Guadalcanal Village Tidal Marsh Mitigation Annual Monitoring Report

December 2000

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GUADALCANAL TIDAL MARSH MITIGATION

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Section 1. Introduction (contract 04A0863)

1.1 Restoration Monitoring Overview

The California Department of Transportation (Caltrans) is mitigating impacts to wetland environments resulting from the widening of Highway 37 by restoring wetland environments in nearby areas. Following studies of potential mitigation sites, Guadalcanal Village (Guadalcanal) was chosen as the mitigation site for the White Slough project. Guadalcanal is a 53 acre (21.4 ha) diked and subsided historic wetland located along the western edge of the City of Vallejo in Solano County, California (Figure 1). Guadalcanal is bordered to the north by Dutchman Slough, to the east by Pritchard Marsh, to the south by Highway 37 and Mare Island, and to the west by Cullinan Ranch. Past uses of Guadalcanal include military housing and recreation (paintball).

The goal of mitigation at Guadalcanal is to restore tidal wetlands through construction of specific elevation contours (grading) and reintroduction of tidal flows via Dutchman Slough. A minimum goal of 18 acres (7 ha) of marshland is to be restored (Wetland Research Associates, Inc. et al. 2000). Hydraulic modeling studies were conducted to approximate water levels, sedimentation rates, and associated development of marsh zones through time. Vegetation types expected to develop at Guadalcanal following reintroduction of tidal flows are upland, high marsh (pickleweed/mixed halophytes), marsh plain (pickleweed/alkali bulrush), low marsh (cord grass/bulrush), mudflat (bulrush in upper portion), and subtidal. Hydraulic modeling produced estimates of each marsh zone that should develop when Guadalcanal is reconnected to Dutchman Slough (north) and when a connection also is made to Cullinan Ranch (west). Establishment of a majority of the targeted marsh environments is expected to occur within 5 years (Wetlands Research Associates, Inc. et al. 2000). Depending on the accretion in the new marsh system, mature marsh conditions are likely to take years or decades to develop (Moffatt and Nichol 1999).

Prior to restoration activities at Guadalcanal, Pritchard Marsh (10 ha) was designated as a model of future marsh attributes to attain (e.g., plant and wildlife assemblages). Pritchard Marsh is adjacent (east) to Guadalcanal and receives tidal flows from Dutchman Slough and the Napa River. The area contains a variety of plant species representing low to high marsh elevations. Plant species within the low marsh zone at the Pritchard Marsh reflect the Napa River freshwater influence. Tidal marsh bordering San Pablo Bay is commonly dominated by cordgrass (*Spartina foliosa*) while low marsh at the more brackish Pritchard Marsh is a co-dominance of alkali bulrush (*Scirpus* sp.) and cord grass (Wetlands Research Associates, Inc. et al. 2000). Special status wildlife species that occur at Prichard Marsh include the salt marsh harvest mouse (*Reithrodontomys raviventris*), Suisun shrew (*Sorex ornatus*), California clapper rail (*Rallus longirostrus obsoletus*), California black rail (*Laterallus jamaicensis coturniculus*), salt marsh common yellowthroat (*Geothlypis trichas sinuosa*), San Pablo song sparrow (*Melospiza melodia samuelis*), and northern harrier (*Circus cyaneus*).

1.2 Existing Baseline Data and Initial Sampling

A monitoring program was developed to detect changes in physical and biological parameters at Guadalcanal through time (Table 1) and is based on the Biological Monitoring Plan for Cullinan Ranch and Tolay Creek Units (Takekawa et al. 1999). Sample sizes are based on the Universal Transverse Mercator grid system at the 125 x 125m (n = 20 grids) and 250 x 250m (n = 9 grids) grid levels (Figures 2 and 3). Analysis of data collected during monitoring efforts will ultimately provide a means of evaluating the success of restoration efforts. Physical characteristics that will be measured include sediment accretion, elevation, water levels, water quality, and erosion. Biological characteristics that will be measured include invertebrates, insect, fish, birds, plants, and mammals. Pre-construction sampling was conducted during summer 2000 and included birds, mammals, plants, water quality, and photo-documentation. Fish, invertebrates, water levels, sediment accretion, and erosion will be monitored once tidal influence has been restored to the site. The following sections of this report describe the

monitoring protocols developed for the Guadalcanal project and present the results of the pre-construction monitoring period (summer 2000).

1.3 Project Personnel

The restoration monitoring team consists of four different groups representing private, non-profit, state, and federal organizations.

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Table 1. Survey types and sampling design for monitoring tidal wetland development at Guadalcanal Village.

Parameter	Number of Sample Points/Transects	Sampling Frequency
Sediment	20 points	3 month interval
Tidal levels	3-5 points	Continuous (15 min interval)
Water quality	10 points (125 x 125 m grid)	3 month interval
Vegetation	18 transects, 3 quadrats/transect (125 x 125 m grid)	3 month interval
Invertebrates	9 points (250 x 250 m grid)	Annually post-construction
Insects	4 quadrats (500 x 500 m grid)	1st, 3rd, and 5th years post-construction
Fish	To be determined	Annually
Birds	9 points/9 areas (250 x 250 m grid)	3 month interval
Mammals	4-9 trapping grids (250 x 250 m grid)	Wet/dry season
Photo-documentation	7 points	Wet/dry season

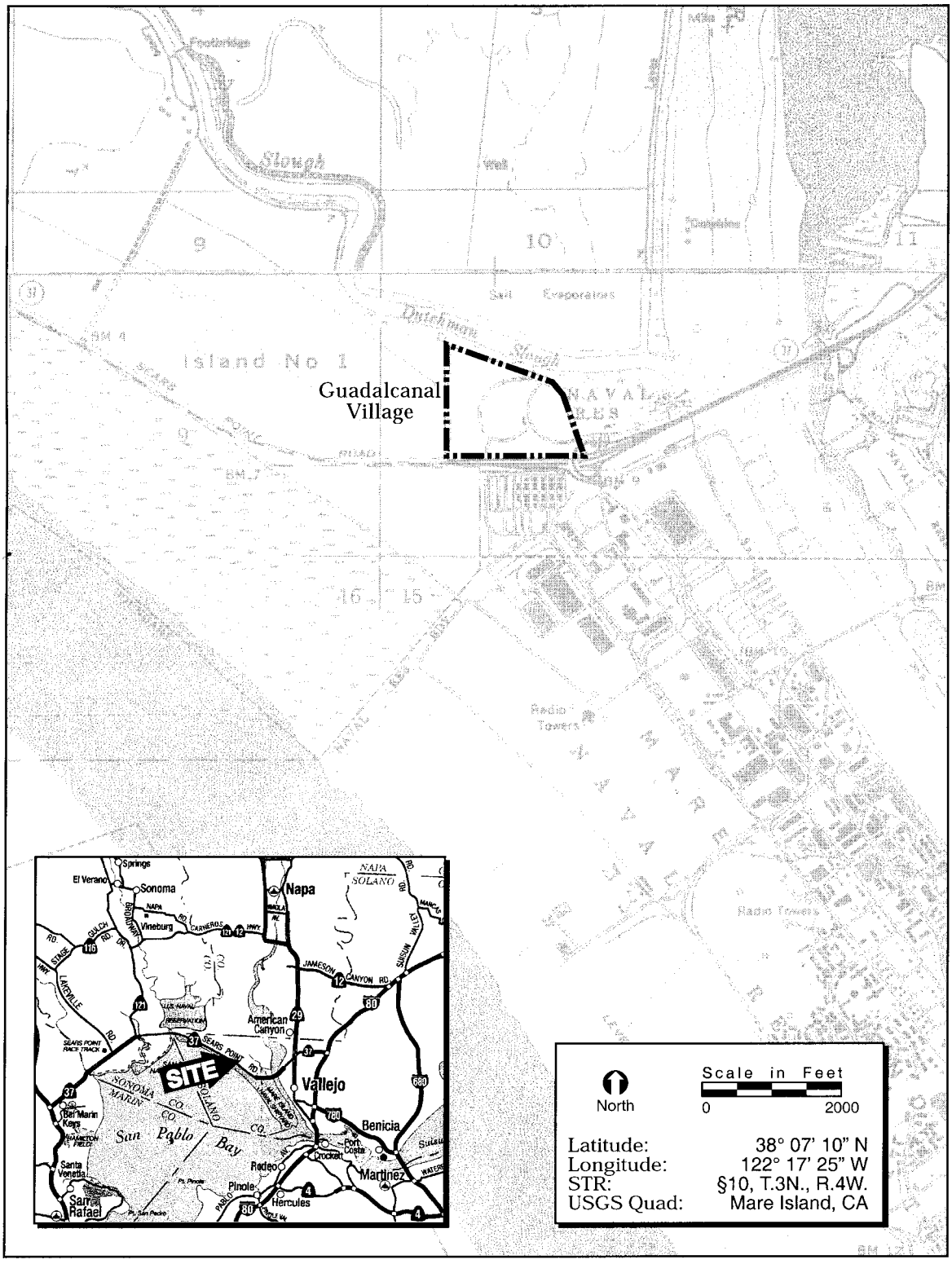

Figure 1. Guadalcanal Village project site and vicinity.

