



Forestry Department

Food and Agriculture Organization of the United Nations

**GLOBAL FOREST RESOURCES
ASSESSMENT**

COUNTRY REPORTS

PUERTO RICO

**FRA2005/203
Rome, 2005**



The Forest Resources Assessment Programme

Sustainably managed forests have multiple environmental and socio-economic functions important at the global, national and local scales, and play a vital part in sustainable development. Reliable and up-to-date information on the state of forest resources - not only on area and area change, but also on such variables as growing stock, wood and non-wood products, carbon, protected areas, use of forests for recreation and other services, biological diversity and forests' contribution to national economies - is crucial to support decision-making for policies and programmes in forestry and sustainable development at all levels.

FAO, at the request of its member countries, regularly monitors the world's forests and their management and uses through the Forest Resources Assessment Programme. This country report forms part of the Global Forest Resources Assessment 2005 (FRA 2005), which is the most comprehensive assessment to date. More than 800 people have been involved, including 172 national correspondents and their colleagues, an Advisory Group, international experts, FAO staff, consultants and volunteers. Information has been collated from 229 countries and territories for three points in time: 1990, 2000 and 2005.

The reporting framework for FRA 2005 is based on the thematic elements of sustainable forest management acknowledged in intergovernmental forest-related fora and includes more than 40 variables related to the extent, condition, uses and values of forest resources. More information on the FRA 2005 process and the results - including all the country reports - is available on the FRA 2005 Web site (www.fao.org/forestry/fra2005).

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The Global Forest Resources Assessment 2005 Country Report Series is designed to document and make available the information forming the basis for the FRA 2005 reports. The Country Reports have been compiled by officially nominated country correspondents in collaboration with FAO staff. Prior to finalisation, these reports were subject to validation by forestry authorities in the respective countries.

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This country report comprises only the following national reporting tables:

- Table T1 – Extent of Forest and Other wooded land
- Table T5 – Growing stock
- Table T6 – Biomass stock
- Table T7 – Carbon stock
- Table T9 – Diversity of tree species

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1 Table T1 – Extent of Forest and Other wooded land

1.1 FRA 2005 Categories and definitions

Category	Definition
Forest	Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds <i>in situ</i> . It does not include land that is predominantly under agricultural or urban land use.
Other wooded land	Land not classified as “Forest”, spanning more than 0.5 hectares; with trees higher than 5 meters and a canopy cover of 5-10 percent, or trees able to reach these thresholds <i>in situ</i> ; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use.
Other land	All land that is not classified as “Forest” or “Other wooded land”.
Other land with tree cover (Subordinated to “Other land”)	Land classified as “Other land”, spanning more than 0.5 hectares with a canopy cover of more than 10 percent of trees able to reach a height of 5 meters at maturity.
Inland water bodies	Inland water bodies generally include major rivers, lakes and water reservoirs.

1.2 National data

Data sources

References to sources of information	Quality (H/M/L)	Variable(s)	Year(s)	Additional comments
Kennaway, T. & Helmer, E.H. (unpublished data) International Institute of Tropical Forestry and Colorado State University	H		1991	Landsat ETM+ satellite image classification
Kennaway, T. & Helmer, E.H. (unpublished data) International Institute of Tropical Forestry and Colorado State University	H		2000	Landsat ETM+ satellite image classification

Classification and definitions

National class	Definition
Lower montane forest (1991 and 2000)	Submontane evergreen tall, elfin and sierra palm cloud forest (moist, wet, rain)
Dry forest (1991 and 2000)	Includes the following forest types: Lowland drought deciduous open woodland/shrubland (dry) ("open" = 25-60% cover) Lowland drought deciduous dense woodland/shrubland (dry) ("dense" = > 60% cover) Lowland drought and semi-deciduous forest and forest shrub on karst and other substrates Lowland drought and semi-deciduous sclerophyllous forest with succulents on serpentine substrate
Moist forest (1991 and 2000)	Lowland seasonal evergreen and semi-deciduous forest and forest/shrub on karst substrate

	Lowland seasonal evergreen coconut palm forest Lowland and submontane evergreen and seasonal evergreen forest Lowland and submontane evergreen and seasonal evergreen forest on karst substrate
Wet forest (1991 and 2000)	Submontane evergreen sclerophyllous forest on serpentine substrate Seasonally flooded forest (Pterocarpus swamp)
Mangrove (1991 and 2000)	Tidally and semi-permanently flooded evergreen sclerophyllous forest

Original data

These estimates are based on unpublished Landsat ETM+ satellite image classification with dates centered around the years 1991 and 2000. Estimates include the mainland island of Puerto Rico and the outlying Puerto Rican islands of Vieques and Culebra.

