Mariana Islands Rates of Change

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Introduction

The following report evaluates rates of change for Habitats identified for Habitat Status Assessments (HSAs) by the Pacific Islands Fish and Wildlife Office's Mariana Islands Geographic Team. These rates are intended for use in identifying changes related to the status quo future scenario as required under the HSA. It utilizes available landcover/vegetation maps for Guam, Rota, Tinian, and Saipan from multiple time periods to identify how each Habitat changes over time. The following Habitats were evaluated in this project: Developed, Native Forest, Monoculture Forest, *Luecaena* Forest, Secondary/Mixed Forest, Coastal, Savanna/Grassland, Scrub/Grass, and Wetlands.

Methods

Guam

Rates of change on Guam were estimated using the 2005 to 2011 change layer from the Coastal Change Analysis Program (CCAP; NOAA 2010, 2017). This layer identifies areas where landcover types changed and stayed the same from 2005 to 2011. Unfortunately, the landcover types used in the CCAP analysis do not match up directly with all of the Habitats used in the Mariana Islands HSAs. Specifically, the CCAP layer does not identify Coastal, Native Forest, Monoculture Forest, Leucaena Forest, Secondary Forest, and Savanna. Therefore, the CCAP categories had to be re-classified using Forest Service maps of the island from 2005 and 2012 (Liu and Fischer 2006a; Liu 2014) and 2016 landcover maps from Amidon et al. (2017). The sections below outline the procedures used for each specific habitat.

Developed – The Developed habitat was identified as all areas classified as Developed Open Space, Impervious Surface, and Cultivated. All areas identified as occurring in one of these classes in 2005 or 2011 were assigned to the Developed habitat for that year.

Coastal – The Coastal habitat includes sand beaches, mangroves, and strand areas. CCAP identifies sand beaches as Unconsolidated Shoreline and mangroves as Estuarine Scrub/Shrub and Estuarine Forest on Guam. Therefore, these areas were identified as part of the Coastal habitat. However, strand areas are lumped into the Scrub/Shrub CCAP class which also includes scrub areas outside the coastal zone. Strand vegetation was identified as Scrub/Shrub CCAP areas that overlapped with strand areas identified in the 2005 Forest Service map of Guam and the 2016 vegetation maps. Unfortunately, 2012 Forest Service maps did not include a strand category.

Savanna – The Savanna habitat is included under the CCAP Grassland category which also includes non-Savanna grass and herbaceous areas. Savanna habitat was identified in the CCAP layer as Grassland that overlapped with savanna areas identified in the 2005 Forest Service map of Guam and the 2016 vegetation maps. Unfortunately, 2012 Forest Service maps did not include a strand category.

Scrub/Grass – The Scrub/Grass habitat includes scrub/shrub and herbaceous areas that are not classified as Savanna or Coastal. Scrub/Grass is included in the Scrub/Shrub, Grassland, and Pasture CCAP categories and was identified as all areas in these classes that did not fall in the Savanna and Coastal habitats above.

Native, Secondary, Monoculture and Leucaena Forests – All forests on Guam are included in the Evergreen Forest CCAP category. Each of these forest types were identified in the CCAP layer using the 2012 and 2005 Forest Service vegetation maps of Guam. Forests which could not be classified as one of these four types were distributed equally among each type.

Wetlands – The Wetland habitat was identified as all areas classified as Palustrine Forested Wetland, Palustrine Scrub/Shrub Wetland, Palustrine Emergent Wetland, Palustrine Aquatic Bed, Estuarine Aquatic Bed, Estuarine Emergent Wetland, and Water. All areas identified as occurring in one of these classes in 2005 or 2011 were assigned to the Wetland habitat for that year.

Once the CCAP change layer was classified into the appropriate HSA habitats, acreages for each transition between habitats was calculated. These acreages were then placed in a transition matrix (Appendix A) to calculate the total increases and decreases in each habitat type over the six year period of the CCAP layer. These total increases and decreases were divided by six (i.e., the number of years between 2011 and 2005) to obtain annual rates of increase and decrease by habitat. These rates were then projected to 2035, using the 2016 veg map as the baseline, to calculate changes in each habitat over the foreseeable future.

