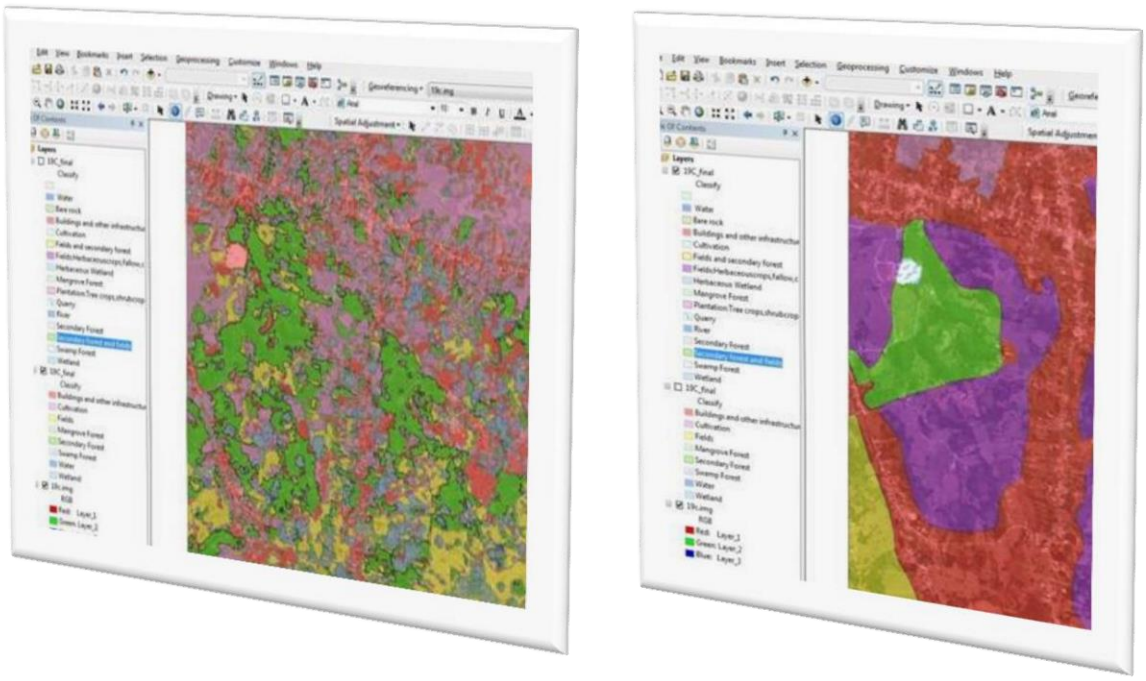
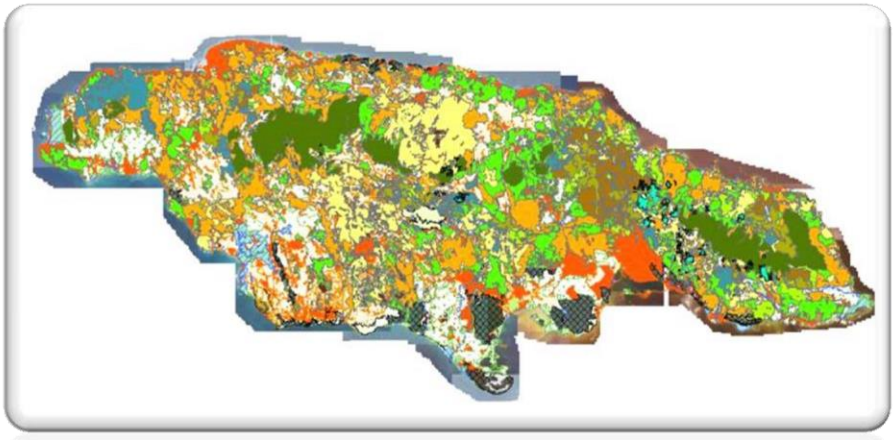
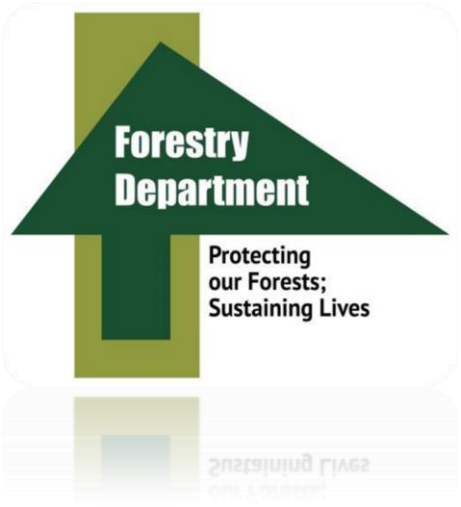
JAMAICA's

LAND USE COVER ASSESSMENT

An comparative assessment of Forest change between 1998 & 2013







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Details and maps can be sourced from the Forestry Department.

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1.0 INTRODUCTION AND BACKGROUND

Land-use/land-cover classification and change assessment is an essential global inventory and monitoring tool for Forest Management activities. As such, activities are essential for further understanding the impact of change on the environment and associated ecosystems at local and national scales. This perspective confirms and supports the mandate of the Forestry Department and directs the Agency in managing our forest resources for the benefit of present and future generations.

The last study on Jamaica's land-use/land-cover change was a joint effort between the Forestry Department and the Canada International Development Agency (CIDA) funded by the 'Trees for Tomorrow Project.' This project concluded that the annual deforestation rate from 1989 to 1998 was estimated to be 0.1%. For this study, 30m LANDSAT imagery was used, and a land use classification was generated with a mapping scale of 1:100,000. Given the coarseness of the images and the small size of many forest plantations, it was difficult to differentiate the land use/cover classes properly. The exercise, therefore, required a more detailed verification to supplement the created data. With the advancement of technology and the availability of high-resolution images of less than 0.6m resolution, a more accurate and detailed classification was made possible by the recent (2011-2013) EU-sponsored Climate Change and Disaster Risk Reduction Project. The object-specific image analysis software – Feature Analyst was selected to conduct a 2013 land use/ cover classification for the Forestry Department. Feature Analyst systematises the process of digitising satellite images through automatic feature extraction (AFE) and creates shape files that can be easily edited using our in-house ArcGIS application. While traditional methods rely on the value of each pixel, object-specific analysis is based on information from a set of similar pixels. Such an approach is vital to forest classification as vegetation often reflects the same pixel value (green).

This technical report outlines the recent methodology used to conduct a Landuse/land-cover classification change for Jamaica. It will also highlight the significant results generated from image analyses and reveal the relevant findings from the derived data.

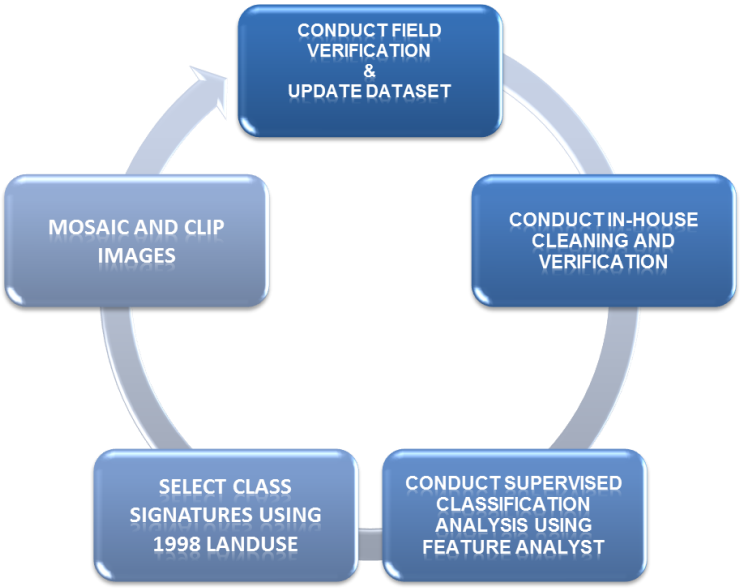
The definitions of forest, deforestation, and the various land-use and forest cover types used in this report are consistent with that of FAO - FRA (2001) and the Agency's 1998 Land Use Change Assessment Report, except in cases where new classes were defined.

Additionally, the Agency does not consider Bamboo (*Bambusa vulgaris*) contributing to forest cover; therefore, it is re-categorised as one of the land use classes in the non-forest cover category (**Appendix 1**).

2. 0 METHODOLOGY

Several steps were involved in determining the land use/land cover classification and change assessment. Each step was interlinked as a cyclic process shown in ***Figure 1*** below and described.

Figure 1 Land use/ cover methodology cycle



2.1 Data Acquisition

To conduct the land use/land cover classification and change assessment, the Forestry Department acquired multispectral satellite images with a resolution of less than one metre (0.6m) compared to the 30m LANDSAT Imagery acquired for the last classification exercise. This high spatial resolution allows our technical team and the software to visualise features on the ground better. Additionally, the natural colour and high spectral resolution allowed for the differentiation of features based on the range or variation of colours.