The definition of forest land used by Kennaway and Helmer is land with $\geq 25\%$ cover of woody vegetation that consists of trees or trees and shrubs.

1.3 Analysis and processing of national data

Calibration

A correction factor was calculated to increase forest area estimates made by Kennaway and Helmer, which had a total land area for Puerto Rico of 881,174.43 ha, to forest area estimates calibrated to the greater land area estimate from FAO STAT (887,000.00 ha).

All forest area estimates made by Kennaway and Helmer were multiplied by the correction factor (1.006611143).

Kennaway and Helmer land area	FAO STAT land area	Correction factor
881,174.43	887,000.00	1.0066

Estimation and forecasting

Forest area estimates from Kennaway and Helmer for 1991 and 2000 were multiplied by the correction factor described in section 1.3.1, by forest type. Then, an annual rate of change (ha/yr) was calculated for each forest type. The annual rate of change for each forest type was multiplied by 5 years and that amount added to that forest type's area in 2000 to forecast forest area in 2005. The rate of change was also subtracted from the 1991 forest area estimate to derive a 1990 forest area estimate.

	1991 forest area (ha)	2000 forest area (ha)	Annual rate of change (ha/yr)	Estimated 2005 forest area (ha)	Estimated 1990 forest area (ha)
Dry	69,983	80,061	1,120	85,660	68,863
Moist	295,401	289,820	-620	286,719	296,021
Wet	5,486	5,449	-4	5,428	5,490
Lower montane	25,257	22,646	-290	21,195	25,547
Mangrove	8,130	8,870	82	9,281	8,048
Totals (ha)	404,257	406,846	288	408,284	403,969
Totals (1000 ha)	404	407	-	408	404

1.4 Reclassification into FRA 2005 classes

The definition of forest land used by Kennaway and Helmer is land with $\geq 25\%$ cover of woody vegetation that consists of trees or trees and shrubs.

1.5 Data for National reporting table T1

FRA 2005 Categories	Area (1000 hectares)		
	1990	2000	2005
Forest	404	407	408
Other wooded land	NDA	NDA	NDA
Other land	483	480	479
...of which with tree cover ¹⁾	NDA	NDA	NDA
Inland water bodies	8.00	8.00	8.00
TOTAL	895	895	895

1) Area of “Other land with tree cover” is included in the area reported under “Other land” and should therefore be excluded when calculating the total area for the country.

1.6 Comments to National reporting table T1

Note that the 1990 forest area estimates (403,969 ha) derived from Kennaway and Helmer’s Landsat ETM+ satellite image classification differs substantially from the forest area estimates published in Franco et al. 1997 (287,000 ha) and used in FRA 2000. There are two reasons for these differences.

First, these new estimates include the islands of Vieques and Culebra, which were excluded from the forest inventory of Franco et al. (1997). Including Vieques and Culebra adds 11,640 ha of forest.

Second, it has been proposed that classification of Landsat imagery captures smaller forest fragments that would have been excluded from the forest classification of aerial photographic imagery used in Franco et al. (1997). Further study of this topic will be undertaken.

Literature cited

Franco, P. A., P. L. Weaver, and S. Eggen-McIntosh. 1997. Forest resources of Puerto Rico, 1990. Southern Resource Bulletin SRS-22, USDA Forest Service Southern Research Station, Asheville, North Carolina).

2 Table T5 – Growing stock

2.1 FRA 2005 Categories and definitions

Category	Definition
Growing stock	Volume over bark of all living trees more than X cm in diameter at breast height (or above buttress if these are higher). Includes the stem from ground level or stump height up to a top diameter of Y cm, and may also include branches to a minimum diameter of W cm.
Commercial growing stock	The part of the growing stock of species that are considered as commercial or potentially commercial under current market conditions, and with a diameter at breast height of Z cm or more.