Rota, Tinian and Saipan

Coastal Change Analysis Program change layers for Rota, Tinian, and Saipan were limited to data layers for Rota and Saipan for the period from the mid-1940s to 2005. Due to the large time span and the large changes in landcover that occurred after World War II on these islands (Fosberg 1960), these change layers were not used for the analysis. Instead, overall changes in landcover were evaluated using tabular data from the 1984, 2005, and 2016 vegetation surveys of each island. Due to variations in the mediums (e.g., satellite imagery, aerial photographs) used to create each of these vegetation estimates and orthorectification error it was not possible to compare each time period directly. Therefore, percentage of each habitat on the island over the different survey periods was evaluated instead of direct comparisons of acreage. In addition, landcover classifications for each survey varied and not all categories were comparable. For example, the 2005 vegetation maps by Liu and Fisher (2006b) included three Developed Habitat categories: Cropland, Urban and Built-up, and Urban Vegetation. Evaluation of the maps indicated that the Urban Vegetation category also included forested areas that would have been classified differently in the other assessments. This lead to an inflated estimate of developed areas in 2005 which affects the overall trend. Similar issues were also encountered with the Luecaena Forest, Secondary Forest, Monoculture Forest, Native Forest, Scrub/Herbaceous, and Savanna Habitats using the 1984 vegetation data from Falanruw et al. (1989). Therefore, not all vegetation categories and years were used in the analysis.

Appendix B summarizes the various landcover/vegetation types from each survey and how they were used in evaluating rates of change for each Habitat type. The percentage of each Habitat on an island in two or more years was evaluated for trends using simple linear regression in R. Percent of island in the Habitat type was the dependent variable while year was the independent variable. Because each Habitat is evaluated independently the rates of changes for all Habitats taken collectively could cause the island to grow or shrink. In order to prevent this from occurring the rates of change were standardized based on the percentage of the island in each Habitat.

Results and Conclusion

Tables 1-2 and 4-10 summarize the change in acres and percent of island for each Habitat on Guam, Rota, Tinian, and Saipan from 2016 to 2035. These estimates represent the status quo of habitat change on each island. A brief discussion on the results for each habitat is provided below along with some information on whether change is likely or associated with mapping error or misclassification. The Conclusion section summarizes the expected changes by island and provides recommendations for future assessments.

Coastal

Table 1 summarizes the changes in acres and percent of island for the Coastal habitat on Guam, Rota, Tinian, and Saipan from 2016 to 2035. The Guam estimate is based on CCAP data from 2005 to 2011 (NOAA 2010) while the changes on the remaining islands are based on 2005 and 2016 data (Liu and Fisher 2006, Amidon et al. 2017). No change is expected on Guam while an increase in Coastal habitat is predicted for Rota, Tinian, and Saipan (Table 1). The changes on Rota, Tinian, and Saipan are likely due to mapping error and inconsistencies in classification because increases in coastal habitat are unlikely. Therefore, we expect little to no change in Coastal habitat in 2035 under the status quo scenario for Guam, Rota, Tinian, or Saipan.

Table 1. *Estimated acreages and percent of island in coastal habitat currently (2016) and in the foreseeable future (2035) for the islands of Guam, Rota, Tinian, and Saipan. Percent (%) change is the difference between the % of land in 2035 and 2016. No data is currently available for projecting habitat change in the foreseeable future for the remaining islands in the archipelago.*

Island	Current (2016)		Future (2035)		% Change 2016 to 2035
	Acres	% of Land	Acres	% of Land	
Guam	955	1%	955	1%	0%
Rota	375	2%	443	2%	18%
Tinian	636	3%	732	3%	15%
Saipan	474	2%	687	2%	45%