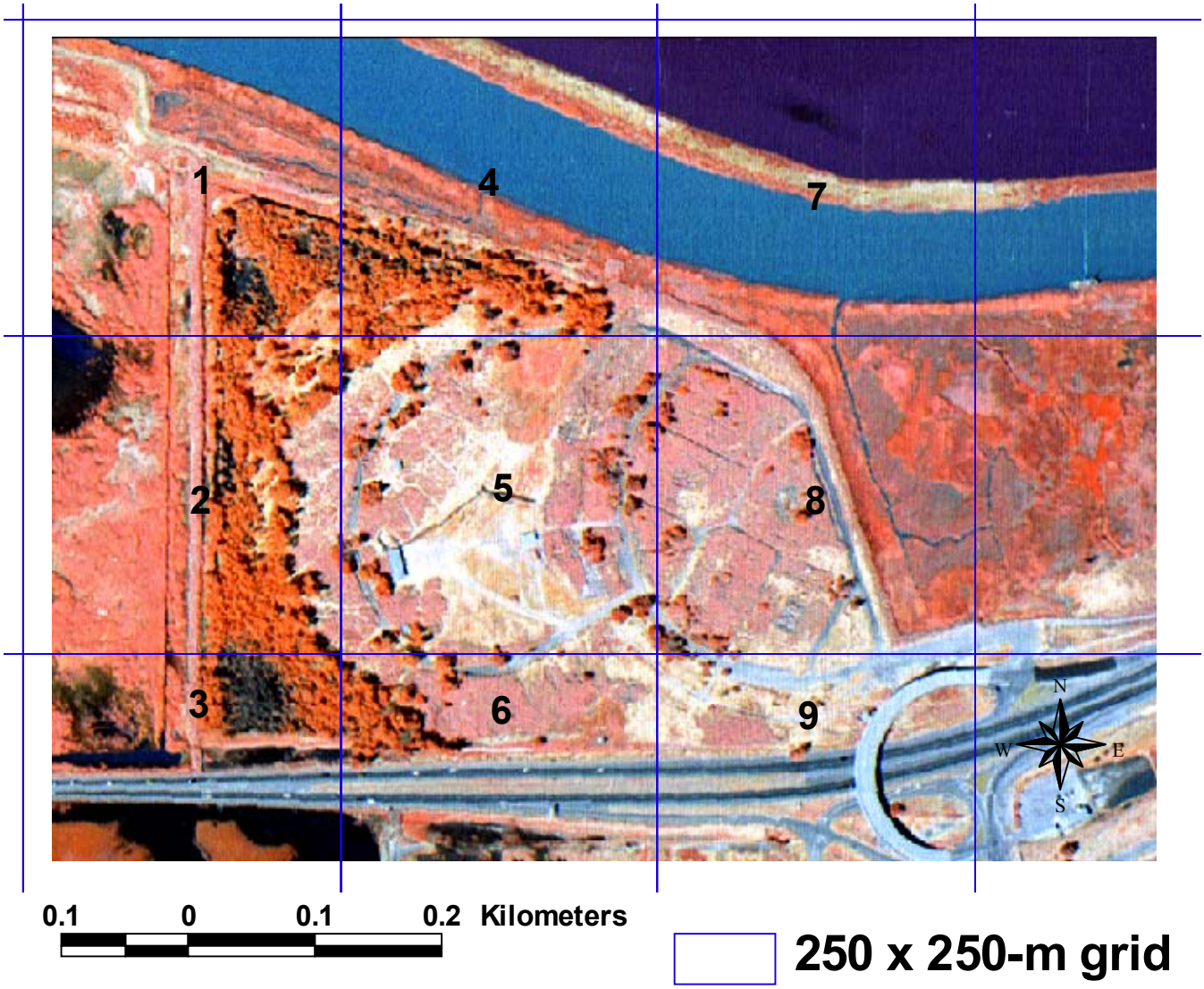

Figure 2. Guadalcanal Village with numbered, 250 x 250 m grid overlay. The center point of each grid that lies within the project area is used for monitoring birds, mammals, and invertebrates.

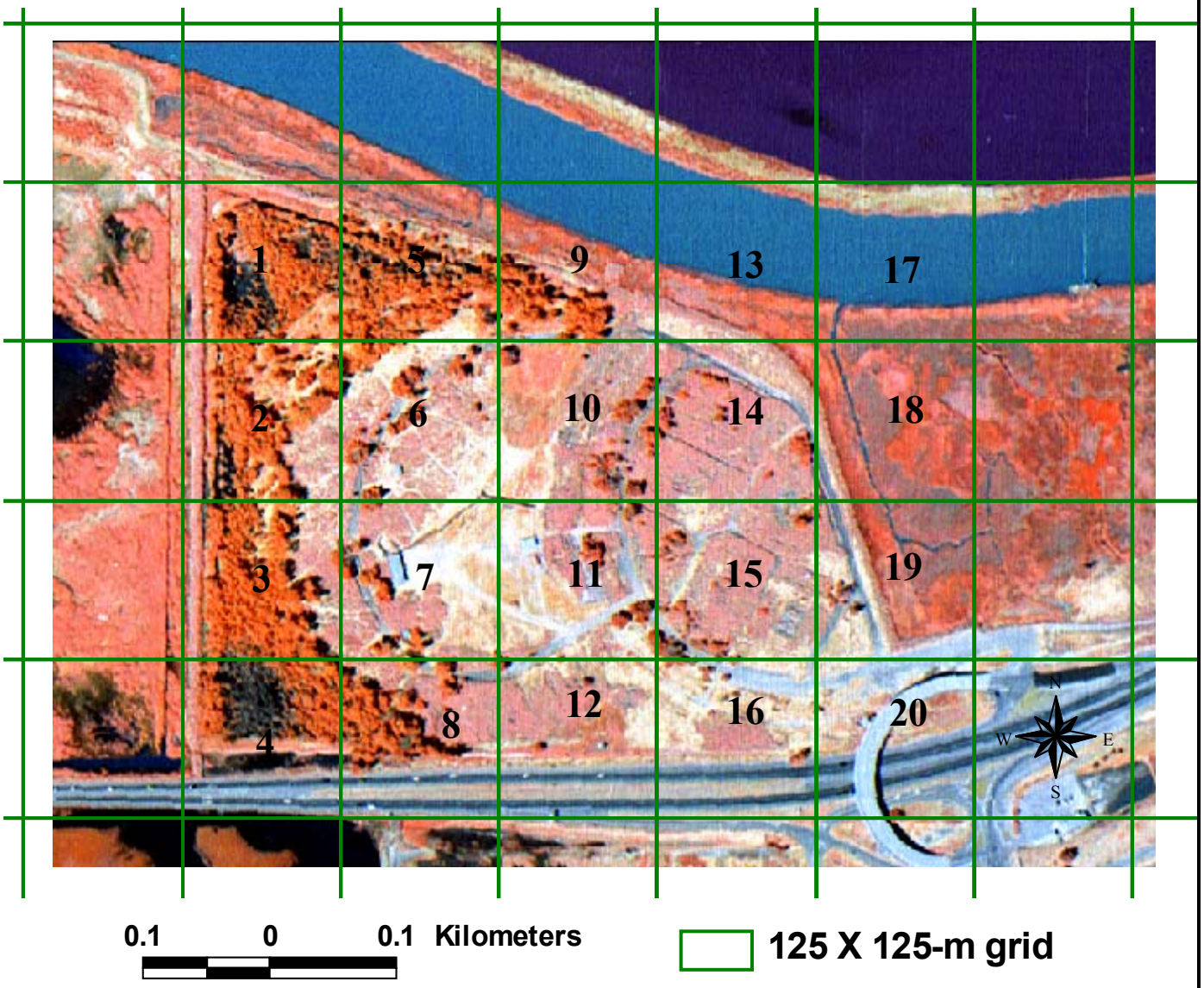

Figure 3. Aerial photo of Guadalcanal Village with numbered, 125 x 125 m grid overlay. The center point of each grid that lies within the project area is used to monitor water quality and vegetation.

Section 2. Hydrogeomorphology (IV.B.1.a-c)

2.1 Introduction

The goal of mitigation at Guadalcanal Village (Guadalcanal) is to restore tidal wetlands through construction of specific elevation contours (grading) and reintroduction of tidal flows via Dutchman Slough. A grading plan was developed to achieve required vegetation types within targeted elevation ranges established from hydrological models (Wetland Research Associates, Inc. et al. 2000). The hydrologic criterion for success at Guadalcanal is the creation of high tide elevations at the upper ends of the interior channels. High tide elevations at the entrance to Guadalcanal should be within 0.08 m of the high water elevations in Dutchman Slough. Expected tidal levels, elevation contours, sedimentation rates, and related marsh development through time will be the primary parameters used to monitor project success. Parameters related to hydrogeomorphology that will be monitored at Guadalcanal include sediment accretion, tidal datum, water quality, and elevation.

2.2 Methods

2.2.1 Sediment accretion rate (IV.B.1.a)

An important physical parameter that depicts changes in elevation and hence development of tidal marsh is the accretion (accumulation) of sediment through time. Sediment accretion is important because it has a direct effect on the development of inter-tidal plant and animal communities (Goals Project 1999). Sediment accretion will be monitored at Guadalcanal using sediment pins.

Sediment pins will be placed in locations representing a range of –1.13 to 1.37 m (mudflat to high marsh zones). The proposed grading plan shows the expected elevation boundaries and associated marsh zones (Wetlands Research Assoc. 2000). Sediment pins

will be installed at approximately 20 locations across Guadalcanal after construction is complete and before tidal influence is reintroduced. Five sediment pins will be placed within each of the following elevation ranges: -1.13 to 0.24 m, 0.24 to 1.16 m, 1.16 to 1.22 m, and 1.22 to 1.37 m. The pins will consist of 2 inch schedule 40 PVC pipe driven into the ground to resistance. Upon installation, the elevation of the top of pins will be determined. A graduated (cm) vertical rod with a flat base will be used to determine distance between the pin top and the sediment surface. Pin measurements will be taken at 3 month intervals and compared with previous measurements. Sediment accretion rates will be calculated as time (cumulative time since levee breach, incremental time periods between sampling) divided by sediment thickness. In addition to sediment accretion, point elevations will also be available from this data since both pin top elevations and thickness of sediment accretion will be known.

2.2.2 Tidal datum (IV.B.1.b)

The development of marsh zones and associated wildlife assemblages is related to many factors of hydrogeomorphology, including land elevations and their relationship to rising and falling tide levels. Tidal cycles and duration of inundation directly influence the physical and chemical aspects of a salt marsh, which, in turn, affect the development of plant and wildlife assemblages.

Up to three water level loggers (Telog) will be installed at Guadalcanal to monitor tide cycles and water levels through time. Placement of water level loggers will be dependent upon post-construction elevation contours, especially with respect to the location and juxtaposition of primary, secondary, and minor channels. Staff gauges will be placed adjacent to each water level logger. Elevation of staff gauge tops will be determined and water levels will be recorded from staff gauges on a monthly basis. This data will be used to calibrate logger tide levels. Water level data will be collected continuously (15 minute intervals) and summarized by pre-determined time intervals. These data will be used to identify patterns of tidal cycles through time (e.g., 24 hour, months, years) and to determine tidal datum, such as mean higher high water (MHHW).

2.2.3 Water quality (IV.B.1.c)

Water quality can be used to assess environmental conditions in developing wetlands that may be detrimental or advantageous for invertebrates and fish. As environmental conditions change at Guadalcanal through time, pH, salinity, dissolved oxygen, temperature, and turbidity will be sampled. Sampling will occur at the center points of alternating 125 x 125 m grid locations (n = 10) on a seasonal basis. Pre-project conditions at Guadalcanal preclude sampling at designated locations because water is limited to a perimeter drainage ditch (north and west). Water quality sampling occurred along the ditch prior to construction activities. Where depths allow, dissolved oxygen and temperature will be sampled along a vertical profile. Data for each sampling session will also include ambient temperature and tide level. Data will be examined seasonally, in relation to time since levee breach, and in relation to other survey results (e.g., fish and invertebrates).