2.2 National data

Data sources

References to sources of information	Quality (H/M/L)	Variable(s)	Year(s)	Additional comments
USDA Forest Service forest inventory completed in 2004	H		2004	Data from a recently completed forest inventory of the US Virgin Islands.
Kennaway, T. & Helmer, E.H. (unpublished data) International Institute of Tropical Forestry and Colorado State University	H		1991	Landsat ETM+ satellite image classification
Kennaway, T. & Helmer, E.H. (unpublished data) International Institute of Tropical Forestry and Colorado State University	H		2000	Landsat ETM+ satellite image classification

Classification and definitions

National class	Definition
Growing stock	All live stems with DBH \geq 12.5 cm except for palm and tree fern species
Growing stock volume	Outside bark stem volume (m ³) of growing stock taken from a 30 cm stump to a 10 cm minimum upper stem diameter. This volume does not include any branch volume, only main bole volume.

Original data

Original data is unpublished at this time, but will be made publicly available through the USDA Forest Service Forest Inventory and Analysis website.

2.3 Analysis and processing of national data

Calibration

Forest area was calibrated to FAO STAT figures as described in the documentation for table T1.

Estimation and forecasting

Mean per hectare growing stock outer bark volume was estimated for dry, moist, wet, lower montane and mangrove forest types. Mean per hectare volume values for each forest type were then multiplied by the number of hectares of each respective forest type for the years 1990, 2000, and 2005. Forest area for each forest type was estimated and forecast as described in the documentation for table T1.

	1990 forest area (ha)	Mean Volume (m ³ /ha)	Total Volume (m ³)
Dry	68,863.22	14.96	1,030,193.80
Moist	296,021.11	75.47	22,340,713.26
Wet	5,490.11	129.44	710,639.98
Lower montane	25,547.11	106.42	2,718,723.56
Mangrove	8,047.78	52.31	420,979.26
Totals	403,969.33		27,221,249.86

	2000 forest area (ha)	Mean Volume (m ³ /ha)	Total Volume (m ³)
Dry	80,061.34	14.96	1,197,717.65
Moist	289,820.30	75.47	21,872,738.04
Wet	5,448.75	129.44	705,286.20
Lower montane	22,645.76	106.42	2,409,961.78
Mangrove	8,869.52	52.31	463,964.59
Totals	406,845.67		26,649,668.26

	2005 forest area (ha)	Mean Volume (m ³ /ha)	Total Volume (m ³)
Dry	85,660.51	14.96	1,281,481.23
Moist	286,719.94	75.47	21,638,753.87
Wet	5,427.96	129.44	702,595.14
Lower montane	21,195.23	106.42	2,255,596.38
Mangrove	9,280.22	52.31	485,448.31
Totals	408,283.87		26,363,874.93

2.4 Reclassification into FRA 2005 classes

The total volume figures above are equivalent to total growing stock.

2.5 Data for National reporting table T5

FRA 2005 Categories	Volume (million cubic meters over bark)					
	Forest			Other wooded land		
	1990	2000	2005	1990	2000	2005
Growing stock	27.22	26.65	26.36	ND	ND	ND
Commercial growing stock	ND	ND	ND	ND	ND	ND

Specification of country threshold values	Unit	Value	Complementary information
1. Minimum diameter at breast height of trees included in Growing stock (X)	cm	12.5 cm	
2. Minimum diameter at the top end of stem (Y) for calculation of Growing stock	cm	10.0 cm	
3. Minimum diameter of branches included in Growing stock (W)	cm	NA	No commercial g.s. estimates made
4. Minimum diameter at breast height of trees in Commercial growing stock (Z)	cm	NA	No commercial g.s. estimates made
5. Volume refers to “Above ground” (AG) or “Above stump” (AS)	AG / AS	AS	
6. Have any of the above thresholds (points 1 to 4) changed since 1990	Yes/No	No	No estimates made in 1990.
7. If yes, then attach a separate note giving details of the change	Attachment	NA	

2.6 Comments to National reporting table T5

Growing stock represents all species of trees with DBH \geq 12.5 cm except for palms and tree ferns. Commercial growing stock is not defined due to the lack of comprehensively defined commercial markets for wood products in Puerto Rico.

