequent sections in quantitative, qualitative, and monetary form. Direct impact areas were estimated based on the occurrence of each habitat type within each of the alternatives. Potential indirect impacts to habitats are broadly discussed within **Section 4.2.2**. Further evaluation of potential indirect impacts will occur during the Preferred Alternative.

4.1 Quantitative

4.1.1 Habitat Impacts

Direct habitat impacts were assessed for each of the shortlisted Build alternatives (B1, B2, B3, and B4) and No-Build. These direct habitat impacts were quantified based on the area needed for the alternatives. Details regarding the corridor widths are within the Engineering Evaluation and Shortlist Evaluation Document.

The No-Build scenario is assumed to have no direct impact on habitats. The habitat mapping within the area of each shortlisted Build alternative can be found in **Attachment A – Attachment D**. A summary of the proposed acres and hectares (ha) of direct impact is provided in **Table 1**:

Table 1: Summary of Habitat Impacts by Alternative

Habitat Type	Impact Acres *(Hectares)*				
	No-Build	**B1**	**B2**	**B3**	**B4**
Man-Modified Land Uses					
Man-modified without trees	---	63.5 *(25.7 ha)*	67.9 *(27.5 ha)*	61.4 *(24.9 ha)*	58.5 *(23.7 ha)*
Man-modified with trees	---	6.5 *(2.6 ha)*	10.4 *(4.2 ha)*	5.7 *(2.3 ha)*	24.2 *(9.8 ha)*
Agricultural	---	---	---	---	0.3 *(0.1 ha)*
Commercial	---	2.2 *(0.9 ha)*	2.1 *(0.9 ha)*	2.1 *(0.9ha)*	6.3 *(2.6 ha)*
Disturbed land	---	0.9 *(0.4 ha)*	0.9 *(0.4 ha)*	0.9 *(0.4 ha)*	1.0 *(0.4 ha)*
Institutional	---	0.1 *(0.1 ha)*	0.1 *(0.1 ha)*	0.1 *(0.1 ha)*	---
Mining	---	---	4.9 *(2.0 ha)*	---	---
Pasture	---	14.5 *(5.9 ha)*	14.5 *(5.9 ha)*	14.5 *(5.9 ha)*	14.5 *(5.9 ha)*
Residential	---	2.5 *(1.0 ha)*	4.8 *(1.9 ha)*	2.5 *(1.0 ha)*	19.4 *(8.0 ha)*
Roads	---	2.4 *(1.0 ha)*	2.6 *(1.1 ha)*	1.9 *(0.8 ha)*	13.1 *(5.3 ha)*
Man-Made Pond	---	0.4 *(0.1 ha)*	0.4 *(0.1 ha)*	0.4 *(0.1 ha)*	0.4 *(0.1 ha)*
Total	**0.0** *(0.0 ha)*	**93.0** *(37.7 ha)*	**108.6** *(43.9 ha)*	**89.5** *(36.2 ha)*	**137.7** *(55.7 ha)*
Coastal Habitat					
Coastal shrubland	---	---	---	---	2.3 *(0.9 ha)*
Total	---	---	---	---	**2.3** *(0.9 ha)*

Habitat Type	Impact Acres *(Hectares)*				
	No-Build	**B1**	**B2**	**B3**	**B4**
Upland Habitats					
Dry forest and woodland	---	0.1 *(0.1 ha)*	---	---	6.0 *(2.4 ha)*
Dry shrubland	---	0.5 *(0.2 ha)*	---	0.6 *(0.2 ha)*	11.9 *(4.8 ha)*
Invasive species - casuarina	---	0.3 *(0.1 ha)*	0.3 *(0.1 ha)*	0.3 *(0.1 ha)*	3.6 *(1.5 ha)*
Palm Hammock	---	1.5 *(0.6 ha)*	1.5 *(0.6 ha)*	1.5 *(0.6 ha)*	0.4 *(0.6 ha)*
Total	**0.0** *(0.0 ha)*	**2.4** *(1.0 ha)*	**1.8** *(0.7 ha)*	**2.5** *(1.0 ha)*	**21.9** *(8.9 ha)*
Wetland Habitats					
Ponds, pools and mangrove lagoons	---	1.9 *(0.8 ha)*	2.3 *(0.9 ha)*	1.3 *(0.5 ha)*	1.4 *(0.6 ha)*
Seasonally flooded mangrove forest and woodland	---	107.5 *(43.5 ha)*	57.8 *(23.4 ha)*	79.9 *(32.3 ha)*	32.8 *(13.3 ha)*
Seasonally flooded mangrove shrubland	---	---	---	---	0.1 *(0.1 ha)*
Seasonally flooded / saturated semi-deciduous forest	---	1.5 *(0.6 ha)*	1.5 *(0.6 ha)*	1.5 *(0.6 ha)*	1.5 *(0.6 ha)*
Seasonally flooded mangrove forest (low density)	---	83.4 *(33.7 ha)*	66.6 *(26.9 ha)*	68.4 *(27.7 ha)*	---
Total	**0.0** *(0.0 ha)*	**194.3** *(78.6 ha)*	**128.2** *(51.9 ha)*	**151.1** *(61.1 ha)*	**35.8** *(14.4 ha)*
Combined Total	**0.0** *(0.0 ha)*	**289.7** *(117.3 ha)*	**238.6** *(96.6 ha)*	**243.0** *(98.4 ha)*	**197.7** *(80.0 ha)*

4.1.2 Important Species Habitat

Direct impacts to important species habitat impacts were assessed for each of the shortlisted Build alternatives (B1, B2, B3, and B4).

The No-Build scenario is assumed to have no direct impact on important species habitats. The important species habitat mapping within the area of each shortlisted Build alternative can be found further below in this section. A summary of the anticipated direct impacts to important species habitats by alternative are presented in **Table 2** below:

Table 2: Summary of Important Species Habitat Impacts by Alternative

Species	Habitat Impact Acres (*Hectares*)				
	No-Build	B1	B2	B3	B4
Parrot Nesting Habitat (Cayman Parrot)	---	117.5 *(47.6 ha)*	91.4 *(37.0 ha)*	80.1 *(32.4 ha)*	15.5 *(6.3 ha)*
Parrot Density (Cayman Parrot)	---	0.3 parrots/acre (*0.6 parrots/ha*)	0.2 parrots/acre (*0.5 parrots/ha*)	0.2 parrots/acre (*0.5 parrots/ha*)	0.2 parrots/acre (*0.5 parrots/ha*)
Mint	---	---	---	---	---
Inkberry	---	---	---	---	---
Marine Turtle Critical Habitat	---	---	---	---	---
Marine Turtle Nesting Beaches	---	---	---	---	---
Pisionia margaratae	---	---	---	---	---
Pygmy blue butterfly	---	---	---	---	0.1 *(0.04 ha)*
Tea Banker	---	---	---	---	0.01 *(0.004 ha)*
White Tailed Tropicbird	---	---	---	---	---
Cuban white-shouldered bat	---	---	---	---	---

4.1.2.1 No-Build

The No-Build scenario is assumed to have no direct impact on important species habitats.

4.1.2.2 Alternative B1

Alternative B1 would directly impact 117.5 acres (47.5 ha) of Parrot Nesting Habitat (**Figure 27**). This accounts for 4.3% of the total Parrot Nesting Habitat within the EIA study area (based on geospatial data provided by DoE in September 2023). To determine the potential impact on parrots depending on this habitat, the impacted area was also examined against parrot density within the study area (2014 geospatial data provided by DoE). Parrot density includes a larger area than parrot nesting habitat as it is based on field observations of parrots and may also include foraging behaviour.

Parrot density along Alternative B1 ranges from 0.04 to 1.34 parrots per acre (0.1 to 3.3 parrots per hectare), with an average density of 0.3 parrots per acre (0.6 parrots per hectare) (**Figure 28**). It is important to note that Alternative B1 (the northern spur) is the only alternative that traverses through an area with a density higher than 3 parrots per hectare (1.2 parrots per acre). Alternative B1 is not anticipated to impact any of the other important species' habitats identified.

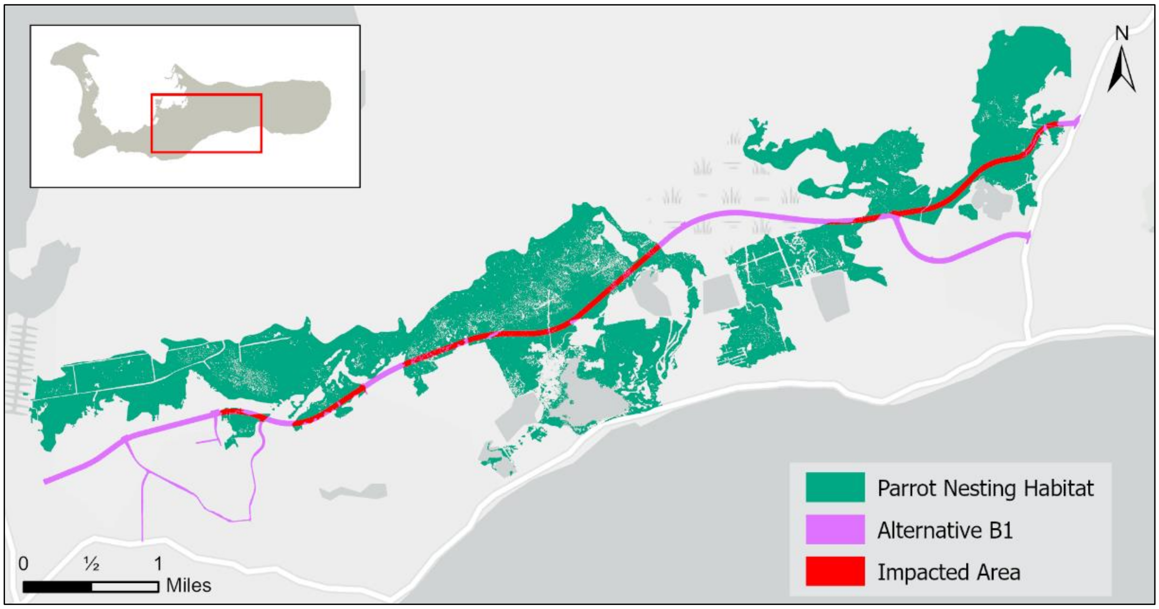


Figure 27: Alternative B1 Impact on Parrot Nesting Habitat
Source: Esri, DoE

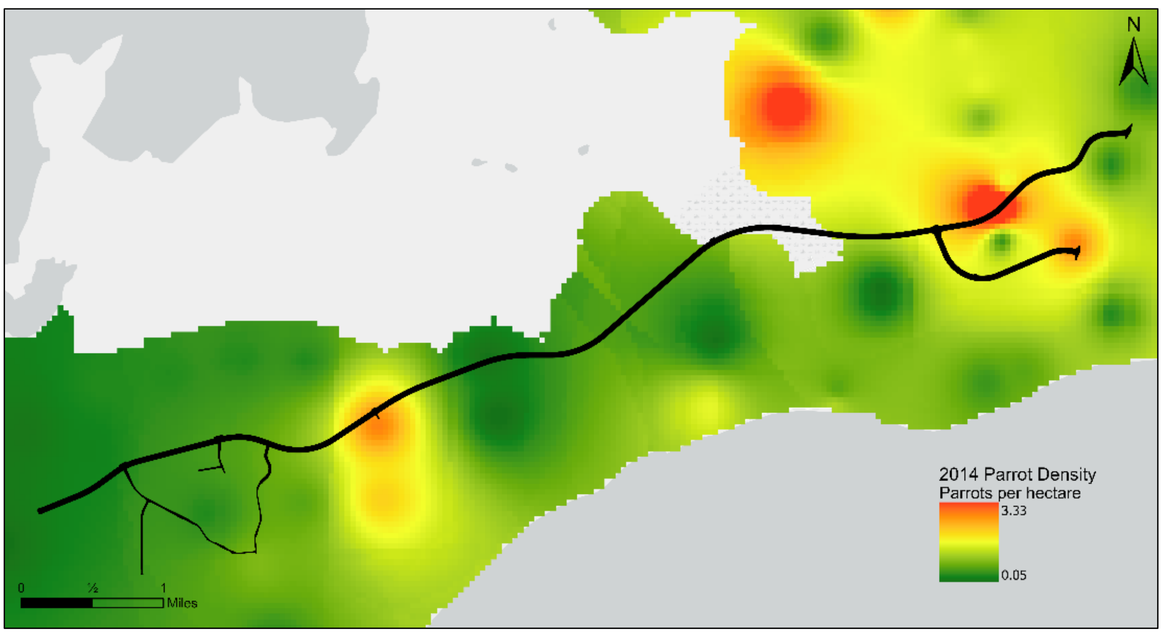


Figure 28: Alternative B1 Impact on 2014 Parrot Density
Source: Esri, DoE

4.1.2.3 Alternative B2

Alternative B2 would directly impact 91.4 acres (37.0 ha) of Parrot Nesting Habitat (**Figure 29**). This accounts for 3.3% of total Parrot Nesting Habitat within the EIA study area (based on geospatial data provided by DoE in September 2023). Parrot density along Alternative B2 ranges from 0.04 to 0.6 parrots per acre (0.1 to 1.5 parrots per hectare), with an average density of 0.2 parrots per acre (0.5 parrots per hectare) (**Figure 30**). Alternative B2 is not anticipated to impact any of the other important species' habitats identified.

Figure 29: Alternative B2 Impact on Parrot Nesting Habitat
Source: Esri, DoE

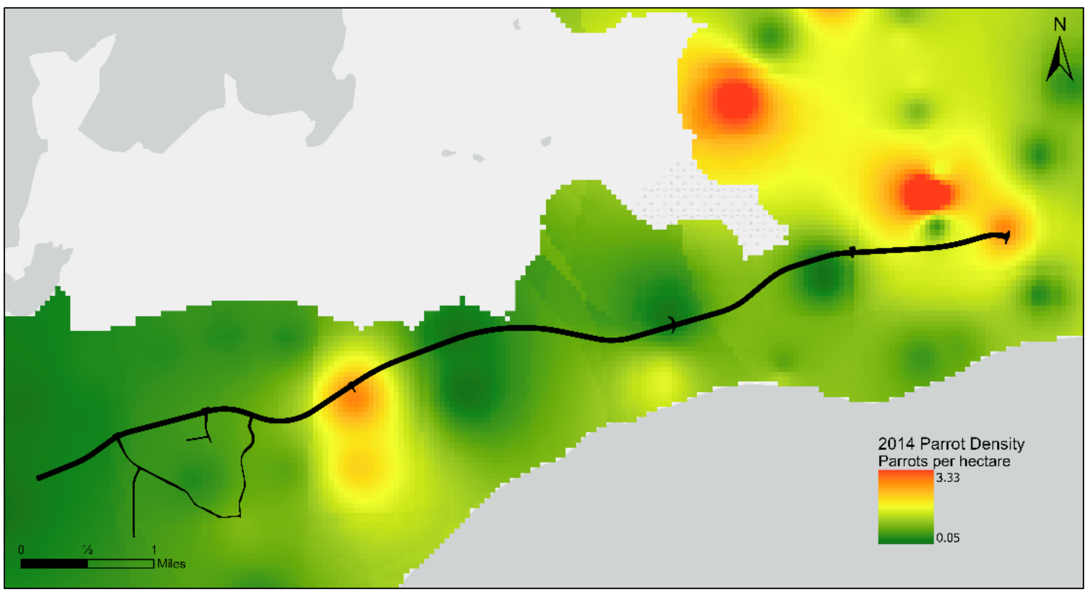


Figure 30: Alternative B2 Impact on 2014 Parrot Density
Source: Esri, DoE

4.1.2.4 Alternative B3

Alternative B3 would directly impact 80.1 acres (32.4 ha) of Parrot Nesting Habitat (**Figure 31**). This accounts for 2.9% of total Parrot Nesting Habitat within the EIA study area (based on geospatial data provided by DoE in September 2023). Parrot density along Alternative B3 ranges from 0.04 to 0.6 parrots per acre (0.1 to 1.5 parrots per hectare), with an average density of 0.2 parrots per acre (0.5 parrots per hectare) (**Figure 32**). Alternative B3 is not anticipated to impact any of the other important species' habitats identified.

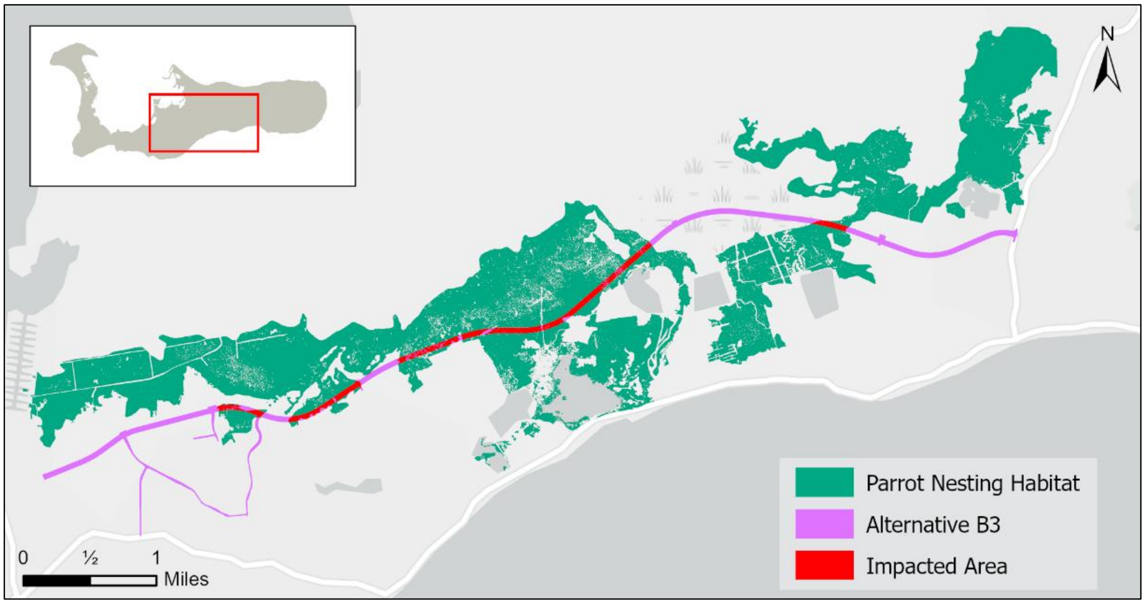


Figure 31: Alternative B3 Impact on Parrot Nesting Habitat
Source: Esri, DoE

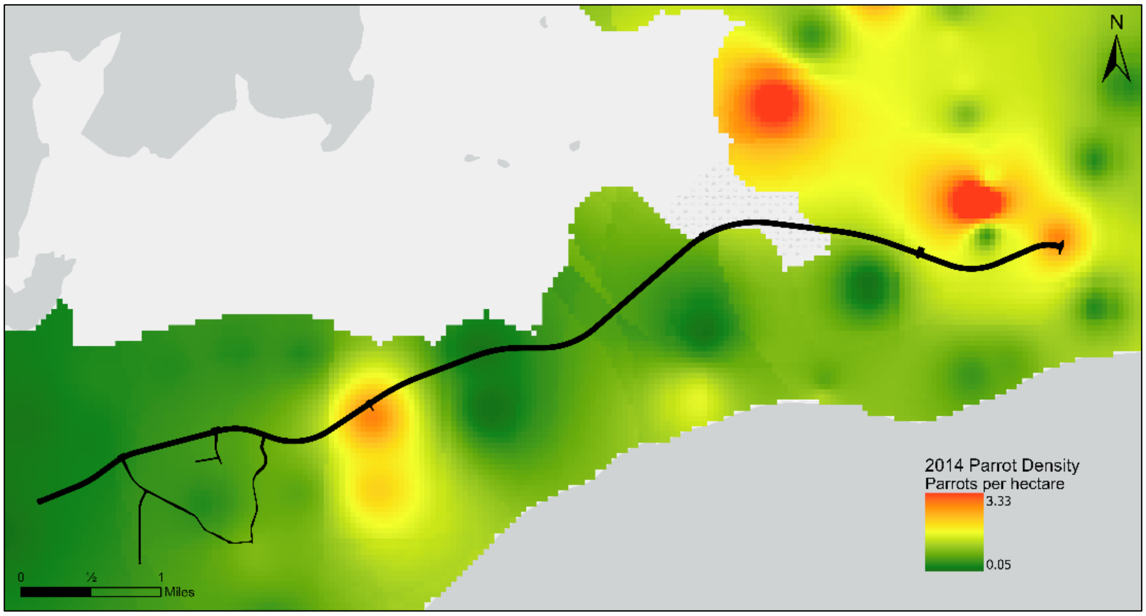


Figure 32: Alternative B3 Impact on 2014 Parrot Density
Source: Esri, DoE

4.1.2.5 Alternative B4

Alternative B4 would directly impact 15.5 acres (6.5 ha) of Parrot Nesting Habitat (**Figure 33**). This accounts for <1% of total Parrot Nesting Habitat within the EIA study area (based on geospatial data provided by DoE in September 2023). Parrot density along Alternative B4 ranges from 0.04 to 0.6 parrots per acre (0.1 to 1.5 parrots per hectare), with an average density of 0.2 parrots per acre (0.5 parrots per hectare) (**Figure 34**).

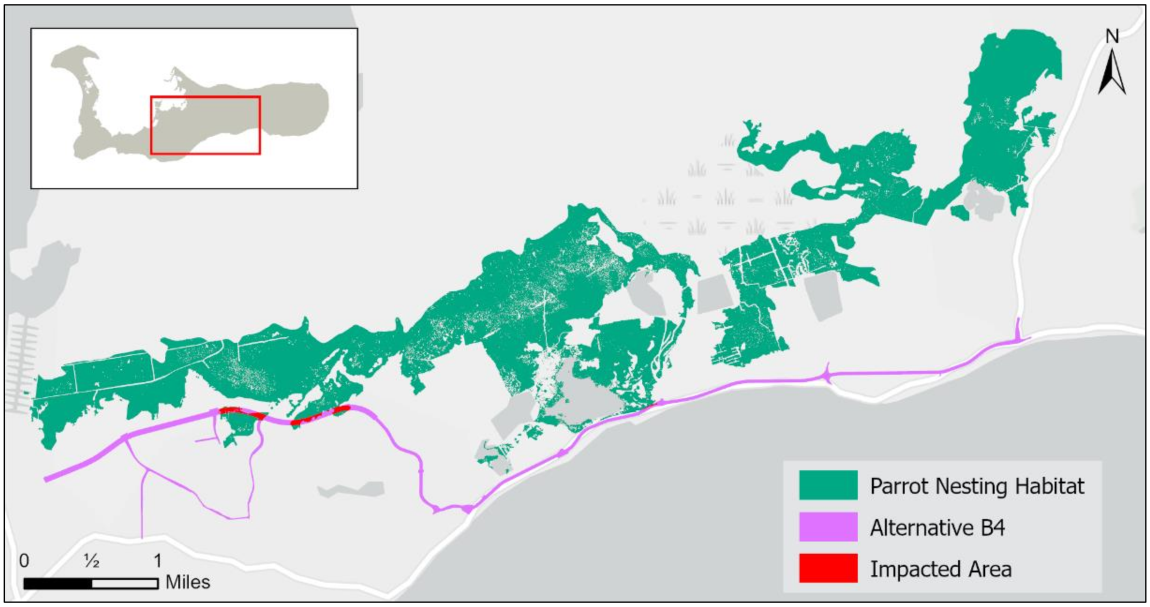


Figure 33: Alternative B4 Impact on Parrot Nesting Habitat
Source: Esri, DoE

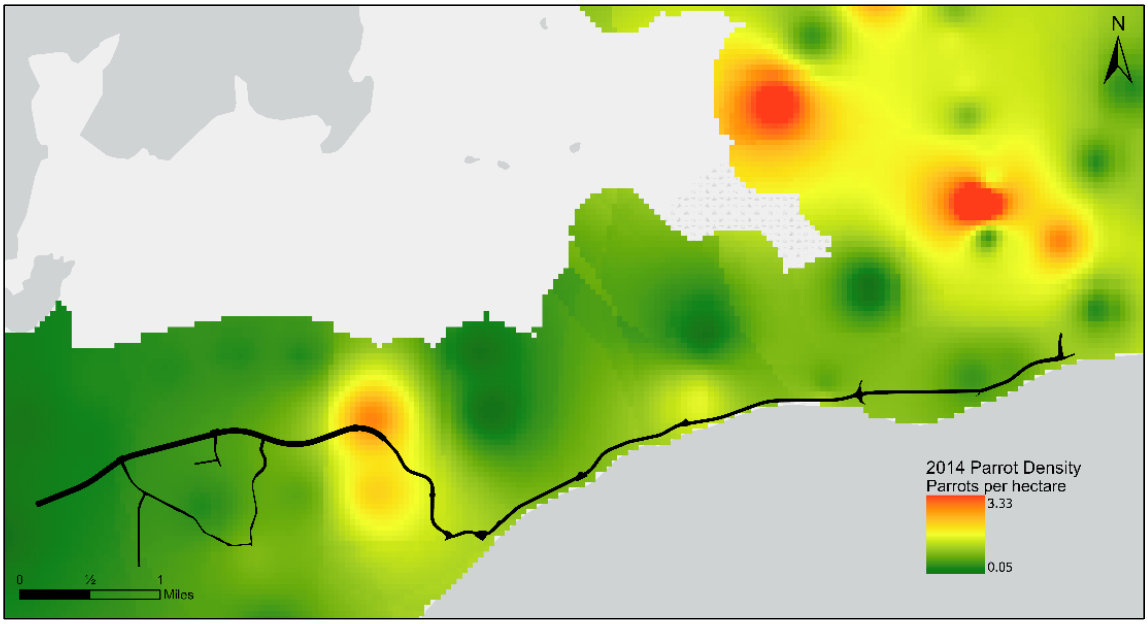


Figure 34: Alternative B4 Impact on 2014 Parrot Density
Source: Esri, DoE

Alternative B4 would also directly impact pygmy blue butterfly habitat (**Figure 35**) and tea banker area (**Figure 36**). The anticipated impact area of pygmy blue butterfly habitat would be 0.1 acre (0.04 ha), which is <1% of the pygmy blue butterfly habitat within the EIA study area. The anticipated impact area of tea banker area habitat would be 0.01 acre (0.004 ha), which is <1% of the tea banker area within the EIA study area.

Figure 35: Alternative B4 Impact on Pygmy Blue Butterfly Habitat
Source: Esri, DoE

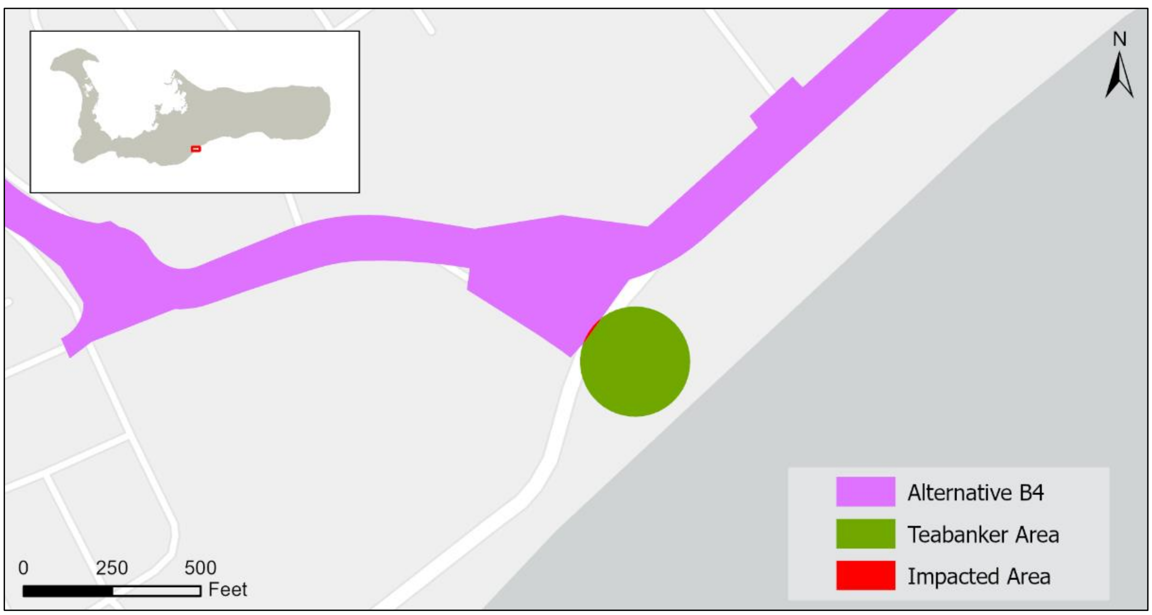


Figure 36: Alternative B4 Impact on Tea Banker Area
Source: Esri, DoE

4.2 Qualitative

The following describes the qualitative assessment for Terrestrial Ecology that is based on the UK Department for Transport's "Transport Analysis Guidance Unit A3: Environmental Impact Appraisal" (WebTAG). The most applicable category for Terrestrial Ecology impacts is "Impacts to Biodiversity." This qualitative assessment follows Section 9 of WebTAG.

4.2.1 Step 1 – Determination of Value

The first step of the qualitative assessment was to determine the value of the identified habitat types. **Table 3** is adapted from WebTAG and provides the criteria and example features for each value category.

Table 3: Guidance on Describing the Biodiversity and Earth Heritage Value of Features

Value	Criteria	Examples
Very high	High importance and rarity, international scale and limited potential for substitution	Internationally designated sites
High	High importance and rarity, national scale, or regional scale with limited potential for substitution	Nationally designated sites or regionally important sites with limited potential for substitution
Medium	High or medium importance and rarity, local or regional scale, and limited potential for substitution	Regionally important sites with potential for substitution or locally designated sites
Low	Low or medium importance and rarity, local scale	Undesignated sites of some local biodiversity and earth heritage interest
Negligible	Very low importance and rarity, local scale	Other sites with little or no local biodiversity and earth heritage interest

Source: TAG Unit A3, Table 8, Environmental Impact Appraisal, November 2023

Cayman Island publications, primarily the 2009 NBAP and 2013 NCA, were reviewed to determine the value ranking for each broad habitat category:

Man-Modified land uses: Based on the 2009 NBAP, urban and man-modified areas are not currently represented in the protected areas of the Cayman Islands. Urban and man-modified areas are a result of human activity and result in the loss of the previous primary habitat once established in that area. Urban and man-modified areas have already resulted in habitat destruction, habitat fragmentation, spread of invasive species, and/or interruption of wildlife corridors. While not primary habitat, man-modified land uses provide habitat for certain animal species and include native fauna, as noted by field biologists in **Section 3.7** above.

Due to the low importance and local scale significance, man-modified land uses receive a rating of **"Low"** on the Value scale.

Coastal habitats: Based on the 2009 NBAP, coastal shrubland, along with mangroves, comprise the natural coastal vegetation of the Cayman Islands. Based on the unique environment and relatively narrow extent along the coastline, coastal shrubland supports a diversity of species, including reptiles such as the Grand Cayman Blue iguana. Coastal shrubland also provides beach stabilization and turtle nesting.

Due to the high importance and national significance, coastal habitats receive a rating of **"High"** on the Value scale.

Upland habitats: Based on the 2009 NBAP, dry shrubland habitat is critically under-represented within the protected areas of the Cayman Islands. Dry shrubland habitat supports a significant and unique biodiversity and provides storm refugia to wildlife during severe weather. Based on the 2009 NBAP, natural woodland is a rarity in the Cayman Islands and dry forest represents the most biodiverse of all terrestrial habitats in the Cayman Islands.

Due to the high importance and national significance, upland habitats receive a rating of **"High"** on the Value scale.

Wetland habitats: Based on the 2009 NBAP, mangrove (wetland) habitats constitute one of the Cayman Islands' most undervalued and severely impacted habitats Mangroves contribute significantly to the biodiversity of both terrestrial and marine ecosystems. The black mangroves within wetland habitats provide nesting habitat for a significant portion of Grand Cayman's national bird, the Cayman Parrot.

Due to the high importance and national significance, wetland habitats receive a rating of **"High"** on the Value scale.

Parrot habitat (nesting and density): Parrot habitat represents habitat for the National Bird, the Cayman Parrot. Based on the 2009 NBAP, the Cayman Parrot is an endemic, near-threatened species. Current factors affecting the parrot include habitat loss, habitat fragmentation, introduced predators, human impact, and road traffic.

