Technical Report No. 40

Mangrove Inventory and Assessment Project in American Samoa Phase 1: Mangrove Delineation and Preliminary Rapid Assessment

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INTRODUCTION

The purpose of this study is to provide a preliminary rapid assessment of the extent and health of mangrove forests in American Samoa. Tutuila and Aunu'u are the only islands in the territory containing mangrove forests. These islands are located at 14°18'S latitude and 170°41'W longitude. The last comprehensive wetland study of American Samoa was conducted in 1992 and included all wetland types, not just mangroves (Biosystems Analysis, Inc. 1992). Some general maps were created along with species lists, total wetland acreage, and wetland losses since 1964. Total wetland area for Tutuila and Aunu'u was reported to be 463 acres (186.9 ha) (Biosystems Analysis, Inc. 1992), of which approximately 175 acres (70.6 hectares) were mangroves.

Mangroves in American Samoa are protected by the Federal Coastal Zone Management Act of 1972 (Title 16, Section 1451 to 1464) and American Samoa's Coastal Management Act of 1990 (Title 24, Section 24.0501 to 24.0510). The purpose of these acts is to provide, "…protection of unique areas and resources including wetlands, mangrove swamps, aquifer recharge areas, critical habitat areas, streams, coral reefs, watersheds, near shore waters, and designated or potential historic, cultural or archaeological sites from destructive or inappropriate development." However, enforcement of such laws has been ineffective due to land ownership issues and difficulty in prosecuting offenders.

In Samoan society, land tenure is an integral part of the social organization and is tied to both the kinship system and village organization (Stover 1990). Often, the village as a whole owns land communally. This land tenure system, as well as Samoan social structure, allows the village council (fono) and the chiefs (matai) to make land use decisions (Filoiali'i et al. 1983). Basic historical Samoan customs regulating land tenure are actively being challenged and changed due to the profound developmental pressures American Samoa is currently experiencing. The traditional communally owned land system is shifting to individually owned land, or freehold land (Stover 1999), which causes complicated land disputes in the courts. The most valued land is located near the flat areas, which are concentrated in the Tafuna Plains of Tutuila island. The average price for one-quarter acre of land in this area can be as much as $35,000 US dollars (Dr. Carol Whitaker, personal communication 2003).

During the last 10 years new practices have affected the wetlands, especially the mangrove forests. Mangrove forests have been used as trash and scrap metal dumpsites, filled

for the construction of homes or businesses, or both. In addition, piggery waste is often discharged directly into wetlands, polluting the water and soils and making it unsafe to swim and fish near the mangroves (Biosystems Analysis, Inc. 1992).

A baseline inventory and assessment of the mangrove ecosystem is needed in order to assess mangrove wetland losses, and to educate landowners and residents about the importance and value of this unique ecosystem. This information will also help natural resource managers understand trends and advise landowners on how best to sustainably manage their lands. The goals of the Mangrove Inventory and Assessment (MIA) Project are to provide an inventory of mangrove forest resources within the Territory of American Samoa, and to document the impacts currently influencing these systems.

This report provides the results of Phase I, the mangrove delineation and rapid assessment, of the MIA project. Phase II, currently underway, will provide a vegetation inventory of each mangrove forest.

MATERIALS AND METHODS

Eight villages on the islands of Tutuila and Aunu'u contain mangrove forests: Alofau, Aoa, Aua, Aunu'u, Leone, Masefau, Nu'uuli, and Vatia. These forests were surveyed and delineated between September 15, 2002 and January 3, 2003. A minimum of two site visits were conducted in each mangrove forest, at low and high tide. The boundary of the mangrove forests was identified by walking the perimeter of the area along the edge of the mangroves with a handheld geographic positioning system (GPS) unit (Trimble GeoExplorer® 3). In cases where walking the perimeter was not possible, as in areas with deep waters or made inaccessible by man-made walls, the boundary was digitized using 2001 1m panchromatic IKONOS satellite imagery as the base layer.

The raw data were subsequently imported to and post-processed in GPS Pathfinder Office 2.80 software, then transferred to ArcView 3.2. The lines were overlaid on 2001 1m panchromatic IKONOS satellite imagery, and obvious errors were manually corrected. Polygons representing the mangrove area were then generated for all sites. The resulting boundaries delineate the current extent of the mangrove forests, not areas that were or could be potential mangrove habitat. The boundaries delineated in this study were for research purposes only and do not represent the United States Army Corps of Engineers jurisdictional wetland boundaries.

In addition to the digital boundary of mangrove forests, the location of piggeries and trash dumpsites (i.e., areas where trash was dumped on a continuous basis, not including incidental dumping) were also recorded using the same methods described above. Piggeries were catalogued according to size as either "small" (less than 5 pigs), "medium" (between 5-10 pigs) and "large" (more than 10 pigs). Abandoned piggeries were also recorded. Trash sites were categorized as "household", "metal", "plastics", and "toxic". Household trash included cans, detergent bottles, plastic plates, food containers, etc. Metal trash ranged from aluminum siding to entire refrigerators or truck beds. The "plastics" category included items such as car tires and paint buckets, while items designated as "toxic" were primarily car batteries due to their high lead content (DWM 2003).

A modified wetland rapid assessment procedure (WRAP, Miller and Gunsalus 1997) was used to categorize impacts to the mangrove forests by observing the following parameter: 1) wildlife utilization, 2) wetland overstory/shrub canopy, 3) wetland vegetative ground cover, 4) adjacent upland support/wetland buffer, 5) field indicators of wetland hydrology, and 6) water quality input and treatment systems. The modified WRAP allowed the establishment of 3 main categories of wetland health: 1) good health, 2) good health but threatened, and 3) severely impacted.

