TERRITORY OF GUAM
FIRE ASSESSMENT

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PURPOSE

The U.S. Forest Service, Pacific Southwest Region, Cooperative Fire program is committed to support and work collaboratively with forestry and fire protection agencies in the Pacific Islands. There are a variety of wildland fire and resource management issues on Guam that are an important priority for local, state and federal agencies. This assessment is a first step to document and quantify the wildland fire situation for all agencies to utilize and build upon for future needs. While the goal of this assessment was to better quantify the fire issues on Guam, it will be also used as a basis for the development of a Fire Management Plan for lands managed by the Navy.

EXISTING CONDITION

Vegetation

Two sources of vegetation data were used for the fire assessment:

1. IKONOS - The entire island of Guam was mapped with IKONOS satellite imagery in 2001. Five groups of cover types were derived from the imagery to make a land cover map for Guam Forestry.
2. US Navy INRMP - Obtained from the US Navy Integrated Natural Resources Management Plan, 2001 which covered only Navy lands.

The vegetation and Natural Resources Conservation Service (NRCS) soil layers were used to cross walk vegetation to Fire Behavior Prediction System fuel models (FBPS). Soil layers were used to identify limestone and volcanic types in order to differentiate the vegetation that grows on the two types of soil. According to area foresters the volcanic soils tend to support most of the swordgrass with other tall grasses and mixed cane, while the limestone soils tend to support the shorter savanna grasses. Although both are part of the savanna community, in this document shorter grass types will be referred to as savanna grass, while longer types will be referred to as swordgrass.

Fuel

The occurrence of wildland fires has been successful in short-term reduction of fuel loads in fire prone areas such as the savanna grass and swordgrass types. It is estimated the swordgrass fuel type can range from 20-40 tons per acre and grow to up to 10 feet tall. Savanna grass tends be 2-4 feet tall and an estimated at 2-3 tons per acre.

Pandanas trees and tangantangan are widely dispersed throughout much of the savanna grass. These species provide some limited torching capability due to the die back of the tree and the associated ladder from the grass to the die back that drapes below the main canopy. Local fire and forestry officials describe these trees as a source for spotting, especially under windy conditions or with higher fire intensity. Examining recently burned areas, these trees tend to be fire resilient if they are not badly scorched.

Forested areas and tree stands susceptible to blow down from severe storms and typhoons will continue to be a problem especially when a drier than normal dry season occurs within 12-24 months after a typhoon. Blow down of hardwood species such as acacia increases the fuel loading of dead and down material. During abnormally dry periods this available fuel may result in high intensity wildland fires that may cause undesirable effects to soil and plants. This is particularly true in areas adjacent to the flammable savanna fuel types and/or in high fire occurrence areas.

Under normal conditions fire does not penetrate any distance into the forested areas due to the high fuel moisture content, but can and does cause damage to fire intolerant species on the edge. Large woody fuels in direct contact with the soil tend to decay within 24 months. Snags created from typhoon tend to remain standing up to 24 months and then fall and decompose quickly.

Areas of blown down *acacia auri* were observed less than 24 months following Typhoon Pongsona (December 2002). These areas have recovered to full canopy cover with full ground cover that was shaded, moist and fairly fire resistant. Larger dead fuels in direct contact with the soil were decomposing rapidly and larger dead fuels not in contact with the ground were very moist. Light leaf litter was very moist and would likely not carry fire under normal dry season conditions nor generate enough heat to preheat larger fuels to combustion.

A custom fuel model was built for the swordgrass fuel type, using a combination of factors from FBPS fuel models 3 (Tall grass) and 7 (Southern rough). The values for fuel loading, fuel bed depth, and moisture of extinction (40%) were adjusted to best represent the potential fire behavior observed by local fire and forestry officials. No fuel inventory was conducted.

