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

October 11, 2013

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

Land Board Members:

SUBJECT: REQUEST APPROVAL OF A FOREST STEWARDSHIP AGREEMENT WITH KAUPAKUEA ORCHARDS, LLC TO PARTICIPATE IN THE STATE FOREST STEWARDSHIP PROGRAM, TMKS (3) 2-8-003-009 AND (3) 2-8-003-010, HAMAKUA DISTRICT, ISLAND OF HAWAII.

BACKGROUND:

The State of Hawaii 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 Hawaii, including but not limited to: groundwater production, decreased soil erosion, wildlife habitat, timber production, recreational and educational opportunities, and local jobs. The assistance provided by the 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 program was established through Chapter 195 F-6, Hawaii Revised Statutes (HRS). Annual funding is provided by the Conveyance Tax Chapter 247-7, HRS, whereby twenty-five percent of the amount collected from this tax is paid into the Natural Area Reserve Fund. The Department of Land and Natural Resources (DLNR) currently has the authority to use $500,000 per year to fund approved Forest Stewardship projects in order to provide financial assistance for private landowners to manage, protect, and restore important natural forest resources on forested and formerly forested properties. The Forest Stewardship Program is implemented pursuant to Chapter 195-F, HRS, and Hawaii Administrative Rules (HAR) Chapter 109. 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 to develop of a long-term Forest Stewardship management plans that are submitted to and reviewed by

the Forest Stewardship Advisory Committee (FSAC). Landowners interested in FSP submit an application to the FSAC which recommends the development of a Forest Stewardship management plan based on eligibility requirement and to ensure the proposed project is in line with the programs' goals of conservation, restoration and/or forest production. Landowners then create a forest management plan that is reviewed by Division staff and the FSAC. The committee then recommends the management plan for approval by the Division and Department.

The award of cost-share support for Forest Stewardship management plan implementation follows a similar process to the development of a management plan. Upon approval of a project's Forest Stewardship management plan, the FSAC reviews the implementation schedule and budget summary to ensure that the practice costs are reasonable and follow the program's previously approved cost-share rates. The FSAC recommends cost-share support for project implementation based on the 10-year implementation schedule in the approved Forest Stewardship management plan. After review by the Division, the request is then submitted to the Board of Land and Natural Resources (BLNR) for consideration. Review and approval of the Forest Stewardship project and management plan as well as authorization of cost-share support for the project by the BLNR is required in order for Department of Land and Natural Resources to enter into the Forest Stewardship Agreement with the landowner. The Division has previously worked with the Department of the Attorney General on developing a Forest Stewardship Agreement template (Exhibit A). Following authorization by the BLNR the landowner is required to enter into a Forest Stewardship Agreement that commits them to implementing their approved management plan over the next 10-years and authorizes state cost-share reimbursement for their project.

The Kaupakuea Orchards Forest Stewardship project proposes to convert approximately 23 acres (23.27 acres) from non-native grassland to a forested landscape of native riparian area and hardwood plantation. The larger property, tax map key (TMK) numbers (3)2-8-003-009 and (3)2-8-003-010, 20.00336 and 21.461158 acres respectively, is designated by the County of Hawaii as Ag-20 in the Hilo-Honomu area of Hawaii County and is designated as Agriculture under the State of Hawaii Land Use Designation. Prior land use includes sugar production, rotating ginger, and cattle ranching. The vision for Kaupakuea Orchards project is to restore forest cover on the upper elevation portions of each TMK by (1) establishing plantations of several high value hardwood species; (2) protect and expand the existing native forest cover along the stream area by controlling invasive weed species and restore a native vegetated buffer along the stream; and (3) provide long-term funding for the project through periodic selection harvests of non-native timber plantations. The FSAC approved the Kaupakuea Orchards Forest Stewardship management plan on May 10, 2013 and the State Forester/Division Administrator approved the management plan on September 27, 2013 (Exhibit B).

DISCUSSION:

The Division is requesting approval of a Forest Stewardship Agreement for the implementation of the Kaupakuea Orchards Forest Stewardship Management Plan and project. Over the course of the 10-year management plan Kaupakuea Orchards, LLC intends to restore a native forest buffer along streams on the property and establish hardwood plantations throughout the rest of the project area. The project management prescriptions and practices will include 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 and site over the next 10 years.

Timber Stand Establishment: Two of the primary goals of the project are to restore forest cover by establishing high value hardwood plantations that will provide surrounding communities with a local source of timber materials, which will ultimately provide long-term funding to sustain ongoing management through periodic selective harvests. Approximately 18 acres of the Kaupakuea Orchards Forest Stewardship project will be dedicated to primarily non-native, non-invasive hardwood plantations. Proposed plantation species for the project include: tropical cedar (*Cedrella odorota*), Mexican cypress (*Cupressus lusitanica*), blue marble (*Elaeocarpus angustifolius*), rainbow eucalyptus (*Eucalyptus deglupta*), ʻōhiʻa (*Metrosideros polymorpha*), East Indian rosewood (*Dalbergia latifolia*), tallowwood (*Eucalyptus microcorys*), narra (*Pterocarpus indicus*), monkeypod (*Samanea saman*), pheasantwood (*Senna siamea*), koa (*Acacia koa*), Honduran mahogany (*Sweitenia macrophlla*), trumpet tree (*Tabebuia rosea*), and teak (*Tectona grandis*). Experimental plantings of these species will be conducted during the first two years of the project to evaluate the growth and shape the species. All of the proposed species have been screened by the Hawaii Pacific Weed Risk Assessment and have either a low risk score or were evaluated to be a low risk at the project site. Trees will be pruned throughout the project period to ensure form consistent with a commercial planting and will be harvested in 40-45 year rotations.

Public environmental benefits provided by the timber portion of the Kaupakuea Orchards Forest Stewardship project include groundwater production, decreased soil erosion, timber production and local job opportunities.