RESULTS

The surveyed mangrove forests were dominated by three species of mangroves: oriental mangrove (*Bruguiera gymnorrhiza* (L.)), red mangrove (*Rhizophora mangle* (L.)), and the puzzlenut tree (*Xylocarpus moluccensis* (Imk.) Roem.). The latter was only found at two sites, Nu'uuli and Aunu'u. Other tree species labeled as mangrove associates (FAO 1994), were intermixed with mangrove trees, including beach hibiscus (*Hibiscus tiliaceus* (L.)), fish-poison tree (*Barringtonia asiatica* (L.) Kurz), and Tahitian chestnut (*Inocarpus fagifer* (Parkinson) F.R. Fosberg).

The mangrove area for Tutuila and Aunu'u was 122.4 acres (49.6 ha, Table 1, Figure 1). Except for the Aunu'u Pala Lake mangrove forest and a few isolated areas within the larger mangroves of Tutuila, the majority of these mangrove forests were surrounded by villages and subject to continuous pollution from piggeries, filling, and trash dumping (Tables 1, 2). One-hundred and sixty-six trash sites bordered the mangrove forests of Tutuila and Aunu'u: 40%

consisted of household waste, 54% of metal, 3% plastic, and 2% toxic materials. A total of 37 piggeries bordered the mangrove forests: 16 large, 4 medium, 13 small, and 4 abandoned.

Of the ten mangrove forests surveyed, 3 classified as being in good health (Aoa, Aunu'u School Swamp, and Aunu'u Pala Lake), 4 were in good health but threatened (Leone, Masefau, Nu'uuli, and Vatia), and 3 were severely impacted (Alofau, Aua, and Aunu'u School Swamp puzzlenut area).

The three smaller forests at Alofau, Aua, and Vatia (Figure 2) comprised only 1.9 acres (0.75 ha). A large portion of Alofau was recently cleared and converted to a taro plantation. Since the 1992 report of BioSystems Analysis, Inc., a large section of Aua was filled. The remaining mangrove forest in Aua was covered with trash, making it impossible to record GPS positions for unique trash piles. The Vatia forest, on the other hand, was almost undisturbed, with only one recent piggery addition. Though it included a small section of oriental mangroves, the Vatia forest was dominated by Tahitian chestnut (Tables 1, 2).

The mangrove forest in Aoa (Figure 3) suffered severe tree damage and death during two hurricanes that occurred in the early 1990's, as testified by local residents and evidenced during the field survey. At the time of the study, there were only a few areas where mangrove seedling regeneration had occurred. Mangrove seedlings were growing in many areas in which they would not be expected to survive due to competition with other species, and there were no living adult trees on which to base the delineation. Thus, it was impossible to delineate only the extent of the mangroves. Therefore, the entire forested wetland area, including the mangrove seedlings, was included in this delineation, which comprised 6.2 acres (2.5 ha).

Nu'uuli (Figure 4) had the largest mangrove area, comprising 75.8 acres (30.7 ha). This area was characterized as a fringing mangrove that extended only a short distance inland and bordered the entire Pala Lagoon. Development had occurred along the entire boundary of the mangrove area, but a few sections extending further towards the ocean have received little impact.

Leone and Masefau (Figures 5, 6) were similar in size and shape, comprising 14.3 and 15.8 acres respectively (5.8 and 6.4 ha). Both sites had a narrow saltwater inlet, but extended far inland and eventually transitioned into freshwater riparian systems. Residential development has occurred along the entire mangrove boundary in Leone, and the eastern boundary of Masefau. Several large piggeries were also found along the boundaries of both sites (Tables 1, 2).

Aunu'u contained four separate mangrove sites. Two sites were associated with Pala Lake (Figure 7) and were 4.4 (1.8 ha) and 9.1 acres (3.7 ha), while the other two were behind the Aunu'u Fou Elementary School (Figure 8). The Pala Lake mangroves were pristine except for a few trash sites on the northwest corner near homes. The "School Swamp" comprised a small area (0.3 acres, or 0.1 ha) of puzzlenut trees and a larger portion dominated by oriental mangroves (1.53 acres, or 0.617 ha). While these two areas were close to each other and usually thought of as one system, they were actually separated by a narrow strip of land. All four of Aunu'u's mangrove forests were unique because they were found inland, rather than along the coast. Since there were no direct surface water connections between these forests and the ocean, it is speculated that these areas receive saltwater from underground percolation.

DISCUSSION

Mangrove forests provide important ecological and socioeconomic values, including maintenance of coastal water quality by filtering pollutants from the land, protection of coastlines from erosion and storm damage, flood mitigation, production of timber and other forest resources, and support for marine life (English et al.1997, Ewel et al. 1998). The Territory of American Samoa is losing approximately 5 acres (2 ha) of mangrove forest each year. If the current trend continues, all mangrove forest area will be lost in the next 25 years. The problem of mangrove loss is exacerbated by the abuse inflicted on the remaining stands. The constant dumping of trash has prevented seedling recruitment and colonization in disturbed areas as observed during the field survey. In addition, presence of large size trash and fill in many locations can ultimately alter the hydrology of these areas by preventing water flow, thus affecting a much larger portion of forest than it occupies. Piggery waste may also pose a threat to the ecosystem, as the effects of elevated levels of nutrients on seedling survival are not well understood. Additionally, the risk of piggery waste pathogens such as *Salmonella* and *Leptospira* being discharged into the waters is also a concern.

Results of this study suggest that more emphasis needs to be placed on dissemination of information about the importance of mangroves within the Territory, and measures to reduce the negative impacts this unique ecosystem is experiencing. Initial efforts to inform local residents about the Mangrove Inventory and Assessment project and its importance to the general public were undertaken between September 2002 and January 2003. The Forestry Division at the

American Samoa Community College aired several television programs informing the public of these efforts and describing the importance of mangrove forests, and two informational brochures on mangrove ecology were created.