It was, therefore, easier to differentiate tone, texture, shape, pattern, and relationships to other objects to identify different land cover classes.

2.2 Software Requirements

Various software can be used to conduct such analysis, for example, eCognition, Feature Analyst, and Image segmentation for ERDAS IMAGINE. Based on the land use/land cover classification requirements, the software referred to as Feature Analyst - an extension for the ArcGIS software was selected for the exercise. This software automates the digitising of satellite images through automatic feature extraction (AFE) and creates shape files that can be easily edited in ArcGIS. Whereas "ERDAS IMAGINE," previously used software, only allowed for image processing.

2.3 Data Preparation

Two primary data were required to facilitate the classification process: high-resolution spectral images and land use/ cover signatures. The processes of preparation are highlighted below:

2.3.1 Image Processing

The images were delivered in scenes with sizes ranging from 2GB to 4GB; at this size, the images are difficult to manipulate. The satellite images were cut into smaller tiles and mosaicked to the 2001 image index to ensure consistency and facilitate fast processing during the classification analysis. This process used the image software ERDAS IMAGINE, which facilitates the images' clipping while maintaining the image's original characteristics.

2.3.2 Signature Preparation

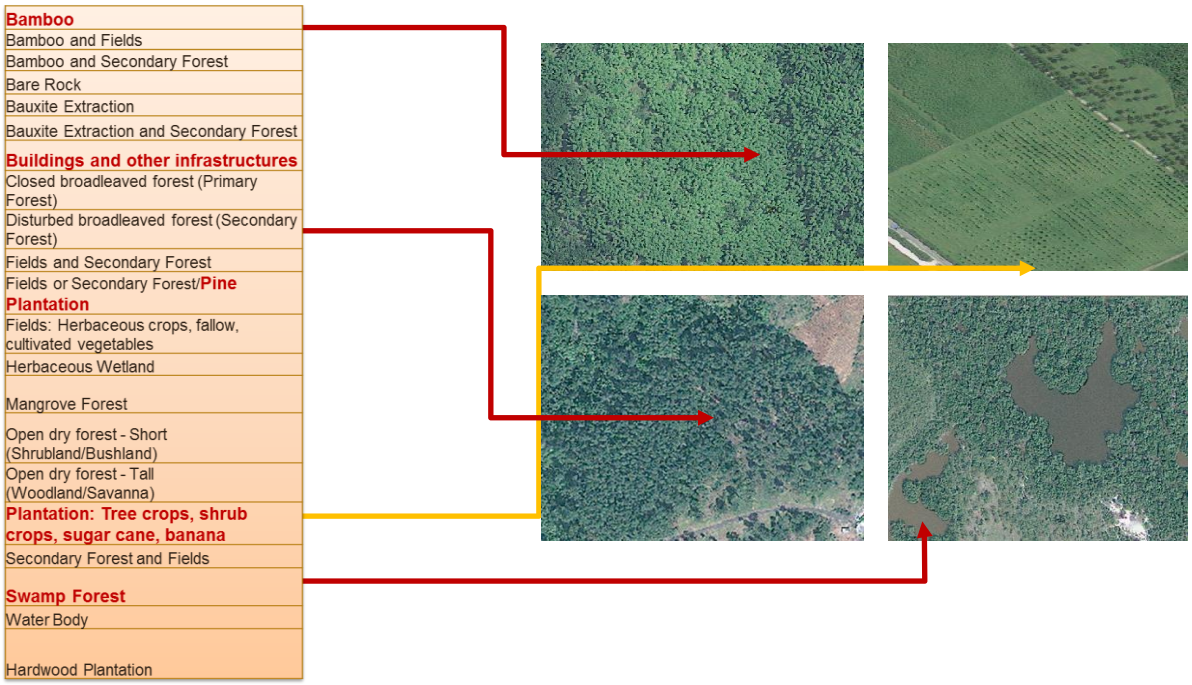
Signatures can be nonparametric, i.e., relying on a ranked order and relationships rather than numbers (feature space). Essentially, signatures represent a particular feature or species that can be identified on a satellite image or aerial photograph. The Agency's photo interpretation manual created during the previous land use exercise guided the development and identification of signatures from the current satellite image. Areas displaying specific characteristics were delineated and coded into classes.

2.3.3 Land Use /Land Cover Classification

The land use classification is derived using the supervised classification methodology in the Feature Analyst – a software extension to ArcGIS. This extension allows for learning

parameters to be entered into the learning process. Input bands provide spectral data, input representations provide spatial data, and learning algorithms provide the mathematical calculations that tie the procedure together. Learning parameters are set up for every feature extraction problem run. Predefined settings can be used based on feature type or set using custom parameters. The premise behind the texture analysis was that forest stand texture might be described according to the size, shape, and spatial arrangement of forest features, as captured in high spatial resolution digital imagery. This new classification utilised the existing categories developed in the 1998 land use/land cover assessment. Given the detailed analysis that could be done, five (5) additional classes were defined (pulled out) from the images and the extent to which these classes were present.

Figure 2: Example of Land cover classes



2.3.4 Data Verification and Quality Check

This classification then underwent several levels of verification to ensure accuracy, completeness, and consistency:

1. Areas were first cross-checked against the satellite image and archival information to ensure that areas were classified correctly. Areas misclassified were split, merged, or re-labeled to reflect the correct classes.
2. Areas were then randomly selected from various classes for field verification—these included areas of uncertainty or where clouds or shadows obscured the features on the ground. The land use cover was then updated with the corrected information.

After conducting this two-stage verification to validate the accuracy of the classification, the National Spatial Data Management Division (NSDMD) was contacted to carry out a quality check and assurance exercise to ensure data integrity. This review assessed the data's structure, properties, topological, spatial, and attribute consistency. After that, all identified inconsistencies or anomalies were corrected and re-verified. The data can be classified as reliable, and the results can be used and reported with authority and confidence, having undergone these various levels of verification and quality assurance.

3.0 RESULTS AND OBSERVATIONS

3.1 Present land use/land cover

Recent analyses of Jamaica's land cover revealed that approximately 40% (439,937.8 ha) of the mainland is covered by forest compared to the 30% reported in 1998. Bamboo, considered forest cover then, is now classified in the non-forested land use category and is therefore not contributing to the 40% coverage.

This variance of ~10% should not be perceived as an increase in forest cover. Instead, the difference is directly attributable to the improved technology and higher-resolution satellite images used in the current analyses to identify better areas with one classification or another.

Of the total areas classified as having forest cover (40 % or 439,937.8 ha), fifty-nine percent (59%) (**Figure 1**) is classified as broadleaf forest. This forest classification is noted for its stratification and high levels of biodiversity. Trees here are usually 5m or more, and crown

cover extends beyond 10%. The broadleaf classification is further divided into ***closed broadleaf*** - having minimal disturbance and ***disturbed broadleaf,*** where disturbance is dominant but less than 15 % of the total area. More pronounced disturbances in the forest classification (higher than 15% but less than 25%) are then classified as secondary forest – a new category identified in the current classification.

Currently, closed broadleaf forest covers 19% of the total acreage of the mainland, a reduction of 4.1% (~3594 ha) of what was in 1998 (***Table 1***).