Developed

Table 2 summarizes the changes in acres and percent of island for the Developed habitat on Guam, Rota, Tinian, and Saipan from 2016 to 2035. The Guam estimate is based on CCAP data from 2005 to 2011 (NOAA 2010) while the changes on the remaining islands are based on 1984 and 2016 data (Falanruw et al. 1989, Amidon et al. 2017). No change is expected on Guam while an increase in Developed is expected for Rota, Tinian, and Saipan (Table 2). Though Guam showed no overall increase in development it should be noted that development is occurring. Table 3 shows an increase in the human population on Guam between 2000 and 2010 while Appendix A shows other Habitats being converted to Developed. However, this development is being counteracted by conversion of Developed areas to Scrub/Herbaceous as they are abandoned. The increases in Developed areas on Rota, Tinian, and Saipan are consistent with what would be expected for those islands, especially considering that the change is based on estimates of development in 1984 and 2016, a period of large population increases on all three islands (Table 3). Saipan shows the largest increase in human population and the largest increase in acreage of Developed habitat (Table 3 and Table 2, respectively). Rota and Tinian show population increases as well but at an order of magnitude less than those occurring on Saipan (Table 3).

Table 2. *Estimated acreages and percent of island in developed habitat currently (2016) and in the foreseeable future (2035) for the islands of Guam, Rota, Tinian, and Saipan. Percent (%) change is the difference between the % of land in 2035 and 2016. No data is currently available for projecting habitat change in the foreseeable future for the remaining islands in the archipelago.*

	Current (2016)		Future (2035)		% Change 2016 to 2035
Island	Acres	% of Land	Acres	% of Land	
Guam	28,705	21%	28,701	21%	-<1%
Rota	1,163	5%	1,574	7%	35%
Tinian	1,533	6%	1,996	8%	30%
Saipan	6,722	23%	9,173	31%	36%

Table 3. *Census estimates of the human population on the islands on Guam, Rota, Tinian, Saipan, and the Northern Islands of the CNMI. References for population estimates are noted and totals for the CNMI without a reference are the sum of the estimates from Rota, Tinian, Saipan, and the Northern Islands.*

		CNMI				
Year	Guam	Rota	Tinian	Saipan	Northern Islands	CNMI Total
1920	13,275[1]	-	-	-	-	5,159[8]
1925	-	-	-	-	-	8,800[8]
1930	18,509[2]	-	-	-	-	19,496[8]
1935	-	-	-	-	-	44,043[8]
1940	22,290[2]	-	-	-	-	-
1950	59,498[2]	-	-	-	-	6,286
1958	-	969[5]	405[5]	7,321[5]	262[5]	8,290
1960	67,044[2]	-	-	-	-	-
1970	84,996[2]	895[5]	710[5]	7,967[5]	68[5]	9,640
1980	105,979[2]	1,261[5]	866[5]	14,549[5]	104[5]	16,780
1990	133,152[3]	2,295[6]	2,118[6]	38,896[6]	6[6]	43,315
2000	154,805[4]	3,283[7]	3,540[7]	62,392[7]	6[7]	69,221
2010	159,358[4]	2,527[7]	3,136[7]	48,220[7]	0[7]	53,883

[1] U.S. Census 1932, [2] U.S. Census 1982a, [3] U.S. Census 1992a, [4] U.S. Census 2010a, [5] U.S. Census 1982b, [6] U.S. Census 1992b, [7] U.S. Census 2010b, [8] Unknown N.D.

Forest

Tables 4-7 summarizes the changes in acres and percent of island for the different forest habitats on Guam, Rota, Tinian, and Saipan from 2016 to 2035. The Guam estimates are based on CCAP data from 2005 to 2011 (NOAA 2010) while the changes on the remaining islands are based on 2005 and 2016 data (Liu and Fisher 2006, Amidon et al. 2017). No change in Native Forest is expected on Guam, a moderate decrease is expected on Rota, a large decrease is expected on Tinian, and a large increase is expected on Saipan (Table 4). The increase on Saipan is likely due to inconsistencies in classification. Native Forest on Saipan is highly fragmented and has not been mapped well over the various assessments. Therefore, we consider that increases in Native Forest on Saipan are unlikely. The decline on Tinian is also likely to be due, in part, to classification inconsistencies. However, some decreases may occur on Tinian. Declines in Native Forest are expected on Rota as areas identified for homestead sites continued to be cleared.