Though American Samoa Power Authority provides trash pick-up services in all of the villages containing mangroves, household waste accounted for 40% of all trash sites. Similarly, a metal scrap yard located in the Tafuna village also offers periodic pick up of large metal items. Addressing the household and metal trash disposal through enforcement of existing laws prohibiting trash dumping would account for 94% of trash found within the mangroves. Car batteries, the most common item in the toxic category, only comprised 2% of total waste. However, the average car battery contains seventeen to eighteen pounds of lead, an extremely toxic material (DWM 2004), thus rendering their proper disposal of primary concern.

Laws are also in existence with respect to piggeries. Both the American Samoa Environmental Protection Agency (ASEPA) and Department of Public Health have enforcement authority related to non-point source pollution. The law states that piggeries cannot be placed within 50 feet of a body of water, including streams, wetlands, and coastal zones (American Samoa Code Section 25.16). As land becomes scarce in the Territory, residents will have to make decisions on the most valuable use of available land while taking into consideration the existing laws. As more residences are built each year to satisfy the increasing population needs, less land will be available for other uses, including piggeries.

Documentation of trash sites in this study probably underestimated total presence of trash within the mangroves for several reasons. First, only trash dumpsites along the borders of the mangroves, and not within the forests themselves, were documented. Second, individual trash sites in the Aua mangrove were not recorded as nearly the entire area is covered in trash. Similarly, only nine primary individual sites at the Aunu'u School Swamp puzzlenut area were recorded even though trash was scattered throughout the mangroves. Moreover, the two sites within the smaller Pala Lake mangrove area went unrecorded due to GPS failure. While the majority of trash sites and piggeries were captured, changes are occurring rapidly as piggeries and trash dumps are either created or cleaned up without public notice.

Ewel et al. (1998) point out that the lack of research documenting the various services mangroves provide may be one reason for the continued exploitation and loss of this type of wetland worldwide. To address the lack of quantitative data on the Territory's mangrove forest

resources, Phase II of the MIA project will provide a detailed quantitative vegetation inventory as a baseline for future monitoring efforts.

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Table 1. Summary of area, trash sites, and piggeries for each mangrove forest.

Village	**Acreage (Hectares)**	**No. of trash sites**	**No. of piggeries**
Alofau	0.6 (0.2)	4	2
Aoa	6.2 (2.5)	3	2
Aua	0.6 (0.3)	throughout	1
Aunu'u			
School Swamp – oriental	1.5 (0.6)	1	0
School Swamp - puzzlenut	0.3 (0.1)	9	0
Pala Lake 1	4.4 (1.8)	2*	0
Pala Lake 2	9.1 (3.7)	0	0
Leone	14.3 (5.8)	45	8
Masefau	15.8 (6.4)	15	7
Nu'uuli	75.8 (30.7)	89	16
Vatia	0.6 (0.3)	0	1
Total**	**122.4 (49.6)**	**166**	**37**

* Unrecorded trash sites, therefore not part of the total.

** Total mangrove acreage does not include the forests found in Aoa and Vatia. Though these two ecosystems contain mangrove tree species, they are not dominant in the canopy layer, and are not classified as mangrove forests.

Table 2. Ecological description, surrounding impacts, and rapid assessment findings for each mangrove forest.

Site Name			
	Alofau	Ecological Description	This mangrove forest is primarily red mangroves (*Rhyzophora mangle*), with only a few oriental mangroves (*Bruguiera gymnorrhiza*) and beach hibiscus (*Hibiscus tiliaceus*) along the edges. The red mangrove mass is too dense to allow access, supporting no understory species. Around the eastern and western edges of the wetland coconut (*Cocos nucifera*) saplings and ornamental shrubs can be found. Clearing and filling for agricultural production (taro) has occurred along the upland boundary.
		Surrounding Impacts	There is evidence of recent clearing on the western and northern edges, the latter being converted to agricultural use. Drainage canals were observed in the taro plantation behind the mangrove, resulting in hydro-modification of the entire site. Four trash sites, 3 household and 1 metal, were recorded surrounding the mangrove forest. Two piggeries, one medium-sized and one small, discharge into the mangroves.
		Rapid Assessment Findings	This mangrove is severely impacted by clearing and trash dumping. Though fish and several crab species were documented throughout the wetland, safe harvest of fish and shellfish from the mangrove is questionable due to trash and piggery contamination.
	Aoa	Ecological Description	Though red and oriental mangrove seedlings are found scattered throughout the wetland, this site no longer classifies as a mangrove forest due to the lack of mangrove dominance in the overstory. Dominant overstory species include Tahitian chestnut (*Inocarpus fagifer*), coconut, and fish-poison tree (*Barringtonia asiatica*) . Understory is primarily composed of seedlings of the above mentioned species, except in the marshy areas dominated by commelina (*Commelina diffusa*) and *Mariscus javanicus.*
		Surrounding Impacts	This wetland is relatively undisturbed along most of its boundary. The only area of impact is located on the southwest corner of the wetland. There are two small piggeries, and three trash dumping areas (two metal and one household). The remaining boundary is bordered by plantations (banana, coconut, taro), low density housing, and an elementary school.
		Rapid Assessment Findings	The wetland appears to be in good health as indicated by tree health and regeneration, invertebrate and vertebrate diversity, and lack of human disturbance. The habitat is also varied allowing for a diversity of species utilization.
	Aua	Ecological Description	Dominant overstory species include red mangrove, oriental mangrove, and beach hibiscus. Other species such as breadfruit, banana, and coconuts have encroached on the wetland, along with several ornamentals such as cat's tails and ginger. Many beach hibiscus trees are leaning at an angle greater than 45^0.
		Surrounding Impacts	The entire western edge of the site is confined by a 6-8 foot high rock wall. Residential homes form the eastern boundary. The northern edge is delimited by an area of higher elevation that has been filled and planted with taro, bananas, and ginger. This mangrove forest is almost entirely covered by trash, mainly household and metal, so it was impossible to record separate trash dumping locations. One large piggery on the western side discharges its waste into the wetland.
		Rapid Assessment Findings	The wetland is severely impacted by trash dumping and clearing. A large portion of wetland on the northern edge has been filled since the 1992 (Biosystems, Inc.) assessment. Banana and taro have been planted in the filled portions; however, their productivity may be minimal since underlaying layers are primarily trash. Fish and crabs have been observed in the wetland, but their consumption is not recommended due to the probable contamination by piggery waste and metal/trash.

