STATE OF HAWAII
DEPARTMENT OF LAND AND NATURAL RESOURCES
Division of Forestry and Wildlife
Honolulu, Hawaii 96813

July 10, 2020

Chairperson and Members
Board of Land and Natural Resources
State of Hawaii
Honolulu, Hawaii

Land Board Members:

SUBJECT: REQUEST APPROVAL OF A REVISED KAUPAKUEA ORCHARDS FOREST STEWARDSHIP MANAGEMENT PLAN AND FOREST STEWARDSHIP AGREEMENT WITH KAUPAKUEA ORCHARDS, LLC, TMKS (3) 2-8-003:009 AND (3) 2-8-003:010, HAMAKUA DISTRICT, ISLAND OF HAWAI'I.

BACKGROUND:

The State of Hawai‘i Forest Stewardship Program (FSP) provides technical and financial assistance to private landowners and land managers committed to the stewardship, conservation, and restoration of important forest resources across the state. These private properties provide a variety of public benefits for the residents of Hawai‘i, including but not limited to: fresh water capture and production, decreased soil erosion, wildlife habitat, forest products, recreational and educational opportunities, and local jobs. The assistance provided by FSP enables private landowners to develop and implement long-term multi-resource management plans to conserve, restore and maintain forested areas on their property.

The FSP was established through Chapter 195F-6, Hawai‘i Revised Statutes (HRS) and provides the Department of Land and Natural Resources with the authority to provide financial assistance to approved Forest Stewardship projects for private landowners to manage, protect, and restore important natural resources on forested and formerly forested properties. The FSP is implemented pursuant to Chapter 195F, HRS, and Section 109, Hawai‘i Administrative Rules (HAR). The program provides cost-share reimbursement for the development of long-term forest management plans and for the implementation of approved Forest Stewardship management plans.

To participate in FSP, interested landowners and managers follow a sequence of application steps in the process of developing a long-term Forest Stewardship management plan. All interested landowners submit their proposed project for review by the Forest Stewardship Advisory Committee (FSAC). The FSAC reviews the proposed project based on program eligibility requirements and assures the proposed project is in line with the program’s goals of conservation, restoration, and/or forest production. Once a proposed project is accepted, the FSAC recommends

the development of a Forest Stewardship management plan and reviews and approves the final management plan. The Forest Stewardship management plan is created by landowners in partnership with natural resource professional/experts and reviewed and approved by both the Division and the FSAC. Final management plans are then recommended for approval by the Department.

At its meeting on October 11th, 2013, under agenda item C-3, the Board approved the Kaupakuea Orchards Forest Stewardship management plan and authorized total cost-share support in the amount of $77,945.00 over a 10-year period from FY14-FY23 for Kaupakuea Orchards LLC to implement the plan through a Forest Stewardship Agreement (Exhibit B). The original project proposed to convert approximately 23 acres from non-native grassland to a forested landscape of native riparian area and hardwood plantation. In accordance with Hawaii Administrative Rule Chapter 109, Sections 13- 109-11: Payback Provision, the Board set a 5% payback rate on commercial harvests occurring from Kaupakuea Orchards until $27,640 (50% of the State cost share provided to the project for the timber component) is repaid.

All FSP projects are asked to review and evaluate their management actions at least once during the implementation of their management plan to assess their success and adjust their practices, as appropriate, to ensure that they meet their project goals and are practicing adaptive management. Additionally, FSP projects may request cost-share adjustments if costs associated with management activities have increased or decreased during the term of their agreement. Kaupakuea Orchards LLC is requesting a revision of the management plan due to unforeseen difficulties in implementing certain management practices in the plan (Exhibit A). Additionally, a reduction in cost-share funding under the Forest Stewardship Agreement is proposed as costs associated with planned management activities have decreased and the landowner would like to enter the maintenance phase for the project.

DISCUSSION:

Kaupakuea Orchards Forest Stewardship project originally proposed to convert approximately 23 acres from non-native grassland to a forested landscape of native riparian area and hardwood plantation by (1) establishing 18 acres of plantations of several high-value hardwood species; (2) protecting and expanding the existing native forest cover along the stream area by controlling invasive weed species and restoring a native vegetated buffer along the stream; and (3) providing long-term funding for the project through periodic selection harvests of non-native timber plantations. The project management prescriptions and practices included fencing the property to protect newly planted areas from feral ungulate damage; invasive species removal; preparation of the site before planting; tree and shrub establishment; and maintenance of the established trees.

The landowner implemented portions of the plan in years one and two of the Forest Stewardship Agreement, including fencing, planting of 5.2 acres and invasive weed control in the riparian zone. Financial reimbursement from the FSP through the contract agreement to date was $16,156.89 in 2014 and 2015 with $19,756.89 of landowner matching contributions.

Kaupakuea Orchards LLC requested revisions to their management plan due to the desire to preserve the sight lines of neighboring property owners. These neighbors bought the property in

2014 after the Forest Stewardship management plan was approved and objected to the plan claiming their quality of life and property values would be negatively impacted by the project. There are sweeping ocean views from the adjacent property that would have been blocked if the project was implemented as originally planned. Additionally, Kaupakuea Orchards LLC determined management actions originally planned for riparian restoration near the stream are too difficult to safely implement due to steep and dangerous terrain.

The Kaupakuea Orchards LLC landowner worked with Division staff on revising the plan to use a portion of the site as for an experimental disease-resistant koa (*Acacia koa*) seed orchard. A 2-acre koa seed orchard was planted on the site in 2017 in partnership with the Hawaii Agriculture Research Center (HARC) and the Division's Forest Stewardship Program. The landowner has committed to continued maintenance of the koa seed orchard and will continue working closely with and providing access to HARC. HARC will have access to the koa seed for the duration of the Forest Stewardship Agreement (to June 30, 2044). HARC has an overall goal of landscape level restoration and will provide seeds to other entities including the Division's state tree nursery and restoration projects. The management plan revision reduces the project area from 23.27 acres to 7.25 and reduces corresponding budgets in years 4 - 10.

The Division will not provide further cost-share support for the revised plan beyond what has already been provided. In accordance with Hawaii Administrative Rule Chapter 109, Sections 13-109-11: Payback Provision, the 5% payback rate on commercial harvests occurring from Kaupakuea Orchards in the Stewardship Agreement will be revised due to the reduction of acreage in timber as well as reduction in state cost-share support. Currently, $12,700 cost-share support was provided for the timber portion of the management plan so the timber payback provision will be revised to $6,350 (50% of the State cost share provided to the project for the timber component).

The Division and Forest Stewardship Advisory Committee reviewed the revised Kaupakuea Orchards Forest Stewardship Plan at their meeting on April 12, 2019, provided comments on the plan, and recommended Division staff determine whether the revised plan was adequate, following an analysis of management activities and payments to determine if any payback of state funds was required. Staff completed a site visit June 10, 2019, worked with landowner to revise the plan and has determined it was acceptable and previous cost-share payments for management practices did not require payback of state funds.

The Division is requesting Board approval of the revised Kaupakuea Orchards Forest Stewardship Plan and associated Forest Stewardship Program Agreement with Kaupakuea Orchards LLC. Per their Forest Stewardship Agreement, Board approval of the revised Kaupakuea Orchards Forest Stewardship plan and Agreement are required, given that changes are being made to the implementation schedule and corresponding annual budget.

CHAPTER 343 – ENVIRONMENTAL ASSESSMENT

Per the requirements of Chapter 343, HRS, and as required for Forest Stewardship projects that have a timber harvesting component, Kaupakuea Orchards, LLC prepared and submitted a Final Environmental Assessment for State of Hawaii Forest Stewardship Program Cost Sharing Grant for a Riparian Restoration and Timber Production Project for review and determination of a finding

of no significant impact (FONSI) by the BLNR. Agencies consulted in the preparation of the Draft Environmental Assessment include the Office of Hawaiian Affairs, DLNR: Historic Preservation Division, DLNR: Division of Forestry and Wildlife, and the County of Hawaii: Planning Department. The Board previously accepted the Finding of No Significant Impact for the project.

RECOMMENDATIONS:

That the Board:

1. Approve the revised Kaupakuea Orchards Forest Stewardship management plan;

2. Authorize the Chairperson to amend, finalize, and execute an amendment to the Forest Stewardship Agreement with Kaupakuea Orchards LLC to participate in the State Forest Stewardship Program subject to the following:

    A. Availability of State Forest Stewardship funds; and
    B. Review and approval as to form of the Forest Stewardship Agreement amendment by the Department of the Attorney General.

Respectfully submitted,

DGS

DAVID G. SMITH, Administrator
Division of Forestry and Wildlife

APPROVED FOR SUBMITTAL:

SDC

SUZANNE D. CASE, Chairperson
Board of Land and Natural Resources

Attachments: Exhibit A and B

EXHIBIT A

Revised Forest Management Plan

June 17, 2020

Kaupakuea Orchards LLC

Original Plan Dated April 2013

Introduction

The Forest Management Plan for Kaupakuea Orchards LLC was finalized in April 2013, and the Forest Stewardship Agreement was approved by the Board of Land and Natural Resources and finalized April 2, 2014. The overall project area was originally 23.27 acres on TMKs (3) 2-8-003:009; 010 (portion). The revised project area is 7.25 acres.

There are three main drivers of the decision to revise the original plan.

The most significant factor is the desire to preserve the sight lines of neighboring property owners, who bought the property in 2014 after the FSP project was approved. These neighbors objected to the original plan and requested changes. There are sweeping ocean views from the adjacent property that would be blocked if the forestry project was implemented as originally planned. Further plantings would cause a major loss to the quality of life for the owners of a twenty-acre parcel mauka of the site. There would also be a significant loss of property value.

The second factor is the decision to incorporate a Hawaii Agriculture Research Center (HARC) experimental disease-resistant Koa (*Acacia koa*) seed orchard project on the site. The original management plan identified planting of wilt resistant koa as an experimental component of the plan (Section 4.2.2). This aspect of experimental management has an increased role in this revised plan with the incorporation of the HARC site.

The third factor is issues related to proposed management plan actions for riparian restoration in the Stream Management Zone (4.45 acres). Proposed riparian management originally included weed control and woody debris management in the riparian zone to help restore these areas with native plants such as ʻōhiʻa (*Metrosideros polymorpha*) and uluhe fern (*Dicranopteris linearis*). Some weed control was completed in year two of the plan. However, management of the riparian areas, as originally planned is extremely difficult due to very steep and dangerous terrain and is not feasible to continue.

Summary of Revisions

Section 5 "Management Prescriptions"

The planting of hardwoods, as originally planned, will not be implemented at the scale in the original plan to preserve the view plane for the neighboring property. This impacts approximately 14 acres in part of compartment H2, and all of compartments H3, H4, and H5 per the original management plan. These areas are currently being used to graze eight head of cattle. The 5.25-acre area currently established with a mix of 95% Eucalyptus and other 5% species (planted Fall 2014) will be the full extent of non-native hardwood forest (see species list below). This stand was planted in fall 2014 with a stocking density of 450 trees/ac, in accordance with the original plan. This stand is well established and requires zero maintenance. No mowing is done. The stand is monitored for general health by way of a walk through a few times a year. General health of planting is excellent except for 2 trees that were struck by lightning last summer.

Species List (Planted 2014)
Eucalyptus deglupta
Eucalyptus robusta
Swietenia macrophylla (Honduran Mahogany)
Cedrella odorata (Spanish Cedar)

The HARC project is incorporated into a two-acre area adjacent to the hardwood planting. Planting at his site occurred in 2017. The establishment report which describes the project is summarized below. The property owner assisted with site preparation for establishment of the seed orchard by mowing the area several times. According to HARC staff (Aileen Yeh and Nikolas Dudley), the seed orchard site has proved challenging for growing koa, due to poor drainage, waterlogged soil conditions, wind damage and pig disturbance. The site has been re-planted by HARC about four times to date (640 trees were planted initially, and additional trees were planted to replace trees that died). Despite challenging conditions, approximately 114 koa trees are still surviving and growing well in some portions of the site that have better drainage. The most vigorous of the plantings are six to eight ft tall. There are still enough trees remaining from different families to warrant continued management of the site. Surviving trees may have beneficial traits for survival in wet conditions, that may prove valuable in producing seed for these types of conditions.

The property owner will continue to assist HARC in maintenance of the koa seed orchard site through periodic mowing, fence maintenance, and pig control. It is anticipated that mowing will only continue for a few more years due to the growing size of the tree crowns. Soon they will be too close together for the mower to pass between cleanly without damaging branches. The property owner will consult with the HARC managers to determine when the mowing could become damaging and should cease. Currently mowing is done about four times a year and takes about three hours each time. The property owner also monitors the site with periodic walk throughs and notifies HARC if anything develops that looks like it might need to be addressed. HARC will continue to monitor tree size, fertilize trees annually and plans to thin the trees to one

tree per plot. The purpose of thinning individual trees by family is to increase canopy size and vigor of selected mother to enhance seed production.

The property owner intends to continue working closely with and providing access to HARC to support the maintenance of the seed orchard. HARC will access the site at most on a quarterly basis, apart from seed collection season, where access would be more frequent. Seed production is anticipated to occur by 2021-2022 (year 4-5). HARC would have access to the seed for the duration of the Forest Stewardship Agreement (to June 30, 2044). HARC has an overall goal of landscape level restoration and will provide seeds to other entities upon request (e.g. the DOFAW state tree nursery and DOFAW restoration projects).

5.3 Riparian restoration

There will be no further riparian area management as the terrain is extremely steep, slick, and therefore dangerous. It is simply beyond the physical scope of the property owner. Areas that were successfully cleared of Strawberry Guava have scattered large ʻōhiʻa trees. The use of biocontrol agents to expand Guava control in this area up the stream gulch is a possibility as some of the current HARC researchers that the property owner is working with have had some success controlling Guava this way on their own farms. Additionally, the health of the large ʻōhiʻa trees will be monitored for the presence of rapid ʻōhiʻa death (ROD). There may be potential opportunities to replant ohia along the top portion of the stream bank where it is less steep, if larger mature ʻōhiʻa die due to ROD.

Section 6 "Budget and Timing"

Fencing - Fencing was reduced and the alignment was changed due to the reduction in the hardwood planting area size. The original plan estimated the entire hardwood planting area would need to be enclosed (5,780 feet of fencing). However, 2,218 feet of fencing was installed in 2014, which encloses the 7.25-acre project area. Existing fencing was improved along the northern side of the revised project area by adding hogwire to existing barbed wire fencing, which reduced the overall cost of fencing.

Revised Forest Stewardship Agreement Budget

Current financial reimbursement from the Forest Stewardship Program through the contract agreement to date was $16,156 in 2014 and 2015 for the first two years of a ten-year contract for $77,945. Actions completed and reimbursed are related to the 5.2-acre planting area (fencing, site preparation, planting and weed control) and 1.75 acres of stream habitat improvement (weed control) and are summarized below:

Year	Original Plan Budget FSP Cost-Share	Revised Cost-share (FSP)	Revised Applicant Cost-Share	Management Practice
Year 1 (2014)	$22,357	$5,820	$5,820	Fencing (2,218 ft)
Year 2 (2015)	$19,650	$10,336	$10,336	5.25 Acre Forestry Planting ($8,484) ➢ Site Prep ➢ Planting ➢ Seeds/Seedlings ➢ Nutrient Mgmt. ➢ Irrigation ➢ Pest Control ➢ Weed Control Stream Habitat Improvement 1.75 acres ($1,852)
Year 3 (2016)	$19,821		-	
Year 4 (2017)	$4,836		$720.00	HARC Planting; Mowing (FSP in-kind contribution 3 hours@$60/hour x 4 times/year) for site preparation and maintenance
Year 5 (2018)	$2,877		$720.00	Mowing HARC site
Year 6 (2019)	$1,892.00		$720.00	Mowing HARC site
Year 7 (2020)	$1,892.00		$720.00	Mowing HARC site
Year 8 (2021)	$1,562.00		$720.00	Mowing HARC site
Year 9 (2022)	$1,562.00			
Year 10 (2023)	$1,496.00			
TOTAL	**$77,945.00**	**$16,156**	**$19,756.89**	

There will be no additional FSP cost-share reimbursement for costs associated with the project beyond what has been received to date. As stated above there is minimal maintenance involved in the Eucalyptus stand and the landowner will contribute in-kind support to the HARC project of $3,600 (mowing to maintain HARC site). The Forest Stewardship Agreement contract was for ten years, followed by a 20-year additional dedication period to maintain management practices for which the landowner received cost share assistance. The agreement will continue to

be in effect until June 30, 2044, which will allow for continued collection of koa seed from the HARC seed orchard over the long-term. Kaupakuea Orchards, LLC will continue maintenance of the installed Forest Stewardship practices for an additional 20 years following the completion of the 10-year cost-sharing portion of the Agreement, through State fiscal year 2044, as required by the program for timber production projects.

Large koa trees in seed orchard

Hamakua Koa Wilt Seed Orchard
Establishment report

Date planted: April 12-13, 2017
Location: 28-891 Kaupakuea Rd, Pepeekeo, 96783 Hawaii Island
Soil Type: Kaiwiki hydrous silty clay loam, 10-20% slope
Soil Test: Averages of 4 samples: pH = 5.6, P = 16.5 ppm, K = 70 ppm, Ca = 44 ppm, Mg = 36 ppm, % Total N =0.46%

Background
One of the major constraints to successful koa reforestation is the koa wilt disease caused by the fungus, *Fusarium oxysporum.* We have developed a koa seedling inoculation technique that is effective for inoculating young koa seedlings with *Fusarium oxysporum*. This allows for rapidly screening of koa seedling families to determine if they are susceptible or resistance to the koa wilt disease. This koa seed source field test will assist in monitoring the durability of resistance to koa wilt among the various seed sources being tested and help validate the long-term effectiveness of the inoculation screening methodology.

Site Background
The site is located in Pepeekeo on Hamakua coast of Hawaii Island. The site is located on the upper boundary of former sugarcane land, which ended operations in late 1980s. Prior to planting the site was fallow and covered by guinea grass (*Megathyrus maximus*).

Objective
Evaluate the growth performance and disease resistance of 25 different koa (*Acacia koa*) seed sources. Koa seed was collected from 110 individual mother trees within the greater Kokee region on Kauai between 2010 - 2013. The half-sib families were screened for resitance to koa wilt disease in greenhouse inoculation trials. The families selected for the orchard showed increased survival in the inoculation trials and were therefore selected for the field planting. Superior trees and families within the planting will be selected based on growth performance and survival to improve orchard genetics and serve as a source of improved seed for future reforestation and restoration efforts in the region.

Justification
Natural variation has produced populations of koa trees that are well adapted to specific environmental conditions. This results in a range of genetic variation within this species. A seed source test is an efficient way to screen for variation by comparing the growth performance of the progeny of many different parents. Going forward, this site can be managed as a seed orchard, or as a breeding arboreta, by leaving only the best individuals from the best performing koa seed sources and removing less desirable ones.

Treatments
30 half-sib families of *Acacia koa* (See seed source list below)

Design and Procedure
This planting consists of first generation half-sib seeds collected from outstanding individual trees across low to mid elevation koa forests on the windward side of Hawaii Island. A modified version of a randomized row-plot design was utilized. The plot locations were modified in each rep to maximize distance between plots of the same

family. Each treatment plot contains five trees. There are four replications. The spacing is 3 meters between rows and 2 meters within each row.

Site Preparation
The guinea grass was sprayed with imazapyr herbicide in December 2016.

Seedling production
Seed from the selected families was sewn in October 2016 at HARC Maunawili. Seedlings were grown in Stuewe and Sons, SC10 containers. Seedlings were hardened at Maunawili and shipped to Kauai for planting.

Planting
Planting holes were dug using 4" auger on a Stihl tree planting auger to a depth of approximately 0.3 meter. Seedlings were planted by hand, and holes were augmented with 100 grams of 0-45-0 fertilizer prior to planting. Approximately 135 grams of gypsum was applied to soil surface around each seedling (spread evenly in 1 meter diameter circle around each seedling).

Koa Seed Source tested

Treatment	Seed source		Treatment	Seed source
1	Rob 2 wp 115		16	Kaala 27
2	Rob 4 wp 118		17	Laupahoehoe wp 149
3	Kaumana City WP 140		18	Hal 4
4	Piihonua wp 138		19	Piihonua wp 134
5	Lau 1		20	Laupahoehoe wp 147
6	Rob 3 wp 116		21	Lau 2
7	Dalton 3		22	Laupahoehoe WP 145
8	Hal's Kaiwiki		23	Laupahoehoe wp 113
9	Laupahoehoe WP 148		24	Piihonua 11
10	Laupahoehoe wp 112		25	Laupahoehoe WP 146
11	Piihonua wp 135		26	Lau 4
12	Rob 1 wp 114		27	Becky 11
13	Kaala 21 Stream		28	Hal 3
14	Kaala 24		29	Big Island Susceptible
15	Antone 2		30	Vol 3

Hamakua, Hawaii Island Koa Wilt Resistant Seed Orchard Map

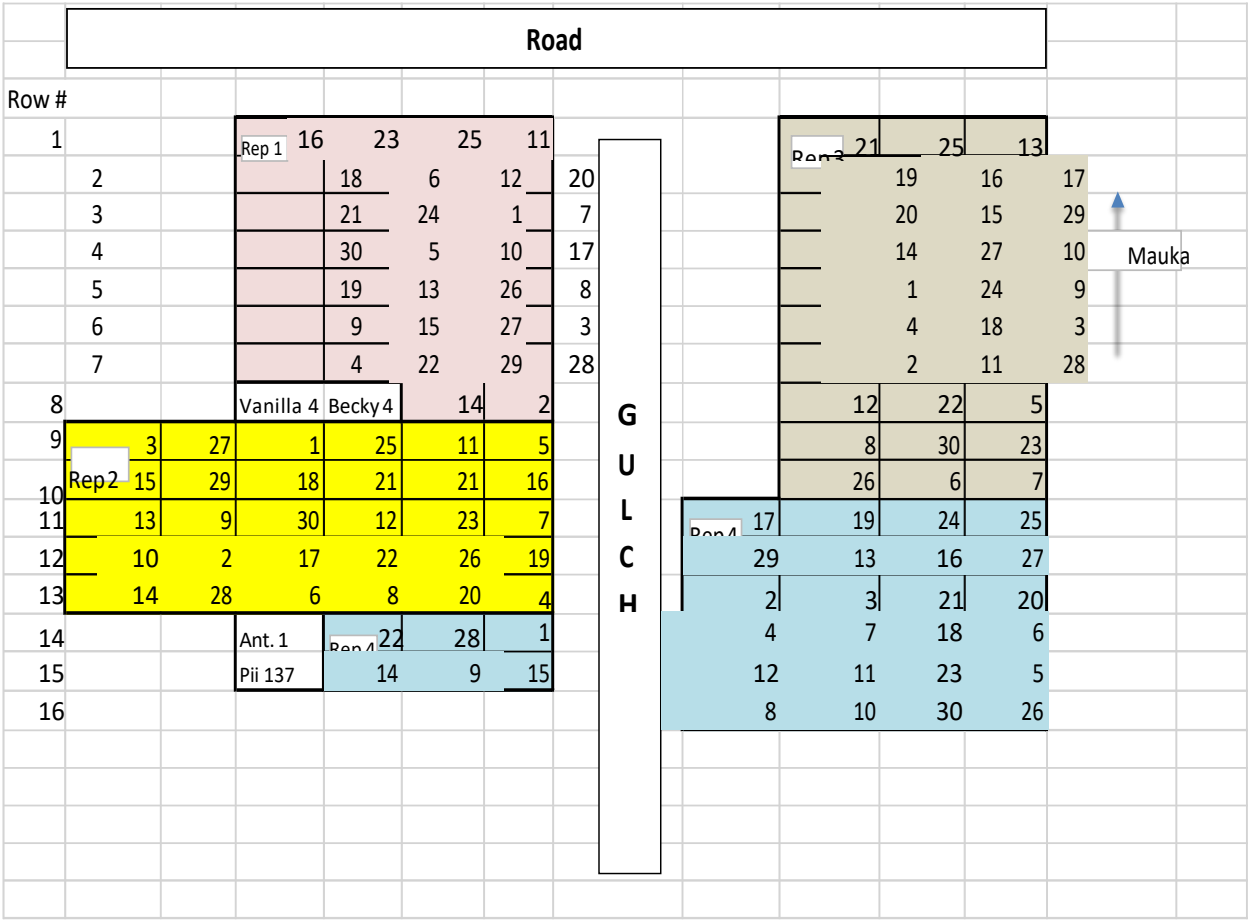


Exhibit B

Forest Management Plan

Kaupakuea Orchards, LLC

April 22nd, 2013

Prepared by
Thomas Baribault, Ph.D., Research Forester

Fore:re Solutions Inc.

1. Applicant and property information

1.1 Applicant

Name:	Christopher Trimarco
Address:	4110 NE 21h Avenue
	Lighthouse Point, FL 33064
Email:	christophertrimarco@mac.com
Phone:	+l(954} 650-0967
Fax:	NA
TMK number:	(3}2-8-003-009; (3)2-8-003-010
State and County Zoning:	Ag 20 (Agricultural District) (Map 1)
Total property acreage:	41.5 acres (Map 2)
Proposed stewardship area:	23.27 acres (Map 2}
Elevational range:	1300 ft (400m) – 1400 ft (430m} ASL
Slope:	5 %
Streams, gulches:	Waia'ama Stream (South boundary)
	Alia Stream (North boundary)

1.2 Consultant

Company:	Forest Solutions, Inc.
Name:	Thomas Baribault
Title:	Research Forester
Address:	P.O. Box 2037
	Kamuela, HI 96743
Email:	tom@hawaiiforest.com
Phone number:	+1 (808} 776-9900 x238
Fax:	+1(808) 776-9901
Plan completion date:	April 8, 2013

I. Forest Stewardship Plan Signature Page

2.1 Professional Resource Consultant Certification:
I have prepared (or revised) this Forest Stewardship Plan. Resource professionals have been consulted and/or provided input as appropriate during the preparation of this plan.

Prepared by: Forest Solutions, Inc.
Professional Resource Consultant's Signature/Dated: 1 IJ / ,.d
Professional Resource Consultant's Name: Nicholas Koci

2.2 Applicant Certification:
I have reviewed this Forest Stewardship Plan and hereby certify that I concur with the recommendations contained within .I agree that resource management activities Implemented on the lands described shall be done so In a manner consistent with the practices recommended herein.

Prepared for: Christopher Trimarco
Applicant's Signature/Date: Ift.::-1JL
Applicant's Name: Christopher Tfimarco

2.3 **State** Forester's Approval:
This plan meets the criteria established for Forest Stewardship Plans by Hawaii's Forest Stewardship Advisory Committee. The practices recommended In the plan are eligible for funding according to state of Hawai'i Forest Stewardship Program guidelines and administrative rules.
Approved by: _____
State Forester's Signature/ Date: _____
State Forester's Name: _____

2.4 Forest Stewardship Advisory Committee
Approved by: _____
Committee Signature/Date: _____
Printed Name: _____

For: Solutions Inc.

II. Forest Stewardship Plan Signature Page

2.1 Professional Resource Consultant Certification:

I have prepared (or revised) this Forest Stewardship Plan. Resource professionals have been consulted and/or provided input as appropriate during the preparation of this plan.

Prepared by: Forest Solutions, Inc.

Professional Resource Consultant's Signature/Date:_____

Professional Resource Consultant's Name: Thomas Baribault

2.2 Applicant Certification:

I have reviewed this Forest Stewardship Plan and hereby certify that I concur with the recommendations contained within. I agree that resource management activities implemented on the lands described shall be done so in a manner consistent with the practices recommended herein.

Prepared for: Christopher Trimarco

Applicant's Signature/Date:_____

Applicant's Name: Christopher Trimarco

2.3 State Forester's Approval:

This plan meets the criteria established for Forest Stewardship Plans by Hawaii's Forest Stewardship Advisory Committee. The practices recommended in the plan are eligible for funding according to state of Hawai'i Forest Stewardship Program guidelines and administrative rules.

Approved by: Division of Fores dlife Administrator

State Forester's Signature/ Date: 2/2-(J/1C

State Forester's Nam[redacted]

2.4 Forest Stewardship Advisory Committee

Approved by: C opeXI ·Y

Cmmittee Signature/Date: [redacted] 10, 'Z-0\'s

Printed Name: [redacted]

Approved by Forest s tewardship Advisory Connnittee on 5/10/13.

Table of Contents

III. Introduction

3.1 Land Use History

In pre-contact Hawaii, this mauka area would likely have been reserved for gathering practices, exploiting such resources as wood, medicinal or ceremonial understory plants, or feathers. In approximately 1899, Pepeekeo Sugar Company began commercial production, which continued through the early 1990's. The property was owned by Hamakua Sugar until 1994; conventional sugar cultivation methods were practiced, including subsoil ripping, irrigation, heavy fertilizer and agrochemical use, and controlled burning. These practices implemented over 95 years led to substantial net losses in soil depth and organic matter, and increased compaction. Thereafter, ownership transferred to a private individual, who leased small portions of the property to rotating ginger producers, alternating with ranching, which continues to the present. The larger original property has been subdivided into the Tax Map Key (TMK} featured in this Forest Management Plan (FMP}, and the current owner plans to transition from a largely herbaceous vegetation type to a mixture of tree species within the project area.

3.2 Current Forest Condition

The property is typical of abandoned cane land in the Hilo-Honomu area, with only a small minority of the property (2.8 acres, or 7%} currently forested. The forest area is restricted to less than four acres within the larger Streamside Management Zone (SMZ) adjacent to Waia'ama Stream, with less than an acre of tree cover elsewhere. Native overstory tree species are a minor component of the SMZ, and the only Hawaiian species present is 'ōhi'a *(Metrosideros polymorpha).* Several native understory species, chiefly ferns, appear in low numbers among the dominant invasive weed species, which is strawberry guava *(Psidium cattleianum) .* An assortment of other weed species are represented to varying degrees, and the pasture area should be considered a completely alien ecosystem dominated by African grasses and assorted broadleaf species. In its current condition, the parcel cannot serve as habitat for any native Hawaiian bird species, or for the Hawaiian bat, all of which require closed canopy forest.

3.3 Management Objectives

Several concurrent management objectives will be pursued on the parcel, including high value hardwood plantations, riparian native species restoration, fruit orchard establishment, and pasture. This FMP is chiefly concerned with the first two objectives (Map 3}:

- Restore forest cover to the upper elevations of each TMK by establishing plantations of several high value hardwood species.
- Protect and expand the existing native forest cover in SMZ by controlling invasive weed species.
- Restore portions of the SMZ where invasive species have dominated the ecosystem.
- Provide long-term financial returns through periodic selection harvests of non-native timber plantations.

The long term goals for this FMP are twofold. First, the project will convert more than 23 acres of marginal pasture land to high value hardwood plantations that can be selection harvested on a 40- to 45-year rotation. Second, invasive species in the SMZ, particularly adjacent to Waia'ama Stream, will be removed and the area restored to a native forest state dominated by 'ōhi'a in the canopy and native ferns such as uluhe *(Dicranopteris linearis)* and hapu'u *(Cibotium glaucum)* in the understory. **The landowner intends to support this important work with a combination of federal (e.g. EQIP) and State of Hawai'i forest stewardship cost sharing programs.**

IV. Property Description

4.1 Existing vegetation cover (Map 3)

4.1.1 Pasture

The vast majority (37.2 acres, 93%) of the area on the property is currently active pasture land **(Fig. 4.1.1).** In the future, intensive pasture will be discontinued on at least 17 acres and likely across the entire parcel. Although the current vegetation cover consists of almost exclusively grasses, without grazing pressure, a suite of non-native woody species would begin to invade. The most likely invaders include common guava *(Psidium guajava),* strawberry guava *(Psidium cattleianum),* faya tree *(Morella faya),* African olive *(Olea europaea subsp.* Cuspidate), tropical ash *(Fraxinus uhdei),* Albizia *(Albizia lebbeck* and *Falcataria mo/uccana),* and ginger *(Hedychium spp)* **(Fig. 4.1.1).**

Figure 4.1.1. Grazing pressure maintained almost completely open land on much of the parcel (top). Regeneration of woody species (bottom) would accelerate without the presence of grazing animals.

4.1.2 Overstory

The property supports very limited canopy cover in the SMZ, comprising almost exclusively guava *(Psidium guajava* and *P. cattleianum)* that reach a maximum height of less than 10 m **(Fig. 4.1.2).** A few specimens of 'ohi'a *(Metrosideros polymorpha)* are present in the Southern SMZ, with several individuals approximately 15 m tall. Also in the Southern SMZ are several areas that contain dead rose apple *(Syzygium jambos)* that was killed after infection with the Myrtaceae generalist rust *Puccinia psidii.* Counter-intuitively, *Psidium spp* are unaffected by *P. psidii,* and are the chief species that appear to be replacing S. jambos in the canopy **(Fig. 4.1.2).** Some seedlings of *F. uhdei* have also escaped from the adjacent State land; these individuals are still juveniles, yet will need to be removed to ensure taxonomic integrity of the SMZ.