Payback of State Funds: In accordance with Hawaii Administrative Rule Chapter 109, Sections 13-109-11: Payback Provision, the BLNR may require a payback provision for projects that have a forest production component to their projects. The BLNR may require that a certain percentage of all matching State funds provided under the Forest Stewardship Agreement be paid back to the program upon each commercial harvest or sale as set forth by the contract between the BLNR and applicant. A commercial timber harvest is defined as a certain minimum volume of timber removed per acre from a minimum acreage of the applicant's project as determined by the Division or as set forth in the contract between the BLNR and the applicant.

The amount of cost-share requested for the timber component of the Kaupakuea Orchards Forest Stewardship project is $55,280. The Division is recommending that 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. The recommendation is consistent with previous FSP projects that contain a timber production component implemented under the program. The Division is requesting that the Board define a commercial timber harvest for the Kaupakuea Orchards Forest Stewardship project as any volume of timber sold within one month period that generates revenue greater than or equal to $1000 gross.

Stream Management Zone Restoration: Kaupakuea Orchards, LLC recognizes that although plantations provide many ecological benefits, production forestry may not be appropriate for all areas of the property, especially in regards to impacts to riparian areas. Therefore approximately 4.5 acres of the Forest Stewardship project is focused on establishing a native forest buffer adjacent to the existing waterway. Management prescription for this portion of the project will include fencing to exclude non-native ungulates, invasive species control, and native forest establishment. To emulate natural forest structure and composition, the native species plantings in the forest buffer will feature native shrubs as well as trees, including mamaki (*Pipturus albidus*), naio (*Myoporum sandwicense*), and pilo (*Coprosma spp*); understory plantings will include uluhe (*Dicranopteris linearis*) and hapu'u (*Cibotium glaucum*) ferns.

These native forest buffers will provide additional public benefits from the project including: wildlife habitat, increased native plant habitat, and a reduction in sediment and nutrient loading into the Waia'ama stream and Ālia stream.

A total of $77,945 in State Forest Stewardship funding is requested to provide cost-share support for the Kaupakuea Orchards Forest Stewardship project, who will be contributing an additional $77,945 toward the completion of the project over the 10 year period of the management plan. The costs associated with the proposed practices are consistent with the intensity of management required for this type of project. Cost-share funds are provided as reimbursement payments for implementation of approved management practices through the State fiscal year 2024. In addition, Kaupakuea Orchards, LLC has agreed to 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.

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 has 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 (Exhibit C). 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. In summary of the Final Environmental Assessment prepared by Kaupakuea Orchards, LLC:

1) The project plans to replace invasive species with native species and high value hardwood species which will expand the area on Hawai'i Island dedicated to native forest protection;
2) The project will manage all proposed forestry activities to be consistent with State of Hawai'i Best Management Practices;
3) The proposed project is consistent with HRS 344 in that the project will not conflict with the long-term goals of State environmental policies or guidelines;
4) The project is not anticipated to have any cumulative adverse effects;

5) The parcels currently contain almost no native Hawaiian plants or fauna and restoration of the stream corridors will improve habitat for native flora and fauna;
6) The project will have a net positive economic benefit for the local community during the establishment and maintenance phases of the timber planting;
7) There are no known public health concerns associated with the proposed project.

Therefore, the Division recommends that the Board accept the Finding of No Significant Impact for the Kaupakuea Orchards Forest Stewardship project. Should the Kaupakuea Orchards, LLC propose any future use of the land that triggers Chapter 343, HRS, Kaupakuea Orchards, LLC shall be responsible for compliance with Chapter 343, HRS, as amended.

RECOMMENDATIONS:

That the Board:

1. Approve the Kaupakuea Orchards Forest Stewardship project and Forest Stewardship management plan;

2. Approve cost-share support in the amount of $77,945 for the implementation of the Kaupakuea Orchards Forest Stewardship management plan;

3. Approve the Final Environmental Assessment for the Kaupakuea Orchards Forest Stewardship project and Accept the Finding of No Significant Impact;

4. Authorize the Chairperson to amend, finalize and execute a 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;
    B. Review and approval as to form of the Forest Stewardship Agreement by the Department of the Attorney General.

Respectfully submitted,

for Roger H. Imoto, Administrator
Division of Forestry and Wildlife

Attachment: (Exhibit A, B and C)

APPROVED FOR SUBMITTAL:

William J. Aila, Jr., Chairperson

Exhibit A

STATE OF HAWAII
FOREST STEWARDSHIP AGREEMENT

This AGREEMENT, made this _____ day of _____ _____, 20___, by and between the BOARD OF LAND AND NATURAL RESOURCES, STATE OF HAWAII ("STATE"), by its Chairperson, whose address is 1151 Punchbowl Street, Honolulu, Hawaii 96813, and _____, ("LANDOWNER") whose address and federal and state taxpayer identification numbers are as follows:_____

_____

_____

Business address

Federal and state taxpayer identification numbers

RECITALS

WHEREAS, Chapter 195F, Hawaii Revised Statutes (HRS), provides for the establishment of a forest stewardship program to encourage and assist private landowners in managing, protecting, and restoring important watersheds, native vegetation, fish and wildlife habitats, isolated populations of rare and endangered plants, and other forest lands that are not recognized as potential natural area reserves; and

WHEREAS, in accordance with HRS Chapter 195F and Title 13, Subtitle 5, Part 1, Chapter 109 of the Hawaii Administrative Rules (HAR), the LANDOWNER has applied, and qualifies, for participation in the forest stewardship program; and

WHEREAS, the LANDOWNER has submitted a forest stewardship management plan, as set forth in Exhibit A hereto, that the STATE agrees is consistent with the policies, goals, and objectives of the forest stewardship program; and

WHEREAS, the STATE desires to assist the LANDOWNER in implementing the forest stewardship management plan with financial and other assistance; and

WHEREAS, money is available to fund this agreement pursuant to: Act 195, SLH 1993, Hawaii Revised Statutes, Section 247-7.