Due to the high importance, national significance, and protection under Part 1 Section 1 of the 2013 NCA, parrot habitat receives a rating of **"High"** on the Value scale.

Pygmy blue butterfly habitat: Based on the 2009 NBAP, the pygmy blue butterfly is endemic to the Cayman Islands and is one of the smallest butterflies in the Western hemisphere. Current factors affecting the butterfly include range limitation, population fragmentation, and insecticide usage.

The pygmy blue butterfly is protected under Part 1 Section 1 of the 2013 NCA, therefore is received a rating of "**High**" on the Value scale.

Tea Banker habitat: Based on the 2009 NBAP, the tea banker is endemic to the Cayman Islands and critically endangered. Tea banker has traditionally been used in preparation of an aromatic tea. Current factors affecting the tea banker include restricted habitat, habitat loss, and spread of invasive species. Attempts to propagate tea banker have been met with little success.

The tea banker is protected under Part 1 Section 1 of the 2013 NCA, therefore is received a rating of "**High**" on the Value scale.

4.2.2 Step 2 – Determination of Magnitude of Impact

The second step of the qualitative assessment was to determine the magnitude of impact based on the anticipated degree of impact. This determination of impact is based on the **Table 4** below:

Table 4: Criteria for Determining the Magnitude of the Impact

Magnitude	Criteria
Major Negative	The proposal (either on its own or with other proposals) may adversely affect the integrity of the key environmental resource, in terms of the coherence of its ecological structure and function, across its whole area, that enables it to sustain the habitat, complex of habitats and / or the population levels of species of interest.
Intermediate Negative	The key environmental resource's integrity will not be adversely affected, but the effect on the resource is likely to be significant in terms of its ecological objectives. If, in the light of full information, it cannot be clearly demonstrated that the proposal will not have an adverse effect on integrity, then the impact should be assessed as major negative.
Minor Negative	Neither of the above apply, but some minor negative impact is evident.
Neutral	No observable impact in either direction.
Positive	Impacts which provide a net gain for wildlife overall.

Source: TAG Unit A3, Environmental Impact Appraisal, Table 10, November 2023

The following describes the evaluation of each shortlisted alternative and the anticipated Magnitude of Impact. For Important Species Habitat, the determination of Magnitude of Impact analysis was limited to three types: parrot habitat (including nesting habitat and density), pygmy blue butterfly habitat, and tea banker habitat. No other Important Species Habitats listed in **Table 2** were directly impacted by any of the alternatives; therefore, analysis of these habitats would provide no comparative value. If an alternative's area would not be anticipated to directly impact a habitat or ecosystem listed, it is assigned a magnitude of "Neutral."

4.2.2.1 No-Build

The No-Build scenario is not anticipated to have a direct impact on land uses or habitat types; therefore, it receives a score of **"Neutral"** for all categories of the Magnitude of Impact scale. Potential indirect impacts, such as noise and wildlife-vehicular collisions, will be evaluated as part of the Preferred Alternative.

4.2.2.2 Alternative B1

Man-Modified land uses: Alternative B1 is anticipated to have a direct impact to 93.0 acres (37.7 ha) of man-modified land uses. The majority (68%) of the impacts to man-modified land uses would be to the man-modified without trees land use (63.5 acres (25.7 ha)). This land use is mostly found within or on the outskirts of residential areas located on the west and east ends of Alternative B1. Though not necessarily of high or medium importance and rarity, this land use is often adjacent to higher valued habitats and provides a buffer for species between the higher value habitats and nearby development. Alternative B1 will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Provided the acres of impact and buffer from high value habitats, Alternative B1 is anticipated to have a measurable negative impact on man-modified land uses and adjacent habitats. However, Alternative B1 is not anticipated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat or surrounding habitats. Therefore, Alternative B1 receives an **"Intermediate Negative"** score on the Magnitude of Impact scale.

Coastal habitats: Alternative B1 is not anticipated to have any direct impacts on coastal habitat; therefore, it receives a score of **"Neutral"** on the Magnitude of Impact scale. Potential indirect impacts, such as impacts to hydrologic connectivity and habitat fragmentation, will be evaluated as part of the Preferred Alternative.

Upland habitats: Alternative B1 is anticipated to have a direct impact to 2.4 acres (1.0 ha) of upland habitats. The majority (63%) of the impacts to upland habits would be to palm hammock (1.5 acres (0.6 ha)). Invasive species – Casuarina impacts account for 13% (0.3 acres (0.1 ha)) of impacts to upland habitats. Alternative B1 will potentially have indirect impacts to the habitat, such reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Provided the low acreage of impact, Alternative B1 is anticipated to have a measurable, but insignificant negative impact on upland habitats. Therefore, Alternative B1 receives a **"Minor Negative"** score on the Magnitude of Impact scale.

Wetland habitats: Alternative B1 is anticipated to have a direct impact to 194.3 acres (78.6 ha) of wetland habitats. The majority (55%) of the impacts are to seasonally flooded mangrove forest and woodland (107.5 acres (43.5 ha)). Seasonally flooded mangrove forest (low density) accounts for 43% (83.4 acres (33.7 ha)) of the impacts to wetland habitats. Alternative B1 will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Provided the acres of impact, Alternative B1 is anticipated to have a measurable negative impact on wetland habitats. However, provided the adjacency of the impacts to developed areas and large-scale size of the connected habitat (CMW system is estimated at 8,655 acres (3,502 ha) in size; see **Figure 1**), Alternative B1 is not anticipated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat. Therefore, Alternative B1 receives an **"Intermediate Negative"** score on the Magnitude of Impact scale.

Parrot Habitat (Nesting and Density): Alternative B1 is anticipated to have a direct impact to 117.5 acres (47.6 ha) of parrot nesting habitat. This accounts for 4.3% of the total parrot nesting habitat within the EIA study area (based on geospatial data provided by DoE in September 2023). Parrot density along Alternative B1 ranges from 0.1 to 3.3, with an average density of 0.3 parrots per acre (0.6 parrots per hectare) (**Figure 28**) (2014 geospatial data provided by DoE). Alternative B1 would potentially have indirect impacts on the parrot and its associated habitat, such as noise and wildlife-vehicular collisions, which will be further evaluated as part of the Preferred Alternative. According to Haakonsson et al. (2017), the growth trend of the Grand Cayman Parrot has been increasing over time despite the effects of anthropogenic and natural disturbances, with an estimated 2014 parrot population size of 6,395 on Grand Cayman.

Provided the acres of impact and density, Alternative B1 is anticipated to have a measurable negative impact on parrot habitat. However, provided the estimated parrot population and growth trend, Alternative B1 is not anticipated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat or population levels. Therefore, Alternative B1 receives an **"Intermediate Negative"** score on the Magnitude of Impact scale.

Pygmy blue butterfly habitat: Alternative B1 is not anticipated to have a direct impact on Pygmy blue butterfly habitat; therefore, it receives a score of **"Neutral"** on the Magnitude of Impact scale. Potential indirect impacts, such as habitat fragmentation and wildlife-vehicular collisions, will be evaluated as part of the Preferred Alternative.

Tea Banker habitat: Alternative B1 is not anticipated to have a direct impact on Tea Banker habitat; therefore, it receives a score of **"Neutral"** on the Magnitude of Impact scale. Potential indirect impacts, such as habitat fragmentation and reduced hydrologic connectivity, will be evaluated as part of the Preferred Alternative.

4.2.2.3 Alternative B2

Man-Modified land uses: Alternative B2 is anticipated to have a direct impact to 108.6 acres (43.9 ha) of man-modified land uses. The majority (63%) of the impacts to man-modified land uses would be to the man-modified without trees land use (67.9 acres (27.4 ha)). This land use is mostly found within or on the outskirts of residential areas located on the west and east ends of Alternative B2. Though not necessarily of high or medium importance and rarity, this land use is often adjacent to higher valued habitats and provides a buffer for species between the higher value habitats and nearby development. Alternative B2 will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Provided the acres of impact and buffer from high value habitats, Alternative B2 is anticipated to have a measurable negative impact on man-modified land uses and adjacent habitats. However, Alternative B2 is not anticipated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat or surrounding habitats. Therefore, Alternative B2 receives an **"Intermediate Negative"** score on the Magnitude of Impact scale.

Coastal habitats: Alternative B2 is not anticipated to have any direct impacts on coastal habitat; therefore, it receives a score of **"Neutral"** on the Magnitude of Impact scale. Potential indirect impacts, such as reduced hydrologic connectivity and habitat fragmentation, will be evaluated as part of the Preferred Alternative.

Upland habitats: Alternative B2 is anticipated to have a direct impact to 1.8 acres (0.7 ha) of upland habitats. The majority (83%) of the impacts to upland habits would be to palm hammock (1.5 acres (0.6 ha)). The remaining impacts would be to the invasive Casuarina (0.3 acres (0.01 ha)). Alternative B2 will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Provided the low acreage of impact, Alternative B2 is anticipated to have a measurable, but insignificant negative impact on upland habitats. Therefore, Alternative B2 receives a **"Minor Negative"** score on the Magnitude of Impact scale.

Wetland habitats: Alternative B2 is anticipated to have a direct impact to 128.2 acres (51.9 ha) of wetland habitats. The majority (52%) of the impacts are to seasonally flooded mangrove forest (low density) (66.6 acres (26.9 ha)). Seasonally flooded mangrove forest and woodland accounts for 45% (57.8 acres (23.4 ha)) of the impacts to wetland habitats. Alternative B2 will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Provided the acres of impact, Alternative B2 is anticipated to have a measurable negative impact on wetland habitats. However, provided the adjacency of the impacts to developed areas and large-scale size of the connected habitat (CMW system is estimated at 8,655 acres (3,502 ha) in size; see **Figure 1**), Alternative B2 is not anticipated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat. Therefore, Alternative B2 receives an **"Intermediate Negative"** score on the Magnitude of Impact scale.

Parrot Habitat (Nesting and Density): Alternative B2 is anticipated to have a direct impact to 91.4 acres (37.0 ha) of parrot nesting habitat. This accounts for 3.3% of total parrot nesting habitat within the EIA study area (based on geospatial data provided by DoE in September 2023). Parrot density along Alternative B2 ranges from 0.1 to 1.5, with an average density of 0.2 parrots per acre (0.5 parrots per hectare) (**Figure 30**) (2014 geospatial data provided by DoE). Alternative B2 will potentially have indirect impacts on the parrot and its associated habitat, such as noise and wildlife-vehicular collisions, which will be further evaluated as part of the Preferred Alternative. According to Haakonsson et al. (2017), the growth trend of the Grand Cayman Parrot has been increasing over time despite the effects of anthropogenic and natural disturbances, with an estimated 2014 parrot population size of 6,395 on Grand Cayman.

Provided the acres of impact and density, Alternative B2 is anticipated to have a measurable negative impact on parrot habitat. However, provided the estimated parrot population and growth trend, Alternative B2 is not anticipated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat or population levels. Therefore, Alternative B2 receives an **"Intermediate Negative"** score on the Magnitude of Impact scale.

Pygmy blue butterfly habitat: Alternative B2 is not anticipated to have a direct impact on Pygmy blue butterfly habitat; therefore, it receives a score of **"Neutral"** on the Magnitude of Impact scale. Potential indirect impacts, such as habitat fragmentation and wildlife-vehicular collisions, will be evaluated as part of the Preferred Alternative.

Tea Banker habitat: Alternative B2 is not anticipated to have a direct impact on Tea Banker habitat; therefore, it receives a score of **"Neutral"** on the Magnitude of Impact scale. Potential indirect impacts, such as habitat fragmentation and reduced hydrologic connectivity, will be evaluated as part of the Preferred Alternative.

4.2.2.4 Alternative B3

Man-Modified land uses: Alternative B3 is anticipated to have a direct impact to 89.5 acres (36.2 ha) of man-modified land uses. The majority (69%) of the impacts to man-modified land uses would be to the man-modified without trees land use (61.4 acres (24.9 ha)). This land use is mostly found within or on the outskirts of residential areas located on the west and east ends of Alternative B3. Though not necessarily of high or medium importance and rarity, this land use is often adjacent to higher valued habitats and provides a buffer for species between the higher value habitats and nearby development. Alternative B3 will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Provided the acres of impact and buffer from high value habitats, Alternative B3 is anticipated to have a measurable negative impact on man-modified land uses and adjacent habitats. However, Alternative B3 is not anticipated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat or surrounding habitats. Therefore, Alternative B3 receives an **"Intermediate Negative"** score on the Magnitude of Impact scale.

Coastal habitats: Alternative B3 is not anticipated to have any direct impacts on coastal habitat; therefore, it receives a score of **"Neutral"** on the Magnitude of Impact scale. Potential indirect impacts, such as reduced hydrologic connectivity and habitat fragmentation, will be evaluated as part of the Preferred Alternative.

Upland habitats: Alternative B3 is anticipated to have a direct impact to 2.5 acres (1.0 ha) of upland habitats. The majority (60%) of these impacts would be to palm hammock (1.5 acres (0.6 ha)). Alternative B3 will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Provided the low acreage of impact, Alternative B3 is anticipated to have a measurable, but insignificant negative impact on upland habitats. Therefore, Alternative B3 receives a **"Minor Negative"** score on the Magnitude of Impact scale.

Wetland habitats: Alternative B3 is anticipated to have a direct impact to 151.1 acres (61.1 ha) of wetland habitat. The majority (53%) of the impacts are to seasonally flooded mangrove forest and woodland (79.9 acres (32.3 ha)). Seasonally flooded mangrove forest (low density) accounts for 45% (68.4 acres (27.7 ha)) of the impacts to wetland habitats. Alternative B3 will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Provided the acres of impact, Alternative B3 is anticipated to have a measurable negative impact on wetland habitats. However, provided the adjacency of the impacts to developed areas and large-scale size of the connected habitat (CMW system is estimated at 8,655 acres (3,502 ha) in size; see **Figure 1**), Alternative B3 is not anticipated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat. Therefore, Alternative B3 receives an **"Intermediate Negative"** score on the Magnitude of Impact scale.

Parrot Habitat (Nesting and Density): Alternative B3 is anticipated to have a direct impact to 80.1 acres (32.4 ha) of parrot nesting habitat. This accounts for 2.9% of total parrot nesting habitat within the EIA study area (based on geospatial data provided by DoE in September 2023). Parrot density along Alternative B3 ranges from 0.1 to 1.5, with an average density of 0.2 parrots per acre (0.5 parrots per hectare) (**Figure 32**) (2014 geospatial data provided by DoE). Alternative B3 will potentially have indirect impacts on the parrot and its associated habitat, such as noise and wildlife-vehicular collisions, which will be further evaluated as part of the Preferred Alternative. According to Haakonsson et al. (2017), the growth trend of the Grand Cayman Parrot has been increasing over time despite the effects of anthropogenic and natural disturbances, with an estimated 2014 parrot population size of 6,395 on Grand Cayman.

Provided the acres of impact and density, Alternative B3 is anticipated to have a measurable negative impact on parrot habitat. However, provided the estimated parrot population and growth trend, Alternative B3 is not anticipated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat or population levels. Therefore, Alternative B3 receives an **"Intermediate Negative"** score on the Magnitude of Impact scale.

Pygmy blue butterfly habitat: Alternative B3 is not anticipated to have a direct impact on Pygmy blue butterfly habitat; therefore, it receives a score of **"Neutral"** on the Magnitude of Impact scale. Potential indirect impacts, such as habitat fragmentation and wildlife-vehicular collisions, will be evaluated as part of the Preferred Alternative.

Tea Banker habitat: Alternative B3 is not anticipated to have a direct impact on Tea Banker habitat; therefore, it receives a score of **"Neutral"** on the Magnitude of Impact scale. Potential indirect impacts, such as habitat fragmentation and reduced hydrologic connectivity, will be evaluated as part of the Preferred Alternative.

4.2.2.5 Alternative B4

Man-Modified land uses: Alternative B4 is anticipated to have a direct impact to 137.7 acres (55.7 ha) of man-modified land uses. The majority (43%) of the impacts to man-modified land uses would be to the man-modified without trees land use (58.5 acres (23.7 ha)). This land use can be found in varying extents throughout the alternative. Though not necessarily of high or medium importance and rarity, this land use is often adjacent to higher valued habitats and provides a buffer for species between the higher value habitats and nearby development. Alternative B4 will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Provided the acres of impact and buffer from high value habitats, Alternative B4 is anticipated to have a measurable negative impact on man-modified land uses and adjacent habitats. However, Alternative B4 is not anticipated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat or surrounding habitats. Therefore, Alternative B4 receives an **"Intermediate Negative"** score on the Magnitude of Impact scale.

Coastal habitat: Alternative B4 is anticipated to have a direct impact to 2.3 acres (0.9 ha) of coastal habitat (coastal shrubland). The coastal shrubland within Alternative B4 is primarily located along the existing Bodden Town Road and adjacent to existing development. Alternative B4 will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Provided the low acreage of impact and proximity to existing development, Alternative B1 is anticipated to have a measurable, but insignificant negative impact on coastal habitats. Therefore, Alternative B4 receives a **"Minor Negative"** score on the Magnitude of Impact scale.

Upland habitats: Alternative B4 is anticipated to have a direct impact to 21.9 acres (8.9 ha) of upland habitats. The majority (54%) of these impacts would be to the dry shrubland habitat (11.9 acres (4.8 ha)). Alternative B4 will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Provided the acres of impact, Alternative B4 is anticipated to have a measurable negative impact on upland habitats. However, Alternative B4 is not anticipated to have an adverse impact to the overall coherence of the ecological structure or function of the habitat or species it supports. Therefore, Alternative B4 receives an **"Intermediate Negative"** score on the Magnitude of Impact scale.

Wetland habitats: Alternative B4 is anticipated to have a direct impact to 35.8 acres (14.4 ha) of wetland habitat. The majority (92%) of project related impacts are to seasonally flooded mangrove forest and woodland (32.8 acres (13.3 ha)). Alternative B4 will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Provided the acres of impact, Alternative B4 is anticipated to have a measurable negative impact on wetland habitats. However, provided the adjacency of the impacts to developed areas and large-scale size of the connected habitat (CMW system is estimated at 8,655 acres (3,502 ha) in size; see **Figure 1**), Alternative B4 is not anticipated to have a significant impact on wetland habitat. Therefore, Alternative B4 receives an **"Minor Negative"** score on the Magnitude of Impact scale.

Parrot Habitat (Nesting and Density): Alternative B4 is anticipated to have a direct impact to 15.5 acres (6.3 ha) of parrot nesting habitat. This accounts for <1% of total Parrot Nesting Habitat within the EIA study area (based on geospatial data provided by DoE in September 2023). Parrot density along Alternative B4 ranges from 0.1 to 1.5, with an average of 0.2 parrots per acre (0.5 parrots per hectare) (**Figure 34**) (2014 geospatial data provided by DoE). Alternative B4 will potentially have indirect impacts to the habitat, such as noise and wildlife-vehicular collisions, which will be further evaluated as part of the Preferred Alternative. According to Haakonsson et al. (2017), the growth trend of the Grand Cayman Parrot has been increasing over time despite the effects of anthropogenic and natural disturbances, with an estimated 2014 parrot population size of 6,395 on Grand Cayman.

Based on the acres of impact, density, estimated parrot population, and growth trend, Alternative B4 is anticipated to have a measurable, but insignificant negative impact on parrot habitat. Therefore, Alternative B4 receives a **"Minor Negative"** score on the Magnitude of Impact scale.

Pygmy blue butterfly habitat: Alternative B4 is anticipated to have a direct impact to 0.1 acres (0.04 ha) of pygmy blue butterfly habitat. This impact area accounts for <1% of the pygmy blue butterfly habitat adjacent to Bodden Town Road and is already located next to a developed area. Alternative B4 will potentially have indirect impacts to the habitat, such as and wildlife-vehicular collisions and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Based on the percentage of impact and location along existing development, Alternative B4 is anticipated to have a negligible impact on pygmy blue butterfly habitat. Therefore, Alternative B4 receives a **"Neutral"** score on the Magnitude of Impact scale.

Tea Banker habitat: Alternative B4 is anticipated to have a direct impact to 0.01 acres (0.004 ha) of tea banker habitat. This impact area accounts for <1% of the tea banker habitat adjacent to Bodden Town Road and is already located next to a developed area. Alternative B4 will potentially have indirect impacts to the habitat, such as reduced hydrologic connectivity and habitat fragmentation, which will be further evaluated as part of the Preferred Alternative.

Based on the percentage of impact and location along existing development, Alternative B4 is anticipated to have a negligible impact on tea banker habitat. Therefore, Alternative B4 receives a **"Neutral"** score on the Magnitude of Impact scale.

A summary of anticipated magnitudes of impact, by alternative, to each identified resource is available below in **Table 5**. The table also includes the resource's biodiversity and earth heritage value for reference.

Table 5: Anticipated Magnitude of Impact by Alternative

Resource	Value	Anticipated Magnitude of Impact by Alternative				
		No-Build	B1	B2	B3	B4
Man-Modified	Low	Neutral	Intermediate Negative	Intermediate Negative	Intermediate Negative	Intermediate Negative
Coastal Habitat	High	Neutral	Neutral	Neutral	Neutral	Minor Negative
Upland Habitats	High	Neutral	Minor Negative	Minor Negative	Minor Negative	Intermediate Negative
Wetland Habitats	High	Neutral	Intermediate Negative	Intermediate Negative	Intermediate Negative	Minor Negative
Parrot Habitat *(Cayman Parrot Nesting and Density)*	High	Neutral	Intermediate Negative	Intermediate Negative	Intermediate Negative	Minor Negative
Pygmy blue butterfly	High	Neutral	Neutral	Neutral	Neutral	Neutral
Tea Banker	High	Neutral	Neutral	Neutral	Neutral	Neutral

4.2.3 Step 3 – Determination Overall Assessment Score

The final step of the qualitative assessment was to determine the overall assessment score based on the guidance table below:

Table 6: Overall Assessment Score Matrix

Magnitude of impact	Biodiversity and earth heritage value				
	Very high	High	Medium	Low	Very Low
Major Negative	Large adverse	Large adverse	Moderate adverse	Slight adverse	Neutral
Intermediate Negative	Large adverse	Large adverse	Moderate adverse	Slight adverse	Neutral
Minor Negative	Slight adverse	Slight adverse	Slight adverse	Slight adverse	Neutral
Neutral	Neutral	Neutral	Neutral	Neutral	Neutral
Positive	Large beneficial	Large beneficial	Moderate beneficial	Slight beneficial	Neutral

Source: TAG Unit A3, Environmental Impact Appraisal, Table 12, May 2023

Table 6 was applied to the anticipated Magnitude of Impact by alternative (**Table 5**), resulting in the qualitative impact ratings presented below in **Table 7**. The qualitative impact rating is a function of both the magnitude of impact and the value of each resource (i.e., an intermediate adverse impact to man-modified resources results in a different qualitative rating than an intermediate adverse impact to wetland habitats due to the difference in resource value).

Table 7: Summary Table of Qualitative Impacts on Terrestrial Ecology Resources

Resource	No-Build	B1	B2	B3	B4
Man-Modified	Neutral	Slight Adverse	Slight Adverse	Slight Adverse	Slight Adverse
Coastal Habitat	Neutral	Neutral	Neutral	Neutral	Slight Adverse
Upland Habitats	Neutral	Slight Adverse	Slight Adverse	Slight Adverse	Large Adverse
Wetland Habitats	Neutral	Large Adverse	Large Adverse	Large Adverse	Slight Adverse
Parrot Habitat *(Cayman Parrot Nesting and Density)*	Neutral	Large Adverse	Large Adverse	Large Adverse	Slight Adverse
Pygmy blue butterfly	Neutral	Neutral	Neutral	Neutral	Neutral
Tea Banker	Neutral	Neutral	Neutral	Neutral	Neutral
Overall Qualitative Rating	**Neutral**	**Large Adverse**	**Large Adverse**	**Large Adverse**	**Moderate Adverse**

4.2.3.1 No-Build

The No-Build scenario received a qualitative rating of "Neutral" for all categories; therefore, the overall qualitative rating is **"Neutral"** for the identified terrestrial ecology resources.

4.2.3.2 Alternative B1

Alternative B1 is anticipated to impact a total of 289.7 acres (117.3 ha) of terrestrial habitats and 117.5 acres (47.5 ha) of important species habitats. Most of these anticipated impacts are to wetland habitats (194.3 acres (78.6 ha)), man-modified habitats (93.0 acres (37.7 ha)), and parrot nesting habitat (117.5 acres (47.5 ha)). Based on the ratings for these three habitats, "Large Adverse", "Slight Adverse", and "Large Adverse" respectively, Alternative B1 was determined to have an overall qualitative rating of **"Large Adverse"**.

4.2.3.3 Alternative B2

Alternative B2 is anticipated to impact a total of 238.6 acres (96.5 ha) of terrestrial habitats and 91.4 acres (37.0 ha) of important species habitats. Most of these anticipated impacts are to wetland habitats (128.2 acres (51.9 ha)), man-modified habitats (108.6 acres (43.9 ha)), and parrot nesting habitat (91.4 acres (37.0 ha)). Based on the ratings for these three habitats, "Large Adverse", "Slight Adverse", and "Large Adverse" respectively, Alternative B2 was determined to have an overall qualitative rating of **"Large Adverse"**.

4.2.3.4 Alternative B3

Alternative B3 is anticipated to impact a total of 243.0 acres (98.4 ha) of terrestrial habitats and 80.1 acres (32.4 ha) of important species habitats. Most of these anticipated impacts are to wetland habitats (151.1 acres (61.1 ha)), man-modified habitats (89.5 acres (36.2 ha)), and parrot nesting habitat (80.1 acres (32.4 ha)). Based on the ratings for these three habitats, "Large Adverse", "Slight Adverse", and "Large Adverse" respectively, Alternative B3 was determined to have an overall qualitative rating of **"Large Adverse"**.

4.2.3.5 Alternative B4

Alternative B4 is anticipated to impact a total of 197.7 acres (80.0 ha) of terrestrial habitats and 15.5 acres (6.3 ha) of important species habitats. Most of these anticipated impacts are to wetland habitats (35.8 acres (14.4 ha)), man-modified habitats (137.7 acres (55.9 ha)), and upland habitat (21.9 acres (8.9 ha)). Based on the ratings for these three habitats, "Slight Adverse", "Slight Adverse", and "Large Adverse" respectively, Alternative B4 was determined to have an overall qualitative rating of **"Moderate Adverse"**.

4.3 Monetary Valuation

The monetary valuation of ecosystem services is based on the quantified direct impacts in Section 2.3.1 and the Cayman Islands Ecosystem Accounting document (**Attachment E**). Based on the 2020 Cayman Islands Ecosystem Accounting, there are currently monetized values for Fisheries, Agriculture, Carbon Sequestration, Coastal Protection, Tourism, and Amenity Value. (Economics for the Environment Consultancy Ltd (EFTEC) & Joint Nature Conservation Committee, 2022)

An evaluation of each category for applicability and application to the Cayman EWA Shortlist of Alternatives is provided as follows. The values presented within this section have been incorporated into the Shortlist Evaluation Cost Benefit Analysis (CBA). The 2020 Cayman Islands Ecosystem Accounting is not all-inclusive of ecosystem services provided on Grand Cayman. Therefore, quantitative and qualitative review of terrestrial ecology has also been provided as part of the Shortlist Evaluation.

4.3.1.1 Fisheries

Ecosystem services from fisheries include the volume in pounds per year (lbs/year) of reef fish caught in the Cayman Islands based on the 2020 Cayman Islands Ecosystem Accounting.

The Shortlist of Alternatives (No-Build scenario and four Build alternatives (B1, B2, B3, and B4)), are anticipated to have no direct impact to marine habitats, including reefs. Therefore, no direct impact to fisheries as described in the 2020 Cayman Islands Ecosystem Accounting are anticipated.

Further evaluation of impact to fisheries, including potential indirect impacts, will be completed as part of the Preferred Alternative as applicable.

4.3.1.2 Agriculture

Ecosystem services from agriculture include the reported livestock production (no./yr.) and reported arable production (t/yr.) based on the 2020 Cayman Islands Ecosystem Accounting. Impacts to agricultural production and/or businesses will be evaluated as part of the land acquisition and valuation process to be completed for the Preferred Alternative. These agricultural ecosystem services will be evaluated once further design and land acquisition information is obtained.

4.3.1.3 Carbon Sequestration

Ecosystem services from carbon sequestration include the total tonnes of CO_2e sequestered each year (tCO_2e/yr) based on the 2020 Cayman Islands Ecosystem Accounting. **Table 8** below shows the average sequestration rate by habitat type utilized within the 2020 Cayman Islands Ecosystem Accounting (**Attachment E**).

Table 8: Carbon sequestration rates by habitat type ($tCO_2e/ha/yr$)

Habitat	Murray et al. (2011); IUCN (2017)	Alongi (2014)[1]	Midpoint
Terrestrial			
Mature tropical forest	2.3	-	2.3
Marine			
Seagrass	4.4	2	3.2
Saltmarsh	8	5.5	6.8
Mangroves	6.3	6.4	6.3
Estuaries	-	1.7	1.7
Shelves	-	0.6	0.6

Table notes: [1]The values reported were converted from $gC/m^2/yr$ to $tCO_2e/ha/yr$ using the IPCC (2018) tC to tCO2e conversion factor of 3.67 gram to tonne and m2 to ha conversion factors.

Source: (EFTEC & Joint Nature Conservation Committee, 2022)

Table 9 shows the hectares of impact, appropriate habitat sequestration rate (based on **Table 8**), and overall carbon sequestration rate for each of the shortlisted alternatives. Applicable WebTAG carbon rates will be applied and represented within the Shortlist Evaluation CBA.

Table 9: Carbon sequestration rates by Alternative

Habitat	Impact Area – Hectares (ha)					Sequestration rate* (tCO2e/ha/yr)	Impacted Sequestration rate (tCO2e/yr)				
	No-Build	B1	B2	B3	B4		No-Build	B1	B2	B3	B4
Man-modified without trees	0.0	25.7	27.5	24.9	23.7	0.0	0.0	0.0	0.0	0.0	0.0
Man-modified with trees	0.0	2.6	4.2	2.3	9.8	2.3	0.0	6.1	9.6	5.3	22.6
Agricultural	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Commercial	0.0	0.9	0.9	0.9	2.6	0.0	0.0	0.0	0.0	0.0	0.0
Disturbed land	0.0	0.4	0.4	0.4	0.4	0.0	0.0	0.0	0.0	0.0	0.0

Habitat	Impact Area – Hectares (ha)					Sequestration rate* (tCO2e/ha/yr)	Impacted Sequestration rate (tCO2e/yr)				
	No-Build	B1	B2	B3	B4		No-Build	B1	B2	B3	B4
Institutional	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mining	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pasture	0.0	5.9	5.9	5.9	5.9	0.0	0.0	0.0	0.0	0.0	0.0
Residential	0.0	1.0	1.9	1.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0
Roads	0.0	1.0	1.1	0.8	5.3	0.0	0.0	0.0	0.0	0.0	0.0
Man-made pond	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Coastal shrubland	0.0	0.0	0.0	0.0	0.9	2.3	0.0	0.0	0.0	0.0	2.2
Dry forest and woodland	0.0	0.0	0.0	0.0	2.4	2.3	0.0	0.1	0.0	0.1	5.6
Dry shrubland	0.0	0.2	0.0	0.2	4.8	2.3	0.0	0.5	0.0	0.6	11.1
Invasive species - casuarina	0.0	0.1	0.1	0.1	1.5	2.3	0.0	0.3	0.3	0.3	3.4
Palm Hammock	0.0	0.6	0.6	0.6	0.2	2.3	0.0	1.4	1.4	1.4	0.4
Ponds, pools and mangrove lagoons	0.0	0.8	0.9	0.5	0.6	6.3	0.0	4.9	5.8	3.4	3.5
Seasonally flooded mangrove forest and woodland	0.0	43.5	23.4	32.3	13.3	6.3	0.0	270.1	147.5	203.7	83.7
Seasonally flooded mangrove shrubland	0.0	0.0	0.0	0.0	0.1	6.3	0.0	0.0	0.0	0.0	0.6
Seasonally flooded / saturated semi-deciduous forest	0.0	0.6	0.6	0.6	0.6	2.3	0.0	1.4	1.4	1.4	1.4
Seasonally flooded mangrove forest (low density)	0.0	33.7	26.9	27.7	0.0	5.0**	0.0	168.7	134.7	138.4	0.0
Total (tCO2e/yr)	**0.0**	**117.3**	**96.6**	**98.4**	**80.0**		**0.0**	**453.5**	**300.7**	**354.6**	**134.5**

**Only coastal and forest ecosystems are valued for carbon sequestration within the 2020 Cayman Islands Ecosystem Accounting. Inclusion of additional habitats, as applicable, will be evaluated as part of the Preferred Alternative.*
***The identified low density habitat was estimated at 80% of the standard sequestration rate*

Further evaluation of impact to carbon sequestration will be completed as part of the Preferred Alternative CBA.