Table 2 cont.

Site name			
	Aunu'u - School Swamp and Puzzlenut	Ecological Description	The School Swamp is dominated by oriental mangroves with swamp fern (*Acrostichum aureum*), bird's nest fern (*Asplenium nidus*), and other ferns (e.g. *Phymatosorus scolopendria*) in the understory. Edge species include beach hibiscus and *Thespesia populnea*. The puzzlenut area consists of densely planted saplings with no adult trees present. These trees grow on volcanic rock with little to no organic soil layer. Both areas are influenced by underground saltwater intrusion.
		Surrounding Impacts	The School Swamp contains only one trash site (metal). The puzzlenut area, on the other hand, has a large quantity of household, metal, and plastic trash throughout. There are no piggeries near these two areas. The two sites are separated by a narrow strip of land growing coconut and banana.
		Rapid Assessment Findings	The School Swamp mangrove forest appears to be in good health as indicated by tree health, regeneration, invertebrate and vertebrate diversity, and lack of human disturbance. The puzzlenut area, however, is severely impacted by trash dumping. The lack of a suitable organic layer of soil may also inhibit tree growth. This area should be protected and enhanced due to the rarity of this tree in American Samoa.
	Aunu'u - Pala Lake Mangroves	Ecological Description	Dominant canopy species include oriental mangrove, with red mangroves fringing the lake. This mangrove forest is largely undisturbed, with complete canopy coverage and ample regeneration. Swamp fern dominates the understory.
		Surrounding Impacts	There are a few household trash sites on the northwest corner of the mangrove forest, closer to residences. No piggeries border the wetland.
		Rapid Assessment Findings	Wetlands appear to be in good health due as indicated by health of trees, regeneration, invertebrate and vertebrate diversity, and lack of human disturbance. The habitat is also diverse allowing for a variety of species utilization.
	Leone	Ecological Description	Dominant overstory species include oriental mangrove, red mangrove, and beach hibiscus. Other species, such as coconut and pandanus, appear in higher elevation areas. Understory species include swamp fern and vines (e.g. *Mikania micrantha*). Some clearing may have occurred in the past on the northern edges of the mangrove forest, where taro plantations are now present.
		Surrounding Impacts	The wetland is threatened due to the number of piggeries and trash dumps sites along the boundaries. Forty-five trash sites were recorded during the survey , of which 46% were household, 46% metal, and 6% plastic. Eight piggeries border the wetland, 1 abandoned, 4 large, 1 medium, and 2 small. Some clearing and wood harvesting is evident on the northeast portion of the mangrove.
		Rapid Assessment Findings	This wetland appears to be in good health as indicated by tree health, regeneration, invertebrate and vertebrate diversity. The habitat is also diverse allowing for a variety of species utilization. However, the large number of piggeries and trash filling threaten aquatic life support.

Table 2 cont.

Site Name			
	Masefau	Ecological Description	Dominant canopy species include oriental mangrove, Tahitian chestnut, and beach hibiscus. Red mangrove patches are present at the saltwater inlet and extend a short distance into the wetland. A large creek winds its way through the mangrove forest, providing continuous freshwater.
		Surrounding Impacts	A pristine freshwater marsh forms the southwestern boundary of the mangrove forest. The northwestern and southeastern boundaries contain several trash sites and piggeries. Seven piggeries, 5 large and 2 abandoned, border the mangrove. Of the fifteen trash sites, 7 are metal, 7 household, and 1 toxic (car battery).
		Rapid Assessment Findings	The wetland appears to be in good health but threatened as indicated by tree health, regeneration, invertebrate and vertebrate diversity. Habitat is also diverse allowing for a diversity of species utilization. However, the large number of piggeries and trash filling threaten aquatic life.
	Nu'uuli	Ecological Description	Dominant canopy species include oriental mangrove, beach hibiscus, and coconuts at the upland transitional border. A thin zone of red mangroves fringes the coastline. At Coconut Point, several large puzzlenut trees are present, intermixed with large oriental mangroves.
		Surrounding Impacts	Extensive portions of the Nu'uuli mangrove forest have been filled, with fill areas covered primarily in vines. Other areas of the mangrove forest, especially the eastern and northeastern boundaries, are threatened by piggeries and trash sites. Overall, there are 89 trash sites bordering the mangrove forest, 58% metal, 37% household, 3% toxic, and 2% plastic. Sixteen piggeries, 1 abandoned, 5 large, 2 medium, and 8 small, border the mangrove.
		Rapid Assessment Findings	Unimpacted wetland areas appear to be in good health as indicated by tree growth, seedling regeneration, invertebrate and vertebrate diversity. Habitat is also diverse allowing for a diversity of species utilization. Large fish and crab species were documented in wetlands. However, the majority of the mangrove border experiences a large number of piggeries, filling for homesites, and trash dumping, which may threaten the wildlife support and may result in contaminated fish and shellfish.
	Vatia	Ecological Description	Dominant canopy species include oriental mangrove and Tahitian chestnut. Oriental mangroves are found only in the first 15 feet of wetland (from the ocean inland), and then quickly give way to a Tahitian chestnut forest. Understory species include swamp fern, and seedlings of oriental mangrove, tahitian chestnut, and fish poison tree. A stream enters the wetland in the southeast corner, thus contributing freshwater to the system.
		Surrounding Impacts	A rock wall delineates the western boundary of the forest, while on the eastern edge there is a fringing area of ornamental hibiscus, with a breadfruit and banana plantation behind it. On the southeastern corner a large piggery discharges effluent directly into the mangrove.
		Rapid Assessment Findings	This wetland appears to be in good health as indicated by tree health, regeneration, invertebrate and vertebrate diversity, and limited human disturbance. However, the large piggery at the southeastern corner discharges its waste directly into the mangrove, potentially contaminating fish and shellfish.