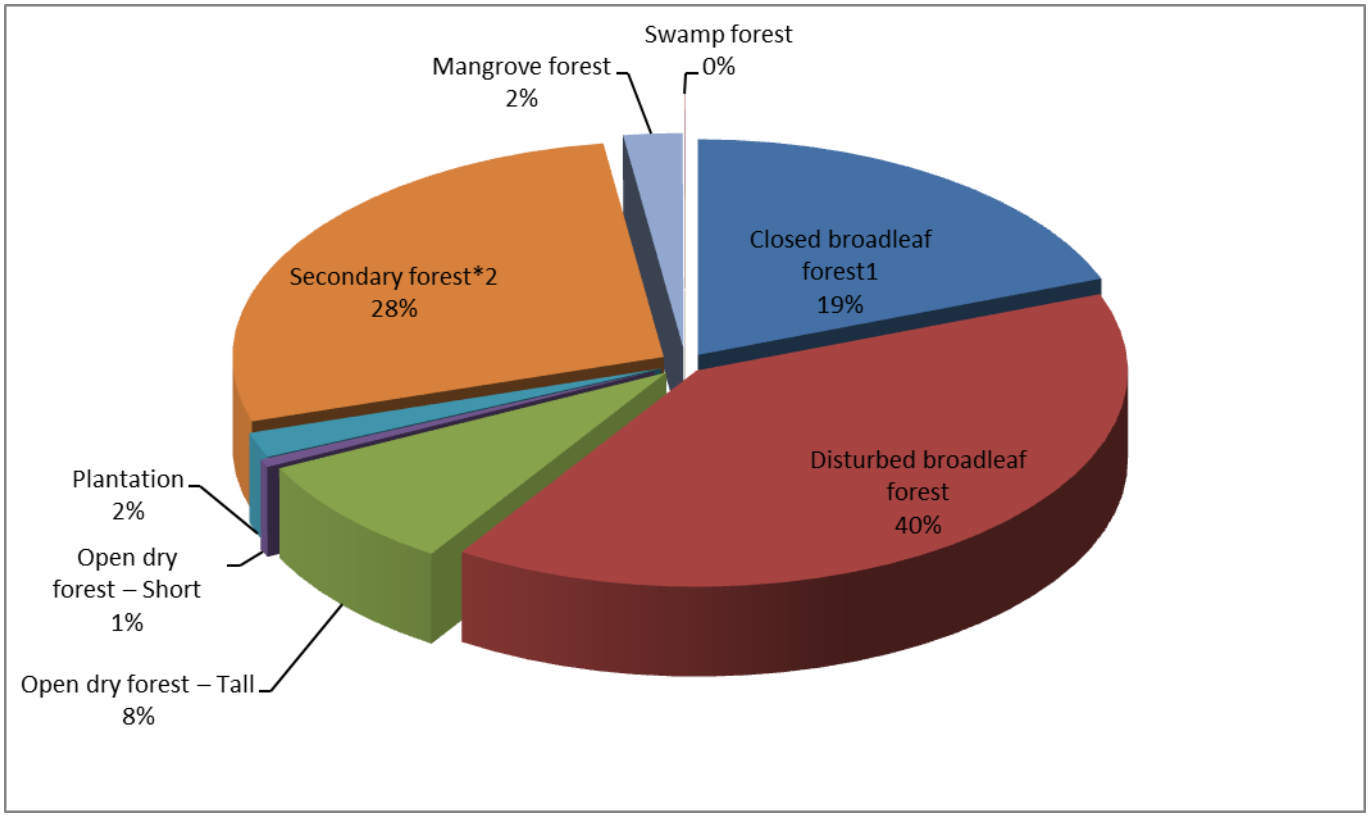


Figure 3: Forest classifications (2013) at the national level.

Just over **19%** of the country is classified as having mixed land use, i.e. a combination of any of the broad forest classifications with that of non-forest. The remaining 41% of the mainland is classified as non-forest, including bamboo (which in 1998 was considered to contribute to forest cover), crop plantations, quarries, waterbodies, infrastructure, etc. (**Table 1**).

3.2 National Forest Cover Change over Time

The current assessment reveals that over the last 16 years (1998-2013), there has been a 0.4% gain in what is currently classified as forest (***See definitions in Appendix 1***). This gain in the forest is attributable mainly to the gain in secondary forestry (ruinate forest) and, to a lesser extent, forest plantations. All other broadleaf forest classifications experienced varying percentages of losses (**Table 1**) over the assessment period.

Currently, there are 8319 ha of forest plantations. A quick comparison to the 1998 forest plantation figures reveals that this amounts to a 1.6% increase. However, this percentage increase must be viewed cautiously, as the 1998 reported figures were solely Pine plantations, whereas current plantations include Pine and other hardwoods.

The swamp forest classification saw the most significant loss or conversion of forest cover percentage-wise. Approximately 95% (~2100 ha) of that reported in 1998 was converted to non-forest land uses. This conversion/loss is predominantly (~81% of the conversion) to three (3) land-use classifications, namely (i) fields of herbaceous crops, fallow, cultivated vegetables, etc., (ii) Herbaceous wetland and (iii) buildings and other infrastructures; in descending order **(L*and cover/ land use matrix in Appendix 2***).

The most considerable loss in hectares (~9489 ha) was seen in the open short dry forest, now primarily converted to bare land and open tall, dry forest. The second largest conversion by size was seen in the open short dry forest with a loss of ~10.6 % (~4,439) ha, most of which is currently identified as disturbed broadleaf and, to a lesser extent, bare rock. Cumulatively, there was an 88% reduction in open dry forests.

Cumulatively, there was a 3.6% reduction in broad leaf cover, which is more significant for the closed broad leaf category (**Table 1**).

The high-resolution images allowed us to identify a new classification within the forest cover category (i.e. >75% coverage) – **secondary forest**. This new classification accounts for 28% of the current national acreage under forest (**Figure 1)**. Its signature is distinctly different from that of disturbed broadleaf forests in that a higher level of disturbance (28%) is recognisable. Of the ~**121,631** ha identified as secondary forest, it is approximated that only a third or 40,453.7 ha were actual or 'real' gains from other non-forest classifications. The remaining two-thirds (80,907 ha) is merely re-classification resulting from technological enhancement and greater image resolutions, allowing for accuracy and precision.

The 'real' gains to secondary forest came from losses/conversions from four (4) previous (1998) classifications, namely Fields (cultivations) and secondary forest (ii) cultivations, i.e., fields of herbaceous crops, fallows, vegetables, etc.) (iii) Crop plantations of tree and shrub crops, sugar cane, banana, etc. and (IV) areas of bauxite extraction.

Other increases and losses should be viewed with the same caveat: not all gains/losses are 'actual' conversions. Technological enhancements coupled with better imagery used in the current assessment allowed for more precise and accurate identification of the various classifications; hence, what is now seen as gains or losses may be a re-classification.

Table 1: National Land Use Change Assessment, 2013 (LUCA-2013).

Land Use/Cover Change in Jamaica: 1998 and 2013, hectares

Forest Land Use /Cover >75% **Land Use/Cover Classification**	1998	2013	Difference hectares	Percent Loss/Gain
Closed broadleaf forest[1]	88,230.5	84636.6	-3,594.0	-4.1
Disturbed broadleaf forest	174,724.6	175590.6	866.0	0.5
Open dry forest – Tall	41,998.5	37559.7	-4,438.8	-10.6
Open dry forest – Short	12,104.0	2615.1	-9,488.9	-78.4
Plantation	8,186.9	8319.0	132.1	1.6
Secondary forest*[2]		40453.7	40,453.7	
Mangrove forest	9,731.4	9732.8	1.4	0.0
Swamp forest	2,247.0	122.9	-2,124.1	-94.5
Sub-total	**337,223.0**	**359,030.4**	**21,807.4**	**6.5**
Annual change in forest cover (percent)				0.4
Secondary forest*		80907.4		
Total Forest Cover		**439,937.8**		
Mixed Land Use/Cover (first class> 50%, second class> 25%)				
Fields and secondary forest	117,966.1	162,877.5	44,911.4	38.1
Bauxite and disturbed broadleaf**	2,851.4			
Bamboo and secondary forest	12,687.2	36,696.0	24,008.8	189.2
Disturbed broadleaf and fields**	165,953.9			
Sub-total	**299,458.6**	**199,573.5**	**-99,885.1**	**-33.4**
Mixed land use/cover growth rate				-2.01
Non-Forest Land Use/Cover				
Bamboo	2,979.4	4,667.4	1,688.0	56.7
Bamboo and Fields	29,155.6	67,029.8	37,874.2	129.9
Bauxite Extraction	4,921.9	3,349.8	-1,572.1	-31.9
Bare Rock	933.9	2,389.5	1,455.6	155.9
Cultivation: (Fields) Herbaceous crops, fallow, cultivated vegetables	274,478.6	147,122.6	-127,356.1	-46.4
Fields: Pasture, grassland*		6,524.8	6524.8	
Herbaceous wetland	10,914.1	15,022.3	4,108.2	37.6
Crop plantation: Tree crops, shrub crops, sugar cane, banana	82,341.3	69,760.2	-12,581.2	-15.3
Buildings and other infrastructure	52,259.8	131,319.4	79,059.6	151.3
Water bodies	1,586.0	4,602.4	3,016.4	190.2
Quarries*		717.8		
Bare land*		7,083.9		
Sub-total	**459,570.7**	**459,589.8**	**19.1**	**0.0**
Non-forest land use/cover growth rate				-0.09
Small islands	164.0			
Total	**1,096,416.3**	**1,099,101.1**		

See table notes below –

Table Notes

For definitions for all land use types used in the assessment, see Appendix 1

* New categories added to land use /cover classification

** Categories for which refined classification was done were removed from the current (2013 classification. These were previously classified in these areas and are accounted for under different classifications.