3 Table T6 – Biomass stock

3.1 FRA 2005 Categories and definitions

Category	Definition
Above-ground biomass	All living biomass above the soil including stem, stump, branches, bark, seeds, and foliage.
Below-ground biomass	All living biomass of live roots. Fine roots of less than 2mm diameter are excluded because these often cannot be distinguished empirically from soil organic matter or litter.
Dead wood biomass	All non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter or any other diameter used by the country.

3.2 National data

Data sources

References to sources of information	Quality (H/M/L)	Variable(s)	Year(s)	Additional comments
USDA Forest Service forest inventory completed in 2004	H		2004	Data from a recently completed forest inventory of the US Virgin Islands.
Kennaway, T. & Helmer, E.H. (unpublished data) International Institute of Tropical Forestry and Colorado State University	H		1991	Landsat ETM+ satellite image classification
Kennaway, T. & Helmer, E.H. (unpublished data) International Institute of Tropical Forestry and Colorado State University	H		2000	Landsat ETM+ satellite image classification

Classification and definitions

National class	Definition
Above-ground biomass	Total biomass in oven-dry kilograms of all live above-ground tree parts, including foliage, as estimated from regression equations that predict above-ground biomass from individual tree DBH and total height measurements. Estimated for all trees with DBH \geq 2.5 cm.
Below-ground biomass	Total biomass in oven-dry kilograms of all live below-ground tree parts, as estimated from a regression equation modelling the relationship between above-ground biomass and below-ground biomass. Estimated for all trees with DBH \geq 2.5 cm.

Original data

Original data is unpublished at this time, but will be made publicly available through the USDA Forest Service Forest Inventory and Analysis website.

3.3 Analysis and processing of national data

Calibration

Forest area was calibrated to FAO STAT figures as described in the documentation for table T1.

Estimation and forecasting

Mean per hectare growing above (AGB) and below (BGB)-ground biomass were estimated for dry, moist, wet, lower montane, and mangrove forest types. Average per hectare AGB and BGB values for each forest type were then multiplied by the number of hectares of each respective forest category for the years 1990, 2000, and 2005. Forest area for each forest type was estimated and forecast as described in the documentation for table T1.

	1990 forest area (ha)	AGB (Mg/ha)	Total AGB (Mg)	BGB (Mg/ha)	Total BGB (Mg)
Dry	68,863.22	37.73	2,598,209.37	8.74	601,864.56
Moist	296,021.11	97.83	28,959,745.30	18.2	5,387,584.22
Wet	5,490.11	101.72	558,454.10	18.33	100,633.74
Lower montane	25,547.11	143.59	3,668,309.68	26.67	681,341.45
Mangrove	8,047.78	58.31	469,265.92	11.57	93,112.79
Totals	403,969.33		36,253,984.38		6,864,536.76

	2000 forest area (ha)	AGB (Mg/ha)	Total AGB (Mg)	BGB (Mg/ha)	Total BGB (Mg)
Dry	80,061.34	37.73	3,021,098.68	8.74	699,383.85
Moist	289,820.30	97.83	28,352,134.50	18.20	5,274,497.59
Wet	5,448.75	101.72	554,254.60	18.33	99,896.22
Lower montane	22,645.76	143.59	3,251,738.80	26.67	603,869.60
Mangrove	8,869.52	58.31	517,220.00	11.57	102,595.54
Totals	406,845.67		35,696,446.58		6,780,242.80

	2005 forest area (ha)	AGB (Mg/ha)	Total AGB (Mg)	BGB (Mg/ha)	Total BGB (Mg)
Dry	85,660.51	37.73	3,232,382.38	8.74	748,295.99
Moist	286,719.94	97.83	28,048,836.60	18.20	5,218,073.48
Wet	5,427.96	101.72	552,140.17	18.33	99,515.12
Lower montane	21,195.23	143.59	3,043,455.50	26.67	565,190.00
Mangrove	9,280.22	58.31	541,169.53	11.57	107,346.16
Totals	408,283.87		35,417,984.18		6,738,420.75

3.4 Reclassification into FRA 2005 classes

3.5 Data for National reporting table T6

FRA 2005 Categories	Biomass (million metric tonnes oven-dry weight)					
	Forest			Other wooded land		
	1990	2000	2005	1990	2000	2005
Above-ground biomass	36.25	35.70	35.42	ND	ND	ND
Below-ground biomass	6.86	6.78	6.74	ND	ND	ND
Dead wood biomass	ND	ND	ND	ND	ND	ND
TOTAL	43.11	42.48	42.16	ND	ND	ND

Thresholds used by the country are the following:

Above-ground biomass (AGB) was calculated for all living trees with DBH \geq 2.5 cm.