2.3 Preliminary Results

Data presented in this report represent the pre-construction period at Guadalcanal. Thus, sediment accretion and tidal levels were not sampled. Installation of sediment pins and tidal data loggers will occur just prior to breaching of the levee to Dutchman Slough.

2.3.1 Water quality

Water quality measurements were made in June 2000 at grid numbers 1-5 and 9 (Table 2). These points are located along the perimeter drainage canal. Measurements included pH, conductivity, dissolved oxygen, temperature, and salinity. Turbidity measures were not included since water depths (range = 18 to 76 cm) were not sufficient for readings with the Horiba probe.

Mean values of pH, conductivity, dissolved oxygen and salinity are low relative to values typically found in estuaries or the ocean. The salinity of estuaries generally ranges from

5 to 30 parts per thousand (ppt) depending on the amount of freshwater or ocean influence. Therefore, the current mean value of 5.5 ppt at Guadalcanal suggests the source of water at Guadalcanal is primarily precipitation. Mean pH at Guadalcanal was 7.12 and represents a low value relative to the recorded range for estuaries (6.8-8.6). Mean dissolved oxygen was measured as 1.4 mg/L. Values of pH and dissolved oxygen from a restored tidal wetland (Tolay Creek, March 2000) within the vicinity of Guadalcanal range from 7.5 to 8.2 and 5.3 to 10.3 mg/L, respectively. Compared to these values, dissolved oxygen at Guadalcanal is low. For our purposes here, conductivity is an indication of the amount of dissolved solids (especially salt) and thus parallels our salinity findings.

Table 2. Water quality measurements at Guadalcanal Village, June 2000.

	PH	Conductivity (mS/cm)	Dissolved Oxygen (mg/L)	Temperature (^{o}C)	Salinity (ppt)
Mean	7.1	9.7	1.4	20.5	5.5
SD	0.40	2.07	1.21	2.17	1.50

Section 3. Benthic Invertebrates (IV.B.1.e)

Benthic invertebrate sampling will be conducted at Guadalcanal following construction activities and reintroduction of tidal flows. Sampling will be conducted on an annual basis for the first 3 years followed by sampling in the 5th year to examine changes in abundance and species diversity. Core samples (10 cm diameter/depth) will be taken to enumerate benthic invertebrates at the centers of the 250 x 250 m grid plots (n = 9). Samples will be screened (0.5 mm) and frozen prior to sorting. Invertebrates will be identified to order or family, counted, dried, and weighed (0.1 mg).

Section 4. Terrestrial Insects (IV.B.1.f)

Terrestrial insect sampling will be conducted during the 1st, 3rd, and 5th years following construction to examine changes in abundance and species diversity. Sampling will occur within each of the 500 x 500 m grid plots overlaying the project area. A vacuum will be used to sample insects from a 0.5 x 0.5 m area. Three passes will be made through the area, each successively deeper. Collected insects will be placed in alcohol and frozen prior to sorting. Insects will be identified to family or order, counted, dried, and weighed (0.1 mg).

Section 5. Fish (IV.B.1.g)

Fish sampling will be conducted at Guadalcanal conducted annually for the first 3 years following construction to examine changes in abundance and species diversity, followed by sampling in the 5th year. Surveys will consist of the use of throw nets, gill nets, and bag seines where sampling allows. Fishing effort for each gear type used will be standardized and replicated to allow for statistical comparisons. Upon capture, fish will be identified to species and tallied. The first 25 individuals of each species captured will be measured for total length and weight. Up to 25 individuals of each species captured will also be collected for subsequent analysis of gut contents to determine use of invertebrates.

Section 6. Vegetation (IV.B.1.d)

6.1 Introduction

Vegetation was sampled at Guadalcanal prior to construction activities. Hydrological models have shown elevations and spatial configuration of channels will change through time. In turn, various marsh plant assemblages will develop and change through time. Target minimum acreages of specific habitat types (e.g., marsh plain, mudflat) have been established and will be used as a measure of restoration success.

6.2 Methods

Vegetation at Guadalcanal was sampled at the center point of each 125 x 125 m Universal Transverse Mercator grid overlaying the project site in June 2000 (n = 20, Figure 4). Grid center points were located using a hand-held GPS receiver and marked with flagging. When a center point fell near a levee, road, or building, a new sample point was selected where vegetation did not appear to be affected by these structures. Transect 17 was not sampled during the June 2000 pre-construction monitoring since this transect is located in Pritchard Marsh, beyond the boundaries of the Guadalcanal project site. Vegetation was sampled once prior to construction activities. Following introduction of tidal flows into Guadalcanal, sampling will occur during the wet and dry seasons each year. Both line-intercept transects and quadrats were used to sample vegetation at Guadalcanal. One line-intercept transect and three quadrats were sampled at the center of each 125 x 125m UTM grid.

The line-intercept method is used to estimate species percent cover. Cover is measured along transects by recording the point along the tape where a particular cover type begins and ends. The intercepts of a particular plant species are added and then divided by the total line length to produce a percentage of total cover (Elzinga et al. 1998). Each line-intercept transect extended from 125 x 125 m grid centers for 15 meters along a randomly-selected compass bearing. Species name and the "intercept length" for each

individual plant encountered along a transect were recorded. Intercepts of species occurring at lengths of less than 10 cm were not recorded.

The quadrat method also is used to evaluate species percent cover. In addition, quadrats may be used to determine stem density and maximum vegetation height. Quadrats (0.50 x 0.50 m) were sampled at three points along each transect. The first quadrat was sampled at 0 m (bottom corners of quadrat at 0 m and 0.5 m), the second at 5 m (corners at 5.0 m and 5.5 m), and third at 10 m (corners at 10.0 m and 10.5 m). Data recorded within quadrats included absolute percent cover, stem density (number of rooted stems), and maximum vegetation height by species. Percent cover was visually estimated for all species within the quadrat area. Objects with less than 5% cover were recorded as present.

Height (cm) was measured from the substrate to the top of the tallest individual of each species in the quadrat. Depth of fallen litter (duff) and water were also measured. Stem counts and maximum height of each plant species were conducted in the same quarter of the quadrat (25 x 25 cm). For individual grasses and other small species, stems were counted in a smaller area (e.g., 5 x 5 cm) and extrapolated to estimate density within the 1 x 1m quadrat area. In addition to the above measurements, date, observer, UTM grid number and coordinates were recorded at each grid sampling location.

6.3 Preliminary Results

A vascular plant species list was compiled for the Guadalcanal Village site (Table 3). A total of 25 plant species were recorded at Guadalcanal of which only 3 species were native.

6.3.1 Transects

Percent cover was calculated for each species for each individual transect and across the Guadalcanal site. Transects 1, 2, 3, 6, and 10 were dominated by duff (31 to 79%), while

sweet fennel dominated transects 9, 11, 12, 13, 14, 16 and 18 (71 to 100%) (Figure 5). Transect 20 was dominated by Mediterranean barley (89%), and transects 5, 8, 15 and 19 were composed largely of bare ground.

Overall, sweet fennel and duff comprised 40% and 18% of total ground cover at the Guadalcanal Village site, respectively (Figure 6). Bare ground comprised 11% of site cover. Wild oat, Mediterranean barley, litter, perennial ryegrass, Sydney golden wattle, annual beard grass, spearscale and curly dock were present in smaller amounts.

6.3.2 Quadrats

Mean percent cover (± standard error) was calculated for each species within quadrat samples (3 quadrats/transect) across all transects (Figure 7). Sweet fennel comprised 37% (± 10) of the site. Duff comprised 24% (± 8), while cover of red gum was 16%(± 6). Sydney golden wattle was 15% (± 8). Wild oat, spearscale, Mediterranean barley, litter and bare ground were also recorded.

Mean percent cover was calculated for each transect using the quadrat samples (Figure 7). Representation of species that occurred in the upper canopy were included in quadrat samples, such as red gum and Sydney gold wattle. Transects 1, 2, 3 and 5 were dominated by red gum (33 to 60%) and duff (63 to 78%). Sweet fennel comprised the majority of transects 8, 10, 11, 12, 13, 14, 16 and 18 (45 to 100%). Transect 20 was composed primarily of Mediterranean barley (78%). Transects 15 and 19 were composed of a mixture of species.

Maximum height of vegetation within quadrats was greatest within transects 8, 10-14, 16 and 18 (Appendix A). These transects were dominated by sweet fennel with height values of up to greater than 302 cm. The height of upper canopy tree species was not recorded. Mean stem density was highest in transects dominated by grass species (Appendix B). These included wild oat (210 stems/m^2), Mediterranean barley (525 stems/m^2) and perennial ryegrass (139 stems/m^2).

Table 3. List of plant species observed at Guadalcanal Village; June 2000.