Table 1: Custom fuel models used in this analysis

Fuel Model	Scenario	Fuel Size	Moisture Content %	Fuel Loading Tons/acre	Wind Speed and Direction
Custom 23	Worst Case	1-hour	6	5	21 mph, northeast
Swordgrass		10- hour	9	5	
		100-hour	12	3	
		Live	150		
		Woody		1	
		Herbaceous		5	
		Depth		6 feet	
Custom 23	Normal Dry	1-hour	8	5	15mph, northeast
Swordgrass		10-hour	10	5	
		100-hour	13	3	
		Live	300		
		Woody		1	
		Herbaceous		5	
		Depth		6 feet	

Weather and Climate

The climate of Guam is almost uniformly warm and humid through the year. Afternoon temperatures are typically about 84-88 degrees with nighttime temperatures dropping to the low to mid 70’s. Relative humidity commonly is 65-75 percent in the afternoon and ranges from 85-

100 percent at night. Though temperatures and humidity vary only slightly throughout the year, rainfall and wind conditions vary markedly, and it is these variations that define the seasons.

The mean annual rainfall on Guam ranges from about 98 inches on the windward, or east, side of the higher mountains to about 79 inches along the coast of the west side of the southern half of the island.

Throughout the year, the dominant winds on Guam are the trade winds that blow from the east or northeast. The trade winds are strongest and most constant during the dry season, when wind speeds of 15 – 25 miles per hour are common. Occasionally there are typhoons, and these bring not only extremely heavy rains, but also violent winds that may result in a surge of water onto low-lying coastal areas.

Fire reports contain very limited weather information that would be particularly helpful in analyzing large fire days. For this assessment limited data such as temperature, dew point, wind and direction was available almost hourly from the National Oceanic Atmospheric Agency (NOAA). A best estimate of dead and live fuel moistures, wind speed and direction were derived from local knowledge and the NOAA weather data. Fuel moistures, 20' feet wind speed and direction were derived using the 1300 hour (1:00 PM) daily observations for the 1983-2002 period. Relative humidity was calculated from temperature and dew point. Fine fuel moistures were then calculated using temperature, relative humidity and adding 1-3 percent to estimate the 10-hour fuel moisture for modeling.

Worst-case and normal dry season scenarios were derived using weather from NOAA for the 1300 hour observation while reviewing any available weather on days with large fires over 1,000 acres.

The U.S. Forest Service Pacific Southwest Region - Cooperative Fire program is coordinating with NOAA and other local agencies to develop a fire danger rating system program for Guam. This effort will enable fire program managers to quantify and predict potential for large fires.

Topography

The southern part of Guam is characterized by mountainous uplands that are deeply dissected by numerous rivers. The northern part of the island is relatively flat limestone plateau. The central part of the island is composed of rolling limestone hills and plateaus. Slopes range from 0-55 %. Mt. Lamlam is the highest point on Guam at 1332 feet. Guam is about 135,680 acres (212 square miles) in size.

Values at Risk

Natural resource values at risk include habitat for threatened and endangered (T & E) species of plants and animals, as well as heritage resources under protection by Guam Forestry. Corral reefs, marine and fresh water aquatic species and habitat are impacted from soil erosion. Guam's reefs contribute to high annual economy through tourism and fisheries. Increased flooding and soil erosion where silt is carried to the ocean and fills in reefs impacts and destroys marine life. The highest priority watershed for protection is the Ugum watershed and river that drains to the water treatment plant.

There are significant developments on Naval lands, including industrial buildings, communications facilities, schools, administrative sites, fuel storage, ordnance bunkers, etc. Most of these facilities are located in relatively non-flammable areas, but some such as fuel storage facilities, communication facilities, and ordnance bunkers are located adjacent to the more flammable savanna communities. Ordnance bunkers may not be directly impacted or actually burn from wildland fire, as they are constructed of non-flammable material and have a small green belt of mowed grass at least 30+ feet around each structure. However, flames, smoke and fire fighting equipment could potentially interrupt or delay operations.

Watershed values are highly important, specifically those that are adjacent to and directly drain into the Fena Valley Reservoir, Navy's primary water source. The Fena Reservoir also provides about 30% of the water needed by Guam. Erosion from a variety of sources, including wildland fire effects the rate of sediment movement into the Fena Valley Reservoir.

Badlands (bare soil) areas adjacent to Fena combined with large wildland fires that remove vegetation may increase erosion potential and impact the watershed. Vegetation management strategies to minimize the direct impacts from wildland fire effects on the watershed are addressed in the Navy's Integrated Resource Management Plan, the Fena Watershed Resource Assessment and will be documented in the Fire Management Plan. Areas where savanna and swordgrass burn combined with steep slopes and badlands have a higher potential for increased erosion when wildland fires occur.