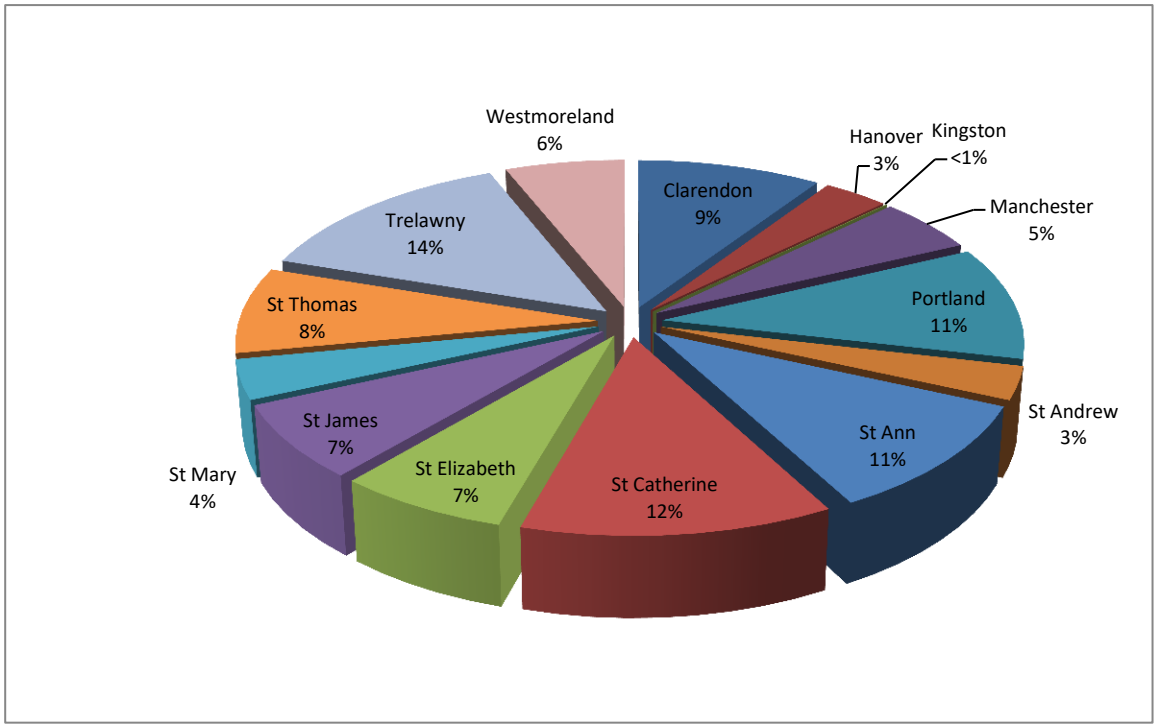
\+ Category for which there is no reference data (1998) or no current information (2013) due to re-classification

1. Secondary forest includes 75% of Secondary forest and fields + 75% of *Secondary forest and bamboo
2. This, by definition, denotes that there is >75% broadleaf forest and <25% fields (this differs from disturbed broadleaf, which has a maximum of 15% fields).
3. 25% of the fields from the "secondary forest & fields" were added to the category "fields and secondary." While 25% of the bamboo was added to the category "bamboo & secondary."
4. Plantation (forest) includes hardwood and otherwise
5. Figures for 1998 were generated from the archival spatial data and may differ slightly from those reported in previous documents such as the National Forest Management and Conservation Plan (NFMCP).

3. 3 Land Use/ Land Cover by Parish

Comparatively, Trelawny accounts for the most significant forest coverage (***Table 2 & Figure 2***) (Appendix 3) in actual hectares and percentage-wise. This occurrence may be because the greater percentage of the area described as the Cockpit Country comprises this Parish. St Catherine, Portland, St. Ann, and Clarendon complete the top five parishes with the largest size (hectares) of forest cover in descending order.

Figure 4: Current (2013) Distribution of Forest Cover across parishes



3.4 Deforestation rates – Parish levels

St Ann has the highest deforestation rate over the assessment period (1998-2013), accounting for an annual deforestation rate of -0.79 or ~4,042.27 ha of forest cover being converted to other land uses, predominantly fields & secondary forest. This rate of deforestation more than doubles that of Hanover, the Parish with the second highest deforestation rate with an annual forest cover loss of ~856.39 ha (-0.38%) (**Table 3**). Most of this forest conversion is to fields and bamboo, secondary forest mixed with bamboo and buildings and other infrastructure, in decreasing magnitude. Clarendon completes the top three parishes with an annual deforestation rate of 0.45%. Interestingly, a larger acreage of land was converted in Clarendon than in Hanover.

Table 2: 2013 Land use/ cover by Parish

Parish

	Classify	Clarendon	Hanover	Kingston	Manchester	Portland	St Andrew	St Ann	St Catherine	St Elizabeth	St James	St Mary	St Thomas	Trelawny	Westmoreland	Total
	Forest Landuse /Cover >75%)															
Land use/ cover 2013	Mangrove Forest	3,775.07	147.16		312.76	129.11	295.96	1.05	2,576.41	264.77	124.45	103.48	323.73	639.97	1,044.30	**9,738.21**
	Closed broadleaved forest (Primary Forest)	298.05	1,828.70		844.89	19,799.34	380.19	9,685.39	1,059.37	1,892.73	7,200.09		9,852.49	30,063.48	1,738.29	**84,643.00**
	Disturbed broadleaved forest (Secondary Forest)	11,944.31	9,993.33		13,764.03	14,713.39	3,036.51	11,158.31	21,577.37	18,485.86	20,260.91	8,091.73	10,357.49	20,977.67	11,229.53	**175,590.42**
	Secondary Forest	11928.84	2,701.03		3,981.16	10,819.00	4,746.25	24,176.65	17,468.09	5,612.84	3,842.85	5,859.22	11,131.02	7,825.39	11,251.12	**121,343.47**
	Swamp Forest		114.12										8.81			**122.93**
	Open dry forest - Short						72.10	48.47		2,236.33				257.94		**2,614.84**
	Open dry forest - Tall (Woodland/Savanna)	13,271.23		221.04	3,197.40		2,457.02	857.51	10,991.41	1,664.89			2,230.47	1,692.80	975.04	**37,558.80**
	Hardwood Plantation	9.40					158.54	30.83		30.90				84.20		**313.88**
	Pine Plantation	395.38				1,828.96	2,560.68	329.63		4.50		1,335.91	1,528.93	20.06		**8,004.05**
	Subtotal	**41,622.28**	**14,784.34**	**221.04**	**22,100.23**	**47,289.80**	**13,707.26**	**46,287.83**	**53,672.64**	**30,192.82**	**31,428.29**	**15,390.34**	**35,432.94**	**61,561.52**	**26,238.28**	**439,929.61**
	Mixed Landuse/cover (first class> 50%, second class> 25%)															
	Bamboo and Fields	3,765.63	1,186.02		382.63	7,793.82	2,902.31	286.43	6,033.10	136.23	1,302.63	6,420.32	3,802.75	191.15	1,906.69	**36,109.70**
	Bamboo and Secondary Forest	578.32			1.03	2,688.07	2,090.59	60.65	5,872.89		1,414.24	15,609.89	1,938.05	4.22		**30,257.94**
	Fields and Bamboo	6,124.54	13,704.86		58.76	1,475.89	1,901.51	1,376.68	1,529.84	291.43	3,927.43	1,914.86	3,000.76	8.21	2,011.78	**37,326.55**
	Fields and Secondary Forest	11,411.51	2,006.69		26,455.38	9,675.53	5,141.10	39,151.70	6,704.05	9,320.34	1,885.64	3,680.73	7,661.41	6,074.80	2,971.75	**132,140.64**
	Subtotal	**21879.995**	**16897.579**	**0**	**26897.79**	**21633.301**	**12035.515**	**40875.4543**	**20139.87279**	**9747.99744**	**8,529.94**	**27,625.81**	**16,402.97**	**6,278.38**	**6,890.22**	**235,834.83**
	Non Forest land use/cover															
	Bauxite Extraction	59.02			1,913.84			981.69		438.50						**3,393.05**
	Bamboo											186.61				**186.61**
	Bare Rock	1,364.42	13.82		0.30	17.94	83.19	10.09	424.78	260.18		50.74	58.73	1.16	5.09	**2,290.42**
	Buildings and other infrastructures	13,995.51	5,699.45	1,375.37	8,661.86	3,107.93	14,197.95	8,926.75	17,491.51	14,509.92	12,030.52	4,697.49	3,607.52	4,640.71	12,769.54	**125,712.05**
	Fields: Bare Land	6,370.53	754.80		3,273.06	3,002.59	1,321.81	6,842.58	5,728.60	2,882.91	1,050.06	1,745.55	3,140.50	2,223.74	3,166.27	**41,503.01**
	Fields: Herbaceous crops, fallow, cultivated vegetables	13,760.41	4,064.04		18,896.22	2,693.22	1,907.50	21,389.27	9,186.34	49,076.59	5,743.75	3,091.88	2,973.03	6,644.73	14,059.94	**153,486.93**
	Fields: Pasture,Human disturbed, grassland	677.47	86.40		439.68			1,453.24	1,106.16	610.85	158.63	481.41	667.32	789.22	147.11	**6,617.49**
	Herbaceous Wetland	903.13	1,469.68		205.51	118.90		79.45	53.45	7,355.53			1,664.51	26.59	2,487.20	**14,363.95**
	Plantation: Tree crops, shrub crops, sugar cane, banana	16,919.68	1,527.43		43.33	1,508.96	37.22	290.27	12,365.50	6,640.75	1,543.23	1,643.27	5,377.76	7,058.95	15,006.87	**69,963.24**
	Quarry	75.70	10.18		114.36	26.18	206.71	30.16	11.96	71.26	58.09	11.08	37.68	40.87	26.09	**720.33**
	Water Body	1,044.12	68.76		2.02	779.35	215.11	77.77	218.43	375.70	33.46	558.46	1,519.37	141.21	65.94	**5,099.70**
	Subtotal	**55,169.99**	**13,694.56**	**1,375.37**	**33,550.19**	**11,255.07**	**17,969.49**	**40,081.26**	**46,586.74**	**82,222.19**	**20,617.76**	**12,466.48**	**19,046.42**	**21,567.18**	**47,734.06**	**423,336.76**
	Total	**118,672.26**	**45,376.47**	**1,596.41**	**82,548.22**	**80,178.17**	**43,712.27**	**127,244.55**	**120,399.26**	**122,163.01**	**60,575.99**	**55,482.63**	**70,882.34**	**89,407.08**	**80,862.56**	**1,099,101.20**