Family	Common Name	Scientific Name	Code	Native	Introduced
Apiaceae	Sweet fennel	*Foeniculum vulgare*	FOVU		X
Asciepiadaceae	Milkweed	*Asclepias species*	ASSP		
Asteraceaea	Italian thistle	*Carduus pycnocephalus*	CAPY		X
	Yellow star thistle	*Centaurea solstitialis*	CESO		X
	Purple star thistle	*Centaurea calcitrapa*	CECA		X
	Pineapple weed	*Chamomilla suaveolens*	CHSU	X	
	Brass buttons	*Cotula coronopifolia*	COCO		X
	Bristly ox-tongue	*Picris echioides*	PIEC		X
Brassicaceae	Field Mustard	*Brassica rapa*	BRRA		X
Chenopodiaceae	Spearscale	*Atriplex triangularis*	ATTR	X	
Convolvulaceae	Bindweed	*Convolvulus arvensis*	COAR		X
Fabaceaea	Sydney Golden Wattle	*Acacia longifolia*	ACLO		X
	Pea	*Lathyrus brownii*	LABR	X	
	Birdfoot trefoil	*Lotus corniculatus*	LOCO		X
Geraniaceae	Common geranium	*Geranium dissectum*	GEDI		X
Myricaceae	Red gum	*Eucalyptus rostrata*	EURO		X
Plantaginaceaea	English plantain	*Plantago lanceolata*	PLLA		X
Poaceae	Wild oats	*Avena fatua*	AVFA		X
	Ripgut brome	*Bromus diandrus*	BRDI		X
	Soft chess	*Bromus hordeaceous*	BRHO		X
	Mediterranean barley	*Hordeum marinum*	HOMA		X
	Barley	*Hordeum murinum*	HOMU		X
	Perennial rye grass	*Lolium perenne*	LOPE		X
	Annual beard grass	*Polypogon monspeliensis*	POMO		X
Polygonaceae	Curly dock	*Rumex crispus*	RUCR		X
Bare ground			BARE		
Duff			DUFF		
Litter			LITR		
Moss species			MOSS		

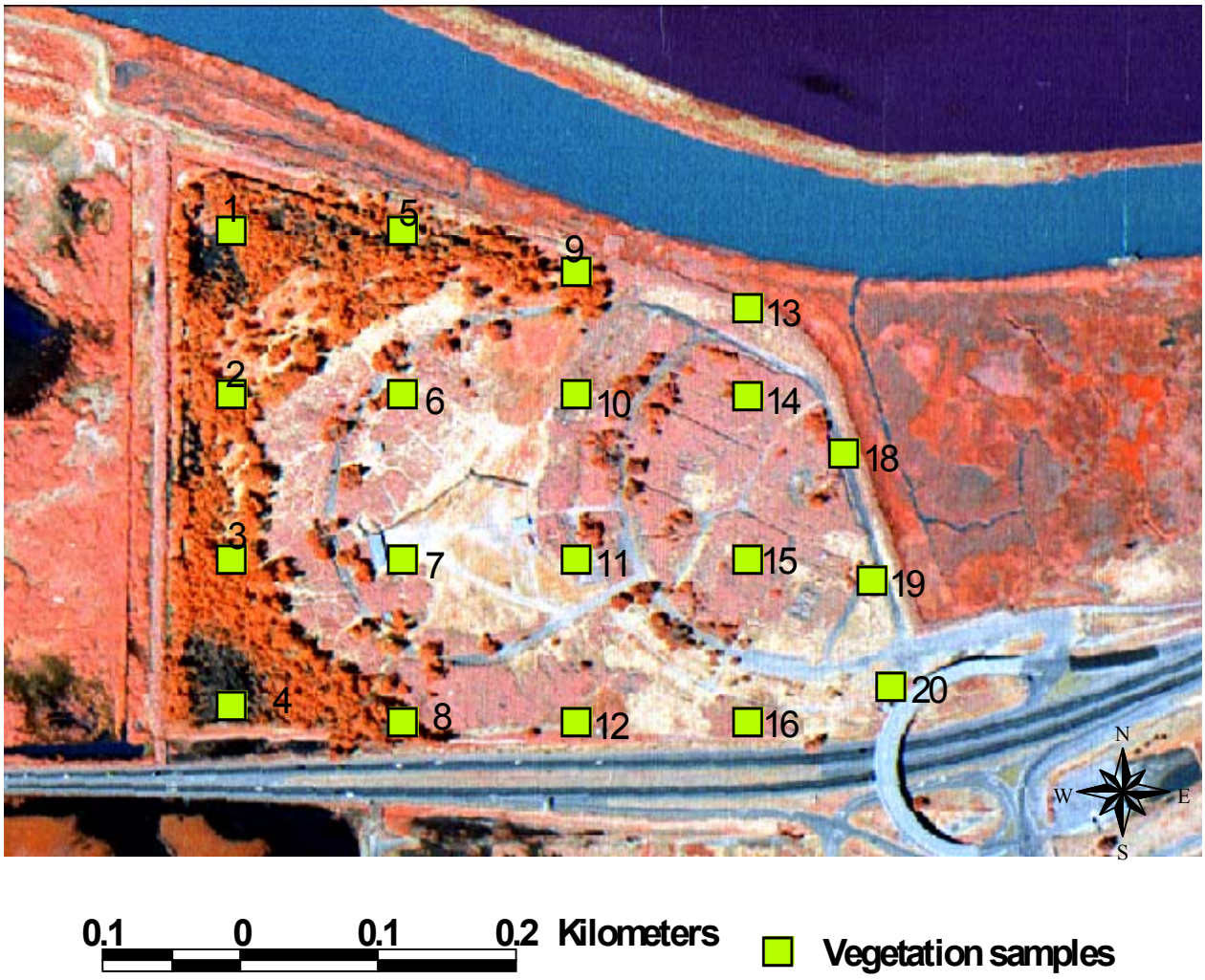

Figure 4. Location of vegetation samples at Guadalcanal Village; June 2000. Infrared photograph, September 1999.

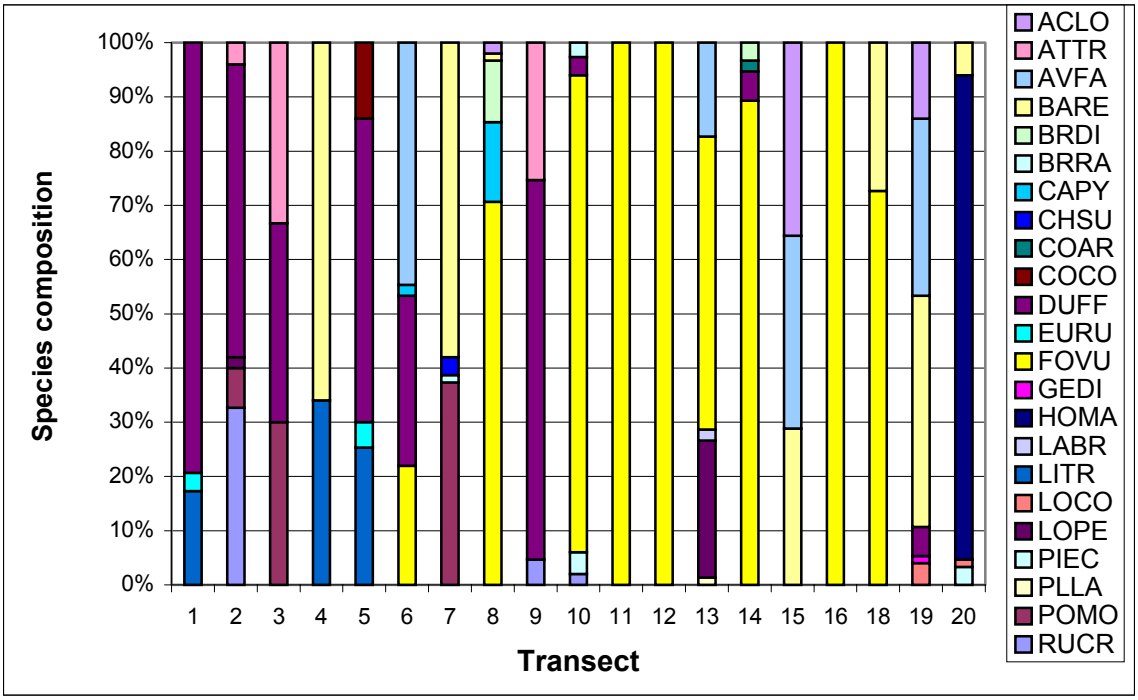

Figure 5. Percent cover of vegetation within each transect at Guadalcanal Village; June 2000. Species with less than 3 percent cover are not shown. Transect 17 was not sampled during pre-construction monitoring because it is located in nearby Pritchard Marsh.

ACLO=Acacia longifolia, ASSP=Asclepias species, ATTR=Atriplex triangularis, AVFA=Avena fatua, BARE=bare ground, BRDI=Bromus diandrus, BRRA=Brassica rapa, CAPY=Carduus pycnocephalus, CESO= Centaurea solstitialis, CECA=Centaurea calcitrapa, CHSU=Chamomilla suaveolens, COAR=Convolvulus arvensis, COCO=Cotula coronopifolia, DUFF=duff, EURO=Eucalyptus rostrata, FOVU=Foeniculum vulgare, GEDI=Geranium dissectum, HOMA=Hordeum marinum, HOMU=Hordeum murinum, LABR=Lathyrus brownii, LITR=leaf litter, LOCO=Lotus corniculatus, LOPE=Lolium perenne, PIEC=Picris echioides, PLLA=Plantago lanceolata, POMO=Polypogon monspeliensis, RUCR=Rumex crispus.

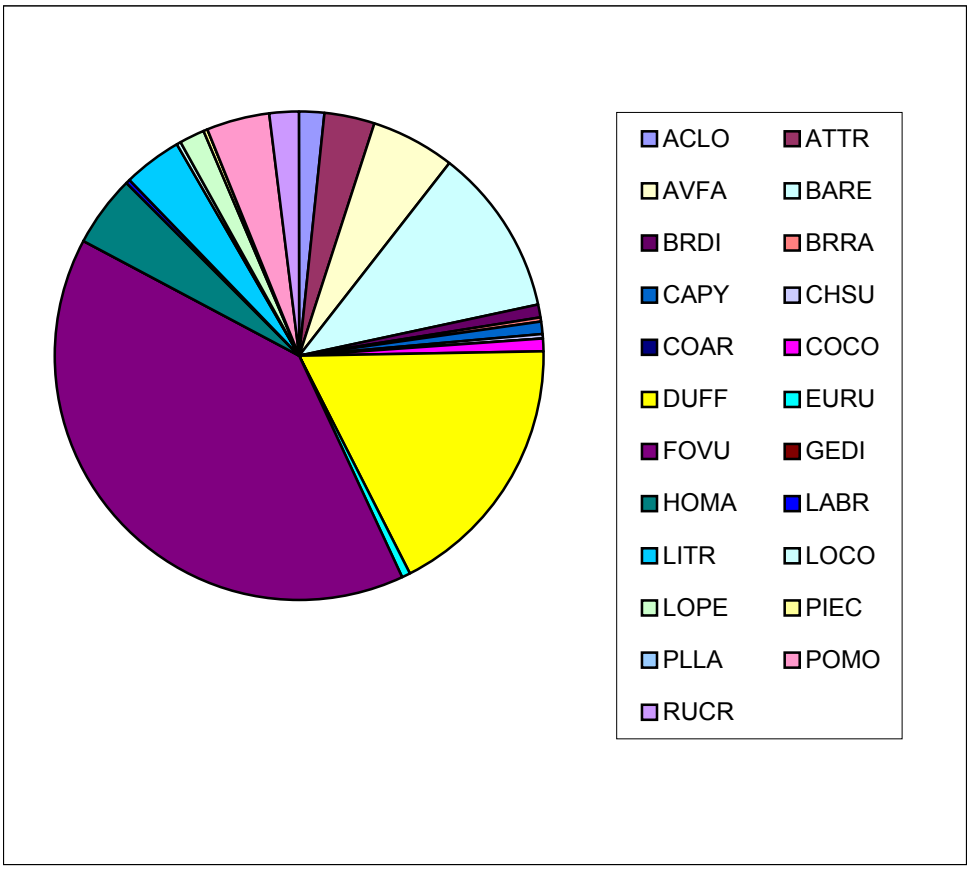

Figure 6. Total percent cover of vegetation across all transects at Guadalcanal Village, June 2000. Species with less than 3 percent total cover are not shown.