Table 4. *Estimated acreages and percent of island in native forest habitat currently (2016) and in the foreseeable future (2035) for the islands of Guam, Rota, Tinian, and Saipan. Percent (%) change is the difference between the % of land in 2035 and 2016. No data is currently available for projecting habitat change in the foreseeable future for the remaining islands in the archipelago.*

	Current (2016)		Future (2035)		% Change 2016 to 2035
Island	Acres	% of Land	Acres	% of Land	
Guam	21,668	16%	21,681	16%	<1%
Rota	10,052	47%	7,207	34%	-28%
Tinian	1,067	4%	471	2%	-56%
Saipan	427	1%	637	2%	49%

Secondary Forest is projected to remain stable on Guam and Rota and decline on Tinian and Saipan (Table 5). A decline on Saipan is expected as a large proportion of the island is Secondary Forest (Table 5) and the increases in Developed (see above) is likely associated with loses in this habitat. A decline on Tinian is also expected as approximately a quarter of the island is in this habitat (Table 5) and increases in Scrub/Herbaceous and Developed habitats (see below) are likely related to the loss of this habitat.

Table 5. *Estimated acreages and percent of island in secondary forest habitat currently (2016) and in the foreseeable future (2035) for the islands of Guam, Rota, Tinian, and Saipan. Percent (%) change is the difference between the % of land in 2035 and 2016. No data is currently available for projecting habitat change in the foreseeable future for the remaining islands in the archipelago.*

	Current (2016)		Future (2035)		% Change 2016 to 2035
Island	Acres	% of Land	Acres	% of Land	
Guam	33,270	25%	32,946	25%	-1%
Rota	2,163	10%	2,212	10%	2%
Tinian	6,202	25%	4,594	18%	-26%
Saipan	10,656	36%	6,369	22%	-40%

Based on the analysis, Monoculture Forest is projected to remain stable on Guam and increase on the remaining islands (Table 6). However, the increases on Rota, Tinian, and Saipan in this habitat are likely related to mapping error and inconsistent classification as new plantings of monoculture forest are not regularly encountered on these islands. The changes on Saipan and Rota are relatively small and consistent with mapping error. The increase on Tinian is substantial. However, review of the imagery from 2005 and 2016 indicates that the increase in this habitat is likely due to misclassification. The Monoculture Forest in the 2016 map was present in the 2005 imagery and was likely misclassified due to the lower resolution of the imagery. Therefore, we conclude that changes in Monoculture Forest are unlikely under the status quo scenario.

Table 6. *Estimated acreages and percent of island in monoculture forest habitat currently (2016) and in the foreseeable future (2035) for the islands of Guam, Rota, Tinian, and Saipan. Percent (%) change is the difference between the % of land in 2035 and 2016. No data is currently available for projecting habitat change in the foreseeable future for the remaining islands in the archipelago.*

Island	Current (2016)		Future (2035)		% Change 2016 to 2035
	Acres	% of Land	Acres	% of Land	
Guam	1,709	1%	1,701	1%	0%
Rota	667	3%	772	4%	16%
Tinian	888	4%	1,676	7%	89%
Saipan	526	2%	741	3%	41%

The analysis indicates that *Leucanea* Forest is projected to remain stable on Saipan, increase slightly on Guam, and decrease on Rota and Tinian (Table 7). The projected decline on Rota is likely related, in part, to mapping and classification errors. Review of the imagery from 2016 and 2005 indicate that the extent of this forest type was consistent between both images and that the decline may be related to over estimates in the 2005 maps. The decline on Tinian is expected as approximately 1/3rd of the island is classified as this habitat (Table 7) and increases in Developed and Scrub/Herbaceous habitats (see associated sections) on this island are likely related to the loss of this habitat.