Not all parishes, however, experienced losses in forest cover. Parishes such as St Catherine, Manchester, and St Thomas (**Table 3)** gained ~16,000 ha of forest cumulatively. These gains were predominantly secondary and disturbed broadleaf forests.

Table 4: Annual deforestation rates at the Parish level

	Forest Cover (Ha)				
PARISH	**1998**	**2013**	**Difference**	**Deforestation Rate**	**Annual rate**
St Ann	32154.49	28112.22	-4,042.27	-12.57	-0.79
Hanover	14057.09	13200.70	-856.39	-6.09	-0.38
Clarendon	35459.30	32909.24	-2,550.06	-7.19	-0.45
Kingston	221.71	221.04	-0.67	-0.30	-0.02
Trelawny	54262.60	56035.33	1,772.74	3.27	0.20
Portland	37088.41	39432.24	2,343.83	6.32	0.39
St James	26452.71	28972.25	2,519.54	9.52	0.60
St Andrew	9187.08	10543.44	1,356.36	14.76	0.92
St Elizabeth	23618.98	26373.82	2,754.84	11.66	0.73
Westmoreland	15855.49	18077.59	2,222.10	14.01	0.88
St Catherine	36931.47	40724.65	3,793.18	10.27	0.64
Manchester	17364.70	25677.69	8,312.99	47.87	2.99
St Thomas	23543.90	27364.73	3,820.84	16.23	1.01
St Mary	10640.42	11381.62	741.20	6.97	0.44
Total	**336,838.32**	**359,026.56**	**22,188.24**	6.59	0.41

Table 3 Notes:

The Parish total variance is from excluding the coastline in the coverage analysis. The missing secondary forestry- 80907.4 ha; was not included in the forest calculation as it is an identified re-classification resulting from technological enhancement and greater image resolutions.

3.5 Land cover on Private vs Public lands

The area of Forest Reserves and Crown Lands managed by the Agency is ~116,761 ha. Of this total, ~105,934 ha has been assessed (parcels identified on the ground and varying levels of boundary verification completed) and validated. Of this assessed total, forest cover is approximately 91 %.

Similarly to the national gain in forest cover, there was a minimal increase in the quality and quantity of the lands managed by the Agency; an annual gain of forty (40) ha of forest cover was estimated. This positive change equates to an annual growth rate of 0.04% on Forest estates (Table 4). The increase in forest quality was seen in the disturbed broad leaf forest classifications, Open dry forest – tall and Mangrove forest. Additionally, secondary forest as a new forest cover class has contributed to this net gain. As previously stated, technological advances have allowed the better classification of this new forest class, which resulted in an overall increase. The Forestry Department manages 24% of the area classified as having forest cover (**Tables 1 and 4**).

Table 4: Forest cover change on lands managed Forestry Department

Land Use/Cover Change in Areas Manage by FD, 1998-2013

Forest Landuse /Cover >75%)				
Land use/cover Classification	**2013 LU Hectares**	**1998 LU Hectares**	**Difference hectares**	**%Percent Loss/Gain**
Mangrove Forest	2,266.83	2,053.42	213.41	10.39
Closed broadleaved forest (Primary Forest)	62,004.18	63,248.85	-1,244.67	-1.97
Disturbed broadleaved forest	16,166.31	19,874.21	-3,707.90	-18.66
Swamp Forest	0.00	38.38	-38.38	-100.00
Open dry forest - Tall (Woodland/Savanna)	10,549.49	9,634.16	915.33	9.50
Open dry forest - Short (Shrubland/Bushland)	101.40	3,306.65	-3,205.25	-96.93
Pine Plantation/ Other	5,637.85	7,148.00	-1,510.15	-21.13
Secondary Forest*	9,212.88		9,212.88	
Subtotal	**105,938.94**	**105,303.67**	**635.27**	0.60
Annual Growth Rate%				**0.04**

**Category for which there is no reference data (1998) or no current information (2013) due to re-classification*

On other forested lands (private and crown) not managed by the Agency, there was also an annual increase in forest cover equating to ~ 7381 ha/ annum (**Table 5**); secondary (ruinate) forests made the most outstanding contribution to this gain. Losses were seen in other categories (as those at the national level). Except for the disturbed broad leaf category, which had a gain of ~4,206 ha (or 2.7%) (**Table 5 and Figure 5)**

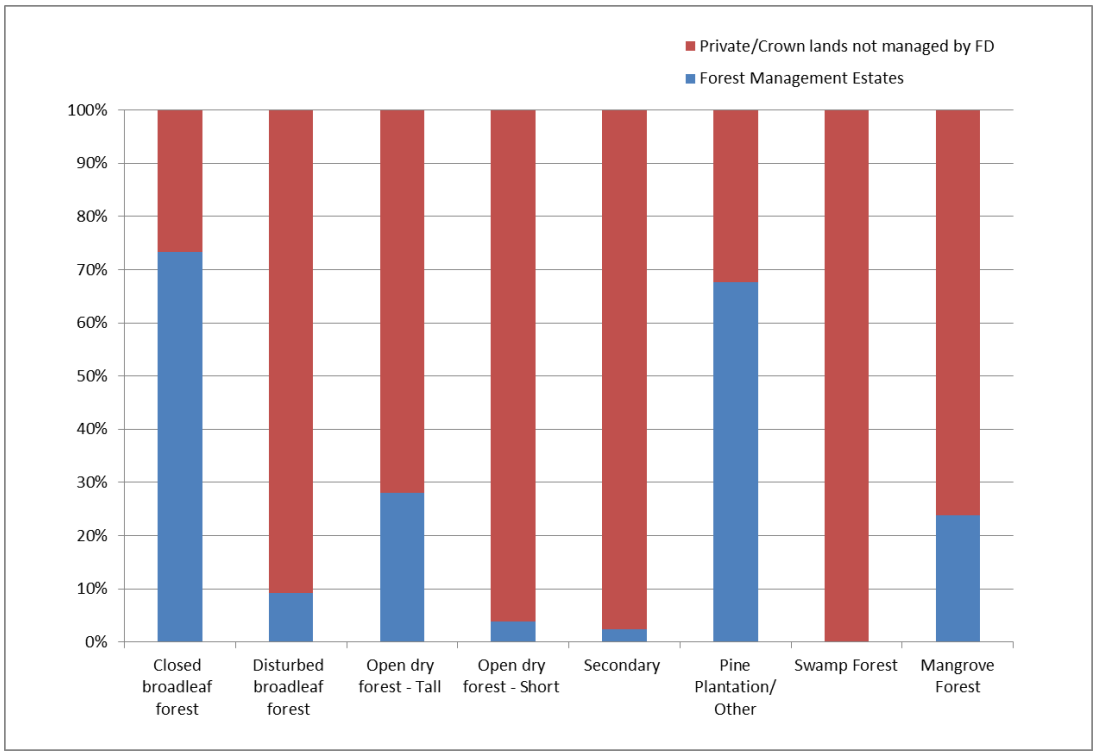
Table 5: Forest cover change on lands NOT managed Forestry Department

Land Use/Cover Change in Areas not Managed by FD, 1998-2013

Forest Landuse /Cover >75%)				
Land use/cover Classification	**2013 LU Hectares**	**1998 LU Hectares**	**Difference hectares**	**%Percent Loss/Gain**
Mangrove Forest	7,423.45	7,677.95	-254.50	-3.31
Closed broadleaved forest (Primary Forest)	22,641.52	24,981.69	-2,340.17	-9.37
Disturbed broadleaved forest (Secondary Forest)	159,056.67	154,850.43	4,206.24	2.72
Swamp Forest	122.79	2,208.65	-2,085.86	-94.44
Open dry forest - Tall (Woodland/Savanna)	27,012.09	32,364.38	-5,352.29	-16.54
Open dry forest - Short (Shrubland/Bushland)	2,518.19	8,797.37	-6,279.18	-71.38
Pine Plantation/ Other	2,688.96	1,038.57	1,650.39	158.91
Secondary Forest *	128553.679			
Subtotal	**350,017.34**	**231,919.04**	**118,098.30**	50.92
Annual Growth Rate%				**3.18**

**Category for which there is no reference data (1998) or no current information (2013) due to re-classification*

Figure 5: Percentage of forest cover (2013) by management status (Forest Management Estates vs other crown and private lands with forest cover).