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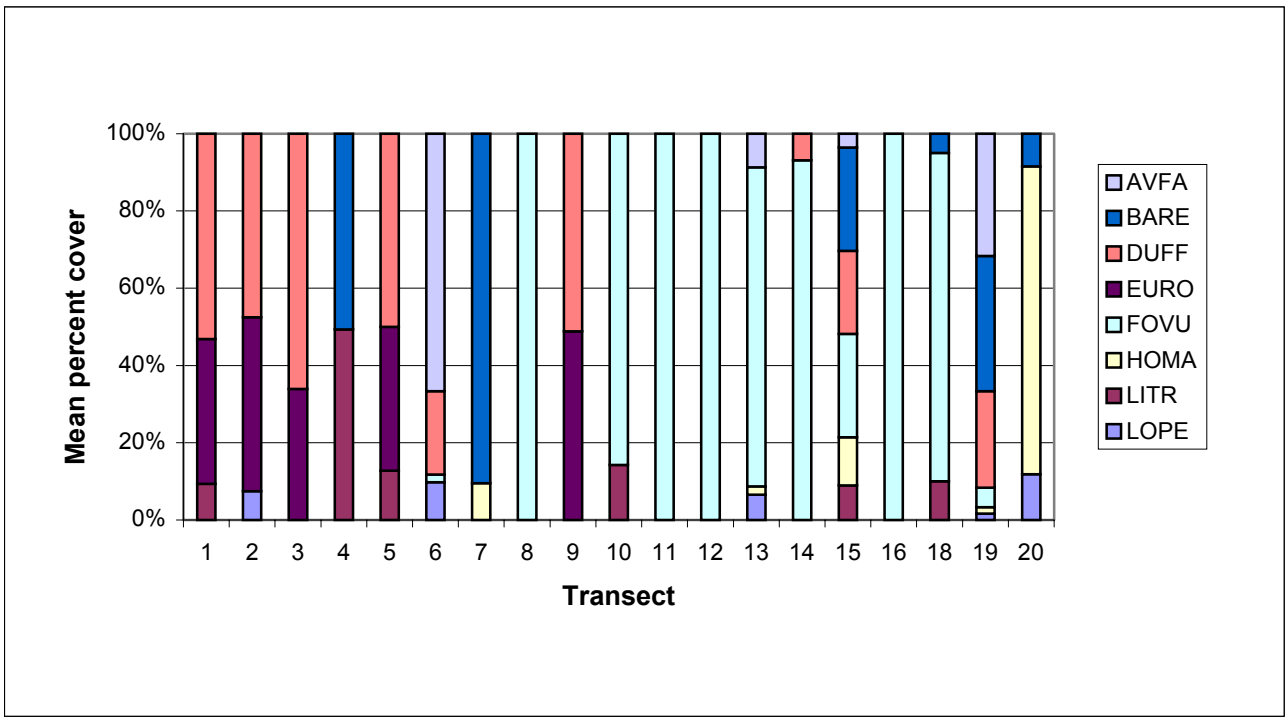

Figure 7. Mean percent cover of plant species at Guadalcanal Village from quadrat samples (3 quadrats per transect, 19 transects total), June 2000. Species with cover of less than 3 percent are not shown. Transect 17 was not sampled since it is located in nearby Pritchard Marsh. These results are similar to transect data although quadrat sampling highlighted overstory tree species such as eucalyptus (EURO) at transects 1-5 and 9.

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Section 7. Birds (IV.B.1.h)

7.1 Introduction

The goal of mitigation at Guadalcanal Village (Guadalcanal) is to restore tidal wetlands and associated habitat for wildlife and plants. This includes bird species that typically occur in tidal marsh of San Pablo Bay. Pritchard Marsh (10 ha), a tidal marsh adjacent (east) of Guadalcanal, will be used as a model for development of bird assemblages at Guadalcanal. Special status bird species recorded from Pritchard Marsh include California clapper rail (*Rallus longirostrus obsoletus*), California black rail (*Laterallus jamaicensis* coturniculus), salt marsh common yellowthroat (*Geothlypis trichas sinuosa*), and San Pablo song sparrow (*Melospiza melodia*).

7.2 Methods

Variable-circular plot (point counts) and area surveys were employed to characterize birds at Guadalcanal prior to construction activities and will be used for future monitoring. The methods and spatial sampling design presented here were established to compare with future trends in bird assemblages at Guadalcanal. Point counts were conducted at the center of each 250m x 250m grid (n = 9 points, Figure 8). When grid centers occurred outside the project area, surveys were conducted from the center of the remaining grid portion within project boundaries. Area surveys for birds or complete counts were also conducted at the 250m x 250m grid level (n = 8 areas). Sampling will be conducted seasonally; spring (Mar-May), summer (Jun-Aug), winter (Dec-Feb), and fall (Sep-Nov).

7.2.1 Variable-circular plot surveys

Variable-circular plot (VCP) surveys are used to derive estimates of bird species richness and density. The VCP method used at Guadalcanal consisted of an observer recording birds seen or heard during a 10-minute period at 8 points (Figure 8). Species, number of individuals observed, and distance from the observer (m) were recorded throughout the 10-min survey period. Species flying over the project area were recorded as such. Data records also included date, time, wind speed (mph), cloud coverage (%), and precipitation. Surveys were conducted within 3.5 hours of sunrise. Pre-construction analyses of VCP data included a summary of bird species richness (no. species) and total bird abundance at Guadalcanal. An estimate of density (no. birds/ha) by species was also calculated. Species flying over the project area were not included in density calculations unless it was clear that individuals were using the area (e.g., aerial foraging).

Density calculations were based on the circular survey area with radius *r*. Radius of the circle was determined by examining the pattern of detectability at varying distances (number of birds by distance). In most cases, detectability decreases with increasing distance. The detection distance where a clear decline in recorded observations occurred was used to calculate density estimates. As the number of surveys conducted at each point increases over time, density estimates will be calculated for more numerous species using the program Distance. Program Distance provides the capability to create detectability functions for each species thereby providing more accurate estimates of density.

7.2.2 Area surveys

Area surveys are a useful method to document the occurrence of larger bird species such as waterfowl and shorebirds that are readily seen and may occur at high densities during some parts of the year. These species can often be under represented in the variable-circular plot method. Area surveys consisted of an observer walking at a constant rate (approx. 3km/h) throughout the project area and recording species and number of

individuals observed within each grid. A global positioning system (GPS) unit and landmark features were used to identify grid boundaries. Data records also included date, time, grid number, wind speed, cloud coverage, and precipitation. Analysis of area survey data included determination of species richness and abundance (total/species) within each grid and across the project area.

7.3 Preliminary Results

Bird surveys at Guadalcanal conducted in June 2000 resulted in the detection of 31 bird species of which 20 and 22 species were detected in VCP and area surveys, respectively (Table 4). Bird species listed as threatened or endangered were not observed at Guadalcanal. Bird species that were observed and are Federal or California listed as Species of Special Concern (FSC\CSC) were double-crested cormorant (*Phalacrocorax auritus*) and northern harrier (*Circus cyaneus*). Double-crested cormorants were only observed flying over the area.

Of the 31 bird species observed, 6 were recorded only while flying over the area. These were the Caspian tern (*Sterna caspia*), cliff swallow (*Hirundo pyrrhonota*), double-crested cormorant, Forster's tern (*Sterna forsteri*), great egret (*Casmerodius albus*), and gull species (*Larus* sp.). Of these species, only cliff swallows were used in density estimates since individuals were observed foraging (aerially) over the project area. All other species were considered wetland-associated species that likely inhabited areas adjacent to (e.g., Pritchard Marsh) or within the vicinity of Guadalcanal.

Similar numbers of species were detected during variable-circular plot (VCP) and area surveys (Table 5). Species not observed during VCP surveys but observed during area surveys were American goldfinch (*Carduelis tristis*), common raven (*Corvus corax*), northern harrier (*Circus cyaneus*), northern mockingbird (*Mimus polyglottos*), and the northern oriole (*Icterus galbula*). As restoration progresses, area surveys will complement VCP surveys, especially with respect to larger shorebird and waterfowl

species. In addition, comparison of area survey results through time will provide a measure of shifts in bird species composition.

Bird density estimates were calculated with VCP survey data. Variable-circular plot data (n = 9 plots) were grouped into two classes based on where they occurred in relation to dominant vegetation features (i.e., eucalyptus forest vs. fennel). The ability to detect birds at varying distances in eucalyptus versus fennel dominated environments was clear when number of birds observed was plotted against detection distance (Figures 9 and 10). Based on these patterns, a 50-m radius circle was used to calculate density estimates in eucalyptus-dominated areas and an 80-m radius circle in areas dominated by fennel. Density estimates showed cliff swallows, red-winged blackbirds (*Agelaius phoeniceus*), and house finches (*Carpodacus mexicanus*) were the most abundant species in eucalyptus-dominated areas and across the project area as a whole (Table 5). In fennel dominated areas, cliff swallows, house finches, and song sparrows were the most abundant species. Species commonly inhabiting salt marsh environments and detected at Guadalcanal included song sparrows (*Melospiza melodia*), marsh wrens (*Cistothorus palustris*), and northern harriers (*Circus cyaneus*). Based on density estimates, these 3 species currently compose <5% of total bird abundance at Guadalcanal. Area surveys resulted in similar results showing these 3 species represented <6% of all birds observed.

Table 4. Bird species recorded during variable-circular plot (VCP) and area surveys at Guadalcanal Village; June 2000.