Table 7. *Estimated acreages and percent of island in Leucaena forest habitat currently (2016) and in the foreseeable future (2035) for the islands of Guam, Rota, Tinian, and Saipan. Percent (%) change is the difference between the % of land in 2035 and 2016. No data is currently available for projecting habitat change in the foreseeable future for the remaining islands in the archipelago.*

Island	Current (2016)		Future (2035)		% Change 2016 to 2035
	Acres	% of Land	Acres	% of Land	
Guam	4,914	4%	5,137	4%	5%
Rota	229	1%	34	0%	-85%
Tinian	8,279	33%	7,567	30%	-9%
Saipan	5,492	19%	5,709	19%	4%

Savanna/Swordgrass

This analysis projects an increase in Savanna on Rota and a decline on Saipan (Table 8). Savanna is expected to remain relatively stable on Guam. Savanna is sometimes lumped with Scrub/Herbaceous so some of these expected changes are, in part, related to misclassification errors. The increase on Rota appears to be related to conversion of bare areas into this habitat after burning. The declines on Saipan appears to be related to conversion to Developed habitat and burning.

Table 8. *Estimated acreages and percent of island in savanna habitat currently (2016) and in the foreseeable future (2035) for the islands of Guam, Rota, Tinian, and Saipan. Percent (%) change is the difference between the % of land in 2035 and 2016. No data is currently available for projecting habitat change in the foreseeable future for the remaining islands in the archipelago.*

	Current (2016)		**Future (2035)**		**% Change 2016 to 2035**
Island	**Acres**	**% of Land**	**Acres**	**% of Land**	
Guam	21,770	16%	21,506	16%	-1%
Rota	224	1%	596	3%	166%
Tinian	0	0%	0	0%	0%
Saipan	1,194	4%	998	3%	-16%

Scrub/Grass

Based on this assessment, Scrub/Grass is projected to increase on all islands except Guam, where only a slight increase is expected (Table 9). The majority of the increase in this this habitat type appears to be associated with conversion from forested habitats. For example, Secondary and Leucaena Forest on Tinian has primarily been converted to this type on Tinian while Native Forest has been converted to this type on Rota. Though not a significant change, the slight increase in this habitat on Guam appears to be associated with abandonment of developed areas (Appendix A).

Table 9. *Estimated acreages and percent of island in scrub/grass habitat currently (2016) and in the foreseeable future (2035) for the islands of Guam, Rota, Tinian, and Saipan. Percent (%) change is the difference between the % of land in 2035 and 2016. No data is currently available for projecting habitat change in the foreseeable future for the remaining islands in the archipelago.*

	Current (2016)		**Future (2035)**		**% Change 2016 to 2035**
Island	**Acres**	**% of Land**	**Acres**	**% of Land**	
Guam	17,748	13%	17,885	13%	1%
Rota	5,902	28%	7,695	36%	30%
Tinian	6,016	24%	7,627	31%	27%
Saipan	3,149	11%	4,300	15%	37%

Wetland

This assessment showed little expected change in the Wetland habitat on Guam in 2035 (Table 10). A slight increase is shown for Rota. However, as wetlands don't naturally occur on Rota this would be associated with man-made wetlands. Tinian and Saipan showed slight declines in wetlands, which may occur as areas are developed or cleared. However, the changes are small in terms of acreage and may be due to mapping and misclassification error.

Table 10. Estimated acreages and percent of island in wetland habitat currently (2016) and in the foreseeable future (2035) for the islands of Guam, Rota, Tinian, and Saipan. Percent (%) change is the difference between the % of land in 2035 and 2016. No data is currently available for projecting habitat change in the foreseeable future for the remaining islands in the archipelago.