4.3.1.4 Coastal Protection

Ecosystem services for coastal protection are represented by the per hectare coastal protection value of coral reefs based on the 2020 Cayman Islands Ecosystem Accounting. These values correspond to avoided damages to residential and commercial properties due to the presence of nearby coral reefs (Guzman et al., 2017).

The Shortlist of Alternatives (No-Build scenario and four Build alternatives (B1, B2, B3, and B4)), are anticipated to have no direct impact to marine habitats, including coral reefs. Therefore, no direct impacts to coastal protection as described in the 2020 Cayman Islands Ecosystem Accounting are anticipated.

Further evaluation of impact to coastal protection, including potential indirect impacts, will be completed as part of the Preferred Alternative.

4.3.1.5 Tourism

Ecosystem services from tourism are measured in reported visitor arrivals (stay-over and cruise ships; visitors/yr.) based on the 2020 Cayman Islands Ecosystem Accounting. The tourism category is broken into three categories:

- Total tourism added value attributed to marine ecosystems,
- Remaining tourism expenditure not attributed to ecosystems, and
- Total willingness to pay to prevent decline in quality of coral reefs from medium to low levels.

Based on the 2020 Cayman Islands Ecosystem Accounting (**Attachment E**), the value to tourism is evaluated based on the quality and value of coral reef areas (marine ecosystems) (Guzman et al., 2017).

The Shortlist of Alternatives (No-Build scenario and four Build alternatives (B1, B2, B3, and B4)), are anticipated to have no direct impact to marine habitats, including coral reef areas. Therefore, no direct impacts to tourism as described in the 2020 Cayman Islands Ecosystem Accounting are anticipated.

Further evaluation of impact to tourism, including potential indirect impacts, will be completed as part of the Preferred Alternative.

4.3.1.6 Amenity Value

Ecosystem services from amenity value are measured in the number of houses and correlating amenity value to mangroves based on the 2020 Cayman Islands Ecosystem Accounting. **Figure 37** below depicts the amenity value of mangroves in USD/ha on Grand Cayman.

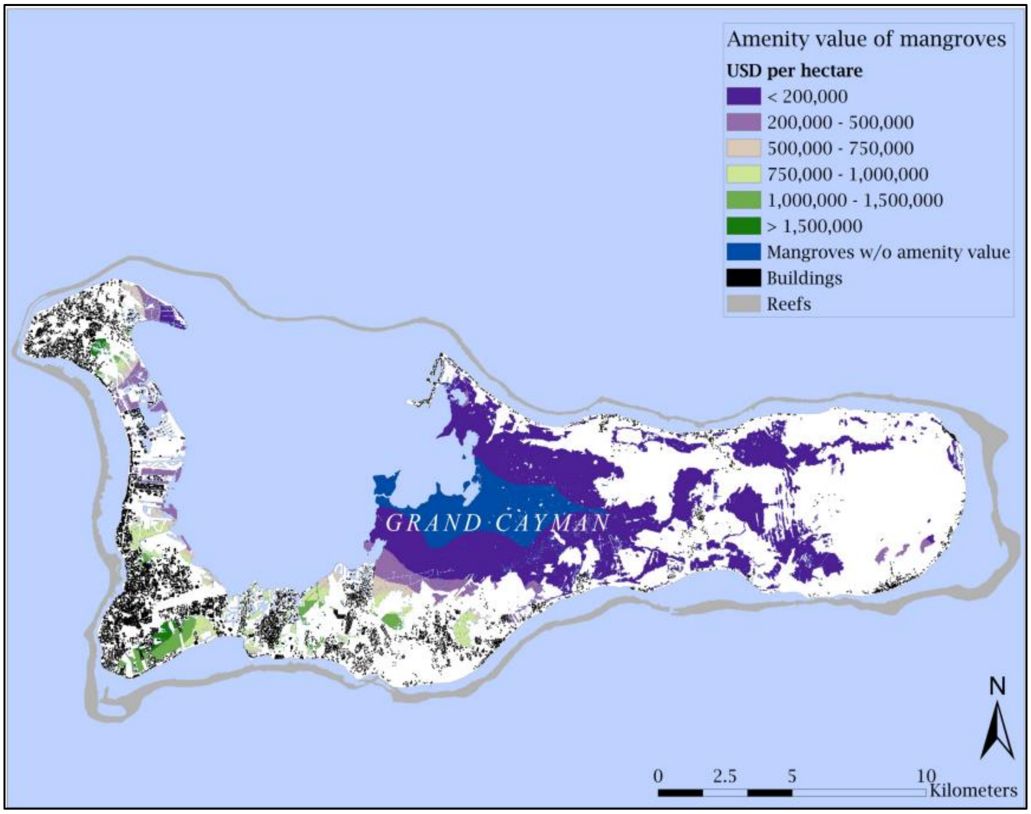


Figure 37: "Amenity value of mangroves on Grand Cayman per hectare. Source data for mangroves is obtained from the DoE habitat map"
Source: Guzman et al., 2017

The amenity value of mangroves is depicted in **Figure 37**, which was determined by Guzman et al (2017); they spatially applied hedonic pricing to estimate the amenity value of mangroves based on their location in Grand Cayman. The spatial data amenity value data obtained from Guzman et al. was overlayed with each shortlisted Build alternative (B1, B2, B3, and B4). Where each alternative intersected the amenity values shown on the map, the intersected area was calculated and the value per hectare was determined. **Table 10** provides the estimated hectares of impact within each range of amenity values and the total estimated amenity value for each shortlisted Build alternative. Amenity value is not calculated on a yearly basis and is considered a one-time cost at the time of construction.

Further evaluation of impacts to amenity value will be completed as part of the Preferred Alternative.

Table 10: Amenity Value of Mangroves by Alternative (based on Figure 37)

	No-Build	B1	B2	B3	B4
Mangrove impact within <$200,000 USD zone (CI$168,000) *(valued at $100,000USD/ha) (CI$84,000/ha)*	0	57 ha $5,700,000 USD *(CI$4,788,000)*	32 ha $3,200,000 USD *(CI$2,688,000)*	40 ha $4,000,000 USD *(CI$3,360,000)*	1.6 ha $160,000 USD *(CI$134,000)*
Mangrove impact within $200,000-$500,000 USD zone (CI$ 168,000-420,000) *(valued at $350,000USD/ha) (CI$294,000/ha)*	0	5.9 ha $2,065,000 USD *(CI$1,734,600)*	5.9 ha $2,065,000 USD *(CI$1,734,600*	5.9 ha $2,065,000 USD *(CI$1,734,600*	4.1 ha $1,435,000 USD *(CI$1,205,400*
Mangrove impact within $500,000-$750,000 USD zone (CI$ 420,000-630,000) *(valued at $625,000USD/ha) (CI$525,000/ha)*	0	1.2 ha $750,000 USD *(CI$630,000)*	1.2 ha $750,000 USD *(CI$630,000)*	1.2 ha $750,000 USD *(CI$630,000)*	0.9 ha $562,500 USD *(CI$472,500)*
Mangrove impact within $750,000-$1,000,000 USD zone (CI$ 630,000-840,000) *(valued at $825,000USD/ha) (CI$693,000/ha)*	0	1.4 ha $1,155,000 USD *(CI$970,200)*	1.4 ha $1,155,000 USD *(CI$970,200)*	1.4 ha $1,155,000 USD *(CI$970,200)*	1.4 ha $1,155,000 USD *(CI$970,200)*
Mangrove impact within $1,000,000-$1,500,000 USD zone (CI$ 840,000-1,260,000) *(valued at $1,250,000USD/ha) (CI$1,050,000/ha)*	0	0.3 ha $375,000 USD *(CI$315,000)*	0.3 ha $375,000 USD *(CI$315,000)*	0.3 ha $375,000 USD *(CI$315,000)*	0.3 ha $375,000 USD *(CI$315,000)*
Mangrove impact within >$1,500,000 USD zone (>CI$ 1,260,000) *(valued at $1,500,000USD/ha) (CI$1,260,000/ha)*	0	0	0	0	0
Total Monetary Value in USD *(CI$)*	**0**	**$10,045,000 USD *(CI$8,437,800)***	**$7,545,000 USD *(CI$6,337,800)***	**$8,345,000 USD *(CI$7,009,800)***	**$3,687,500 USD *(CI$3,097,500)***

5 Shortlist Evaluation Summary

The Shortlist Evaluation included a quantitative analysis (Section 4.1), a qualitative analysis (Section 4.2), and a monetary valuation (Section 4.3) for each of the shortlisted Build alternatives along with the No-Build scenario. The listed evaluations have been compiled into Table 11 below.

For the unavoidable impacts reported, mitigation measures to aid in offsetting impacts may be possible. Mitigation measures have not been considered as part of this Shortlist Evaluation but will be investigated and identified for the Preferred Alternative and documented in the forthcoming Environmental Statement Document.

Table 11: Summary Table Terrestrial Ecology Shortlist Evaluation

Resource	No-Build	B1	B2	B3	B4
Man-Modified	Neutral	Moderate Adverse 93.0 acre *(37.7 ha)*	Moderate Adverse 108.6 acre *(43.9 ha)*	Moderate Adverse 89.5 acre *(36.2 ha)*	Moderate Adverse 137.7 acre *(55.7 ha)*
Coastal Habitat	Neutral	Neutral	Neutral	Neutral	Large Adverse 2.3 acre *(0.9 ha)*
Upland Habitats	Neutral	Slight Adverse 2.4 acre *(1.0 ha)*	Slight Adverse 1.8 acre *(0.7 ha)*	Slight Adverse 2.5 acre *(1.0 ha)*	Large Adverse 21.9 acre *(8.9 ha)*
Wetland Habitats	Neutral	Large Adverse 194.3 acre *(78.6 ha)*	Large Adverse 128.2 acre *(51.9 ha)*	Large Adverse 151.1 acre *(61.1 ha)*	Slight Adverse 35.8 acre *(14.4 ha)*
Parrot Habitat *(Cayman Parrot Nesting and Density)*	Neutral	Large Adverse 117.5 acre *(47.5 ha)*	Large Adverse 91.4 acre *(37.0 ha)*	Large Adverse 80.1 acre *(32.4 ha)*	Slight Adverse 15.5 acre *(6.3 ha)*
Pygmy blue butterfly	Neutral	Neutral	Neutral	Neutral	Neutral 0.1 acre *(0.04 ha)*
Tea Banker	Neutral	Neutral	Neutral	Neutral	Neutral 0.01 acre *(0.004 ha)*
Overall Qualitative Rating	**Neutral**	**Large Adverse**	**Large Adverse**	**Large Adverse**	**Moderate Adverse**
Overall Acres of Resource Impacts	**0.0** *(0.0 ha)*	**407.2 acre** *(164.8 ha)*	**330.0 acre** *(133.5 ha)*	**323.2 acre** *(130.8 ha)*	**213.3 acre** *(86.3 ha)*
Amenity Value Loss USD *(CI$)*	**$0**	**$10,045,000 USD** *(CI$8,437,800)*	**$7,545,000 USD** *(CI$6,337,800)*	**$8,345,000 USD** *(CI$7,009,800)*	**$3,687,500 USD** *(CI$3,097,500)*
Carbon Sequestration Loss (tCO2e/yr)	**0.0**	**453.5**	**300.7**	**354.6**	**134.5**

The following summarizes the results of the analysis for the identified terrestrial ecology resources:

- *No-Build* – The No-Build scenario is anticipated to have no direct impacts on the identified resources (0 acres) resulting in an overall **Neutral** qualitative rating, no loss of amenity value, and no loss of carbon sequestration.

- *Alternative B4* – Alternative B4 would be the least impactful of the four Build alternatives since it is qualitatively ranked as **Moderate Adverse**, results in the lowest overall acreage of resource impacts, results in the lowest monetary loss of amenity value, and results in the least amount of carbon sequestration loss.

- *Alternative B2* – Alternative B2 would be the second least impactful of the four Build alternatives. While Alternative B2 has the same overall qualitative rating as Alternative B1 and Alternative B3 (**Large Adverse**), Alternative B2 results in less monetary loss of amenity value and lower carbon sequestration loss than either alternative. Alternative B2 results in a slightly higher overall acreage of resource impacts than Alternative B3 (approximately 2% higher). However, the loss of amenity value and carbon sequestration are approximately 10% and 15% lower than Alternative B3, respectively. Therefore, it is anticipated to be less impactful than Alternative B3 overall.

- *Alternative B3* – Alternative B3 would be the third least impactful of the four Build alternatives. Alternative B3 has the same overall qualitative rating as Alternative B1 and Alternative B2 (**Large Adverse**). However, as discussed in the Alternative B2 section above, Alternative B3 is anticipated to overall be more impactful than Alternative B2 based on the higher loss of amenity value and carbon sequestration.

- *Alternative B1* – Alternative B1 would be the most impactful of the four Build alternatives. While Alternative B1 has the same overall qualitative rating as Alternative B2 and Alternative B3 (**Large Adverse**), Alternative B1 results in the highest overall acreage of resource impacts, results in the highest monetary loss of amenity value, and results in the highest amount of carbon sequestration loss.

This Terrestrial Ecology Assessment is one in a series of Technical Reports that have been prepared for the Shortlist Evaluation. The level of impacts and the identification of the least impactful alternative will differ based on the resource/feature evaluated in each of the Technical Reports. Therefore, the least impactful alternative described in this evaluation summary and in each technical document **does not** move an alternative forward to the Preferred Evaluation nor does it constitute any special weighting or extra consideration in the Shortlist Evaluation Document. The comprehensive analysis of all the resources/features evaluated along with the rationale for the identification of the Preferred Alternative are presented in the Shortlist Evaluation Document.

6 References

Alongi, D.M. (2012) Carbon sequestration in mangrove forests. Future Science Group, Carbon Management, Volume 3, Issue 3, pages 313-322. https://doi.org/10.4155/cmt.12.20

Biber, P. D. (2006). Measuring the effects of salinity stress in the red mangrove, Rhizophora mangle L. *African Journal of Agricultural Research*, *1*(1), 1.

Bradley, P.E., Cottam, M., Ebanks-Petrie, G., & Solomon, J. (2004) Important Bird Areas of the Cayman Islands. BirdLife International. http://datazone.birdlife.org/userfiles/file/IBAs/CaribCntryPDFs/cayman_islands_(to_uk).pdf

Burton F.J. (2007). Vegetation Classification for the Cayman Islands. *In:* Burton, F.J. 2007. Threatened Plants of the Cayman Islands. Kew Publishers, London.

Cayman Turtle Centre. (2021). *Bird Nesting Season Advice from our Terrestrial Programmes Team*. Cayman Turtle Conservation and Education Centre LTD. https://www.turtle.ky/blog/bird-nesting-season-advice-from-our-terrestrial-programmes-team

DaCosta-Cottam, M., Olynik, J., Blumenthal, J., Godbeer, K. D., Gibb, J., Bothwell, J., ... & Ebanks-Petrie, G. (2009). Cayman Islands National Biodiversity Action Plan 2009. *Cayman Islands: Cayman Islands Government, Department of Environment*.

Economic and Statistics Office, Cayman Islands (July 2022) The Cayman Islands' 2021 Census of Population and Housing Report. Census Cayman Islands. https://www.eso.ky/UserFiles/page_docums/files/uploads/the_cayman_islands_2021_census_of_popula.pdf

Economics for the Environment Consultancy Ltd (eftec) & Joint Nature Conservation Committee. (2022). Cayman Islands Ecosystem Accounting 2020 Ecosystem Account.

Florida Museum. (n.d.). *Adaptations: Mangroves*. https://www.floridamuseum.ufl.edu/southflorida/habitats/mangroves/adaptations/

Guzman, A., Schep, S., van Zanten B., van Beukering, P., Nieto, E., Hoogeveen, R., Stangl, A., Schutter, M., Ebanks-Petrie, G. and Austin, T. (2017). The Economics of Enhancing the Marine Protected Areas of the Cayman Islands, December 2017. Commissioned by the Department of Environment of the Cayman Island Government. [online]. Available at: https://www.wolfscompany.com/project/the-economics-of-enhancing-the-marine-protected-areas-in-the-cayman-islands/

Haakonsson, J. E., Harvey, J., & Rivera-Milán, F. F. (2017). Conservation status of Grand Cayman (Amazona leucocephala caymanensis) and Cayman Brac (Amazona leucocephala hesterna) Parrots. Journal of Caribbean Ornithology, 30(1), 33-38.

Lovelock, C. E., Ball, M. C., Martin, K. C., & C. Feller, I. (2009). Nutrient enrichment increases mortality of mangroves. *PloS one*, *4*(5), e5600.

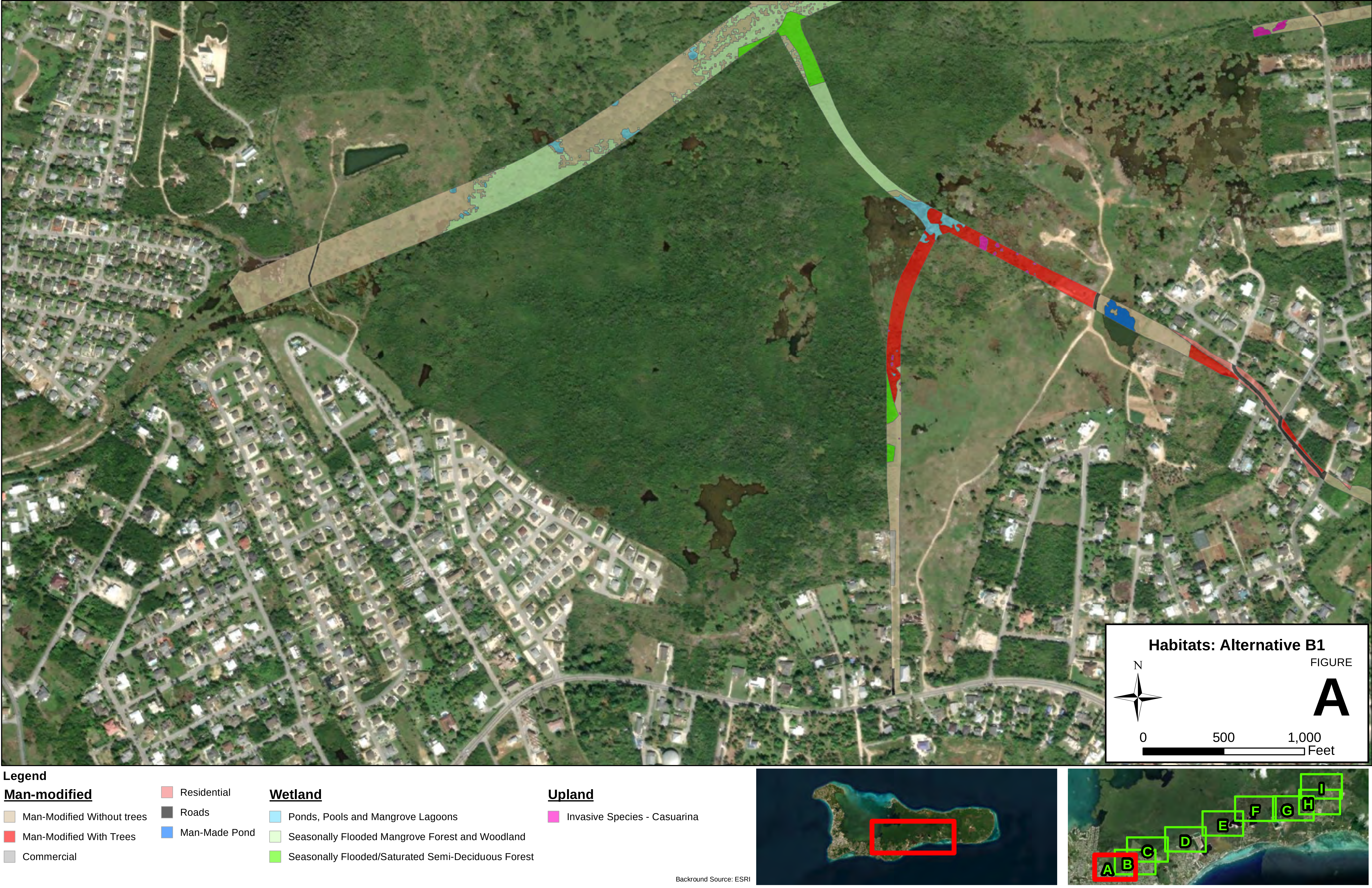
Matto, A. A., Jaikishun, S., & Ram, M. (2023). Impacts of different salinity levels on seedling growth and survival of black mangrove (Avicennia germinans). *Asian Journal of Forestry*, *7*(1).

Tran, T. V., Reef, R., & Zhu, X. (2022). A review of spectral indices for mangrove remote sensing. *Remote Sensing*, *14*(19), 4868.

U.S. Geological Survey. (n.d.) *What do the different colors in a color-infrared aerial photograph represent?* https://www.usgs.gov/faqs/what-do-different-colors-color-infrared-aerial-photograph-represent

Attachment A

Alternative B1 Habitat Mapping



Habitats: Alternative B1
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Feet
Legend
Man-modified
Man-Modified Without trees
Man-Modified With Trees
Commercial
Residential
Roads
Man-Made Pond
Wetland
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Seasonally Flooded/Saturated Semi-Deciduous Forest
Upland
Invasive Species - Casuarina
Backround Source: ESRI
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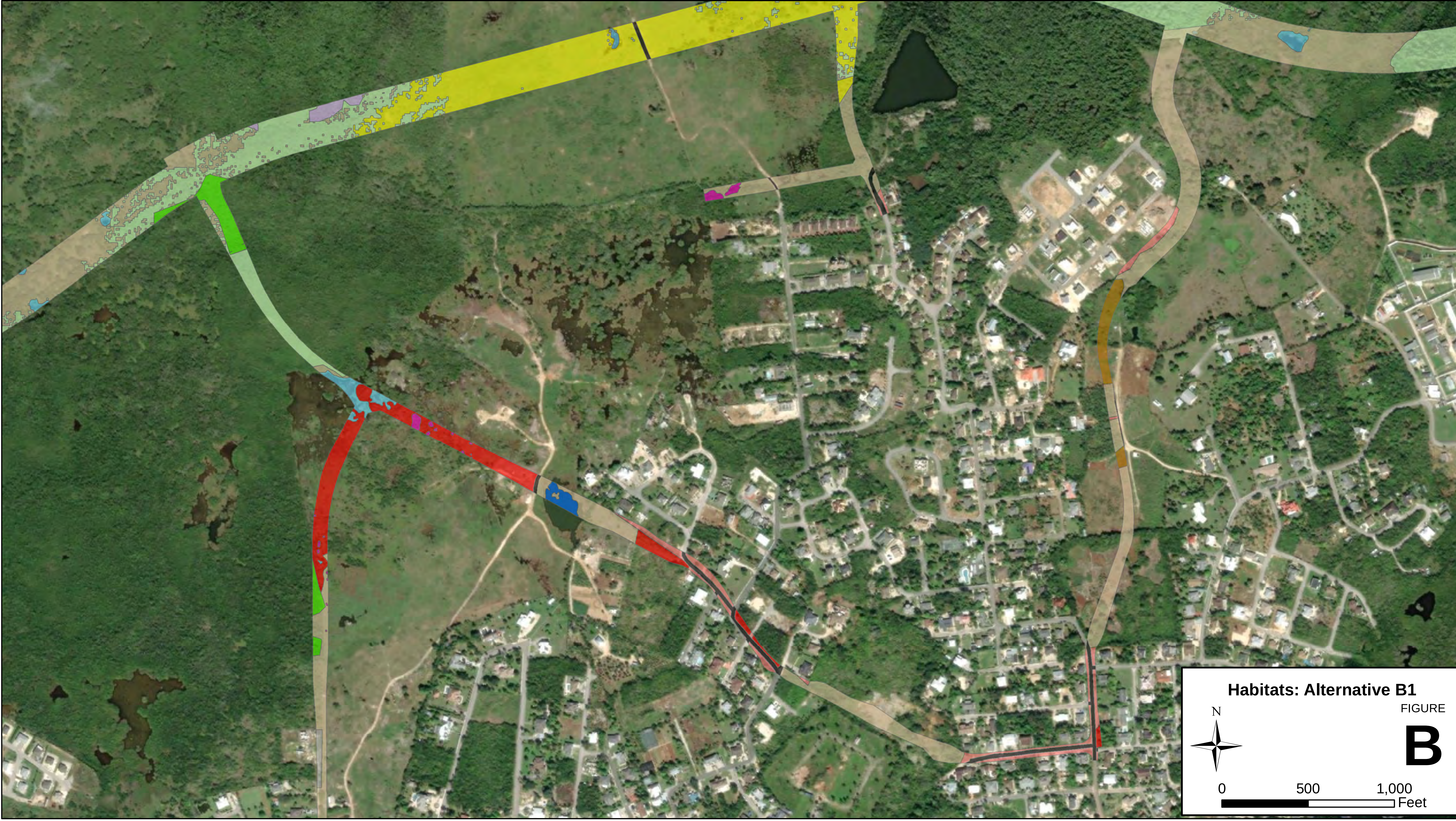


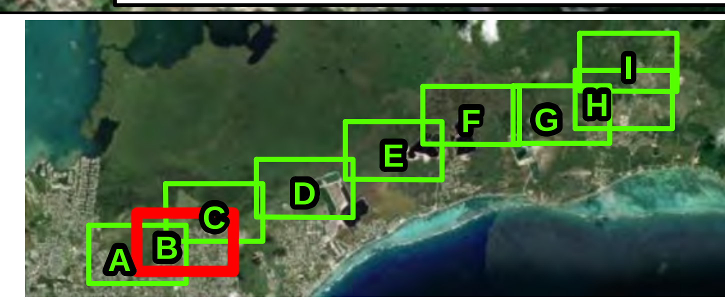
Legend

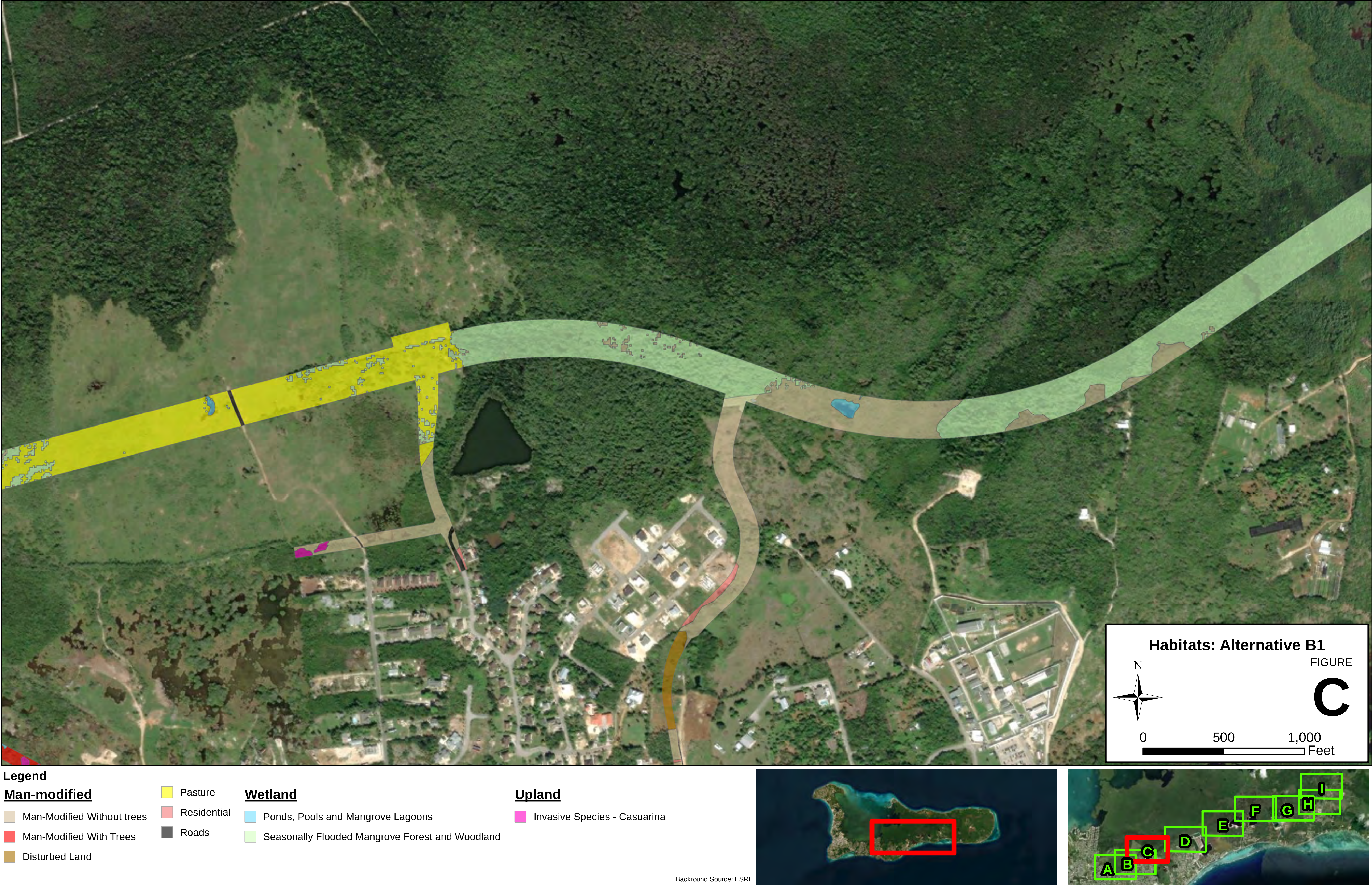
Man-modified
- Man-Modified Without trees
- Man-Modified With Trees
- Commercial
- Disturbed Land
- Pasture
- Residential
- Roads
- Man-Made Pond

Wetland
- Ponds, Pools and Mangrove Lagoons
- Seasonally Flooded Mangrove Forest and Woodland
- Seasonally Flooded/Saturated Semi-Deciduous Forest