3.6 Comments to National reporting table T6

Above-ground biomass (AGB) was calculated for all living trees with DBH \geq 2.5 cm using the following equations.

Lower montane forest, palo colorado forest type equation (Weaver and Gillespie 1992)

$$AGB = 4.7962 + 0.0310 * D_{BH}^2 H_T$$

Subtropical Wet forest (Scatena et al. 1993)

$$AGB = e^{(0.950 * \ln D_{BH}^2 H_T - 3.282)}$$

Subtropical Moist forest (Brown et al. 1989)

$$AGB = e^{(-3.1141 + 0.9719 * \ln D_{BH}^2 H_T)}$$

Subtropical Dry forest (Brown 1997)

$$AGB = e^{(-1.996 + 2.32 * \ln D_{BH}^2)}$$

Sierra palm species *Prestoea montana* for all life zones (Brown 1997)

$$AGB = 10.0 + 6.4 * H_T$$

Mangrove species *Rhizophora mangle* (Cintrón and Schaeffer-Novelli 1984)

$$AGB = [125.957 * (D_{BH}^2 H_T^{0.8557})] / 1000$$

Mangrove species *Laguncularia racemosa* (Cintrón and Schaeffer-Novelli 1984)

$$AGB = [70.0513 * (D_{BH}^2 H_T^{0.9084})] / 1000$$

Mangrove species *Avicennia germinans* (Fromard et al. 1998)

$$AGB = 0.14 * (D_{BH}^{2.4})$$

Below-ground biomass was derived using the equation in (Cairns et al. 1997) for estimating individual tree BGB for tropical forests:

$$BGB = e^{(-1.0587+0.8836 \ln AGB)}$$

Literature cited

- Brown, S. 1997. Estimating biomass and biomass change in tropical forests. A primer. FAO Forestry Paper 134, Food and Agriculture Organization of the United Nations, Rome.
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4 Table T7 – Carbon stock

4.1 FRA 2005 Categories and definitions

Category	Definition
Carbon in above-ground biomass	Carbon in all living biomass above the soil, including stem, stump, branches, bark, seeds, and foliage.
Carbon in below-ground biomass	Carbon in all living biomass of live roots. Fine roots of less than 2 mm diameter are excluded, because these often cannot be distinguished empirically from soil organic matter or litter.
Carbon in dead wood biomass	Carbon in all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter or any other diameter used by the country.
Carbon in litter	Carbon in all non-living biomass with a diameter less than a minimum diameter chose by the country for lying dead (for example 10 cm), in various states of decomposition above the mineral or organic soil. This includes the litter, fomic, and humic layers.
Soil carbon	Organic carbon in mineral and organic soils (including peat) to a specified depth chosen by the country and applied consistently through the time series.

4.2 National data

Data sources

References to sources of information	Quality (H/M/L)	Variable(s)	Year(s)	Additional comments
USDA Forest Service forest inventory completed in 2004	H		2004	Data from a recently completed forest inventory of the Puerto Rico.
Kennaway, T. & Helmer, E.H. (unpublished data) International Institute of Tropical Forestry and Colorado State University	H		1991	Landsat ETM+ satellite image classification
Kennaway, T. & Helmer, E.H. (unpublished data) International Institute of Tropical Forestry and Colorado State University	H		2000	Landsat ETM+ satellite image classification

Classification and definitions

National class	Definition
Above-ground carbon	Total carbon in oven-dry kilograms of all live above-ground tree parts, including stem, stump, branches, bark, seeds, and foliage, as estimated from regression equations that predict above-ground biomass from individual tree DBH and total height measurements, and then multiplying by a factor of 0.5. Estimated for all trees with DBH \geq 2.5 cm.
Below-ground carbon	Total carbon in oven-dry kilograms of all live below-ground tree parts, as estimated from a regression equation modelling the relationship between above-ground biomass and below-ground biomass, then multiplying by a factor of 0.5. Estimated for all trees with DBH \geq 2.5 cm.