Island	Current (2016)		Future (2035)		% Change 2016 to 2035
	Acres	% of Land	Acres	% of Land	
Guam	1,094	1%	1,094	1%	0%
Rota	75	0%	109	1%	46%
Tinian	35	0%	31	0%	-11%
Saipan	452	2%	417	1%	-8%

Conclusion

A wide variety of potential changes in each habitat are expected on the different islands. However, the main changes in habitats expected by island as part of the status quo include:

- Guam is projected to experience a slight loss of Secondary Forest and Savanna and a slight increase in Scrub/Grass and *Leucanea* Forest in the foreseeable future.
- Rota is projected to see an increase in Developed and Scrub/Grass and loss of Native Forest as it's converted to those habitats.
- Tinian is projected to see the loss of Native, Secondary and Leucaena Forests as they're converted to Scrub/Grass and Developed habitats.
- Saipan is projected to see primarily loss of Secondary Forest as it's converted to Developed and Scrub/Grass.

One of the challenges of this assessment was mapping and misclassification errors associated with the various landcover assessments. This was especially true for the data used to assess changes on Rota, Tinian, and Saipan. The CCAP change data used for Guam provided the most consistent assessment as the data has been assessed for classification and mapping errors. However, the landcover categories used for the CCAP data were too broad and wouldn't allow direct translation to the habitats used in the HSAs. Therefore, these broad categories had to be cross-walked to the habitats using other vegetation assessments. This is expected to have caused misclassification and mapping errors to creep into the assessment. We recommend that future assessments rely on the CCAP data but that additional time be factored into the assessment to allow subclassification of the CCAP data into the habitat types used in this assessment using the original imagery. For example, the 2005 and 2011 imagery used to create the CCAP layers could be used to more accurately subdivide Evergreen Forest into the different forest types used in this assessment. We also recommend that, if possible, a longer time period be assessed with the CCAP data. The six year period used for Guam only showed slight changes while a longer term dataset may have showed larger scale changes which would have been more comparable to the data from Rota, Tinian and Saipan.

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Appendices

Appendix A. Habitat transition matrix for the island of Guam from 2005 to 2011 using CCAP change data with vegetation classifications from 2005, 2012, and 2016 vegetation maps (Amidon et al. 2017, Liu 2014, Liu and Fisher 2006b). All acreages are in acres.

	Barren	Developed	Scrub/Grass	Coastal	Savanna	Evergreen Forest	Lucaena Forest	Monoculture Forest	Secondary Forest	Native Forest	Wetland	Water	Marine	Sum 2005	% Isle 2005
Barren	1713	329	504	2	1301	0	22	21	47	24	5	14	0	3983	3%
Developed	267	25684	876	0	83	0	72	4	298	20	9	11	0	27324	19%
Scrub/Grass	254	736	14354	3	244	0	589	48	686	564	25	17	0	17521	12%
Coastal	6	2	3	466	0	0	2	3	5	1	4	7	0	500	0%
Savanna	148	73	732	0	18944	0	2	14	72	39	14	4	0	20043	14%
Evergreen Forest	84	572	237	0	104	0	0	0	0	0	4	7	0	1008	1%
Lucaena Forest	40	94	65	0	0	0	4336	0	0	0	0	0	0	4535	3%
Monoculture Forest	1	1	8	0	0	0	0	1104	0	0	0	0	0	1114	1%
Secondary Forest	112	556	285	0	0	0	0	0	27983	0	5	3	0	28943	20%
Native Forest	42	46	236	0	0	0	0	0	0	24807	1	18	0	25150	17%
Wetland	11	22	0	3	0	0	0	0	0	0	3781	23	0	3840	3%
Water	15	10	10	25	0	0	1	1	3	2	3	276	0	344	0%
Marine	0	0	0	0	0	0	0	0	0	0	0	0	12677	12677	9%
Sum 2011	2693	28126	17310	499	20676	0	5023	1194	29094	25457	3851	380	12677	146980	1
% Isle 2011	2%	19%	12%	0%	14%	0%	3%	1%	20%	17%	3%	0%	9%	100%	

Appendix B. Cross-walk table of landcover/vegetation type by survey and HSA Habitat and how the data was evaluated to determine rates of change on Rota, Tinian, and Saipan.