Figure 4.1.2. Canopy trees are primarily *Psidium* species (top left), with a small contingent of the native 'ohi'a (top right). *Psidium* is replacing *5. jambos* as a consequence of fungal pathogen attack (bottom).

4.1.3 Understory

The understory of the SMZ property is invaded with smal ler strawberry guava almost to the exclusion of native species. Several species of ginger *(Hedychium spp.)* and raspberry *(Rubus spp)* are also present, but grazing has controlled these species to a large extent. In limited sections of the Southern SMZ, dense mats of the Hawaiian native uluhe fern have managed to suppress strawberry guava; unfortunately, this dynamic is a losing battle for the uluhe. The native hapu'u fern (C. *glaucum)* is in the process of being out competed by the guavas **(Fig. 4.1.3).**

Figure 4.1.3. Grazing has controlled ginger and raspberry (top). Aggressive competition from guava species has almost eliminated the hapu'u fern from the SMZ understory (bottom).

4.2 Forest health

4.2.1 /nvasive species

Forest health, such as exists on the property, is exceedingly poor due to the majority component of non-native weed species. Strawberry guava in particular is antithetical to long term forest health, and will universally replace native trees without management intervention. In every respect, the forest management activities proposed in this FMP will lead to quantitative and qualitative improvements in forest health metrics.

4.2.2 Fire risk

The property is moist year round, with rainfall in excess of 150 inches evenly distributed throughout the year **(Map 1, Fig. 4.4.1).** Consequently, fire risk is low, and is not expected to pose a threat to the forest investment or to the restoration effort. Furthermore, the streams that define the North and South boundaries **(Map 2)** provide sources of fire fighting water, while the road at the Eastern edge of the timber compartments **(Map 3)** serves as a fire break. At the Western edge of the property, open pasture is unlikely to carry any significant fire risk. Thickets of uluhe fern may carry fire in the event of extremely dry and windy conditions that prevail for extended periods, however the total area occupied by uluhe is negligible, and all of this area is adjacent to Waia'ama Stream.

4.2.2 Pests and pathogens

The most significant pathogenic threats to forest health in the Hilo area are fungal agents. In particular, the genera *Fusarium* and *Puccinia* kill the invasive species rose apple (5. *jambos)* may threaten the congeneric 'ohi'a as well. 'ohi'a is somewhat resistant to the pathogen, so it is still recommended for restoration planting. Another fungal pest is the koa wilt *Fusarium oxysporum,* although the Hawai'i Agricultural Research Center (HARC) is actively developing potentially wild-resistant koa varieties, which would be targeted for planting on an experimental basis as

they become available.A timely alternative to resistant koa may be to use seeds from trees adjacent to the property, which through the very fact of their survival have demonstrated some ability to resist wilt, either based on phenotype or pathogen escape. As a consequence of possible wilt damage and no suitably resistant seedling stock, koa remains an experimental component of this FMP.

4.3 Soils

4.3.1 Classification

A single main soil class,the Kaiwiki hydrous silty clay loam, is represented across the property. A precise description of this soil is derived verbatim from the USDA NRCS Soils Data Viewer, 2011:

> *The Kaiwiki hydrous silty clayloam component makes up 90 percent of the map unit. Slopes are 5 to 15 percent. This component is on ashfields on Java flows on shield volcanoes on islands. The parent material consists of volcanic ash. Depth to a root restrictive layer is greater than 60 inches. The natural drainage class is well drained. Watermovement in the most restrictive layer is moderately low. Available water to a depth of 60 inches is very high. Shrink-swell potential is very high. This soil is notflooded. It is not ponded. There is no zone of water saturation within a depth of 72 inches. Organic matter content in the surface horizon is about 12 percent. This component is in the F159AYSOOH I Acacia koa-Metrosideros polymorpha-cibotium Menziesii/freycinetia Arborea ecological site* ***(Appendix A).*** *Non irrigated land capability cf assifkation is 4e. Irrigated land capability classification is 43. This soil does not meet hydric criteria.*

4.3.2 Description

Due to a prolonged history of heavy land use by sugar cultivation and rotational ginger production, and continued issues with soil compaction and erosion as a consequence of cattle grazing activities,the soil on the property is marginally productive. There has been some surface erosion due to slope, high rainfall and cattle activity, though this is concentrated along pathways and access roads, and the minor SMZ on the Northern drainage.

Taxonomic class: Kaiwiki hydrous silty clay loam

Geographic setting: The Kaiwiki soils are on windward mountain slopes with an Eastern aspect. Elevations range from 1,300 to 1,400 feet, and slopes are 0 to 10 percent. The soils formed in volcanic ash. The average January temperature is 66 degrees F.;the average July temperature is 75 degrees F.;and the mean annual soil temperature is 62 degrees F.

Drainage and permeability: Well drained **(Map 4);** slow runoff; rapid permeability.

4.3.3 Geochemistry

The chemical and physical properties of the soils that dominate the parcel are typical of the Hilo area. In particular, the soils are acidic, with pH (as tested in a water suspension) between 5.3 and 5.7 **(Map 5).** The species selected for planting in this FMP (§5.6) all tolerate some degree of substrate acidity. One constraint to tree growth is the relatively limited amount of solar radiation that reaches the ground. The orographic effect produces significant cloud cover, constraining the area to the lowest productivity class on Hawai'i Island in spite of its tropical latitude **(Map 6).**

4.4 Water resources

4.4.1 Rainfall

Average annual rainfall for the property reaches 155 inches (3940 mm) per year,with no pronounced dry period. Heavier rainfall concentrated between November and April, with marginally drier summers **(Fig. 4.4.1).** Based on this information,planting activities should be targeted for winter to early spring, while weed control and other preparation and maintenance should be completed between July a nd September.

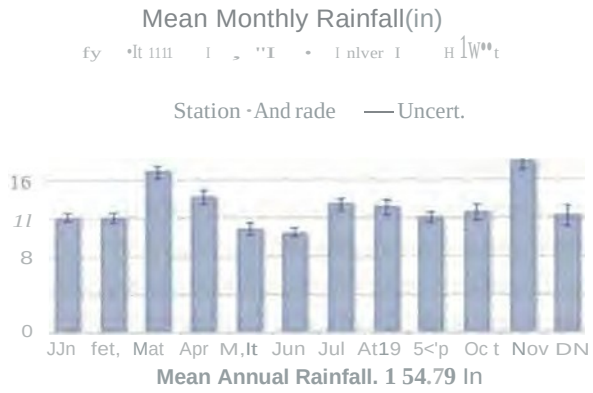


Figure 4.4.1. Mean annual rainfall for the area surrounding the property1.

4.4.2 Streams

One continuous stream (the Waia'ama Stream) defines the Southern boundary of the property, while an intermittent stream (the Alia Stream) is located at the Northern boundary **(Map 2).** Inthe center of the Northern parcel is an intermittent drainage bridged by a large concrete box culvert constructed in 1925 (§4.10).

4.4.3 Wetlands

Portions of each TMK contain low areas in which water may collect during heavy rains, but these areas do not qualify as streams or wetlands. Technically and functionally there are no wetlands on the property. The slope of the property and steep banks on streams and intermittent drainages prevent water accumulation.

4.5 Historical or cultural resources

Aside from the 1925 historical yet still functional culvert,no unusual or suspect items have been found during comprehensive reconnaissance of the property. A long history of sugar cultivation most likely erased any potentially important historical,cultural,or archaeological signatures; a full archaeological survey has not occurred.

[1]Giambelluca TW, Chen Q, Frazier AG, Price JP, Chen Y-L, Chu P-S, Eischeid J., and Delparte, D. 2011. The Rainfall Atlas of Hawai'i. http://rainfall.geography.hawaii.edu.

4.6 Fauna

Ground birds, including kalij pheasant *(Lophura /eucomelanos)* and wild turkeys *(Meleagris gallopavo),* are frequently observed on the property though their direct impacts on the forest are small; they do carry invasive weed seeds around. Also potentially present are Pueo *(Asioflammeus)* and lo *(Buteo solitarius).* The Hawaiian hoary bat *(Lasiurus cinereus)* is almost certainly not present. The bat may live in the nearby forest, however,and therefore may be encountered in the vicinity. No 'alala (Hawaiian crow) sightings have occurred, though the area may have been part of its original habitat. Other native birds common to the area can be found in the ecological site description prepared by the USDA NRCS and appended to this document as **Appendix A** (pp A1 – A33).

Feral pigs *(Sus scrofa)* and escaped domestic cattle *(Bos taurus)* are the largest wildlife threats to establishing forest plantings; a proposed hog-wire fence and gate system (§4.9) should eliminate both cattle and pig disturbance. Cattle are devastating to young trees of all species, as they preferentially browse meristem tissues and occasionally strip bark off saplings. The other major damage caused by cattle is erosion **(Fig. 4.6.1),** particularly inthe SMZ where the animals disturb soils as they walk to the water to drink.

Figure 4.6.1. Soil erosion in the SMZ caused by cattle. Fencing would eliminate this damage.

4.7 Endangered species

Although a biological assessment has not been completed and is not anticipated,endangered species have not been sighted in the area. The purpose of this plan is to establish productive forestry operations on 18.82 acres, and to restore native riparian habitat on 4.45 acres. Endangered plant species will not be used for this restoration effort because their survival rates are not optimal,and the most important objective is to establish robust native species. It is anticipated that endangered animal species may use the riparian zones as corridors, though the total area is likely too limited to serve as residential habitat. Please refer to the full ecological site description prepared by the NRCS for additional details on flora and fauna associations **(Appendix A).**

4.8 Existing recreational or aesthetic values

Exceptional views of the Pacific exist throughout the property **(Fig. 4.8.1),** and the waterfall on Waia'ama Stream is an important feature that will be preserved **(Fig. 4.8.2).** To ensure that the ocean remains visible, forestry uses are limited to areas where line of sight vectors from the home site to the ocean are uninterrupted **(Map 1).** Consequently, forestry compartments are located mauka of the North-South access route, with the exception of compartment H05, which, although below the road, nonetheless does not interfere with views **(Map 2).** Restoration of native Hawaiian species in the SMZ will be accomplished by removing invasive species (e.g. strawberry guava) and replacing the vegetation with such native species as 'ohi'a, uluhe, and hapu'u ferns. These restoration activities will both improve the aesthetic appearance of the waterfall and enhance the ecological value of the riparian buffer.

Figure 4.8.1. This exceptional ocean view would be preserved during implementation of the FMP.

Figure 4.8.2. Aesthetic features on the property include a small waterfall, which would be preserved during forest establishment and SMZ restoration.

4.9 Infrastructure

4.9.1Access

Significant access infrastructure exists on the property. A road constructed by Hamakua Sugar Company bisects the property, and a concrete box culvert constructed in 1925 allows easy crossing of the drainage in the Northern parcel **(Map 2, Fig. 4.9.1).** Some access improvement will need to occur, chiefly removing organic debris from the existing road bed. All access improvements will be conducted within the

confines of the existing road alignment following the State of Hawaii Best Management Practices (BMP, **Appendix B).** Maintenance to the culvert appears to be unnecessary at this juncture, although the structure should be monitored for deterioration,particularly spalling of the concrete due to corrosion of steel reinforcements.

Figure 4.9.1. A concrete culvert (top) allows the old sugar company road (bottom) to safely cross the drainage in the Northern parcel.

4.9.2 Fencing

The Northern boundary of the property is effectively fenced with barbed wire **(Fig. 4.9.2),** but the Eastern boundary is only partially fenced, and is unfenced at the culvert. The Waia'ama Stream acts as a partial natural fence, with the waterfall and steep banks preventing cows from escaping to or entering from the State parcel to the South. The mauka (West) boundary of both parcels is unfenced,however; and cattle and feral pig access must be restricted before planting can begin. **Hunting and trapping will also be employed to control ungulats if necessary.**

Figure 4.9.2. Barbed wire fencing and gates protect the Northern boundary of the property.

Additional fencing will be necessary across the remainder of the project perimeter.

Fencing will be needed to protect both the restored native forest and the new hardwood plantings primarily from cattle, although the mauka hog-wire fence will also restrict feral pig incursions. Improvements should be made to existing North fence to also restrict pig access; fencing shallow portions adjacent to the Waia'ama Stream is also advised in order to completely enclose the planting area. Fence material will be 6' hog-wire with a barbed skirt to prevent undermining. Fences will need periodic inspection for integrity, and will be repaired as needed every 6 months while the seedlings are young (to year 2), and annually thereafter.

V. Management Prescriptions

5.1Compartments and Working Circles

5.1.1Compartmentalization

To accomplish the major objectives outlined in this plan (§3.3), several specific management prescriptions (Rx) will be implemented on each land area. From administrative and operational standpoints, the property has been divided into nine management units **(Map 3),** which are referred to herein as **compartments (Table 5.1.1).** Compartment boundaries were designated using existing roads cut through the property before purchase. This FMP is concerned with management of SMZ and hardwood compartments, pasture compartments,though part of the property, are excluded from this plan and from this list of Rx. A unique identifying number is provided for each compartment to facilitate tracking budgets, expenditures, inventory, and yields over time. Such a numerical system is suited for managing this extensive collection of information in a database.

5.1.2 Working circles

A **working circle** is a collection of defined management Rx assigned to each compartment. For this FMP, compartments have been assigned to one of three working circles, either hardwood planting,streamside restoration,or pasture **(Table 5.1.1).** Activities in the pasture working circle are outside the scope of this management plan. A given compartment type will receive a common Rx;for example, SMZ compartments will receive invasive species control during restoration (§5.3), as well as planting of native species (§5.6). Similarly, activities conducted in hardwood compartments will include competition control prior to and after planting (§5.3), site preparation (§5.4),planting of hardwood trees (§5.5), and several maintenance operations (§5.6). Ultimately hardwoods would also be harvested (§5.7). Collectively, these sets of common Rx define a compartment type in terms of management objectives; areas of a given type are referred to as **working circles.** The scheduling and cost estimates of management are detailed at the compartment level based on area (§VI); Rx will likely be implemented according to different schedules in different compartments. The objectives for the project include restoration of native forest cover, timber production of both native and non-native trees, and riparian protection. The proposed Rx will both expand native wildlife habitat and improve overallforest health.

Table 5.1.1. Compartments include hardwood forestry areas, streamside management zones, and pasture. Pasture compartments do not feature in this FMP. Certain compartments are assigned road segments (length unit: miles) for reference purposes during improvement activities.

Name	Type	UID	Acres	Road Length
HOl	Hardwood	101	3.89	0.08
H02	Hardwood	102	4.16	0.09
H03	Hardwood	103	3.62	0.27
H04	Hardwood	104	5.36	0.07
HOS	Hardwood	105	1.80	0
P01	Pasture	201	10.51	0.18
P02	Pasture	202	7.72	0.1
S01	SMZ	401	3.52	0.17
S02	SMZ	402	0.93	0

5.2 Access and improvements

Access to the property from the main highway is via the Kaupakuea Homestead Road. To reach this road when driving North from Hilo, one should pass the 10 mile marker and then turn mauka (left) across from Sugar Mill Road (an important landmark is the large metal gear prominently displayed at this intersection). At the 0.8 mile distance after the left turn is a fork in the road-the left option should be taken, which is a one-lane paved road. On this road, one should travel 1.9 miles, at which

point there is a two-panel farm gate to the left, which is adjacent to utility pole #67. The property access route continues through this gate to the South (toward Hilo), shortly arriving at the concrete box culvert **(Fig. 4.9.1).** This road will provide operational access during the planting and maintenance phases of the project, as well as serving as the routine access for the landowner. The road is passable by heavy equipment for site preparation as well as ATV and tractor traffic for intermediate maintenance. Ultimately, harvesting equipment would also access the site through this point. Portions of the access road are in ideal condition, with a gravel base and a capped and crowned construction. Numerous sections have been covered by organic debris, however. Access improvement activities will primarily involve removing organic matter from the existing road, and the final condition of the access will conform to road construction BMP **(Appendix B).**

5.3 Riparian restoration site preparation

5.3.1 Restoration weed control

Streamside management zones require special selection of methods for controlling invasive weeds that address three concerns:

i. Herbicide agents safe for riparian areas.

ii. Effective termination of weed species.

iii. Woody debris management in advance of native species planting.

5.3.1.1 Riparian compatible herbicides

Certain herbicide agents must be avoided due to their toxicity to aquatic organisms either in fresh or salt water. Substantial restoration work next to the Waia'ama Stream will require the use of herbicides to eliminate strawberry guava and other plants, but the particular chemical and dose selected must be safe for use near streams. For example, the chemical triclopyr is not labeled for use where it may contaminate water systems, while the chemical aminopyralid is so labeled[2].

5.3.1.2 Weed control methodology

On extreme slopes (greater than 50%), two methods will be employed to deliver herbicides **(Fig. 5.3.1). A frill treatment** will be used for larger trees (blade or drill), with delivery of herbicide using a calibrated injection system.

Figure 5.3.1. Frill methods for controlling larger woody stems include the traditional blade incisions (top) as well as drilled holes (bottom). Hand pulling or dilute foliar application of herbicides are options for juvenile woody species or mature herbaceous weeds.

[2] http://www.cdms.net/LabelsMsds/LMDefault.aspx?pd=776S&t=

In areas with relatively shallow slopes less than 50%, which is approximately the upper limit where crews can realistically work without highly specialized equipment, invasive tree cover will be controlled using a **cut stump treatment .** In this approach,trees are severed at the base using either a blade or a chainsaw; herbicides are then immediately applied to the exposed vascular tissue. To prepare for planting native tree species, further management of woody debris will be required.

5.3.1.3 Woody debris management

The current density of *P. cattleianum* cover in many sections of the riparian zone is extreme (see **Fig. 4.1.2** for examples). Following cut stump treatment, debris would be assembled into linear piles (windrows) along contour, providing at once some measure of erosion control and defining the restoration planting beds. For subsequent native tree species plantings, in the area between windrows soil would be prepared manually using a pick or motorized auger device. It will be important to carefully schedule weed termination, soil preparation,and planting. Restoration planting should begin almost immediately in cut stump treatment areas so that the plantings have maximum advantage against weeds,which would require several months to colonize. In extremely steep areas,killing the current cover and leaving it in place is acceptable-roots of the dead trees will stabilize the steep banks of the Waia'ama Stream, and will prevent immediate re-colonization. These areas can be occupied over the long term with uluhe fern.

5.4 Hardwood Site Preparation

A clearly defined series of steps will be followed to bring the property from its current marginal pasture cover to a state ready for tree planting **(Fig. 5.4.1).** These steps are (1) terminating the current grass cover, (2) loosening the compacted pasture soils with a heavy forestry disk, and (3) constructing mounded planting rows using a bedding plow.

Figure 5.4.1. Completed site preparation procedures result in weed-free mounded planting beds consisting of loosened soil that are designed to improve drainage around seedling roots.

5.4.1 Pre-plant grass control

The deliberate reservation of a SMZ between hardwood compartment boundaries and the riparian areas is designed so that chemical control of pasture grasses site preparation can be utilized without posing a threat to aquatic ecosystems. Chemical control to remove weed species will be conducted approximately 2 months prior to planting,which minimizes potential for herbicide damage to planted trees. Herbicide mixes will depend on the species involved,labeled use rates,and desired mode of action. Wet soils in the area mean that particular attention is needed to prevent runoff of soil-borne chemicals or leaching of any applied materials.

5.4.2 Soil preparation

Mechanical disking and bedding should be used; a bulldozer already on-site for access improvement and home site work may be used to pull the site preparation implements in a bid to minimize costs. The Rx calls for two passes with a heavy forestry disk to incorporate the existing grass sward into the surface soil horizon,followed by one pass of a bedding plow equipped with a ripper shank to disrupt any hardpan. In

abandoned sugar plantation areas, this procedure was successfully employed for some of the Hamakua eucalyptus plantations. Inwet areas like Pepeekeo,beddingelevates the seedling root zone and allows trees to establish in soilwith improved drainage. The mostfertile surface soils, typically the top five inches,are collected by the bedding plow and concentrated inthe center of the bed,improving soilfertility in the area immediately surroundingthe seedlings. In addition,the bed height assists with competition control,physically elevating the seedlings above their herbaceous competitors and reducing the cost of subsequent chemical competition control.

5.5 Planting

5.5.1 Species Selection

The suite of hardwood species suitable for the property were selected based on their nutrient requirements, tolerance of comparable soil properties, potential market value, and (when the information was available) their growth performance in nearby plantings and trials. Species were ranked according to a composite assessment. The top-ranked species (4, **Table 5.5.1)** received this rank because they are known to grow well in this area as well as to demand a high market price. For example, *Elaeocarpus angustifolius* is among the hardest and therefore most durable tropical hardwood species, while *Eucalyptus deg!upta* has some demand by Hawai'i Island cabinet makers. The species *Cupressus lusitanica* is relatively obscure in the local market, yet in its native Mexico and Central America it is in high demand for furniture and cabinetry, with wood very similar to tsugi pine *(Cryptomeria japonica)* . Here,it would be used as a proven windbreak species, which with appropriate silviculture could be harvested on a limited basis. Although *Cedrel!a odorata* enjoys a relatively small market share in Hawaii,the available product is quickly sold and always in demand. The native Hawaiian species 'ohi'a *(Metrosideros polymorpha)* is included in the highest rank category for restoration because it is adapted to the site and represents the best option for SMZ restoration. To emulate natural forest structure and composition, the native species plantings in the SMZ would feature shrubs as well, including mamaki *(Pipturus albidus),* naio *(Myoporum sandwicense),* and pilo *(Coprosma spp).* Understory plantings would include uluhe and hapu'u ferns. Species designated for operat ional use would be planted in the first year across the majority of compartments HOl and H02 **(Map 2,Table 5.5.2).** One acre in H01would be reserved for experimental plantings **(Table 5.5.2)** such as koa, mahogany, and rosewood.

Two species are known to perform well in the area **(Fig.5.5.1)** as well as to have an established market-these operational species would be planted across all but one acre in the compartments HOl and H02 in the first year **(Table 5.5.2).** Experimental species would be planted on the reserved acre, and their performance in the first year would determine which species are planted in compartments H03-H05 in the second year **(Table 5.5.2).** Depending on results of the experimental plantings, it may be the case that the original operational species are planted again in the remaining compartments . For the SMZ, all plantings would focus on *M. polymorpha,* with planting scheduled for years three through 10 **(Table 5.5.2).**

Several high value hardwoods (those ranked 3) are potentially suited to the site, and may be marketable **(Tables 5.5.1, 5.5.2).** Honduran mahogany *(Swietenia macrophylla)* and teak *(Tectona grandis),* though listed in the initial FSP proposal,grow very slowly and with poor form on an adjacent property **(Fig.5.5.1).** As a result, these species are not favored for the project **(Table 5.5.1).** The species *Tabebuia rosea* does not have an established market, but its high wood quality suggests that it should be planted on an experimental basis **(Table 5.5.1).**

Table 5.5.1. A selection of high value hardwood species will be planted, including experimental species in the first year. Species are ranked according to known performance in the area. Species that have a positive track record are ranked 4; species with potential are ranked 3.Some species have high value but may suffer from disease or poor performance, or unknown factors (rank 2); species ranked 1are, although selected in the FSP proposal,are not recommended due to known failure.

Genus	Species	Common	Use	Appr. Cost	Rank*	Weed Riskt	Share
Cedrella	*odorata*	tropica lcedar	Experimental	$1.50	4	2	2%
Cupressus	*lusitanica*	Mexican cypress	Windbreak	$1.50	4	6	2%
Elaeocarpus	*angustifolius*	blue ma rble	Operationa l	$3.00	4	4	40%
Eucalyptus	*deglupta*	rainbow euca lyptus	Operationa l	$2.20	4	2	40%
Metrosideros	*polymorpha*	ohi'a	Restoration	$7.00	4	NA	
Dalbergia	*latifolia*	East Indian rosewood	Experi menta l	$3.29	3	5	2%
Eucalyptus	*microcorys*	tallowwood	Experimenta l	$1.00	3	1	2%
Pterocarpus	*indicus*	narra	Experimenta l	$2.89	3	4	2%
Samanea	*saman*	rnonkeypod	Experi menta l	$2.75	3	4	2%
Senna	*siamea*	pheasantwood	Experimental	$2.75	3	5	2%
Acacia	*koa*	koa	Experi menta l	$2.00	2	NA	
Sweitenia	*macrophylla*	Honduran mahogany	Experi menta l	$5.50	2	-2	2%
Tabebuia	*rosea*	trumpet tree	Experi menta l	$2.50	2	3	2%
Tectona	*g_randis*	teak	Exeeri menta l	$4.75	1	-5	2%

• Ranking: 4: Known to succeed I 3: Expected to succeed I 2: Possible or Unknown I 1: Drawbacks

thttp://www. betany.hawa ii.edu/faculty/da ehler/wra/full_table .asp.html

Many of the high value hardwood species proposed for this project rank between 1and 6 on the University of Hawai'iweed risk assessment scale. Although these risk values suggest some potential for invasiveness, three factors neutralize this threat. First, the project area is completely surrounded by non-native ecosystems that contain species with far higher weed risk values-these areas act as a containment buffer. Second, the weed risk values 1-6 are minimal compared with the species that this project replaces (e.g. strawberry guava (WRA 18) or tropical ash (WRA 11)).Third, the land management prescription calls for aggressive brush control in the hardwood plantings; although this prescription targets primarily species that are truly weeds, it would also address any regeneration of the timber species.

Table 5.5.2. Two operational species would be planted in compartments HOl and H02 in the first year. Exper imental species would also be planted in the first year, and their performance would determine the species set for the second planting. All species listed are abbreviated by the concatenation of the first three letters of their genus and species names.

Compartment	Type	Planting year	Species: Operati0nal	Species: Experimental
H01	Hardwood	1	Elaang, Eucdeg	Cedodo, Dallat, Eucmic, Pteind, Samsam, Sensia, Acakoa
H02	Hardwood	1	Elaang, Eucdeg	
H03	Hardwood	2		*Pending experimental results*
H04	Hardwood	2		*Pending experimental results*
HOS	Hardwood	2		*Pending experimental results*
S01	SMZ	3-10	Metpol	
S02	SMZ	3-10	Metpol	

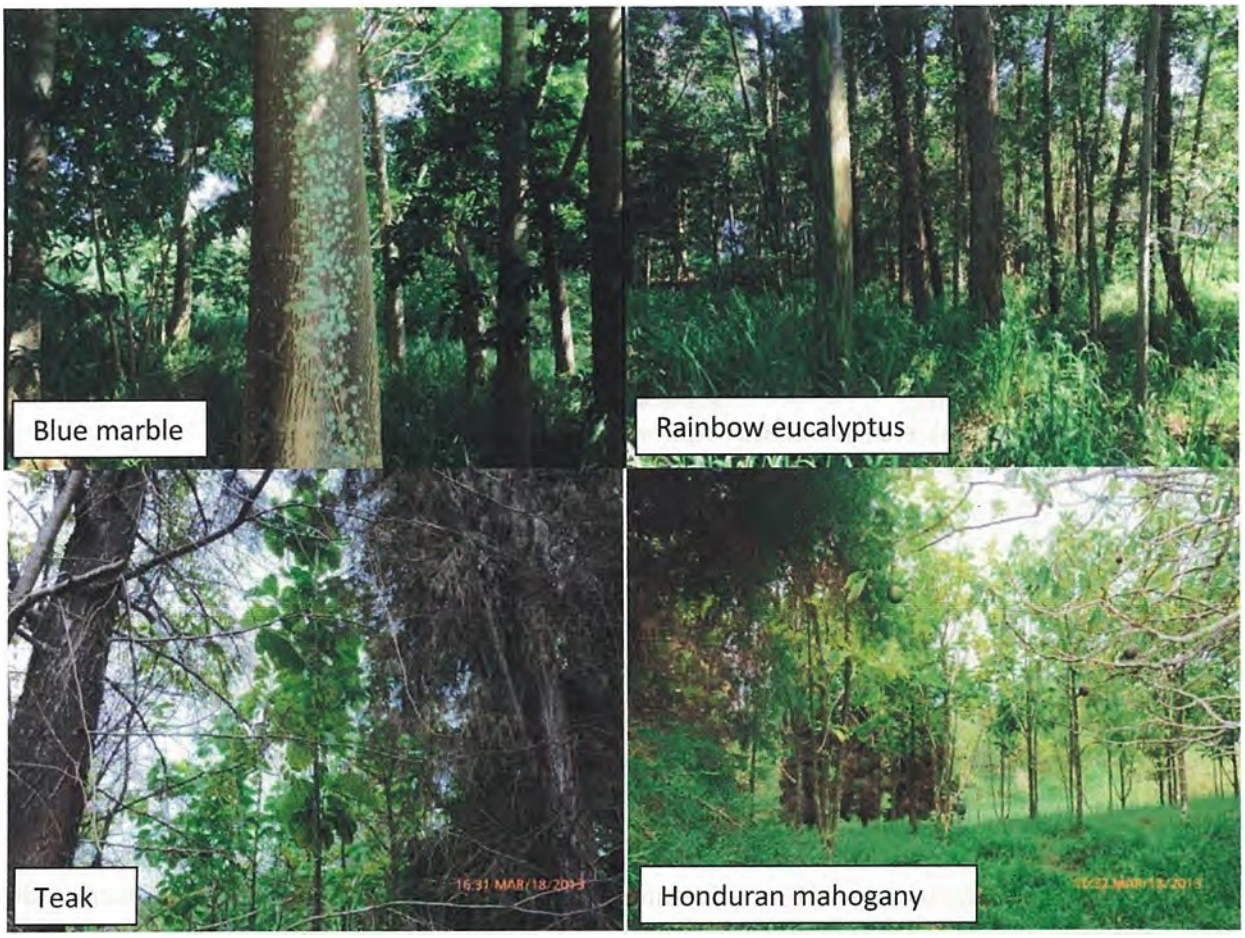


Figure 5.5.1. Performance of operational species (top) is exceptional in the area. Disfavored species originally listed in the FSP proposal should be excluded from plantings because of known performance failures (bottom left) or planted on an experimental basis (bottom right).

5.5.2 Planting

Hand planting will use a tree spade or dibble as appropriate for the nursery stock. Effective mechanical site preparation will facilitate rapid planting rates, anticipated to exceed 1,000 trees per day. Standard planting techniques require that laborers perforate a hole at least as deep as the length of the seedling root stock. The seedling is placed into this hole (1) so that the root collar is marginally lower than the level of the soil, and (2) so that the root mass is vertical. Roots should not be bent in relation to the sides of the hole ("J-rooting"), and one of the most important roles of project management during planting is to spot-check planted seedlings to ensure that J-rooting or other technical deficiencies on the part of the crew have not occurred. After the seedling is placed in the ground, loose soil is firmly packed around the roots such that the root collar is level with the soil surface. A slight tug on the seedling (without breaking the top) is used to check the adequacy of soil tamping.

5.5.3 Restoration planting

Planting techniques for restoration areas are comparable to timber, with different spacing. Windrows should be six feet apart, and trees should be spaced five feet apart. This 6' x S' spacing yields a density of 1,452 trees per acre (hereafter, "tpa").

5.6 Maintenance

5.6.1 Fertilizer

While the soils on the property are relatively fertile, crown fertilizer treatment will aid in early seedling development and enhance their vigor **(Table 5.6.1).** The fertilizer will also aid in getting the seedling canopy out of the weed zone more quickly, thereby reducing future competition control requirements. Based on (1) the Consultant's experience with similar projects in the Hamakua District, (2) soil test results from a similar property, and (3) detailed NRCS reports, an appropriate fertilizer formulation to apply immediately after planting is a 10-30-10 plus minor elements. For later fertilizer application, an 11-52-00 formulation is suitable. Both treatments would be a crown application in which the fertilizer dose is spread in a ring surrounding the seedling and a radial distance of six inches.

Table 5.6.1.

Formula (N-P-K)	Treatment	Timing
10-30-10+	4 oz / tree, crown 12" in diameter	At planting
11-52-00	4 oz / tree, crown at dripline	8 months

5.6.2 Competition control

Selective herbicides will be used as needed for post-planting competition control until 2 years of age or site dominance by canopy closure of young trees. Four competition control entries are anticipated, which is the standard operating procedure for other plantations in the Hamakua District. Grasses will be the maintarget for this operation, as annual herbaceous species are normally not as threatening to young seedlings. The overarching objective, however, is to maintain a clean growing site for early tree development. Hand weeding will be employed if weeds are too close to the base of trees; however, this will be used judiciously as it is a costly operation. Another option is to mulch trees, using either recycled rubber rings or 3' x 3' black tree mats around the seedlings, both of which will be tested for cost effectiveness. These options would need to be reviewed on a cost basis prior to full implementation.