NOW, THEREFORE, in consideration of the promises contained in this AGREEMENT, the STATE and the LANDOWNER agree as follows:

A. SCOPE OF SERVICES

The LANDOWNER hereby agrees to implement the forest stewardship management plan set forth in Exhibit A and the project described in the "Scope of Services" set forth in Attachment S1 in proper and satisfactory manner as determined by the STATE, both of which are hereby made a part of this AGREEMENT. The STATE hereby agrees to assist the LANDOWNER in implementing the forest stewardship management plan, all in accordance with the terms and conditions set forth in Attachments S1, S2, S3, S4, S5, and S6, attached hereto.

B. COMPENSATION

The LANDOWNER shall be compensated for performance of the project under this AGREEMENT according to the "Compensation and Payment Schedule," set forth in Attachment S2, which is hereby made a part of this Agreement.

C. TIME OF PERFORMANCE

The performance required of the LANDOWNER under this AGREEMENT shall be completed in accordance with the "Time of Performance" set forth in Attachment S3, which is hereby made a part of this AGREEMENT.

D. CERTIFICATE OF EXEMPTION FROM CIVIL SERVICE

The "State of Hawaii Certificate of Exemption from Civil Service," set forth in Attachment S4, is hereby made a part of the AGREEMENT.

E. OTHER TERMS AND CONDITIONS

The "State of Hawaii Special and General Conditions for Forest Stewardship Program Agreements," set forth in Attachment S5, and the General Conditions attached hereto, are hereby made a part of this AGREEMENT. For the purposes of this AGREEMENT the term "CONTRACTOR" in the "General Conditions" shall mean the LANDOWNER.

F. STANDARDS OF CONDUCT DECLARATION

The "Standards of Conduct Declaration" by LANDOWNER, set forth in Attachment S6, is hereby made a part of this AGREEMENT. For the purposes of this AGREEMENT the term "CONTRACTOR" in the "Standards of Conduct Declaration" shall mean the LANDOWNER.

IN WITNESS WHEREOF, the parties execute this AGREEMENT by their signatures to be effective as of the date first above written.

STATE

By _____
Chairperson of the Board of Land and Natural Resources

_____
Print Name

Date_____

LANDOWNER

By_____

_____
Print Name

Date_____

Approved by the Board of
Land and Natural Resources on

_____.

APPROVED AS TO FORM:

_____
Deputy Attorney General

Exhibit A

LANDOWNER'S ACKNOWLEDGMENT

STATE OF HAWAII)
) SS.
COUNTY OF _____)

On this _____ day of _____, 20____, before me personally appeared_____, to me personally known, who being by me duly sworn, did say the he/she is the_____ _____, the LANDOWNER named in the foregoing instrument, and the he/she is authorized to sign said instrument on behalf of the LANDOWNER, and acknowledges that he/she executed said instrument as the free act and deed of the LANDOWNER.

_____
Notary Public, State of Hawaii

_____

My Commission Expires:_____

Date of the Notarized Document: _____
Number of Pages: _____
Identification or Description of the Document being Notarized: _____
_____
_____
Printed Name of Notary: _____ _____ Circuit
_____
Notary's Signature and Notary's Official Stamp or Seal Date

STATE OF HAWAII

CONTRACTOR'S STANDARDS OF CONDUCT DECLARATION

For the purposes of this declaration:

"Agency" means and includes the State, the legislature and its committees, all executive departments, boards, commissions, committees, bureaus, offices; and all independent commissions and other establishments of the state government but excluding the courts.

"Controlling interest" means an interest in a business or other undertaking which is sufficient in fact to control, whether the interest is greater or less than fifty per cent (50%).

"Employee" means any nominated, appointed, or elected officer or employee of the State, including members of boards, commissions, and committees, and employees under contract to the State or of the constitutional convention, but excluding legislators, delegates to the constitutional convention, justices, and judges. (Section 84-3, HRS).

On behalf of _____, CONTRACTOR, the undersigned does declare as follows:

1. CONTRACTOR ☐ is* ☐ is not a legislator or an employee or a business in which a legislator or an employee has a controlling interest. (Section 84-15(a), HRS).
2. CONTRACTOR has not been represented or assisted personally in the matter by an individual who has been an employee of the agency awarding this Contract within the preceding two years and who participated while so employed in the matter with which the Contract is directly concerned. (Section 84-15(b), HRS).
3. CONTRACTOR has not been assisted or represented by a legislator or employee for a fee or other compensation to obtain this Contract and will not be assisted or represented by a legislator or employee for a fee or other compensation in the performance of this Contract, if the legislator or employee had been involved in the development or award of the Contract. (Section 84-14 (d), HRS).
4. CONTRACTOR has not been represented on matters related to this Contract, for a fee or other consideration by an individual who, within the past twelve (12) months, has been an agency employee, or in the case of the Legislature, a legislator, and participated while an employee or legislator on matters related to this Contract. (Sections 84-18(b) and (c), HRS).

CONTRACTOR understands that the Contract to which this document is attached is voidable on behalf of the STATE if this Contract was entered into in violation of any provision of chapter 84, Hawaii Revised Statutes, commonly referred to as the Code of Ethics, including the provisions which are the source of the declarations above. Additionally, any fee, compensation, gift, or profit received by any person as a result of a violation of the Code of Ethics may be recovered by the STATE.

CONTRACTOR

By _____
(Signature)

Print Name _____

Print Title _____

Name of Contractor _____

_____

Date _____

* Reminder to Agency: If the "is" block is checked and if the Contract involves goods or services of a value in excess of $10,000, the Contract must be awarded by competitive sealed bidding under section 103D-302, HRS, or a competitive sealed proposal under section 103D-303, HRS. Otherwise, the Agency may not award the Contract unless it posts a notice of its intent to award it and files a copy of the notice with the State Ethics Commission. (Section 84-15(a), HRS).

STATE OF HAWAII

SCOPE OF SERVICES

SECTION 1 - SCOPE OF WORK

1.1 MANAGEMENT AREA - The project area to be managed is the _____ Forest Stewardship project area; TMK NUMBER(S) _____as designated on maps found in _____to this AGREEMENT.