Fire Behavior

Potential fire behavior was modeled utilizing the FLAMMAP fire behavior computer program. For the purpose of this assessment, vegetation types on volcanic and limestone soils were cross walked to fire behavior prediction system fuel model (FBPS) and used as input into FLAMMAP to assess potential rates of spread and flame lengths under average dry wildland fire conditions and under periods of drought or worst case weather.

Typical savanna grass on limestone soils was categorized as FBPS fuel model 2 (short grass and shrubs,) where fire spread is governed by the fine herbaceous fuels that have cured or are nearly cured.

Savanna communities on volcanic soils tend to host the taller, thicker swordgrass and were analyzed using a custom model. Custom fuel model 23 represents a combination of FBPS fuel model 3 (tall grass) and FBPS fuel model 7 (Southern Rough). Fires burn through the surface and shrub strata with equal ease and can occur at higher dead fuel moisture contents because of the flammability of live foliage. The savanna communities, primarily swordgrass and savanna grass, are the most flammable portions of the landscape relative to the other vegetation types and should be the focus for fire hazard mitigation.

Fuel model 23 - Swordgrass -- The normal dry season estimated potential rates of spread averaged 76 chains per hour with 30 foot average flame lengths. (See table 2). Aircraft and equipment would be needed to attack these fires until a change in weather and or fuel occurs.

Fuel model 2 – Savanna grass – Normal dry season conditions produce fires of an intensity that can usually be directly attacked by firefighters and fire equipment, although flame lengths exceeding 4 feet usually preclude direct attack by hand crews. Fires typically stop spreading when they reach forest communities and/or a significant break in the continuity of fuel, provided the conditions do not support spotting.

Under worst case dry season conditions, both grass types exhibit fire behavior characteristics beyond the capability of handcrews. Indirect suppression tactics and or aircraft would be necessary on fires occurring under these conditions.

All forest types were categorized using FBPS fuel model 8 with increased fuel moistures to reflect typical Guam forest conditions. Under normal dry season conditions, fires spreading into forest communities from savanna communities usually stop spreading due to higher dead and live fuel moistures. Fires may burn into the forested area approximately 10-12 feet before fuel moistures prevent spread. The general forest types tend to exhibit minimal to no rate of spread. Modeling these fuel types using the standard FBPS models is difficult to calibrate in this climate.

Table 2: Fire Behavior Outputs for Navy Lands

Fuel Type	Scenario	Flame length	Rate of Spread
Swordgrass 23	Worst Case	30 feet	165 chains/hr
Swordgrass 23	Normal Dry	20 feet	76 chains/hr
Savanna 2	Worst Case	9 feet	75 chains/hr
Savanna 2	Normal Dry	6 feet	35 chains/hr

Fire History

Fire reports are completed at the end of each year by the 911 dispatch center. Fire records are available in a Microsoft Access database format for 1979-2002. The fire reports are not necessarily consistent for each year. Data is missing related to weather, fuel type, burning index, and spread component for several years and many records have errors in the date or in the location recorded.

Using the fire report data, fires were totaled annually to obtain number of fires and acres. Fire report ownership codes 6 (Federal) and 7 (Private/Local/Federal) were used to attempt to query for federal acres and number of fires. It was not possible to accurately separate fires on Navy land from the database, therefore all fires with codes that indicated burning on federal lands and secondly those that burned on a combination of private, local and federal lands are represented below. It is not evident if ownership is reported for the origin of the fire or is reported for the overall fire area.

An attempt was made to link the fire report data to grid location and extract fire records pertaining to Navy lands by grid location (see next section). These records show 61% of the fires and 71% of the acres burned within grids on and adjacent to Navy lands were reported as caused by debris burning, approximately 16% of the fires and 16% of the acres burned were reported as caused by campfires. This compares closely to reported percentages for Guam as a whole for debris burning and campfires. In contrast, the recent Wildland Fire Prevention and Education Team Final Report from March 2003, found that over the last three years, 2,020 arson fires have burned over 6,000 acres in Guam. According to the report, an average of approximately 750 wildland fires burn per year in Guam and up to 80% are caused by arson.