5.6.3 Pruning and singling

The two operational species typically do not need pruning (removal of lower branches) or singling (selection of only one competitive leader). These species are therefore expected to show good form with minimal intervention. Most of the pruning and singling efforts directed toward the first year plantings will therefore focus on the experimental species, some of which, particularly 5. *saman* and 5. *siamea,* are prone to excessive branching at a young age, particularly if attacked by rose beetle (§5.6.5). The potential wood value of these latter legumes is quite high, however, and could justify the expense of form control.

5.6.4 Thinning

Although thinning will certainly be needed to bring the original planting density (e.g. 454 tpa) to the final harvest density of 150 tpa at 45 years, the actual thinning operation would likely occur in the second decade of management. As such, it is not explicitly featured in this iteration of the FMP, as it is not a simple matter to predict exactly when thinning would need to occur.

Moreover, thinning is an operation that can occur over several years, and it is likely most cost effective at this scale for the landowner to conduct the thinning themselves with management guidance rather than for a forestry crew to complete the work. Ideally, this would be based on the culmination of current annual increment, or by proxy, diameter, as determined by permanent sampling plots described in the monitoring section.

5.6.5 Integrated pest management

A vigorous stand of trees is the best defense against insect and fungal pathogens, allowing

trees to resist attacks or to recover from attacks autonomously. To a significant extent, species selection should avoid pest and disease problem, since trees adapted to the site will experience less environmental stress and therefore be less susceptible to pests and diseases. However, certain species are known to be vulnerable to certain diseases,but they are nonetheless worth planting.

For example, both *S. saman* and *S. siamea* may suffer from potentially lethal defoliation by the Chinese rose beetle *(Adoredus sinicus)* when less than two r three years old. Controlling the beetles is thus only a priority when the trees are young,and the value of the wood more than offsets pest control costs. The native '6hi'a may be susceptible to the fungal pathogen *Puccinia psidii,* but '6hi'a is the only real option for tree species restoration in the SMZ so this risk must be taken. All pest and disease control should be accomplished in an integrated pest management (1PM) framework.

The 1PM approach,which can be applied to both weed and insect pests,focuses on (1) monitoring potential pest agents,(2) identifying threshold densities or populations at which pests cause unacceptable economic damage, and (3) identifying and applying the most effective control agent. To control insect pests in 1PM, the first step is to identify potential pest species. This requires a monitoring program that can take on varying degrees of sophistication. When damaging levels of the pest are discovered, the first option for control methods is typically a pheromone-based trapping system or adhesive traps. Chemical insecticides are used if control is impossible with more benign methods.

5.6.6. Monitoring

A critical element of forest management is an active and effective monitoring program. It is possible for the landowner to implement an effective monitoring program with minimal guidance from a forest management professional,and this model would be followed for the proposed project. Monitoring would take place in three spheres to determine performance of (1) experimental plantings established in year 1,(2) operational timber plantings across compartments HOI-HOS, and (3) native species restoration in the SMZ. Standard tree biometric data would be collected on an annual basis for all of the trees in the experimental block, for one or two permanent sample plots per compartment (each 1/SOth acre, or 26.3' diameter), and at select locations in the SMZ. In the early years, tree height and survival would be the two data categories. Once trees reach sufficient size to have a measurable diameter at 1.4 m above the ground,diameter would also be recorded. Data analysis would follow standard statistical methods. In the experimental block,first-year growth and survival data would help to determine which species would be planted in compartments H03 – H04 in the second year. Later, height and diameter growth data would reinforce financial model predictions, ultimately to develop site-specific growth curves for each of the species planted at the site.

5.7 Harvesting

In the longterm, hardwood harvestingwould occur using a partial selection system in which 100 tpa would be removed at first maturity (anticipated to be 40 years), and a second harvest of SO tpa would be removed at 45 years. The precise harvest schedule will depend strongly on the difference between maintenance cost increases and increases in value with additional tree growth. Risk mitigation is also a factor that would favor limiting rotation length. This FMP assumes harvests at 40 and 45 years, which would be conducted accordingto standard harvesting best management practices **(Appendix B).** The vagaries of the market may ultimately dictate a different harvest regime, but this outcome is not possible to forecast.

VI. Budget and Timing

Budgeting and management schedules for the Forest Stewardship Program are presented for the first ten years of the project. Management activities through the first rotation of hardwood timber are presented in a subsequent financial analysis. The most substantial single cost for this project is fencing, which would be required to ensure that timber plantings are not destroyed by feral pigs or errant bovines. The area that must be fenced includes the hardwood timber planting areas; the SMZ does not need to be fenced because (1) the hardwood zone fence excludes cows from the SMZ and (2) feral pigs are less likely to disturb plantings amidst windrows than plantings in bedded areas .The upper bound estimate for length of fence required for this exclosure is 5,780 feet, while the lower bound length (if the North border fence is not improved) is 5,180 feet. Other large expenditures include site preparation and planting ($1,300 acre·\ seedlings (average $1,050 acre·1), silvicultural maintenance ($500 acre-1), and SMZ restoration site preparation ($5,600 acre-1, but limited to four acres). Seedlings of high value hardwood species are expensive due to a combination of factors, including rarity, difficulty of propagation, and lengthy nursery stays. Site preparation is a considerable expense because of the small scale, while silviculture consists of a variety of actions performed over two years. Each activity is assigned a corresponding NRCS code for ease of later use.

6.1 Decadal Budget

Table 6.1.1. Anticipated costs, distributed by activity and compartment, for the first year. Fencing includes the entire hardwood planting project perimeter (top) or excludes the North border (bottom) which is currently fenced only with barbed wire. **Costs in this section (§6.1) are on a per-acre basis, except trail construction and access control, which are on a per-foot basis, and seedling costs (per-seedling basis, 454 tpa).**

Activity	NRCS code	Cost unit[1]	Start month	Compartment H01 3.9 ac	H02 4.2 ac	H03 3.6 ac	H04 5.4 ac	H05 1.8 ac	S01 3.5 ac	S02 0.9 ac
Year 1										
Management plan		$193	-12	$ 752	$ 803	$ 700	$ 1,037	$ 348	$ 681	$ 180
Trail Construction	383	$1.58 t	-6	$ 667	$ 751	$ 2,252	$ 584	$	$	$
Access Control	472	$7.00 t	-6	$ 8,092	$ 8,092	$ 2,023	$ 12,138	$ 8,092	$	$ 2,023
Year subtotal:				$ 9,512	$ 9,645	$ 4,975	$ 13,758	$ 8,440	$ 681	$ 2,203
FSP %:				50%	50%	50%	50%	50%	50%	50%
Applicant share:				$ 4,756	$ 4,823	$ 2,488	$ 6,879	$ 4,220	$ 340	$ 1,101
FSP share:				$ 4,756	$ 4,823	$ 2,488	$ 6,879	$ 4,220	$ 340	$ 1,101
Year 1 Applicant total: $ 24,607.29				Year 1 FSP Total: $ 24,607.29						
t cost per foot										

Activity	NRCS code	Cost unit[1]	Start month	Compartment H01 3.9 ac	H02 4.2 ac	H03 3.6 ac	H04 5.4 ac	H05 1.8 ac	S01 3.5 ac	S02 0.9 ac
Year 1										
Management plan		$193	-12	$ 752	$ 803	$ 700	$ 1,037	$ 348	$ 681	$ 180
Trail Construction	383	$1.58 t	-6	$ 667	$ 751	$ 2,252	$ 584	$	$	$
Access Control	472	$7.00 t	-6	$ 7,210	$ 7,210	$ 1,803	$ 10,815	$ 7,210	$	$ 1,803
Year subtotal:				$ 8,630	$ 8,763	$ 4,755	$ 12,435	$ 7,558	$ 681	$ 1,982
FSP %:				50%	50%	50%	50%	50%	50%	50%
Applicant share:				$ 4,315	$ 4,382	$ 2,377	$ 6,218	$ 3,779	$ 340	$ 991
FSP share:				$ 4,315	$ 4,382	$ 2,377	$ 6,218	$ 3,779	$ 340	$ 991
Year 1 Apelicant total: $ 22,402.29				Year 1 FSP Total: $ 22,402.29						
t cost per foot										

Table 6.1.2.Anticipated costs, distributed by activity and compartment, for the second year.

Activity	NRCS code	Cost unit[1]	Start month	Compartment H01 3.9 ac	H02 4.2 ac	H03 3.6 ac	H04 5.4 ac	H05 1.8 ac	501 3.5 ac	502 0.9 ac
				Year 2						
Tree Site Preparation	490	$150	-2	$ 584	$ 623	$ 543	$ 804	$ 270	$	$
Deep Tillage	324	$350	-1	$ 1,362	$ 1,453	$ 1,267	$ 1,876	$ 630	$	$
Tree Estab. Planting	612	$150	0	$ 584	$ 623	$	$	$	$	$
Tree Estab. Seedlings (expr.)	612	$4.50	0	$ 2,043	$	$	$	$	$	$
Tree Estab. Seedlings (ops.)	612	$3.50	0	$ 6,181	$ 6,594	$	$	$	$	$
Nutrient management	590	$160	0	$ 622	$ 664	$	$	$	$	$
Weed Control	315	$140	2	$ 545	$ 581	$	$	$	$	$
Weed Control	315	$140	6	$ 545	$ 581	$	$	$	$	$
Integrated Pest Management	595	$114	8	$ 442	$ 471	$	$	$	$	$
Nutrient management	590	$160	8	$ 622	$ 664	$	$	$	$	$
Weed Control	315	$140	10	$ 545	$ 581	$	$	$	$	$
Stream Habitat Improvement	395	$7,000	10	$	$	$	$	$	$ 7,000	$
Year subtotal:	--	--	--	$ 14,073	$ 12,834	$ 1810	$ 2,680	$ 900	$ 7,000	$
FSP %:			--	50%	50%	50%	50%	50%	50%	50%
Applicant share:				$ 7,036	$ 6,417	$ 905	$ 1,340	$ 450	$ 3,500	$
FSP share:	--			$ 7,036	$ 6,417	$ 905	$ 1,340	$ 450	$ 3,500	$
Year 2 Applicant total:	$ 19,648835			Year 2 FSP Total:	$			19,648.35		

Table 6.1.3. Anticipated costs, distributed by activity and compartment, for the third year.

Activity	NRCS code	Cost unit[1]	Start month	Compartment H01 3.9 ac	H02 4.2 ac	H03 3.6 ac	H04 5.4 ac	H05 1.8 ac	501 3.5 ac	S02 0.9 ac
				Year 3						
Site Preparation	490	$60	12	$	$	$ 217	$ 322	$ 108	$	$
Tree Estab. Planting	612	$150	12	$	$	$ 543	$ 804	$ 270	$	$
Tree Estab. Seedlings (ops.)	612	$4.00	12	$	$	$ 6,574	$ 9,734	$ 3,269	$	$
Nutrient management	590	$160	12	$	$	$ 579	$ 858	$ 288	$	$
Weed Control	315	$140	14	$ 545	$ 581	$ 507	$ 750	$ 252	$	$
Tree Pruning	660	$59	14	$ 230	$ 245	$	$	$	$	$
Integrated Pest Management	595	$114	16	$	$	$ 411	$ 608	$ 204	$	$
Weed Control	315	$140	18	$	$	$ 507	$ 750	$ 252	$	$
Nutrient management	590	$160	20	$	$	$ 579	$ 858	$ 288	$	$
Stream Habitat Improvement	395	$7,000	10	$	$	$	$	$	$ 7,000	$
Weed Control	315	$140	22	$	$	$ 507	$ 750	$ 252	$	$
Year subtotal:			--	$ 774	$ 826	$ 10,424	$ 15,434	$ 5,183	$ 7,000	$
FSP %:			--	50%	50%	SO%	50%	SO%	50%	50%
Applicant share:		--	--	$ 387	$ 4'13	$ 5,212	$ 7,717	$ 2,592	$ 3,500	$
FSP share:	--	--	--	$ 387	$ 413	$ 5,212	$ 7,717	$ 2,592	$ 3,500	$
Year 3 Applicant total:	$ 19,820.57			Year 3 FSP Total:	$			19,820.S7		

Table 6.1.4.Anticipated costs, distributed by activity and compartment, for the 4th year.

Activity	NRCS code	Cost unit-	Start month	Compartment H01 3.9 ac	H02 4.2 ac	H03 3.6 ac	H04 5.4 ac	H05 1.8ac	S01 3.5 ac	S02 0.9 ac
				Year 4						
Tree Pruning	660	$59	24	$	$	$ 214	$ 316	$ 106	$	$
Tree Pruning	660	$59	24	$ 230	$ 245	$	$	$	$	$
Weed Control	315	$110	24	$	$	$ 398	$ 590	$ 198	$	$
Stream Habitat Improvement	395	$7,000	10	$	$	$	$	$	$ 7,000	$
Critical Area Planting	342	$375	28	$	$	$	$	$	$ 375	$
Year subtotal:		—		$ 230	$ 245	$ 612	$ 906	$ 304	$ 7,375	$
FSP %:				50%	50%	50%	50%	50%	50%	50%
Applicant share:			---	$ 115	$ 122	$ 306	$ 453	$ 152	$ 3,688	$
FSP share:			—	$ 115	$ 122	$ 306	$ 453	$ 152	$ 3,688	$
Year 4 Apelicant total:	$ 4,835.78			Year 4 FSP Total:	$			4,835 78		

Table 6.1.5. Anticipated costs, distributed by activity and compartment, for the 5th year.

Activity	NRCS code	Cost unit-[1]	Start month	Compartment H01 3.9 ac	H02 4.2 ac	H03 3.6 ac	H04 5.4 ac	H05 1.8 ac	S01 3.5 ac	S02 0.9 ac
				Year 5						
Form correction 2	666	$59	36	$	$	$ 214	$ 316	$ 106	$	$
Stream Habitat Improvement	395	$7,000	10	$	$	$	$	$	$ 1,848	$ 1,953
Critical Area Planting	342	$375	40	$	$	$	$	$	$ 1,320	$
Year subtotal:		--		$	$	$ 214	$ 316	$ 106	$ 3,168	$ 1,953
FSP %:				50%	50%	50%	50%	50%	50%	50%
Applicant share:	—			$	$	$ 107	$ 158	$ 53	$ 1584	$ 977
FSP share:			—	$	$	$ 107	$ 158	$ 53	$ 1,584	$ 977
Year 5 1icant total:	$ 2,878.62			Year 5 FSP Total:	$			2,878 62		

Table 6.1.6. Anticipated costs, distributed by activity and compartment, for the 6th year.

Activity	NRCS code	Cost unit-[1]	Start month	Compartment HOI 3.9 ac	H02 4.2 ac	H03 3.6 ac	H04 5.4ac	HOS 1.8ac	S01 3.5 ac	S02 0.9 ac
				Year 6						
Stream Habitat Improvement	395	$7,000	10	$	$	$	$	$	$ 2,464	$
Critical Area Planting	342	$375	52	$	$	$	$	$	$ 1,320	$
Year subtotal:		--		$	$	$	$	$	$ 3,784	$
FSP %:				50%	50%	50%	50%	50%	50%	50%
Applicant share:				$	$	$	$	$	$ 1,892	$
FSP share:				$	$	$	$	$	$ 1,892	$
Year 6 Applicant total:	$ 1,892.00			Year 6 FSP Total:	$			1,892.00		

Table 6.1.7. Anticipated costs, distributed by activity and compartment, for the 7th year.

Activity	NRCS code	Cost unit-[1]	Start month	Compartment HOI 3.9 ac	H02 4.2 ac	H03 3.6 ac	H04 S.4ac	HOS 1.8ac	SOI 3.5 ac	S02 0.9 ac
				Year 7						
Strea m Habitat Improvement	395	$7,000	10	$	$	$	$	$	$ 2,464	$
Critical Area Planting	342	$375	64	$	$	$	$	$	$ 1,320	$
Year subtotal:				$	$	$	$	$	$ 3,784	$
FSP %:				50%	50%	50%	50%	50%	50%	50%
Applicant share:				$	$	$	$	$	$ 1,892	$
FSP share:				$	$	$	$	$	$ 1,892	$
Year 7 Applicant total:	$ 1,892.00			Year 7 FSP Total:	$			1,892.00		

Table 6.1.8. Anticipated costs, distributed by activity and compartment, for the 8th year.

Activity	NRCS code	Cost unit-[1]	Start month	Compartment HOI 3.9 ac	H02 4.2 ac	H03 3.6 ac	H04 5.4 ac	HOS 1.8 ac	S01 3.5 ac	S02 0.9 ac
				Year 8						
Stream Habitat Improvement	395	$7,000	10	$	$	$	$	$	$ 2,464	$
Critical Area Planting	342	$375	76	$	$	$	$	$	$ 660	$
Year subtotal:				$	$	$	$	$	$ 3,124	$
FSP %:				50%	50%	50%	50%	50%	50%	50%
Applicant share:		--		$	$	$	$	$	$ 1,562	$
FSP share:				$	$	$	$	$	$ 1,562	$
Year 8 Applicant total:	$ 1,562.00			Year 8 FSP Total:	$			1,562.00		

Table 6.1.9. Anticipated costs, distributed by activity and compartment, for the 9th year.

Activity	NRCS code	Cost unit	Start month	Compartment H01 3.9 ac	H02 4.2 ac	H03 3.6 ac	H04 5.4 ac	HOS 1.8ac	S01 3.5 ac	S02 0.9 ac
Year 9										
Stream Habitat Improvement	395	$7,000	10	$	$	$	$	$	$ 2,464	$
Critical Area Planting	342	$375	88	$	$	$	$	$	$ 660	$
Year subtotal:				$	$	$	$	$	$ 3,124	$
FSP %:				50%	50%	50%	50%	50%	50%	50%
Applicant share:			—	$	$	$	$	$	$ 1,562	$
FSP share:				$	$	$	$	$	$ 1,562	$
Year 9 Applicant total:	$	1,562.00		Year 9 FSP Total:	$			1,562.00		

Table 6.1.10. Anticipated costs, distributed by activity and compartment, for the 10th year.

Activity	NRCS code	Cost unit	Start month	Compartment H01 3.9 ac	H02 4.2 ac	H03 3.6 ac	H04 5.4 ac	HOS 1.8ac	S01 3.5 ac	S02 0.9 ac
Year 10										
Stream Habitat Improvement	395	$7,000	10	$	$	$	$	$	$ 2,464	$
Critical Area Planting	342	$375	100	$	$	$	$	$	$ 528	$
Year subtotal:				$	$	$	$	$	$ 2,992	$
FSP %:				50%	50%	50%	50%	50%	50%	50%
Applicant share:	---			$	$	$	$	$	$ 1,496	$
FSP share:				$	$	$	$	$	$ 1,496	$
Year 10 Applicant total:	$	1,496.00		Year 10 FSP Total:	$			1,496.00		

Table 6.1.lla. Total anticipated costs for the first decade of the hardwood project and SMZ restoration activities, where the entire project perimeter is fenced in the first year.

Activity	NRCS code	Cost unit[1]	Start month	Compartment H01 3.9 ac	H02 4.2 ac	H03 3.6 ac	H04 S.4 ac	HOS 1.8 ac	S01 3.5 ac	S02 0.9 ac
Project Budget Summary: Years 1- 10										
Compartment subtotal	--	--		S 24,588	S 23,sso	S 18,035	$ 33,095	$ 14,934	$ 42,032	$ 4,156
Plantation estab. subtotal:	—	—	—	S 15,077	$ 13,905	$ 13,059	$ 19,336	$ 6,494	$	$
Estab. per acre subtotal:	—	—	—	$ 3,876	$ 3,351	$ 3,608	$ 3,608	$ 3,608	$	$
FSP %:	—	—	—	50%	50%	50%	50%	50%	50%	50%
Applicant share:	—	—	—	S 12,294	$ 11,775	$ 9,017	$ 16,547	$ 7,467	$ 21,016	$ 2,078
FSP share:	—	—	—	S 12,294	$ 11,775	$ 9,017	$ 16,547	$ 7,467	$ 21,016	$ 2,078
Applicant total:				$	80,195					
FSP total:					80l195					
$ Prolect total:				$	160,389					

Table 6.1.llb.Total anticipated costs for the first decade of the hardwood project and SMZ restoration activities,where fencing in the first year occurs on the SlJth, East, and West project boundaries but not along the North boundary.

Activity	NRCS code	Cost unit[1]	Start month	Compartment H01 3.9 ac	H02 4.2 ac	H03 3.6 ac	H04 5.4 ac	HOS 1.8ac	S01 3.5 ac	S02 0.9 ac
Project Budget Summary: Years 1- 10										
Compartment subtotal	—	--	—	$ 23,706	$ 22,668	$ 17,814	$ 31,772	$ 14,052	$ 42,032	$ 3,935
Plantation estab.subtotal:	—	--	—	$ 15,077	$ 13,905	$ 13,059	$ 19,336	$ 6,494	$	$
Estab. per acre subtotal:	—	—	—	$ 3,876	$ 3,351	$ 3,608	$ 3,608	$ 3,608	$	$
FSP %:		--	—	50%	50%	50%	50%	50%	50%	50%
Applicant share:		—	—	$ 11,853	$ 11,334	$ 8,907	$ 15,886	$ 7,026	$ 21,016	$ 1,968
FSP share:	--	—	—	$ 11,853	$ 11,334	$ 8,907	$ 15,886	$ 7,026	$ 21,016	$ 1,968
Applicant total:				$	77,990					
FSP total:				$	77,990					
Pro1ect total:				$	155,979					

6.2 Schedule of activities

Table 6.2.1. Activities scheduled for each compartment during the first five-year management interval, after which hardwood establishment and early rotation maintenance have been completed. Dark green cells indicate that an activity should begin in a given month of a given year in the compartment indicated. Light green cells indicate that a given activity does not occur. Note that management compartment 502 does not involve Critical Area Planting because this area bisects timber compartments and will be overtopped by timber trees.

Activity	NRCS code	Year	Start month	Compartment H01	H02	H03	H04	HOS	501	502
Year 1										
Management plan		1	-12							
Trail Construction	383	1	-6							
Fence	472	1	-6							
Year 2										
Tree Site Preparation	490	2	-2							
Deep nllage	324	2	-1							
Tree Estab.Planting	612	2	0							
Tree Estab. Seedlings	612	2	0							
Tree Estab. Seedlings	612	2	0							
Nutrient management	590	2	0							
Weed Control	315	2	2							
Weed Control	315	2	6							
Integrated Pest Management	595	2	8							
Nutrient management	590	2	8							
Weed Control	315	2	10							
Stream Habitat Improvement	395	2	10							
Year 3										
Site Prepa ration	490	3	12							
Tree Estab. Planting	612	3	12							
Tree Estab.Seedlings	612	3	12							
Nutrient management	590	3	12							
Weed Control	315	3	14							
Tree Pruning	660	3	14							
Integrated Pest Management	595	3	16							
Weed Control	315	3	18							
Nutrient ma nagement	590	3	20							
Stream Habitat Improvement	395	3	10							
Weed Control	3 15	3	22							
Year 4										
Tree Pruning	660	4	24							
Tree Pruning	660	4	24							
Weed Control	315	4	24							
Stream Habitat Improvement	395	4	10							
Critical Area Plantin	342	4	28							
Year 5										
Form correction 2	666	5	36							
Stream Habitat Improvement	395	5	10							
Critical Area Plantin	342	5	40							

Table 6.2.2. Activities scheduled for each compartment during the second five-year management interval, which focuses on SMZ restoration. Dark green cells indicate that an activity should begin in a given month of a given year in the compartment indicated. Light green cells indicate that a given activity does not occur.

Activity	NRCS code	Year	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
Year 6										
Stream Habitat Improvement	395	6	10							
Critical Area Plantin	342	6	52							
Year 7										
Stream Habitat Improvement	395	7	10							
Critical Area Planting	342	7	64							
Year 8										
Stream Habitat Improvement	395	8	10							
Critical Area Planting	342	8	76							
Year 9										
Stream Habitat Improvement	395	9	10							
Critical Area Plantin	342	9	88							
Year 10										
Stream Habitat Improvement	395	10	10							
Critical Area Plantin	342	10	100							

6.3. Economic analysis

6.3.1 Overview

Eventual profitability of the project can be assessed using a core financial model that accepts a variety of parameters to represent the major hardwood crop tree species. For example, a financial model may accept as input the cost of site preparation and establishment, silviculture prescriptions, monitoring, and harvesting. Output from the financial model includes annual net cost, internal rate of return (IRR), and net present value (NPV). Both IRR and NPV are evaluated using a 0.4% annual increase in stumpage price above a baseline, which constrains the 45-year stumpage price to not more than 20% greater than the original. In all cases, NPV is evaluated at a real discount rate of 8%, such that when IRR drops below 8% NPV becomes negative.

For this analysis, it is assumed that the planted species is blue marble (*E. angustifolius),* and that a variety of conditions are met over the course of the rotation. In particular, a growth function dictates that the trees grow to approximately 25 m in height, achieving a diameter of 42 cm by 40 years, and 45 cm by 45 years. A growth rate of 344 bf $ac^{-1}year^{-1}$ can be derived from the growth curve, although this linear approximation properly included in the model in its original nonlinear functional form. Certain costs are globally defined, including establishment, silviculture, and maintenance- these values reflect the budgets (§6.1) and schedules (§6.2) cited above. Additional parameters are required for the economic analysis, including approximate price per board foot of harvested timber (stumpage value), as well as a cost of harvesting, which is set to a fraction of revenues in proportion to the growth curve. Harvesting is programmed to occur once, in the 45th year, and is based on a final stem density of 150 tpa.

The analysis conveys project outcomes for two cases, (I) where indirect costs of fencing are factored into the overall project profitability and (II) where fencing costs are excluded from analysis. To represent a range of possible outcomes based on price and cost fluctuations, project performance is calculated as a function of stumpage price for a fixed seedling cost, and then as a function of seedling cost for a fixed stumpage price. In this way, it is possible to assess performance along two continuous independent variables.

6.3.2 Performance with fencing costs

When fencing prices are included in the economic analysis of the project, profitability is difficult to achieve. Using a fencing cost of $36,050, or the lower price expected for this project based on not fencing the Northern boundary, profitability would occur only at relatively high cost and price parameters. In particular, for a fixed seedling cost of $3.00, NPV only becomes positive for stumpage prices approaching $2.30 **(Table 6.3. a).** This stumpage value is potentially quite high, with $1.00 a more conservative estimate.

Table 6.3. a. Economic analysis for increasing stumpage prices at a fixed seedling cost of $3.00 and discount rate of 8%, where fencing is considered.

	Stumpage (Seedl i ngaost fi1<ed at $3.00/tree)				
Costs	s1.oo	$1.25	s1.50	$1.80	$2.30
IRR	5.80%	6.43%	6.92%	7.41%	8.06%
NPV				-	$2,059
NPV/ac					$109

Table 6.3. b. Economic analysis for increasing seedling costs at a fixed stumpage price of $2.30.

	Seed lin g cost (Stumpage fixed at $2.30/bf)				
Costs	$1..00	$2.00	$3.00	$4.QO	$5.00
IRR	8.56%	8.29%	8.06%	7.84%	7.65%
NPV	$17,881	$9,970	$2,059	($5,853)	($13,764)
NPV/ac	$950	$530	$109	($311)	($731)

Using the high stumpage price necessary to reach non-negative returns, performance may

also be assessed by varying seedling cost between $1.00 (a very low estimate) to $5.00 (a potential price depending on nursery source). When seedling prices approach $4.00, NPV dips into negative territory **(Table 6.3. b),** suggesting that the project may be economically viable at the stumpage price of $2.30 only if seedling costs can be kept at approximately $3.00 **(Fig. 6.3.1).**

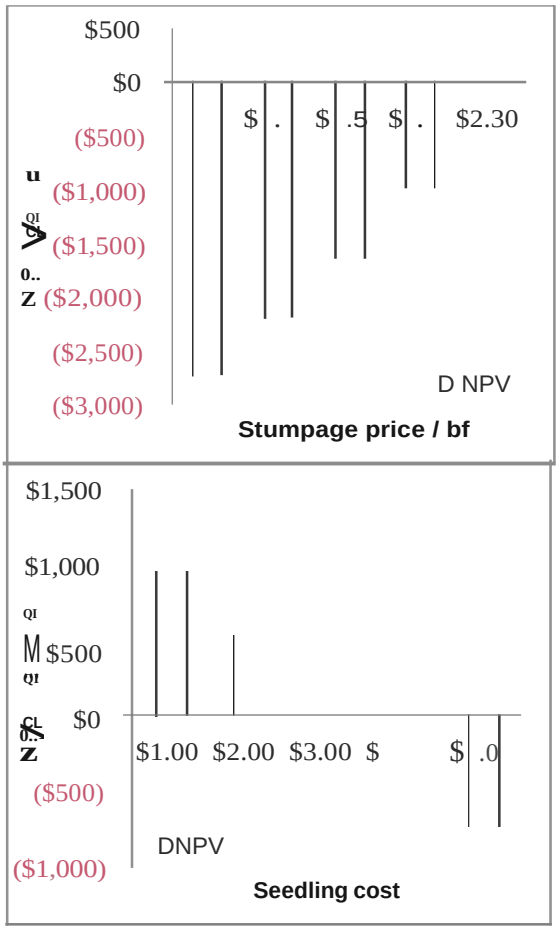


Figure 6.3.1. Financial performance of the *E. angustifolius* investment evaluated for a 45 year rotation across a range of stumpage prices (top) and seedling costs (bottom).

The precise cost and price points at which overall project profitability is achieved for this set of assumptions may be computed by iterating the model across the domain at which NPV transitions from negative to positive.

6.3.3 Performance without fencing costs

Planting high value hardwoods may be reasonably profitable when considering direct costs only. Fencing is an indirect cost for this project, necessary only because of factors unrelated to forestry (i.e. preventing damage from feral animals). When potential project performance is evaluated solely for the elements of the plan related directly to forestry, overall profitability is achievable within reasonable limits for costs and expected prices. Specifically, for a fixed seedling price of $3.00, IRR outweighs the discount rate when stumpage price approaches $1.50, and for a modest price increase of $0.30, per-acre NPV nears $800 **(Table 6.3.2a).**

Table 6.3.2a. Economic analysis for increasing stumpage prices at a fixed seedling cost of $3.00 and discount rate of 8%, excluding the cost of fencing.