Upland
- Invasive Species - Casuarina
- Palm Hammock

Backround Source: ESRI




Habitats: Alternative B1
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Man-modified
Man-Modified Without trees
Man-Modified With Trees
Disturbed Land
Pasture
Residential
Roads
Wetland
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Upland
Invasive Species - Casuarina
Backround Source: ESRI
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Habitats: Alternative B1
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Feet
Legend
Man-modified
Man-Modified Without trees
Roads
Wetland
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Seasonally Flooded Mangrove Forest (low density)
Upland
Palm Hammock
Backround Source: ESRI
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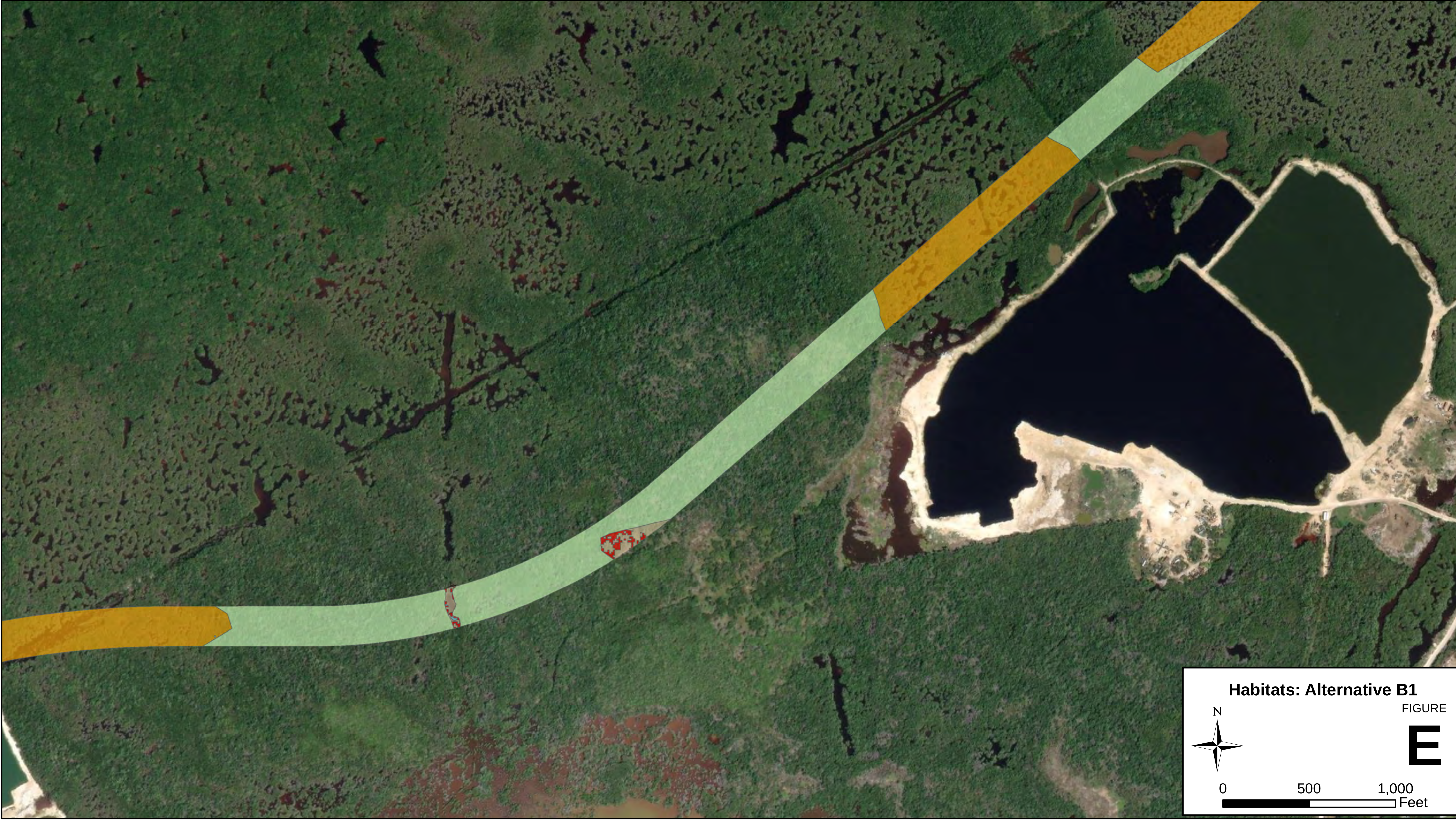


Legend

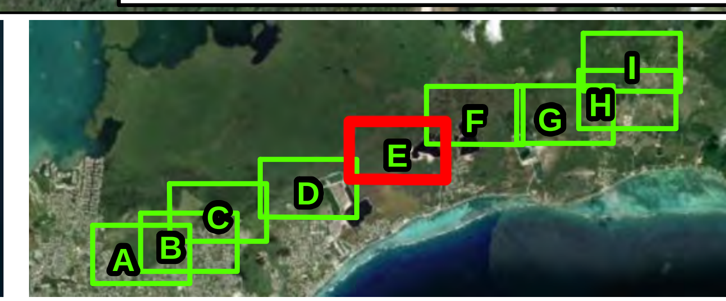
Man-modified

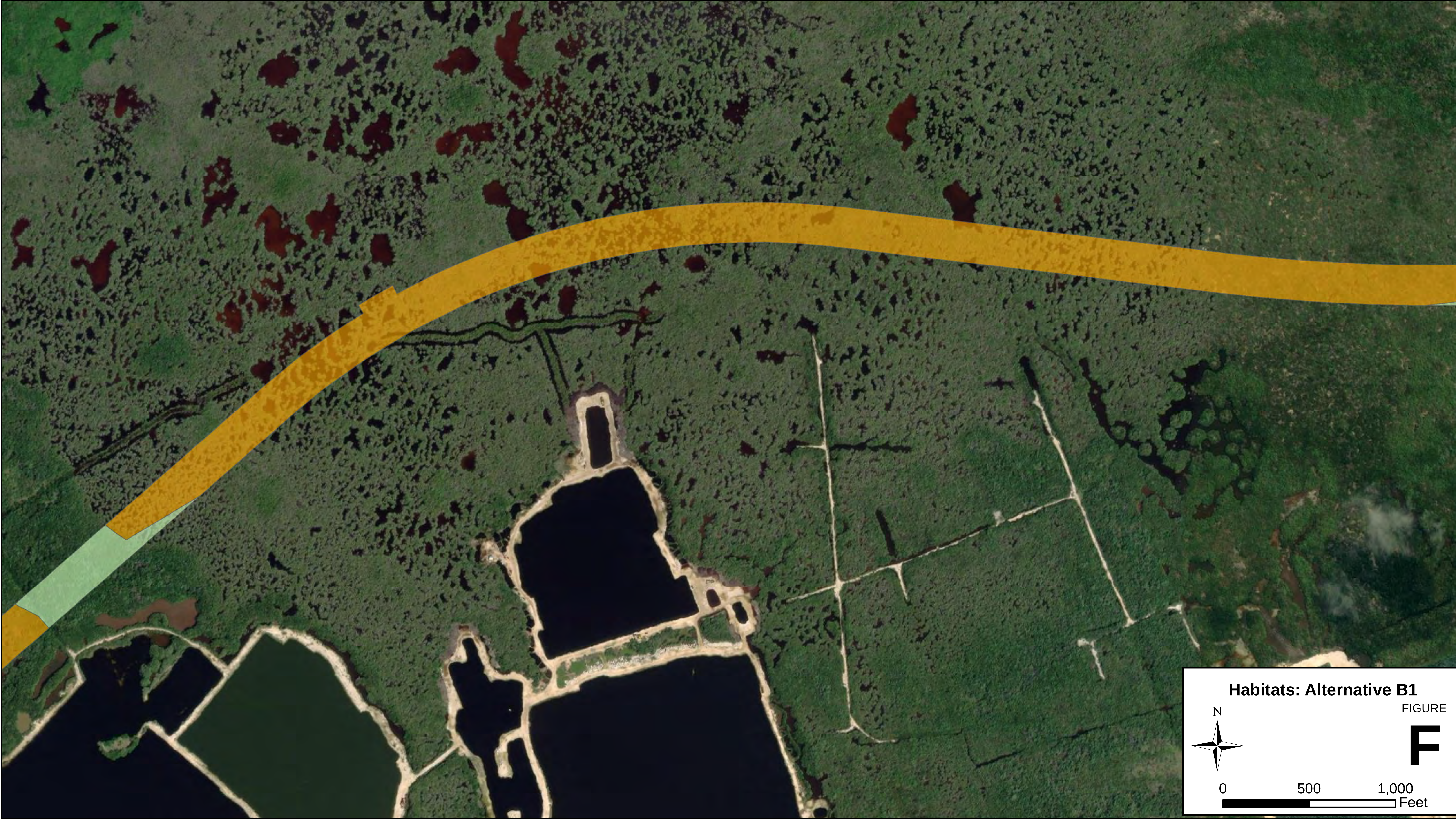
- Man-Modified Without trees
- Man-Modified With Trees

Wetland

- Ponds, Pools and Mangrove Lagoons
- Seasonally Flooded Mangrove Forest and Woodland
- Seasonally Flooded Mangrove Forest (low density)

Backround Source: ESRI



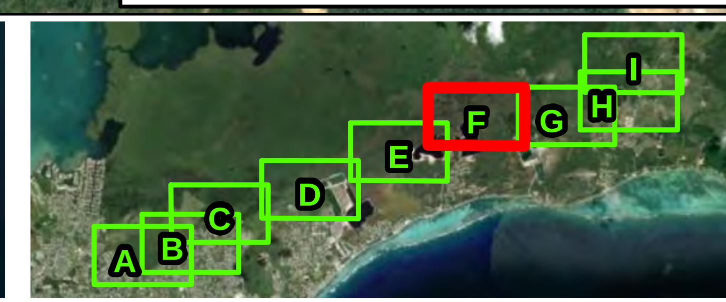


Legend

Wetland

- Seasonally Flooded Mangrove Forest and Woodland
- Seasonally Flooded Mangrove Forest (low density)

Backround Source: ESRI



Legend

Man-modified

Man-Modified Without trees

Man-Modified With Trees

Commercial

Residential

Wetland

Seasonally Flooded Mangrove Forest and Woodland

Seasonally Flooded Mangrove Forest (low density)

Upland

Dry Forest and Woodland

Dry Shrubland

Backround Source: ESRI


Habitats: Alternative B1
FIGURE
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Legend
Man-modified
Man-Modified Without trees
Man-Modified With Trees
Commercial
Institutional
Residential
Roads
Wetland
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Seasonally Flooded Mangrove Forest (low density)
Backround Source: ESRI
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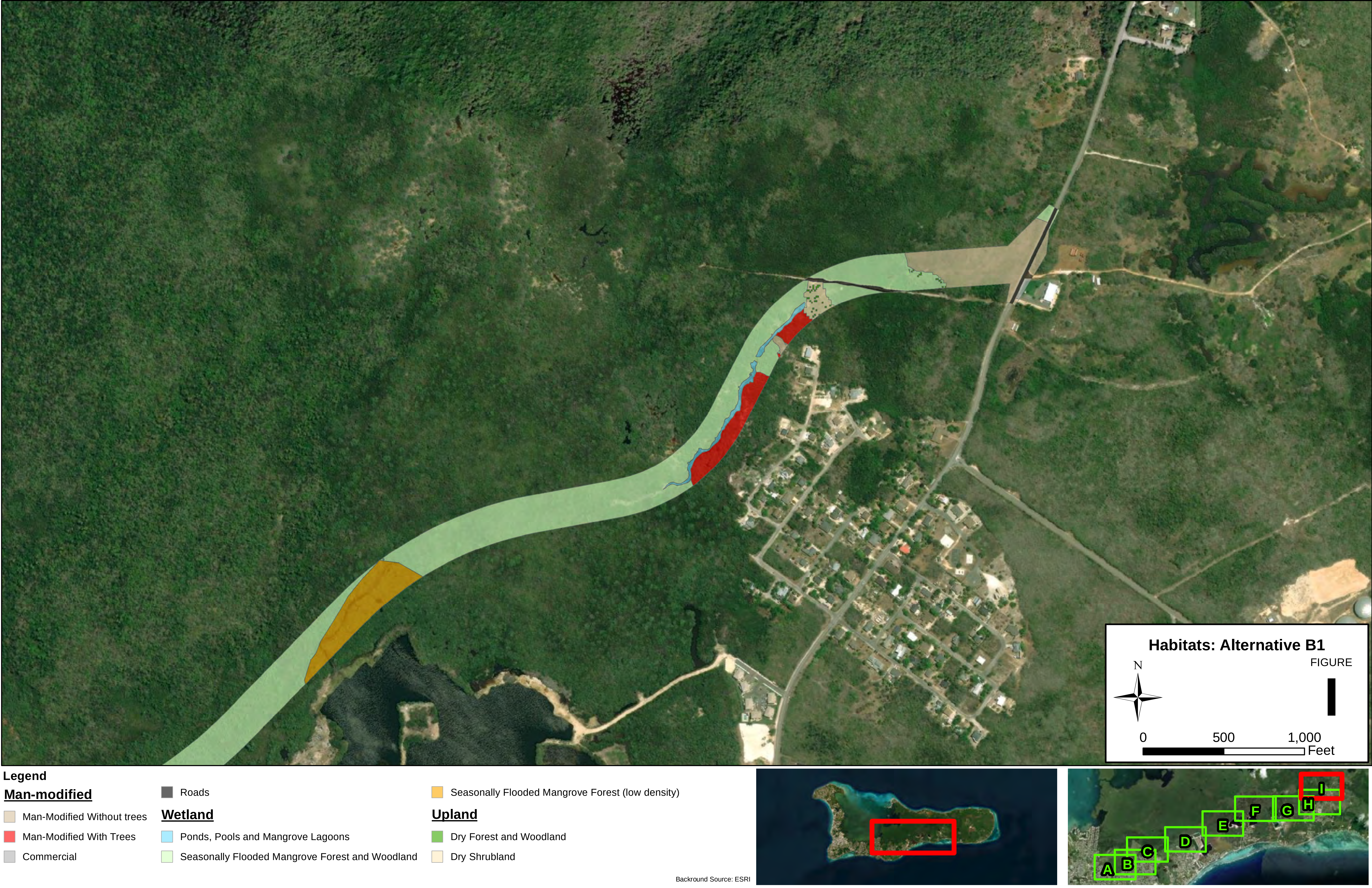
Habitats: Alternative B1
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Man-modified
Man-Modified Without trees
Man-Modified With Trees
Commercial
Roads
Wetland
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Seasonally Flooded Mangrove Forest (low density)
Upland
Dry Forest and Woodland
Dry Shrubland
Backround Source: ESRI
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Attachment B

Alternative B2 Habitat Mapping

Habitats: Alternative B2
FIGURE
A
N
0
500
1,000
Feet
Legend
Man-modified
Man-Modified Without Trees
Man-Modified With Trees
Commercial
Residential
Roads
Man-Made Pond
Upland
Invasive Species - Casuarina
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Seasonally Flooded/Saturated Semi-Deciduous Forest
Backround Source: ESRI
A
B
C
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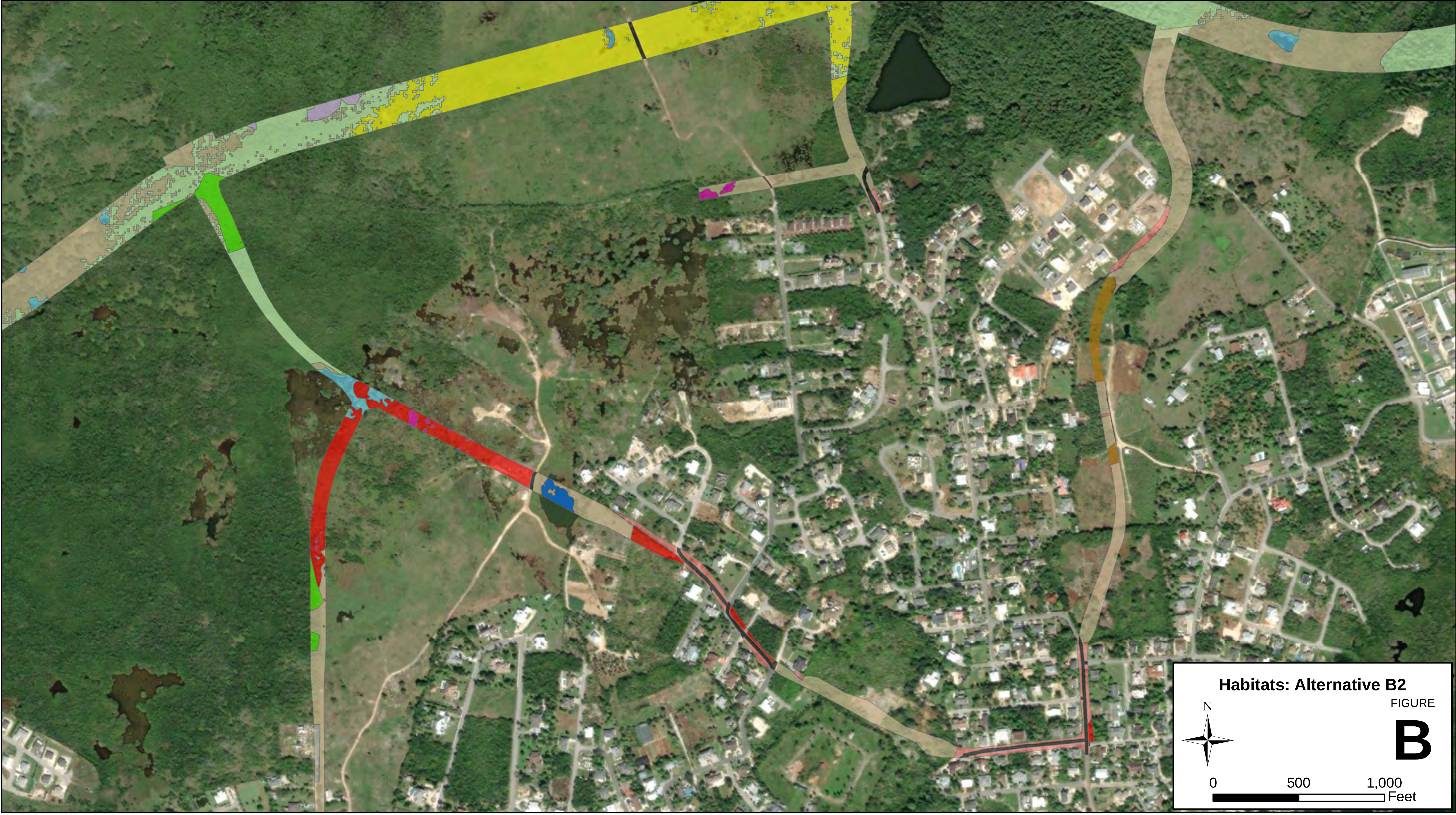


Legend

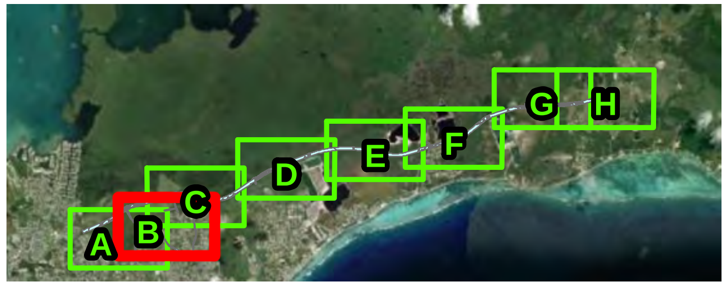
Man-modified

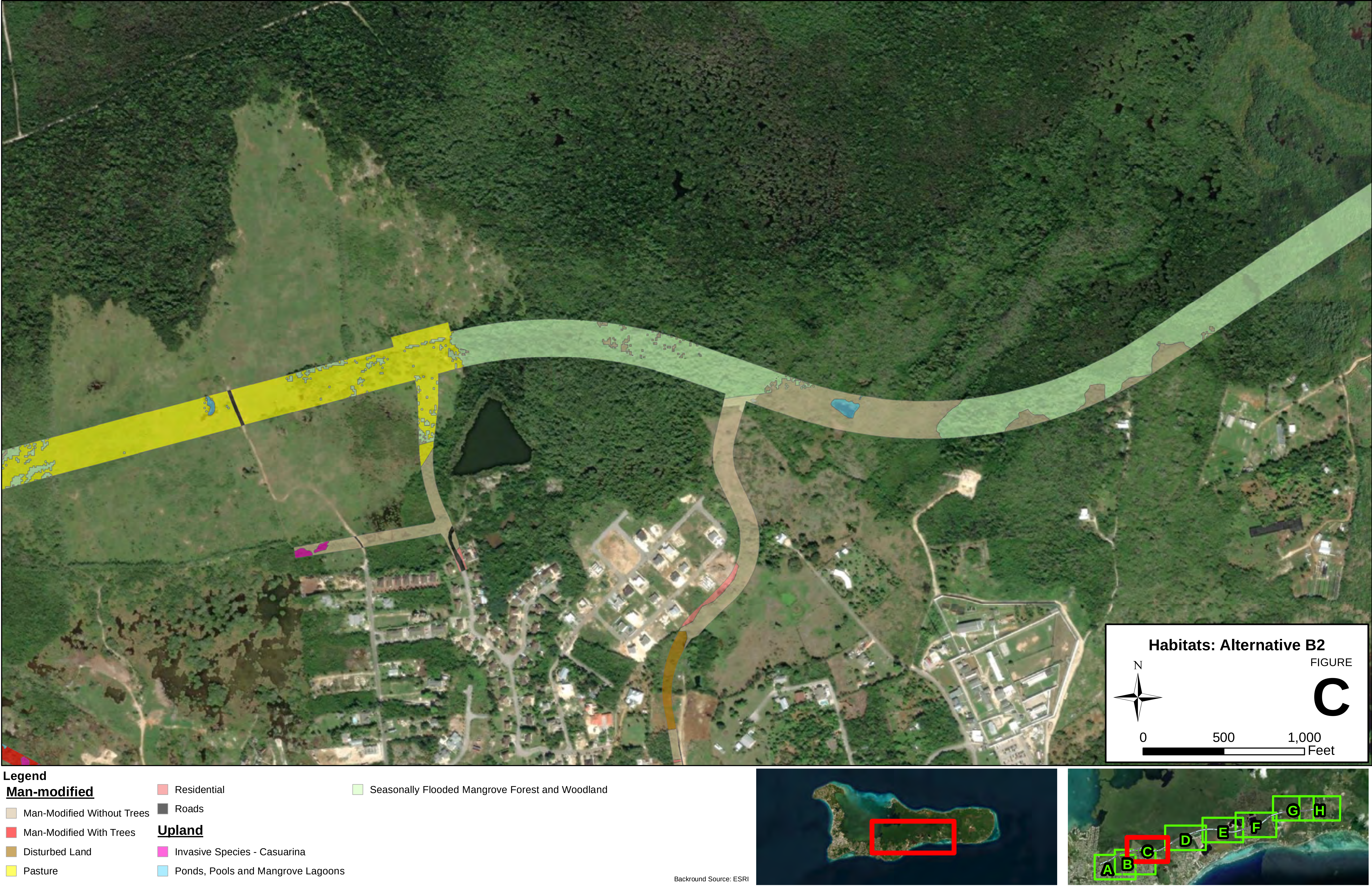
- Man-Modified Without Trees
- Man-Modified With Trees
- Commercial
- Disturbed Land
- Pasture
- Residential
- Roads
- Man-Made Pond

Upland

- Invasive Species - Casuarina
- Palm Hammock
- Ponds, Pools and Mangrove Lagoons
- Seasonally Flooded Mangrove Forest and Woodland
- Seasonally Flooded/Saturated Semi-Deciduous Forest

Backround Source: ESRI





Habitats: Alternative B2
FIGURE
C
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1,000
Feet
Legend
Man-modified
Man-Modified Without Trees
Man-Modified With Trees
Disturbed Land
Pasture
Residential
Roads
Upland
Invasive Species - Casuarina
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Backround Source: ESRI
A
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C
D
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Habitats: Alternative B2
FIGURE
D
N
0
500
1,000
Feet
Legend
Man-modified
Man-Modified Without Trees
Roads
Upland
Palm Hammock
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Seasonally Flooded Mangrove Forest (low density)
Backround Source: ESRI
A
B
C
D
E
F
G
H

Habitats: Alternative B2
FIGURE
E
N
0
500
1,000
Feet
Legend
Man-modified
Man-Modified Without Trees
Man-Modified With Trees
Mining
Residential
Roads
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Seasonally Flooded Mangrove Forest (low density)
Backround Source: ESRI
A
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C
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F
G
H


Habitats: Alternative B2
FIGURE
F
N
0
500
1,000
Feet
Legend
Man-modified
Man-Modified Without Trees
Man-Modified With Trees
Mining
Residential
Roads
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest (low density)
Backround Source: ESRI
A
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C
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G
H


Habitats: Alternative B2
FIGURE
G
N
0
500
1,000
Feet
Legend
Man-modified
Man-Modified Without Trees
Man-Modified With Trees
Commercial
Residential
Roads
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Seasonally Flooded Mangrove Forest (low density)
Backround Source: ESRI
A
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Habitats: Alternative B2
FIGURE
H
N
0
500
1,000
Feet
Legend
Man-modified
Man-Modified Without Trees
Man-Modified With Trees
Commercial
Institutional
Residential
Roads
Seasonally Flooded Mangrove Forest and Woodland
Backround Source: ESRI
A
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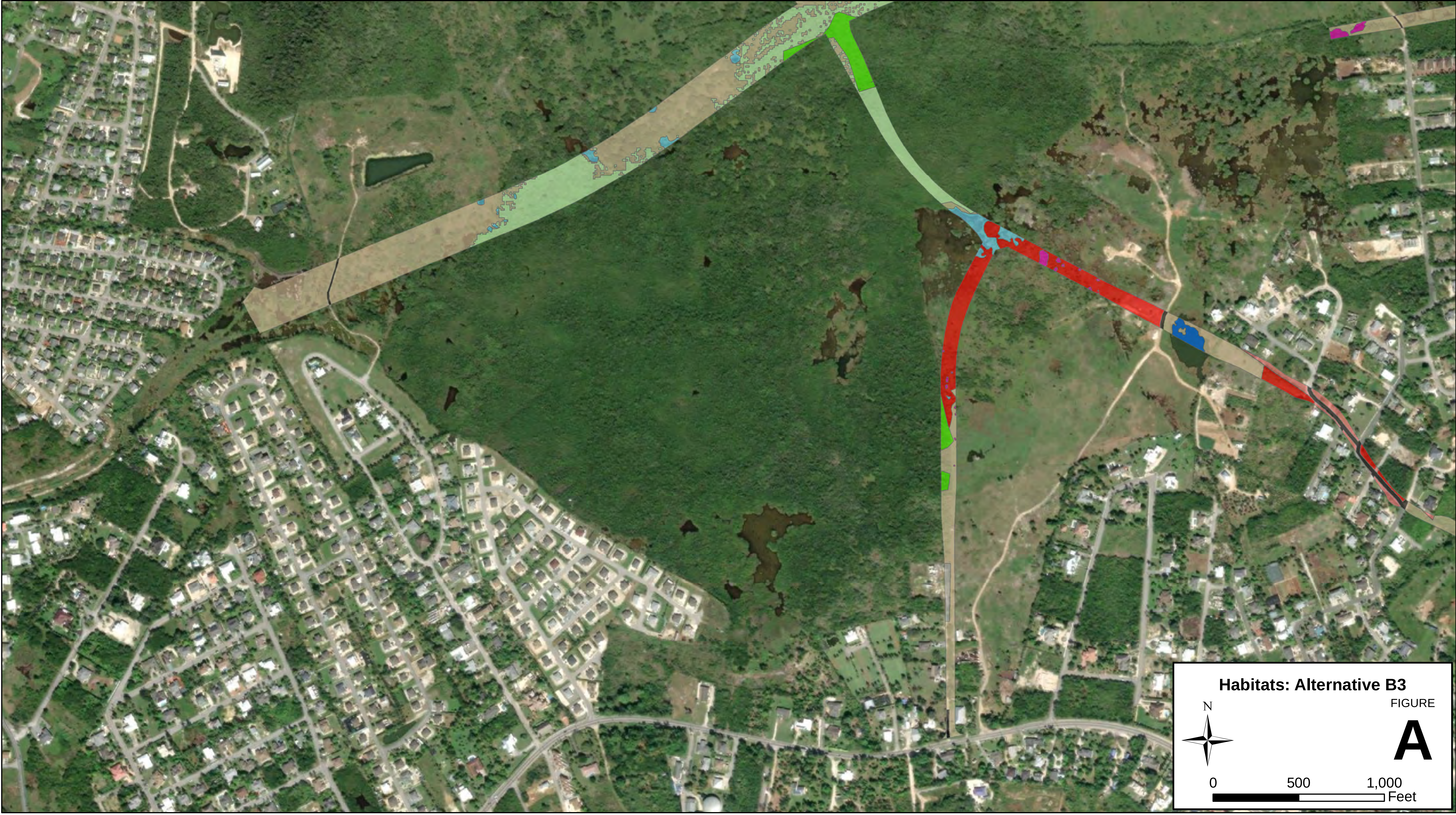
E
F
G
H

Attachment C

Alternative B3 Habitat Mapping



Legend

Man-modified

- Man-Modified Without Trees
- Man-Modified With Trees
- Commercial
- Residential
- Roads
- Man-Made Pond

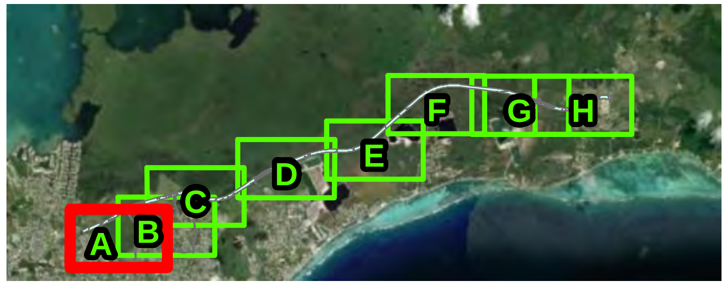
Upland

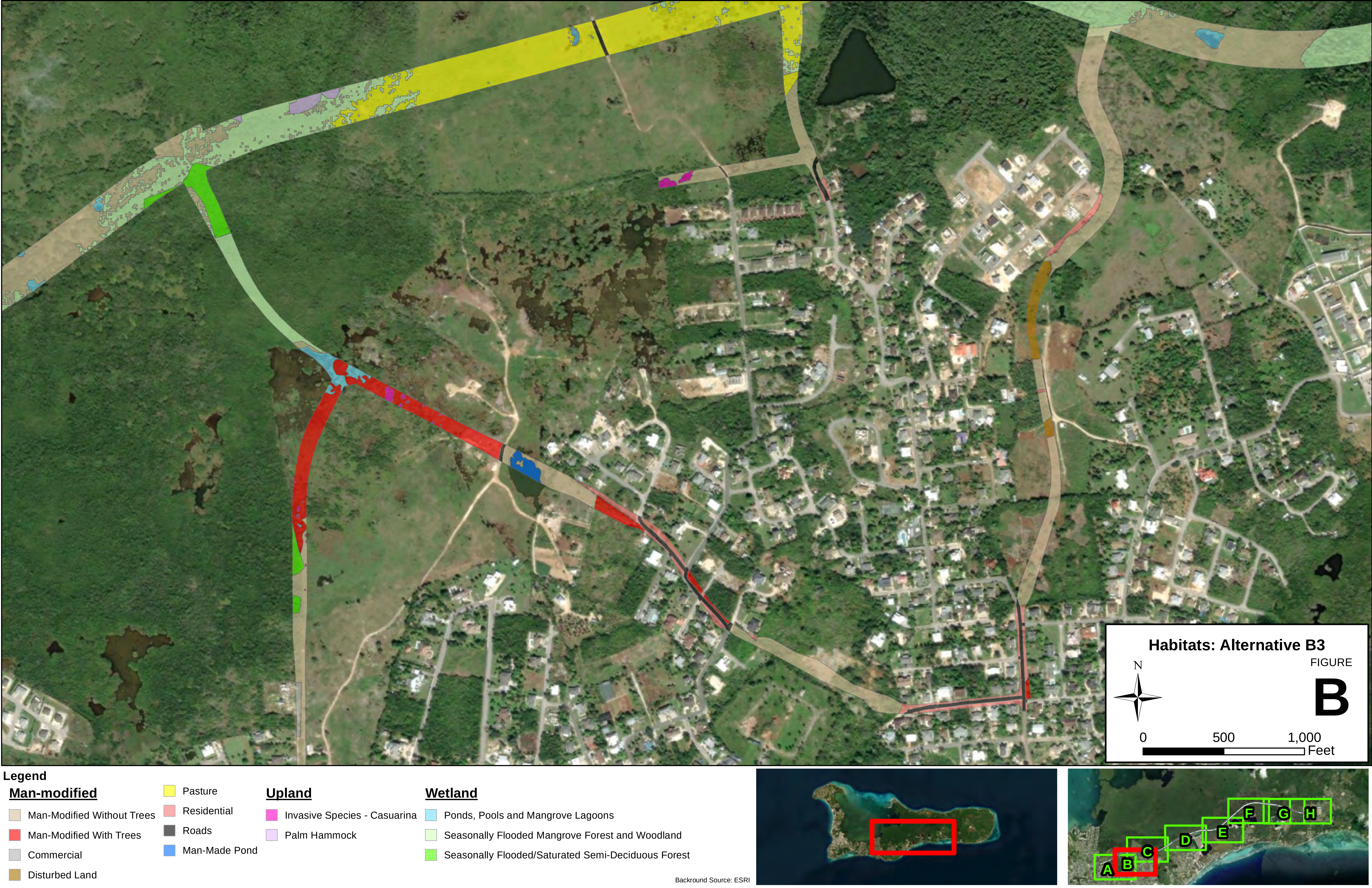
- Invasive Species - Casuarina

Wetland

- Ponds, Pools and Mangrove Lagoons
- Seasonally Flooded Mangrove Forest and Woodland
- Seasonally Flooded/Saturated Semi-Deciduous Forest