The following table is derived from fire report data, extracting records pertaining to Federal land according to ownership code in the fire report. Fire report data is available for periods 1997-2002, however data related to Federal vs other land ownership was not recorded for these years.

Table 3: Guam annual fire statistics 1979- 2002 from fire report data.

YEAR	ACRES BURNED	NUMBER OF FIRES	FEDERAL ACRES	FEDERAL # OF FIRES
1979	7481	552	75	6
1980	3286	303	662	5
1981	6183	495	17	5
1982	5767	521	175	1
1983	10,339	972	3090	3
1984	1676	526	179	3
1985	1039	305	30	9
1986	1401	359	69	10
1987	10,330	1513	1376	87
1988	11,069	868	825	37
1989	2481	322	1070	15
1990	2	5	0	0
1991	1541	45	73	16
1992	9912	1036	1424	102
1993	3256	1130	0	0
1994	327	181	6	5
1995	5628	598	537	22
1996	634	280	3	4
1997	972	524	No data	
1998	13,312	1942	No data	
1999	588	513	No data	
2000	3366	977	No data	
2001	1101	471	No data	
2002	2434	492	No data	

The data in Table 3 was derived solely from fire report data.

Fire History Mapping

Locations of fires for 1979-1999 had been kept on hard copy grid maps in an atlas format, but were lost in the last typhoon. For the period of 1979-1999, the geographic location of fires was reported using the 1000-meter square Guam Uniform Grid System, used by the Bureau of Planning since 1975. To best obtain a spatial view of fire history, the grid system was re-projected to match existing Guam Geographic Information System (GIS) data sets. Fire report data was then merged into one data set, with each fire linked to a grid block. The exact location of each fire within a grid block was not possible to determine. The grid was then displayed over a map of the island using graduated colors based on the number of fires within each grid block (Appendix E).

Due to the different formats recorded in the fire history data set, only fires that had consistent grid information were displayed on the grid map for years 1979-1999. The last three years (2000-2002) of fire reports recorded only street location, therefore it was not possible to identify a specific grid block to spatially represent the fire location. Reporting fire location by grid was discontinued in February of the 1999 fire season. There were more fires that occurred during this period than are displayed due to the inconsistencies in grid format entered into the fire history database.

Risk and Hazard Assessment
It was determined through discussion with local fire and forestry managers that areas with steep slopes and conditions conducive to high intensity fire were of particular concern to them, due to the potential for erosion. To represent the hazard over the landscape posed by this combination of factors, data layers for flame length, rate of spread, and slope were each classified into relative groups (see Table 4 below) and then combined to categorize areas as relatively LOW, MODERATE, HIGH, and VERY HIGH hazard. Slope was used to evaluate the potential for erosion, while rate of spread and flame length represented fire behavior potential.

Relative class / Score	Flame length	Rate of spread	Slope	Relative Hazard (Total score)
Low / 1	<1	<1	0-19	3-5
Moderate / 2	1-4	1-20	20-35	6-8
High / 3	5-9	21-100	36-50	9-10
Very high / 4	10+	>100	>50	11-12

The fire occurrence layer derived from fire report grid location was used to determine the relative risk of a fire occurring, identifying grids that had greater than 5 fires/year. See Appendix F - Hazard and Risk Map. Where these higher fire frequency grids overlap with areas of relatively HIGH or VERY HIGH hazard, there may be an even greater potential for problems with erosion due to the increased potential for occurrence of higher intensity fire.

SUMMARY
According to the local fire and forestry officials the threshold in fire size that tends to create problems begins at approximately 10 acres. At this size the organization is stretched to its maximum suppression capability. Beyond 10 acres, suppression forces cannot keep pace with fire growth due to fire intensity and rate of spread.

Areas with the greatest potential for large fire occurrence and subsequent erosion are those with an overall hazard rating of HIGH and VERY HIGH. Most at risk are the high and very high hazard areas that also have a high fire frequency.

Strategic plans should be developed to treat high priority watersheds and convert areas with the highest fire hazard and erosion potential to an acceptable level. Many opportunities exist to reduce the flammability of and subsequent erosion to key watersheds by strategically developing fuel breaks along roads and ridges while converting areas of swordgrass to a less flammable vegetation type, such as forest.