	Stumpage (Seedling cost fixed at $3.00/tree)				
Costs	$1.00	$1.25	$1.50	$1.80	$2.30
IRR		7.61%	8.12%	8.61%	9.27%
NPV			$2,545	$14,880	$35,438
NPV/ac			$135	$791	$1,883

Table **6.3.2b.** Economic analysis for increasing **seedling costs at** a **fixed stumpage** price of **$1.50.**

	Seedling cost (Stumpage fixed at $1.50/bf)				
Costs	$1.00	$2.00	$3.00	$4.00	$5.00
IRR	8.99%	8.51%	8.12%	7.77%	7.47%
NPV	$18,367	$10A56	$2,545	($5,367)	($13,278)
NPV/ac	$976	$556	$135	($285)	($706)

Excluding the cost of fencing, economic performance of this project becomes quite reasonable. For example, a per-seedling cost of $3.00 is well within the price range offered by several Hawaii Island nurseries for comparable species (e.g. £. *deglupta),* and positive NPV can be achieved at this level for a stumpage price of $1.50 **(Table 6.3.2a).** Infact, seedling costs between $3.00 and $4.00 can still be borne at this stumpage price level **(Table 6.3.2b)** with positive NPV **(Fig. 6.3.2).**

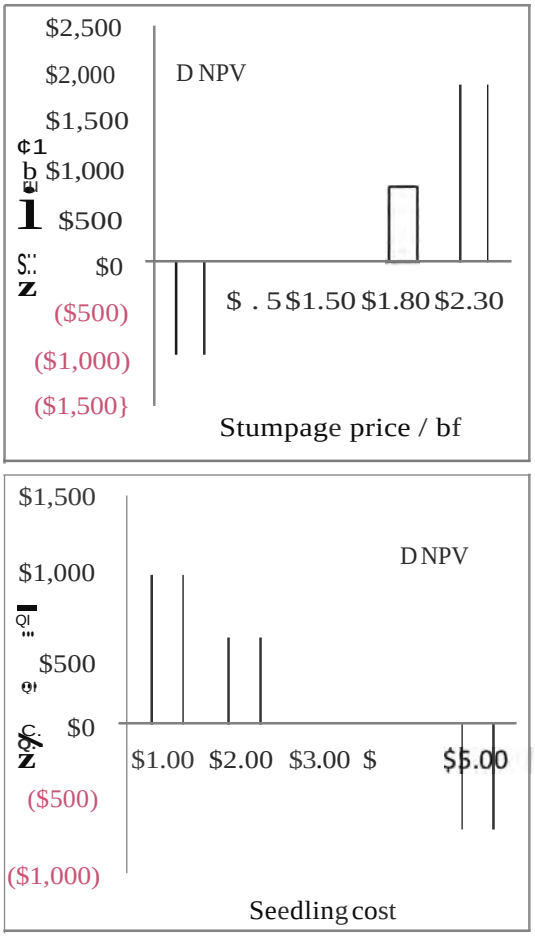
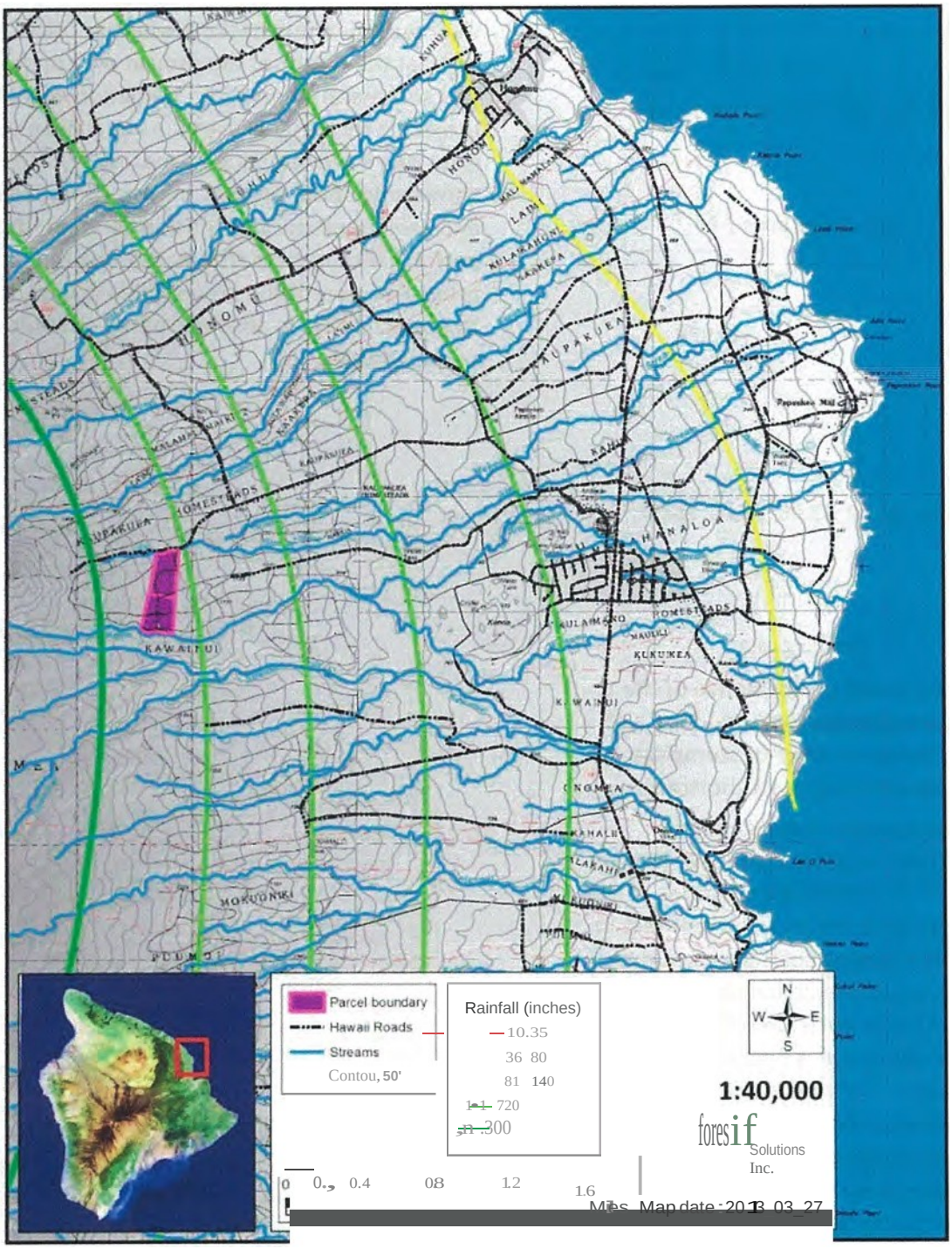


Figure 6.3.2. Financial performance of the *E. angustijolius* investment evaluated for a 45 year rotation across a range of stumpage prices (top) and seedling costs (bottom).

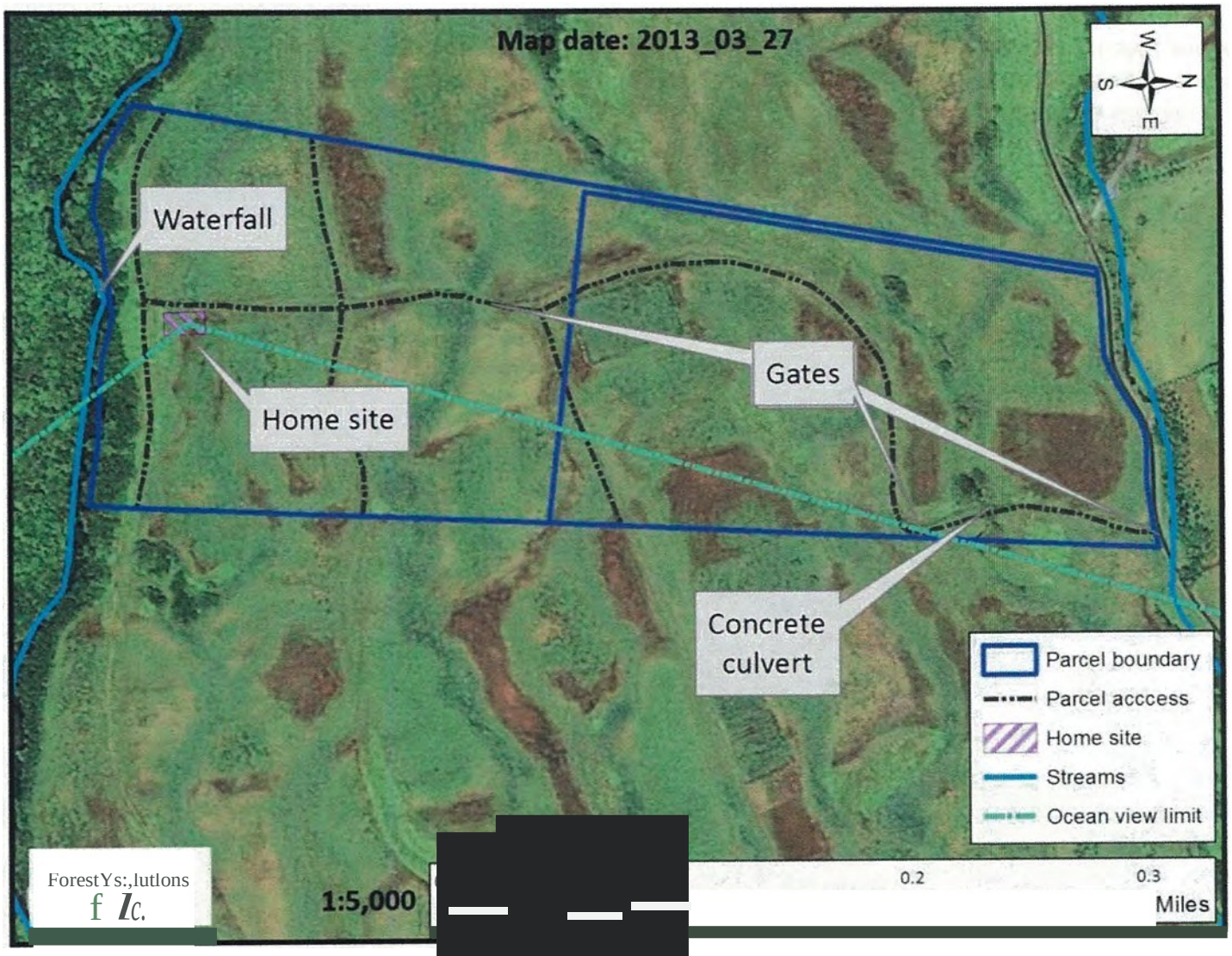
As a concluding remark about general profitability, these economic analyses impose several bounds on the initial conditions of the project in order for a return to be realized. In particular, when fencing costs are excluded, seedling costs must remain below $4.00 in order for the 45 year rotation to be profitable, assuming that stumpage is limited to $1.50 / bf. Higher stumpage prices allow the seedling costs to increase without compromising profitability. Conversely, stumpage prices less than $1.50/ bf are unprofitable when the seedling costs is $3.00; greater stumpage prices improve performance, but lower seedling costs can also achieve the same result. **The single most important factor in determining whether the project represents profit or loss is the fencing element.** At seedling costs and stumpage prices where the no-fence model is profitable, the with-fence model is well into the negative NPV range. Overall, the economic analysis provides a clear guideline for checking whether prices and costs at the outset of the project are conducive to a successful investment. Valuation of the project in the early phases (i.e. establishment) is far more accurate due to reasonably accurate knowledge about present market conditions and likely short-term trends. In contrast, the performance metrics that determine the project's future value are essentially impossible to predict either in absolute terms or in terms of uncertainty.

VII. Maps

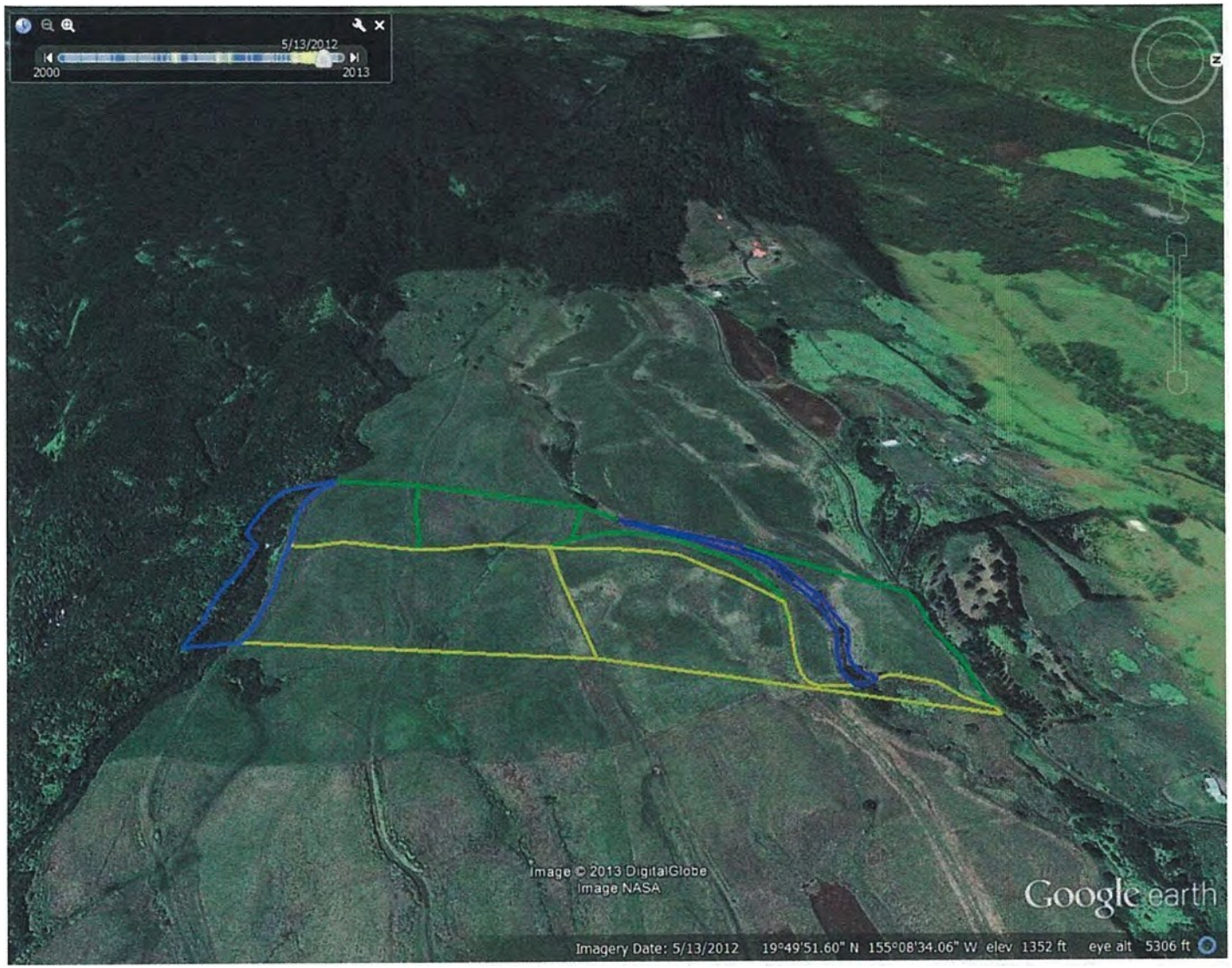


Map 1. Location of the Kaupakuea Orchards LLC property in relation to the Hamakua Coast; Hilo is located approximately 8 miles to the South. Rainfall exceeds 141 inches annually.

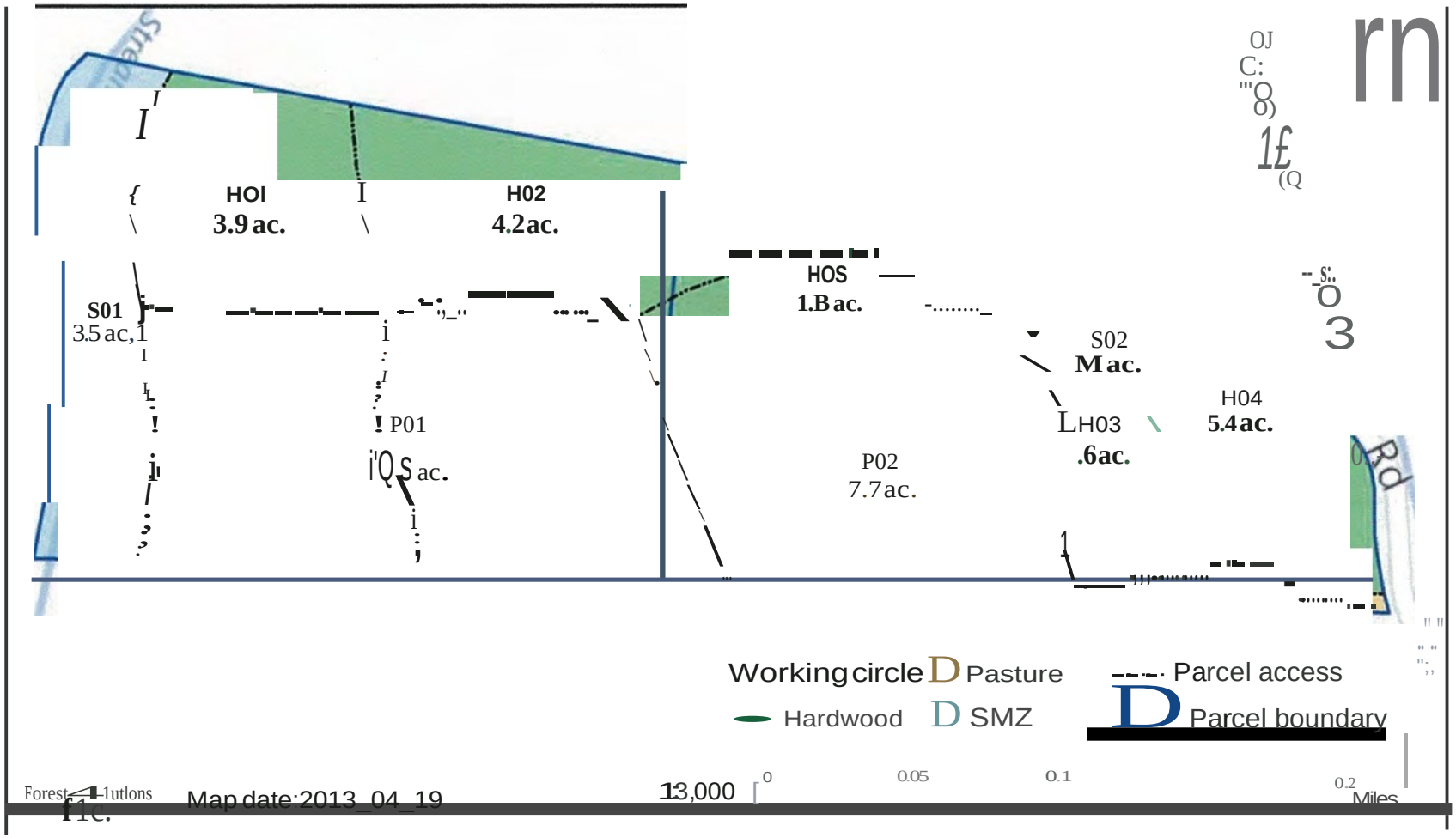
Map 2.



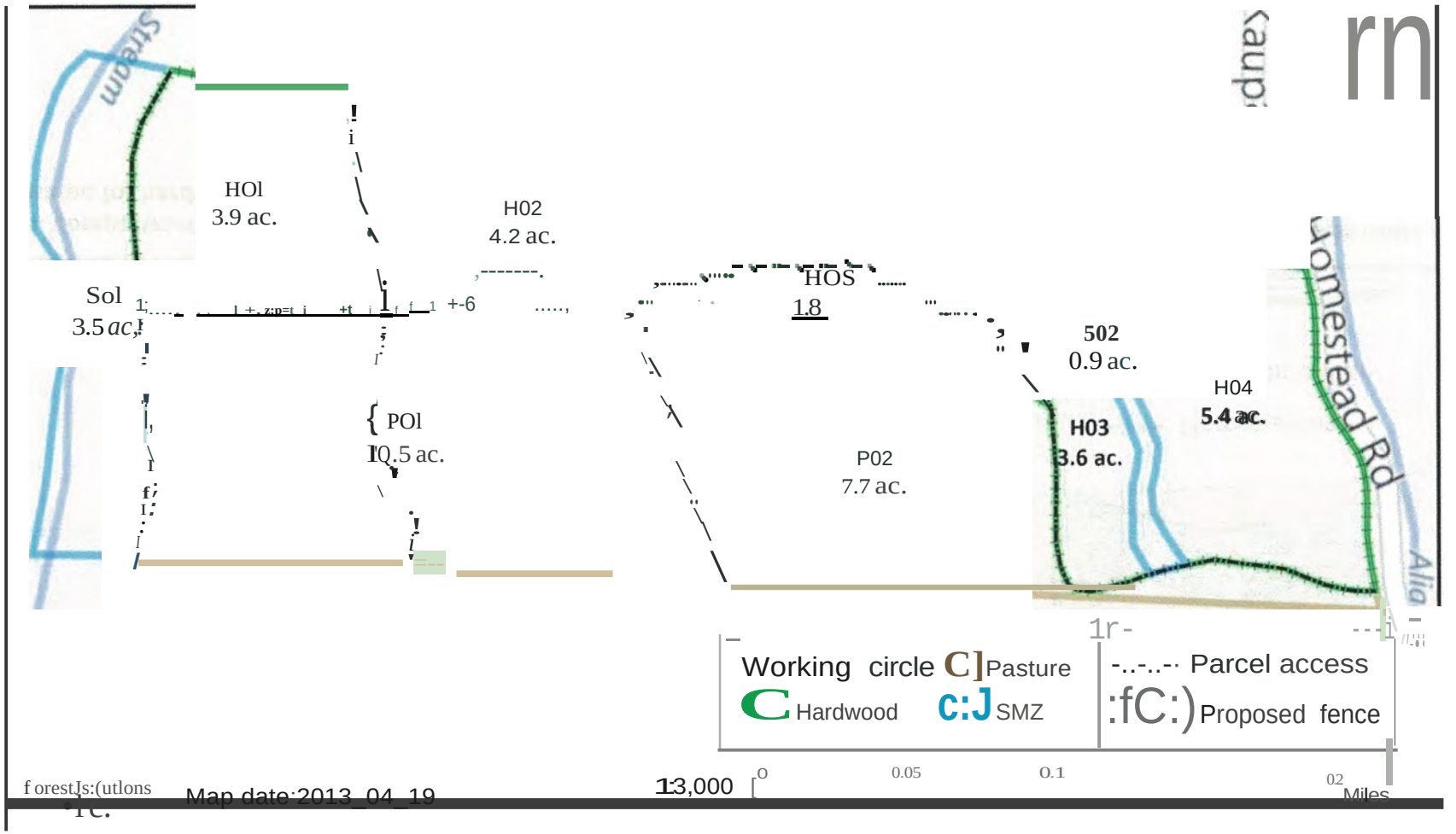
Map 2a. Parcel boundaries define a 19.59-acre parcel to the North and a second 21.90-acre flag lot to the South. The land is bordered by streams on the North and South sides. Forestry is planned for mauka sections, with open land uses planned makai of the access route. A home site is located to the South; the FMP will manage forest cover such that ocean view vectors (blue dash) are unobstructed.



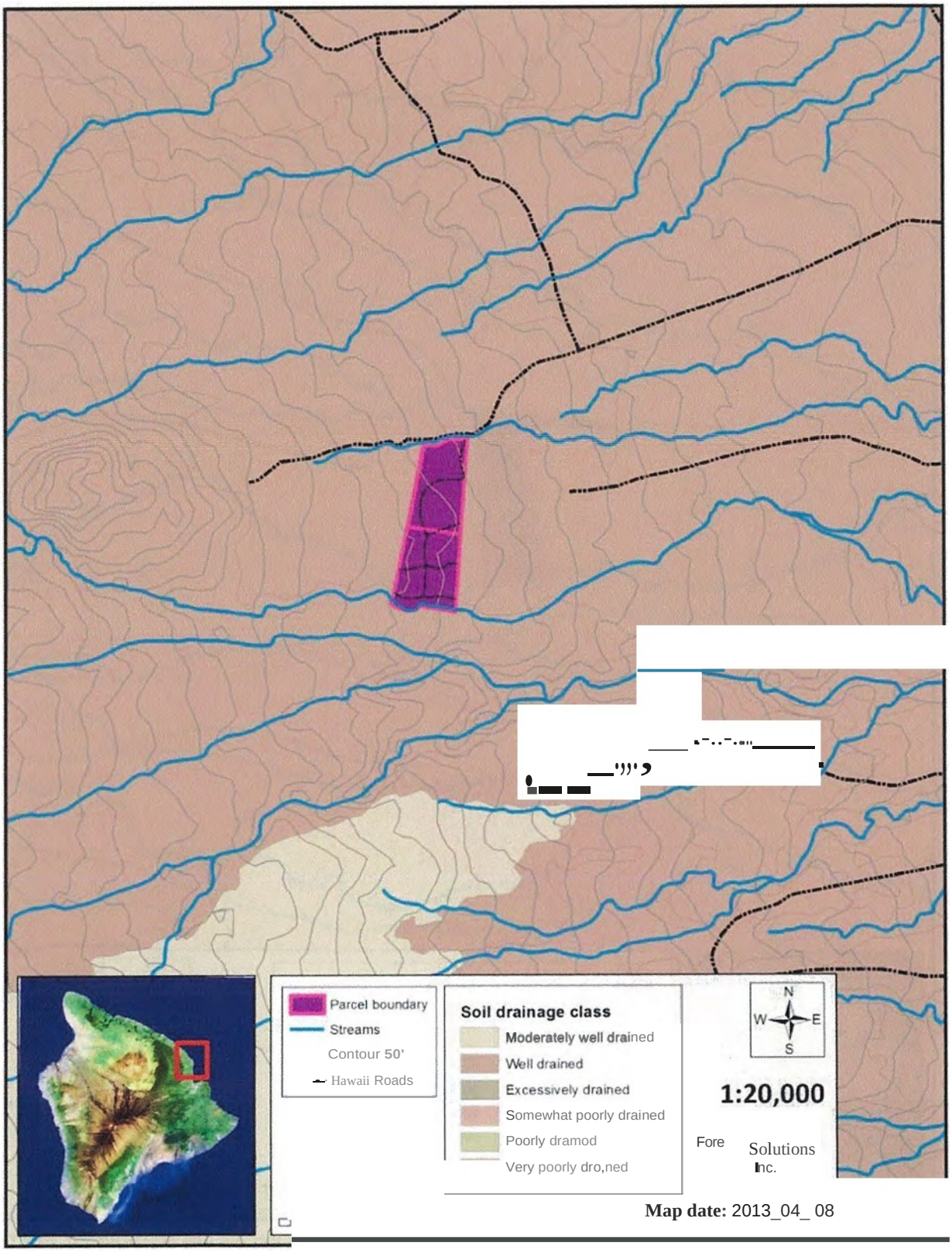
Map 2b. Compartment boundaries are defined in part by pre-existing roads, parcel boundaries, drainages, and other features that are visible in three dimensional relief. This 2012 image (Google Earth) clearly shows the Southern border SMZ and State forested parcel, with additional nearby forest upslope.



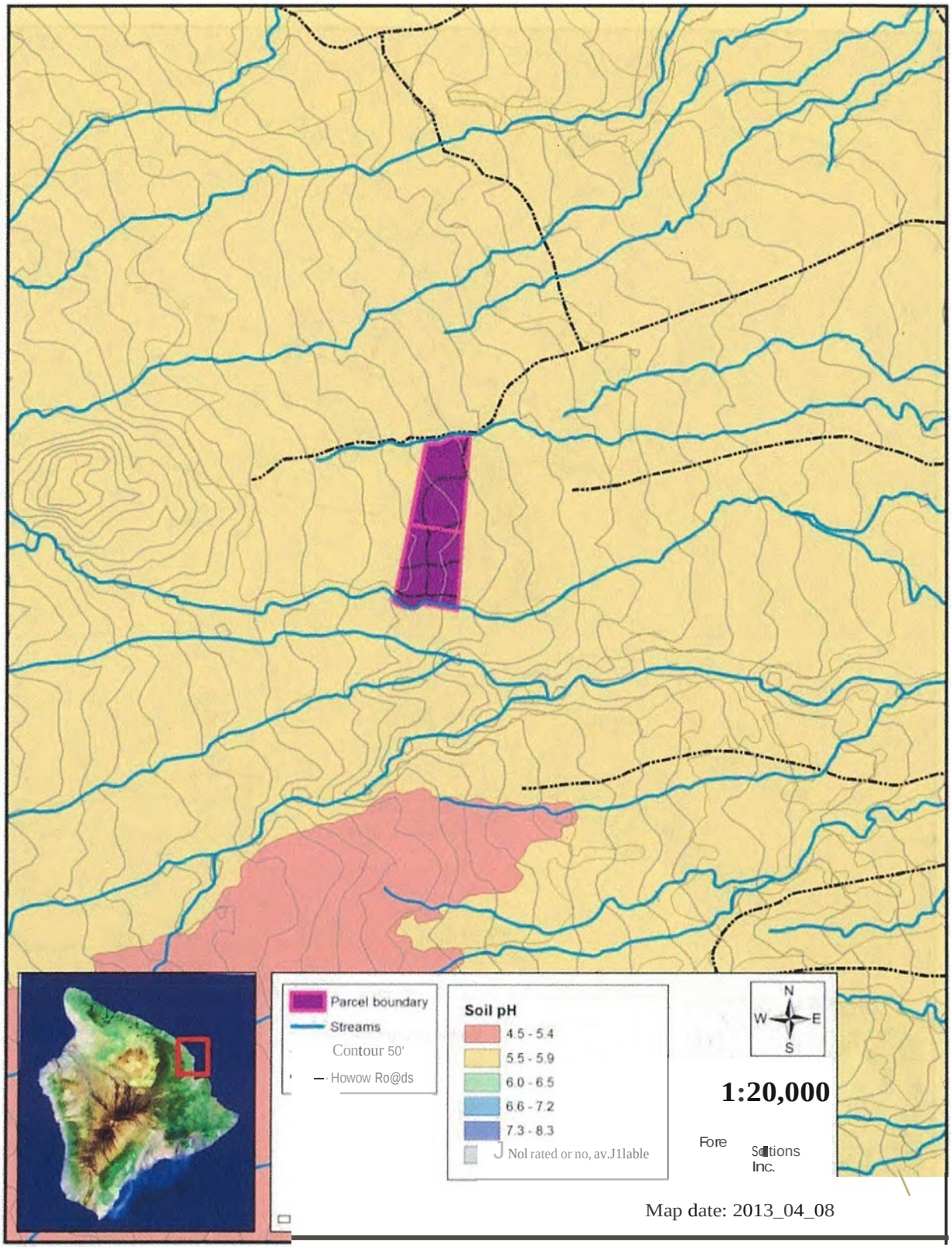
Map 3. Compartment divisions were assigned according the existence of access routes. Areas mauka of the central access route are designated for hardwood planting,while areas adjacent to the riparian sections are reserved for SMZ management.



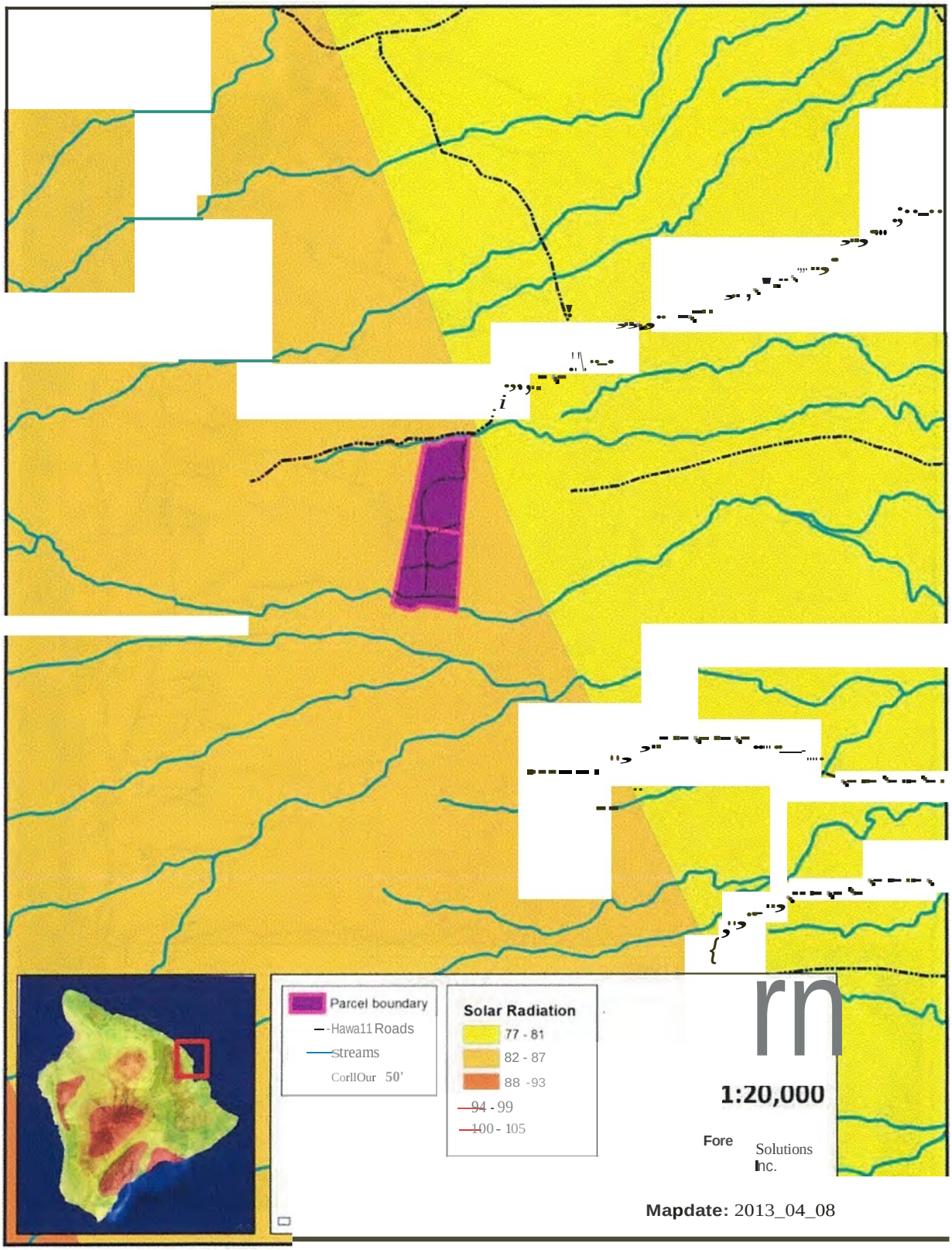
Map 4. Fencing will be necessary surrounding the hardwood planting areas, with a maximum of 5,780 feet of fencing required. Should it be decided that the existing barbed wire fence along the North boundary is adequate, total length of new fencing would be 5,150 feet.