Original data

Original data is unpublished at this time, but will be made publicly available through the USDA Forest Service Forest Inventory and Analysis website.

4.3 Analysis and processing of national data

Calibration

Forest area was calibrated to FAO STAT figures as described in the documentation for table T1.

Estimation and forecasting

Forest area for each forest type was estimated and forecast as described in the documentation for table T1.

4.4 Reclassification into FRA 2005 classes

NA

4.5 Data for National reporting table T7

FRA 2005 Categories	Carbon (Million metric tonnes)					
	Forest			Other wooded land		
	1990	2000	2005	1990	2000	2005
Carbon in above-ground biomass	18.13	17.85	17.71	ND	ND	ND
Carbon in below-ground biomass	3.43	3.39	3.37	ND	ND	ND
Sub-total: Carbon in living biomass	21.56	21.24	21.08	ND	ND	ND
Carbon in dead wood	ND	ND	ND	ND	ND	ND
Carbon in litter	ND	ND	ND	ND	ND	ND
Sub-total: Carbon in dead wood and litter	ND	ND	ND	ND	ND	ND
Soil carbon to a depth of _____ cm	ND	ND	ND	ND	ND	ND
TOTAL CARBON	ND	ND	ND	ND	ND	ND

4.6 Comments to National reporting table T7

Carbon in above and below-ground biomass was estimated by multiplying above and below-ground biomass values from table T6 by 0.5.

5 Table T9 – Diversity of tree species

5.1 FRA 2005 Categories and definitions

Category	Definition
Number of native tree species	The total number of native tree species that have been identified within the country.
Number of critically endangered tree species	The number of native tree species that are classified as “Critically endangered” in the IUCN red list.
Number of endangered tree species	The number of native tree species that are classified as “Endangered” in the IUCN red list.
Number of vulnerable tree species	The number of native tree species that are classified as “Vulnerable” in the IUCN red list.

5.2 National data

Data sources

References to sources of information	Quality (H/M/L)	Variable(s)	Year(s)	Additional comments
IUCN Red List of threatened species	H	Vulnerable and endangered species	2000	Secondary source

Classification and definitions

Original data

5.3 Data for National reporting table T9

FRA 2005 Categories	Number of species (year 2000)
Native tree species	NDA
Critically endangered tree species	22
Endangered tree species	16
Vulnerable tree species	16

5.4 Comments to National reporting table T9

The lists of endangered and vulnerable species include all plant species, not only trees.

Critically endangered species:

Auerodendron pauciflorum

Banara vanderbiltii

Buxus vahlii

Callicarpa ampla

Calyptanthes kiaerskovii

Cordia rupicola

Cordia wagnerorum

Cornutia obovata

Eugenia woodburyana
Henriettea membranifolia
Ilex cookii
Leptocereus quadricostatus
Myrcia paganii
Pleodendron macranthum
Psidium sintenisii
Solanum drymophilum
Styrax portoricensis
Ternstroemia luquillensis
Ternstroemia subsessilis
Trichilia triacantha
Xylosma pachyphyllum
Zamia portoricensis

Endangered species:

Brunfelsia portoricensis
Calypttranthes portoricensis
Calypttranthes thomasiana
Coccoloba rugosa
Erythrina eggersii
Eugenia haematocarpa
Goetzea elegans
Guaiacum officinale
Guaiacum sanctum
Ilex sintenisii
Maytenus cymosa
Nectandra krugii
Pouteria hotteana
Schoepfia arenaria
Stahlia monosperma
Zanthoxylum thomasianum

Vulnerable species:

Antirhea portoricensis
Antirhea sintenisii
Calypttranthes luquillensis
Chrysophyllum pauciflorum
Gaussia attenuata
Juglans jamaicensis
Manilkara pleeana
Manilkara valenzuelana
Mappia racemosa
Marlierea sintenisii
Maytenus ponceana
Picrasma excelsa
Schefflera gleasonii
Tabernaemontana oppositifolia
Zamia amblyphyllidia
Zanthoxylum flavum