RECOMENDATIONS

1. Better tracking of daily weather and especially weather when wildland fires occur would be useful to determine when the potential for large fires is the greatest and other associated fire analysis. Hourly weather data taken from the airport is available from the National Oceanic and Atmospheric Administration (NOAA). If possible, it would be beneficial to set up a remote automated weather station (RAWS) on the southern portion of the island, where the primary problems with fire occur. Live fuel moisture sampling may also be beneficial in developing background data for fire occurrence analysis. Developing a fire danger rating system in Guam would be extremely beneficial.

2. Fire location - If the agency's goals are to work towards integrating fire history into a GIS database, changes need to be made to the fire reports, format and data recording. The current system is not adequate.

Large fires should be mapped using a GPS to download into a GIS. Even a latitude/longitude point location would be much more useful for fire and forestry officials when starting to move toward using GIS.

Locating the fire origin using a Global Positioning System device (GPS) is desired, but may not be possible for Guam at this time. Another option would be to pinpoint the location on a hardcopy map and derive the latitude/longitude point. The points can then be imported into a GIS layer. At a minimum, utilization of the existing grid system is the least desirable option, although recording the quadrant of the grid block (similar to subsection) for each fire location might improve the use of that system. The existing method of recording a road name doesn't provide sufficient data for mapping fire locations.

3. Fire Reports – The fire report format needs to be reviewed and quality of data monitored. The data for 2000-2002 cannot be mapped and there is little information to perform any meaningful fire analysis other than cause, date and size.

- Ownership should be reported for the origin of the fire. The current ownership codes combine more than one ownership type in several of the code numbers, making it difficult to accurately extract fire records pertaining to only federal lands (or any other landowner type).

- Fire reports should be completed as soon as possible after fires occur. Many of the fires were recorded at the end of the season and important information about them may have been lost.

- A consistent, comprehensive fire report format needs to be established to capture data necessary for fire analysis, especially for larger fires. The reporting system needs to be redesigned for ease of completion and consistent input. A drop down menu and selection may be a good option.

- Increasing the oversight of data entry and quality control are essential. Each year the fire report format has varied, making compilations of the data difficult.

Formatting errors throughout the data set have also complicated the process. Problems such as mixing text and numbers into single columns were problematic when trying to join all years into one data set. Column headings changed many times from each year to the next, adding to inconsistencies in the data. Incomplete data, such as grid location or fire size, eliminated many records from the final data set.

References

Soil Survey of Territory of Guam – USDA Soil Conservation Service May 1988

Aid to Determining Fuel Models For Estimating Fire Behavior, USDA, Forest Service, Anderson, Hal, April 1982.

US Navy Integrated Resource Management Plan, 2001

Vegetation Strategy for Southern Guam Draft - Bell, Fred, Falanruw, Margie Lawerence, Bart, Limitiaco, Dave, Nelson, Dave. September 2002.

Final Report, Widland Fire Prevention and Education Team, March 2003.

Appendices:

A. **Large Fire History Table**
B. **Photo references of fuel models**
C. **Land Cover Map**
D. **Potential flame length under worst weather conditions**
E. **Guam Fires by Grid Map**
F. **Hazard and Risk Map**

Appendix A – Large Fire History

The largest fires 1000 acres and greater during years 1979-2002 are displayed below.

Date & Time	Size Acres	Land ownership	Cause	Weather	Location
May 28, 1998 Thursday, 1158 hrs	1,970	2 Private & Local Government	Incendiary	None on fire report – NOAA records @ 1054 hours 15 mph 20' wind from East 86 degrees	Tenjo Vista, Piti
February 25, 1983 Friday, 1000 hours	1,446	1 - Private	Debris burning	None on fire report – no records from NOAA records @ 1000 hrs 14 mph wind 20' from East 81 degrees	Grid 3D43
June 21, 1983 Wednesday, 0900 hours	1,108	1 - private	Incendiary	None on fire report – NOAA records @ 0900 wind9 mph from South temp 76 degrees.	Grid 4A46
April 11, 1979 Wednesday, 1400 hours	1,000	1- private	Debris burning	No specific on fire report, max temperature 87 degrees, min RH 65%	Grid 3D26
March 11, 1987 Wednesday, 1500 hours	1,000	1 - private	Incendiary	None on fire report – NOAA records 1500 hours 86 degrees, wind from east, 17mph, gusts to 23 mph	Grid 4B38
March 17, 1995 Saturday, 1600 hours	1,000	Navy	Incendiary	None of fire report – NOAA records wind from NE, 16 mph, 82 degrees, overcast	Naval Mag border of 1985 site