Common Name	Code	Scientific Name	Area Survey (*n* = 8 grids)	VCP Survey (*n* = 9 plots)	Observed flying over area
Allen's hummingbird	ALHU	*Selasphorus sasin*	X	X	
American goldfinch	AMGO	*Carduelis tristis*	X		
American robin	AMRO	*Turdus migratorius*	X	X	
Anna's hummingbird	ANHU	*Calypte anna*	X	X	
barn swallow	BASW	*Hirundo rustica*	X	X	
brown-headed cowbird	BHCO	*Molothrus ater*	X	X	
black phoebe	BLPH	*Sayornis nigricans*	X	X	
Brewer's blackbird	BRBL	*Euphagus cyanocephalus*	X	X	
bushtit	BUSH	*Psaltriparus minimus*	X	X	
Caspian tern	CATE	*Sterna caspia*			X
cliff swallow	CLSW	*Hirundo pyrrhonota*	X	X	X
common raven	CORA	*Corvus corax*	X		
double-crested cormorant	DCCO	*Phalacrocorax auritus*			X
European starling	EUST	*Sturnus vulgaris*	X	X	
Forster's tern	FOTE	*Sterna forsteri*			X
great egret	GREG	*Casmerodius albus*			X
gull species	GULL	*Larus sp.*			X
house finch	HOFI	*Carpodacus mexicanus*	X	X	
Killdeer	KILL	*Charadrius vociferus*		X	
marsh wren	MAWR	*Cistothorus palustris*	X	X	
mourning dove	MODO	*Zenaida macroura*	X	X	
northern harrier	NOHA	*Circus cyaneus*	X		
northern mockingbird	NOMO	*Mimus polyglottos*	X		
northern oriole	NOOR	*Icterus galbula*		X	
raptor species	RAPT		X		
red-winged blackbird	RWBL	*Agelaius phoeniceus*	X	X	
ring-necked pheasant	RNPH	*Phasianus colchicus*	X	X	
song sparrow	SOSP	*Melospiza melodia*	X	X	
turkey vulture	TUVU	*Cathartes aura*			X
western scrub jay	WSJA	*Aphelocoma oerulescens*		X	
yellow-rumped warbler	YRWA	*Dendroica coronata*	X	X	

Table 5. Number of individuals observed and density estimates of bird species based on variable-circular plot surveys (n = 9) at Guadalcanal; June 2000. Species showing the highest density values are indicated in bold.

	Eucalyptus Dominated (n = 4 plots)[a]		**Fennel Dominated (n = 5 plots)**		**Total Project Area[c]**
Species	Density[b] (no./ha)	Total No. Individuals (6.9 ha)	Density (no./ha)	Total No. Individuals (15.36 ha)	No. Individuals (22.26 ha)
house finch	**2.87**	20	**2.19**	34	**54**
cliff swallow	**11.15**	77	**12.93**	199	**276**
red-winged blackbird	**10.19**	70	0.60	9	**79**
Brewer's blackbird	1.91	13	*		13
bushtit	1.27	9	0.20	3	12
Allen's hummingbird	0.96	7	*		7
northern oriole	0.64	4	0.20	3	7
song sparrow	0.64	4	**0.80**	12	16
yellow-rumped warbler	0.64	4			4
American robin	0.32	2			2
brown-headed cowbird	0.32	2	0.20	3	5
mourning dove	0.32	2	0.20	3	5
western scrub jay	0.32	2			2
Anna's hummingbird	*				≥1
marsh wren	*		0.10	2	2
ring-necked pheasant	*				≥1
barn swallow			0.30	5	5
black phoebe			0.20	3	3
European starling			0.20	3	3
Killdeer			0.10	2	2

[a]Density estimates based on the primary environmental attribute that likely affected detectability (distance). At Guadalcanal, the attribute chosen was the dominant vegetation type: eucalyptus trees or fennel.
[b]Formula: [(mean no. individuals/point)/area of circle].
[C]Total number birds = {(density for eucalyptus*area of eucalyptus)+(density for fennel*area of fennel)}
* = species detected but not within the chosen radius for a density estimate.

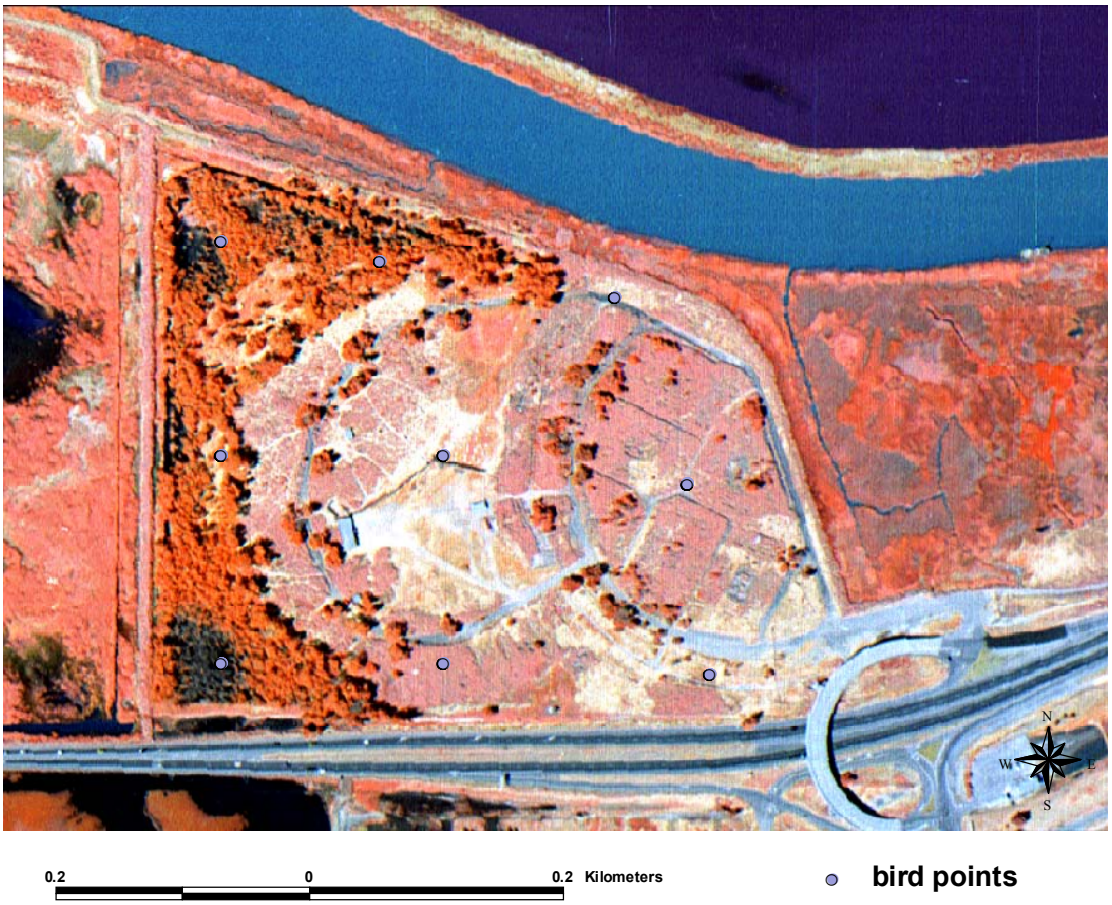

Figure 8. Bird survey locations (variable-circular plot) at Guadalcanal Village; June 2000. Infrared photograph, September 1999.

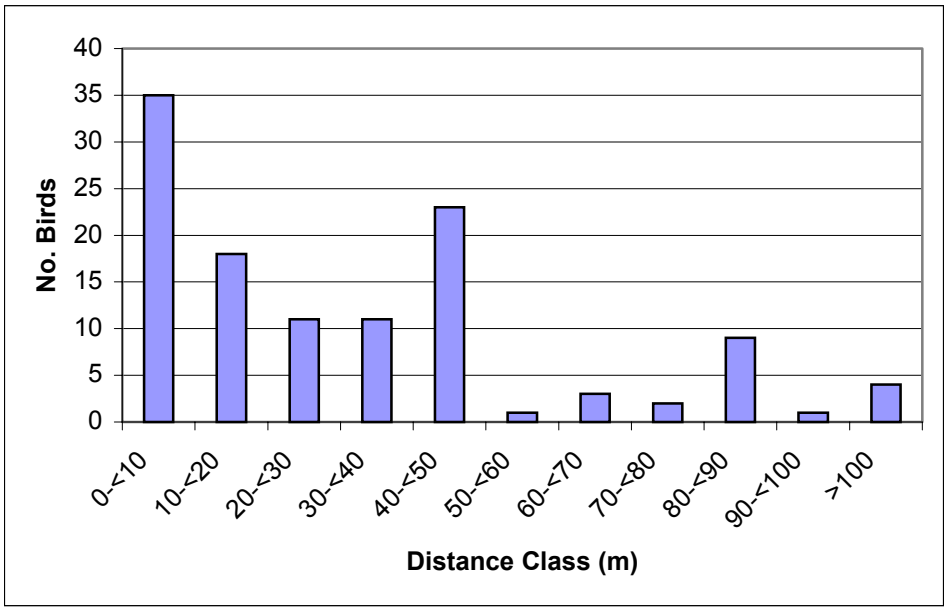

Figure 9. Number of birds detected by distance class during variable circular plot surveys in eucalyptus dominated areas (n = 4 plots) at Guadalcanal Village.

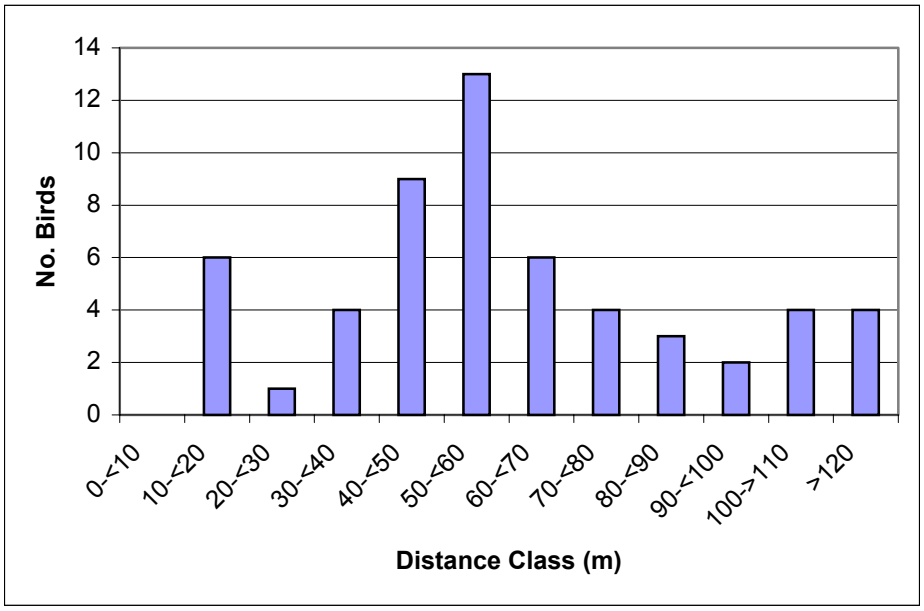

Figure 10. Number of birds detected by distance class during variable circular plot surveys in fennel dominated areas (n = 5 plots) at Guadalcanal Village.