4.0 Conclusions

A recent international report by Thomson Reuters Foundation - 2015[1] indicated that "*Satellite data suggest forest loss is accelerating*." This finding is somewhat consistent with the output of our current analyses – there were forest cover losses in all substantial forest categories except secondary forest.

This increase in the degraded forest may be attributable to socio-economic drivers at two levels:- (i) the decrease in international demand for bauxite in the first decade of the 21st century led to the reduction of mining. This occurrence resulted in the reduction of forest cover removal through open karst mining and forest cover re-established on mined-out/reclaimed

[1] Sourced from http://news.yahoo.com/satellite-data-suggests-forest-loss-accelerating-145351593.html, March 2015

areas through natural regeneration and succession over 16 years. Even though somewhat checked, open karst mining continued in St Ann, one of the contributors to the high deforestation level seen in Parish (ii) the reduction in agriculture and the recent surge of intensive agricultural practices utilising greenhouse technology. The increased intensity of hurricanes/storms/tropical depressions impacting the island (occurring over the assessment period), drought, diminishing interest in farming, and increased agricultural imports have led to the abandonment of agricultural lands, some of which have reverted to secondary forests.

Even though secondary forests provide some essential ecosystem functions, they will result in broad leaf cover through succession if left undisturbed. The likelihood of this occurring will depend on future land policies and practices.

Appendix 1: Definitions of Key Terms

Landuse/cover		Definition
Class	**Sub-class**	
Forest	Closed Broadleaved (PF)	Forest cover consisting of broad leaf trees at least 5 m tall and crowns interlocking with minimal human disturbance. This is as close to primary forest as one can get.
	Disturbed Broadleaved (SF)	Forest with broadleaf trees at least 5 m tall and species-indicators of disturbance such *as Cecropia peltata* (trumpet tree). This category has less than 15% disturbance.
	Tall Open Dry (WL)	Open natural woodland or forest with trees at least 5 m tall and crown not in contact in the drier part of Jamaica with species-indicators such as *Symphonia globulifera* (hog plum) and *Roystonea princeps* (Royal palm).
	Short Open Dry (SL)	Open scrubs, shrubs, bushes or brushland with trees or shrubs 1-5 m tall and crowns not in contact in the drier part of Jamaica with species-indicators such as *Prosopis juliflora* (cashew) or *Stenocereus hystrix* (Columnar cactus).
	Swamp (SW)	Edaphic forest (waterlogged soils) with a single tree storey with indicator species such as *Symphonia globulifera* (hog plum) and *Roystonea princeps* (Royal palm).
	Mangrove (MG)	Edaphic forests (areas with brackish water) are composed of trees with stilt roots or pneumatophores with indicator species such as *Rhizophora mangle* (red mangrove).
	Secondary Forest (DS)	A new classification identified (2013) having broadleaf forests equal to or greater than 75% with disturbance levels between 10 - 25%. This level of disturbance distinguishes it from disturbed broad leaf forests.
	Plantations (Forest (PP)	Forest cover is re-established by reforestation or natural regeneration consisting of hardwood species such as Mahogany & Mahoe and Softwoods such as the Caribbean Pine.
Mixed	Fields and Secondary Forest (SC)	>50% fields , >25% Secondary Forest
	Disturbed Broadleaf Forest and Fields	>50% Disturbed Broadleaved Forest; >25% fields
	Bamboo and Fields (BC)	>50% bamboo: >25% fields
	Fields and Disturbed Broadleaved Forest and	>50% field; >25% Disturbed Broadleaved Forest
	Bauxite Extraction and Disturbed Broadleaved Forest	>50% bauxite extraction; >25% Disturbed Broadleaved Forest
Non-Forest	Plantation (Crop)	Tree and shrub crops like sugar cane, bananas, citrus, and coconuts.
	Fields	Cultivated herbaceous crops, shrub crops, fallow, legumes, or grasslands/pastures.
	Bamboo	*Bambusa vulgaris* (Bamboo breaks) on the lower shale hill (disturbed forest).Not considered as a forest type. Removed in reforestation programmes administered by the Agency
	Bamboo and Disturbed Broadleaf Forest and	>50% bamboo: >25% Disturbed Broadleaf Forest
	Herbaceous Wetland	Edaphic vegetation (soil waterlogging) with herbaceous plants.
	Water Bodies	Lakes, rivers & streams, ponds, etc.
	Small Islands	Mainly sand/limestone, un-vegetated small islands (cays)

FAO Definitions	Bare Rock	Bare sand/rock
	Bauxite Extraction	Surface mining/bauxite
	Buildings and Other Infrastructure	Buildings and other constructed features such as airstrips, roads, bridges, etc.
	Forest	Land with tree crown cover (or equivalent stocking level) of more than 75% on an area of more than 2.25 hectares (modified FAO).
	Deforestation	The conversion of forested lands to another land use or the long-term reduction of the tree canopy cover (modified FAO)

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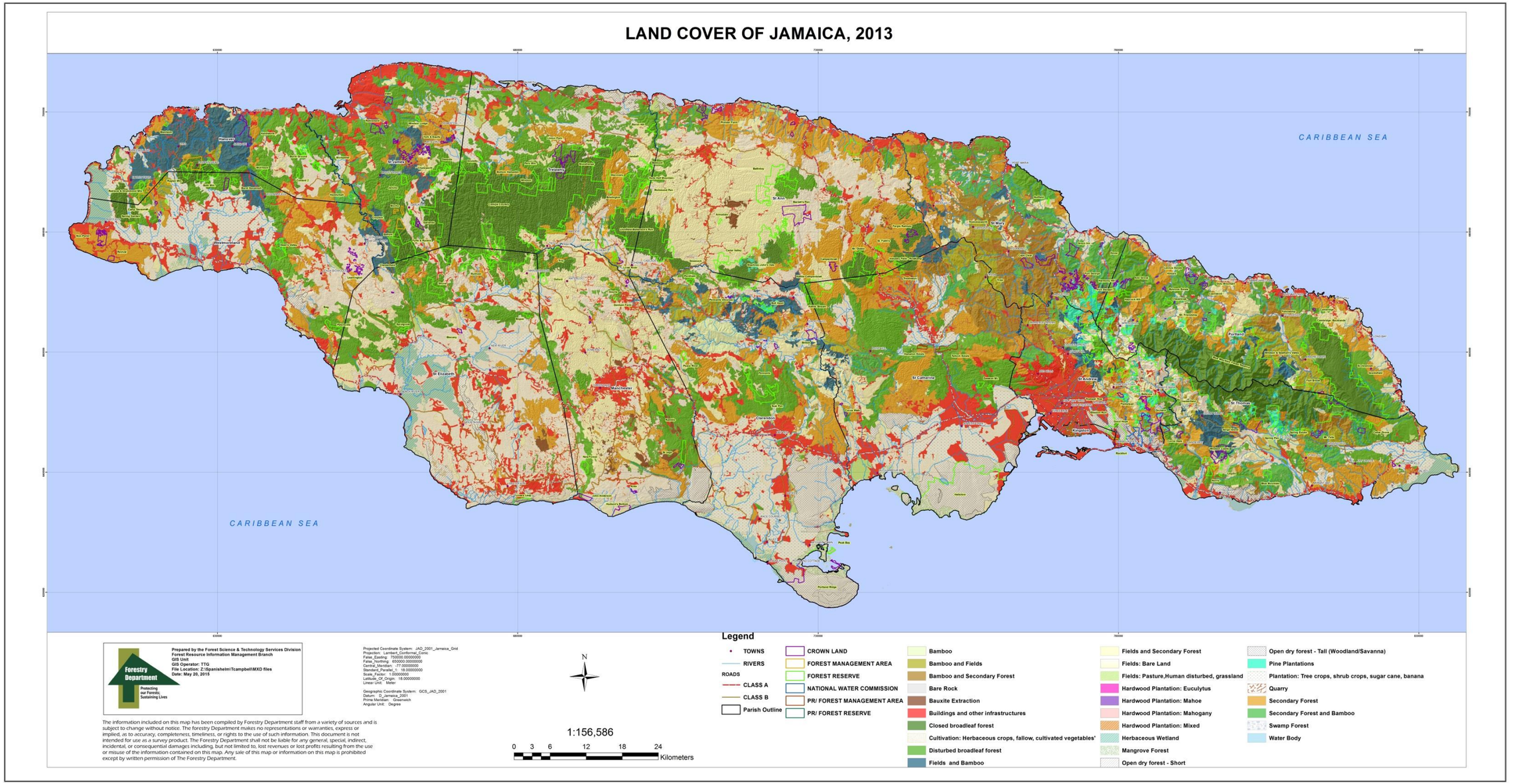
Land Cover 2013