Backround Source: ESRI





Habitats: Alternative B3
FIGURE
B
N
0
500
1,000
Feet
Legend
Man-modified
Man-Modified Without Trees
Man-Modified With Trees
Commercial
Disturbed Land
Pasture
Residential
Roads
Man-Made Pond
Upland
Invasive Species - Casuarina
Palm Hammock
Wetland
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Seasonally Flooded/Saturated Semi-Deciduous Forest
Backround Source: ESRI
A
B
C
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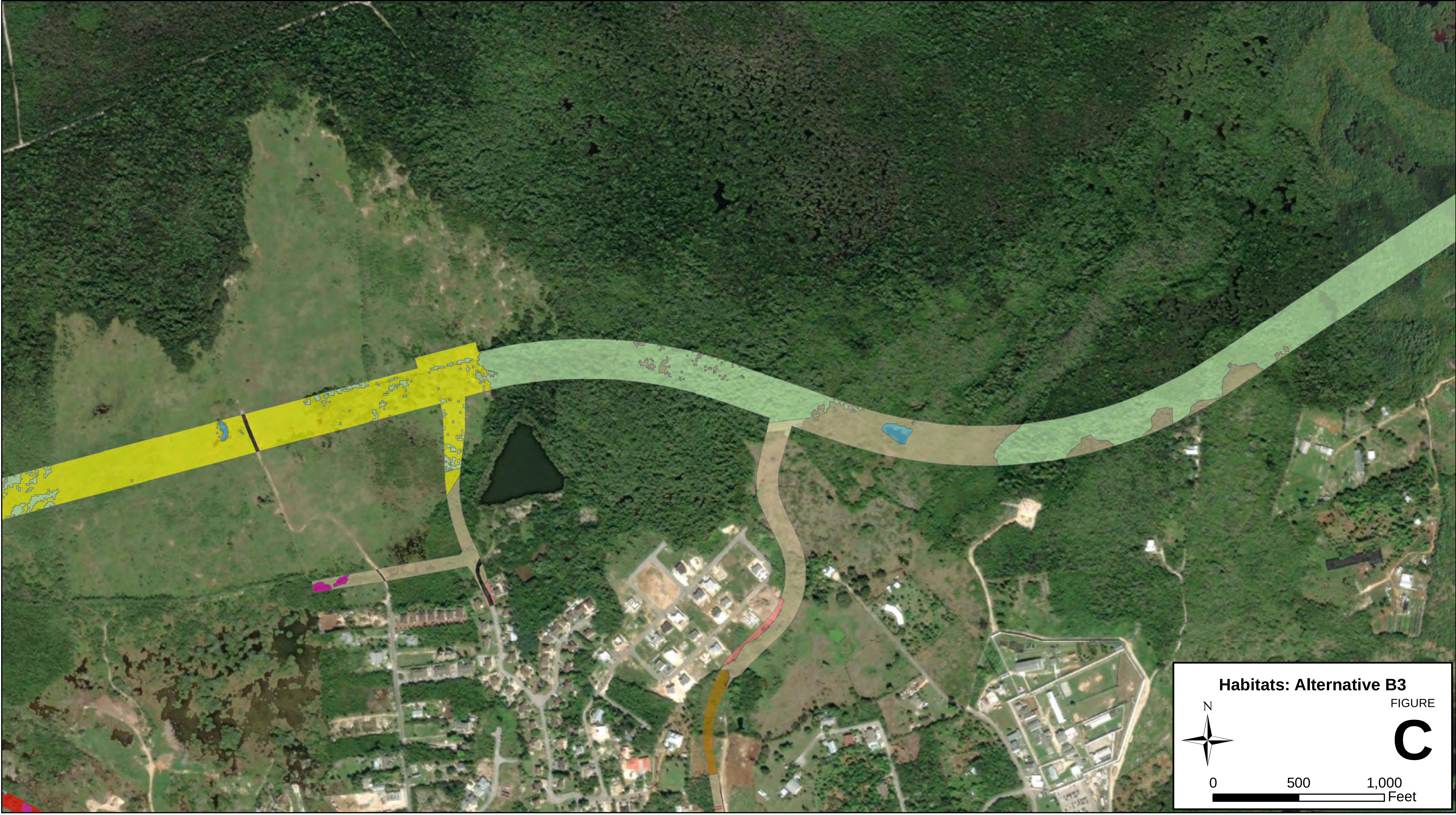


Legend

Man-modified

- Man-Modified Without Trees
- Man-Modified With Trees
- Disturbed Land
- Pasture
- Residential
- Roads

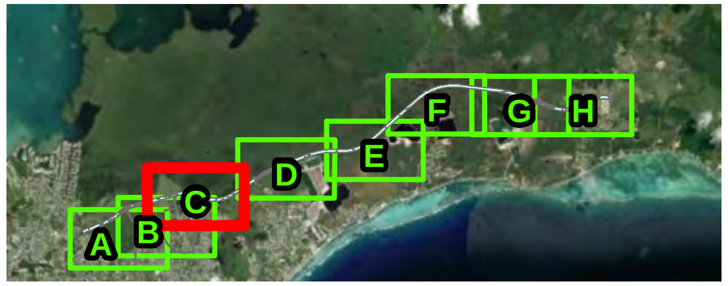
Upland

- Invasive Species - Casuarina

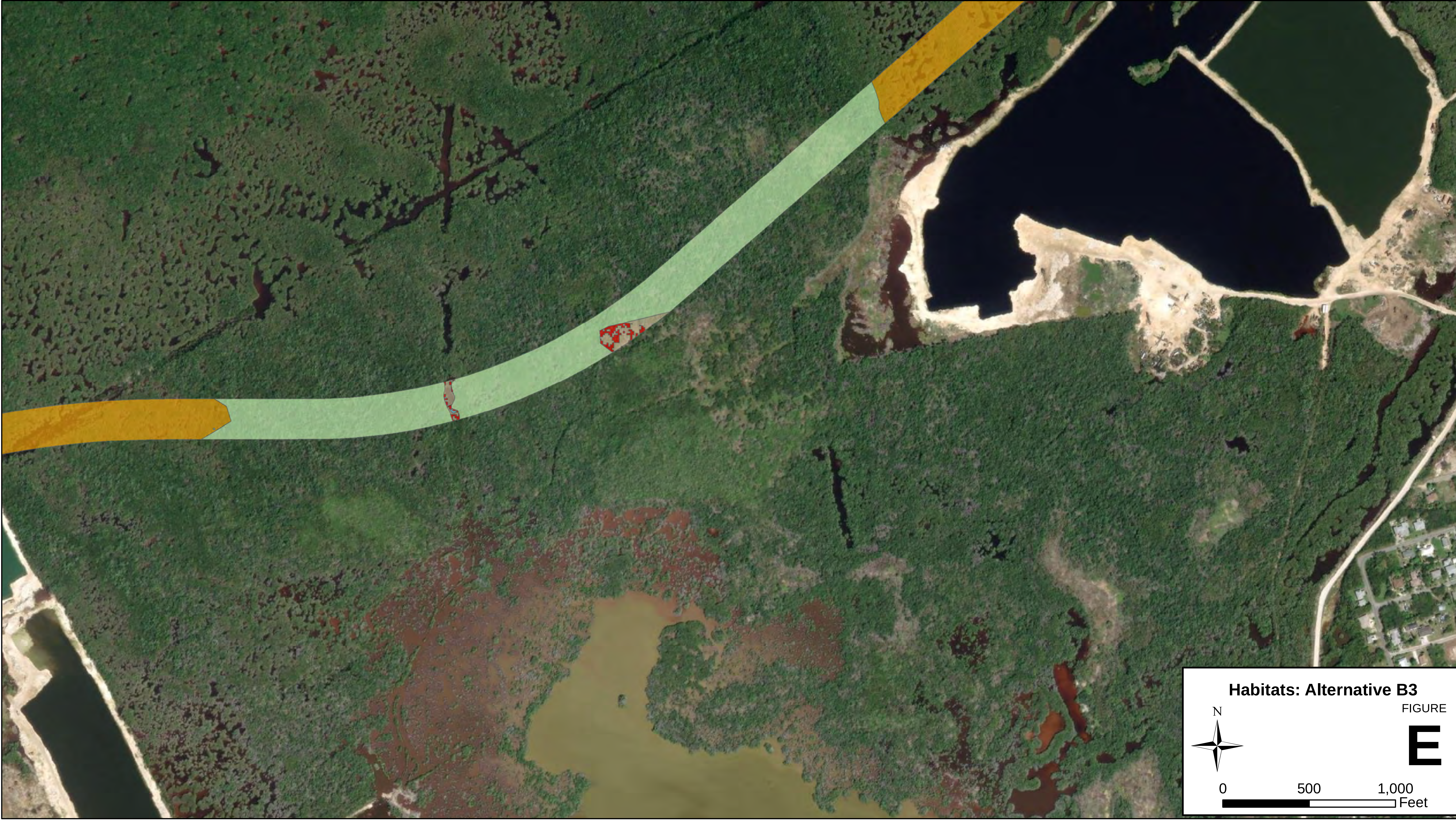
Wetland

- Ponds, Pools and Mangrove Lagoons
- Seasonally Flooded Mangrove Forest and Woodland

Backround Source: ESRI



Habitats: Alternative B3
FIGURE
D
N
0
500
1,000
Feet
Legend
Man-modified
Man-Modified Without Trees
Roads
Upland
Palm Hammock
Wetland
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Seasonally Flooded Mangrove Forest (low density)
A
B
C
D
E
F
G
H
Backround Source: ESRI



Legend

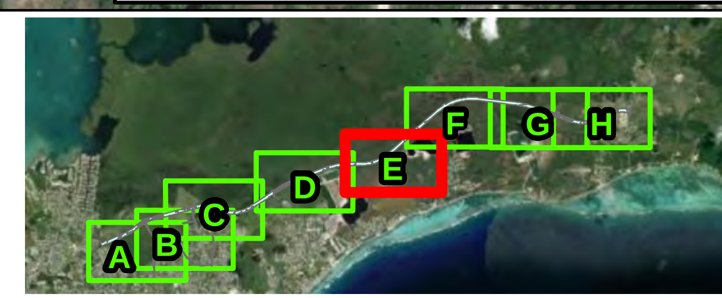
Man-modified

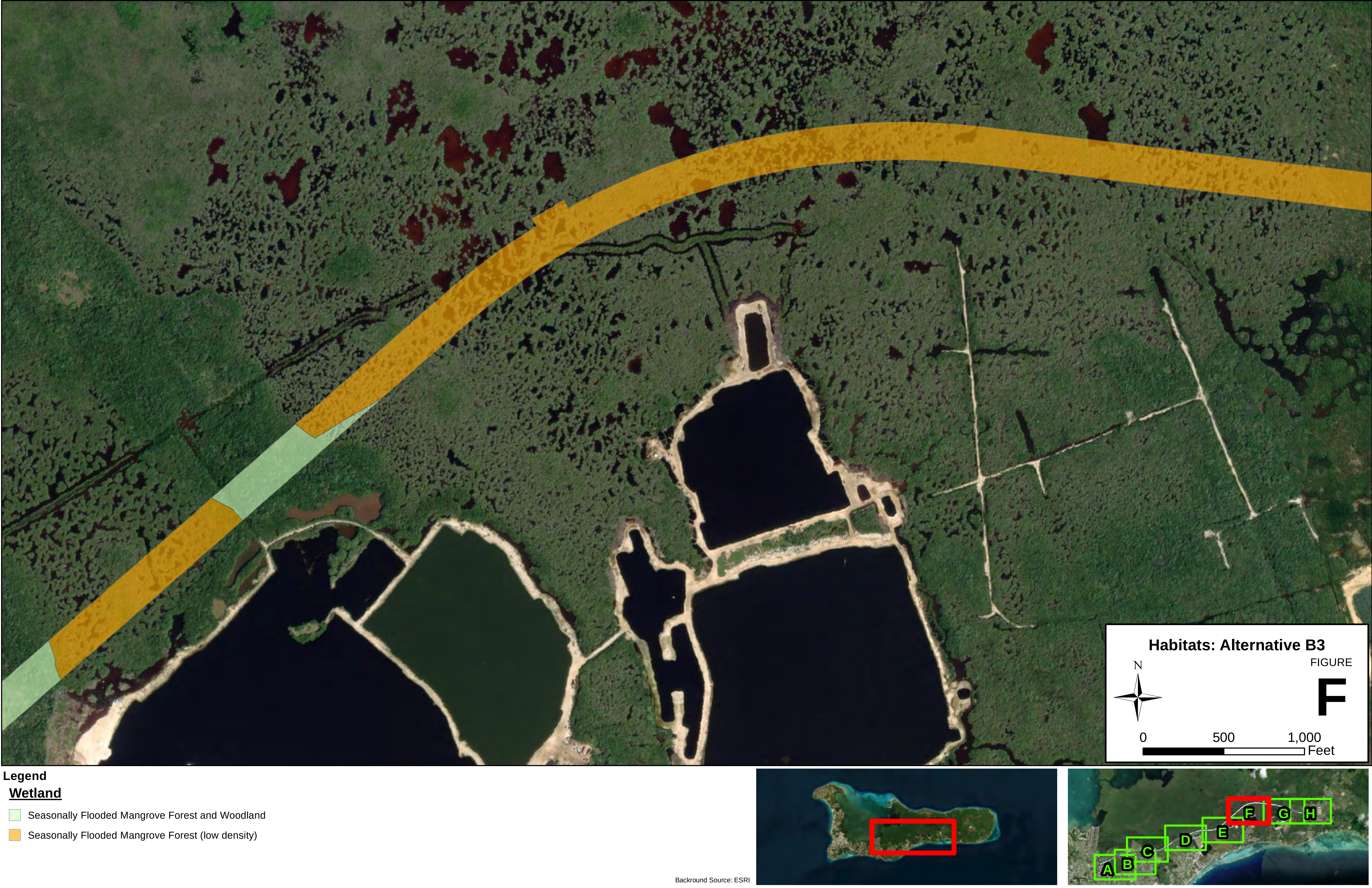
- Man-Modified Without Trees
- Man-Modified With Trees

Wetland

- Ponds, Pools and Mangrove Lagoons
- Seasonally Flooded Mangrove Forest and Woodland
- Seasonally Flooded Mangrove Forest (low density)

Backround Source: ESRI





Habitats: Alternative B3
FIGURE
F
N
0
500
1,000
Feet
Legend
Wetland
Seasonally Flooded Mangrove Forest and Woodland
Seasonally Flooded Mangrove Forest (low density)
Backround Source: ESRI
A
B
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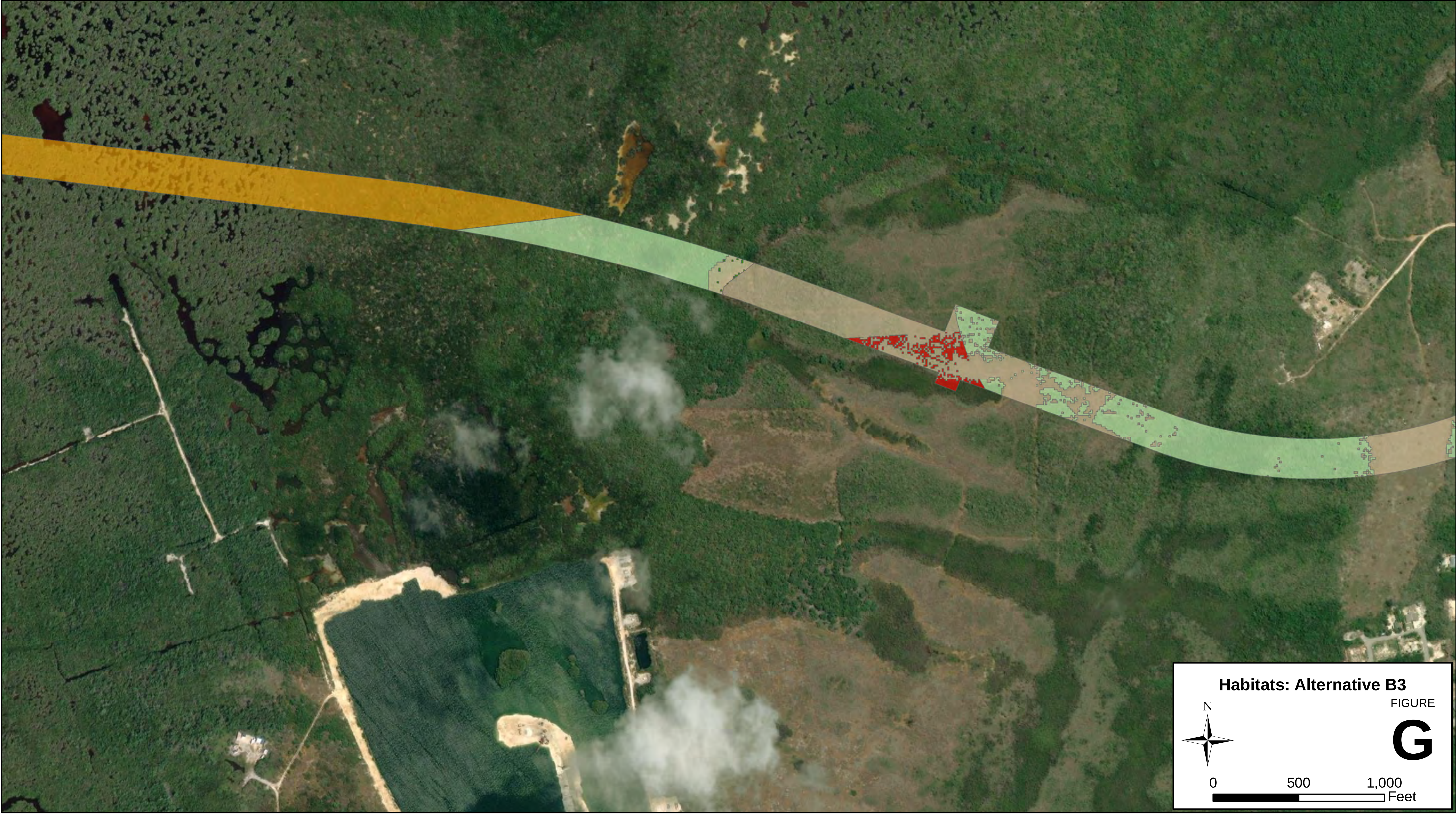


Legend

Man-modified
- Man-Modified Without Trees
- Man-Modified With Trees

Upland
- Dry Forest and Woodland
- Dry Shrubland

Wetland
- Seasonally Flooded Mangrove Forest and Woodland
- Seasonally Flooded Mangrove Forest (low density)

Backround Source: ESRI

Legend

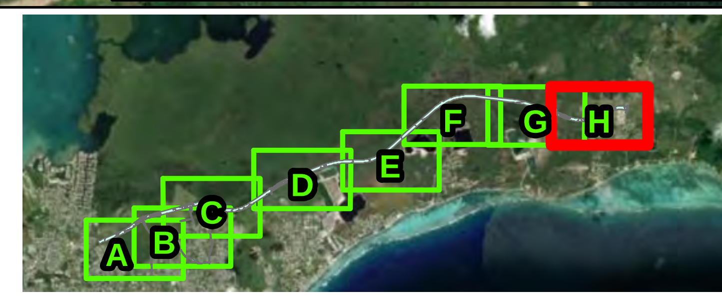
Man-modified

- Man-Modified Without Trees
- Man-Modified With Trees
- Commercial
- Institutional
- Residential
- Roads

Wetland

- Seasonally Flooded Mangrove Forest and Woodland

Backround Source: ESRI



Attachment D

Alternative B4 Habitat Mapping


Habitats: Alternative B4
FIGURE
A
N
0
500
1,000
Feet
Legend
Man-modified
Man-Modified Without Trees
Man-Modified With Trees
Commercial
Residential
Roads
pond
Upland
Invasive Species - Casuarina
Wetland
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Seasonally Flooded/Saturated Semi-Deciduous Forest
Backround Source: ESRI
A
B
C
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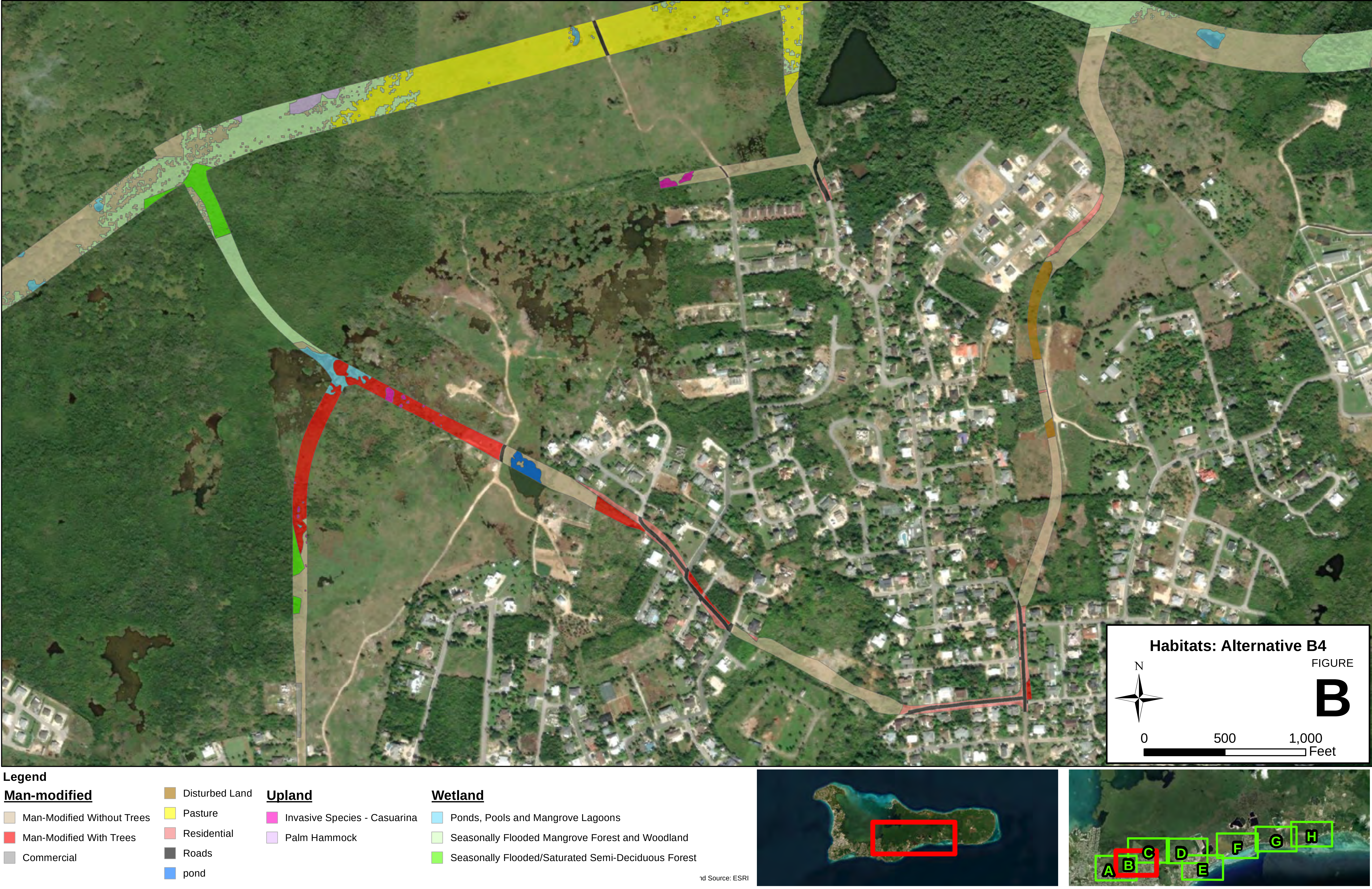

Habitats: Alternative B4
FIGURE
B
N
0
500
1,000
Feet
Legend
Man-modified
Man-Modified Without Trees
Man-Modified With Trees
Commercial
Disturbed Land
Pasture
Residential
Roads
pond
Upland
Invasive Species - Casuarina
Palm Hammock
Wetland
Ponds, Pools and Mangrove Lagoons
Seasonally Flooded Mangrove Forest and Woodland
Seasonally Flooded/Saturated Semi-Deciduous Forest
nd Source: ESRI
A
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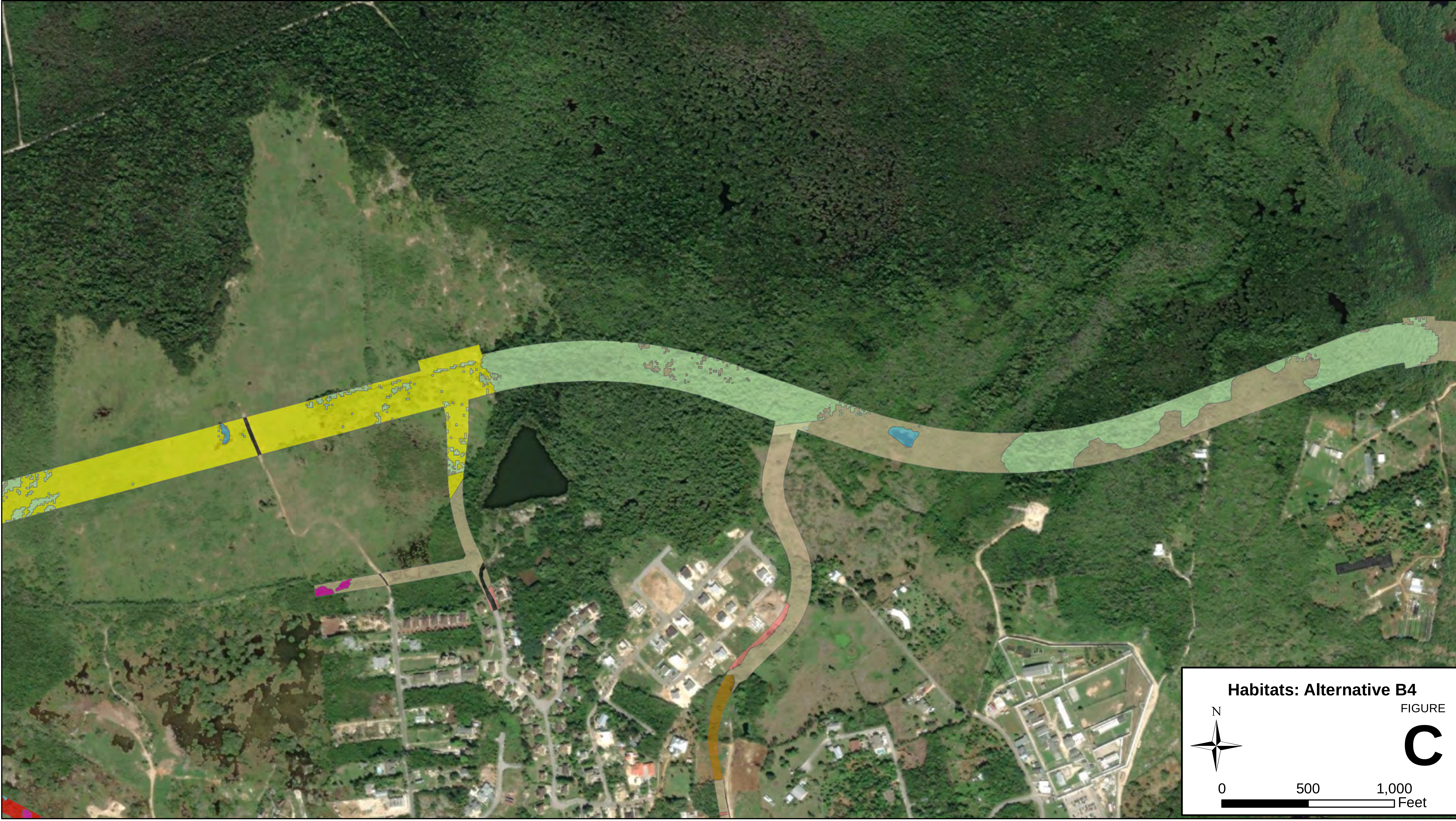

Legend

Man-modified

- Man-Modified Without Trees
- Man-Modified With Trees
- Disturbed Land
- Pasture
- Residential
- Roads

Upland

- Invasive Species - Casuarina

Wetland

- Ponds, Pools and Mangrove Lagoons
- Seasonally Flooded Mangrove Forest and Woodland

Backround Source: ESRI


Habitats: Alternative B4
FIGURE
D
N
0
500
1,000
Feet
Legend
Man-modified
Man-Modified Without Trees
Man-Modified With Trees
Agricultural
Residential
Roads
Wetland
Seasonally Flooded Mangrove Forest and Woodland
Backround Source: ESRI
A
B
C
D
E
F
G
H

Legend

Man-modified
- Man-Modified Without Trees
- Man-Modified With Trees
- Commercial
- Residential
- Roads

Upland
- Invasive Species - Casuarina

Wetland
- Ponds, Pools and Mangrove Lagoons
- Seasonally Flooded Mangrove Forest and Woodland

Coastal
- Coastal Shrubland

Backround Source: ESRI

Legend

Man-modified
- Man-Modified Without Trees
- Man-Modified With Trees
- Commercial
- Residential
- Roads

Upland
- Dry Forest and Woodland
- Dry Shrubland
- Invasive Species - Casuarina

Wetland
- Ponds, Pools and Mangrove Lagoons
- Seasonally Flooded Mangrove Forest and Woodland

Coastal
- Coastal Shrubland

Backround Source: ESRI

Legend

Man-modified
- Man-Modified Without Trees
- Man-Modified With Trees
- Residential

- Roads

Upland
- Dry Forest and Woodland
- Dry Shrubland

Wetland
- Seasonally Flooded Mangrove Forest and Woodland
- Seasonally Flooded Mangrove Shrubland

Coastal
- Coastal Shrubland

Backround Source: ESRI


Habitats: Alternative B4
FIGURE
H
N
0
500
1,000
Feet
Legend
Man-modified
Man-Modified Without Trees
Man-Modified With Trees
Disturbed Land
Residential
Roads
Upland
Dry Forest and Woodland
Dry Shrubland
Invasive Species - Casuarina
Wetland
Seasonally Flooded Mangrove Forest and Woodland
Coastal
Coastal Shrubland
Backround Source: ESRI
A
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Attachment E

Cayman Islands Ecosystem Accounting

Cayman Islands Ecosystem Accounting

2020 Ecosystem Account

February 2022

Funded by UK Government

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eftec.co.uk

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Frederic Burton (DoE Cayman Islands)

Reviewer

Jake Kuyer (eftec)

Acknowledgements

We would like to thank those who provided data to support this work.

Disclaimer

Document evolution

Final report	01/2022	Reviewed by Jake Kuyer

This report is based on eftec's Version 2 – January 2020 report template.

2020 Ecosystem Account

At 264 square kilometres with a population of 65,786 in 2020 (Economics and Statistics Office, 2021), the Cayman Islands is dependent on its wealth of environmental assets, in fact the environment contributes at least an estimated **CI$ 62 million** in value to the Cayman Islands in 2020 (Table 2). These environmental assets provide an abundance of benefit to the people across the Cayman Islands including the: value added to the tourism industry (CI$21 million per year); carbon sequestered by coastal and forest habitats (CI$12 million per year); amenity value due to mangroves (CI$1.3 billion); and other more difficult to measure values such as local recreation and the biodiversity that makes life richer to both local inhabitants and visitors. The economic prosperity and wellbeing of the people of the Cayman Islands are fundamentally linked to effective management of the environment, and an understanding of the value that it provides.

Ecosystem accounts provide economic evidence that supports the delivery of sustainable value from environmental assets[1]. Effective management of the environment must consider the extent and underlying condition of ecosystems over time, as well as the range of benefits they provide and the economic value of those benefits to different stakeholder groups. Specifically, the data in ecosystem accounts can help address several fundamental questions for policy and planning:

- What environmental assets are present and what state are they in? How does this change over time?
- What benefits does the environment provide? How are these received by beneficiaries?
- What is the economic value of these benefits? How is this value distributed across the population?

The environmental and socioeconomic data produced within Ecosystem Accounts provide a basis for answering these questions. Their importance is reflected in the development of the System of Environmental Economic Accounting – Ecosystem Accounts (SEEA-EA)[2], by the United Nations (UN). Officially adopted by the UN as a Statistics standard in March 2021, the SEEA-EA supports the implementation of ecosystem accounting as a part of National Accounts by National Statistics Offices around the world (see Box 1).