1.2 THE PRIMARY OBJECTIVES - The STATE and LANDOWNER shall direct their efforts under this AGREEMENT to do the following: fund the management of and manage the natural resources of the _____ Forest Stewardship project area ("Forest Stewardship project area") in accordance with the MANAGEMENT PLAN, attached as _____ to this AGREEMENT, and all approved amendments thereto, with the intention of _____ in the ..... community.

1.3 SCOPE OF WORK - The LANDOWNER shall perform the following technical and professional services:

(a) Management plan. The LANDOWNER shall carry out the management activities outlined in the approved MANAGEMENT PLAN, attached as _____ to this AGREEMENT.

(b) Consultation. The LANDOWNER shall be available for consultation regarding progress, upon request by the STATE.

1.4 AUTHORITY TO CARRY OUT MANAGEMENT PLAN - The LANDOWNER hereby represents that it has authority to carry out the MANAGEMENT PLAN and that it is the landowner of "Forest Stewardship project area" as defined in Section 195F-2, Hawaii Revised Statutes, as amended.

1.5 NO INCONSISTENT ACTIVITIES - The LANDOWNER shall not take any action on the "Forest Stewardship project area", which will undermine or conflict with the approved MANAGEMENT PLAN.

II. SECTION 2 - CONTROL AND PROGRESS OF THE WORK

STATE OF HAWAII

SCOPE OF SERVICES

2.1 REPORTS - The LANDOWNER shall submit to the STATE, reports showing work accomplished at the following times:

(a) Progress Reports. A progress report shall be due on December 31 of each year under this AGREEMENT for which funding has been approved. This report shall include a description of the approved MANAGEMENT PLAN accomplishments and activities, areas needing technical advice, an accounting of expenditures with documentation, and proposed modifications to the current year's management activities. This report shall be submitted to the STATE within 30 days following the due date. If the LANDOWNER would like more than 2 reimbursements per year, a progress report shall accompany each reimbursement request and the "Forest Stewardship project area" shall be made available for a site visit by Department of Land and Natural Resources personnel.

(b) Annual Report. An annual report shall be due on or before June 30 of each year under this AGREEMENT for which funding has been approved. In the event the contract is executed less than 6 months prior to June 30, then no annual report is due on June 30 of that year. This report shall include a description of MANAGEMENT PLAN accomplishments and activities, areas needing technical advice, and proposed modifications to the next year's approved management objectives, projects and budget. This report shall also include a detailed accounting of expenditures for the preceding 12-month period to provide the basis for the annual reconciliation of the STATE's and the LANDOWNER's respective shares of funding as determined pursuant to Attachment S2, Section 1.1. This report shall be submitted to the STATE within 60 days of due date. This report may also request, subject to approval by the STATE, changes to the management plan, for either or both the practice implementation schedule and/or the budget/payment schedule in order to best consolidate and rectify the past year's outcomes or lack thereof.

STATE OF HAWAII

SCOPE OF SERVICES

2.2 DELEGATION OF AUTHORITY - As used herein and throughout this AGREEMENT, unless the context clearly indicates otherwise, the STATE shall include the State of Hawaii Department of Land and Natural Resources and its authorized employees, agents and representatives.

STATE OF HAWAII

COMPENSATION AND PAYMENT SCHEDULE

SECTION 1 – PAYMENT

1.1 SCOPE OF PAYMENT -

(a) STATE's Payment. In full satisfaction of the STATE's funding share of the approved MANAGEMENT PLAN, which is contingent upon satisfactory completion by the LANDOWNER of the management activities described in the approved MANAGEMENT PLAN, attached as Exhibit A to this AGREEMENT, the STATE agrees to pay the LANDOWNER a total sum not to exceed ___ . 00/100 Dollars ($_____) according to the schedule outlined below that includes fiscal year 20XX through 20XX for completion of the management activities described in the approved MANAGEMENT PLAN. Payments shall be made by the STATE to the LANDOWNER as partial annual reimbursements for actual expenditures made by the LANDOWNER in completing the management activities described in the approved MANAGEMENT PLAN only after the corresponding progress or annual report has been reviewed by the STATE and all reported management activity accomplishments have been verified following an inspection of the "Forest Stewardship project area" by the STATE. Actual expenditures may include but are not limited to in-kind services such as heavy equipment operation and sources of labor. All funds to be paid by the STATE to the LANDOWNER shall be encumbered on an annual basis for the forthcoming fiscal year provided that the STATE has approved the continuation of management activities outlined in ..... of this AGREEMENT for the forthcoming fiscal year.

If in any fiscal year the allocated annual funds are not exhausted due to the LANDOWNER not completing all management activities described in the MANAGEMENT PLAN for that year, the LANDOWNER may request that these funds be incorporated in the following year's encumbrances to complete the management activities which were not completed. If there are sufficient funds available to accommodate LANDOWNER's request and the STATE approves the

request, this change will be incorporated by written amendment to the AGREEMENT.

If in any fiscal year the STATE does not appropriate, and/or the STATE does not approve the expenditure of, funds sufficient to meet the STATE's funding share of the approved MANAGEMENT PLAN, this AGREEMENT shall automatically terminate without penalty at the end of the last fiscal year for which any funds have been appropriated and approved, subject to Attachment S5, Section 4.1, regarding partial State funding.

(b) LANDOWNER's Share. In full satisfaction of the LANDOWNER's funding share of the approved MANAGEMENT PLAN, the LANDOWNER agrees to fully complete the management activities described in the approved MANAGEMENT PLAN, and to initially assume all corresponding actual annual expenditures in expectation of the STATE's partial reimbursement for satisfactory completion of these management activities. Expenditures for implementation of the approved MANAGEMENT PLAN which are less than the amounts allocated in the approved budget may be made by the LANDOWNER in its discretion so long as the quality of materials and work as called for in the approved MANAGEMENT PLAN are not adversely affected.