Section 8. Mammals (IV.B.1.i)

8.1 Introduction

The goal of mitigation at Guadalcanal Village (Guadalcanal) is to restore tidal wetlands including habitat for a variety of mammal species that occur in tidal marsh of San Pablo Bay. Pritchard Marsh (10 ha), a tidal marsh adjacent (east) of Guadalcanal, will be used as a model for development of mammal assemblages at Guadalcanal. Special status mammal species recorded from Pritchard Marsh include salt marsh harvest mouse (*Reithrodontomys raviventris*) and Suisun shrew (*Sorex ornatus sinuosa*).

8.2 Methods

Small mammals were live trapped using Sherman traps (7.7 x 9.0 x 23.0-cm) at Guadalcanal during the pre-construction period. Trapping occurred at 4 locations established at center points of a 250 x 250-m grid configuration (Figure 11). Following reintroduction of tidal flows into Guadalcanal, mammals will be trapped at the same locations during the wet and dry seasons of each year.

Traps were placed in a 5 x 5 grid pattern with 10-m spacing (total = 25 traps). Each trap site was flagged and assigned a unique number. Trapping at each grid occurred for 3 consecutive nights and traps were set before dusk and checked within 1 hour of sunrise. Polyester batting was placed within each trap to protect captured animals from exposure (e.g., wind, rain). Traps were baited with a mixture of dry seeds and chopped walnuts.

Species identification, sex, age, mass (mg), reproductive condition, and presence of wounds or parasites were recorded for all individuals captured. Reproductive condition in males was characterized by presence and development of the testes. Reproductive condition in females was characterized by the presence and development of mammaries and whether or not the animal was pregnant. Animals captured and identified to the genus *Reithrodontomys* or *Sorex* also included records of body length, tail length, tail

width 20-mm from the base of the tail, right hind foot length, ear length, venter coloration of tail and belly, bicoloration of tail, and behavior (e.g., aggressive). Captured individuals were uniquely marked by removing fur with small scissors for purposes of determining the number of recaptures. Data for each trapping event also includes date, location, time, lunar phase, and weather.

Results of pre-project trapping efforts are reported as capture success among sites and species. As the number of sampling periods increases and environmental conditions shift at Guadalcanal through time, analyses will encompass seasonal analyses of mammal species richness and abundance.

8.3 Preliminary results

During June 2000, 40 new individuals (excludes recaptures) representing 3 species of small mammals were captured at Guadalcanal. These were house mouse (*Mus musculus*), California vole (*Microtus californicus*), and Norwegian rat (*Rattus norvegicus*). House mice and Norwegian rats are non-native species. House mice were the most abundant species encountered, representing 82.5% of all newly captured animals (Figure 12). A single California vole was captured at Grid 5. Grids 6 and 8 showed the greatest number of new captures relative to other trap locations (Figure 13). Grids 6 and 8 were located in fennel-dominated areas. Grid 4, located in a eucalyptus dominated area, showed the lowest capture success (Figure 13).

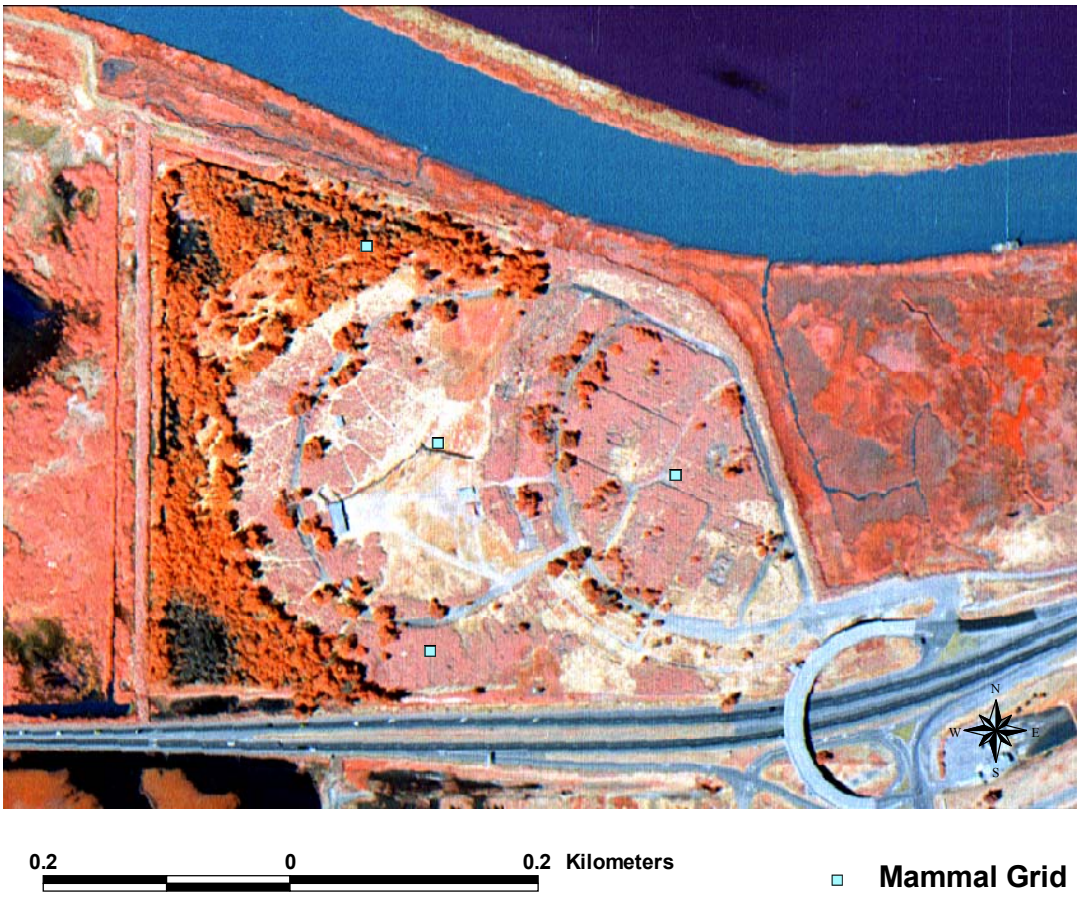

Figure 11. Location of small mammal sampling grids at Guadalcanal Village; June 2000. Infrared photograph, September 1999.

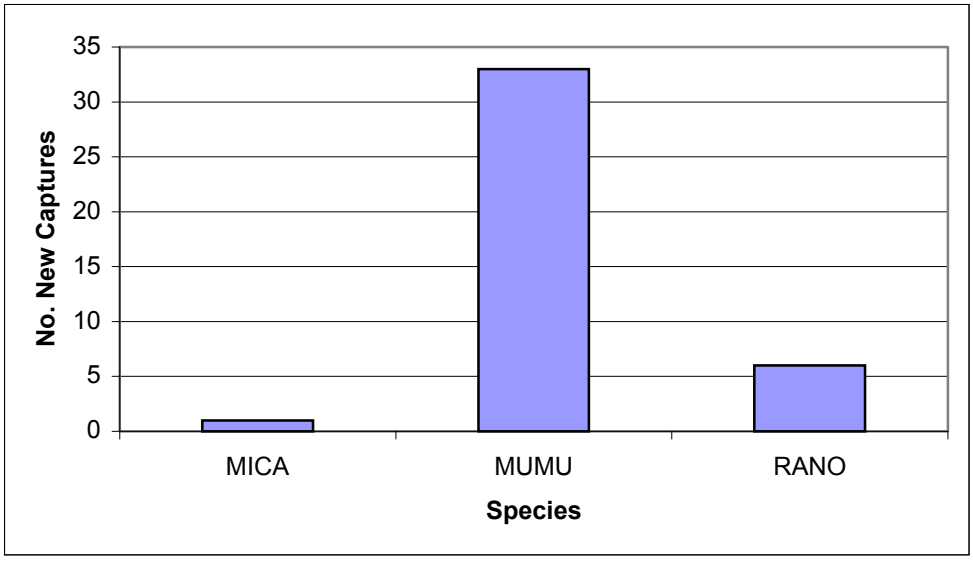

Figure 12. Number of small mammal captures by species at Guadalcanal Village; June 2000. Species symbols are as follows: MICA, (California vole, *Microtus californicus*), MUMU (house mouse, *Mus musculus*), RANO (Norwegian rat, *Rattus norvegicus*).

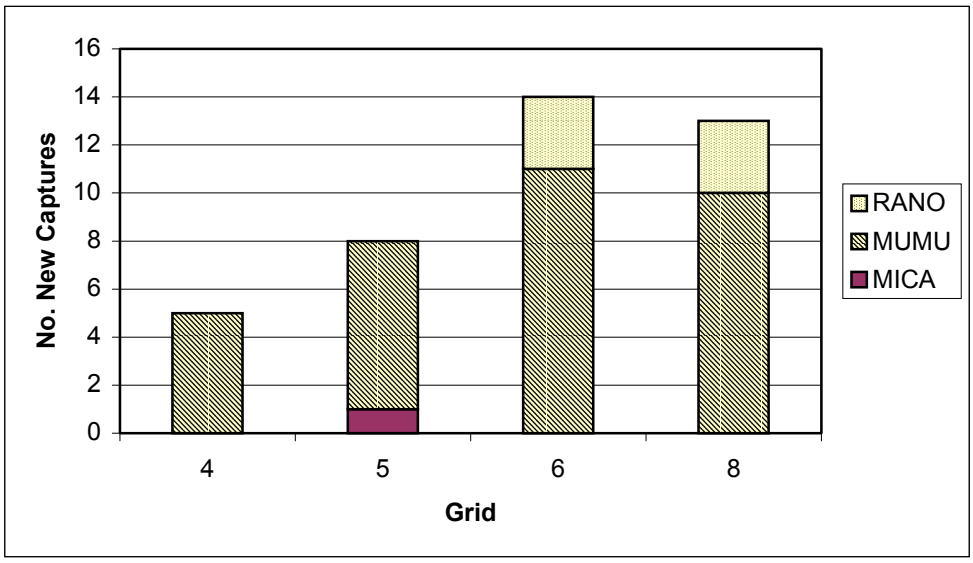

Figure 13. Number of small mammal captures among sampling grids at Guadalcanal; June 2000.