Appendix B - Photo references of fuel models

Savanna and swordgrass fuel type – fuel model 23

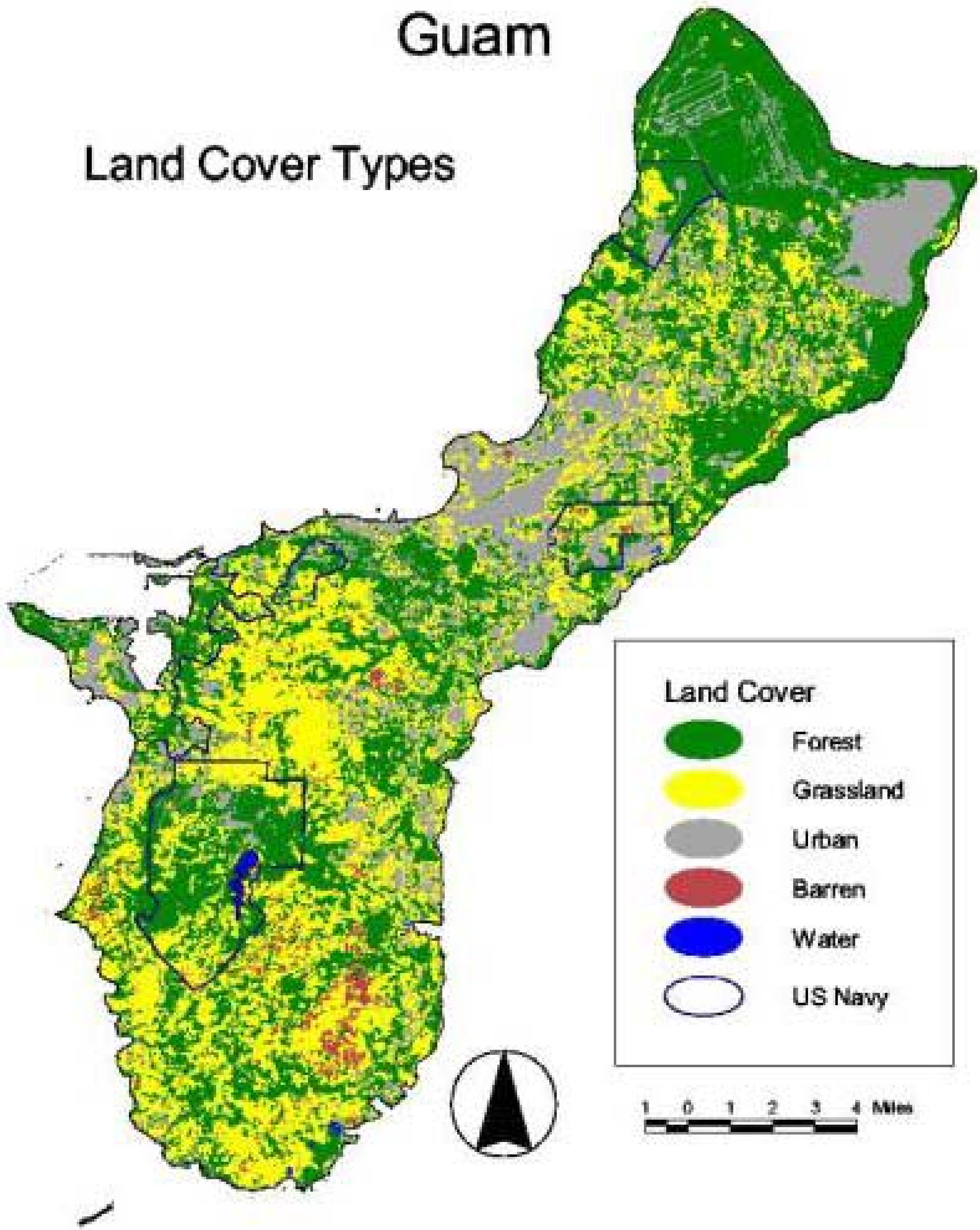
Forest at the edge of Savanna – fuel model 8