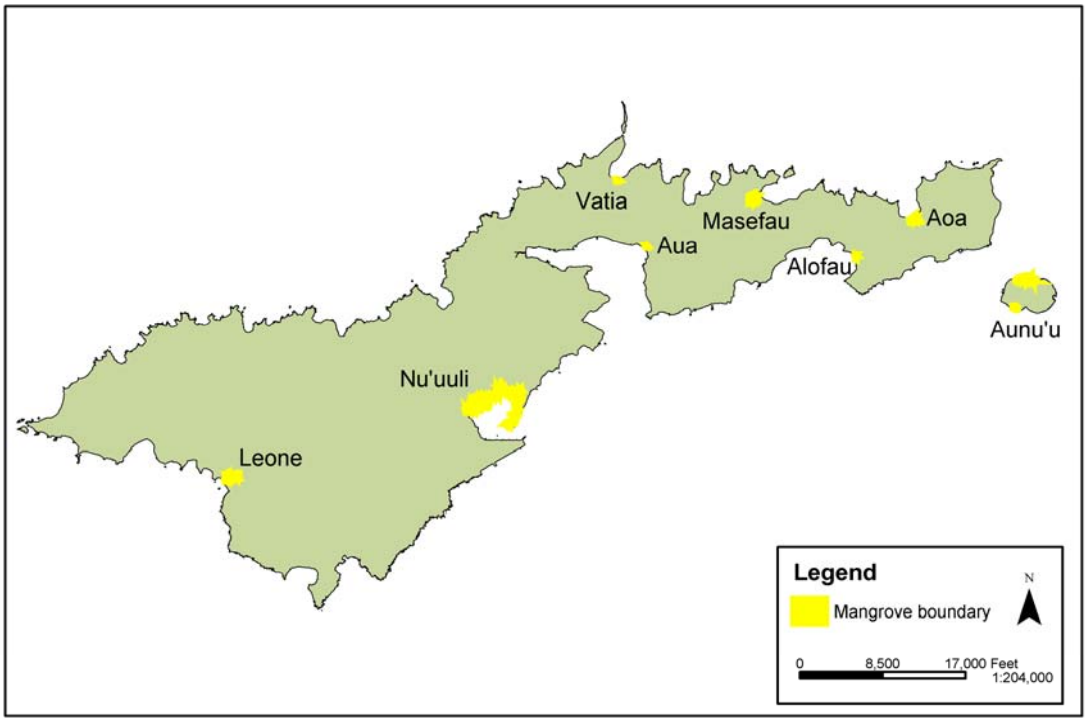

Figure 1. Eight villages traditionally containing mangrove forests on the islands of Tutuila and Aunu'u, American Samoa.

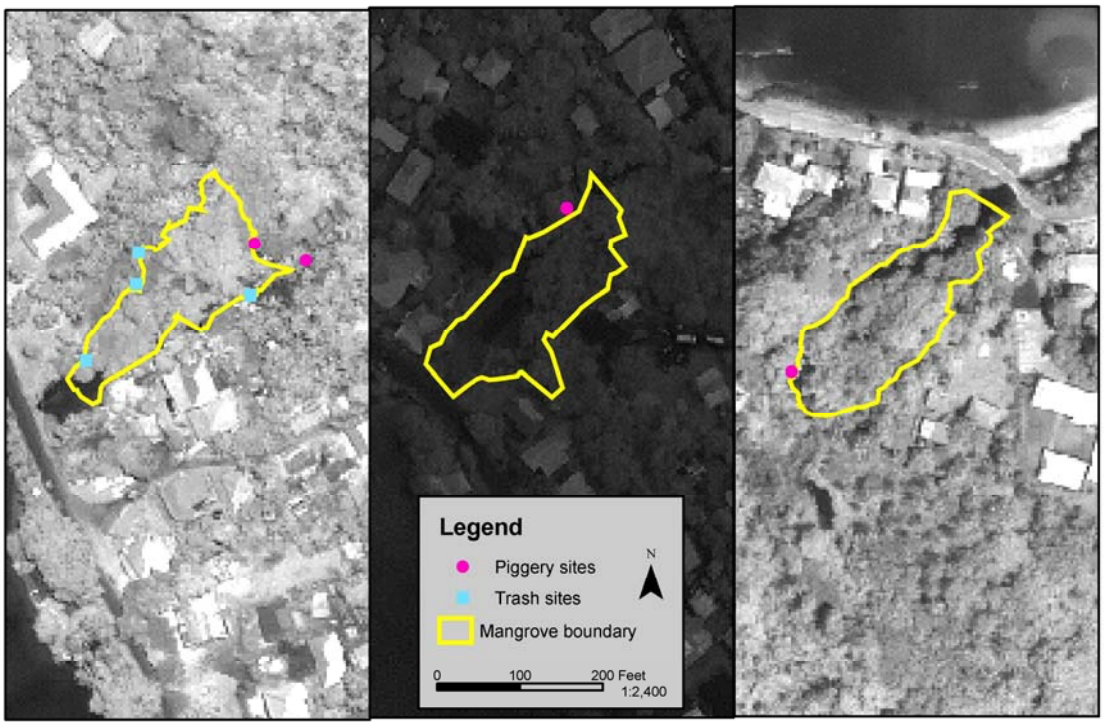

Figure 2. Mangrove delineation of Alofau (left), Aua (center), and Vatia (right).