HSA Habitat	Vegetation/Landcover Class	Survey Year	Source
Bare	Bare Rock	2016	Amidon et al. 2017
	Bare Soil/Gravel	2016	Amidon et al. 2017
	Sand	2016	Amidon et al. 2017
	Barren/Sandy Beach/Bare Rocks	2005	Liu and Fisher 2006
	Barren	1984	Falanruw et al. 1989
Coastal	Coastal Scrub	2016	Amidon et al. 2017
	Mangrove Wetland	2016	Amidon et al. 2017
	Mangrove Swamp	2005	Liu and Fisher 2006
	Strand	2005	Liu and Fisher 2006
Coastal (Not Analyzed)	Strand	1984	Falanruw et al. 1989
	Mangrove Forest	1984	Falanruw et al. 1989
Developed	Agriculture	2016	Amidon et al. 2017
	Developed	2016	Amidon et al. 2017
	Developed Vegetation	2016	Amidon et al. 2017
	Cropland	1984	Falanruw et al. 1989
	Urban	1984	Falanruw et al. 1989
Developed (Not Analyzed)	Cropland	2005	Liu and Fisher 2006
	Urban and Built-up	2005	Liu and Fisher 2006
	Urban Vegetation	2005	Liu and Fisher 2006
Leucaena Forest	Leucaena Thicket	2016	Amidon et al. 2017
	Leucaena Leucocephala (Tangantangan)	2005	Liu and Fisher 2006
Leucaena Forest (Not Analyzed)	Secondary Veg	1984	Falanruw et al. 1989
Monoculture Forest	Casuarina Forest	2016	Amidon et al. 2017
	Coconut Forest	2016	Amidon et al. 2017
	Agroforest -- Coconut	2005	Liu and Fisher 2006
	Casuarina Thicket	2005	Liu and Fisher 2006
Monoculture Forest (Not Analyzed)	Agroforest with Coconut	1984	Falanruw et al. 1989
	Coconut Plantation	1984	Falanruw et al. 1989
	Agroforest	1984	Falanruw et al. 1989
	Casuarina Thickets	1984	Falanruw et al. 1989
Native Forest	Native Limestone Forest	2016	Amidon et al. 2017
	Native Volcanic Forest	2016	Amidon et al. 2017
	Native Limestone Forest	2005	Liu and Fisher 2006
	Palma Brava Grove	2005	Liu and Fisher 2006
	Ravine Forest	2005	Liu and Fisher 2006
Native Forest (Not Analyzed)	Native Forest	1984	Falanruw et al. 1989
	Atoll Forest	1984	Falanruw et al. 1989

HSA Habitat	Vegetation/Landcover Class	Survey Year	Source
Savanna	Grassland	2016	Amidon et al. 2017
	Savanna Complex	2005	Liu and Fisher 2006
Savanna (Not Analyzed)	Savanna/Grassland	1984	Falanruw et al. 1989
Scrub/Herbaceous	Mixed Grass/Herbaceous	2016	Amidon et al. 2017
	Scrub/Shrub	2016	Amidon et al. 2017
	Other Shrub and Grass	2005	Liu and Fisher 2006
Scrub/Herbaceous (Not Analyzed)	Secondary Veg	1984	Falanruw et al. 1989
	Savanna/Grassland	1984	Falanruw et al. 1989
Secondary Forest	Bamboo Thicket	2016	Amidon et al. 2017
	Hibiscus Thicket	2016	Amidon et al. 2017
	Mixed Introduced Forest	2016	Amidon et al. 2017
	Agroforest	2005	Liu and Fisher 2006
	Mixed Introduced Forest	2005	Liu and Fisher 2006
Secondary Forest (Not Analyzed)	Agroforest	1984	Falanruw et al. 1989
	Introduced Trees	1984	Falanruw et al. 1989
	Secondary Veg	1984	Falanruw et al. 1989
Wetland	Emergent Wetland	2016	Amidon et al. 2017
	Open Water	2016	Amidon et al. 2017
	Water	2005	Liu and Fisher 2006
	Wetland	2005	Liu and Fisher 2006
	Marsh	1984	Falanruw et al. 1989
	Water	1984	Falanruw et al. 1989
Not Analyzed	Shadow	2016	Amidon et al. 2017

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