STATE OF HAWAII

COMPENSATION AND PAYMENT SCHEDULE

PATRICK & SHEILA CONANT FOREST STEWARDSHIP

PROJECT BUDGET/PAYMENT SCHEDULE:

YEAR	Total Budget	Land Owner share	State Share
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
Total			

1.2 PAYMENT SCHEDULE –

(a) Progress Payment. Within 30 days following receipt of the progress report as provided in Attachment S1, Section 2.1(a) for each year for which the STATE has agreed to pay the LANDOWNER as outlined in the schedule above and for which funding has been appropriated, the STATE shall pay to the LANDOWNER a portion of the STATE's funding share of the approved MANAGEMENT PLAN as a partial reimbursement of actual expenditures made to complete approved management activities. This payment shall be subject to the LANDOWNER's satisfactory completion of the corresponding approved management activities described in the approved MANAGEMENT PLAN, attached as Exhibit A to this AGREEMENT, and calculated on the basis of actual expenditures made by the LANDOWNER. This payment shall also be subject to the STATE's approval of such progress report.

(b) Annual/Final Payment. Within 30 days of receipt of the annual report as provided in Attachment S1, Section 2.1(b), the STATE shall pay to the LANDOWNER the balance of the STATE's approved annual funding share. This payment shall be subject to the LANDOWNER's satisfactory completion of the corresponding

annual management activities described in the approved MANAGEMENT PLAN, attached as Exhibit A to this AGREEMENT, and calculated on the basis of actual expenditures made by the LANDOWNER.

(1) Annual or Final Acceptance and Payment - Annual or final acceptance means a written notice from the STATE to the LANDOWNER advising the LANDOWNER of the satisfactory fulfillment of the AGREEMENT's annual or final requirements.

1.3 UNAUTHORIZED WORK - The LANDOWNER shall not receive matching STATE funds for management activities not designated in the approved MANAGEMENT PLAN. All work completed by the LANDOWNER prior to receipt of a fully-executed copy of this AGREEMENT, and prior to STATE approval of funding for any subsequent years and prior to STATE approval of any subsequent amendments to the approved MANAGEMENT PLAN, shall be at the LANDOWNER's own volition and risk, including work performed during the period of any deliberations by the STATE in anticipation of approval; provided, however, that if funding and/or amendments applicable to such work are subsequently approved, the LANDOWNER may be paid for such work even if performed prior to such approval.

SECTION 2 - FISCAL RECORDS MAINTENANCE, RETENTION, AND ACCESS

2.1 The LANDOWNER shall maintain, in accordance with generally acceptable accounting practices, fiscal records and supporting documents and related files, papers and reports that adequately reflect all direct and indirect expenditures and management and fiscal practices materially related to the LANDOWNER's performance of services paid for by State funds under this AGREEMENT.

(a) The STATE, the Comptroller of the State of Hawaii, and any of their authorized representatives, the committees (and their staff) of the Legislature of the State of Hawaii, and the Legislative Auditor of the State of Hawaii shall have the right of access to any book, document, paper, file, or other records of the LANDOWNER

that is materially related to the performance by the LANDOWNER of services funded by the STATE under this AGREEMENT, in accordance with generally accepted audit procedures, for the purposes of monitoring and evaluating the LANDOWNER's performance of services and the LANDOWNER's management program and fiscal practices to assure the proper and effective expenditure of funds under this AGREEMENT; provided, however, that no party conducting any such audit or examination shall copy, distribute, or retain any of such information or records, with the understanding that it is not the intention that the LANDOWNER's financial and other records and information be made public.

(b) The right of access shall not be limited to the required retention period but shall last as long as the records are retained. The LANDOWNER shall retain all records related to the LANDOWNER's performance of services funded under this AGREEMENT for at least 3 years after the date of submission of the LANDOWNER's annual reports for any designated period and payment for such expenditures by the STATE in accordance with its matching share, except that if any litigation, claim, negotiation, investigation, audit, or other action involving the records has been started before the expiration of the 3-year period, the LANDOWNER shall retain the records until completion of the action and resolution of all issues that arise from it or until the end of the regular 3-year retention period, whichever occurs later.

STATE OF HAWAII

TIME OF PERFORMANCE

SECTION 1 - EXECUTION OF AGREEMENT

1.1 EXECUTION OF AGREEMENT - This AGREEMENT shall be promptly executed by the STATE and the LANDOWNER upon approval by each party.

1.2 CERTIFICATION AND APPROVAL OF AGREEMENT - This AGREEMENT shall not be considered binding upon the STATE, unless the availability of the funds therefore has been duly certified as prescribed by Section 103-39, Hawaii Revised Statutes, as amended. Further, this AGREEMENT shall not be considered to be fully executed unless the Office of the Attorney General of the State of Hawaii has approved this AGREEMENT as to form.

SECTION 2 - TERM

2.1 INITIAL TERM - The initial term will be for a minimum of Thirteen (13) years following the completion of any and all management practices for which the LANDOWNER has received cost-share assistance. Accordingly, this AGREEMENT shall commence on the date of full execution hereof and shall be in effect until _____; subject, however to earlier termination as provided in this AGREEMENT.

2.2 STATE FUNDING CONDITION - This AGREEMENT is subject to continued funding of the STATE's share of the approved management budget as outlined in Attachment S2, Section 1.1. Annual funding is provided by the Conveyance Tax pursuant to Act 195, SLH 1993, Section 247-7, Hawaii Revised Statutes, whereby twenty-five percent of the amount collected from this tax shall be paid into the natural area reserve fund from which funds are dispersed to the natural area partnership and forest stewardship programs, and by way of Act 269, SLH 2000 to projects undertaken in accordance with watershed management plans. Payments are then made through the forest stewardship program to reimburse landowners for implementing approved stewardship management practices. Any balance remaining in this fund at the end of any fiscal year shall be carried forward

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into the fund for the next fiscal year. If in any fiscal year the STATE does not appropriate, and/or the STATE does not approve the expenditure of, funds sufficient to meet its share of the approved management budget, this AGREEMENT shall automatically terminate without penalty at the end of the last fiscal year for which any funds have been appropriated and approved, subject to Attachment S5, Section 4.1, regarding partial State funding.