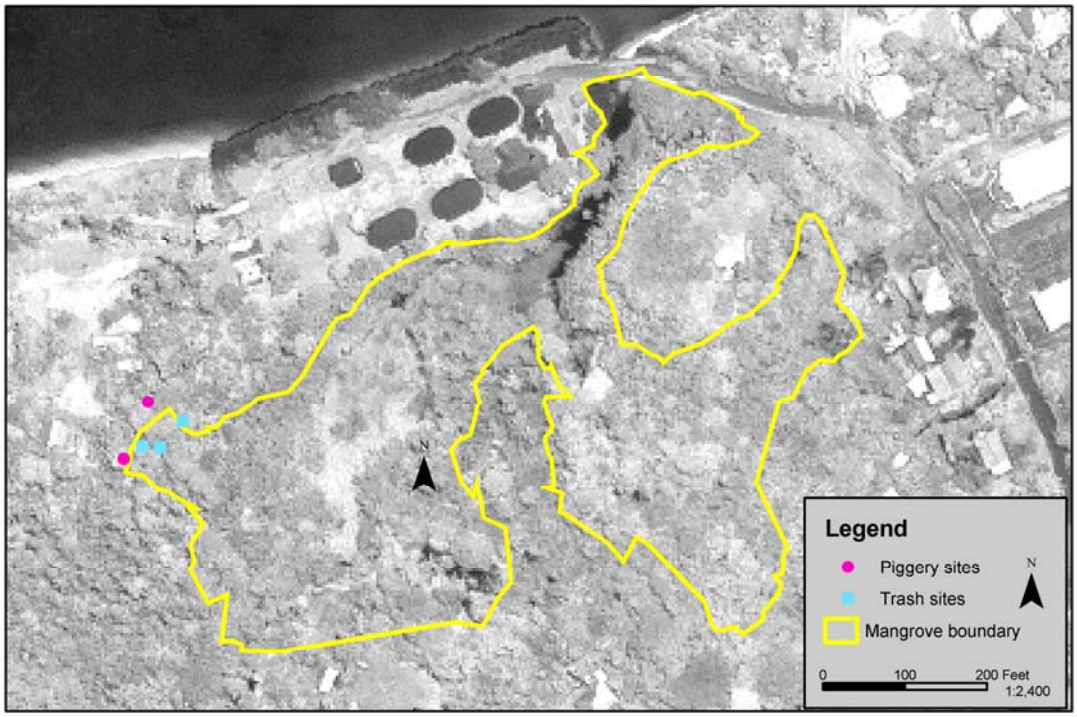

Figure 3. Delineation of Aoa's mixed forest.

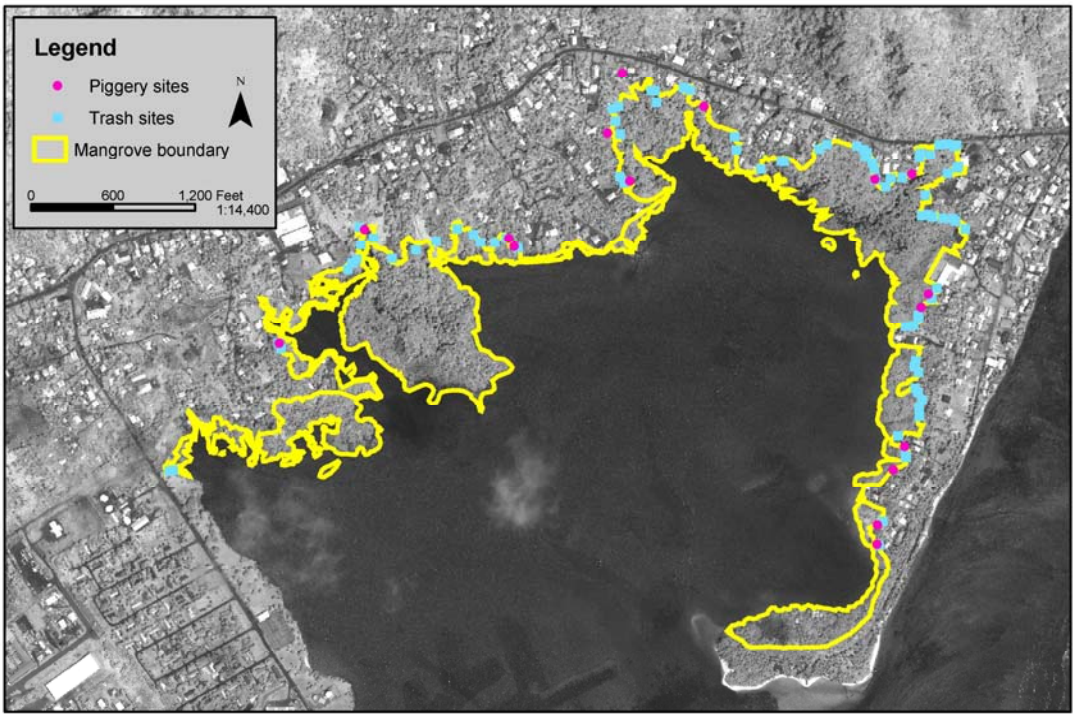

Figure 4. Mangrove forest area in Nu'uuli.