Typical fuel complex around Navy Bunkers

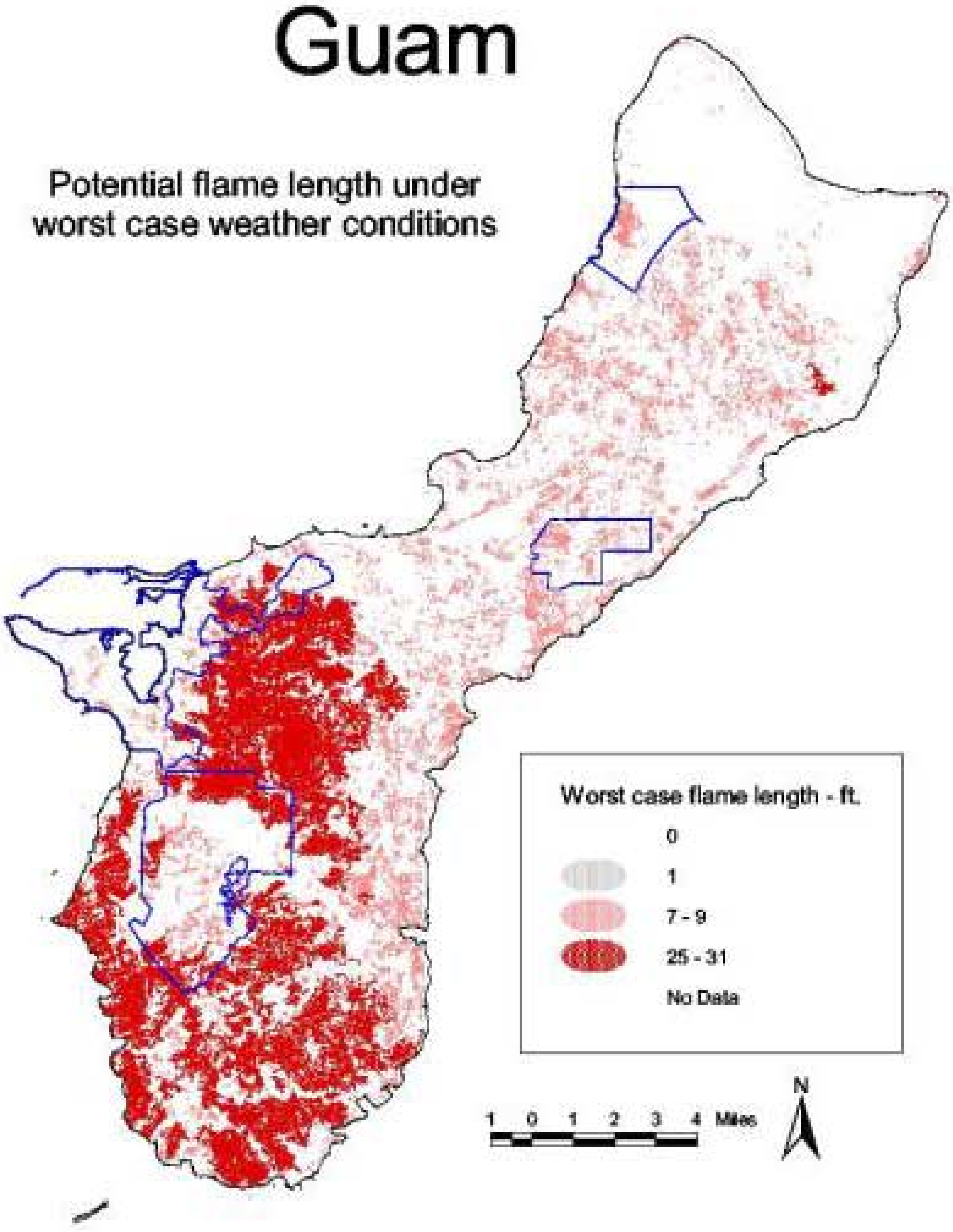
Fire Break #3

January 2004 - Acacia post blow down from Typhoon Pongsona November 2002

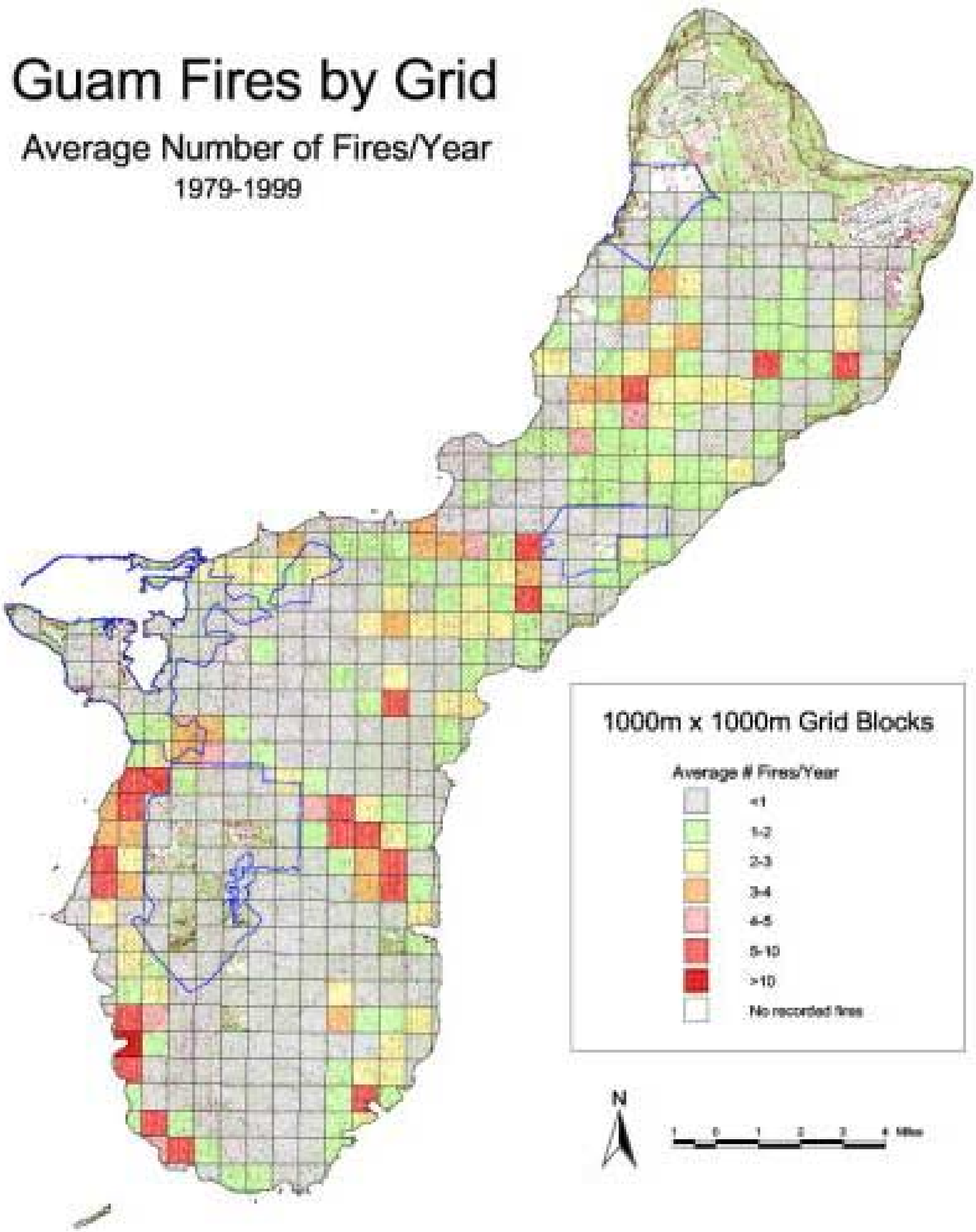
Appendix C. Land Cover Map



Appendix D.


Guam
Potential flame length under worst case weather conditions
Worst case flame length - ft.
0
1
7 - 9
25 - 31
No Data
1 0 1 2 3 4 Miles
N

Appendix E. Guam Fires by Grid Map



Appendix F. Hazard and Risk Map