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CERTIFICATE OF EXEMPTION FROM CIVIL SERVICE

1. By Heads of Departments Delegated by the Director of the Department of Human Resources Development ("DHRD").*

Pursuant to a delegation of the authority by the Director of DHRD, I certify that the services to be provided under this Contract, and the person(s) providing the services under this Contract are exempt from the civil service, pursuant to § 76-16, Hawaii Revised Statutes (HRS).

(Signature) _____ (Date) _____

(Print Name) _____

(Print Title) _____

* This part of the form may be used by all department heads and the heads of attached agencies to whom the Director of DHRD expressly has delegated authority to certify § 76-16, HRS, civil service exemptions. The specific paragraph(s) of § 76-16, HRS, upon which an exemption is based should be noted in the contract file. If an exemption is based on § 76-16(b)(15), the contract must meet the following conditions:

(1) It involves the delivery of completed work or product by or during a specific time;
(2) There is no employee-employer relationship; and
(3) The authorized funding for the service is from other than the "A" or personal services cost element.

NOTE: Not all attached agencies have received a delegation under § 76-16(b)(15). If in doubt, attached agencies should check with the Director of DHRD prior to certifying an exemption under § 76-16(b)(15). Authority to certify exemptions under §§76-16(b)(2), and 76-16(b)(12), HRS, has not been delegated; only the Director of DHRD may certify §§ 76-16(b)(2), and 76-16(b)(12) exemptions.

2. By the Director of DHRD, State of Hawaii.

I certify that the services to be provided under this Contract, and the person(s) providing the services under this Contract are exempt from the civil service, pursuant to §76-16, HRS.

(Signature) _____ (Date) _____

(Print Name) _____

(Print Title, if designee of the Director of DHRD) _____

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SPECIAL CONDITIONS

SECTION 1 – INSPECTIONS

1.1 The STATE shall have the right to make inspections of the "Forest Stewardship project area" after prior notice to the LANDOWNER. In addition, the STATE shall be obligated to inspect the work on the "Forest Stewardship project area" not less frequently than once per year under this AGREEMENT, and more frequently in the case of a LANDOWNER default as provided in Section 4.1(d) below or when the LANDOWNER makes more than 2 reimbursement requests per year as provided in Attachment S1, Section 2.1. The STATE shall notify the LANDOWNER within a reasonable time thereafter of any perceived defaults in the LANDOWNER's implementation of the approved MANAGEMENT PLAN. The LANDOWNER hereby represents that it has authority to allow access to the "Forest Stewardship project area" by the STATE in connection with this AGREEMENT, conditional upon receipt of a liability waiver, acceptable to the LANDOWNER for all state personnel visiting the "Forest Stewardship project area".

SECTION 2 - AMENDMENTS

2.1 The LANDOWNER may propose for approval by the STATE, and the STATE may approve, minor alterations to the approved MANAGEMENT PLAN, which will not have a material adverse impact on the achievement of the overall management objectives of the approved MANAGEMENT PLAN. This includes minor changes to the practice implementation schedule and/or changes in the budget/payments schedule so long as the total management activities do not subtract from or exceed the total scope of the approved MANAGEMENT PLAN and the budget/payments schedule does not exceed the total annual budget allocations up to and including the budget request for that year, and so long as the STATE has sufficient funding available to accommodate such a request.

2.1 The LANDOWNER may propose for approval by the STATE, and the STATE may approve, significant changes to the approved MANAGEMENT PLAN or budget to adapt to current conditions. Significant amendments to the approved MANAGEMENT PLAN shall include an amended budget, which will increase the overall STATE's funding share

above the total amount set forth in the approved budget/payment schedule. The STATE shall make the proposed amendments available for public review prior to final approval.

2.3 The proposed amendments may include, without limitation, re-establishment of management priorities, increase or reduction of the specified work, increases to the budget/payments schedule, or time for performance of specified tasks, all as determined considering the natural conditions of the "Forest Stewardship project area," existing management priorities, threats, potential for decline of the natural resource during any period under consideration, availability of specialized labor or technical expertise, permitting requirements and time needed to obtain permits, and other material factors.

2.4 Any proposed expenditures which will increase the overall STATE's funding share above the amount set forth in the approved budget of the approved MANAGEMENT PLAN, which are proposed either as a result of additional costs required to implement the approved MANAGEMENT PLAN or as a result of amendments to the approved MANAGEMENT PLAN, must be mutually agreed upon in advance by and between the STATE and the LANDOWNER. If so agreed upon the approval of these expenditures shall be incorporated in written amendment to this AGREEMENT.

2.5 Economic Hardship. Notwithstanding other provisions of this AGREEMENT, in the event that the LANDOWNER determines in good faith that it is financially unable without undue economic hardship to fulfill its funding share as provided in Attachment S2, Section 1.1(b), or to carry out fully the management activities described in the approved MANAGEMENT PLAN, attached as Exhibit A to this AGREEMENT, within the budget and time period established thereby, the LANDOWNER may apply to the STATE to renegotiate the terms thereof.

(a) Negotiation of Amendment. In such event, the STATE and the LANDOWNER shall meet and negotiate in good faith an acceptable amendment to the approved MANAGEMENT PLAN that seeks to accomplish the significant objectives of the approved MANAGEMENT PLAN reasonably within the LANDOWNER's

financial means. The amendment may include, without limitation, re-establishment of management priorities and reduction and/or deferral of the specified work, involving significant costs, and/or extension of time for performance of specified tasks, all as determined considering the natural conditions of the "Forest Stewardship project area," existing management priorities, threats, potential for decline of the natural resource during any period under consideration, other potential sources of funding, and other material factors.