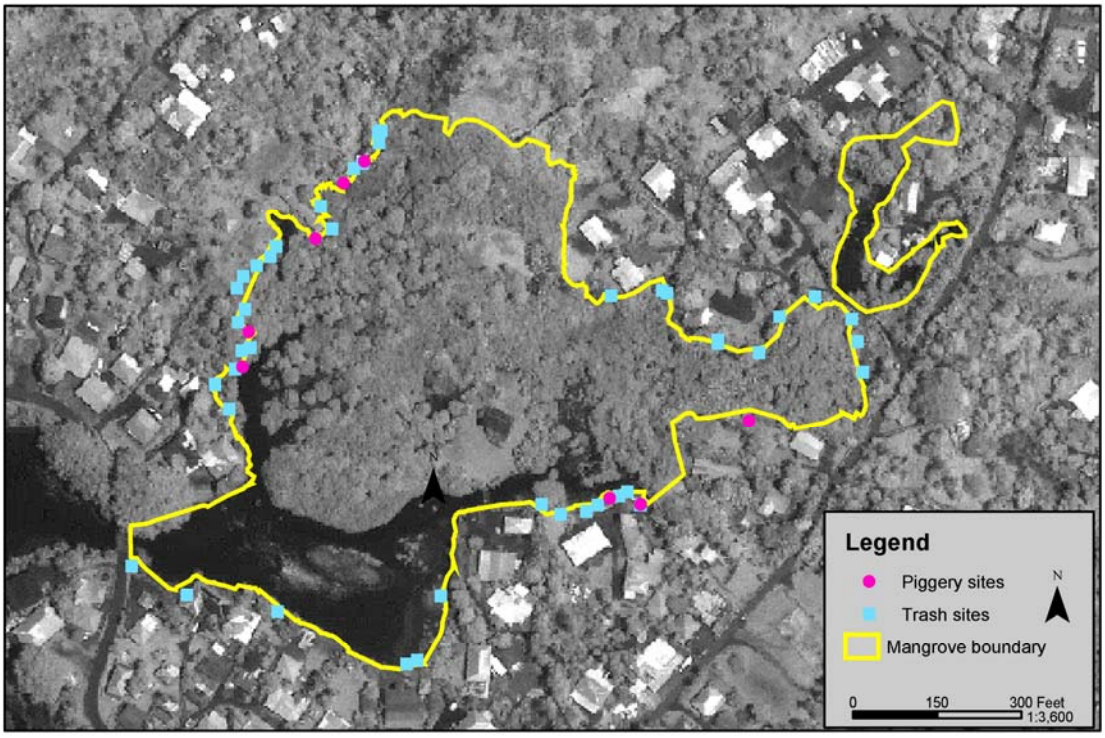

Figure 5. Mangrove forest area in Leone.

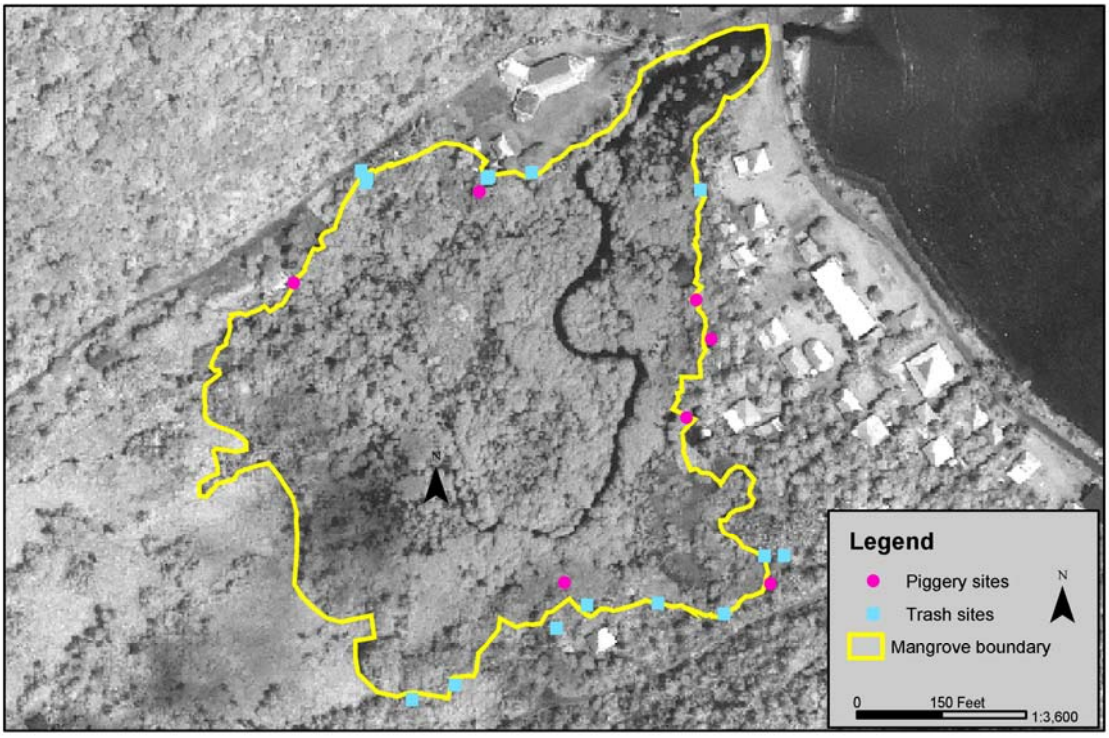

Figure 6. Mangrove forest area in Masefau.