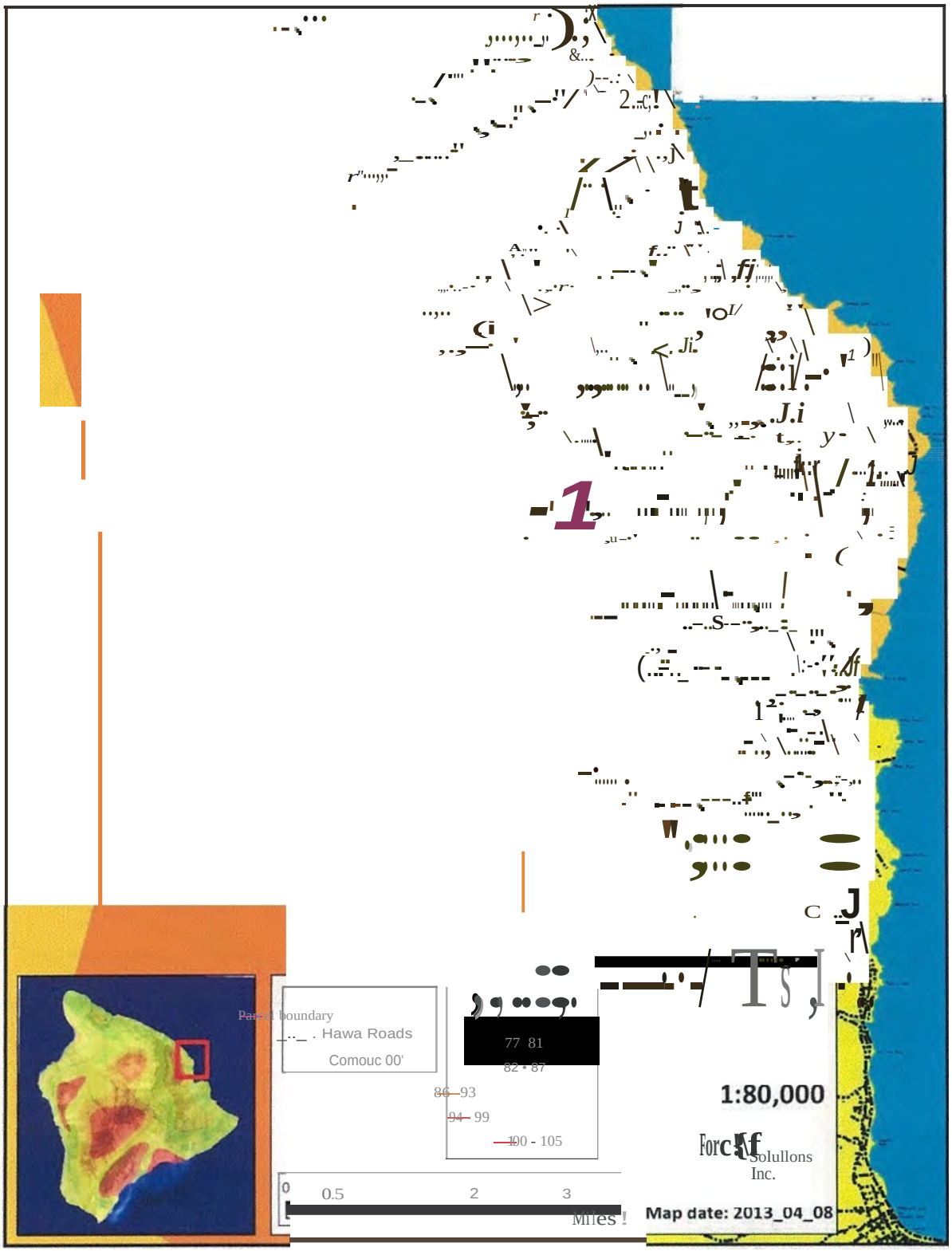
Map 5. Soils across the entire parcel are well drained.



Map 6. Uniformly acidic soils exist on the property, but the selected species are suitable for this type of substrate.



Map 7. Cloud cover inthe area significantly reduces the amount of solar radiation available for photosynthesis, but several tree species thrive here nonetheless.



Map 8. Solar radiation patterns are complex over a medium scale, a consequence of the orographic effect, prevailing wind direction, the Mauna Kea cloud inversion layer, and the increase in irradiance with elevation.

VIII Appendices

Appendix A. Ecological site description (Document Page 41)

http://efotg.nres.usda.gov/references/public/HI/F159AYSOOHI_Ta11_Stature_Wet_Koa-Ohia_Hapuu_Forest.doc

Appendix B. Best management practices, State of Hawaii (Document Page 66)

http://www.state.hi.us/dlnr/dofaw/pubs/BMPs___bestmanagement.pdf

Ecological Site Description

ECOLOGICAL SITE CHARACTERISTICS

Site Identification

Site Type: **Forestland**	Site ID: **F159AY500ID**	MLRA: **159A**
Colloquial Site Name: **Tall Stature Wet Koa – Ohia/Hapu'u Forest**		
Official Site Name: ***Acacia koaMetrosideros polymorpha/Cibotium menziesii/Freycenetia arborea***		

Soils data from 1973 survey pending new soil survey.

Physiographic Features

This ecological site occurs on volcanic ash flows on sloping mountainsides of shield volcanoes. Ash flows range from deep to very deep on the underlying lava.

Landform: (1) **volcanic ash flow** Landform: (2) Landform: (3)	Minimwn	Maximum
Elevation (feet):	**1200**	**6400**
Slope (percent):	0	**35**
Water Table Depth (inches):	–	–
Flooding: Frequency: Duration:	 **none** –	 **none** –
Ponding: Depth (inches): Frequency: Duration:	 – – –	 – – --
Runoff Class:	**low**	**medium**
Aspect: (1) **E** Aspect: (2) **N**		

Climatic Features

Average annual precipitation ranges from 50 to 140 inches. Most of the precipitation falls from November through April, with April being the wettest month. Average annual temperature ranges from 54 to 71 degrees F. The climate generally can be classified as udic and tropical in nature.

Climate chart

	Minimum	Maximwn
Frost Free Period (days):	**365**	**365**
Freeze Free Period (days):	**365**	**365**
Mean Annual Precipitation (inches):	**50**	**140**

Monthly Precipitation (inches) and Temperature (°F)												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Dct	Nov	Dec
Precip. Avg.	**14.0**	**19.0**	**21.2**	**22.8**	**17.4**	**9.7**	**15.l**	**18.3**	**10.5**	**15.5**	**21.2**	**21.1**
Temp. Max.	**73.l**	**72.6**	72.7	**73.4**	**74.2**	**75.9**	**76.3**	**76.9**	**77.6**	**77.0**	**75.4**	**72.9**
Temp. Min.	**60.7**	**59.7**	**60.1**	**61.4**	**62.4**	**63.7**	**64.3**	**65.2**	**64.6**	**64.2**	**63.1**	**61.3**
Climate Station: (1)	**Honomu Mauka 138, 1949-1978**											

Influencing Water Features

This ecological site contains perennial streams in very deep, steep-sided gulches. The sides and bottoms of these gulches are dominated by alien trees, particularly African tulip tree *(Spathodea campanulata)*, Alexandrian palm *(Archontophoenix alexM drae)*, kukui *(Aleurites moluccana)*, and gunpowder tree *(Trema orientale)*.

Representative Soil Features

Typical soils are deep to very deep basic volcanic ash deposited over 'a'a lava or pahoehoe lava. Landscape surfaces in this ecological site are 11,000 to 300,000 years old. Soils are moderately well or well drained. Available water capacity ranges from x to x inches. Available water capacity refers to the volwne of water available toplants in the upper 40 inches of soil, including rocks, at field capacity. Permeability is moderately rapid to rapid. Runoff potential ranges from low to moderate. Moist surface colors range from dark reddish brown to very dark brown. Soil reactions (pH in CaCli) range from slightly to extremely acid in surface horizons and slightly to extremely acid in subsurface horizons. Soil temperature regimes are isothermic. Soil moisture regimes are udic (soil moisture control section is not dry in any part for as long as 90 cumulative days in normal years).

Predominant Parent Materials: **basic volcanic ash** Kind: deposited over 'a'a lava or pahoehoe lava Origin:	Surface Texture: (I) **silt loam** Surface Texture: (2) **silty clay loam** Subsurface Texture Group: --
Surface Fragments <=3" (%Cover): 0-10 Surface Fragments >3" (%Cover): 0-10	Rock Fragments <=3" (%Volume):O-I0 Rock Fragments >3" (%Volume): 0-10
Drainage Class: moderately well to well	Permeability Class: moderately rapid to rapid

	Minimum	Maximum
Depth (inches):	SO	>**60**
Electiical Conductivity (mmhos/cm):	0	**2**
Sodiwn Adsorption Ratio:	0	0
Calcium Carbonate Equivalent (percent):	0	0
Soil Reaction (I ;I Water):		
Soil Reaction (.0-lM CaC12):		
Available Water Capacity (inches):		

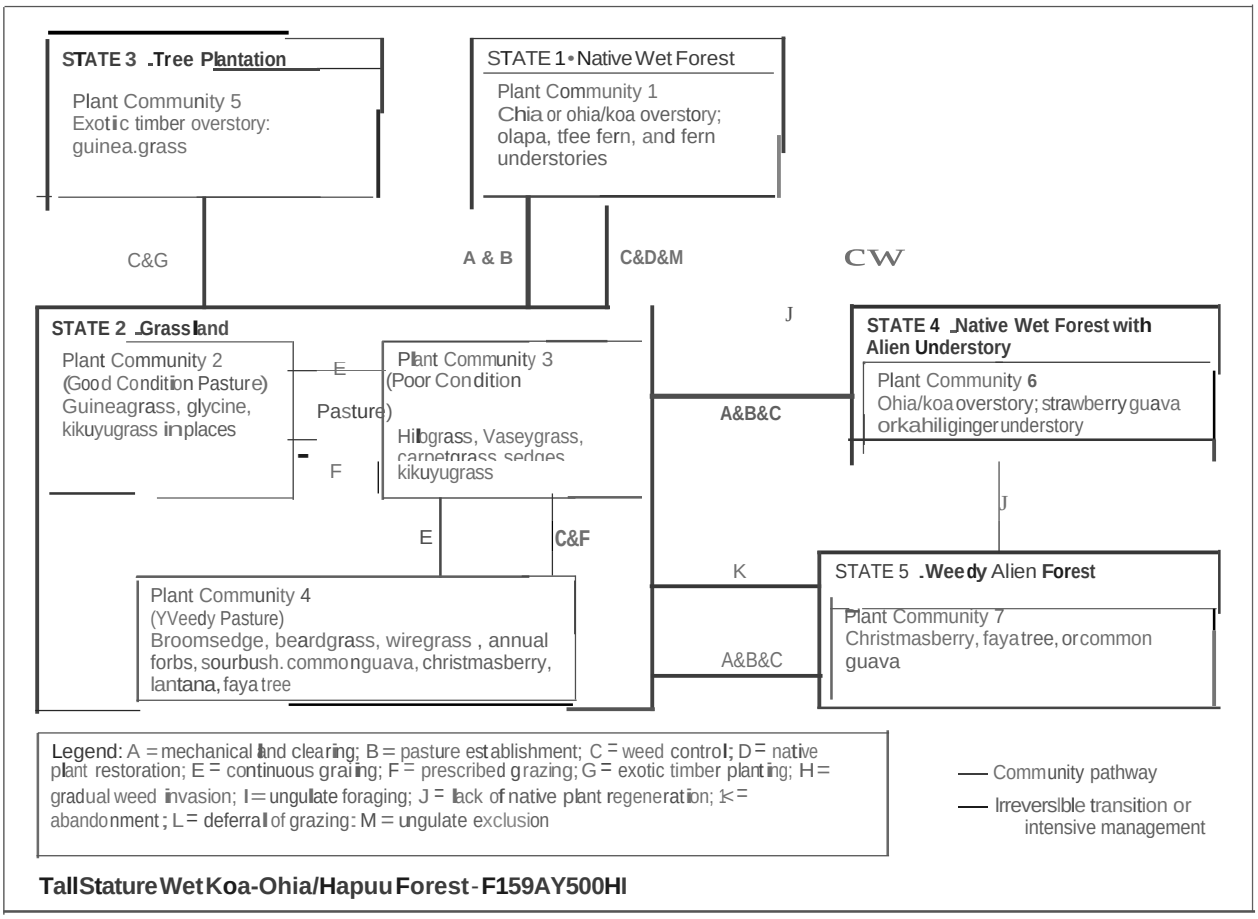
PLANT COMMUNITIES

Ecological Dynamics of the Site

This ecological site occurs on a soils formed in volcanic ash in warm, moist to wet regions of Hamakua, North Hilo, and South Hilo Districts of the Island of Hawai'i. Plant communities evolved without the presence of large mammals or the regular occurrence of fires. Much of the 01iginal forest area remains as native forest. However, the native plant community has distw·bed and, in some areas, removed due to agriculture, urban development, establishment of exotic timber trees,

domestic and feral ungulate foraging, and alien species invasion. Foraging by cattle, pigs, and/or goats, or clearing and abandonment accelerate invasion by alien weeds. However, alien weeds appear able to successfully invade native stands regardless of human or ungulate disturbances. Major weeds include strawberry guava, cbristrnasberry, kahili ginger, and alien grasses. Guineagrass and kikuyugrass pastures become infested with unpalatable grasses and shrubs under conditions of improper pasture and grazing management.

State and transition diagram



State 1 – Native Wet Forest

Plant Community 1

This state represents the Historic Climax Plant Community. The general aspect is a forest of tall overstory witb an open or closed upper canopy of ohia or ohia and koa trees up to 100 feet tall, a seconda1y canopy of diverse trees species 30 to 60 feet tall, a dense tree fem canopy 10 to 30 feet tall, and a diverse understoty of shrubs and fems. Vines are common both on the ground and on trees. All three Big Island tree fem species are present; they frequently have very tall trunks. These forests have standing live timber of 800 to 5700 cubic feet per acre, with a representative value of about 3000 cubic feet per acre. Typical low values are about 1500 cubic feet per acre.

Overstory tree canopy cover of ohia and koa can vary from about 10% to 80%. However, understory composition is controlled by the cover of the secondary canopy of medium-stature, secondary canopy tree species and especially by the cover of tree ferns, which is usually in the range of 60% to 90%. Koa and ohia do not reproduce successfully in the typically shady understory of intact Native Wet Forest. Tree ferns, medium-stature trees such as olapa, kopiko, kolea!au

nui, kawa'u, hame, and olomea, and shrubs such askanawao and clermontia reproduce well in the understory. The ground layer of small fems is typically very dense when ungulates are not present.

The dominant tree canopy can be ohia trees or a combination of ohia and koa tree.s. Wewere unable to discern any consistent conelation between dominant tree canopy composition and soil type, rainfall, elevation, or any other environmental variable (PENDING NEW SOIL SURVEY OF THE HAMAKUA AREA). It is probable that long-term disturbance history controls koa occturence. Koa is a fast gi"owing, opportunistic species that is able to take advantage of temporary openings in the dense forest canopy.

Pathways from this state/plant community

To State 2, Grassland, via "A and B":

A =mechanical land clearing; B = pasture establishment.

Native Forest can be converted to Grassland by clearing theforest with heavy machinery; most pastures in this ecological site were originally cultivated for sugar cane and later converted to pasture. At higher, cooler elevations kikuyugrass ancVor pangolagrass have been planted. At lower elevations where pastures are on old sugarcane plantations, guineagrass (a former weed in the plantations) has volunteered.

To State 4, Native Wet Forest with Alien Understory, via "H&l&J":

H = gradual weed invasion; I = ungulate foraging; J = lack of native plant regeneration.

Native Forest can convert to Native Forest with Alien Understory by gradual replacement of the understory by alien shmbs, vines, and small trees that outcompete the native understory species. This process is accelerated by ungulate foraging that disturbs the soil surface and directly destroys native plants and prevents their regeneration.

Plant species listed in the following tables have been obsened in the course of field work or are derived from re.liable records.

Abbreviations:

Origin: n = native (endemic or indigenous); a = alien (introduced by humans).

Type: t = tree; tf =tree fern; s = shrub; h = herb (forb); v = vine; f = fern; g = grasslike (grasses, sedges, rushes).

Comoos1 e representation of State 1. Plant Commumtv 1. Native Wet Forest.

Scientific name	%Canopy covet" by height class (ft) 0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.J - 120	Total Cover	Local common name	NRCS common name			NRCS Code
Mettosideros oolvmoroha	tr	tr	Ir	tr	20	▮	20	'Ohi'a lehua	'ohi'a lehua	D	▮	MEP05
Acacia koa	Ir	tr	tr	Ir	20	▮	20	koa	koa	a	t	ACKO
Cheirodendron trigynwn	1	▮	J	5	1		10	olapa	olapalapa	n	▮	CHTR2
Perrotletia sandwicensi s	tr	tr	I	I			▮	olomea	olomea	D	l	PESA3
Uex anomala	tr	tr	I	1	tr		▮	kawa'u	Hawai"i holly	n	▮	!LAN
Myrsine lessertiaoa	(T	tr	1	5			5	kolea lau nui	kolea lau nui	n	▮	MYLE2
Psychotria sp.	tr	I	I	▮			I	kopiko	wild coffee	n	▮	PSYCH
Charpentiera sp.	tr	▮	▮				I	papala	papala	n	t	CHARP
Coprosma rhynchocarpa	tr	▮	I	5			5	pile	woodland mirrorplao !	n	t	CORH
Antidesma plalyphyllum	tr	1	1	(T			▮	hame,ba·a	ha"a	n	t	ANPL2
An!idesma pulvinatum	IT	J	I	tr			l	bame	hame	D	I	ANPU2
Gardenia remyi	?	?	'/	?			?	nanu	Remy'sgardenia	n	t	GARE
Hedyotis terminali s	tr	tr	▮				l	manono	variable slarviolel	n	I	HETE21
Prilchardia lanigera	?	" ▮	?	?			?	loulu	lou·ulu	D	I	PRLA4
Urera glabra	tr	tr	▮	I			I	opuhe	hopue	n	t	URGL
Myrsiae sand\vicensis	tr	tr	tr				tr	kolea !au li'i	kolea ƌu Ji "i	a	1	MYSA2
Platydesma remyi	?	'?	?				?	pilo kea	Hawai "i pilo kea	n	t	PLRE4
Cibotium glaucum	I	l	20	40			50	hapu "u	hapu ·u	n	If	CIGL
Cibotium menziesii	▮	I	5	IO			20	bapu u "i'i	hapu "u Ii	a	If	CIME8
Cibotium chamissoi	tr	tr	tr	▮			l	hapu 'u	Chamisso's manfern	n	tf	CICH
Clermontia lindseyana	'!	'l	!				?	"oha wai	hillside clermoatia	n	s	CLLl3

Composite reoresentation of State 1. Plant Community 1, Native Wet Forest.

Scientific name.	%Canopy cover by height class (ft) 0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120	Total Cover	Local common name	NRCS common name	Origin	Life Cycle	NRCS Code
Clermontia peleana	?	?	?				?		pele clermootia	n	s	CLPE2
Clermontia sp.		1	1				1	·oba wai	clennontia	n	s	CLERM
Cyrtandra tinti nDabula		?					?	l1a'iwale	Laupahoehoe cyrtaodra	n	s	CYTl
Pipturus albidus		tr	1				1	mamaki	Waimea pipturus	n	s	PIAL2
Broussaisia arguta	tr	1	5				5	kanawao	kanawao	o	s	BRAR6
Eurya saJtdwicensis	?	?					?	anini	anini	n	s	EUSA6
Vaccinium calycinum	1	1	1				1	ohelo	obelo kau la\1	n	s	VACA8
Styphelia tameiameiae		tr					tr	pukiawe	pukiawe	o	s	SITA
Trematolobelia grandifolia	?	?	?				?		largeflower false Iobelia	n	s	TRGRS
Cyanea platyphylla	?	?	?				?	haba	Puna cyanea	n	s	CYPA7
Cyanea tritomantha	?	?	?				?	·aku	'alrdku	o	t	CYTR6
Cyrtandra giffardii	?	?					?		forest cyrtandra	D	s	CYGI3
Cyrtandra platypbylla	1	t					1	·rnbia	'ilibia	n	s	CYPLS
Cyrtandra sp.	tr	1					1	ha 'iwale	Cyrtandra	n	s	CYRTA
Peperomfa sp.	1						1	ala·ala wai nui	peperomia	n	h	PEPER
Astelia menziesiana	1						1	kaluaba	pua'akuhinia	n	b	ASME4
Pbytolacca sandwicensis	tr	tr					tr	popolo Im mai	Hawai'i pokeweed	n	b	PHSA2
JoinviJlea ascendens	?	?					?	'ohe	'obe	n	h	JOAS
Korthalsella sp.							1	hulumoa	kortbal mistletoe	n	h	KORTH
Stenogyoe calamiJJthoides									bog stenogyne	n	v	STCA9
Stenogyne rnacrantha	?						?		Hawai'i stenogyne	n	v	STMA3
Stenogyne scroohuJarioides	?						?		mohihi	n	v	STSC4
Pbyllostegia floribunda	?						?		Hawai'i phylloslegia	D	v	PHFL6
Phyllostegia racemosa	?						?		kiponapona	n	v	PHRA6
Pbyllostegia vestila	?						?		stream bed phyllostegia	D	h	PHVE4
Phyllostegia warsbaueri	?						?		Laupahoehoe nhvlloste!!ia	n	v	PHWA3
Rubus hawaiiensis							1	'akala	Hawai'i blackbenry	D	v	RUHA
Smilax melastomifolia							1	hoi lruahiwi	Hawai'i greenbrier	D	v	SMME
Freycenetia arborea								'ie'e	'ie'ie	n	v	FRAR
Alyxia oliviformis		1						maile	maile	D	v	ALOL2
Embelia pacifica								kilioe	kilioe	n	v	EM.PA
Athyrium tnicrophyllum	1							'akolea	akolea	D	f	ATMI
Sadleria sp.		1					1	ama'u	Sadleria	n	f	SADLE
Adenopborus oinnatifidus							1		graceful kibifern	n	f	ADPI
Adenopborus tamarisdnus							1	wahini nobo mauna	wabini nono manna	n	f	ADTA
Asplenium schizoohvllum							1		fringed spleenwort	n	f	ASSC8
Coniogramme pilosa	1						1	lo'ulu	loulu	n	f	COP13
Dicranopteris linearis							1	uluhe	Old World forkedfern	n	f	DlLl
Diplazium sandwichianum	1	1					1	ho'i'o	Hawai'i lwinsorus fern	n	f	DISA3
Dryopteris hawaiiensis									Hawari woodfem	n	f	DRHA
Dryopteris sandwicensis		1							Pacific wood fern	n	f	DRSA
Dryopteris wallicbiana		5					5	To nui	alpine woodfem	n	f	DRWA
Grammitis tenella	1							kolokolo	kolokolo	D	f	GRTE
Lepisorus thunbergianus	1						1	pakahakaha	weeping fern	D	f	LETH6
Lycopodiella cernua	tr						tr	pakahakaha	weeping fern	n	f	LETH6

Composite representation of State 1 Plant Communit 1 Native Wet Forest.

Scientific name	%Canopy cover by heigh_t class (ft) 0.1 2	2.1 4.5	4.6 13	13.1 40	40.1 80	80.1 120	Total Cover	Local common name	NRCS common name			NRCS Code
Mecodium recurvum								'ohi'a ku	ohiaku	D	f	HYRE
Nephrolepis exaltata								Boston swordfern	Boston swordfern	n	f	NEEX
Nothoperanema rubiginosum									island Iacefem	n	f	NORU
Ophiodenna pendulum								puapuamoa	Old World adder's ton e	n	f	OPPEP
Pneumatopteris sandwicensis								ho'i'o kula	Hawai'i airfem	n	f	PNSA
Psilotum complanatum								moa nahele	flatfork fern	D	f	PSC03
Psilotum nudum								moa	whisk fern	n	f	PSNU
Pteridium aguilinum	tr						tr	brackenfern	western brackenfern	n	f	PTAQ
Pteris cretica								'oali	Cretan brake	n	f	PTCR2
Pteris excelsa								waimakanui	waimakanui	n	f	PTEX
Sticherus owhyensis								uluhe	Hawai'i umbrella fern	D	f	STOW
Diplopterigium pinnatum	tr						tr	uluhe lau nui	scrambling fern	D	f	DlPD
Elaphoglossum crassifolium								stag's tongue,'ekaba	royal tonguefem	D	f	ELCR2
Elapboglossum alaeacewn								maku'e	ekaha	n	f	ELHl3
Spbeoomeris chinensi s	lr						tr	pala'a	Chinese creepingfern	n	f	ODCH
Microlepia strigosa								palapalai	palapalai	n	f	MIST4
Asplenium sp.									spleenwort	n	f	ASPLE
Asplenium normale									rainforest spleenwort	n	f	ASN04
Vandenboschia sp.								vandenboschia	vandenboscbia	n	f	VANDE
Uncinia uncinata									Hawai'ibirdcatching sed e	n	g	UNUN
Carex wahuensis									Oahu sedge	n	g	CAWA
Carex alligata									Hawai'i sedge	n		CAALI2
Grasslike												
Native Forbs												
Exotic Forbs												
Native Vines/Epiphytes	5						5					
Exotic Vines												
Small ferns	20	10	1				30					
Native Shrubs		5	10				10					
Exotic Shrubs												
Native Trees			10	20	40		60					
Tree ferns (native)			20	50			70					
Exotic Trees & tree ferns												
Lichen												
Moss (on ground & logs)	10						IO					
Moss (on trees)	20						20					
Logs on ground (>4" dia.)	5						5					
Litter (not logs)	70						70					
Surface rocks (>3" dia.)												
Surface rocks 3" dia.)												
Bare Soil	tr						tr					

Understory species canopy cover under a range of overstory canopy covers in Native Wet Forest. Overstory includes uuuer tree, secondary tree, and tree tern canopies combm. ed.

Common Name	Scientific Name	Understory Species Canopy Cover as a function of Overstorv Canopy Cover *Overstory Canopy Cover Percent*		
		50	70	90
'ohi'a lehua	*Metrosideros polymorpha (seedlings and savlinzs)*	5	1	tr
koa	*Acacia koa (seedlinf!s and savlinzs)*	5	1	tr
mamaki	*Pivturus albidus*	5	1	tr
olapa	*Cheirodendron trif!Vnum*	10	5	5

State 1, Plant Community 1, Native Wet Forest.

State 2 – Grassland

This state is comp1ised of three grassland plant communities. Most of the pastures in this ecological site are on former sugar plantations where guineagrass was an agricultural weed. Guineagrass now has taken over these lands as the dominant pasture grass. Kikuyugrass is the dominant grass, sometimes with pangolagrass, in some higher elevation areas where these species have been planted. More information on these kikuyugrass/pangolagrass pasturescan be found in Ecological Site Description Fl 60XY502HI -Mauna Kea Koa-Mamane.

Plant Community 2 (Good Condition Pasture) consists of guineagrass with an admjxtw·e of glycine (perennial soybean). Continuous grazing that does not allow the favored forage species time to recover from defoliation results in Plant Community 3 (Poor Condition Pasture), which is dominated by lower value forage species but contains enough remnant guineagrass (or kikuyugrass in some cases) to allow for a transition back to Plant Community 1 with prescribed grazing.

Longer-term continuous grazing leads to Plant Community 4 (Weedy Pasture), which consists of low value grass species and increasing cover of alien shrubs and tree saplings. Improvement of this Plant Community requires weed control and prescribed grazing.

Pathways from this state

To State 1 –Native Forest, via "C&D&M":

C = weed control; D = lack of fire; D = native plant restoration; M = ungulate exclusion.
It may be possible to recreate a plant community resembling Native Forest from Pasture. Weed control must be applied to pasture species and the many opportunistic plant species that invade the site. Weed control would be a pe1petual process to capture and maintain the site at least until a closed canopy of native trees developed. Animal foraging (domestic or feral) would have to be eliin.inated by excluding all ungulates from the restoration site, but domestic ungulates would be useful to initially reduce grass cover and to manage vegetation outside the restoration site pedmeter. Extensive planting of native species would follow. Increased shade from trees growing on the site causes a shift from C4 (warm-season) grass dominance (typically gwneagrass or k:ikuyugrass) to C4 or C3 (cool-season) shade-tolerant grasses (typically meadow 1icegrass, Hilograss, or carpetgrass). This shade tolerant grass layer can be very dense and detrimental to establishmen t of native plants. It may be possible to suppress these grasses by planting native shrubs and tree fems that produce dense shade near the ground and litter that covers the grass.

To State 3 –Tree Plantation, via "C&G":

C = weed control; G = exotic timber planting.
Pasture may be converted to Tree Plantation by site preparation and planting of timber species (usually eucalyptus) and weed control.

To State 5 –Weedy Alien Forest, via "K":

K = abandonment.
Abandonment of pastures leads to rapid invasion ofalien tree species that take over from the initial growth of grasses and weedy shrubs. Common weed tree species are strawben-y guava, christmasberry, faya tree, and common guava.

Plant Community 2 – Good Condition Pasture

The dominant grass species in this pasture type is guineagrass that bas volunteered in old su garcane plantations. In higher elevation areas, kikuyugrass and sometimes pangolagrass have been planted.

Pathways from this plant community

To Plant Community 3, Poor Condition Pasture, via "E":

E = continuous grazing.
Good Condition Pasnu-e degrades to Poor Condition Pasture by continuous grazing that weakens preferred guineagrass or kikuyugrass and legumes in relation to poor forage species such as Hilograss, nanowleaf carpetgrass, and sedges.

State 2, Plant Community 2, Good Condition Pasture.

This list of plants and their relative proportions are based on near-normal years. Fluctuations in species composition and relative production may change from year to year depending upon precipitation or other climatic factors.

Common/Group Name	Scientific Name	Symbol	Functional Group	lbs./acre	% Comp
GRASSES					
Naturalized Warm Season Tallgrasscs			**1**	**11,900-14,000**	**85-100**
guineagrass	Urochloa maxima	URMA3	**l**	11,900-14,000	85-100
Napier elephantgrass	Pennisetum purpureum	PEPU2	I	T-140	T-1
Naturalized Warm Season Mid-Grasses			**2**	**T-140**	**T-1**
kikuyugrass	Peonisetum clandestinum	PECL2	2	T-300	T-5
Hilograss	Paspalum coojugatum	PAC014	2	T-140	T-1
Rhodesgrass	Chloris gayana	CHGA2	2	T-140	T-1
Green kyllinga	Kyllinga brevifolia	**KYBR**	2	T-140	T-1
Vaseygrass	Paspalum urvillei	**PAUR2**	2	T-140	T-1
Nata l Tedtop	Melinis repens	MERE9	2	T-140	T-1
smutgrass	Sporobolus indicus	SPIN4	2	T-140	T-1
East Indian crabgrass	Digitaria setigera	D1SE6	2	T-140	T-1
hairy crabgrass	Digitaria sanguinalis	DISA	2	T-140	T-1
wiregrass (goosegrass)	Eleusine indica	ELIN3	2	T-140	T-1
broomsedge	Andropogon virginicus	ANVI	2	T-140	T-1
beardgrass	Schizachyriu m condensatum	SCCOI O	2	T-140	T-1
FORBS					
Naturalized Forbs			**3**	**140-700**	**1-5**
perennial soybean	Neonotonia wightii	NEWI2	3	140-420	1-3
three-flowered ticktrefoil	Desmodium triflorum	DETR4	3	140-420	1-3
Japanese tea	Chamaecrista nict1tans	CHN12	3	T-140	T-1
sensitive plant	Mimosa pudica	MIPU8	3	T-140	T-1
smooth rattlepod	Ctotalaria pallida var. obovata	CRPAO	3	T-140	T-1
lilac tasse!Oower	Emilia sonchifolia	EMSO	3	T-140	T-1
common sow thistle	Sonchus oleraceus	SOOL	3	T-140	T-1
lion's ear mint	Leonotis nepetffolia	LENE	3	T-140	T-1
spiny amaranth	Arnaranthus spinosus	AMSP	3	T-140	T-L
SHRUBS					
Naturalfacd Shrubs, Half-Shrubs, and Trees			**4**	**140-700**	**1-5**
bush indigo	lndigofera suffruticosa	INSU	4	140-420	T-1
sourbush	Pluchea carolinensis	PLCAIO	4	T-140	T-1
guava	Psidiwn guajava	PSGU	4	T-140	T-1
false mal low	Malvastrum coromandelianum	MAC06	4	T-140	T-L
christmasberry	Schinus terebinthifolius	SCTE	4	T-140	T-l
balloon plan!	Asclepias physocarpa	ASPH2	4	T-140	T-1
castor bean	Ricinum communis	RJC03	4	T-140	T-1

State 2, Plant Community 2, Good Condition Pasture.