(b) Disputes. If the STATE and the LANDOWNER are unable to agree reasonably and in good faith on a suitable amendment to the approved MANAGEMENT PLAN, the parties shall refer any such disputes to arbitration as provided in the General Conditions, Section 11.

(c) No Termination for Economic Hardship. This provision shall not be construed to allow the LANDOWNER or the STATE to terminate this AGREEMENT for economic hardship; it is rather intended to provide a mechanism for reasonable revisions to the approved MANAGEMENT PLAN for economic hardship.

SECTION 3 - PAYBACK OF STATE FUNDS

3.1 In the event that the LANDOWNER sells, conveys, or otherwise transfers LANDOWNER's right, title, or interest in the "Forest Stewardship project area," or any portion thereof, during the initial term of this AGREEMENT as defined in Attachment S3, Section 2.1, the LANDOWNER shall within 90 days of the sale, conveyance or transfer of title or interest in the "Forest Stewardship project area," pay back to the STATE a portion of the amount paid by the STATE to the LANDOWNER pursuant to this AGREEMENT. The amount to be paid back to the STATE shall be that fraction of the total matching funds received by the LANDOWNER under this AGREEMENT that is equal to the fraction of the "Forest Stewardship project area" that is sold, conveyed or otherwise transferred by the LANDOWNER.

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3.2 In the event that the LANDOWNER sells, conveys, or otherwise transfers LANDOWNER's right, title, or interest in the "Forest Stewardship project area," or any portion thereof, during the initial term of this AGREEMENT as defined in Attachment S3, Section 2.1, the LANDOWNER will not be required to reimburse the STATE as set forth in Attachment S5, Section 3.1 for the cost-share assistance received if the person(s) who acquire the property contractually agree to assume full responsibility for this AGREEMENT for the initial term of the AGREEMENT, including but not limited to management and financial responsibilities and penalties contained herein. See Agenda Item _____, as amend, approved at the Board of Land and Natural Resources ..... meeting. Nothing in this provision shall relieve the LANDOWNER of its obligations under this AGREEMENT.

SECTION 4 - TERMINATION; DEFAULT; PENALTY PAYBACK

4.1 TERMINATION OF THE AGREEMENT - It is mutually agreed that this AGREEMENT may be terminated for any one of the following reasons on the following terms:

(a) No State Funding. This AGREEMENT shall be terminated if the STATE does not approve funding for the forthcoming fiscal year of the approved MANAGEMENT PLAN. In such event, this AGREEMENT shall automatically terminate without penalty at the end of the funding period then in effect.

(b) Partial State Funding. This AGREEMENT may be terminated by the LANDOWNER if the STATE approves only a portion of its share of funding for the forthcoming fiscal year as outlined in the budget provided in the approved MANAGEMENT PLAN.

(1) In such event, the LANDOWNER shall elect, by written notice to the STATE, either:

(A) to terminate this AGREEMENT without penalty at the end of the funding period then in effect; or

(B) to revise the approved MANAGEMENT PLAN and budget in the LANDOWNER's reasonable discretion to accomplish significant management goals which can reasonably be funded with the amount of STATE funding actually approved.

(c) Transfer to Government Agency. This AGREEMENT may be terminated without penalty if the "Forest Stewardship project area" is transferred or sold to a government agency committed to forest stewardship and that possesses the technical and professional skills to manage the "Forest Stewardship project area" natural resources.

(d) LANDOWNER Default. This AGREEMENT may be terminated by the STATE upon substantial evidence that progress being made by the LANDOWNER in carrying out the approved MANAGEMENT PLAN is inadequate, incorrect, or insufficient to substantially complete on a timely basis the work called for in the approved MANAGEMENT PLAN subject to the lack of performance notification provisions set forth below.

(1) Penalties Apply. In the event of termination for default in accordance with these provisions, the penalty payback provisions set forth below shall apply.

(2) Lack of Performance Notification. In such event, the STATE may terminate for default, provided the STATE adheres to the following procedures for notice and opportunity to cure prior to termination:

(A) The STATE shall first notify the LANDOWNER in writing of any perceived inadequacy, incorrectness or insufficient progress. The STATE and the LANDOWNER shall meet within two weeks

thereafter, and every three months thereafter until one year following the date of the notice, and discuss in good faith the perceived failure and the reasons therefore and any subsequent progress or lack thereof. If the reason for the failure is a good faith inability of the LANDOWNER to carry out the terms of the MANAGEMENT PLAN for reasons beyond the LANDOWNER's reasonable control, including without limitation economic hardship as described in Attachment S5, Section 2.5 above, the STATE and the LANDOWNER shall specifically consider the need to amend the approved MANAGEMENT PLAN, including extending the time to carry out the work called for in the approved MANAGEMENT PLAN and/or revising the budget established in the approved MANAGEMENT PLAN, subject to the provisions of Attachment S1, Section 1.5 and Attachment S5, Section 2 of this AGREEMENT regarding amendments to this AGREEMENT and the approved MANAGEMENT PLAN. Following the date of the notice, the STATE shall be obligated to inspect the "Forest Stewardship project area" once each quarter after notifying the LANDOWNER, to determine the updated status of the perceived default.

(B) Following the expiration of the one year period following notice of default given by the STATE to the LANDOWNER and failure of the LANDOWNER to remedy the default, or to make significant progress to remedy the default if by its nature the default cannot reasonably be remedied within one year, the STATE may elect to notify the LANDOWNER of its intention to terminate this AGREEMENT for default. Such notice shall be in writing, shall state that the STATE will terminate the AGREEMENT for default on a date not less than 3 months thereafter if the LANDOWNER

does not remedy the default, or to make significant progress to remedy the default if by its nature the default cannot reasonably be remedied within 3 months, and shall specify that penalties as provided under this AGREEMENT shall apply.

(C) If the LANDOWNER fails to remedy the default within 3 months thereafter, or to make significant progress to remedy the default if by its nature the default cannot reasonably be remedied within 3 months, the STATE may terminate this AGREEMENT effective immediately for default by written notice thereof to the LANDOWNER.