Development of ecosystem accounts provide indicators that compliment national economic and social indicators (such as GDP and demographic trends), and this evidence can support policy development and decision making, such as:

- Effective decision-making which impacts on the environment and the benefits it provides;
- Action on climate change, including mitigation, adaptation and resilience to impact;
- Delivery of international initiatives, such as the UN Sustainable Development Goals (SDGs)3; and
- A green post-COVID economic recovery, and in particular a sustainable tourism sector.

For ecosystem accounts to be a valuable addition to government and organisational policy and planning strategy, they should be embedded into the decision-making process, and updated on an annual basis both

[1] See Box 1 for more detail.

[2] See: https://seea.un.org/ecosystem-accounting

[3] More information is available at: https://sdgs.un.org/goals

to provide current data and to monitor trends over time. A partnership of eftec, the UK Joint Nature Conservation Committee (JNCC), the New Economics Foundation, and the Cayman Islands Department of Environment (DoE), with funding from the UK Government via the Darwin Initiative, have continued developing the ecosystem accounting process in the Cayman Islands. The aim is to embed the consistent production of national environmental statistic through ecosystem accounting within the Cayman Islands Government.

Physical flow and monetary flow

A range of benefits have been assessed within the Ecosystem Account, with estimated annual physical flow and monetary values given a confidence rating, as described in Table 1. The confidence rating is based on the robustness of the evidence and assumptions used. The Ecosystem Service Flow and Asset Accounts are presented in Table 2. The supplementary information is presented in Table 3. Note that the evidence presented in the summary table should be interpreted as a partial valuation of the total contribution of the environment to the Cayman Islands. The Cayman Islands environment provides additional benefits, such beach erosion protection and local recreation, which cannot be accurately quantified or valued at this time due to data limitations. Future iterations of the accounts should seek to address these gaps to provide a fuller valuation (see Appendix A of the Technical Report).

Table 1: Description of confidence

Confidence	Symbol	Description
Low	● (red)	Evidence is partial and significant assumptions are made so that the data provides only order of magnitude estimates of value to inform decisions and spending choices.
Medium	● (yellow)	Science-based assumptions and published data are used but there is some uncertainty in combining them, resulting in reasonable confidence in using the data to guide decisions and spending choices.
High	● (green)	Evidence is peer reviewed or based on published guidance so there is good confidence in using the data to support specific decisions and spending choices.
No colour	●	Not assessed

Table 2: Ecosystem Service Flow and Asset Accounts

Produced at: January, 2022	Ecosystem Service Flow Accounts						Ecosystem Asset Account (PV* CI$m)
	Physical flow (unit/yr.)			Monetary value (CI$m/yr.)			
	Reporting	Confidence	Physical indicator	Reporting	Confidence	Valuation metric	
Fisheries	702,000	●	Volume of reef fish caught in the Cayman Islands (lbs/yr.)	3	●	Net benefit value of recreation, subsistence and small-scale commercial fishing on coral reefs	51
Agriculture	5,061	●	Total livestock production (no./yr.)	2	●	Total value of livestock production	25
	-	●	Total arable production (t/yr.)	18	●	Total value of arable production	272
Carbon sequestration	68,500	●	Total tonnes of CO_2e sequestered by coastal ecosystems (tCO_2e/yr.)	11	●	Total value of CO_2e sequestered by coastal ecosystems	272
	9,393	●	Total tonnes of CO_2e sequestered by forest ecosystems (tCO_2e/yr.)	1	●	Total value of CO_2e sequestered by forest ecosystems	37
Coastal protection	-	●	Area of coral reef (km^2)	7	●	Coastal protection value by coral reefs	112
Tourism	598,263	●	Total visitor arrivals (stay-over and cruise ships) (visitors/yr.)	21	●	Total tourism added value attributed to marine ecosystems	943
Amenity value	26,197	●	Number of houses (no.)	-	●	Amenity value of mangroves	1,306
			Total value	**62**	●	**Mix of values**	**3,020**

* The present value (PV) is the sum over 25-years. It is the total monetary value of a stream of benefits profiled over time, accounting for greater worth being placed on nearer term values than those further in the future.

Table 3: Supplementary information

Produced at: January, 2022	Ecosystem Service Flow Accounts						Ecosystem Asset Account (PV* CI$m)
	Physical flow (unit/yr.)			Monetary value (CI$m/yr.)			
	Reporting	Confidence	Physical indicator	Reporting	Confidence	Valuation metric	
Other exchange values							
Tourism	598,263	●	Total visitor arrivals (stay-over and cruise ships) (visitors/yr.)	59	●	Remaining tourism expenditure not attributed to ecosystems	2,706
Welfare values							
Tourism	598,263	●	Total visitor arrivals (stay-over and cruise ships) (visitors/yr.)	35	●	Total WTP to prevent decline in quality of coral reefs from medium to low levels	1,873
Non-monetised benefits							
Water supply		●			●		
Renewable energy		●			●		
Beach erosion protection		●			●		
Local recreation	378	●	Total number of diving spots (no.).		●		

* The present value (PV) is the sum over 25-years. It is the total monetary value of a stream of benefits profiled over time, accounting for greater worth being placed on nearer term values than those further in the future.

Ecosystem Extent and Condition Accounts

Spatial analysis was conducted to assess the ecosystems present within the Cayman Islands. The quantity (i.e., extent) and quality (i.e., condition) of the present ecosystems are recorded in the Ecosystem Extent Account (**Table 4**) and Ecosystem Condition Account (**Table 5**), respectively. Beyond the extent and condition of ecosystems, other indicators for spatial configuration and other forms of capital are also included in the assessment (**Table 6**). The accounts can be used to monitor changes in the environmental assets over time. The terrestrial and marine ecosystem of the Cayman Islands are mapped in **Figure 1, Figure 2** and **Figure 3.**

Table 4: Ecosystem Extent Account

IUCN Code	Ecosystem	Grand Cayman	Cayman Brac	Little Cayman	Cayman Islands
Terrestrial					
Total area (km^2)		**200**	**38**	**29**	**267**
F2.7	Permanent salt and soda lakes	-	0.1	-	0.1
MFT1.2	Intertidal forests and shrublands	62	0.1	2	64
MT1	Shorelines biome	-	0.9	0.6	2
MT2.1	Coastal shrublands and grasslands	1	1	1	4
T1.2	Tropical-subtropical dry forests and scrubs	15	12	1	29
T3.1	Seasonally dry tropical shrublands	25	7	16	47
T5.3	Sclerophyll hot deserts and semi-deserts	0.9	-	-	0.9
T7.4	Urban and industrial ecosystems	10	1	0.4	11
T7.5	Derived semi-natural pastures and old fields	17	-	-	17
TF1.1	Tropical flooded forests and peat forests	13	0.4	4	19
TF1.2	Subtropical/temperate forested wetlands	0.8	-	-	0.8
TF1.3	Permanent marshes	0.2	-	0.04	0.3
TF1.4	Seasonal floodplain marshes	0.4	0.01	0.1	0.5
Marine (benthic and lagoon shelf)					
Total area (km2)		**658**	**21**	**209**	**893**
M1.1	Seagrass meadows	80	0.2	3.2	83
M1.3	Photic coral reefs	282	13	111	406
M1.6	Subtidal rocky reefs	269	8	95	373
M1.7	Subtidal sand beds	18	0.1	0.5	21
M1.8	Subtidal mud plains	10	-	-	10

Source: See Appendix A.1 for input data sources.
Table Notes: See Appendix C for DoE and IUCN ecosystem typology comparison.

Table 5: Ecosystem Condition Account

Category	Sub-category	Grand Cayman	Cayman Brac	Little Cayman	Cayman Islands
Ecological communities and species					
Area of dry forest above 20 feet elevation (km^2)		38	-	-	38
Area of protected land (km^2)		14	1	2	17
Area of proposed protected land (km^2)		44	10	15	69
Marine protected area (km^2)		88	7	15	110
Carbon stock in habitats (MgC)	Inside MPAs	446,100	100	12,600	458,800
	Outside MPAs	2,616,800	8,200	192,000	2,817,000
Total area of species-specific habitat (km^2)		5	15	2	22

Category	Sub-category	Grand Cayman	Cayman Brac	Little Cayman	Cayman Islands
Species points by type (#)	Aegiphilia caymanensis	2	-	-	2
	Pisonia margaratae	119	-	-	119
	Sister Islands Rock Iguana Cyclura nubila caymanensis - nest locations	-	-	238	238
Land					
Total land area owned by the Crown (km^2)		162	29	84	275
Total land area owned by the National Trust (km^2)		123	15	19	157

Source: See Appendix A.2 for input data sources.

Table 6: Other indicators

Category	Sub-category	Grand Cayman	Cayman Brac	Little Cayman	Cayman Islands
Spatial configuration					
Number of caves (#)		31	25	2	58
Area of sinkholes (km^2)					0.04
Other forms of capital					
Number of public moorings (#)	Inside MPAs	88	20	40	148
	Outside MPAs	155	48	26	229

Source: See Appendix A.3 for input data sources.

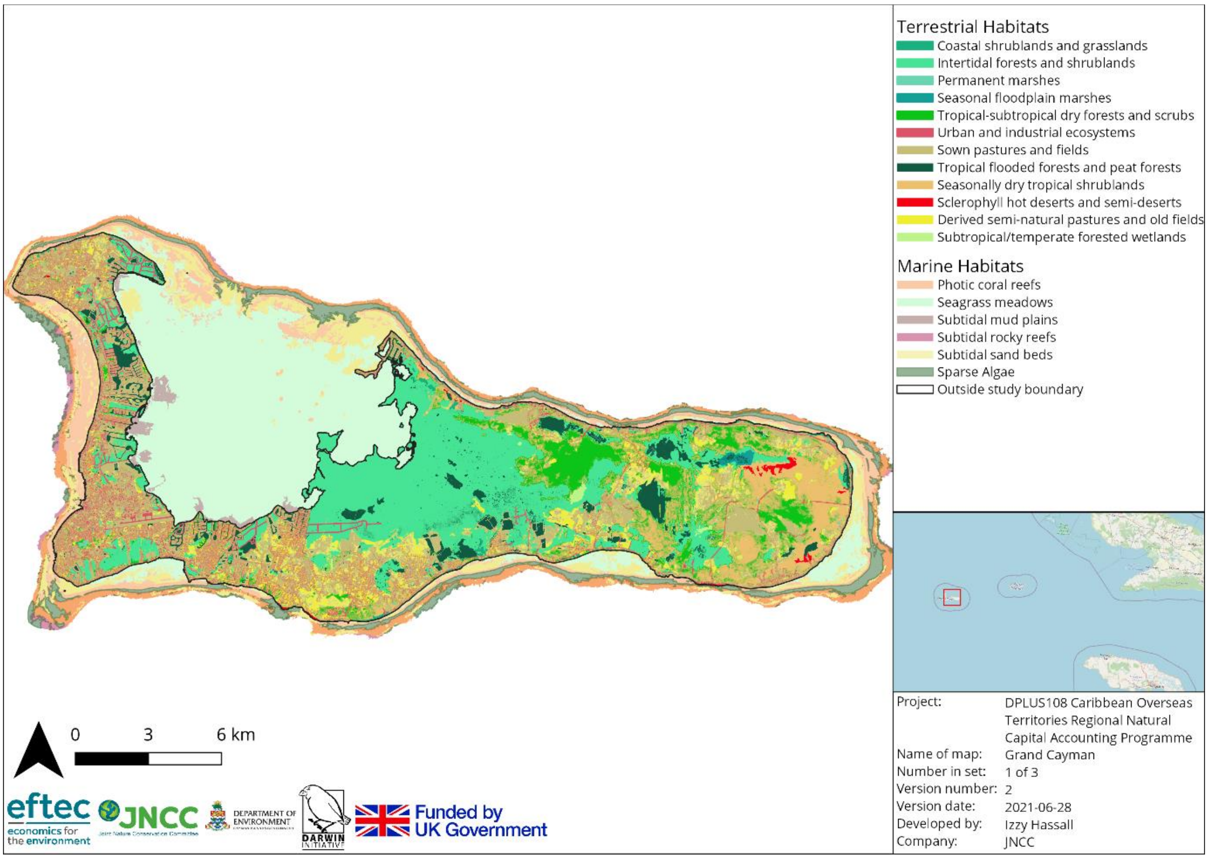

Figure 1: Grand Cayman terrestrial and marine ecosystems
Source: JNCC GIS analysis of Landcover 2013, Benthic Shelf 2008 and Lagoon Shelf (2008) from Cayman Islands DoE

Figure 2: Cayman Brac terrestrial and marine ecosystems

Source: JNCC GIS analysis of Landcover 2013, Benthic Shelf 2008 and Lagoon Shelf (2008) from Cayman Islands DoE

Figure 3: Little Cayman terrestrial and marine ecosystems

Source: JNCC GIS analysis of Landcover 2013, Benthic Shelf 2008 and Lagoon Shelf (2008) from Cayman Islands DoE

Box 1: Ecosystem accounts

The ecosystem accounting approach helps frame the interconnection between humans and the environment in economic terms. The environment can be viewed as an asset, or natural capital, that provides a revenue of ecosystem goods and services, which benefit people. This includes provisioning services, such as agricultural produce or fisheries, regulating services, such as protection from natural hazards and carbon sequestration, and cultural services, such as tourism and local recreation. These benefits can be measured and valued in a consistent and structured manner, and compiled into an accounting framework, called ecosystem accounts. Ecosystem accounts produce environmental statistics which provide an evidence base on the benefits provided by the environment.

An ecosystem account is structured as a set of component accounts, each of which require data to be consistently collected and collated in a systematic way. The main components of an ecosystem account are:

- **Ecosystem Extent and Condition Accounts** - an inventory that holds details on the state of all the ecosystem assets that are present, including their extent and condition (quality and other relevant factors). For example, the spatial area of a reef system, and its health in terms of suitable indicators.
- **Ecosystem Services Flow Account (physical terms)** – contains the flow of goods and services which are dependent on the ecosystem assets that are identified in the extent and condition accounts. This includes benefits related to the provisioning, regulating and cultural goods and services provided by ecosystems.
- **Ecosystem Services Flow Account (monetary terms)** – calculates the annual value of the estimated flow of benefits that are captured in the Ecosystem Services Flow Account (physical terms).
- **Ecosystem Asset Account** – records the net present value approach to obtain values in monetary terms for ecosystem assets based on the monetary valuation of ecosystem services.

This set of accounts therefore monitor the presence and state of different habitats, the benefits these provide, and the value that humans receive from them. When updated year on year they provide a useful means to monitor and evaluate growth or decline in any of these contributing elements, while also helping to understand the relationship between the environment, the services it provides, and how humans use and value them.

The data collection and analysis for the Cayman Islands 2020 Ecosystem Account occurred in parallel to the development and publication of the SEEA-EA standard. As such while the Cayman Islands 2020 Ecosystem Account is generally aligned with the direction and intention of the SEEA-EA standard, full compatibility should be worked towards as the implementation of the SEEA standard continues to evolve globally over time.

Contents

1. Introduction

eftec, with project partner Joint Nature Conservation Committee (JNCC) and funding from the UK Government, have initiated *natural capital accounting* with the environment and statistics departments of the local governments of five UK Overseas Territories (OTs)[4]. The purpose is to build initial *ecosystem accounts* and to provide a foundation for data collection and processing to produce national environmental statistics in support of better decision making.

As far as possible, the ecosystem accounting work is aligned to producing UN SEEA-EA compatible accounts. The UN adopted the SEEA-EA as an internationally recognised statistical standard in March 2021. This is an important step supporting the development and integration of ecosystem accounts into national accounts, and thereby forming a basis of environmental economic evidence for policy makers. The SEEA-EA standard is new, much work is yet to be done on practical implementation. It will take time before a comprehensive and broadly applicable guidance is developed and consistently put into practice. Therefore, the accounts can be expected to evolve over time, becoming more robust and complete through subsequent iterations. The current project establishes the groundwork from which this can occur.

Ecosystem accounts are a structured way to measure and monitor the benefits provided by the natural environment. They can be produced alongside other national accounts as a basis for understanding human dependence and impact on the environment, and to inform policy and planning decisions. They should be updated annually to build up the available evidence base, to demonstrate change over time, and to improve on the methods applied.

This report gives an overview of the concepts, process and structure of ecosystem accounts, and current progress on their implementation. It provides additional context for the Ecosystem Account summarised above. The remaining sections are structured as follows:

- **Section 1:** Introduction
- **Section 2:** Background on natural capital and ecosystem accounts
- **Section 3:** Implementation of ecosystem accounting
- **Section 4:** Conclusion

[4] The OTs included in this project are: Anguilla, British Virgin Islands, Cayman Island, Montserrat and Turks and Caicos Islands.

2. Natural Capital and Ecosystem Accounts

This section presents the background and concepts of natural capital and ecosystem services, also describing the process which produces ecosystem accounts and the structure of the accounts. As the SEEA-EA is recently published, the relationship with natural capital accounting is still evolving. As applied in this report, the SEEA-EA standard for ecosystem accounting can be thought of as a subset of the broader process of natural capital accounting. They generally apply the same concepts and methods. SEEA-EA does so in a more specific way to align with the System of National Accounts (which is the internationally agreed standard set of recommendations on how to compile measures of economic activity, such as GDP).

2.1 Concepts

Natural capital is defined by the UK Natural Capital Committee as: "the elements of nature that directly and indirectly produce value or benefits to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions". Natural capital, or ecosystem assets, provide benefits to people, through ecosystem services. The focus of ecosystem accounting is to measure and value the benefits from ecosystem services and the underlying ecosystem assets, and to present this evidence in a structured format called ecosystem accounts.

In the Common International Classification of Ecosystem Services (CICES), ecosystem services are defined as 'the contributions that ecosystems make to human well-being'. They are seen as arising from the interaction of biotic and abiotic processes and refer specifically to the 'final' outputs or products from ecological systems, specifically the things directly consumed or used by people. Ecosystem services are therefore the flows of benefits which people gain from natural ecosystems, and natural capital is the stock of ecosystems from which these benefits flow (**Figure 2.1**). Ecosystem services can be subdivided into provisioning, regulating, cultural and supporting services (**Box 2.1**).

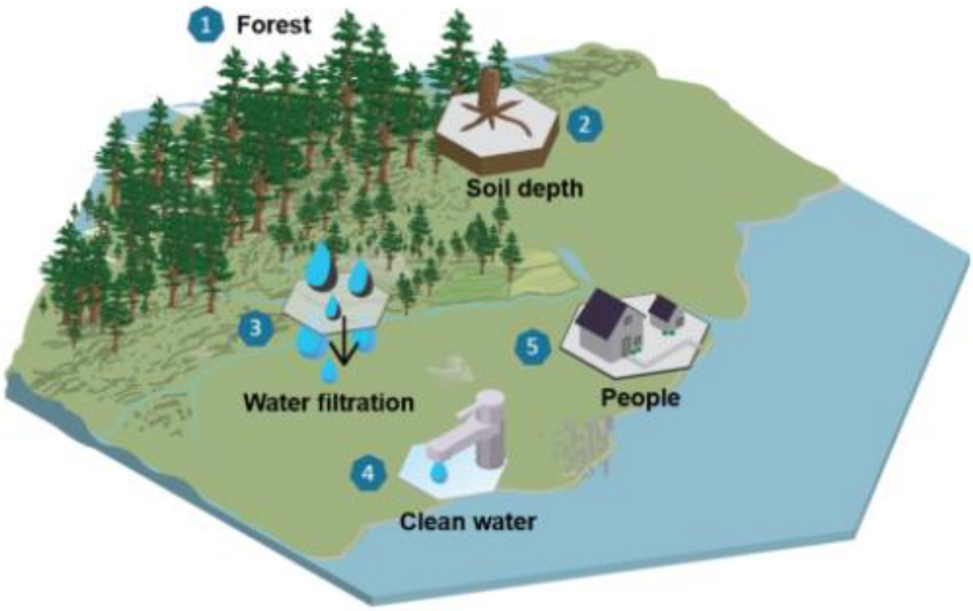

Figure 2.1: How ecosystem assets generate ecosystem services to beneficiaries in a spatial relationship
Source: UN (2021)

Viewing the environment through the lens of natural capital is an effective means to consider its value in the language of economics. Using the concept of capital and expressing the value of ecosystem services in monetary terms helps to integrate the natural environment into decision-making, in which it can otherwise be invisible.

Box 2.1: Types of ecosystem services

The most widely used definition of ecosystem services is from the Millennium Ecosystem Assessment: "the benefits people obtain from ecosystems". It further categorised ecosystem services into four types:

- **Provisioning services**: material outputs from nature (e.g., seafood, water, fibre, genetic material).
- **Regulating services:** indirect benefits from nature generated through regulation of ecosystem processes (e.g., mitigation of climate change through carbon sequestration, water filtration by wetlands, erosion control and protection from storm surges by vegetation, crop pollination by insects).
- **Cultural services:** non-material benefits from nature (e.g., spiritual, aesthetic, recreational, and others)
- Provisioning, regulating and cultural services are referred to as final ecosystem services and are underpinned by **Supporting services**. These are the fundamental ecological processes that support the delivery of other ecosystem services (e.g., nutrient cycling, primary production, soil formation).
- Analysis of benefits from natural capital also includes **abiotic services**, the benefits arising from fundamental geological processes (e.g., the supply of minerals, metals, oil and gas, geothermal heat, wind, tides, and the annual seasons).

2.2 The ecosystem accounting process

Ecosystem accounting is a process of compiling and linking data on the quantity and quality of ecosystem assets and physical and monetary data on the benefits they provide. The data are presented in a consistent framework, which should as far as possible align with the SEEA-EA standards for producing ecosystem accounts. These accounts present evidence to measure and monitor benefits from ecosystems consistently over time to inform policy and planning decisions. In the same way that the structured recording of other national statistics in conventional national accounts informs and improves a country's economic and social decisions, ecosystem accounts can inform better management of a country's ecosystem assets.

Ecosystem accounts are structured as a set of interrelated component accounts that record the value that is provided by a country's ecosystem assets. The aim of these accounts is to answer the following key questions:

- What ecosystem assets do we have? -> An Ecosystem Extent and Condition Account (together sometimes referred to as an *asset register)* is an inventory that holds details of the stocks of ecosystem assets that are present within the geographical boundary of the country. For example, a coral reef may contain a variety of species and the quality of this diversity may be measured by the number of species recorded on the site for a few selected taxa (e.g., fish, coral). The asset register helps track trends in the quantity and quality of ecosystems.

- What benefits do these assets provide? -> An Ecosystem Services Flow Accounts (physical terms) contains the flow of goods and services which are dependent on the ecosystems that are identified in the extent and condition accounts. This account provides information on the benefits provided by ecosystems, with the flows measured in different physical units (e.g., number of recreational visits or visitors, weight of produce).
- What is the value of these benefits? -> An Ecosystem Services Flow Accounts (monetary terms) calculates the annual value of the estimated flow of goods and services that are captured in the Ecosystem Services Flow Accounts (physical terms). The Ecosystem Asset Account measures the aggregate value of flows of goods and services into the future.

2.2.1 Data collection

Some relevant data will already exist, such as economic data for natural resources, the tourism sector, and utilities and infrastructure data. Additional data can be collected through social research including surveying, economic and econometric analysis, and monitoring of environmental outputs and levels of usage. Geo-referenced socio-economic data along with infrastructure maps can be compared with habitat maps to help identify and measure location specific use.

In practice, secondary data in a readily useable format may be limited, especially with regards to regulating services. Resource and time constraints can further limit primary data collection. This may require an innovative approach with what is available, clearly caveated with assumptions and further inferences to fill remaining gaps and making use of modelling where possible. In such cases, it is important to prioritise the most material benefits in the given context and to focus on where the most value is being provided.

2.3 Structure of ecosystem accounts

This section provides more detail on the component accounts which together make up the ecosystem account. **Figure 2.2** presents the links between the components of ecosystem accounts.

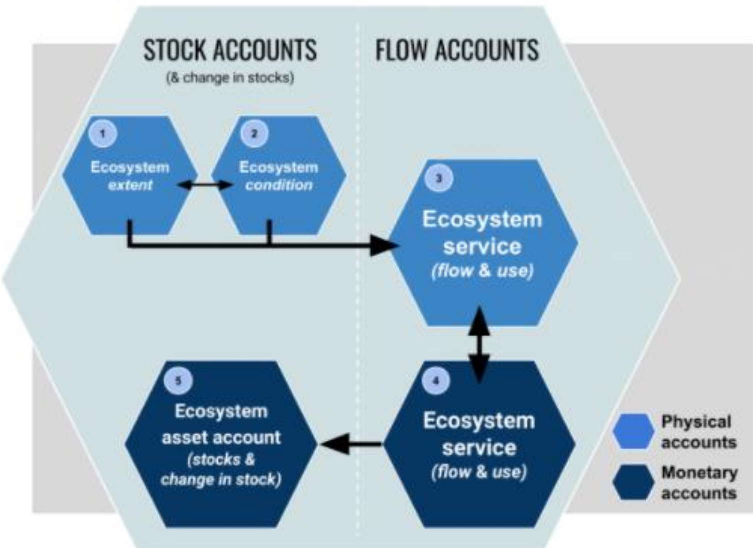

Figure 2.2: Ecosystem accounts and how they relate to each other
Source: UN (2021)

2.3.1 Ecosystem Extent and Condition Accounts

The extent and condition accounts (or asset register) record the quantity and quality of all of the ecosystem assets in a given area. The asset register therefore acts as an inventory that holds details of the stocks of ecosystem assets that are relevant to the accounts, along with information on their quality, functionality, and other relevant factors.

The foundation for an asset register is the distribution and condition of ecosystems which are present within the accounting area. Ecosystem extent can be determined and mapped by desk-based analysis, such as with data available from existing surveys and obtained through existing remote sensing techniques such as Earth Observation (EO) and processed using Geographic Information Systems (GIS). The combination of remote sensing and on-the-ground techniques provides a strong evidence base from which to build the spatial basis for an asset register.

2.3.2 Ecosystem Service Flow Accounts - Physical Terms

The Ecosystem Service Flow Accounts - Physical Terms account records the flow of goods and services from ecosystems in the asset register. They provide a physical measure of the quantity of benefits provided on an annual basis and include information on the variety of ways that the environment provides value to people. These benefits include the provisioning, regulating and cultural services provided by ecosystems, such as fisheries, sea surge protection and locations for tourism.

Not all physical flows from ecosystems will be significant or material for evaluating. The most relevant flows of benefits should be identified and prioritised for inclusion in an account. Once the prioritised benefits that are possible to quantify are identified, the annual flows should be measured. The approach to measuring the benefits provided within the OTs will vary between territories by type of ecosystem service and benefit.

2.3.3 Ecosystem Service Flow Accounts – Monetary Terms and Ecosystem Asset Accounts

The Ecosystem Service Flow Accounts - Monetary Terms measures the monetary value of the flows of benefits that are captured in the Ecosystem Service Flow Accounts - Physical Terms. It aims to measure the exchange value of both market and non-market ecosystem services through different economic valuation techniques. This applies to both the annual value of ecosystem services and the ecosystem asset value, measured as the aggregate value of the expected annual stream of benefits over the defined assessment period (set out in the Ecosystem Asset Account).

As the monetary accounts measures value in a common metric, money, it allows for comparison between different benefits within the accounts, and between different accounts. Importantly, it also allows for comparison across many other factors which may act as inputs to decision making, such as: national economic accounts; the financial cost of an intervention; replacement costs for critical infrastructure; the price paid for public provision of alternative services; and income revenue streams from traditional capital assets. Monetary values help assess trade-offs across these factors, and to justify allocation of resources to environmental management and protection.

2.3.4 Account summary

Physical flows and monetary flows should be recorded separately, and then reported together. This creates added value by showing the links between ecosystems, ecosystem services and the value of benefits to people. Where monetary valuations are uncertain, but suggest certain benefits are important, physical flow indicators might be the best measure. In the context of the OTs, it may be likely in some cases that producing Ecosystem Service Flow Accounts - Physical Terms is more feasible than monetary valuations, but even so the aim should be to build monetary accounts to guide the collection of the most important data for the Ecosystem Service Flow Accounts - Physical Terms. Results should always be expressed with appropriate caveats to ensure that the monetary units applied reflect the value as accurately as possible. A traffic light system can be used to indicate uncertainties in data or methods applied in the Ecosystem Account (see **Table 1**).

Table 1: Presenting uncertainty in the physical and monetary terms of ecosystem services

Level of confidence	Symbol	Description of confidence
High	●	Evidence is peer reviewed or based on published guidance so there is good confidence in using the data to support specific decisions.
Medium	●	Science-based assumptions and published data are used but there is some uncertainty in combining them, reasonable confidence in using the data to guide decision.
Low	●	Evidence is partial and significant expert judgement-based assumptions are made so that the data provides only order of magnitude estimates of physical quantity or monetary value.

3. Implementation of ecosystem accounting

This section outlines the implementation of the ecosystem accounts, covering progress and next steps of the current ecosystem accounting activities, and areas to explore for applying the ecosystem accounts to policy and planning.

3.1 Current progress and next steps

The current project has initiated and developed ecosystem accounts in the five Caribbean UK OTs. Further embedding them involves engagement with government departments and other stakeholders to gain an understanding of key issues, discuss the concepts and uses of the accounts, and identify and collect available data.

Ideally, the process should be embedded in national statistics outputs through annual updates of the accounts, building more reliable data systems and methodologies with each iteration. Data collection and management systems will need to be developed further to ensure the quality of outputs is of an appropriate level to inform policy and planning. This may involve the use of standardised protocols and knowledge about data handling and processing; however, adoption of these broader protocols must also be applicable to the specific local context. These data collation processes should be led by the statistics departments of each OT, who have expertise in generating accurate and consistent data sets, and can align to the SEEA-EA statistics guidance.

While progress needs to be made, it does not necessarily have to be resource intensive once accounting systems are set up, which can then evolve over time rather than requiring significant investment in any one time period. Updates can be streamlined so that as new data is generated, it is fed into the ecosystem accounting system as a matter of routine. While the accounts should be produced on an annual basis, it is not necessary to update every element of them every year – so long as it is transparent what is updated and what is not.

The frequency of updates needs to take into account how sensitive different variables are to change, and aspects of the accounts which would not be expected to change much year on year, or for which resource intensive primary research is needed, may be updated less regularly. However, a significant benefit of the accounts is their ability to monitor trends and provide up to date information to decision makers, and as such they should be reproduced regularly. Any progress or improvement, even if incomplete, will add value to the overall process, and its ability to effectively feed into decision making. As the accounts become increasingly complete records of the value that ecosystems provide, they should become further embedded in the OTs policy and planning systems and a vital component of government statistics and public record.

In the context of sustained pressure to develop, and focus on economic growth in the OTs, it is especially critical to understand what impacts development has on the environment and its ability to provide ecosystem services which benefit people. By initiating and building on the Ecosystem Accounts in the OTs, it is hoped that additional information will be generated that will directly contribute to this understanding and improved management of the economy and environment for the sustainable prosperity and well-being of the people of the OTs.

3.2 Use of ecosystem accounts

The ultimate purpose of ecosystem accounts is to facilitate improved management of the economy and environment. Better evidence leads to better informed decisions, but those decisions are reliant on understanding and interpretation of the evidence. A considerable advancement of ecosystem accounts is their ability to compile ecological, biophysical, socioeconomic, economic, and other diverse data and produce evidence in a readily useable format. The structure of ecosystem accounts provides a consistent means to present this evidence, but it can also be adapted to specific uses, producing indicators and other information fit for purpose.

There are many areas that the evidence from ecosystem accounts can contribute to, such as:

- Link to progress on the SDGs
- Link to progress on domestic policy
- Inform on land use planning
- Monitor progress (growth) / deterioration (decline) over time
- Engage with the private sector
- Understand distribution of benefits (sectoral, individuals)
- Understand proportion of economy dependent / at risk
- Understand scale of potential economic impact in from specific decisions
- Identify priority areas for value provision and maintenance
- Identify targets for investment and enhancement
- Information for public awareness campaigns
- Inform industrial and economic strategy
- Understand tax base effects
- Understand resident use and benefit of environment
- Investigate future impact and sustainability
- Conduct economic planning through scenario analysis
- Consider potential climate change impacts
- Target spending for a green economic recovery
- Create indicators to track success management / highlight areas for improvement
- Improve data management and flow across departments and sectors creating efficiencies
- *Many other specific uses are possible

Future work should aim to link the ecosystem accounts to relevant policy aims and initiatives. The next phase of the current project will begin to explore this by working with the local government departments to establish priority areas for further development.