Section 9. Photo Documentation

Photographing landscapes provides a relatively inexpensive way of visually tracking changes through time. Seven points along the boundary of Guadalcanal will be used as one of the methods to track environmental changes through time (Figure 14). At each location, a series of photos are taken and later merged together to provide a panoramic view of Guadalcanal. In June 2000, the first set of images was taken to document pre-restoration conditions (Figure 15). These images clearly show the site is dominated by eucalyptus and fennel. In December 2000, a second set of images was taken to show vegetation removal activities at Guadalcanal (Figure 16). Following reintroduction of tidal influence, photos will be taken at the 7 points at least one time per year.

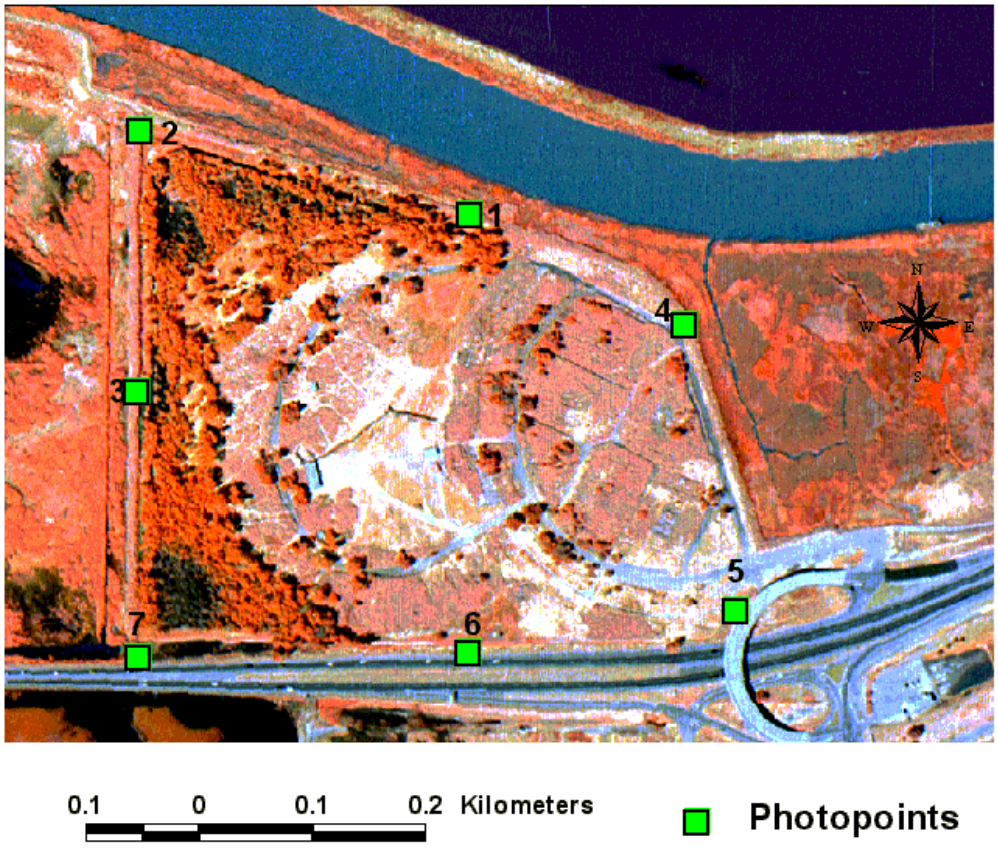

Figure 14. Infrared image of Guadalcanal (September 1999) showing locations of photodocumentation.

Figure 15. Photo documentation of environmental features at Guadalcanal Village (pre-construction); June 2000. Images taken at different compass bearings were later merged to produce a panoramic view at each photo point.

Point No. 1

Point No. 2

Point No. 3

Point No. 4

Point No.5

Point No. 6

Point No. 7.

Figure 16. Vegetation removal at Guadalcanal Village during December 2000. View is from photopoint 5.

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Appendix A. Average maximum vegetation height within quadrats (*n*=3 quadrats/transect, *n* =18 transects). Transect 17 was not sampled since it is located within nearby Pritchard Marsh.

Species	Transect																				
	1	**2**	**3**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**18**	**19**	**20**	**Mean**	**St. Dev**	**St. Err**
ACLO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	12.0	0.0	1.6	4.6	1.1
ASSP	0.0	0.0	0.0	0.0	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9	7.9	1.9
ATTR	0.0	8.7	13.7	1.7	0.0	0.0	0.0	26.7	11.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.4	7.2	1.7
AVFA	0.0	0.0	0.0	0.0	57.7	0.0	0.0	0.0	0.0	0.0	0.0	39.7	25.0	16.0	103.3	0.0	33.0	0.0	15.3	28.0	6.6
BARE	0.0	0.0	0.0	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	75.3	1.3	0.0	4.4	17.7	4.2
BRDI	0.0	0.0	0.0	0.0	2.0	0.0	18.3	0.0	0.0	0.0	0.0	27.3	13.7	11.0	0.0	0.0	4.0	0.0	4.2	8.0	1.9
BRHO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	80.3	0.0	9.7	0.0	0.0	0.0	0.0	5.0	18.9	4.5
CAPY	0.0	0.0	0.0	0.0	26.7	0.0	11.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	6.7	1.6
CECA	0.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	26.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	6.3	1.5
CESO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.3	15.3	1.1	3.7	0.9
COAR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	48.3	0.0	0.0	0.0	44.0	0.0	0.0	0.0	0.0	0.0	5.1	14.9	3.5
COCO	0.0	0.0	0.0	4.0	0.0	9.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	2.3	0.6
DUFF	5.3	5.0	4.0	6.7	2.0	0.0	0.0	6.7	0.0	0.0	0.0	0.0	41.0	24.3	0.0	0.0	50.3	0.0	8.1	14.9	3.5
EURO	0.0	0.0	0.0	8.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	2.0	0.5
FOVU	0.0	0.0	0.0	0.0	20.3	0.0	137.3	0.0	109.3	302.3	181.0	208.0	175.0	93.3	189.7	197.0	54.0	0.0	92.6	97.4	23.0
GEDI	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	26.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	6.2	1.5
HOMA	0.0	0.0	0.0	0.0	14.0	12.3	0.0	0.0	0.0	0.0	0.0	41.0	0.0	17.3	0.0	0.0	8.7	34.7	7.1	12.6	3.0
HOMU	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.7	0.0	0.0	0.0	0.0	0.0	0.3	1.3	0.3
LABR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	21.7	0.0	0.0	39.0	0.0	0.0	30.0	0.0	0.0	0.0	5.0	12.0	2.8
LITR	38.7	0.0	0.0	41.0	0.0	0.0	0.0	0.0	60.0	0.0	0.0	0.0	0.0	2.3	0.0	2.7	0.0	0.0	8.0	18.2	4.3
LOCO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	1.1	4.7	1.1
LOPE	0.0	29.3	0.0	0.0	15.0	9.7	0.0	0.0	0.0	0.0	0.0	43.7	0.0	5.7	0.0	0.0	3.3	40.0	8.1	14.4	3.4
MOSS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.1
PIEC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	13.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	1.7	4.2	1.0
POMO	0.0	23.7	16.3	0.0	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	6.7	1.6
RUCR	0.0	28.7	0.0	0.0	0.0	0.0	0.0	41.3	121.7	0.0	0.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	10.9	29.9	7.1
Mean	1.7	3.7	1.3	2.4	6.6	1.7	6.4	3.1	16.9	11.6	7.0	18.4	11.8	7.7	12.4	11.3	6.6	3.9			
St. Dev	7.6	8.9	4.1	8.2	14.0	3.7	27.0	9.5	33.1	59.3	35.5	44.0	35.5	18.8	41.7	40.8	15.1	10.5			
St. Err	1.5	1.8	0.8	1.6	2.7	0.7	5.3	1.9	6.5	11.6	7.0	8.6	7.0	3.7	8.2	8.0	3.0	2.1			

Appendix B. Mean stem density of vegetation within quadrats (n = 3 quadrats/transect, n = 18 transects).

	Transect																				
	1	**2**	**3**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**18**	**19**	**20**	**Mean**	**St. Dev**	**St. Err**
ACLO	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	208	0	12	49	12
ASSP	0	0	0	0	92	0	0	0	0	0	0	0	0	0	0	0	0	0	5	22	5
ATTR	0	1	16	0	0	0	0	5	1	0	0	0	0	0	0	0	0	0	1	4	1
AVFA	0	0	0	0	175	0	0	0	0	0	0	110	4	3	4	0	210	0	28	65	15
BARE	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	7	0	0	0	2	0
BRDI	0	0	0	0	1	0	101	0	0	0	0	10	3	3	0	0	1	0	7	24	6
BRHO	0	0	0	0	0	0	0	0	0	0	0	152	0	3	0	0	0	0	9	36	8
CAPY	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CECA	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CESO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	325	18	77	18
COAR	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	1	0
COCO	0	0	0	2	0	10	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1
DUFF	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
EURO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FOVU	0	0	0	0	3	0	10	0	5	21	96	52	6	4	14	14	42	0	15	25	6
GEDI	0	0	0	0	0	0	0	0	9	0	0	0	0	0	0	0	0	0	1	2	1
HOMA	0	0	0	0	4	15	0	0	0	0	0	59	0	194	0	0	83	525	49	129	30
HOMU	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0
LABR	0	0	0	0	0	0	0	0	1	0	0	8	0	0	1	0	0	0	1	2	0
LITR	11	0	0	3	0	0	0	0	14	0	0	0	0	208	0	7	0	0	13	49	12
LOCO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
LOPE	0	1	0	0	68	2	0	0	0	0	0	139	0	1	0	0	42	12	15	36	8
MOSS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
PIEC	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	142	8	33	8
POMO	0	1	12	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	1	4	1
RUCR	0	1	0	0	0	0	0	1	6	0	0	0	0	1	0	0	0	0	0	1	0
Mean	0	0	1	0	13	2	4	0	2	1	4	20	1	16	1	1	23	39			
St. Dev.	2	0	4	1	40	4	20	1	3	4	19	45	2	54	3	3	58	121			
St. Err.	0	0	1	0	8	1	4	0	1	1	4	9	0	11	1	1	11	24			