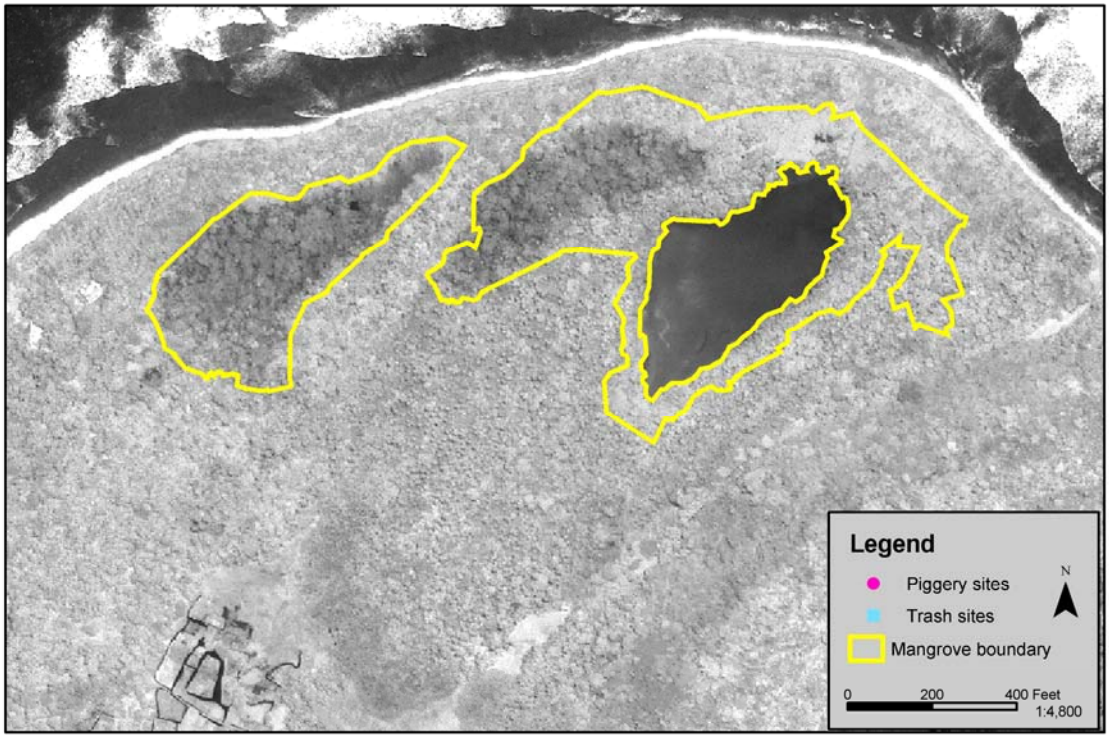

Figure 7. Mangrove forests at Pala Lake, Aunu'u.

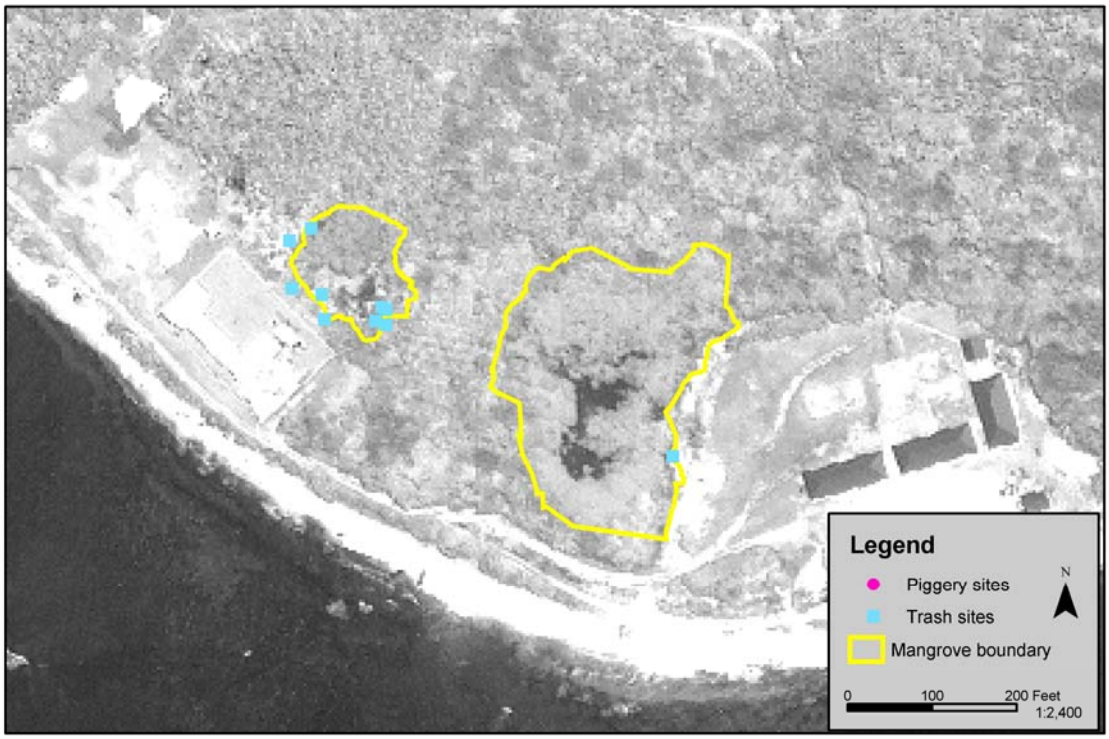

Figure 8. Mangrove forests in Aunu'u, behind Aunu'u Fou Elementary School.