4. Conclusion

The 2020 ecosystem accounts represent progress towards establishing an evidence base on the value that the environment provides. However, it should not be considered a one-off assessment, but rather a part of an ongoing process of data collection, methodological improvement and policy and planning implementation that should occur annually. As the SEEA-EA becomes more widely adopted, ecosystem accounts will increasingly inform government policy and planning internationally. The OTs are at the forefront of this process with the current set of accounts but will need to commit to their ongoing development and uptake to maintain this position as the practice evolves.

Specifically, future effort to further develop ecosystem accounting can focus on:

- **Stakeholder engagement** – presenting the approach and results to a wide range of stakeholders to build awareness and support.
- **Capacity building** – support for the continued development of the technical skills required to compile and update Ecosystem Accounts.
- **National Statistics Offices** – working with government statisticians to embed the SEEA-EA in National Accounts.
- **Policy and planning implementation** – develop and promote the use of Ecosystem Accounts to support policy and planning aims and objectives.
- **Draw on regional ecosystem accounting practitioners** – share knowledge and experiences across the OTs, including data, methodologies and applications of Ecosystem Accounts.
- **Link with regional and international organisations and initiatives** – make connections with Caribbean regional and international organisations with an environmental, national statistics, or ecosystem accounting focus.
- **Continued alignment with evolving SEEA guidance** – update the accounts alongside the recommendations of SEEA on methodological development and emerging good practice.

References

Alongi, D. M. (2014) Carbon sequestration in mangrove forests. Carbon Management, 3 (3), p.313-322. Available at: https://www.researchgate.net/publication/274116107_Carbon_sequestration_in_mangrove_forests

Department for Business, Energy & Industrial Strategy (BEIS). (2019). Green Book supplementary guidance: valuation of energy use and greenhouse gas emission for appraisal, Table 3. Available at: https://www.gov.uk/government/publications/valuation-of-energy-use-and-greenhouse-gas-emissions-for-appraisal

Department of Environment. (2020). Input Data for the Calculation of Greenhouse Gas Emissions to Air: Cayman Islands 2019 Inventory. Prepared for AETHER.

Economics and Statistics Office. (2020a). The Cayman Islands' Compendium of Statistics 2019. [online]. Available at: https://www.eso.ky/2019compendiumofstatistics.html#2

Economics and Statistics Office. (2020b). The Cayman Islands' System of National Accounts Report 2019. [online]. Available at: https://www.eso.ky/annualnationalaccountsreport.html

European Environment Agency (EEA) (2018) Common International Classification of Ecosystem Services (CICES) - Version 5.1. Available at: https://cices.eu/resources/

Guzman, A., Schep, S., van Zanten B., van Beukering, P., Nieto, E., Hoogeveen, R., Stangl, A., Schutter, M., Ebanks-Petrie, G. and Austin, T. (2017). The Economics of Enhancing the Marine Protected Areas of the Cayman Islands, December 2017. Commissioned by the Department of Environment of the Cayman Island Government. [online]. Available at: https://www.wolfscompany.com/project/the-economics-of-enhancing-the-marine-protected-areas-in-the-cayman-islands/

HM Treasury. (2021). GDP deflators at market prices, and money GDP, December 2020 (Quarterly National Accounts). [online]. Available at: https://www.gov.uk/government/collections/gdp-deflators-at-market-prices-and-money-gdp

HM Treasury. (2020). The Green Book: appraisal and evaluation in central government. [online]. Available from: https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent

HM Revenue & Customs. (2020). HMRC yearly average and spot rates - Average for the year to 31 December 2019. [online]. Available at: https://www.gov.uk/government/publications/exchange-rates-for-customs-and-vat-yearly

Intergovernmental Panel on Climate Change. (2018). Working Group III: Mitigation - Appendix IV: Units, Conversion Factors, and GDP Deflators. Available at: http://www.ipcc.ch/ipccreports/tar/wg3/index.php?idp=477

Keith, D., Ferrer, J., Nicholson, E., Bishop, M., Polidoro, B., Ramirez-Llodra, E., Tozer, M., Nel, J., Nally, R., Gregr, E., Watermeyer, K., Essl, F., Faber-Langendoen, D., Franklin, J., Lehmann, C., Etter, A., Roux, D., Stark, J., Rowland, J., Brummitt, N., Fernandez-Arcaya, U., Suthers, I., Wiser, S., Donohue, I., Jackson, L., Pennington, R., Pettorelli, N., Andrade, A., Kontula, T., Lindgaard, A., Tahvanainan, T., Terauds, A., Venter, O., Watson, J., Chadwick, M., Murray, N., Moat, J., Pliscoff, P., Zager, I. and Kingsford, R. (2020). The IUCN Global Ecosystem Typology v1.01: Descriptive profiles for Biomes and Ecosystem Functional Groups. Available at: https://seea.un.org/content/iucn-global-ecosystem-typology-v101-descriptive-profiles-biomes-and-ecosystem-functional

Murray, R., Pendleton, L., Jenkins, W.A. and Sifleet, S. (2011). Green Payments for Blue Carbon: Economic Incentives for Protecting Threatened Coastal Habitats. Nicholast Institute Report. [online]. Available at: https://nicholasinstitute.duke.edu/sites/default/files/publications/blue-carbon-report-paper.pdf ; as cited in IUCN (2017) Blue carbon issues. Available at: https://www.iucn.org/resources/issues-briefs/blue-carbon

ONS. (2020). Gross domestic product (average) per head, at current market prices: SA. UK Economics Accounts time series (UKEA). [online]. Available at: https://www.ons.gov.uk/economy/grossdomesticproductgdp/timeseries/ihxt/ukea

Schep, S., Johnson, A., van Beukering, P., and Wolfs E. (2012). The fishery value of coral reefs in Bonaire: applying various valuation techniques. Institute for Environmental Studies.

Schutter, M., Lacle, F., Botzen, W., van Beukering P. and Wolfs, E. (2014). The economics of expanding hte Marine Protected Areas of the Cayman Islands: The cultural and recreational value of the Marine Environment to the Cayman Islands' residents. IVM Institute for Environmental Studies. [online]. Available at: http://www.wolfscompany.com/wp-content/uploads/2016/02/R14-35-Recreational-and-cultural-value-of-marine-environment-Cayman-Islands-final-report.pdf

U.S. Bureau of Economic Analysis (BEA). (2021). [online]. Available at: https://fred.stlouisfed.org/series/GDPDEF

United Nations. (2021). System of Environmental-Economic Accounting—Ecosystem Accounting: Final Draft. Available at: https://unstats.un.org/unsd/statcom/52nd-session/documents/BG-3f-SEEA-EA_Final_draft-E.pdf

Van Beukering, P., Brouwer, R., Schep, S., Wolfs, E., Brander, L., Ebanks-Petrie, G. and Austin, T. The impact of invasive species on tourism: The case of lionfish in the Cayman Islands. Wolfs Company, IVM Institute for Environmental Studies. [online]. Available at: https://www.wolfscompany.com/wp-content/uploads/2016/02/R14-32-Tourism-value-and-lionfish-final-report.pdf

Williams, I., and Ma, H. (2013). Estimating Catch Weight of Reef Fish Species Using Estimation and Intercept Data from the Hawaii Marine Recreational Fishing Survey. Pacific Islands Fish. Sci. Cent. Admin. Rep. H-13-04. Pacific Islands Fish. Sci. Cent., Natl. Mar. Fish. Serv., HI 96822-2396. NOAA, Honolulu. [online]. Available at: https://www.researchgate.net/publication/275273995_Estimating_Catch_Weight_of_Reef_Fish_Species_Using_Estimation_and_Intercept_Data_from_the_Hawaii_Marine_Recreational_Fishing_Survey

Appendix A - Methodology

This annex sets out the input data and methods used to develop the Cayman Islands 2020 Ecosystem Account (Cayman-Island-EA-2020-January2022.xls) and provides guidance on how to update each component of the account.

For each component, a description of the input data, its source and a workbook reference for where it is applied are provided, along with how often the data should be updated (definitions for frequency are described in Table A.1).

Table A.1: Definitions of frequency of input data updates

Frequency	Definition
Annually	The underlying source should be updated on an annual basis
As source is updated	The underlying source is expected to be updated in the future (i.e., sources that are not updated annually). The accounts should be updated when new data from the same source is available.
As new evidence becomes available	The underlying source is not expected to be updated; a new source would be required to update this input

The remainder of this section is structured as follows:

- Ecosystem Extent Account (Section A.1)
- Ecosystem Condition Account (Section A.2)
- Ecosystem Service Flow and Asset Accounts and Supplementary Information (Section A.3); and
- Input tabs (Section A.4).

A.1 Ecosystem Extent Account

The Ecosystem Extent Account records information on the area of terrestrial and marine ecosystems within the ecosystem accounting area, i.e., the Cayman Islands' terrestrial and marine boundary. Table A.2 sets out the data sources used to estimate the terrestrial and marine ecosystem extent, which have been applied by GIS specialists at JNCC using GIS modelling software QGIS. The Ecosystem Extent Account should be updated when the source GIS layers are updated. The Ecosystem Extent Account is within the tab: '**A1. Asset Register**' of the ecosystem accounting workbook.

Table A.2: Input data for the Ecosystem Extent Account

Description	Source	Frequency	Workbook reference
Terrestrial habitat map	Landcover 2013 (DoE, 2013).	As source is updated	A1. Asset register tab
Shelf benthic habitat map	Shelf Benthic classification 2008 (DoE, 2008)	As source is updated	A1. Asset register tab
Lagoon benthic habitat map	Lagoon Benthic classification 2008 (DoE, 2008)	As source is updated	A1. Asset register tab

A.2 Ecosystem Condition Account

The Ecosystem Condition Account records information on the quality of ecosystems within the ecosystem accounting area. Condition indicators can be associated with ecological communities and species, freshwater, land or soil elements of ecosystems. Table A.3 provides an overview of the data used within the Ecosystem Condition Account of the Cayman Islands. The Ecosystem Condition Account is set within the tab: '**A1. Asset Register**'.

Table A.3: Input data for the Ecosystem Condition Account

Description	Source	Frequency	Workbook reference
Ecological communities and species			
Area of dry forest above 20ft elevation	Derived from GC Dry Forest Above 20ft Elevation_WGS84UTM.shp	As source is updated	A1. Asset register tab
Area of protected land	Combination of sources listed in workbook	As source is updated	A1. Asset register tab
Area of proposed protected land	Combination of sources listed in workbook	As source is updated	A1. Asset register tab
Area of Marine Protected Areas (MPAs)	Combination of sources listed in workbook	As source is updated	A1. Asset register tab
Total carbon stock (in and outside MPAs)	Guzman et al. (2017)	As new evidence becomes available	A1. Asset register tab
Area of species habitats by type	Combination of sources listed in workbook	As source is updated	A1. Asset register tab
Species points	Combination of sources listed in workbook	As source is updated	A1. Asset register tab
Land			
Land area owned by The Crown	Combination of sources listed in workbook	As source is updated	A1. Asset register tab
Land area owned by the National Trust	Combination of sources listed in workbook	As source is updated	A1. Asset register tab

A.1.1 Other indicators

Beyond extent and condition of ecosystems, other details on environmental assets have been included in the Cayman Islands 2020 account. These reflect details of spatial configuration which could reflect sinkholes and caves, as well as other forms of capital such as renewable energy generation sites, areas of accessible greenspace as well as public moorings. Table A.4 provides an overview of the data sources used to generate these other indicators for the Cayman Islands, which are set within the tab: **'A1. Asset Register'**.

Table A.4: Input data for other indicators

Description	Source	Frequency	Workbook reference
Spatial configuration			
Number of caves		As source is updated	A1. Asset register tab
Area of sinkholes		As source is updated	A1. Asset register tab
Other forms of capital			
Number of public moorings (inside and outside MPAs)		As source is updated	A1. Asset register tab

A.3 Ecosystem Service Flow and Asset Accounts

This section covers the ten benefits included in the 2020 Ecosystem Account. For quantified and monetised benefits, it outlines the methods used to value each benefit and the input data that needs to be updated for future accounts. For unquantified or non-monetised benefits, a summary of the existing data, sources and next steps are outlined.

A scope and materiality[5] assessment was conducted to show which benefits are likely to be provided by these ecosystems, and which have been possible to include in this account and which not. The scope and materiality assessment should be updated as new benefit are added or when new ecosystems are included in the Ecosystem Account. This assessment is set within the tab: **'Scope & materiality assessment.'**

Within the accompanying Excel workbook (Cayman-Island-NCA-2020-January2022.xls), each benefit has a separate calculation tab, with all estimates of annual flows summarised within the Ecosystem Service Flow Account – Physical Terms (tab **'A2. Physical terms'**) and the Ecosystem Service Flow Account – Monetary Terms (tab **'A3. Monetary terms'**). The monetary account tab also presents an estimate of the monetary ecosystem asset value[6] (Ecosystem Asset Account) expressed as a present value of the estimated flow of benefits over the accounting period (25 years).

This section starts with an overview of the physical flow and monetary valuation metrics and the profiling assumptions applied for each benefit.

A.1.2 Overview

An overview of the physical flow and monetary valuation metrics and methods are provided in Table A.5. The benefits are split into the following sections:

- **Ecosystem Service Flow Account and Asset Accounts –**approach to monetary valuation aligns with the System of Environmental Economic Accounting- Ecosystem Accounting (SEEA-EA) standard which applies exchange values[7] to be comparable to other national accounts (e.g., as applied in the System of National Accounts (SNA)).

  Monetary values based on data from previous years have been inflated to 2020 prices (Economics and Statistics Office, 2021; U.S. BEA, 2021; HM Treasury, 2022). The monetary values of benefits are calculated per year and summed and discounted over time to estimate present value of benefits using a declining discount rate (starting at 3.5%) (HM Treasury, 2020) and a 25-year study period. **Table A.6** describes the assumptions used to estimate the future flows of benefits over this assessment period. These assumptions should be revisited as new evidence becomes available.

- **Supplementary information** – The SEEA-EA guidance recognises that exchange values do not capture all information useful for decision makers. This section includes additional information outside the scope of the Ecosystem Account, under the following categories:
  - **Other exchange values –** Additional monetary benefits based on exchange values but are outside the scope of the Ecosystem account, e.g., remaining visitor expenditure attributed to

[5] An impact or dependency on natural capital is material if considering it, as part of the set of information used for decision making, has the potential to alter that decision.

[6] One of the five core accounts in SEEA EA, this account records information on stocks and changes in stocks (additions and reductions) of ecosystem assets, as well as accounting for ecosystem degradation and enhancement (UN, 2021).

[7] Exchange values are equivalent to the price as set by a market (i.e., the price at which supply equals demand) or the price at which an exchange would occur in a hypothetical market. Notably this differs from welfare values which include the surplus value created in addition to the exchange value (i.e., the consumer surplus).

ecosystems. This includes economic values which is dependent on ecosystems, but which might not be entirely attributable to ecosystems within the SEEA-EA framework. For example, expenditure on some activities may not be feasible without the support of ecosystem assets, but only a subset of this expenditure would be attributable to ecosystems within SEEA-EA, as labour and other capitals might also contribute to the production of the good or service

- **Welfare values –** Monetary benefits that are based on welfare value metrics such as willingness to pay values. Note that this value includes the consumer surplus that is additional to the exchange value as adopted in the SEEA-EA framework, which also makes it an extension of the value reported with the SNA.
- **Non-monetised benefit –** There are two types of non-monetised benefits. Firstly, where data for quantifying the physical flow is available and is useful to monitor over time, but there is currently insufficient data nor an appropriate methodological approach to conduct monetary valuation. Secondly, where material benefits exist that are not feasible or not desirable to monetise (e.g., biodiversity, spiritual value, iconic species).

Table A.5: Overview of benefits

Benefit	Physical indicator	Monetary valuation metric and method
Ecosystem Service Flow and Asset Accounts		
Fisheries	Volume of output	Market prices
Agriculture	Volume of output	Value added by production
Carbon sequestration	Tonnes of CO_2e sequestered	Non-traded central carbon value BEIS (2019), £/tCO_2e
Coastal protection	-	Coastal protection value by coral reefs
Local recreation	Recreational visits	Recreational expenditure
Tourism	Tourist visits	Tourist expenditure (value added to tourism industry attributed to ecosystems)
Amenity value	Number of houses	Property uplift value attributed to mangroves
Supplementary information		
Other exchange values		
Tourism	Tourist visits	Remaining visitor expenditure attributed to ecosystems
Welfare values		
Tourism	Tourist visits	Willingness to pay to prevent decline in quality of coral reefs
Non-monetised benefits		
Water supply	-	-
Renewable energy	-	-
Beach erosion	-	-
Local recreation	Number of diving spots	-

Table A.6: Benefit profile assumptions over time

Benefit	Physical terms	Monetary terms
Ecosystem Service Flow and Asset Accounts		
Fisheries	No change in volume of fish caught compared to the baseline year.	Assumed constant economic value of benefit over time.
Agriculture	Average number of goats, cattle, pigs and poultry (2015-2020).	Average detailed value added by livestock production (2015-2019)[1].
	-	Average detailed value added by arable production (2015-2019).

Benefit	Physical terms	Monetary terms
Carbon sequestration	No change in sequestration rates over time.	Value of carbon emissions increase over time in line with BEIS (2019).
Coastal protection	-	Assumed constant economic value of benefit over time.
Tourism	Average number of tourists (2016-2020).	Average expenditure per person per night (2016-2020).
Amenity value	No change in number of houses compared to the baseline year.	Assumed constant economic value of benefit over time.
Supplementary information		
Other exchange values		
Tourism	Average number of tourists (2016-2020).	Assumed constant economic value of benefit over time.
Welfare values		
Tourism	Average number of tourists (2016-2020).	Assumed constant economic value of benefit over time.
Non-monetised benefits		
Water supply	-	-
Renewable energy	-	-
Beach erosion	-	-
Local recreation	-	-

Table notes:
[1] Updated figure not available. Will be available as part of SNA update.

A.1.3 Fisheries

The marine ecosystems surrounding the Cayman Islands provide habitat for a variety of species of fish and other sea life. This in turn supports commercial, subsistence and recreational fishing activities across the Cayman Islands. It should be noted that within the context of the Cayman Islands commercial fishing is small-scale[8]. The inclusion of fisheries in the accounts helps to track the annual value that marine natural capital contributes through this benefit.

Method overview

Guzman et al. (2017) produce estimates of the economic value of reef fish, as this is attributed to local marine ecosystems. Catch of pelagic species was beyond the scope of the study, as these species "rely on foreign ecosystems for most of their lives" (p.18). The study estimates that in 2016, the number of reef fish caught was 390,000. To produce an estimate of weight (lbs), this is multiplied by the assumed average weight of reef fish of 1.8 lbs/fish (Williams and Ma, 2013) to generate an estimated annual volume of reef fish landings. Recent records of fish landings are not available for the Cayman Islands, therefore the 2016 estimated in Guzman et al. (2017) is assumed to be representative of current and future years.

The study estimates the value of artisanal fishing for recreation, subsistence and small-scale commercial purposes using a net factor income approach[9]. As such, the value of reef fish is treated as a production factor, and Guzman et al. (2017) also include labor costs in the total value as they are a benefit to the Cayman Islands economy.

[8] This is based on evidence from Meier et al. (2011) and Henshall (2009) cited in the Guzman et al., 2017).

[9] Market-based valuation method that estimates the net benefit of fishing by taking into account costs of other production factors and revenue generated.

Following the approach set out in Guzman et al. (2017), total annual revenue from the relevant fishing activities is estimated by multiplying the estimated volume of reef fish caught by the average price, CI$7.5/lbs. Resulting in an estimate of total annual revenue of recreation, subsistence and small-scale commercial fishing equal to CI$5.3 million, in 2020 prices. Total annual costs are estimated as 44%[10] of total revenue which is CI$2.3 million. The annual net benefit is estimated as the difference between total revenue and total cost, just below CI$3 million in 2020 prices. After 2020, it is assumed that revenues and costs remain constant therefore the 2020 value is representative of future years. Note that this is an estimate for the Cayman Islands and has not been disaggregated to the three Islands.

How to update the account

The benefits are estimated in the tab: **'S1. Fisheries'**. Table A.7 provides an overview of the input data for the benefit, including the frequency data should be updated and the workbook reference in the account.

Table A.7: Input data for the fisheries benefits

Description	Source	Frequency	Workbook reference
Physical terms			
Estimated number of reef fish caught in the Cayman Islands	Guzman et al. (2017)	As new evidence becomes available	1.1a
Average weight of reef fish, lbs/fish	Williams and Ma (2013)	As new evidence becomes available	1.1b
Monetary terms			
Average price of reef fish species in the Cayman Islands, US$/lbs	Guzman et al. (2017)	As new evidence becomes available	1.2a
Estimated total annual value of recreational, subsistence and small-scale commercial fishing on coral reefs	Guzman et al. (2017)	As new evidence becomes available	1.2b
US GDP deflator	US BEA (2021)	Annually	1.2c
Exchange rate: US$ to CI$	Economics and Statistics Office (2021)	As source is updated	1.2d
Fishing costs as proportion of total annual revenue	Schep et al. (2012) in Guzman et al. (2017)	As new evidence becomes available	1.2e

The method applied in the 2020 account can be refined using up to date data on the quantity of landings across the three Islands, as an understanding of the breakdown of catch by purpose (i.e., recreational vs commercial vs subsistence). This would help identify beneficiaries more clearly within the account. In addition to the catch, updated evidence on average price as well as costs would allow for monitoring of changes in the fishing industry in the Cayman Islands. Finally, accurate data and approaches to estimation of the contribution of other factors of production (e.g., physical capital and labour) to the overall economic value would allow for a more refined estimation of the contribution that is directly attributable to ecosystems.

[10] Based on evidence in Schep et al. (2012) looking at artisanal fishing in Caribbean coral reef ecosystems.

A.1.4 Agriculture

Agricultural activities in the Cayman Islands include livestock (goats, pigs, cattle and poultry) and non-livestock production. A break down of non-livestock production is not reflected in the 2020 account, as this data was not available.

Method overview

For each livestock type, the Department of Agriculture records total count for various age groups (e.g., kids <2months, calf 6-12 months). The number of goats, pigs, cattle and poultry are included in the Statistics Compendium (Economics and Statistics Office, 2021). For each livestock type, annual production is set equal to the 2020 figures in these evidence bases. Future production levels for goats, pigs, cattle and poultry are estimated as a five-year average (2015-2020). Note that poultry production is an estimate for the Cayman Islands and has not been disaggregated to the three Islands, whilst remaining livestock production can be disaggregated to Grand Cayman and Cayman Brac.

Farm gate prices for agricultural outputs were not readily available to be included in the 2020 account. As an alternative measure, the detailed value added for 'growing of agricultural crops' and 'farming of animals' in the Cayman Islands latest National Accounts (Economics and Statistics Office, 2020) has been used. For each category, the accounting year is set equal to the 2019 detailed value inflated to 2020 prices, with the future monetary value estimated as a five-year average (2015-2020) (Economics and Statistics Office, 2020). Once the detailed value for 2020 is available it can be added to the Ecosystem Account.

How to update the account

The benefits are estimated in the tab: **'S2. Agriculture'**. Table A.8 provides an overview of the input data for the benefit, including the frequency data should be updated and the workbook reference in the account.

Table A.8: Input data for agricultural benefits

Description	Source	Frequency	Workbook reference
Physical terms			
Grand Cayman total number of goats	Economics and Statistics Office (2021)	As source is updated	2.1a
Grand Cayman total number of pigs	Economics and Statistics Office (2021)	As source is updated	2.1b
Grand Cayman total number of cattle	Economics and Statistics Office (2021)	As source is updated	2.1c
Cayman Brac total number of goats	Economics and Statistics Office (2021)	As source is updated	2.1e
Cayman Brac total number of pigs	Economics and Statistics Office (2021)	As source is updated	2.1f
Cayman Brac total number of cattle	Economics and Statistics Office (2021)	As source is updated	2.1g
Sister Islands total poultry	Department of Environment (2020)	Source has been superseded by updated source	2.1h
Cayman Islands total poultry production	Economics and Statistics Office (2021)	As source is updated	2.1i
Monetary terms			
Detailed value added by industry - Agriculture	Economics and Statistics Office (2020)	As source is updated	2.2a

The Cayman Islands GHG inventory (Department of Environment, 2020) does indicate that there is non-livestock farming. Production (e.g., tonnes of crops) and the value (e.g., farmgate price) should be included in the next iteration of the account. The monetary value of non-livestock or arable production is currently captured within the detailed value added of the industry for growing of agricultural crops (Economics and Statistics Office, 2020). A better understanding of data collected through agricultural surveys that feed into the Cayman Islands annual national accounts is necessary.

Future iterations of the account could estimate the contribution of other factors of production (e.g., physical capital and labour) to the overall economic value to allow for a more refined estimation of the contribution that is directly attributable to ecosystems.

A.1.5 Water supply

Based on Cayman Islands 2010 census, the main source of water supply to households in the Cayman Islands (approx. 88%) is from mains (city water or desalinated water), this is followed by cistern, rain or trucks (7%) and wells (5%) (Economics and Statistics Office, 2021). Production of potable water is from desalination and groundwater abstractions, with non-potable water being distributed through trucks and pipelines. It is therefore dependent on natural capital stocks.

Method overview

Water Authority Cayman and Cayman Water Company have provided statistics on production in Grand Cayman, supply in Cayman Brac as well as desalinated water consumption by consumer group over time (Economics and Statistics Office, 2021). A monetary value has not been identified, which is a data gap in the 2020 account.

How to update the account

The benefits are estimated in the tab: **'S3. Water supply'**. Table A.9 provides an overview of the input data for the benefit, including the frequency data should be updated and the workbook reference in the account.

Table A.9: Input data for water supply

Description	Source	Frequency	Workbook reference
Physical terms			
Water production in Grand Cayman, 2015-2020	Economics and Statistics Office (2021)	As source is updated	3.1a
Water supply in Cayman Brac, 2015-2020	Economics and Statistics Office (2021)	As source is updated	3.1b
Desalinated water consumption by consumer group, 2015-2020	Economics and Statistics Office (2021)	As source is updated	3.1d
Main source of water supply	Economics and Statistics Office (2021)	As source is updated	3.1e

The 2020 account does not provide a quantified estimate for water supply. Further research is required to determine available data on the Cayman Islands to develop an appropriate valuation approach. For example, on the difference in costs associated with desalination and purification of groundwater could be as an estimate of the value of water supply dependent on the water filtration provision of the ecosystem service.

A.1.6 Renewable energy

With increasing pressure to move towards a low carbon society, renewable energy is an ever-growing sector. On the Cayman Islands, the Caribbean Utilities Company ltd launched the Consumer Owned Renewable Energy (CORE) programme in 2009 (Department of Environment, 2020). The programme allows consumers in Grand Cayman to connect private solar systems or wind turbines to the national grid system. In doing so, consumers generate their own electricity whilst also reducing their own energy bills.

Method overview

The CUC CORE programme is divided into two sub-groups: Feed-in-Tariffs (FIT) structure and the distributed energy resources (DER) programme. The number of customers and kilowatt rated capacity is reported in the Cayman Islands Greenhouse Gas Inventory data (Department of Environment, 2020). The GHG inventory data does include the CUC's CORE Programme tier rate systems as CI$/kW for residential and commercial instalments.

The Cayman Islands GHG inventory (Department of Environment, 2020) does also provide a count of the number of approved applications and number of planning permit applications for the instalment of solar panels or solar farms. Further disaggregation of this data would be useful to include in the account, in order to establish how many approved applications for solar farms there are across the Cayman Islands. Solar panels on buildings would not be included in the Ecosystem Account.

How to update the account

The benefits are estimated in the tab: **'S4. Renewable energy'**. Table A.10 provides an overview of the input data for the benefit, including the frequency data should be updated and the workbook reference in the account.

Table A.10: Input data for renewable energy

Description	Source	Frequency	Workbook reference
Physical terms			
Summary of CUC CORE FIT programme	Department of Environment (2020)	As source is updated	4.1a
Summary of CUC DER programme	Department of Environment (2020)	As source is updated	4.1b
Solar panel or solar farms applications	Department of Environment (2020)	As source is updated	4.1c
Monetary terms			
CUC's Core programme rate tier	Department of Environment (2020)	As source is updated	4.2a

The data presented within the 2020 account provides a starting point for the next iteration of the account, where energy generated from these renewable energy sources can be valued using the CUC's core programme rate tier system. This would require additional data on distinguishing residential and commercial generation, as well as the correct application of the tier system rates.

A.1.7 Carbon sequestration

Carbon sequestration refers to the ability of the natural environment (both terrestrial and marine) to remove carbon from the atmosphere. This benefit contributes towards global climate regulation. It is estimated using the sequestration rates for each habitat (tonnes CO_2 equivalent per hectare), the extent of each habitat, and the non-traded price of carbon.

Method overview

Guzman et al. (2017) estimated carbon sequestration (Megagram carbon per year) potential in seagrass and mangroves in the Cayman Islands as part of the economic analysis for the expansion of marine protected areas (MPAs). These estimates have been converted to tonnes of carbon dioxide equivalent using a tC[11] to tCO_2e conversion factor of 3.67 (IPCC, 2018). These estimates of coastal ecosystem carbon sequestration are used in the 2020 account. For mangroves, an average rate of approximately 10.2 tCO2 per hectare has been used in Guzman et al. (2017), which is slightly higher than the estimated midpoint rate applied in the other Caribbean overseas territories (6.3 tCO2e/ha/yr) as shown in Table A.11.

Table A.11 shows the global average per hectare carbon sequestration rates for terrestrial and marine habitats. Two main sources are used as the basis of the carbon sequestration rate estimates – Murray et al. (2011); as cited in IUCN (2017) and Alongi (2014). The midpoint sequestration rates between the two sources are used in the analysis.

Table A.11: Carbon sequestration rates by habitat type (tCO_2e/ha/yr)

Habitat	Murray et al. (2011); IUCN (2017)	Alongi (2014)[1]	Midpoint
Terrestrial			
Mature tropical forest	2.3	-	2.3
Marine			
Seagrass	4.4	2.0	3.2
Saltmarsh	8.0	5.5	6.8
Mangroves	6.3	6.4	6.3
Estuaries	-	1.7	1.7
Shelves	-	0.6	0.6

Table notes:

[1] The values reported were converted from gC/m^2/yr to tCO_2e/ha/yr using the IPCC (2018) tC to tCO2e conversion factor of 3.67, gram to tonne and m2 to ha conversion factors.

The total amount of CO_2 equivalent sequestered is estimated by multiplying these per hectare rates with the total hectare area of the respective habitat type, as recorded in the Ecosystem Extent Account. For the Cayman Islands, the tCO_2e sequestered by forest ecosystems is considered additional to the figures produced by Guzman et al. (2017). Table A.12 summarises the assumed carbon sequestration rate for each ecosystem type.

Table A.12: Assumed carbon sequestration rate for each ecosystem type

Ecosystems in the Ecosystem Extent Account	Applied sequestration rate
Seagrass beds	Seagrass
Seasonally flooded mangrove shrubland	Mangroves
Seasonally flooded mangrove forest and woodland	Mangroves

[11] 1 MgC = 1 tC

Tidally flooded mangrove forest and woodland	Mangroves
Tidally flooded mangrove and shrubland	Mangroves
Ponds, pools and mangrove lagoons	Mangroves
Seasonally flooded/saturated semi-deciduous forest	Forest
Xeromorphic semi-deciduous forest	Forest
Dry forest and woodland	Forest
Invasive species – casuarina	Forest
Coastal mahogany forest	Forest

The amount of CO_2e sequestered by coastal and forest ecosystems is then valued following the BEIS (2019) guidance. The economic value of carbon sequestration is estimated using the non-traded central price, £75 per tonne of CO_2e in 2020. The UK carbon prices were multiplied by the relative GDP per capita in the Cayman Islands as compared to the UK (Economics and Statistics Office, 2021; ONS, 2021) and then converted to Cayman Island dollars (HMRC, 2021). The carbon price is then multiplied by the estimated tonnes of CO_2e sequestered by coastal and forest ecosystems.

How to update the account

The benefits are estimated in the tab: **'S5. Carbon sequestration'**. Table A.13 provides an overview of the input data for the benefit, including the frequency data should be updated and the workbook reference in the account.