Annual Production lbs./acre	
Above Normal	16,000
Normal	14,000
Below Norrnal	10,000
Percent Ground Cover	
Plant	65
Litter	30
Cryptogams	0
Bare ground	*5*

Plant Community 3 – Poor Condition Pasture

Poor Condition Pasture is dominated by grasses oflow forage value such as Hilograss, narrowleaf carpetgrass, and sedges. Desirable forage legumes have been grazed out.

Pathways from this plant community

To Plant Community 2, Good Condition Pasture, via "F":

F = prescribed grazing.

Poor Condition Pasture can be reconverted to Good Condition Pasture by prescribed grazing. A prescribed grazing plan provides for intensive but temporary grazing of pastures that ensmes that cattle consume some low-value forage species along with preferred forages and allows preferred forages time to recover from defoliation. The grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing. Invading broomsedge and beardgrass may be controlled by mowing their seed stalks before seed set and by liming to increase soil pH.

To Plant Community 4, Weedy Pasture, via "E":

E = continuous grazing.

Poor Condition Pasture degrades to Weedy Pasture by long-term continuous grazing. Guineagrass cover is greatly reduced and largely replaced by low-value forage grasses. Weedy forbs such as spiny amaranth, alien blackberries, and alien shrubs such as sourbush have increased. Broomsedge and beardgrass often are the most abundant grass species.

Composite representation of State 2, Plant Community 3, Poor Condition Pasture.

Scientific name	% Canopy cover by height class (ft) 0.1–2	2.1–4.5	4.6–13	13.1–40	40.1–80	80.1–120	Total Cover	Local common name	NRCS common name			NRCS Code
Psidium guajava	1							common guava	guava	a		PSGU
Scheffiera actinophylla	tr						Ir	octopus tree	octopus tree	a		SCAC2
Falcataria moluccana	tr	tr					tr	albizia	peacocksplume	a	t	FAMO
Schinus terebintl1ifolius	tr						1	chrlstmasbeyry	BraziJian peppertree	a	t	SCTE
Spathodea campanulata	tr	tr					tr	African tuliptree	AfricantuJiplree	a	t	SPCA2
Morella faya	tr	tr					tr	faya tree	firetree	a	l	MOFA
Pluchea carolinensis	tr	I	I				1	sourbush	cure for all	a	s	PLCAIO
lndigofera suffrutie-0sa		J						bush indigo	anil de pasto	a	s	INSU
Ricinus communis	tr		I				l	castor bean	castor bean	a	s	RJC03
R.ubus argutus	tr	I						Florida blackberry	sawtooth blackberry	a	v	RUAR2
Rubus rosifolius	tr	I						thimbleberry	West Indian rasnberrv	a	v	RURO
Nephrolepis mulliOora	1						l	scaly swordfern	scaly swordfern	a	f	NEHI
Pteridium aquilinum	tr						IT	bracken fern	western brackenfern	n	r	I'TAQ
Dicranopteris linearis	tr						Ir	ulu he	Old World forkedfero	n	f	DILi
Ageratina riparia	IT						IT	Hamakua pamakani	spreading snakeroot	a	h	AGRI2
Asclepias physocarpa	tr							balloonplant	balloonplant	a	h	ASPH2
Chamaecrista nictitans	1							partridge pea	partridge pea	a	h	CHNU
Mimosa pudica	J						I	sensi1iveplanl	shameplanl	a	h	MIPUS
Commelina dilTusa	1						1	honohono	climbing dayOower	a	h	C0Dl5
Crotalaria pallida var. obovata								smooth raltlepod	smooth rattlebox	a	h	CRPAO
Desmodium triOorum	tr						tr		Lhreellower licktrefoil	a	h	DETR4
Emilia sonchifolia	1							Flora's paintbrush	liJac tasselDower	a	h	EMSO
Sonchus oleraceus							1	pualele	e-0mmon sowthislle	a	h	SOOL
Malvastrum coromandelianum								false mallow	lhreelobe false mallow	a	h	MAC06
Leonotis nepetifolia	1							lion's ear	Christmas candlestick	a	h	LENE
Amaranlhus spinosus							1	spiny amaranth	spiuy amaranth	a	h	Al\1SP
Kyllinga brevifolia	5						5		shortleaf spikesedge	a	g	KYBR
Saccharum spontaneum			tr				IT	wild sugarcane	wild sugarcane	a	g	SASP
Axonopus fissifolius	20						20	1nnrowleaf carpetgrass	common carpetgrass	a	g	AXFI
Sporobolus indicus							1	smut grass	smut grass	a	g	SPTN4
Urochloa maxima		20					20	guineagrass	guineagrass	a	g	URMA3
Pennisetllm clandestinum								kikuyugrass	kikuyugrass	a	g	PECL2
Chloris gayana							I	Rhodes grass	Rhodes grass	a	g	CHGA2
Digitaria sanguinalis	1						1		hairy crabgrass	a	g	OISA
Digitaria setigera									East Indian crabgrass	a	g	DISE6
Eleusine indica							1	yiregrass	Indian goosegrass	a	g	ELIN3
Melinis repens							1	Nata.I redtop	rose Natal grass	a	g	MERE9
Andropogon virginicus	5						5	broomsedge	broomsedge blueslem	a	g	ANVT2
Schizachyrium e-0ndeosatum	5						5	beardgrass	Colombian bluestem	a	g	SCCO1
Setaria parviflora	5						5	yellow foxtail	marsh bristlegrass	a	g	SEPAIO
Paspalum urvillei								Vasey grass	Vasey's grass	a	g	PAUJU
Paspalum conjugatum	20						20	hilograss	hilograss	a	g	PAC014

Composite representation of State 2, Plant Community 3, Poor Condition Pasture.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	O.l 2	2.1 4.5	4.6 13	13.1 40	40.1 80	80.J 120						
Grasslike	80	20					100					
Native Forbs												
Exotic Forbs	*5*						*5*					
Native Viues/Epiphytes												
Exotic Vines												
Small ferns												
Native Shrubs												
Exotic Shrubs	tr											
Native Trees												
Tree ferns (native)												
Exotic Trees & tree ferns												
Lichen												
Moss (on ground & logs)												
Moss (on trees)												
Logs on ground (>4" dia.)												
Litter (not logs)	*50*						50					
Surface rocks (>3" dia.)												
Surface rocks (S3" dia.)												
Bare Soil	*5*						*5*					

State 2, Plant Community 3, Poor Condition Pasture.

Plant Community 4 - Weedy Pasture

Weedy Pastureis dominated by low-value forage species such as ffilograss, nairnwleaf carpetgrass, broomsedge, and beardgrass. Alien blackbenies, shrubs such as sourbush, and forbs such as spiny amaranth occupy much of the site. Small tree species and saplings oflarge tree species have become common.

Pathways from this plant community

To Plant Community 2, Good Condition Pasture, via "C&F":

C = weed control; F = prescribed grazing.

Weedy Pasture can be converted to Good Condition Pasture by a combination of weed control and prescribed grazing Weeds such as alien blackberries, sourbush, and spiny amaranth are not controllable by domestic livestock and must be killed with herbicide. The grazing prescription will require removal oflivestock from the pasture until guineagrass has reestablished adequately to support grazing. Thereafter, the grazing plan may require splitting the herd, creating additional water sources, and creating multiple pastures by cross-fencing.

Composite representation of State 2, Plant Community 4, Weedy Pasture.

Scientific name	%Canopy cover by height cluss (ft)						Total Cover	Local common name	NRCS common name			NRCS Code
	O .J - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.I - 80	80.1 - 120						
Psidiwn guajava	I	I	10				10	common guava	guava	a	(	PSGU
Schefilera actinophylla	IT	1					I	octopus tree	octopus tree	a	I	SCAC2
Falcataria moluccana	Ir	Ir	1				I	albizia	peacocksplume	a	t	FAMO
Schinus terebinthifolius	tr	I	5				5	christniasberry	Brazilian peppertree	a	I	SCTE
Spathodea campaoulata	tr	Ir	1				I	African tuliptree	African tuliptree	a	I	SPCA2
Acacia confusa	Ir	Ir	1				I		Formosan koa	a	ı	ACCO
Lantana camara	1	5	I				5	lantana	lantana	a	s	LACA2
Pluchea carolineosis	LT	5	I				5	sourbush	cure for all	a	s	PLCAIO
Ricinus communis	tr	1	1				1	castor bean	castor beau	a	s	RIC03
Rubus argutus	Ir	1	1				1	Florida blackberry	sawtooth blackberry	a	v	RUAR2
Rubus rosifolius	tr	I	I				I	thimbleberry	West fndiao rasoberrv	a	v	RURO
Nepbrolepis multitlora	1						1	scaly sword.fem	scaly sword.fem	a	f	NEHI
Ageratina riparia	1						I	Hamakua pamakani	spreading snakeroot	a	h	AGRI2
Asclepias physocarpa	1'	I	1				1	balloonplaot	balloonplant	a	h	ASPH2
Chamaecrista nictitans	1						1	partridge pea	partridge pea	a	h	CHN12
Mimosa pudica	I						I	sensiti veplant	shruneplant	a	h	MIPU8
Commelina diffusa	l						I	honohono	climbing dayOower	a	h	CODI5
Crotalaria pallida var. obovata	l	1					1	smooth rattlepod	smooth rntt lebox	з	b	CRPAO
Emilia sonchifolia	1						1	Flora's paintbrnsh	lilac tasselOower	a	h	EMSO
Sonchus oleraceus	J						I	pualele	common sowthistle	a	b	SOOL
Malvastrum coromaodelianum	1	I					1	false mallow	threelobe false mallow	a	h	MAC06
Leoonis oepetifolia	I						1	lion's ear	Christmas candlestick	a	h	LENE
Amarantbus spioosus	I	5					5	spiny amaranth	spiny amaranth	a	h	AMSP
KyUioga brevifolia	5						5		shortleaf spikesedge	a	g	KYBR
Axonopus fissifolius	20						20	narrowleaf carpetgrass	common carpetgrass	a	g	AXFr
Sporobolus indicus	I						I	smut grass	smut grass	a	g	SPJN4
Urochloa maxima		5					5	guineagrass	guineagrass	a	g	URMA3
Chloris gayana	l						I	Rhodesgrass	Rhodes grass	a	g	CHGA2
Digitaria sanguinalis	I						1		hairy crabgrass	a	g	DISA
Digitaria setigera	I						I		East Indian crabgrass	a	g	DlSE6
Eleusine indica	l						1	wiregrass	Indian goosegrass	a	g	ELIN3

Composite representation of State 2, Plant Community 4, Weedy Pasture.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name			NRCS Code
	0.1 2	2.1 4.5	4.6 13	13.1 40	40.1 80	80.1 120						
Melinis repens	J						1	Natal redtop	rose Natal grass	a	g	MERE9
Andropogon virginicus	5	10					10	broomsedge	broomsedge bluestem	a	g	ANVI2
Schizachyrium condensatum	5	10					10	beardgrass	Colombian bluestem	a	g	SCCOIO
Setaria parviflora	5						5	yellow fox.tail	marsh bristlegrass	a	g	SEPAlO
Paspalum urvillei								Vasey grass	Vasey's grass	a	g	PAUR2
Paspalum conjugatum	20						20	hilograss	hilograss	a	g	PAC014
Grasslike	60	30					80					
Native Forbs												
Exotic Forbs	5	5					JO					
Native Vines/Epiphytes												
Exotic Vines	tr											
Small ferns												
Native Shrubs												
Exotic Shrubs		10					JO					
Native Trees												
Tree ferns (native)												
Exotic Trees & tree ferns			JO				JO					
Lichen												
Moss (on ground & logs)												
Moss (on trees)												
Logs on ground (>4" dia.)												
Litter (not logs)	40						40					
Surface rocks (>3" dia.)												
Surface rocks (:53" dia.)												
Bare Soil	JO						JO					

State 2, Plant Community 4, Weedy Pasture.

State 3 - Tree Plantation

Plant Community 5

Tree Plantations in this ecological site are primarily eucalyptus plantations that have been established on old sugarcane lands. Guineagrass is often abundant beneath the trees. Strawberry guava is a common understo1yweed.

Composite representation of State 3 Plant Communit 5 Tree Plantation.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name			NRCS Code
	O.J 2	2.1 4.5	4.6 13	13.1 40	40.1 80	80.1 120						
Eucalyptus sp.	tr		I		90	5	90	eucalyptus	gum	a		EUCAL
Psidium cattleianum	tr	tr	tr				tr	waiawi	strawberry guava	a		PSCA
Clidemia hirta	tr							Koster's curse	soapbush	a	s	CLHI3
Hedychium gardnerianum	tr	tr					tr	kahili ginger	Kahila garland-lily	a	h	HEGA
Rubus rosifolius	tr						Ir	thimbleberry	West Indian raspberry	a	v	RURO
Nephrolepis multiflora								scaly swordfern	scaly swordfern	a	f	NEHI
Urochloa maxima	10	10					10	guineagrass	guineagrass	a	g	URivfA3
Microlaena stipoides								meadow ricegrass	weeping grass	a	g	MIST
Paspalum conjugatum								hilograss	hilograss	a		PAC014
Grasslike	JO	10					20					
Native Forbs												
Exotic Forbs	tr	tr					tr					
Native Vines/Epiphytes												
Exotic Vines	tr						IT					
Small ferns												
Native Shrubs												
Exotic Shrubs	tr						tr					
Native Trees												
Tree ferns (native)												
Exotic Trees & tree ferns	tr				90	5	90					
Lichen												
Moss (on ground & logs)												
Moss (on trees)												
Logs on ground (>4" dia.)	I						I					
Litter (not logs)	80						80					
Surface rocks (>3" dia.)												
Surface rocks (3" dia.)												
Bare Soil	5						5					

State 3, Plant Community 5, Tree Plantation with Alien Understory.

State 4 -Native Forest with Alien Understory

Plant Community 6

This plant community has an intact or diminished overstory of large ohia and/or koa trees with a dense understory of alien shrubs, fems, grasses, and/or small trees. Native species are unable to regenerate in this plant community and eventually die out. With time, large alien tree species would probably emerge to form a new overstory.

Pathways from this state/plant community

To State 1, Native Wet Forest, via "C&D&M":

C = weed control; D = native plant restoration; **M** = ungulate exclusion.

It is possible to recreatea plant community resembling Native Forest from Native Forest with Alien Understory. Before restoration of native plants, alien understory plants must be eliminated by weed control and brush management practices, and ungulates must be excluded from the restoration site. Native species that have been eliminated or greatly reduced in numbers must be restored by replanting.

To State 2, Pasture, via "A&B&C":

A = mechanical land clearing; B = pasture establishment; C = weed control.

Pasture may be created from Native Forest with Alien Understory by mechanical clearing of weedy and remnant native understory plants; native overstory trees may be harvested for timber, destroyed, or left for shade. If leaving large native trees for shade, care must be taken to not damage roots within about 20 feet of the trees. Introduced pasture grasses may then be seeded or sprigged into the site. Herbicide applications will benecessary before and during pasture establishment to control reemerging weed species.

To State 5, Weedy Forest with Alien Understory, via "J":
J = loss of native plant regeneration.
The large, mature native ohia and koa trees that form the overstory of Native Forest with Alien Understory are unable to successfully regenerate due to the very dense, shady weed understory. Eventually the large native trees die and are replaced by more competitive large alien tree species.

Composite representation of State 4, Plant Community 6, Native Forest with Alien Understory.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name			NRCS Code
	0.1 2	2.1 4.5	4.6 13	13.J 40	40.J 80	80.J 120						
Metrosicieros polymorpha					IO		10	'ohi'a lehua	'ohi'a lehua	n		MEP05
Acacia koa					10		10	koa	koa	n		ACKO
Psychotria sp.	tr	Ir	tr	tr				kopiko	wild coffee	n		PSYCH
Psidium cattleianum		5	10	20			30	waiawi	strawberry guava	a		PSCA
Ficus sp.	IT	Ir	tr	tr	tr		IT	strangler fig	fig	a	I	FICUS
Cibotium glaucum								hapu'u	hapu'u	n	If	CIGL
Cibotium menziesii			tr					hapu'u 'i'i	hapu'u li	n	If	CJME8
Cyathea cooperi	tr	tr	tr				tr	Australian tree fern	Cooper's cyathea	a	tr	CYCOI8
Clidemia hirta								Koster's curse	soapbush	a	s	CLHJ3
Peperomia sp.	Ir						tr	'ala'ala wai nui	peperomia	n	h	PEPER
Hedychiwn gardnerianum								kahili ginger	Kahila garland-lily	a	b	HEGA
Polygonum punctatum								water smartweed	dotted smartweed	a	h	POPU5
Freycenetia arborea	tr						tr	'ie'ie	'ie'ie	n	v	FRAR
PassiOora mollissima								banaoa poka	banana passionflower	a	v	PAM05
Dicranopteris linea.ris	tr						tr	uluhe	Old World forkedfem	n	f	DILi
Lepisorus thunbergianus	tr						tr	pakabakaha	weeping fern	n	f	LETH6
Psilotum nudum	IT						tr	moa	whisk fern	n	f	PSNU
Setaria pahni folia	tr						tr	palmgrass	paltngrass	a	g	SEPA6
Axonopus fissifoliu s								narrowlea ved ca et ass	common carpetgrass	a	g	AXFI
Microlaena stipoides								meadow ricegrass	weeping grass	a	g	MIST
Grasslike												
Native Forbs	IT						tr					
Exotic Forbs												
Native Vines/Epiphytes	tr						tr					
Exotic Vines												
Small ferns												
Native Shrubs												
Exoti c Shrubs												
Native Trees	IT	IT	tr	tr	20		20					
Tree ferns (native)												
Exotic Trees & tree ferns		5	10	20	tr		30					
Lichen												
Moss(on ground & logs)	10						IO					
Moss (on trees)	20						20					
Logs on ground (>4" dia.)	5						5					
Liner (not logs)	70						70					
Surface rocks (>3" dia.)												
Surface rocks 3" dia.)												
Bare Soil	5						5					

Understory species canopy cover under a range of overstory canopy covers in Native Forest with Alien Understory.

Common Name	Scientific Name	Understory Species Canopy Cover as a function of Overstory Canopy Cover		
		Overstory Canopy Cover Percent		
		30	***60***	***90***
strawben-y guava	*Psidium cattleianum*	90	90	90
common guava	*Psidium guajava*	SO	40	5
christmasberry	*Schinus terebinthifolius*	90	60	S
guineagrass	*Urochloa maxima*	80	50	10
meadow ricegrass	*Microlaena stipoides*	20	30	70

State 4, Plant Community 6, Native Forest with Alien Understory.

State 5 – Weedy Alien Forest

Plant Community 7

This state is comprised of one plant community dominated by alien species in both the overstory and understory. StrawbeITy guava, christmasberry, or common guava may dominate a given site, but strawbeITy guava will become dominant with time. Understory vegetation usually is very sparse to nonexistent. Remnant, tall koa or ohia trees may be present. Native kopiko trees and tree ferns may still occur in very small numbers.

Pathways from this state/plant community

To State 2 – Pastures, via "A&B&C":

A = mechanical land clearing; B = pasture establishment; C = weed control.

Pasture may be created from Weedy Forest with Alien Understory by mechanical cleating of oversto1yand understory vegetation. Introduced pasture grasses may then be seeded or sprigged into the site. Herbicide applications will be necessary before and during pasture establishment to control reemerging weed species.

Composite representation of State 5, Plant Community 7, Weedy Alien Forest.

Scientific name	%Canopy cover by height class (ft) 0.1 2	2.1 4.5	4.6 13	13.1 40	40.J 80	80.1 120	Total Cover	Local common name	NRCS common name	O		NRCS Code
Metrosideros polymorpha					tr		tr	'oh i'a lehua	'ohi'a lehua	n		MEP05
Acacia koa					tr		tr	koa	koa	n		ACKO
Psychotria sp.	tr	tr	tr	tr			tr	kopiko	wild coffee	n		PSYCH
Psidium cattleianum		JO	30	30			70	waiawi	strawberry guava	a		PSCA
Psidium guajava		tr						common guava	guava	a		PSGU
Schinus terebinthifolius								christmasberry	Brazilian peppertree	a		SCTE
Morella faya								faya tree	firetree	a		MOFA
Cibotium glaucum							tr	hapu 'u	hapu\i	n	tf	CIGL
Clidemia hirta								Koster's curse	soapbush	a	s	CLHI3
Hedychium gardnerianum							J	kahili ginger	Kabila garland-lily	a	h	HEGA
Polygonum punctatum							1	water smartweed	dotted smartweed	a	h	POPU5
Passiflora mollissima								banana poka	banana passionflower	a	v	PAM05
Dicranopteris linearis	tr						tr	uluhe	Old World forkedfern	n	f	DILi
Setaria palmifolia	tr						tr	palmgrass	palmgrass	a	g	SEPA6
Axonopus fissifolius								narrowleaved ca et ss	common carpetgrass	a	g	AXFI
Microlaena stipoides										a		MIST
Grasslike												
Native Forbs												
Exotic Forbs												
Native Vines/Epiphytes												
Exotic Vines												
Small ferns	tr						tr					
Native Shrubs												
Exotic Shrubs												
Native Trees	tr	tr	tr	tr	tr		tr					
Tree fems (native)			tr				tr					
Exotic Trees & tree ferns		5	20	20			50					
Lichen												
Moss (on ground & logs)	5						5					
Moss (on trees)	IO						10					
Logs on ground (>4" dia.)	tr						tr					
Litter (not logs)	70						70					
Surface rocks (>3" dia.)												
Surface rocks (::,3" dia.)												
Bare Soil	5						5					

State 5, Plant Community 7, Weedy Alien Forest.

ECOLOGICAL SITE INTERPRETATONS

Forest Site Productivity

Common Name	Scientific Name	Estimated Productivity						
		Site Index		Cubic Feet (CMAI)		Other Units		
		Low	High	Low	High	Low	High	Unit
'ohi'a lehua	*Metrosideros po/ ymorvha*					**800**	**2000**	**cu. ftJac**
koa	*Acacia koa*					**1500**	**3700**	**cu.ft.lac**

Animal Community

Animal Community - Wildlife Interpretations

This site provides habitat to a variety of small, medium-sized, and large introduced birds such as doves, wild turkey, ring-necked pheasant, Eurasian skylark, Erckel's francolin, black francolin, and khalij pheasant. States that provide open grassland or savannah-like settings provide habitat for other in1portant wildlife such as the Hawaiian hawk and the Hawaiian owl. This site can also provide habitat to the following native birds: Hawaii elepaio, omao, Hawaii amakibi, apapane, iiwi, Hawaiian crow, ou, Hawaii akepa, akiapolaau, as well as the Hawaiian hoary bat. Feral pigs, sheep, and cattle are very common; they provide hunting opportunities but are ve1y destructive to the native vegetation.

Animal Community - Grazing Interpretations

The following table lists suggested initial stocking rates for cattle under the Forage Value Rating system for only State 2, Plant Commun ity 2, Good Condition Pasture, with guineagrass. For kikuyugrass pastw·es on this ecological site, refer to grazing interpretations in Ecological Site Description Fl60XY502HI -Mauna Kea Koa-Mamane. The following are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Sometimes the current plant composition does not entirely match any particular plant community described in this ecological site description. Because of this, a field visit is recommended to doclunent plant composition and production. More precise can-ying capacity estimates should eventually be calculated using the following stocking rate iofo1mation along with animal preference data, pa1ticular1y when grazers other than cattle are involved. Under more intensi ve grazing management, improved harvest efficiencies may result in an increased stocking rate.

Forage Value Rating [1,]	Acre/AUM [31]	AUM/Acre [3,]
Very High ?!	0.20 – 0.22	5.13 -4.49
High	0.22 – 0.26	4.49 – 3.85
Moderate	0.26 .39	3.85 -2.56
Low	0.39 - +	2.56 - +

Jj The Forage Value Rating System is not an ecological evaluation of State 2, Plant Community 2, Good Condition Pasture. It is a utilitarian rating of the existing forage value for that specific plant community.

y Conservationists must use considerable judgment , because some pastures in the Very High forage class could be producing less than normal volumes of forage, and adjustments would need to be made in the initial stocking rate.

'Jl Stocking rates vary in accordance with such factors as kind and class of 1ivestock or wildlife, season of use, harvest efficiency and fluctuations in climate. Figures shown are calculated assuming a 30% adjustment factor to account for harvest efficiency and the "take half -leave half 'principle. Actual use records and on-site invento1ies for individual sites, together with a determination of the degree to which the sites have been grazed, offer the most reliable basis for developing initial stocking rates.

The Good Condition Pasture plant community on this site is suitable for grazing by all kinds and classes oflivestock, at any season, particularly cattle. However, this site is best utilized for grazing during the major plant growth pe1iod described in the "Climate" section. This site is suited for grazing by both cow-calf operations and stocker operations. However, sheep can be grazed on this site as well. This site is poorly suited to continuous year-long use if the Good Condition Pasture plant community is to be maintained. Herbaceous forage can be deficient in protein during the drier months.

Plant Preference for Cattle

Common Name	Scientific Name	Plant Part	Fora2e Preferences											
			J	F	M	A	M	J	J	A	S	O	N	D
Guinea.grass	*Urochloa maxima*	entire	P	P	P	P	P	P	P	P	P	P	P	P
Napier elephantgrass	*Pennisetum ourvureum*	entire	P	P	P	P	P	P	P	P	P	P	P	P
Kikuyugrass	*Pennisetum clandestinum*	entire	P	P	P	P	P	P	P	P	P	P	P	P
Pangolagrass	*Di£itaria eriantha*	entire	P	P	P	P	P	P	P	P	P	P	P	P
Smutgrass	*Sporobolus indicus*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Hilograss	*Paspalum conjugatwn*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Narrowleaf carpetgrass	*Axonoous fissifolius*	entire	U	U	U	U	U	U	U	U	U	U	U	U
East Indian crabgrass	*Di£itaria seti£era*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Hairy crabgrass	*Di£itaria sanf111inalis*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Natal redtop	*Melinis repens*	entire	D	D	D	D	D	D	D	D	D	D	D	D
Rhodesgrass	*Chlorisgayana*	entire	D	D	D	D	D	D	D	D	D	D	D	D
Broomsedge bluestem	*Androoof!on virf!inicus*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Bushybeard bluestem	*Schizachvriwn condensah1m*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Wiregrass	*Eleusine indica*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Yellow foxtail	*Setaria./irmula*	entire	U	U	U	U	U	U	U	V	U	U	U	U
Green kyllinga	*Cypen1s brevffolius*	entire	U	U	V	U	U	U	U	U	U	U	U	U
Vasev1n-ass	*Paspalum urvillei*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Glycine	*Neonotonia wihtii*	entire	P	P	P	P	P	P	P	P	P	P	P	P
Three-flowered tickletrefoil	*Desmodium trifiorum*	entire	D	D	D	D	D	D	D	D	D	D	D	D
Japanese tea	*Chamaecrista nictitans*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Sensitive plant	*Mimosa pudica*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Smooth rattlepod	*Crotalaria pa/lida var. obovata*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Common sowthistle	*Emilia sonchifolia*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Lion's ear mint	*Leonotis neoetifolia*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Spiny amaranth	*Amaranthus soinosus*	entire	N	N	N	N	N	N	N	N	N	N	N	N
Bush indigo	*Jndiofera suflruticosa*	entire	D	D	D	D	D	D	D	D	D	D	D	D
Sourbush	*Pluchea carolinensis*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Cbristmasberry	*Schinus terebinthifolius*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Thirnbleberry	*Rubus rostfolius*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Balloonplant	*Asclepias physocarpa*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Castor bean	*R.icinum commimis*	entire	T	T	T	T	T	T	T	T	T	T	T	T

Legend: P=Preferred,D=Desirable, U:::,Undesirable, N=Not Consumed, E=Emergency, T=Toxic, X:aUsed, but degree of utilization unknown.

Hydrology Functions

Recreation Uses

Hunting is the most common recreational use.

Wood Products

There is good potential forproduction of timber in tbjs ecological site, including eucalyptus and high-value specialty woods such as koa. However, there has been very little utilization of the resource to date.

Other Products

Other Information

SUPPORTING INFORMATION

Associated Sites

Site Name	Site ID	Site Narrarive

Similar Sites

CollomriaJ Site Name	Site ID	Site Narrative
Ohia-Koa!Hapu 'u-Kancrw'QO Forest	Fl 59BY500HI	Similar wet forest on younger ash soils in Kau District.

State Correlation

There are no correlations to ecological sites in other states.

Inventory Data References

Data Source	Sample ID			
	Number	Year	State (FIPS)	County (FIPS)
HI Forest ESD field sheet	1	2008	HI	Hawaii
HI Forest ESD field sheet	2	2007	HI	Hawaii
HI Forest ESD field sheet	17	2006	HI	Hawaii
HI Forest ESD field notes	1	2008	HI	Hawaii
HI Forest ESD field notes	4	2006	HI	Hawaii
NRCS-Range-417	1	2001-2003	HI	Hawaii
Hawaii-Range- I	7	2001-2003	HI	Hawaii

Type Locality

	Site #1 <NAD83 datum)	Site#2	Site #3
Latitude:	N l 9d55m59.4s		
Lon1?itude:	Wl 55dl7m25.6s		
State:	ID		
County:	Hawaii		
General Description:	Hawaii County, Island of Hawaii, USGS Quad: Keanakolu. From main (highest) Laupahoeboe NAR gate, drive mauka 2.5 miles. Walk W 100 yards into forest.		

Relationship to Other Established Classifications

1.	Jacobi, J.D. 1989. Vegetation Maps of the Upland Plant Communities on the Islands of Hawai'i, Maui, Moloka 'i, and Lana'i. Technical Report 68. Cooperative National Park Resow·ces StudiesUnit, University of Hawai'i at Manoa and National Park Service.
2.	Ripperton, J.C. and E.Y. Hosaka. 1942. Vegetation zones of Hawai'i. Hawai'i Agricultural Experiment Station Bulletin 89:1-60.
3.	U.S. Dept. oflnterior-U.S. Geological Survey. 2006. AGAP Analysis of Hawai'i. Final Reoort and Data.

Other References

1.	Armstromt. R.W. 1973. Atlas of Hawai 'i. Universitv of Hawaf i Press. Honolulu.
2.	Maly, K. and O. Maly. 2004. A Cultmal Study of the Pu 'u O 'Umi Natural Area Reserve and Kohala-Hamak-ua Mountain Lands, Districts of Kobala and Hamakua, Island of Hawaii. Kumu Pono Associates LLC, Hilo, HI.
3.	Mueller-Dombois, D. and F.R. Fosberg. 1998. Vegetation of tbe Tropical Paci.fie Islands. Springer-Verlag New York, Inc.
4.	Palmer, D.D. 2003. Hawai'i'sFerns and Fem Allies. University of Hawai'i Press, Honolulu.
5.	Pratt, H.D. 1998. A Pocket Guide to Hawai'i's Treesand Shrubs. Mutual Publishing, Honolulu.
6.	Rock, J.F. The Inrugenous Trees of the Hawaiian Islands. 1[51] edition 1913, reprinted 1974,Charles E. Tuttle Company, Rutland, VT and Tokyo, Japan.
7.	Sohmer, S.H. and R Gustafson. 2000. Plants and Flowers of Hawai 'i. Universitv of Hawai 'i Press, Honolulu.
8.	Wagner, WL, DR Herbst, and SH Sohmer. 1990. Manual of the Flowering Plants of Hawai' i. Bisb.op Museum Special Publication 83, University of Hawaii Press,Honolulu.

Site Description Approval

Author	Date	Annroval	Date
David Clausnitzer	**07/07/2008**	**David Clausnitzer**	**07/07/2008**
Joseph Mav	**2003**		
Loretta **J.** Metz	07/07/2008	Loretta **J.** Metz	07/07/2008

BEST MANAGEMENT PRACTICES

FOR

MAINTAINING WATER QUALITY

IN HAWAII

State of Hawaii
Depanmcnt of Land and Natural Resources
Division of Forestry and Wildlife
February 1996

FORE\\'ORD

Best Management Practices (BMPs) are effective. practical, structural or nonstructural methods which prevent or reduce the movement of sediment, nutrients, pesticides and other pollutants from the land to surface or ground water, or which otherwise protect water quality from potential adverse effects of silvicultural activities. These practices are deve1oped to achieve a balance between water quality protection and the production of wood crops within natural and economic limitations.

A thorough understanding of BMPs and the flexibility in their application are of vital importance in selecting BMPS which offer site specific control of potential nonpoint source pollution. With each situation encountered at various sites, there may be more than one correct BMP for reducing or controJling potential nonpoint source poll ution. Care must also be taken to select BMPs that are practical and economical while mai ntaining both water quality and the productivity of forest land.

The Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500 (and as amended by Sec. 319, 1986}, require the management of nonpoint sources of water pollution from sources including forest-related activities. BMPs have been developed to guide forest landowners, other land managers and ti mber harvesters toward voluntary compliance with this act. Maintenance of water quality to provide "fishable" and "swimmable" waters is central to this law's objectives. The Environmental Protection Agency (EPA) recognizes the use of BMPs as an acceptable method of reducing nonpoint source pollution.

Nonpoint source is diffuse pollution that comes from almost everywhere; it even occurs naturally to a certain extent. The amount of pollutants from any particular spot is small and insignificant, but when combined from over the landscape, can create water quality problems. **Although it** is unrealistic to expect that all nonpoint source pollution can be eliminated, BMPs can be used to minimize the impact of forestry pract ices on waler quality. These practices must be reasonable, achievable and cost effective. The adoption and use *of* BMPs will provide the mechanism for attaining the following water quality goals:

- to maintain the integrity of stream courses
- to reduce the volume of surface runoff originating from an area of forest management disturbance and running directly into surface water;
- to minimize the movement of pollutants i.e. pesticides, nutrients , petroleum products, etc. and sediment to surface and ground water;
- to stabilize e,;posed mineral soil areas through natural or artificial revegetation means.

The intent of this guide is to promote better stewardship of t he forest resources. This guide delineates environmentally responsible land management methods which, when applied properly, minimizes adverse impacts on t he forest ecosystem and maximizes landowner objectives. Unusual situat ions may arise or pollut ion control measu res other than those recommended here may be found. In these cases, common sense is most often the best **guide.**

Information presented in this guide is not to be used as the basis for setting water quality standards or as the basis of required use of watershed protection practices. Compliance **with** any watershed protection practices would be on a voluntary basis backed up with a public water quality educat ion and awareness program. Changing of water quality standards or the required use of protection practices should not be attempted without careful study or the beneficial effects gained from modifying existing silvicultural practices now in use.

INTRODUCTION

The Division of Forestry and Wildlife (DOFAW) is mandated by HRS, Chapter 183 to "...devise ways and means of protecting, extending, increasing, and utilizing the forests and forest reserves, more particularly for protecting and developing the springs, streams, and sources of water supply to increase and make that water supply available for use.••"

The number one resource that is generated by the forest is water. Since the establishment of the Department of Agriculture and Forestry in 1900, the concern for the protection of forest lands for the purpose of water has been a high priority. Fencing to keep out wild cattle and other feral animals and reforestation efforts to re-establish watersheds have been the key to the continuance of the production of high quality water.

In 1961, Hawaii created, by law, the nation 's first statewide zoning districts, and today approximately 95% of the Hawaii's four mi Ilion acres are zoned for agricultural or conservation uses. The Conservation district, which is under the jurisdiction of the Depanment of Land and Natural Resources (DLNR), encompasses almost one-half of the State.of which one million acres is state-owned. The majority of Conservation lands are covered by forests, but also contain grasslands, coastlines, cliffs, offshore islets, and wetlands. Vegetative communities include lowland and montane rainforests and u nique examples of tropical biodiversity , much of it endangered.

The Division of Forestry and Wildlife recognizes the need for responsible stewardship of the natural resources, which include soil and water. The success **or** BMPs to protect water quality within Hawaii depends on mutual cooperation and trust among landownen, industry, environmentalists, wood producen, regulatory agencies, governmental officials, and the general public. All have an interest in good land management as it relates to water quality.

THE FOREST/WATER RELATIONSIIlP

The forest and water resources are mutually dependent upon one another. Forests depend on water, namely rain, surface water, and groundwater for their growth and reproduclion. Major long-term changes in the water supply can cause permanent changes in the content, quality and vitality of forest lands.

On the other hand, surface and groundwater quantity and quality are largely influenced by the surface on which rain falls and through which it percolates. The tremendous filtering capacity of forest lands provide effe.ctive and high quality groundwater recharge.

Hawaii*s streams and aquifers all benefi t from che presence of forests. In addition to these water quality benefits, forests provide needed wood and fiber products, wildlife habita aquatic resources and habitat, recreation values and aesthetic benefits. IL is in managing forests for these benefits that damage co the water resource can result. Following is a brief discussion of the most commonly used forest management practices and the impacts they can have on the quality of the water resource.

Timber Harvesting

The removal of trees from a site has little impact on water quality, as Jong as the trees do not provide vital shade to streams and as long as the slope of the land is not excessive. The natural warmth of many streams can be exaggerated by removi ng shading vegetation from their banks. Increased water temperature promotes lower dissolved oxygen levels, placing stress on fish and other aquatic organisms.

Removing timber per se does not directly cause significant water quality changes, since ground cover is not excessively disturbed during proper logging operations. On steep slopes, however, careless timber removal can increase the likelihood of runoff and soil loss. This may lead to water quality degradation as well as a loss of site productivity. Steep areas should therefore be logged carefully using proper harvesting techniques for the sake of both water quality protection and site protection.

Rod Construction and Drainage Techniques

All facets and phases of a sound forest management program rely heavily on accessibility to the forest. Consequently, temporary and permanen t access roads are necessary components of all management programs. They are also one of the most costly investments made in a forests.

Temporary access roads are constructed to facilitate ha.rvesting operations, site preparation and planting and often abandoned after the new stand is established . When abandoned, these temporary roads are normally allowed to revegetate natu rally or are planted with trees.

Pollutants front Silvicultural Acti\'ities

The major types of water poll utants that can be generated from forest management disturbances to the forest ecosystem include sediment, nutrients, pesticides, and debris.

1) Sediment

Sediment is the most common pollutant resulting from silvicultural activities. Sediment principally results from erosion of soil, but may also include organic matter. Excessive sediment upsets balanced ecology within streams by smothering bottom dwelling organisms in the water, interfering with photosynthesis by reducing light penetration, serving as carriers of nutrients and pesticides, inhibiting fish reproduction and altering stream flow.

2) Nutrients

Nutrients, primarily phosphorous and nitrogen fertilizers, are sometimes applied to the forest to stimulate tree growth. Soluble nutrients may reach surface or ground water through runoff, seepage, and percolation. Insoluble forms may be absorbed on soil particles and reach water by direct wash-off of debris and recently applied fertilizer. Excessive nutrients lead to an imbalance in natural life cycles of water bodies.

3) Pesticides

Pesticides, if applied during silvicultural activities, may be soluble or insoluble. Pesticides in surface or ground water may result in toxicity problems, affecting water quality and food sources for aquatic life.

4) Debris

Tree limbs, tree tops, and other waste materials are the principal organic pollutants from silviculture. They reach streams through direct pushing or feiling into water drainages, and washout during storms. Organic materials may place an oxygen demand on the receiving water body during the decomposition process. ln addition, associated problems may include odor, color, taste and nutrients. Inorganic material such as oil cans and pop bottles are also considered nonpoint source debris.

BEST MANAGE1\1ENT PRACTICES

1.1 Forest Roads

Standards and Use

Forest roads are managed to provide adequate access to lands for timber management, fire suppression, wildlife habitat improvement and a variety of dispersed and developed recreational activities. Generally .these are low volume roads that must carry heavy loads for short periods of time. The potential for adverse impacts from forest roads exists in areas where steep slopes, erodible soils, or where forest roads are located near water. Forest roads cause more erosion than any other forest ry activity. Most of this erosion can be prevented by locating, constructing, and maintaining roads to mini mize soil movement and pollution of streams. **The** need for higher standard roads can be alleviated through better road-use management. Design roads to the minimum standard necessary to accommodate anticipated use and equipment.

Planning, Desi&n, and Location

A well planne.d access system is a sound method of reducing erosion and sedimentation in areas requiring frequent or temporary access. Proper location and construction of roads will provide for safety, longer operating periods, lower maintenance and operating costs, and minimal impacts to water quality. The value of the resource served and site characteristics wilt influence the choice of road construction standards and maintenance activi ties. The following practices **are** recommended:

(1) Use a design to minimize damage to soil and water quality.

(2) Roads should be designed no wider than necessary to accommodate the immediate anticipated use.

(3) Design cut and fi\J slopes to minimize mass soil movement.

(4) Provide culverts, dips, water bars, and cross drainages to minimize road **bed** erosion.

(5) Design bridge and culvert installations using stream flow data, with a margin of safety proportional to the importance of the road and the protected resources.

(6) Provide drainage where surface and groundwater cause slope instability .

(7) Avoid divening water from natural drainage ways. Dips, water bars, and cross drainage culverts should be placed above stream crossings so that water can be filtered through vegetative buffers before entering streams.

(8) Locate roads to fit the topography and minimize alterations to the natural features.

(9) Avoid marshes and wetlands.

(10) Minimize the number of stream crossings.

(11) Cross streams at right angles to the stream channel.

(12) A road may not be located in a Streamside Management Zone (SMZ) except where access is needed to a water crossing. or where there is no feasible alternative. A road in any SMZ must be designed and located to minimize adverse effects on fish habitat and water quality.

Construction

Once the road's location and design is staked out. road construction begins. Timber is out. logs and vegetation are removed and piled along the lower side of the right of-way.

Most forest roads are built by excavating a road surface. Road design and layout on-the-ground show machine operators the proper cut slopes and indicate cut slope steepness. The bulldozer starts at the top of the cut slope, excavating and sidecasting material until the desired road grade and width is obtained. Material from cuts is often pushed in front of the blade to areas where fill is needed. Road fill is used to cover culverts and build up flat areas. Since fill must support traffic, it needs to be spread and compacted in layers to develop strength. The following practices are recommended:

(1) Construct roads when moisture and soil conditions are not likely to result in excessive erosion or soil movement.

(2) The boundaries of all SMZs shall be defined on the ground prior to the beginning of any earth-moving activity.

(3) Construct a road sufficient to carry the anticipated traffic load with reasonable safety and with minimum environmental impact.

(4) When using existing roads, reconstruct only to the extent necessary to provide adequate drainage and safety.

(5) Avoid construction during wet periods, when possible, to minimize unnecessary soil disturbance and compaction.

(6) Road grades should be kept at less than 10%, except where terrain requires shon, steep grades.

(7) Minimize the number of stream crossings. Stream crossing construction should minimize disturbance of the area in which the crossing is being constructed.

(8) As slope increases, additional diversion ditches should be constructed to reduce the damages caused by soil erosion; ditches, adequate culverts, cross drains, etc., should be installed concurrent with construction.

(9) To control erosion, cut and fill slopes should conform to a design appropriate for the particular soil type and topography.

(10) Stumps, logs, and slash should be disposed of outside of the road prism; in no cases should they be covered with fill material and incorporated into road beds.

(11) Stabilize the side banks of a road during construction to aid in the control of erosion and road deterioration; this may require mesh or other stabilizing material in addition to planting and/or seeding and other structural measures.

(12) Water bars should be located to take advantage of existing wing ditches and cross drainage. Water bars should be constructed at an angle of 30 to 45 degrees to the road. Water bars should be periodically inspected and damage or breeches should be promptly corrected. Install water bars at recommended intervals to provide the drainage. Water bar spacing recommendations are as follows:

Grade...o.L.Road	Distancc.Jkt.eo Watecl>acs
2%	250 ft.
5%	135 ft.
10%	80 ft.
15%	60 ft.
20%	45 ft.
25%	40 ft.
30%	3S ft.
40%	30 ft.

Water bars may need to be spaced closer together depending on soil type and rainfall.

(13) Bridges and overflow culverts should be constructed to minimize changes in natural stream beds during high water.

(14) Culverts on perennial streams should be installed low enough to aJJow passage of aquatic life during low water.

Maintenance

Maintenance of active and inactive roads shall be sufficient to maintain a stable surface, keep the drainage system operating, and protect the quality of streams. The following are recommended:

(1) Maintenance should include cleaning dips and crossdrains, repairing ditches, marking culverts inlets to aid in location, and clearing debris from culverts.

(2) Keep culverts, flumes, and ditches functional before and during the rainy season to diminish danger of clogging and the possibility of washouts. This can be done by clearing away any sediment or vegetation that could cause a problem. Provide for practical and scheduled preventative maintenance programs for high risk sites that will address the problems associated with high intensity rainfall events.

(3) Conduct road surface maintenance as necessary to minimize erosion of the surface and subgrade.

(4) During operations. keep the road surface crowned or outsloped, and keep the downhill side of the road free from berms except those intentionally constructed for protection of fill.

(5) Avoid using roads during wet periods if such use would likely damage the road drainage features.

(6) Water bars should be inspected after major rain storms and damage or breeches should be promptly corrected.

Harvesting -Temporary Access Roads and Landings

(1) The location of temporary access roads (logging roads) should be planned before operations begin.

(2) Road construction should be kept to a minimum.

(3) Landings should be located to minimize the adverse impact of skidding on the natural drainage pattern.

(4) Logging roads and landings should be located on firm ground.

(5) Landings should be kept as small an area as possible.

(6) When operations are completed, provisions should be made to divert water run-off from the landings and roads.

2.1 Pre-Harvest Planning

Pre harvest planning is the collection of in formation about the area to be harvested and the synthesis of that information i nto an effective environ mental plan. This plan will consider the silvicultural prescription for the species and site, the best estimate of the ti me and method of harvest and any post·harvest site preparation and reforestation activities.

At this **stage,** it is assumed that all federal, state, and local govern ment regulations regarding harvesting have been met.

An effective pre-harvest plan will take into consideration all aspects of the timber harvest which may lead to water quality degradation and plan for the implementation of BMPs which will minimize or avoid the adverse effects of the operation. The objective of pre harvest planning from the perspective of non-poi nt source pollution is to determine which BMPs are necessary to protect water quality and how those BMPs will be implemented. The following is recommended:

{1) A pre harvest plan should include the following information:

A. Physical and administrati ve description

1. Property boundaries & administrative boundaries (zoning, etc.)
2. Topography
3. Location of streams and drainages
4. Location of SMZs and buffer strips
5. Forest types
6. Soil types
7. Areas of ecological and/or archaeological concerns

B. Management Activities

1. Design and construction techniques for all new roads, skid trails, and landings or modification of existing roads, skid trails and landings.
2. Felling and bucking techniques
3. Yarding systems and layout
4. Planned stream crossings
5. Disposal of waste materials (machine lubricants)
6. Post-harvest site preparation
7. Reforestation activities

(2) The use of topographic maps, road maps, aerial photos, forest type maps, and soil surveys in combination with field reconnaissance is essential to determine site conditions and plan operations.

(3) Field reconnaissance with a trai ned forester or one who is knowledgeable about the specific area is highly recom mended.

(4) Preliminary planning should consider the maintenance of existing drainage patterns and the location of environmentally sensitive areas such as streams, wet areas, and high erosion hazard areas.

(5) The design of roads, skid trails, and landings shall be integrated to minimize their impact.

(6) The grade of logging roads and skid trails should be less than 10% when possible, with 3-5% being the norm. Long, straight, unbroken grades are to be avoided. Adequate surface drainage shall be provided.

(7) Time the harvesting activity for the season or moisture conditions when the least impact occurs.

(8) A final pre-harvest site review shall be conducted by management so that road alignments and other considerations can be visually checked prior to road construction. **The** reconnaissance plan shall be modified as necessary to make desirable adjustments based on the final site review.

2.1 Timber Harvesting

Standards and use

Tunber harvesting is an integral part of most forest management programs. Harvesting operations cause a temporary disturbance in the forest as well as diminish water quality. However, it can **be** conducted in a manner where the impact *to* water quality is mini mized and the re-establishment of vegetative cover is realized. Guideli nes to help reduce the potential for nonpoint source pollution from harvesting trees are as follows:

Fellin& and Bucking

(1) Careful felling can mini mize the impact of subsequent phases of the logging operation.

(2) Trees should not be felled into streams, except where no safe alternative **exists.** In the latter case, such trees should be removed promptly.

Skidding

(1) Skidding should be done so as to avoid disrupting natural drainage and to prevent excessive soil displacement.

(2) Stream channels or road ditches should not be used as skid trails.

(3) Skid trails on steep slopes should have occasional water bars.

(4) Servicing of equipment involving fuel, lubricants, or coolants should be performed in places where these materials cannot enter streams. Spent oil should be collected for proper disposal, never poured on the ground.

(5) Upon completion of logging, erosion-prone areas should be mulched or seeded.

Mechanical Site Preparation

(1) Avoid excessive soil compaction.

(2) Minimize erosion and the movement of sediment into waters.

(3) Prevent accumulation of debris in ponds, streams, or rivers.

(4) Windrows, disking, bedding, and planting with "furrow" type mechanical planters should follow contours.

(5) Avoid complete disking of steep slopes with extremely erodible soil.

(6) Plant trees on contour.

Disposal of Debris and Litter

(1) Logging debris in streams should be removed immediately.

(2) Debris from landings should not be pushed into drains, streams or Streamside Management Zones (SMZs)

(3) All trash associated with the logging operation should be promptly removed (not buried) and hauled to a legal disposal site.

3.0 Silvicultural Chemical Management

Description and Purpose

Pesticides are used on forest lands to facilitate meeting forest management objectives. The purpose of a pesticide application is to rid an area of undesirable vegetation or control insects or diseases to promote the establishment, survival, growth or maintenance of a desired species or condition.

Planning Considerat ions

Planning is an essential first step i n reducing pest problems. A plan is needed by which the application of pesticides is utilized in an efficient manner that produces no adverse impacts on the environment. The maintenance of water quality is an important consideration in all aspects of pesticide operation planning.

Pesticide Selection

When the decision is made to use pesticides, choose products suitable for use on the target **species** and registered for the intended uses. Use only pesticides registered by the Environmental Protection Agency. Prior to using any pesticide, carefully read and follow all label directions.

When selecting pesticide options, more than effectiveness and cost should be evaluated. Consideration should be given to site factors. application conditions and techniques and products that can influence impacts to water quality.

Three main characteristics can greatly affect a pesticide potential to contaminate surface or ground water. They are solubility, absorption and breakdown rate.

1) Solubility

Solubility is the ability of a pesticide to dissolve in water. The greater the solubility, **the greater** the chance that the chemical wilt leach to grou nd water.

2) Absorption

Absorption is the inherent ability of a pesticide to bi nd with soil. Some pesticides stick very tightly to soil while others are easily dislodged. A greater absorption means a pesticide will remain longer in the soil and thus be less likely to leach down into the ground water before it has degraded. Absorption increases as soil organic matter increases.

3) Breakdown Rate

Breakdown rate or half-life is the time a pesticide takes to degrade or breakdown into other chemical forms. Pesticides that do not break down quickly can be hazardous if they move to ground water or surface water.

In a given situation, pesticides with the highest water solubilities, greatest persistence, lowest affinities for absorption to organic matter and other soil components, and highest application rates have the greatest potential for movemen t in surface water or to ground water. An alternative means of minimizing the potential movement of a pesticide is to select a non-broadcast application

technique for the same pesticide that reduces the amount of the chemical applied directly to the soil.

Procedures for Chemical Use

Proper pesticide management practices make efficient use of chemical while preventing contamination of surface water or ground water. Residues of pesticides used in forestry can **affect** water quality at several phases of the chemical use cycle. These phases are: 1) transportation, 2) storage, 3) mixing and loading, 4) application, and 5) cleanup and disposal. To minimiz.c potential impacts on water quality , use of the following practices is encouraged .

A) Transportation

(1) {nspect all contai ners prior to loading and ensure all caps, plugs and bungs are tightened.

(2) Handle containers carefully when loading them onto vehicles.

(3) Secure containers properly to prevent shifting during transport.

(4) Check containers periodically enroute.

(5) Limit access to containers during transport to prevent tampering.

(6) Educate and inform the driver of the proper transponation precautions.

(7) Never transport pesticides unless arrangements have been made to receive and store them properly.

B) Storage

(1) Chemicals should be managed and stored in accordance with all applicable **federaJ,** state, or local regulations. These would include:

(a) The EPA container registration label, as printed on the label;

(b) Label instruction for use as provided by the manufacturer;

(c) Requirements or the use, application, and registration of pesticides;

(d) Requirements relating to 1he licensing of applicators.

(2) All containers should be labeled in accordance with applicable federal, state and local regulations.

(3) Apply pesticides under favorable weather conditions. Never apply a pesticide when there is a likelihood of significant drift.

(4) Always use pesticides in accordance with label instruction, and adhere to all Federal and State policies and regulations governing pesticide use.

E) Cleanup and Disposal

(1) Before disposal, containers should be rinsed as described in equipment cleanup.

{2) Cleanup should be in a location where chemicals will not enter any stream, **pond,** or where stream pollution might occur.

(3) Rinse empty pesticide containers and mixing apparatus as many times as needed. This flushing should be applied in spray form to the treated area, NOT into the ground near streams.

(4) Dispose of pesticide wastes and containers according to federal and **state laws.** Some pesticide wastes are specifically identified as hazardous wastes by **law and** must behandled and disposed of in accordance with hazardous waste regulations. For more information about proper management of waste pesticides, contact **the** Depanment of Health, Environmental Health Administration.

Other chemicals

Improper storage and handling of oil products and fuel can be a water quality hazard. Improper disposal of oil or fuel can contaminate ground water and seep into streams. The following arerecommended:

(1) Locate facilities away from streams and be prepared to clean up spills.

(2) Know and comply with regulations governing the storage, handling, application (including licensing of applicators), and disposal of hazardous substances.

(3) Do not transport, handle, store, load, apply or dispose of any hazardous substance or fertilizer in such a manner as to pollute water supplies or cause damage or injury to land, including humans, desirable plants and animals.

(4) Do not store, mix, or rinse hazardous substances or fertilizers within the streamside management zone or where they might enter streams or waterways.

(5) Develop a contingency plan for hazardous substance spills. including cleanup procedures.

(6) Report all spills to the Department of Health. Environmental Health Administration.

4.1 Streamside Managen 1ent Zone (SMZ)

The Special Management Zone (SMZ) is a specific area associated with a stream. lake, wetland or other waterbody that is designated and maintained during silviculture operations. The purpose of the SMZ is to protect water quality by red ucing or eliminati ng forestry related ouputs, i.e. sediment, nutrients, logging debris. chemicals, and water temperature fluctuations that can adversely affect aquatic communities. SMZs provide shade, streambank stability and erosion control, as well as detritus and woody debris which benefi t the aquatic ecosystem in general. In addition, the SMZ is designed to mai ntai n certain forest attributes that will provide specific wildlife habitat values. Snags. den and cavity trees as wen as mast producing trees, left in the SMZ, are necessary to meet habitat requirements for certai n wildlife.

The SMZ has specific criteria, that defines operational restrictions and special management objectives. In addition, the SMZ has a specific width which is based on the size and type of waterbody involved.

A Strcamside Management Zone (SMZ) is an area covered with vegetation or ground cover on both sides of perennial, intermittent streams and other bodies of open water, where extra pn:caution is used in carrying out forest management practice . The SMZ also provides shade and functions as a buffer when fertili:7.ers, pesticides, etc. are applied to adjacent lands. For practical purposes, an SMZ muse be wide enough to protect water quality and stream characteristics. Precaution is needed in carrying out forest management practices in order to protect bank edges and water quality. Determini ng the necessary width involves in part a judgement factor based on reliable local experience.

SMZs should be used where: l) water quality is impaired and adjacent land use contributes to that degradation. 2) good water quality exists and protection against potential future impairment is desired, 3) streambank erosion is a concern, 4) wildlife habitat enhancement is desired, and/or S) silviculturc practices arc to be implemented, and 6) the Jower edge of cropland , grassland, or forest land is adjacent to permanent or intermittent streams, or border streams, rivers, ponds or intermittent or permanently flooded, cpen·water wetlands.

SMZ benefits include the following:

(1) Shade - Trees within the SMZs provide shade to maintain cool water temperatures which aid in the spawing of fish. Without trees and overhanging shrubs, stream temperatures would increase during the summer. Some fish species and aquatic organisms would then be unable to live in the streams. Jn the summer, water from shaded streams eventually flows into larger bodies of water and helps maintain its fish and aquatic life by keeping these waters cool all the way downstream .

(2) **Eood** - Leaves and insects drop imo streams from overhanging trees and shrubs. In fact, 90% of the food in the forested streams comes from bordering vegetation.

(3) ErotectioLStrearobanks - Many streambanks are: stabilized by streambank trees. They anchor banks and prevent erosion during periods of high water. **Removing** trees and shrubs and substituti ng shallow rooted grasses can lead to stre.ambank collapse and stream sediment. Bank overhang is created by stream flows undercutting che siream bank and tree roots. Fish can rest, hide from predators, and feed in these protected areas.

(4) Booding - Healthy SMZs stabilize floodplai ns. During times of high **water,** SMZs reduc.e the velocity of floodwaters.. Their dense vegetation and deep humus slow down racing water. Forest floodplai ns suffer less damage when **SMZ.s are** protected during harvesting activities.

(5) Recreat:oo - The recreational activities that we enjoy in and around streams **are** many. This includes swimming, fishing. camping, hunting, and backpacking to name a few.

(6) Timber Prodi1C!ian • For those who grow and harvest trees, the fact is that trc= often grow best in SMZs. Tree!i respond to those deep, fertile. and moist **soils.** Logging activities should not be eliminated ·within SMZs but modified to **fosurc** that stream channels and banks are protected from disturbance. SMZs arc not timber harvest "keep out" zones, but there are locations where timber harvesting activities must be modified to protect the many benefits mentioned above.

Recommendations

SMZs should be maintained along all perennial s(reams or where forest disturbances occur and surface runoff will carry sediment loads. SMZs should be mai ntained around streams, ponds, perennial flowing natural springs, and a.!l springs and reservoirs serving as domestic water supplies. The following best management practices are recommended:

(l) The width of SMZs should be determined depending on 1he followi ng conditions: slope of land adjacent to stream, wil erodibility, precipitation, knowledge of particular are.a, sensitivity of stream, etc. These factors can be obtained from soil maps, on-the-ground evaluatiori and measurements,weather data, etc.

(2) SMZs should be designed on a case-by-case basis. Most important is that SMZs be consistent with stream characteristics and wide enough to protect water quality.

Soil Type	Percent Slope	SMZ Widt h (each side)
Sli2htlv erodible	0-5	35'
Sliehtlv erodi ble	5-20	35-50'
Sliehtlv erodible	20+	50-160'
Erodible	0-5	35-50'
Erodible	5-20	80' minimum
Erodible	20+	l60' minimum

Table 1. Recommended Widths for Streamside Management Zone

(NOTE: Please contact you r local Natural Resources Conservation Senice office to determine the erodibility factor or the soil before detenninine the proper width of the **SMZ.]**

(3) On relatively flat terrain (0-5%) on slightly erodible soils, the width of an SMZ should be at least 35 feet wide on each side of a stream.

(4) On relative flat terrain (0-5%) on erodible soils, the SMZ width should range between 35 to 50 feet on each side of a stream.

(5) On slightly erodible soils wi th slopes ranging between 5 and 20 percent, the SMZ width should range between 35 to SO feet wide on each side of a stream.

(6) On erodible soils with slopes ranging between 5 and 20 percent, the SMZ width should range between 50 to 160 feet on each side of a stream.

(7) On slightly erodible soils with slopes exceeding 20 percent, the SMZ width should **be at** least 80 feet on each side of a stream.

(8) On erodible soils with slopes exceeding 20 percent, the SMZ widlh should be a minimum of 160 feet on each side of a stream.

(9) Partial harvesting is acceptable. A minimum of 50% of the original crown cover or SO square feet of basal area per acre, evenly distributed, should be retained in the SMZ. This may be adjusted to meet on-sjte conditions.

(10) Clearcutting is always prohibited within the SMZ.

(11) Designate SMZs to provide stream shading, soil stabilization, sediment and water filtering effects. and wildlife habitat.

(12) Strive to protect the forest floor and understory vegetation from unnecessary damage. Do not remove (harvest) trees from banks, beds or slopes if it will destablilize the soil. Trees on the south and west banks provide the most critical shading of water.

(13) Access roads should cross perennial or intermittent streams at or near a right angle.

(14} Drainage structures such as ditches, cross drain culverts, water bars, rolling dips, and broad-based dips should be used on alJ roads prior to their entrance into an SMZ to intercept and properly discharge runoff waters.

(15) SMZs may be desirable on intermittent streams for large drainage areas where wildlife is a major Jandowner concern or for other reasons.

5.0 Fencing

(1) Fencing out livestock, pigs. and other animals in certain areas will help to prevent water quality degradation of streams, protect threatened and endangered plants, **reduce soil** compaction and maintain soil productivity. Fencing is applicable where desired **forest** reproduction, soil hydrologic values, existing vegetation, aesthetic values. and recreation arc prevented or damaged by these animals.

(2) Pastures should be fenced separately from wood lands. Consider maintenance **as well as** ease of construction when planning a fence location. By taking advantage of natural barriers such as cliffs, the cost of animal exclusion can be reduced. Also consider **use of** fences to protect vegetation that provides wildlife food and cover.

(3) Fences should be permanent stock fences built in accordance with good construction principles and workmanship.

6.0 Wildfire Damage Control and Reclamation/Prescribed Burn

The prevention, control, and extinguishment of an wildfires on grass, brush, and watershed lands and the implementation of a prescribed fire program is a desirable goal. Where wildfires do oc.cur, the first and foremost concern is to control the fireand limit the damage. Fire suppression activities can add to the problem of water quality protection.

The loss of vegetative cover, destruction of soil-holding feature of root masses, the exposure of bare mineral soil, is a combination that makes the area burned a highly erodible one. The effects of suppression efforts and equipment operations necessary to control and stop the fire can magnify the erosion problem.

The following are best management practices for wildfi re control and reclamation:

(l) The first and foremost concern in wildfire control is to prevent harm or damage to people and property. Firel ine best management practices should incorporate minimum impact strategies, which meet land and resou rce management objectives;

(2) Areas with bare mineral soils should be revegetated and areas where vegetative cover has been killed or severely degraded should be regenerated with plant species appropriate for the soil conditions;

(3) First priority for revegetation/reforestation should be given to banks of surface water bodies so that the SMZ is reestablished;

(4) Firelines should be stabilized and, if necessary, revegetated. Erodible areas altered by suppression equipment activities should be repaired and revegetated as necessary;

(5) Access road surfaces should be repaired and stabilized as necessary.

(6) Whenever possible, avoid using fire suppression chemicals over watercourses **and** prevent their runoff into watercourses. Do not clean application equipment in watercourses or locations that drain *into* watercourses.

(7) Provide advance planning and training for firefighters that considers water quality impacts when fighting wildfires. This can include increasing awareness so **direct** application of fire suppression chemicals to waterbodies is avoided and firelines are appropriately placed.

(8) Include rehabili tative practices as part of suppression and post·suppression tactics and strategies to mitigate non·point source pollution .

6.1 Fireline Construction and Maintenance

Fireline construction and maintenance is an essential part of forest and other land management activities. It deals with site preparation burning, prescribed burning. aod wildfire defense and control. A number of control practices can be implemented during fireline construction to **prevent** UMecessary erosion. Periodic inspection and proper maintenance can prevent potential erosion on established firelanes. The following are best management practices for fireline construction and maintenance:

(1) Firelines should be constructed on the peri meter of the burn area and along the boundary of the Streamside Management Zone. The purpose of protecting the Streamside Management Zone from tire is to safeguard the filtering effects of the litter and organic matter;

(2) Firelines should follow the guidelines established for logging trails and skid trails with respect to waterbars and wing ditches, and should be only as wide and **as deep** needed to permit safe prescribed burns or fire suppression needs;

(3) Firelines which would cross a drainage should be turned parallel to the stream or have a wing ditch or other structure allowing runoff in the line to be dispersed rather than channeled directly into the stream.

(4) All firelines should be assessed after the fire is controlled for appropriate stabilization, and if necessary, proper rehabilitation should be done while equipment and people are in place.

62 Prescribed Burn

(1) Intense prescribed fire for site preparation shall be conducted only if it achieves desired results with minimum impacts to water quality.

(2) Burning on steep slopes or highly erodible soils should be conducte.d when they arc absolutely necessary and should follow carefully planned prescriptions.

(3) Carefully plan burning to adhere to time of year. weather. topography. and fuel conditions that will help achieve the desired results and minimize impacts on water quality. With proper planning, prescribed fires should not cause **excessive** sedimentation due to the combined effect of removal of canopy species and the loss of soil-binding ability of the subcanopy and herbaceous vegetation roots, in streamside vegetation, small ephemeral drainages, or on very steep slopes.

(4) Site preparation burning creates the potential for soil movement. Burning in the SMZ reduces the filtering capacity of the litter. All efforts should be made to plan bums to minimize impacts on the SMZ.