Land use/Cover Matrix 1998-2013

Land cover 1998

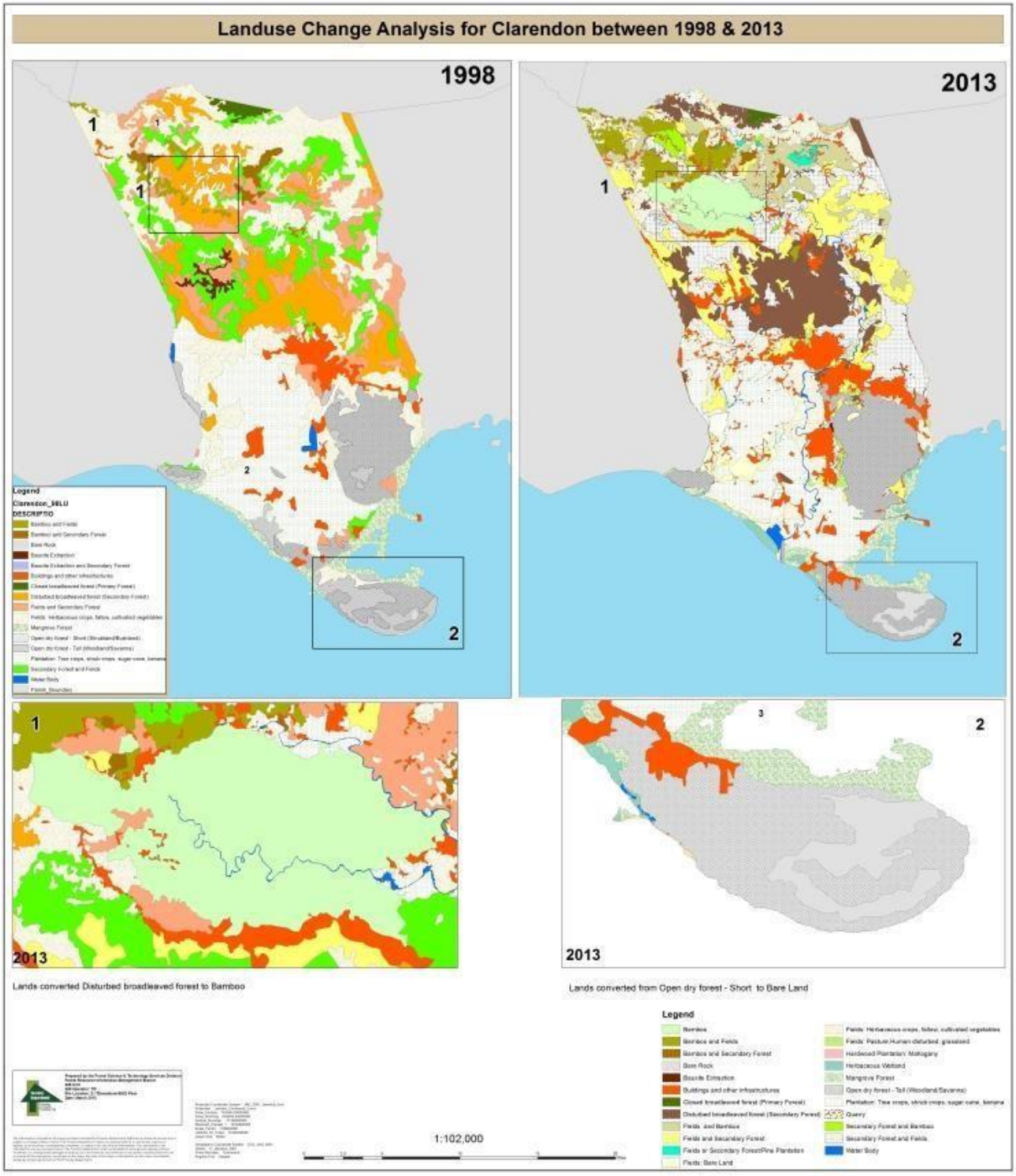
		Forest							Mixed								Non-Forest									
Description		**PF**	**SF**	**WL**	**SL**	**PP**	**MG**	**SW**	**CS**	**BS**	**BF**	**SC**	**BB**	**BC**	**BE**	**BR**	**FC**	**HW**	**PC**	**BA**	**WA**	**island**	**lake**	Unclassified	**TOTAL GAIN (ha)**	**DIFFERENCE 2013-1998**
Forest Land Use /Cover >75%)																										
PF		75193.93	5502.49	200.82	3.17	446.62			991.31	1.07	4.46	1363.96	119.33	493.00			296.08		10.64	12.22	4.87			0.07	**84,644**	-3,720
SF		5938.12		6906.15	288.46	131.85	8.24	4.93	14013.56	1.20	516.95	28906.60	183.11	1020.46	406.82	58.29	8473.84	201.44	2078.18	876.80	2.99			15.53	**70,034**	-3,201
WL			212.12		3847.77		61.00	0.51	416.07			857.43				503.22	1639.42	3.51	432.12	352.54	1.97		0.01	6.75	**8,334**	-4,451
SL			54.69	75.35			0.09		0.08							0.49	152.70			9.16				0.47	**293**	-9,491
PP		588.34	1948.81						528.46		13.46	1630.89	0.01	518.10			1245.77			0.50					**6,474**	4,154
MG				385.85	229.59			139.65	86.01			24.56				0.08	173.76	50.92	78.85	105.58	88.57	114.85	0.35	150.86	**1,629**	-194
SW																	8.20							0.58	**9**	-2,124
DS		4605.62	31928.79	694.05	498.40	587.16	4.10	39.60	21394.13	570.70	787.21	53819.24	164.87	1995.23	237.44		16829.92	122.65	2511.93	877.47	5.29			16.11	**137,690**	137,690
Mixed Land use/cover (first class> 50%, second class> 25%)																										
CS		1252.53	12787.61	281.09	20.58	249.63	4.24	20.32		2037.64	689.99	36824.58	141.64	671.55	3364.52		37756.01	4.62	3268.69	1312.39			1.22	19.86	**100,709**	14,063
BF		74.54	3551.94	27.09		359.17			5133.18			9000.09	884.31	4535.41			3305.80		138.81	252.85					**27,263**	17,573
FB		202.09	5205.83	174.51		293.13			5374.01		1881.33	8274.42	343.36	2124.83			1676.64		541.97	148.59					**26,241**	26,241
Non-forest land use/cover																										
BB			2093.17			27.19			652.17		299.26	278.93		394.92			912.45		9.32	0.00					**4,667**	1,687
BC		73.59	2239.02			74.13			3903.06		1051.02	4123.17	540.54				7993.69		125.63	72.96					**20,197**	337
CB		126.12	1560.81			95.15			9247.42		3540.48	3057.49	535.90	5920.11			12802.91		362.43	59.73					**37,309**	37,309
BE		21.26	137.61	6.69	27.96				656.27	18.20		677.61					1218.10		8.16	348.28					**3,120**	-1,526
BR		2.89	4.79	1411.86	198.46		2.98	28.15	7.12			34.89					146.95		14.31	123.91				11.44	**1,988**	1,407
FC		166.82	2445.44	240.22	749.90	33.01	312.70	934.91	9957.56	24.20	170.38	4531.84	37.30	438.00	217.55	0.09		63.29	9503.16	1592.42	71.71			31.33	**31,522**	-120,650
PA		0.01	36.57	116.64	0.38		0.00	139.37	192.74	0.01	0.76	125.35		3.09			4670.01	3.99	1263.96	64.61				4.08	**6,622**	6,622
HW			7.03	119.66	105.08		749.45	609.75	67.28			799.15					1447.49		222.29	20.74	35.62			59.54	**4,243**	3,540
PC		71.96	599.39	469.12	247.63		43.30	1.11	1586.01		136.77	2355.65		235.00			9890.70	53.74		550.90	37.57			1.48	**16,280**	-12,269
BA		13.87	2308.33	871.99	201.68	0.27	373.18	177.10	11436.37	165.22	531.15	8948.42	14.65	1338.68	414.05	15.13	39190.87	75.30	5892.05		396.06	0.06	1.18	345.30	**72,711**	64,904
BL			182.21	684.34	3071.31		28.87		159.42			110.03					1302.03	0.24	1240.50	390.07	4.42			21.84	**7,195**	7,195
QA		1.32	42.18	68.48	4.92		2.28		42.36	1.00	6.34	66.92		32.32	6.08		196.42	0.15	14.68	234.88					**720**	720
WA		30.99	367.49	27.68	255.64	22.69	56.40	10.34	749.30		60.43	517.17	15.37	139.54	0.13		729.77	104.57	799.46	237.66			513.27	63.19	**4,701**	3,498
Unclassified			18.29	23.38	33.47		176.72	27.29	51.56			66.78				3.29	111.97	18.34	32.35	163.03	37.53	23.00			**787**	
TOTAL LOSS (ha)		**88,364**	**73,235**	**12,785**	**9,784**	**2,320**	**1,824**	**2,133**	**86,645**	**2,819**	**9,690**	**166,395**	**2,980**	**19,860**	**4,647**	**581**	**152,171**	**703**	**28,550**	**7,807**	**687**	**138**	**516**	**748**		