Table A.13: Input data for carbon sequestration benefits

Description	Source	Frequency	Workbook reference
Physical terms			
Ecosystem extent	Asset register tab (A1)	As new evidence becomes available	5.1a
Carbon sequestration potential in coastal ecosystems in the Cayman Islands	Guzman et al. (2017)	As new evidence becomes available	5.1b
Terrestrial and marine carbon sequestration rates	Murray et al. (2011), as cited in IUCN (2017); Alongi (2014)	As new evidence becomes available	5.1d, 5.1e
Monetary terms			
Cayman Islands GDP per capita at current basic prices	Economics and Statistics Office (2021)	As source is updated	5.2c
UK GDP per capita at current market prices	ONS (2021)	Annually	5.2d
UK Carbon prices	BEIS (2019)	As source is updated	5.2e; UK Carbon prices full tab
GBP to CI$ exchange rate	HMRC (2020)	Annually	5.2i;
UK GDP deflator	HM Treasury (2021)	Annually	UK GDP deflators tab

Data inputs for the physical flow can be updated as science and understanding of carbon sequestration rates of ecosystems improves. The 2020 Ecosystem Account for the Cayman Islands applies UK carbon values as per BEIS (2018). The UK carbon values were updated in September 2021 to reflect the UK's net zero policy commitment. Future iterations of the account could be aligned to the updated UK values and/or to voluntary carbon market exchange values. The values used should reflect Cayman Islands climate policy, abatement technologies and other context from the accounting year.

A.1.8 Coastal protection

The natural capital of the Cayman Islands marine coastal habitats provides protection to the Cayman Islands from damage and flooding due to sea surge from storms and other adverse weather events. Reefs, sand bars, mangrove stands, dunes and even seagrass beds all help to absorb energy and mitigate the impact of waves and rising waters. This can have the significant effect of defending vulnerable built infrastructure on the Cayman Islands.

Method overview

Guzman et al. (2017) estimated the coastal protection value of coral reefs in the marine protected areas of the Cayman Islands using an avoided damage approach. GIS is used to determine the flood damages that occur during a 1-in-25-year return time storm event[12], as well as modelling the proportion[13] of these damages that are prevented by nearby coral reefs. Coastal protection value can be assessed both through direct effects (e.g., property damage) and indirect effects (e.g., infrastructure damage, business interruption). The indirect avoided damages are not included in this analysis.

Based on the values estimated by Guzman et al. (2017), the total annual coastal protection value by coral reefs in the Cayman Islands of approximately CI$6.6 million, in 2020 prices. This was attributed across the Cayman Islands based on proportions in Guzman et al. (2017)[14]. As the estimates only reflect the direct avoided damages to properties it is a "lower-bound estimate of the actual economic value of this service" (Guzman et al., 2017, p,24).

How to update the account

The benefits are estimated in the tab: **'S6. Coastal protection'**. Table A.14 provides an overview of the input data for the benefit, including the frequency data should be updated and the workbook reference in the account.

Table A.14: Input data for coastal protection benefits

Description	Source	Frequency	Workbook reference
Monetary terms			
Estimated annual coastal protection value by coral reefs in the Cayman Islands	Guzman et al. (2017)	As new evidence becomes available	6.2a
Estimated attribution of coastal protection value to coral reefs by island	Guzman et al. (2017)	As new evidence becomes available	6.2b
US GDP deflator	US BEA (2021)	Annually	6.2c
Exchange rate: US$ to CI$	Economics and Statistics Office (2021)	Annually	6.2d
Relative reef contribution	Guzman et al. (2017)	As new evidence becomes available	6.2e

The approach requires GIS analysis and the specified data inputs with which to model the impact. The

[12] The characteristics of this event are based on data from Hurricane Ivan (Category 4) in 2004. This was provided by the Cayman Island DoE.

[13] This represents the relative reef contribution (RRC) that mitigates damage and is calculated for each coastal transect. See Burke et al. (2008) for more detail on this method.

[14] Should be noted that the estimated attribution proportions do not sum to 100%. This needs to be investigated further to refine the calculation.

modelling can be updated with the most up-to-date infrastructure and habitat maps as they are produced. Doing so on a regular basis will track changes in development and vegetative cover which can help monitor the change in the risk of damage from sea surge due to changing land use, as well as to identify high risk flooding areas for future development planning. Property value and damage cost estimates should also be updated as available.

A.1.9 Beach erosion prevention

Coastal vegetation, such as seagrass, coral reefs, mangroves and other shoreline habitats, prevents sand loss as a result of wave backwash both during storm events and high-water levels. Some beach movement is normal over time, however in the absence of the existing coastal habitats dunes. Coastal erosion poses a significant threat to beaches in the Cayman Islands, particularly the important tourist hotspot Seven Mile Beach, Grand Cayman.

The prevention of erosion contributes to benefits in marine ecosystems and maintaining the aesthetic quality of coastal habitats that attract tourists and recreational users. However, the tourism aspects of this service are captured in the assessment of the tourism benefit (see Section A.1.11). The focus here would be more specifically on the avoidance of beach erosion as a benefit to infrastructure protection.

How to update the account

The quantification and monetisation of avoided beach erosion attributed to coastal ecosystems across the Cayman Islands requires an understanding of the current rate of erosion. The Cayman Islands DoE have access to satellite imagery that could be used to generate an average rate of beach area loss. As well as the rate of erosion in the absence of ecosystems, such as reefs and mangroves, that provide protection to beach erosion (akin to modelling coastal protection or surface flooding).

Beach erosion risk depends on many factors, including sea level rise, wave energy, coastal slope, beach width and height among others. Understanding wave dynamics is key to identifying vulnerable areas and potential mitigation strategies. Evidence will be available in the future to align with ongoing work by Wood Group UK Limited generating storm surge risk estimates by using the same model to produce beach erosion risk outputs. The SWAN model is a third-generation wave model developed by Delft University of Technology that simulates wave parameters in coastal areas. SWAN accounts for many physical processes such as wave generation, propagation, dissipation, whitecapping, and bottom friction.

The proposed beach erosion modelling will use outputs from the SWAN model, such as wave height and wave force, to estimate beach erosion risk. A baseline model will be compared to different bottom roughness and depth scenarios to predict the impact of historical coral reefs and potential areas of coral restoration on beach erosion risk, with a focus on Seven Mile Beach.

Further research is required to identify an appropriate monetary unit value, as there is a risk of double-counting with other benefits such as tourism and local recreation which rely on the beach as an ecosystem to support use. As such, avoiding beach erosion can be viewed as an intermediary regulating service, which is ‘capitalised’ as a benefit to people in other benefits.

A.1.10 Local recreation

'Local recreation' is a relatively broad term and encompasses a wide variety of cultural activities that natural capital provides to local residents. This can include opportunities for physical interaction with the natural environment such as recreation. However, while evidence exists on tourist use of the environment, local recreational use of the environment is less well understood.

Method overview

The natural environmental is important for recreational use by residents on the Caymans Islands. Existing evidence on recreational activities undertaken by locals has been assessed as part of Schutter et al. (2014) which through a survey identified the types of activities undertaken by residents (born on the Cayman Islands and born elsewhere). In addition, there are approximately 378 diving spots across the Cayman Islands (Guzman et al., 2017) utilised by both residents and tourists[15], although the number of divers has not been identified. The total number of diving spots is reported as a non-monetised benefit.

How to update the account

The benefits are estimated in the tab: **'S9. Local recreation'**. Table A.15 provides an overview of the input data for the benefit, including the frequency data should be updated and the workbook reference in the account.

Table A.15: Input data for local recreation benefits

Description	Source	Frequency	Workbook reference
Physical terms			
Recreational activities undertaken by local residents	Schutter et al. (2014)	As new evidence becomes available	8.1a
Number of dives spots per area	Guzman et al. (2017)	As new evidence becomes available	8.1b

Further research into and the collection of more data, such as via surveys, on local recreation use (e.g., number of divers) and expenditure patterns is required to assess the value of this benefit across the Cayman Islands.

A.1.11 Tourism

Tourism is a major contributor to the economic prosperity of the Cayman Islands. Popular attractions include the pristine beaches across the Cayman Islands, sting rays, caving, and diving tours amongst other elements of the marine and coastal environment of the Cayman Islands. The tourism value of the Cayman Islands was one of the ecosystem services assessed as part of the Guzman et al. (2017) analysis. For the purposes of this study, the same general approach[16] has been applied, but using updated figures for visitor numbers and expenditure.

Method overview

The Caymans Islands Immigration Department and the Department of Tourism record visitor arrivals (stay-over and cruise ship) to the Cayman Islands, with annual figures by mode of travel (air or sea) reported in

[15] Diving activities by tourists is captured under the Tourism in tab S9 (see A.1.11).

[16] Note that Guzman et al. (2017) estimated consumer and producer surplus to generate a net benefit of tourism activities. In this study, consumer and producer surplus are kept separate, where consumer surplus is reported as supplementary information and the producer surplus is included in the ecosystem account.

the Cayman Islands' Compendium of Statistics (Economics and Statistics Office, 2021). Visitor arrivals are adjusted to exclude air arrivals visiting the Cayman Islands for business, this is done by multiplying the proportion of air arrivals visiting for business (7% in 2020) by the current year's recorded air arrivals, with the product subtracted from the 2020 total stay-over arrivals (Economics and Statistics Office, 2021). Cruise ship visitors are set equal to the latest total figures of number of landed visitors (Economics and Statistics Office, 2021). Landed cruise ship in 2020 is currently not available, therefore has been estimated using the ratio between actual cruise ship arrivals to landed visitors multiplied by the 2020 actual arrivals (Economics and Statistics Office, 2021). Note when this information is available it can be used to update the 2020 account. Future number of arrivals are estimated as a five-year average (2016-2020) for each visitor type (Economics and Statistics Office, 2021).

Guzman et al. (2017) further sub-divided visitors into divers and non-divers using the estimated proportion of stay-over tourists that are divers (13%) from 2016 data provided by the Cayman Islands Department of Tourism. This proportion is assumed to remain constant over time and visitor type and is therefore applied to the annual number of tourist arrivals (stay-over and cruise ship) and the five-year average.

The value of arrivals in the account is estimated using the reported average expenditure per visitor per night (i.e., no distinction between visitor types) (Economics and Statistics Office, 2021), multiplied by the estimated proportion of expenditure across 11 categories[17] for each visitor type (stay-over or cruise ship) and diver/non-diver (Guzman et al., 2017). For each visitor type and spend category, total annual tourism expenditure is estimated using average daily tourist spend, the assumed average length of stay[18] and the annual estimated number of visitors. Following the approach set out in Guzman et al. (2017), total annual tourism expenditure in each category for each visitor is multiplied by the assumed proportion (100% for donations and 25% for all other categories) of total spend that corresponds to added value of the tourism industry (Schep et al., 2012). The value added is then multiplied by an assumed factor of ecosystem dependence for each expenditure category (Guzman et al., 2017). This produces the total annual tourism added value attributed to marine ecosystems. For the future monetary flow, the five-year average (2016-2020) total tourism expenditure is estimated (Economics and Statistics Department, 2021), and the same approach is followed where the proportions applied remain constant and the five-year average length of stay of stay-over tourist is estimated (Economics and Statistics Office, 2021).

The remaining annual and five-year visitor expenditure by visitor type (i.e., remaining 75% of total expenditure) is adjusted for ecosystem dependence as well (Guzman et al., 2017). These values are reported as supplementary information to the Ecosystem Account.

The benefit of tourism activities can also be captured in welfare value terms. Guzman et al. (2017) estimate consumer surplus of local ecosystems in the Cayman Islands based on the willingness to pay (WTP) of tourists to prevent the decline in quality of coral reefs from medium to low levels. This uses a value transfer of average WTP per tourist per day of CI$30, in 2020 prices, derived through a choice experiment (Van Beukering et al., 2014). This was applied to the number of stay-over and cruise ship visitors in 2020. In future years, the average WTP to prevent reef quality decline remains constant with the value varying in line with future visitor assumptions (i.e., estimated four-year average). As the ecosystem accounting

[17] Expenditure categories identified by Guzman et al. (2017) include: airfare, accommodation, local transportation, diving, snorkelling, fishing, other water-based activities, land-based activities, food and beverage, shopping and donations.

[18] Stay-over visitors' average length of stay is reported as number of nights in the Cayman Islands' Compendium of Statistics (Economics and Statistics Office, 2020a), whilst cruise ship visitors are assumed to not stay beyond one day (Guzman et al., 2017).

framework prefers the use of exchange values, this welfare value is included as a supplementary indicator.

How to update the account

The benefits are estimated in the tab: **'S9. Tourism'**. Table A.16 provides an overview of the input data for the benefit, including the frequency data should be updated and the workbook reference in the account.

Table A.16: Input data for tourism benefits

Description	Source	Frequency	Workbook reference
Physical terms			
Visitor arrivals in the Cayman Islands	Economics and Statistics Office (2021)	Annually	9.1a
Cruise ship visitor arrivals	Economics and Statistics Office (2021)	Annually	9.1b
Visitor air arrivals by purpose of visit	Economics and Statistics Office (2021)	Annually	9.1c
Visitor air arrivals by accommodation type	Economics and Statistics Office (2021)	Annually	9.1d
Tourist accommodation	Economics and Statistics Office (2021)	Annually	9.1e
% of stay-over tourists that are divers	Guzman et al. (2017)	As new evidence becomes available	9.1f
Monetary terms			
Stay over visitor expenditure	Economics and Statistics Office (2021)	Annually	9.2a
Cruise ship visitor expenditure	Economics and Statistics Office (2021)	Annually	9.2b
Average willingness-to-pay per tourist per day to prevent decline in quality of coral reefs from medium to low levels	Van Beukering et al. (2014)	As new evidence becomes available	9.2c
Proportion of expenditure on each category	Guzman et al. (2017)	As new evidence becomes available	9.2d
Factors of ecosystem dependence by expenditure category	Guzman et al. (2017)	As new evidence becomes available	9.2e
Net ecosystem benefits in the tourism industry	Guzman et al. (2017)	As new evidence becomes available	9.2f
Total annual value of local ecosystems for tourism in the Cayman Islands	Guzman et al. (2017)	As new evidence becomes available	9.2g
US GDP deflators	US BEA (2021)	Annually	9.2h
Exchange rate: US$ to CI$	Economics and Statistics Office (2021)	Annually	9.2i
Average length of stay of cruise ship visitors (days)	Guzman et al. (2017)	As new evidence becomes available	9.2j
% of total spend that corresponds to added value of tourism industry	Guzman et al. (2017)	As new evidence becomes available	9.2k

Tourism data should be updated annually in regard to tourist numbers for each type of visit, while average expenditure data should be updated when relevant survey data is published in order to capture trends, and no more than every five years to capture changing patterns of use and perceived value. Other data inputs should be updated as new evidence becomes available (e.g., dependence factors).

A.1.12 Amenity value

Accessibility and proximity to green and blue space can be capitalised into real estate prices (see Nafilyan and Lorenzi (2019) for UK example). In the context of the Cayman Islands this could refer to the value that ecosystems such as coral reefs and mangroves potentially add to real estate prices.

Method overview

Guzman et al. (2017) undertook a hedonic pricing analysis to assess the effect that proximity to coral reefs and mangroves, in comparison to other attributes of residential properties, has on real estate prices. This was only applied to houses on Grand Cayman, as usable observations from the CIREBA database were only available for Grand Cayman. The study[19] found that marine ecosystems contribute to higher property values and provides a framework for extrapolating the mean amenity value per house in the study sample to the total number of residential buildings in Grand Cayman.

Average amenity value per house is estimated by dividing the modelled amenity value of mangroves (US$26 million, in 2016 prices) by the number of usable observations in the CIREBA dataset (686). The unit amenity value is inflated to 2020 prices and converted to Cayman Island dollars, as it is assumed that property prices in 2016 (and therefore the monetary unit value) are representative of the current year. As an approximation of the overall value, the average amenity value per house is extrapolated to Grand Cayman by multiplying by the total number of residential properties on the Island, approximately 26,200 on Grand Cayman in 2020 (Economics and Statistics Office, 2021). The estimated amenity value of mangroves represents a stock value and is therefore not recorded as an annual flow.

How to update the account

The benefits are estimated in the tab: **'S10. Amenity value'**. Table A.17 provides an overview of the input data for the benefit, including the frequency data should be updated and the workbook reference in the account.

Table A.17: Input data for amenity value

Description	Source	Frequency	Workbook reference
Physical terms			
Number of households on the Cayman Islands	Economics and Statistics Office (2021)	As source is updated	10.1a
Monetary terms			
Modelled amenity value of mangroves for houses in the dataset following the hedonic pricing function	Guzman et al. (2017)	As new evidence becomes available	10.2a
CIREBA dataset sample	Guzman et al. (2017)	As new evidence becomes available	10.2b
US GDP Deflator	US BEA (2021)	Annually	10.2c; US GDP deflators tab

[19] For more details on the hedonic pricing analysis used please see Guzman et al. (2017).

US$ to CI$ exchange rate	Economics and Statistics Office (2021)	As source is updated	10.2d

A.4 Input data tabs

There are several input tabs that are linked throughout the workbook as background information (e.g., ecosystem classification) and as inputs to calculations (e.g., CPI index, discount factors) across multiple benefits. Table A.18 provides an overview of these input tabs and the frequency that these data sources should be updated.

Table A.18: Input data tabs

Tab name	Description	Source	Frequency
Cayman Islands ecosystem classification	Ecosystem classification alignment between Cayman Islands extent layers and IUCN Global Ecosystem typology	Ecosystem Extent Account data (Table A.2); IUCN GET (v1.01)	As account is updated
UK Discount Factors	UK discount factors used throughout the workbook.	HM Treasury (2020)	As source is updated
Cayman Islands CPI	Cayman Islands annual CPI used throughout workbook	Economics and Statistics Office (2021)	Annually
US GDP deflators	US GDP deflators used throughout the workbook.	US BEA (2021)	Annually
UK GDP deflators	UK GDP deflators used throughout the workbook.	HM Treasury (2021)	As source is updated[1]
UK Carbon prices full	BEIS modelled carbon prices (£) used throughout the workbook.	BEIS (2019)	As source is updated[2]
Cayman Islands population statistics	Cayman Islands population statistics (people, households, average household size) used throughout the workbook.	Economics and Statistics Office (2021)	Annually

Table notes:

[1] The HM Treasury released updated UK GDP deflators every quarter as well as part of the Spring or Autumn budget.

[2] The UK carbon values were updated in September 2021 to reflect the UK's net zero policy commitment. Future iterations of the account could be aligned to the updated UK values and/or to voluntary carbon market exchange values. The values used should reflect Cayman Islands climate policy, abatement technologies and other context from the accounting year.

Appendix B - Changes in account values

Table B.1 and Table B.2 sets out the value estimated in the previous Cayman Islands Ecosystem Accounts and notes key reasons for the changes in values. All monetary values are presented in the reporting year price year, e.g., 2020/21 account values are reported in 2020. Sources GDP deflators in the Cayman Islands and the UK have been updated, which impacts the monetary value across all benefits.

Table B.1: Changes in Ecosystem Service Flow and Asset Account values

Produced at: January 2022	2019/20			2020/21			Notes on changes
	Ecosystem Service Flow Account		Ecosystem Asset Account (PV25 CI$m)	Ecosystem Service Flow Account		Ecosystem Asset Account (PV25 CI$m)	
	Physical terms	Monetary terms (CI$m)		Physical terms	Monetary terms (CI$m)		
Fisheries	702,000	3	50	702,000	3	51	Data inputs have remained the same, with monetary unit value inflated to current price year.
Agriculture	26,204	2	22	5,061	2	25	Monetary unit value inflated to current price year. **Input data change:** Poultry production (physical flow) reported for Cayman Islands within the latest Statistics Compendium (2021). However, similar figures are not available disaggregated.
	-	16	244	-	18	275	Data inputs have remained the same, with monetary unit value inflated to current price year.
Carbon sequestration	68,500	11	257	68,500	11	272	Data inputs have remained the same, with monetary unit value inflated to current price year.
	9,393	1	35	9,393	1	37	
Coastal hazard protection	-	6	111	-	7	112	Data inputs have remained the same, with monetary unit value inflated to current price year.
Tourism	2,119,533	71	1,089	598,263	21	943	Data inputs have remained the same, with monetary unit value inflated to current price

Produced at: January 2022	2019/20			2020/21			Notes on changes
	Ecosystem Service Flow Account		Ecosystem Asset Account (PV25 CI$m)	Ecosystem Service Flow Account		Ecosystem Asset Account (PV25 CI$m)	
	Physical terms	Monetary terms (CI$m)		Physical terms	Monetary terms (CI$m)		
							year. Note 2020 expenditure data is currently not available.
Amenity value	27,667	-	1,362	26,197	-	1,306	Data inputs have remained the same, with monetary unit value inflated to current price year.
	Total	**110**	**3,170**	**Total**	**62**	**3,020**	

Table B.2: Changes in Supplementary Information

Produced at: January 2022	2019/20			2020/21			Notes on changes
	Physical terms	Monetary terms (CI$m)	Ecosystem Asset Account (PV25 CI$m	Physical terms	Monetary terms (CI$m)	Ecosystem Asset Account (PV25 CI$m	
Other monetary values							
Tourism	2,119,533	206	3,140	598,263	59	2,706	Data inputs have remained the same, with monetary unit value inflated to current price year. Note 2020 expenditure data is currently not available.
Welfare values							
Tourism	2,119,533	134	127	598,263	35	1,873	Data inputs have remained the same, with monetary unit value inflated to current price year.
Non-monetised benefits							
Water supply	-	-	-	-	-	-	
Renewable energy	-	-	-	-	-	-	
Beach erosion	-	-	-	-	-	-	
Local recreation	378	-	-	378	-	-	Data inputs have remained the same.

Appendix C - Ecosystem service classification comparison

The Common International Classification of Ecosystem Services (CICES) was chosen as a reference point for ecosystem service typology to enable comparison of ecosystem services between accounts (EEA, 2018). CICES is a globally recognised classification of ecosystem services and referenced within the SEEA EA guidance (UN, 2021). The typology structure consists of four levels – section, division, group and class. See EEA (2018) for more guidance on using CICES.

Table C.1 compares the benefit typology used in this account with the CICES class.

Table C.1: Ecosystem services typology comparison

Shorthand	CICES Class
Fisheries	Animals reared by in-situ aquaculture for nutritional purposes
Agriculture	Animals reared for nutritional purposes; Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes
Water supply	Surface water for drinking
Renewable energy	Wind energy, Solar energy; Geothermal energy
Carbon sequestration	Regulation of temperature and humidity, including ventilation and transpiration
Coastal protection	Hydrological cycle and water flow regulation (Including flood control, and coastal protection)
Beach erosion protection	Control of erosion rates
Local recreation	Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions
Tourism	Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions
Amenity value	Characteristics of living systems that enable aesthetic experiences
Water quality	Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals

Appendix D - Ecosystem classification comparison

To allow the national accounts to be aggregated with other Overseas Territory accounts and compared between countries, the International Union for Conservation of Nature (IUCN) Global Ecosystem Typology (GET) Ecosystem Functional Groups (EFG) was cross-referenced with the terrestrial and marine ecosystem typology used within the Department of Environment (DoE). The IUCN GET is a global typological framework that applies an ecosystem process-based approach to ecosystem classification for all ecosystems around the world. The typology structure consists of six levels. The top three levels – realm, biome and ecosystem functional group - are aligned with the System of Environmental Economic Accounting (SEEA) Ecosystem Type reference (UN, 2021, s*ee Section 3.4 – Classifying ecosystem assets for more guidance*).

Table D.1 sets out the alignment between the habitat classifications completed by eftec and JNCC. Note that all lagoon benthic habitats have been classified as marine shelf biome habitats, as there are no intertidal equivalents, and while the lagoon will have a brackish influence, the areas neighbour the marine shelf.

Table D.1: Ecosystem classification comparison

Terrestrial/ benthic	Cayman Islands classifications	IUCN GET			Notes on alignment
		Realm	Biome	Ecosystem functional group	
Terrestrial	Xeromorphic semi-deciduous forest	Terrestrial	T1 Tropical–subtropical forests	T1.2 Tropical-subtropical dry forests and scrubs	
Terrestrial	Coastal shrubland	Marine-Terrestrial	MT2 Supralittoral coastal systems	MT2.1 Coastal shrublands and grasslands	
Terrestrial	Seasonally flooded mangrove shrubland	Terrestrial-Freshwater	TF1 Palustrine wetlands	TF1.1 Tropical flooded forests and peat forests	Deep peat is characteristic of these communities. They are not intertidal; however, despite being dominated by mangroves.
Terrestrial	Dry shrubland	Terrestrial	T3 Shrublands & shrubby woodlands	T3.1 Seasonally dry tropical shrublands	This is at 0.5-5m height.
Terrestrial	Dwarf vegetation and vines	Marine-Terrestrial	MT2 Supralittoral coastal systems	MT2.1 Coastal shrublands and grasslands	
Terrestrial	Seasonally flooded grasslands V.A.1.N.g	Terrestrial-Freshwater	TF1 Palustrine wetlands	TF1.4 Seasonal floodplain marshes	Not intertidal and not near coast.
Terrestrial	Semi-permanently flooded grasslands V.A.1.N.h	Terrestrial-Freshwater	TF1 Palustrine wetlands	TF1.3 Permanent marshes	Refers to standing water near urban areas (not coastal or intertidal)

Terrestrial/ benthic	Cayman Islands classifications	IUCN GET			Notes on alignment
		Realm	Biome	Ecosystem functional group	
Terrestrial	Ponds, pools, and mangrove lagoons	Terrestrial-Freshwater	TF1 Palustrine wetlands	TF1.1 Tropical flooded forests and peat forests	Note mangrove lagoons have highly organic (peat rich) sediments and probably store and sequester carbon. Area-wise they probably dominate this class, so perhaps we should lump them in TF1.1?
Terrestrial	Urban	Terrestrial	T7 Intensive land-use	T7.4 Urban and industrial ecosystems	
Terrestrial	Dry lakebed	Freshwater	F2 Lakes	F2.7 Permanent salt and soda lakes	This is rarely dry Only on Cayman Brac - looks to be (possibly seasonally) dry part of mangrove lagoon
Terrestrial	Shoreline	Marine-Terrestrial	MT1 Shorelines biome	n/a	Classified as Biome rather than Group as Cayman Islands classification relates to all shoreline.
Terrestrial	Man-modified	Terrestrial	T7 Intensive land-use	T7.2 Sown pastures and fields	
Terrestrial	Seasonally flooded mangrove forest and woodland	Marine-Freshwater-Terrestrial	MFT1 Brackish tidal	MFT1.2 Intertidal forests and shrublands	Not on the coast, buffered by tidally flooded mangroves. Classified these areas as "MFT1.2 Intertidal forests and shrublands" after confirming mangrove cover roughly matched Global Mangrove Watch.
Terrestrial	Man-modified with trees	Terrestrial	T7 Intensive land-use	T7.5 Derived semi-natural pastures and old fields	
Terrestrial	Tidally flooded mangrove forest and woodland	Marine-Freshwater-Terrestrial	MFT1 Brackish tidal	MFT1.2 Intertidal forests and shrublands	
Terrestrial	Dry forest and woodland	Terrestrial	T1 Tropical–subtropical forests	T1.2 Tropical-subtropical dry forests and scrubs	
Terrestrial	Seasonally flooded / saturated semi-deciduous forest	Terrestrial-Freshwater	TF1 Palustrine wetlands	TF1.2 Subtropical/temperate forested wetlands	Not intertidal, but directly next to mangroves not mangrove vegetation. This is under the 'Forest and Woodland' section of habitat classes.
Terrestrial	Invasive species - casuarina	Terrestrial	T1 Tropical–subtropical forests	T1.2 Tropical-subtropical dry forests and scrubs	In carbon terms it is a forest, even though invasive. Casuarina is an evergreen tree.
Terrestrial	Tidally flooded mangrove shrubland	Marine-Freshwater-Terrestrial	MFT1 Brackish tidal	MFT1.2 Intertidal forests and shrublands	
Terrestrial	Salt tolerant succulents	Marine-Terrestrial	MT2 Supralittoral coastal systems	MT2.1 Coastal shrublands and grasslands	Succulent forb veg, coastal/tidal areas, edges of wetlands/mangroves
Terrestrial	Sparsely vegetated rock	Terrestrial	T5 Deserts and semi-deserts	T5.3 Sclerophyll hot deserts and semi-deserts	
Terrestrial	Black candlewood	Terrestrial	T3 Shrublands & shrubby woodlands	T3.1 Seasonally dry tropical shrublands	This is a flowering evergreen, drought and salt tolerant

Terrestrial/ benthic	Cayman Islands classifications	IUCN GET			Notes on alignment
		Realm	Biome	Ecosystem functional group	
Terrestrial	Man-modified without trees	Terrestrial	T7 Intensive land-use	T7.2 Sown pastures and fields	
Terrestrial	Coastal mohagany forest	Terrestrial	T1 Tropical–subtropical forests	T1.2 Tropical-subtropical dry forests and scrubs	Only on Little Cayman, not intertidal
Terrestrial	Tidal tropical or subtropical annual forb vegetation	Marine-Freshwater-Terrestrial	MFT1 Brackish tidal	MFT1.2 Intertidal forests and shrublands	Succulent forb veg, coastal/tidal areas, edges of wetlands/mangroves
Shelf benthic	Aggregated patch reef	Marine	M1 Marine Shelfs	M1.3 Photic coral reefs	
Shelf benthic	Uncolonised hardbottom	Marine	M1 Marine Shelfs	M1.6 Subtidal rocky reefs	Pavement, dominated by algae with coral/sponge cover <10%
Shelf benthic	Spur and groove	Marine	M1 Marine Shelfs	M1.3 Photic coral reefs	Hard coral cover (dead and alive), grooves - sand/hardbottom
Shelf benthic	Sand	Marine	M1 Marine Shelfs	M1.7 Subtidal sand beds	Uncolonised sand
Shelf benthic	Rubble	Marine	M1 Marine Shelfs	M1.6 Subtidal rocky reefs	Dead unstable coral rubble and rocks, colonised often by algae
Shelf benthic	Reef crest	Marine	M1 Marine Shelfs	M1.3 Photic coral reefs	
Shelf benthic	Individual patch reef	Marine	M1 Marine Shelfs	M1.3 Photic coral reefs	
Shelf benthic	Colonised hardbottom	Marine	M1 Marine Shelfs	M1.6 Subtidal rocky reefs	Pavement coral cover 10-70%, rock colonised by algae/soft corals
Shelf benthic	Beach rock	Marine	M1 Marine Shelfs	M1.7 Subtidal sand beds	Cemented sand, flat rock-like substrate *Unsure what else to classify as, but could be M1 Marine shelf biome if wanted wider
Shelf benthic	Aggregate reef	Marine	M1 Marine Shelfs	M1.3 Photic coral reefs	
Lagoon benthic	Beach rock	Marine	M1 Marine Shelfs	M1.7 Subtidal sand beds	This refers to cemented sand, flat rock-like substrate. Closest match to the IUCN habitat classification is M1.7 Subtidal sand beds.
Lagoon benthic	Backreef	Marine	M1 Marine Shelfs	M1.3 Photic coral reefs	Dead unstable coral rubble/rocks landward of reef crest, colonised by algae
Lagoon benthic	Vegetated sand	Marine	M1 Marine Shelfs	M1.1 Seagrass meadows	Vegetated sediment - assigned if algae is dominant over seagrass beds - however "seagrass meadows" does include algae in description
Lagoon benthic	Hardbottom	Marine	M1 Marine Shelfs	M1.6 Subtidal rocky reefs	Low relief pavement/rubble, colonised by algae
Lagoon benthic	Seagrass beds	Marine	M1 Marine Shelfs	M1.1 Seagrass meadows	
Lagoon benthic	Sediment	Marine	M1 Marine Shelfs	M1.7 Subtidal sand beds	Unvegetated sand

Terrestrial/ benthic	Cayman Islands classifications	IUCN GET			Notes on alignment
		Realm	Biome	Ecosystem functional group	
Lagoon benthic	Lagoonal coral	Marine	M1 Marine Shelfs	M1.3 Photic coral reefs	
Lagoon benthic	Vegetated peat	Marine	M1 Marine Shelfs	M1.8 Subtidal mud plains	Vegetated sediment
Lagoon benthic	Silt	Marine	M1 Marine Shelfs	M1.8 Subtidal mud plains	Bare or sparsely vegetated sediment

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