(5) All bladed firelines, for prescribed fire and wildfire activities.should be built so as to minimize erosion. If necessary, the firelines should be stabilized with **water** bars and/or other appropriate techniques to control excessive sedimentation or erosion of the fireline. Include any erosion control practices in the construction of firelines.

71 Reforestation

Reforestation refers to those operations undenaken to establish a new forest. Site preparation, for the purpose of forest regeneration. is a basic silvicultural tool where for competing vegetation and

reduction of logging debris are necessary. Common sire preparation techniques include, manual, mechanical, fire, and herbicides.

Regeneration includes hand and machine planting and direct seeding. Since hand planting and **direct** seeding pose no water quality problems, BMPs are not necessary. Some mineral soil **exposure** does occur with machine planting and BMPs are offered.

1) Sites should recei ve the minimu m preparation necessary to successfully control competing vegetation and establish a desirable timber stand. In general, the more intensive the treatment, the more concern for water quality.

2) When working on slopes, mechanical operations such as ripping, she.aring, etc., should follow contours.

3) Hand planting, direct seeding or natural regeneration should be used on protected areas adjacent to streams or on slopes too steep to machine plant.

A P P E N D I C E S

1. Definition of Tenns
2. Road Construct ion Applications
3. Streaamide Management Zone
4. AvaUable istance
5. Suggested Readings

definition of terms

DEFINITION of TERMS:

Best Manaeement Practices -- effective, practical, structural or nonstructural methods which prevent or reduce the movement of sediment, nutrients, pesticides and other pollutants from the land to surface or ground water, or which otherwise protect water quality from potential adverse effects of silvicultural activitie$. These practices are developed to achieve a balance between **water** quality protection and the production of wood crops within natural and economic limitations.

Bucking -- to saw felled trees into predetermined lengths.

Clearcuttin& -- the removal of all standing trees within a designated area.

Cross drain -- a cross ditch used to move water from one side of the road to the other side to prevent accumulation of runoff without the need of a culvert or bridge.

Culvert -- a conduit through which surface water can flow under roads.

Divemon ditch - a ditch built across the top of a slope to divert surface water from that slope.

Felling -- the process of severing trees from stumps.

Fl.l'ebreaks -- naturally occurring or man-made barriers preventing the spread of fire.

F"ireline construction the construction of a barrier used to prevent the spread of fire.

Intermittent streams streams that provide water flow continuously during some seasons of the year but little or no flow during the remainder of the year.

Landing -- an area in the field where logs are collected.

Non-point source -- a source of water pollution which are induced by natural processes, including precipitation, seepage, percolation, and runoff; and not traceable to any discrete or identifiable source.

Perennial streams -- streams which provides water flow at all times except during extreme drought.

Pesticides -- any herbicide, insecticide, or rodenticide, but does not include non-toxic repellents or other chemicals.

om.mercial thinnin& - the removal of selected trees within an established forest destined for commercial use.

Prescribed burning -·the controlled application of fire as **a** management tool in forest management.

Reforestation -- the successful reestablish ment of tree species following harvest.

SUvkultural practices·- all forest management practices, including the establishment. composition, constitution, and growth of forests.

Site preparation -the removal of unwanted vegetation and other material prior to reforestation.

Skid trails -- routes over which logs are moved to a landing or road.

Streamside Management Zone -- an area on each side of the banks and above the head of intermittent streams, perennial streams, and other drains or bodies of water where extra precaution in carrying out best management practices is needed to protect bank edges and water quality.

Waterbar – a cross drainage diversion ditch and/or hump in a trail or road for the purpose of diverting surface water runoff into roadside vegetation, duff, ditch, or dispersion area to minimize the volume and velocity which can cause soil movement and erosion.

Wetlands – geographic areas that are inundated or saturated by surface or groundwater **at a** frequency or duration sufficient to support (and under normal circumstances do support) a prevalence of vegetation typically adapted for life in saturated soil conditions.

Wing ditch·- a water turnout or diversion ditch constructed to move and disperse water away from the road and side ditches into adjacent undisturbed areas so that the volume and velocity of water is reduce on slopes.

Yarding -- the method of log transport from the harvest area to the storage area.

BROAD BASED **DIPS**

pef fnftfon:

A dip and reverse slope in a truck road surface with an outslope fn the dip for natural cross drainage .

Purpose :

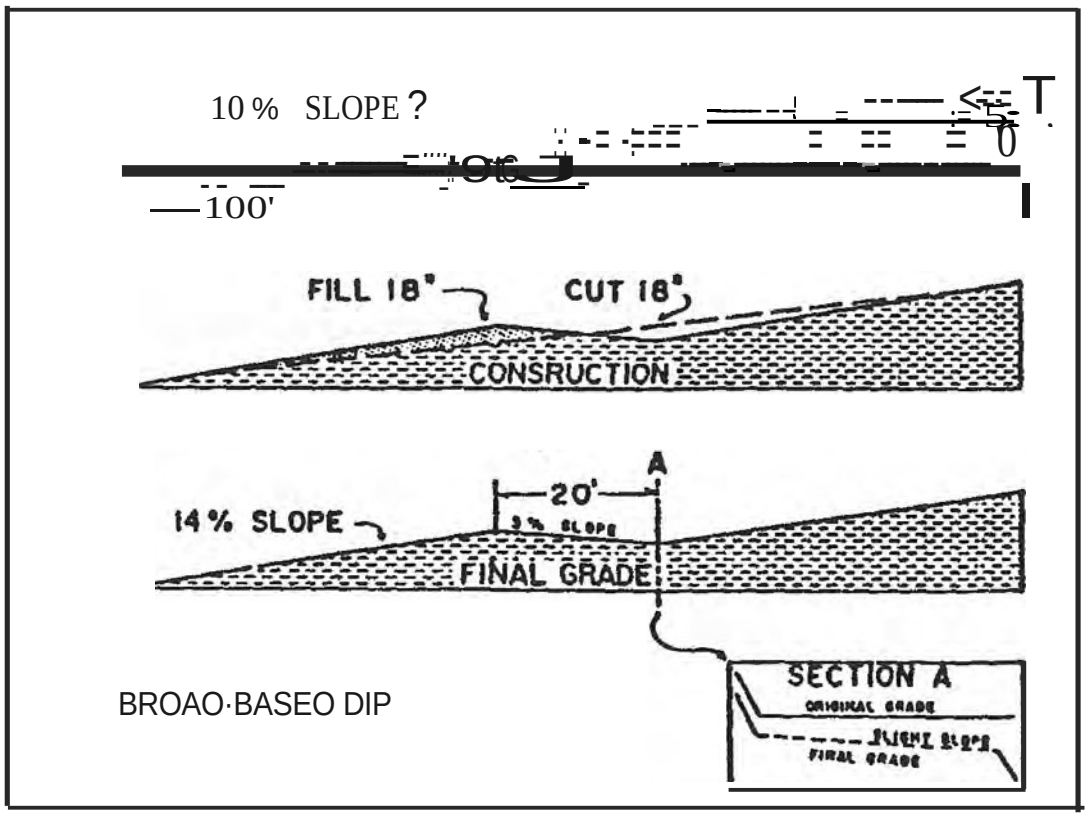
To provide cross drainage on insloped truck roads to prevent build-up of excessive surf ace runof f and subsequent erosion.

Condition$ Where Practice Appl ies:

Use on truck roads and heavily used skid trails having a gradient of 10% *or* less. May be substituted for other cross dra inage structures where no tntermittent or permanent streams are present.

Guidelines:

- Proper construct fon requ ires an experienced bulldozer operator•
- Installed after the basic roadbed has been constructed and before major hau ling use.



BROAO·BASEO DIP

- On grades steeper than 8%, surface dips with stone (approx. 3" diameter) or gravel.
- Use dips on approaches to steep declines in heavily used skid trails.
- Discharge area should be protected with stone, grass sod, heavy litter cover or slash and logs to reduce the velocity and filter the water.

PACING FOR BROAD BASED DIPS

Road Grade (percent)	Spacing Between Dips (feet)
2	300
4	200
6	165
8	150
10	140
12	130

WATER BARS

Def fnfttfon:

An earthen or reinforced berm constructed across a truck road or skid tr•11.

eurpose:

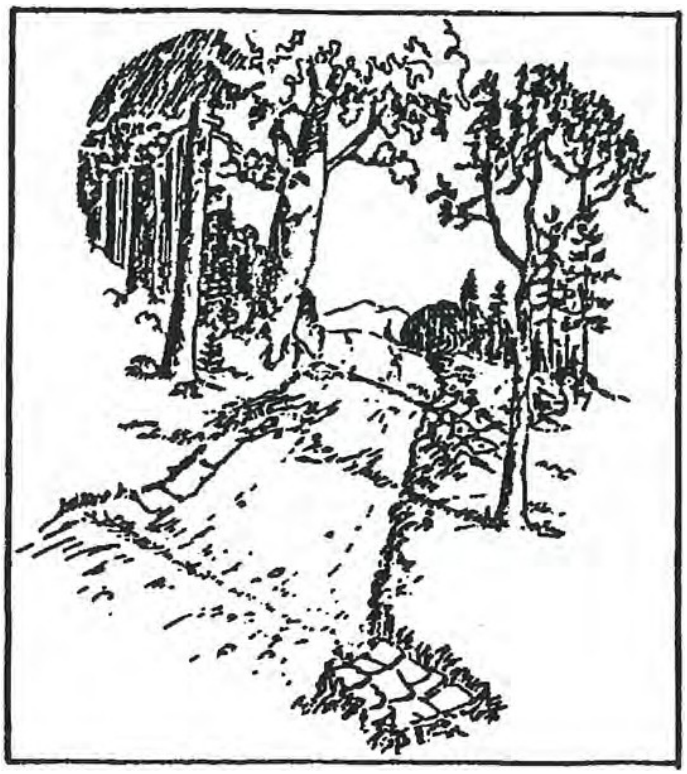
To intercept and divert water from side ditches and truck road or skfd tra11 surfaces, thereforeminimizing erosion by decreasing the slope length of surface water flow.

Conditions Where Practice Applies:

Utilized on any sloping truck road or skid trail where surface water runoff may cause erosion.

Gu idelines:

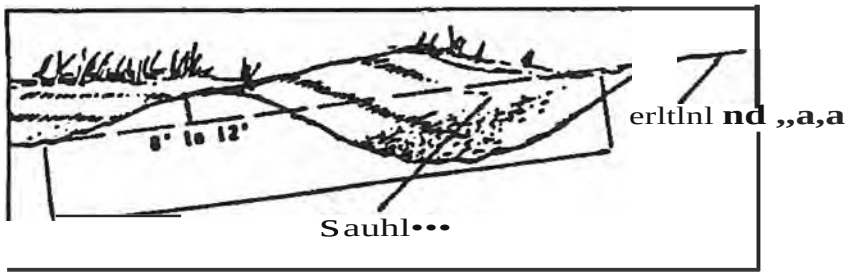
* Start placement of water bars at the farthest skid trail and work back to the log landing and then to the truck road.
- Install water bars with a skfdder blade, dozer blade, or by hand•
- Install water bars at the top of any sloping road or trail and at proper spacing along steep sections.



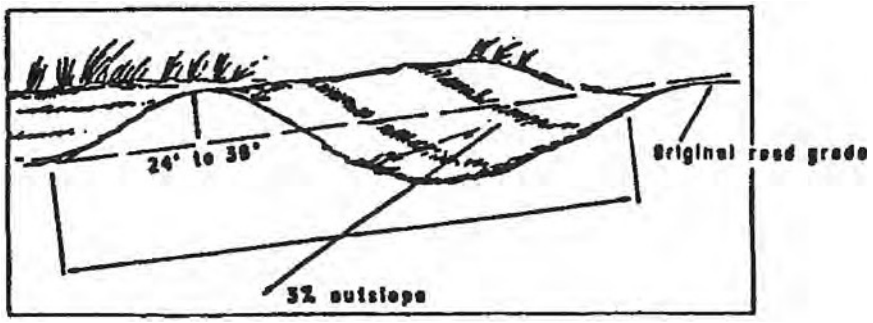
- Water bars may be shallow or deep depending on the need.
- Soil should be 1eft along the lower side of the water bar.
- * Should be constructed at a 30• - 35'angle downslope from a lfne perpendicular to the direction of the truck road or skid trail.
- * Should drain at 1 3% outslope onto undisturbed litter or vegetation.
- The uphill end of the water bar should extend beyond the side ditch line of the road or trail to fully intercept any water flow.
- * The downhill end of the water bar should be fully open and extended far enough beyond the edge of the road or tra;l to disperse runoff water onto undisturbed forest floor.
- Place rocks. slash, or logs to disperse water coming from a water bar•
- * If the road or trail fs to be kept open after the harvesting operation, the following guidelines should be used fn order to preserve effective water bars.

Reinforce the water bars
.. Keep travel to a minimum
Use only in dry weather
Make frequent inspections
Maintain as needed

SHALLOW WATER BAR



DEEP WATER BAR



SPACING FOR WATER BAAS

Road/Trail Grade (percent)	Spacing Between Water Bars (f eet)
2	250
S	135
10	80
15	60
20	45
30	35

CROSS DRAINAGE CULVERTS

Oeff nitfon:

Corrugated pipe, well casing, dredge pipe, or other suitable material placed under a truck haul road or major skid road to transmit ditch runoff and seeps from a drainage area of less than 10 acres.

Purpose:

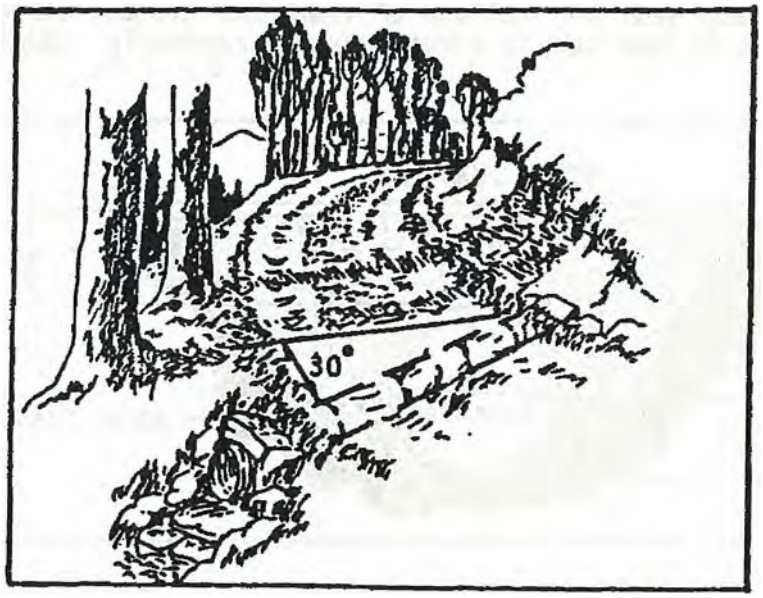
To co1lect and transmit water flows from side ditches and seeps, under truck hau1 roads and major skfd trails safely without eroding a drainage system or road surface.

Conditions Where Practice Applies

For any size operation where cross drainage of storm water is required temporarily or permanently.

Guidelines:

- This is the most expensive method of road cross drainage and should be used where heavy road use is anticipated during and after the harvestf ng operation.



* When sizing culverts for temporary roads, allow for periods of high flow, such as spring runoff or cloudbursts.

- The **minimum size** culvert to be installed is 12 fnch diameter and 20 **feet** tn length.

- When constructfng roads on sfdeh111 locations, dftch uphill side of th roadway to intercept surface runoff.

- Allow fnlet end of culvert to extend 1nto sfde ditch so that it intercepts water flowing tn the ditch. Construct a berm across the side d itch to assist in diverting water into the culvert.

- Allow outlet end of culvert to extend beyond any f ill and empty onto an apron of rock, gravel or logs.

- Space culverts according to road grade :

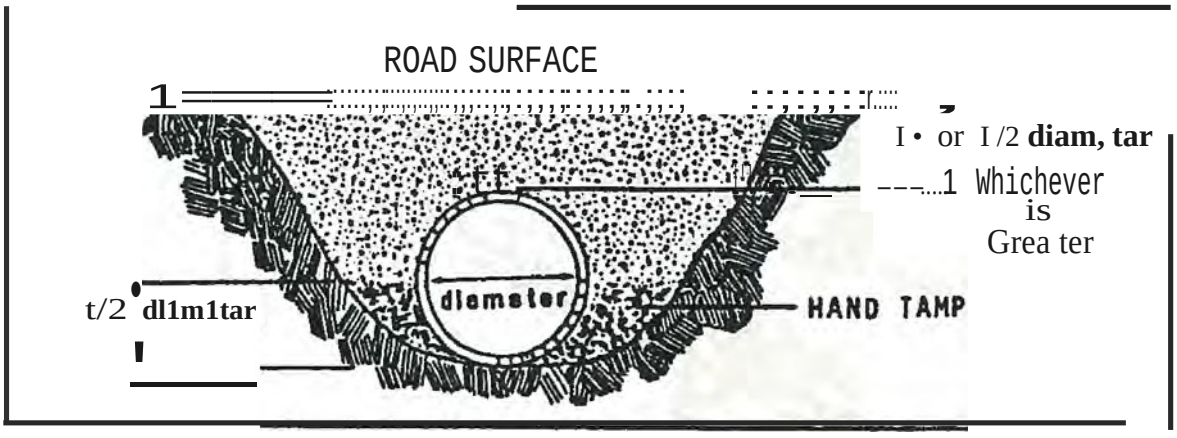
On gentle slopes (1-2%)	300 feet
On **eoderate** slopes (3-10%)	150 feet
On **steep** slopes (10%+)	100 feet or less

- Culverts should be installed at a 30-35 degree angle downgrade•

- Culverts should be sloped at least 5 inches for every 10 **feet** of length to permit self-cleaning.

* When harvesting operation has been completed, the road should be stabtlfzed by installing water bars and removing a11 pipe culverts from truck roads which will not be maintained.

* Culverts, when not maintained, are very likely to become blocked with rocks, ice or other debris. Runoff water can become rerouted over and around the culvert and may wash out sections of road fnto brooks, streams, ponds or wetlands. It fs important to clean culverts regularly. Check after **every storm .**



- Culvert size selection should be based on the size of the drainage area of 1 forested watershed and should be able to handle the largest flows.

- Estimating drainage area by taking measurements on a USGS topographic **map,** using contour lines to define the drainage limits. The Soil Conservation Service can assist you with determination of drainage area.

OPEN TOP CULVERTS

Def init ion:

A wooden culvert placed across truck haul roads to convey surface runoff and stde ditch flows across to downslope side.

Purpose:

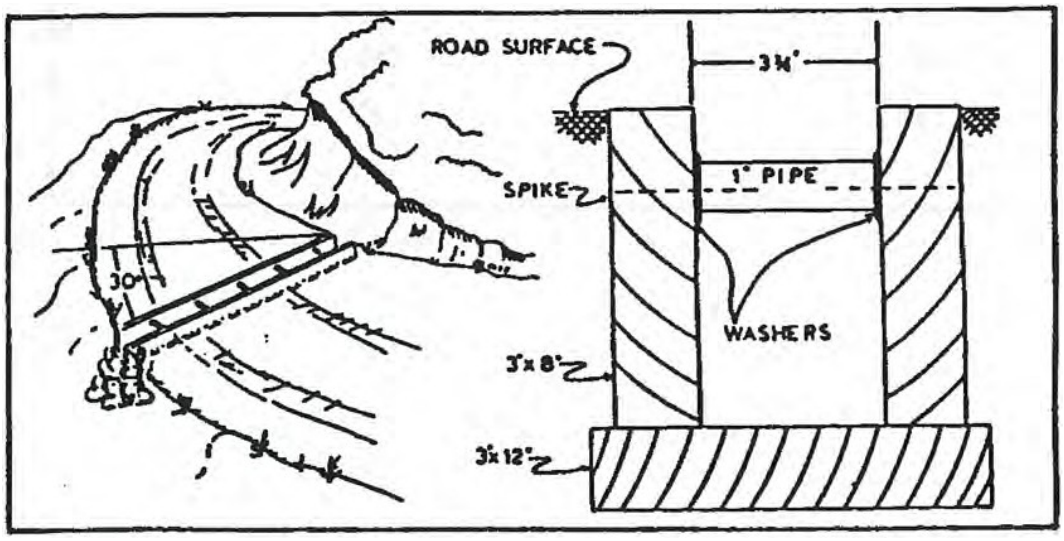
To collect and direct road surface storm runoff and upslope side d itch f lows across road without eroding drainage system or road surfaces.

Conditions Where Practice Applies:

Thfs is a temporary dra fnage structure for on-gof ng harvesting operations. Property built and maintained, it can be used for cross drainage on roads of smaller operations as a substitute for a pipe culvert. This practice should not be used for handling intermittent or live streams or skid trail cross drainage.

Guidelines:

- Can be constructed of cull logs or from sawn lumber. If made of durable wood or treated material, these culverts will give many years of service.



* To be installed flush with the road surface and skewed at an angle not less than 30 degrees downgrade.

- Allow the inlet end to extend into the cut slope or side ditch so that it intercepts water.
- Allow outlet end to extend beyond any fill and empty onto an apron of rock, gravel or logs.
- Open top culverts must be cleaned regularly to remove sedfments, gravel, and logging debris to allow normal function of structure at all times.

SPACING FOR OPEN TOP CULVERTS

Road Grade (percent)	Spacing Between Culverts (feet)
2	300
4	200
6	165
8	[illegible]
10	140
12	130

road construction applications

OUTSLOPING

Definition:

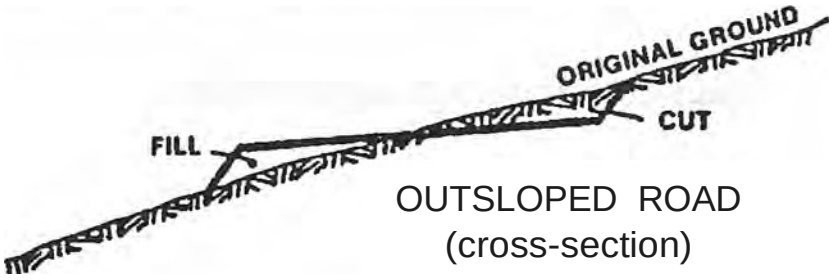
A section of road is sloped slightly (1-3%) from the cut bank to the outside edge of the road bed.

Purpose:

Effective way of limiting erosion because water is removed from the road surface quickly and diverted on to the forest floor.

Condition Where Practice Applies:

Used when the area is entirely rock, *or* when water can be diverted on to undisturbed forest floor.



OUTSLOPED ROAD
(cross-section)

INSLOPING

Definition:

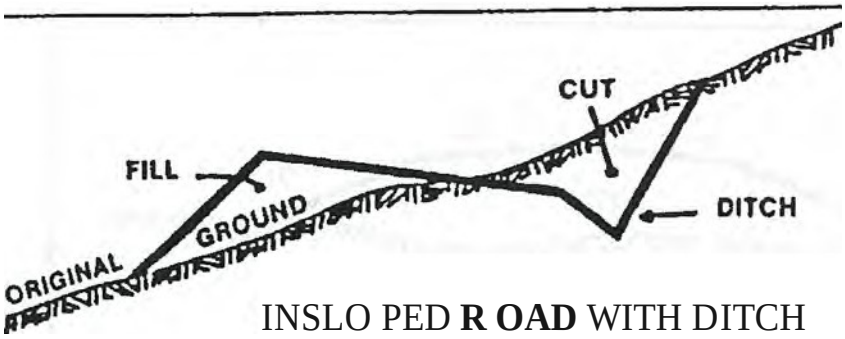
A section of road is sloped slightly (1-3%) toward the cut bank.

Purpose :

Effective way of limiting erosion because water is removed from the road surface quickly and diverted directly to the inside ditch which will carry the water into a culvert.

Condition Where Practice Applies :

Used when the soils are easily saturated or highly erodible. This will limit the amount of ditch water which will flow on to unstable fills.



INSLO PED **R OAD** WITH DITCH
(cross-section)

CROWNING

Oef inition :

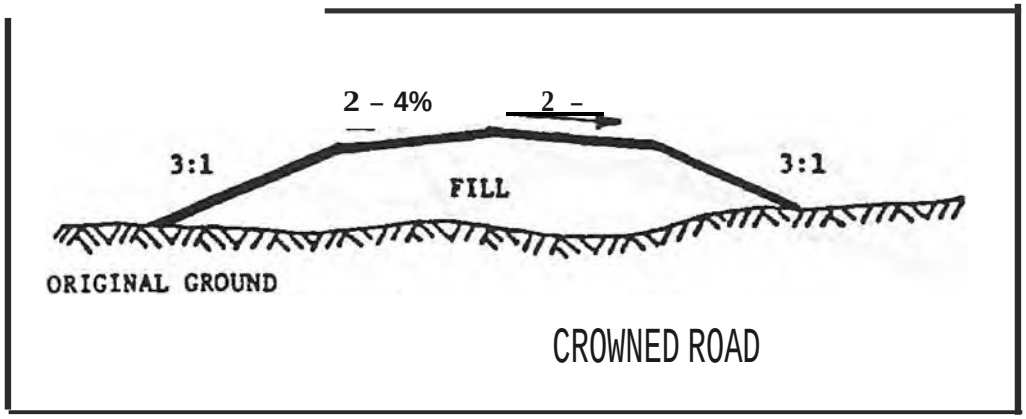
A section of road f s sloped slightly {2-4%)from the center line of the road to the outside edges of the roadbed.

Purpose :

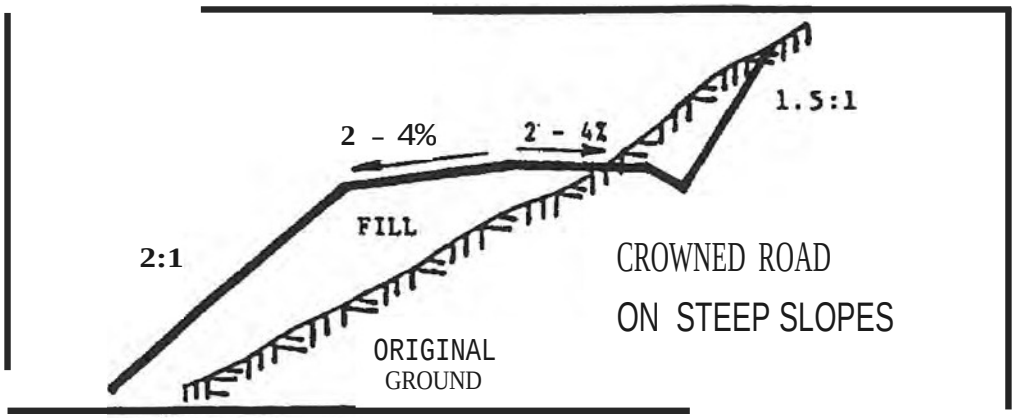
Effective way of 1imitf ng erosion because water is removed from the road surface quickly and diverted directly onto the forest floor or into a ditch which will carry the water into a culvert.

Conditions Where Practice Applies :

Used when soils are easily saturated *or* highly erod;ble when adjacent areas are relatively level with roadbed or on steep side hills.



CROWNED ROAD



CROWNED ROAD
ON STEEP SLOPES

streamside management zone

STREAMSIDE I"1ANAG EIENT ZONE

Streamside Management Zones (SMZs) should be maintained along all perennial streams or where forest disturbances occur and surface runoff will carry sediment loads. SMZs should **be** maintained around streams, ponds, perennial flowing natural springs, and all springs and reseIYoirs serving as domestic water supplies.

The width of SMZs should be varied, depending on the following conditions: slope of land adjacent to stream, soil erodibility, precipitation, knowledge of panicular area, sensitivity of stream, etc. These factors can be obtained from soil maps, on-the-ground evaluation and measurements, weather data, etc.

SMZs should be designed on a case-by-case basis. Most important is that SMZs be consistent with stream characteristics and wide enough *t o* protect water quality.

The following is offered as a guideline:

Soil Type	Percent Slope	SMZ Width **(each** side)
Sli2htlv erodible	*0-5*	35'
Slihtly erodible	5-20	*35-50'*
Slightly erodible	20+	50-160'
Erodible	0-5	35-50'
Erodible	5-20	80' mini mum
Erodible	20 +	160[1] mi ni mu m

[NOTE: Please contact you r local Natura l Resou rces Conservat ion Service office to determine the erodibility factor of the soil before determining t he proper width of the **SMZ.]**

available assistance

Available Assistance

Department of Land & Natural Resources
Division of Forestry and Wildlife
1151Punchbowl Street, Room 325
Honolulu, m 96813
Telephone: (808) 587-0166 Facsimile: (808) 587-0160

Hawaii Branch

P.O. Box 4849
Hilo, Ill 96720-0849
Telephone:(808) 974-4221
Facsimile:(808) 974-4226

Mani Branch

54 High Street
Wailuku, Hi 96793
Telephone: (808) 984-8100
Facsimile: (808) 984-8111

Qabn Brauch

2135 Makiki Heights Drive
Honolulu, In 96822
Telephone: (808) 973-9778
Facsimile: (808) 973-9781

Kauai Branch

3060 Eiwa Street, Rm. 306
Lihue, m 96766-1875
Telephone: (808) 274-3433
Facsimile: (808) 274-3438

Natural Resources Conservation Service
Prince Kubio Federal Bldg., Rm 4-118
Honolulu, ID**96850**
Telephone: (808) 541-2600

Hawaii District Offices

Hilo Office
154 Waianuenue Avenue
Hilo, HI 96720
Telephone: (808) 961-5502

Kealakekua Office
P.O. Box 636
Kealakekua, HI 96750
Telephone: (808) 322-2484

Kamuela Office
P.O. Box 1089
Kamuela, HI 96743
Telephone: (808) 885-6602

Pahala Office
P.O. Box 807
Pahala, ID 96777
Telephone: (808) 928-6185

Natural Resources Conservation Service, cont'd.

Mani District Offices

Wailuku Office
70 S. High Street
Wailuku, lil 96793
Telephone: (808) 2444-3729

Molokai Office
P.o:Box 376
Kaunakakai, m 96748
Telephone: (808) 567-6530

Kanai District Office

Lihue Office
4334 Rice Street, Rm. 104
Lihue, lll 96766
Telephone: (808) 245-6513

Consulting Foresters

Contact the Division of Forestry and Wildlife at (808) 587-0166 for the latest list.

NOTES

Suggested Readings

1 Logging Roads and Skid Trails, A Guide for Soil Protection and Timber Access," Indiana Department of Natural Resources - Division of Forestry, 21 pp.

2 Dcllberg, Robert A., "Road Building for Small Private Roads," Mendocino County Resource Conservation District, Ukiah, CA., July 1992, 73 pp.

3 Walbridge, T.A. Jr., "The Direct Location of Forest Roads," Virginia Polytechnic and **State** University, Blacksburg, **VA.,** 1990, 70 pp.

4 Walbridge, T.A.Jr., "The Paper Location of Forest Roads," Virginia Polytechnic and **State** University, Blacksburg, **VA.** , 1990, 75 pp.

5 Walbridge, T.A. Jr., "Field Tables for the Direct Location of Forest Roads," Virginia Polytechnic and State University, Blacksburg, VA., 1991, 15 pp.

6 Wenger, Karl F., "Forestry Handbook, Second Edition," Society of American Foresters, 1984, 1.335 pp.

7 "f.rosion and Sediment Control Guide for Hawaii," Soil Conservation Service, 1981, 178 pp.

STATE OF HAWAII
STATE PROCUREMENT OFFICE

CERTIFICATE OF VENDOR COMPLIANCE

This document presents the compliance status of the vendor identified below on the issue date with respect to certificates required from the Hawaii Department of Taxation (DOTAX), the Internal Revenue Service, the Hawaii Department of Labor and Industrial Relations (DUR), and the Hawaii Department of Commerce and Consumer Affairs (DCCA).

Vendor Name: **KAUPAKUEA ORCHARDS, LLC**

OBA/Trade Name: **KAUPAKUEA ORCHARDS, LLC**

Issue Date: **04/23/2014**

Status: **Compliant**

Hawaii Tax#:
FEIN/SSN#: XX-XXX6800
UI#: No record
DCCA FILE#: 89665

Status of Compliance for this Vendor on issue date:

Form	Department(s)	Status
A-6	Hawaii Department of Taxation	Compliant
	Internal Revenue Service	Compliant
COGS	Hawaii Department of Commerce & Consumer Affairs	Compliant
LIR27	Hawaii Department of Labor & Industrial Relations	Compliant

Status Legend:

Status	Description
Exempt	The entity is exempt from this requirement
Compliant	The entity is compliant with this requirement or the entity is in agreement with agency and actively working towards compliance
Pending	The entity is compliant with DUR requirement
Submitted	The entity has applied for the certificate but it is awaiting approval
	The entity is not in compliance with the requirement and should contact the issuing agency for more information

Not
Compliant