Appendix 2: Land use/cover matrix 1998 and 2013

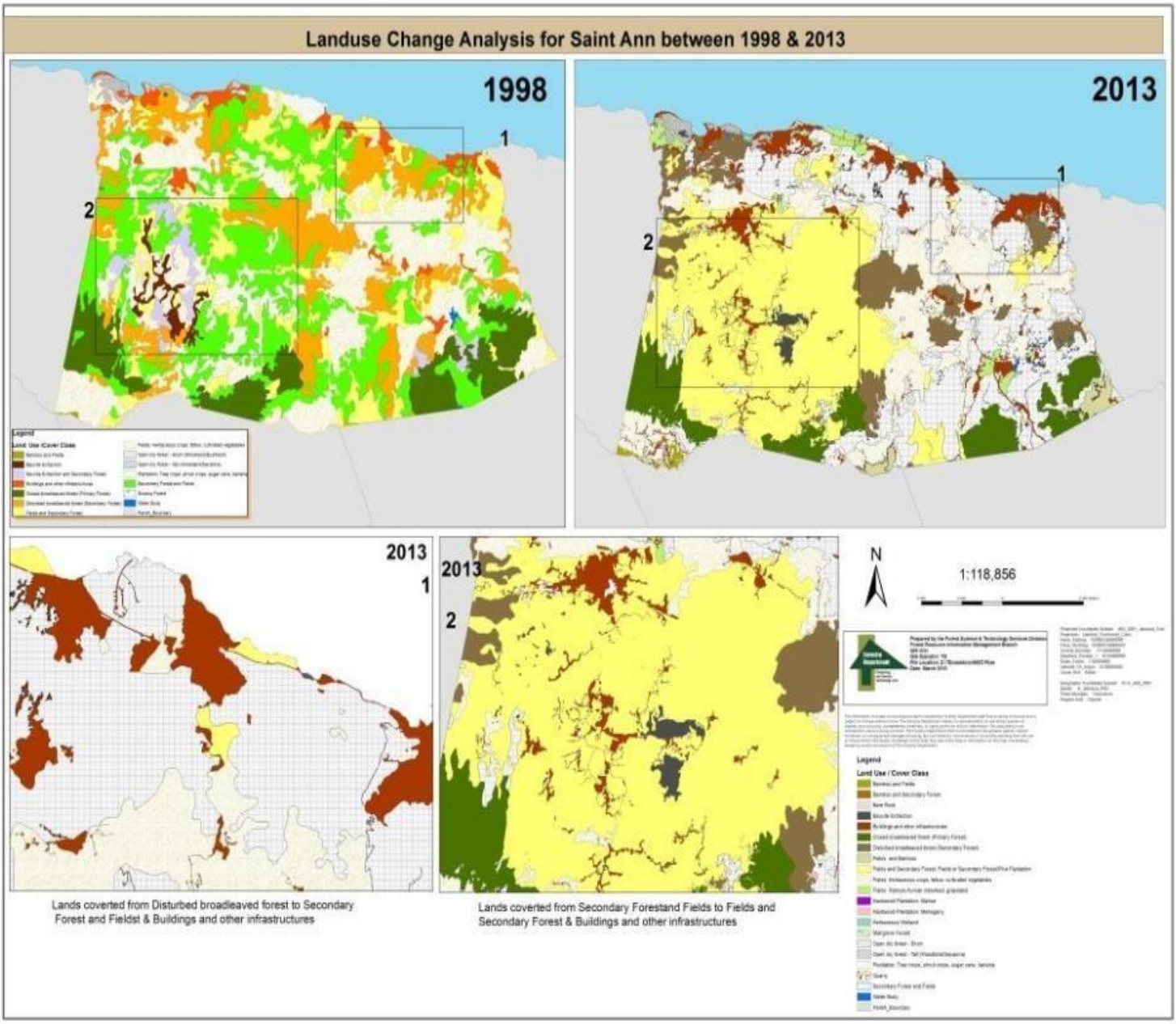


Appendix 3: 2013 Land use/cover map

Forestry Department, LUCA 2013.

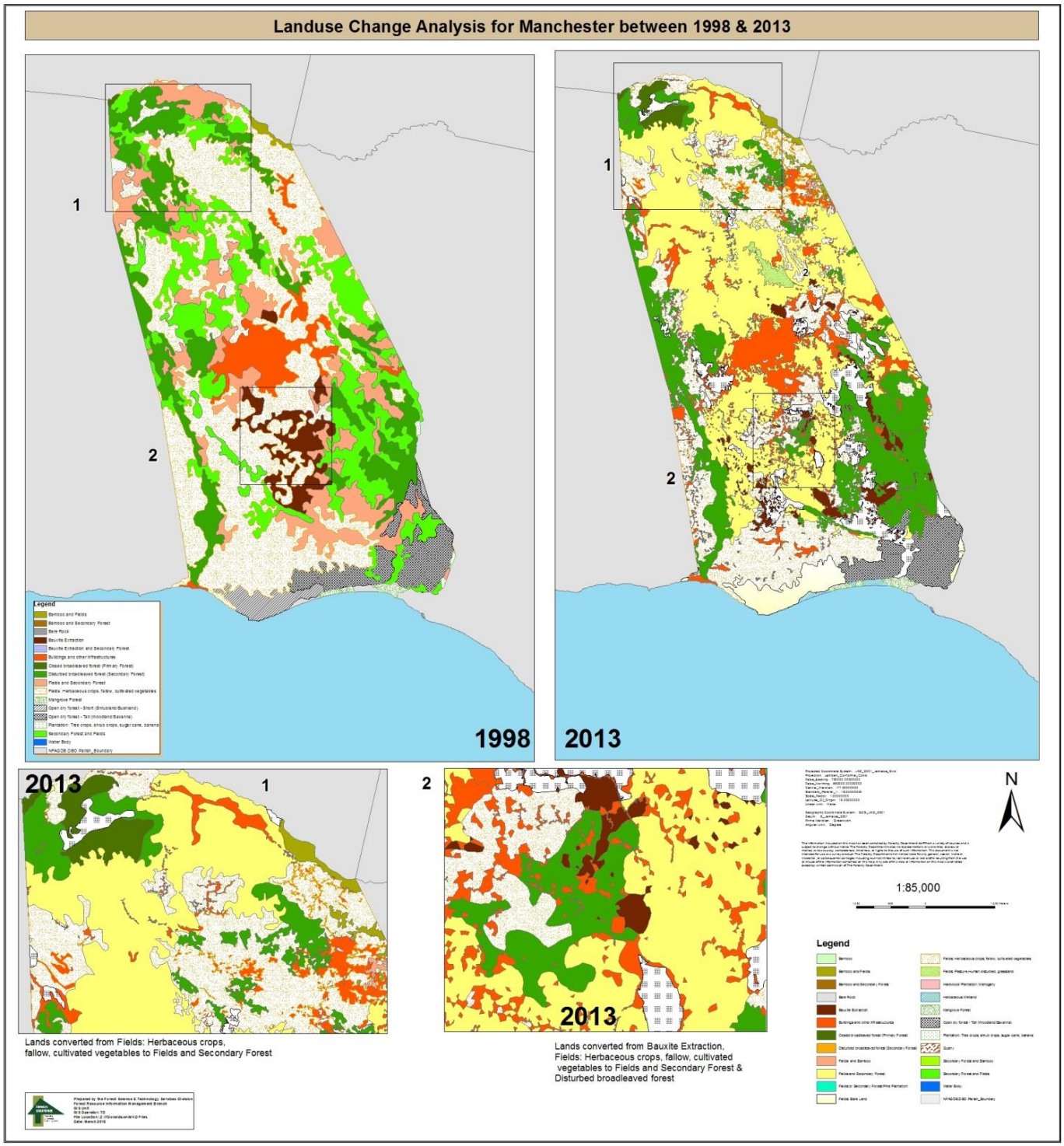


Forestry Department, LUCA 2013.



Appendix 5: Map showing the land uses changes in the parish of Trelawny from 1998-2013.

Forestry Department, LUCA 2013.



Appendix 6: Map showing the land use changes in the Parish of Manchester from 1998-2013.

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