(D) The STATE shall be deemed to have complied with these provisions if it attempts in good faith to meet with the LANDOWNER and to inspect the "Forest Stewardship project area" as provided above, whether or not the LANDOWNER cooperates in such procedures.

(3) All disputes regarding default and termination under this AGREEMENT, which cannot be resolved by the parties, shall be referred to arbitration as provided in the General Conditions, Section 11.

(4) If the LANDOWNER has not fully performed its work under this AGREEMENT on expiration or termination of this AGREEMENT, the STATE may withhold the final payment to the LANDOWNER pending full completion of the LANDOWNER's work. This withheld payment shall be paid by the STATE to the LANDOWNER on final acceptance and tax clearance as provided in Attachment S2, Section 1.2 (b) and the General Conditions, Section 17.

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4.2 PENALTY PAYBACK -

(a) Payback and Penalties. In the event that the LANDOWNER defaults on this AGREEMENT as provided in Attachment S5, Section 4.1(d) above and the STATE has followed the Lack of Performance Notification procedures as outlined in Attachment S5, Section 4.1(d)(2) above, the LANDOWNER shall promptly pay to the STATE the following payback and penalty monies:

(1) Refund of State Funds - 3 Years. All funds paid from the initial date of this AGREEMENT by the STATE to the LANDOWNER in the previous 3 years (or such portion thereof as STATE shall have funded if this AGREEMENT shall have been in effect for less than 3 years) shall be returned to the STATE. In the event that this AGREEMENT shall have been in effect for more than 3 years, the LANDOWNER shall be liable to pay back State funds for the immediately preceding 3 years. In addition, the LANDOWNER shall pay to the STATE a penalty of two percent of the total of funds that are returned to the STATE.

(b) No Other Party Liable. Only the LANDOWNER receiving State funding under the FOREST STEWARDSHIP PROGRAM shall be liable to the STATE under this AGREEMENT for the payback and penalty.

(c) Disputes. The LANDOWNER shall have the right to submit any disputes to the arbitration procedure as outlined in the General Conditions, Section 11 if it feels that the imposition of payback, and/or additional penalties is unwarranted.

4.3 VIOLATIONS OF AGREEMENT - It is expressly understood and agreed that violations which are not caused by the LANDOWNER shall not constitute or give rise to a default by the LANDOWNER under this AGREEMENT and no penalty provisions shall apply to the LANDOWNER.

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4.4 EFFECT OF EMINENT DOMAIN -

(a) Full Condemnation. If any action in eminent domain for the condemnation of the fee title of the entire "Forest Stewardship project area" described herein is filed, or if the "Forest Stewardship project area" is acquired in lieu of eminent domain for a public improvement by a public agency or person or whenever there is any such action or acquisition by the federal government or the state government or any person, instrumentality or agency acting under authority or power of the federal government or the state government, this AGREEMENT shall be deemed null and void without penalty as to the land actually being condemned or so acquired as of the date the action is filed, and upon the termination of such a proceeding, this AGREEMENT shall be null and void without penalty for all land actually taken or acquired.

(b) Partial Condemnation. When such an action to condemn or acquire less than all the entire "Forest Stewardship project area" is filed, this AGREEMENT shall be deemed null and void without penalty as to the portion so condemned or acquired.

(c) Adjustment of approved MANAGEMENT PLAN. The land actually taken by the means set forth above in this Section shall be removed from this AGREEMENT and the approved MANAGEMENT PLAN and budget adjusted accordingly on a reasonable basis by the STATE and the LANDOWNER.

SECTION 5 - INCORPORATION OF CHAPTER 195F, HAWAII REVISED STATUTES

5.1 Incorporation. The provisions of chapter 195F, Hawaii Revised Statutes, as amended, are incorporated by reference into this AGREEMENT. In the event that there is any conflict between the provisions of this AGREEMENT and the provisions of chapter 195F, Hawaii Revised Statutes, the latter shall be controlling.

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5.2 Renumbering. In the event that chapter 195F, or any of the sections under chapter 195F, Hawaii Revised Statutes, are renumbered, any references to the chapter or sections in this AGREEMENT shall be deemed renumbered accordingly.

EXHIBIT A

_____ Forest Stewardship Management Plan.

Exhibit B

Forest Management Plan

Kaupakuea Orchards, LLC

April 22nd, 2013

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

Forest Solutions Inc.

I. Applicant and property information

1.1 Applicant

Name:	Christopher Trimarco
Address:	4110 NE 27th Avenue
	Lighthouse Point, FL 33064
Email:	christophertrimarco@mac.com
Phone:	+1 (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)
	Ālia 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

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: Nicholas Koch

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:_____
State Forester's Signature/ Date:_____
State Forester's Name:_____

2.4 Forest Stewardship Advisory Committee

Approved by:_____
Committee Signature/Date:_____
Printed Name:_____

Forest 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: Roger Imoto

State Forester's Signature/ Date: 9/27/13

State Forester's Name: Roger Imoto, DOFAW Administrator

2.4 Forest Stewardship Advisory Committee

Approved by: May 10, 2013

Committee Signature/Date:_____

Printed Name: M. Irene Sprecher, Cooperative Resource Forester

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 Hāmākua 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 moluccana*), 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 ʻōhiʻa (*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 ʻōhiʻa (top right). *Psidium* is replacing *S. jambos* as a consequence of fungal pathogen attack (bottom).

4.1.3 Understory

The understory of the SMZ property is invaded with smaller 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 Invasive 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 (*S. jambos*) may threaten the congeneric 'ōhi'a as well. 'ōhi'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 clay loam component makes up 90 percent of the map unit. Slopes are 5 to 15 percent. This component is on ash fields on lava 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. Water movement 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 not flooded. 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 F159AY500HI Acacia koa-Metrosideros polymorpha-cibotium Menziesii/freycinetia Arborea ecological site (**Appendix A**). Non irrigated land capability classification 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 and September.

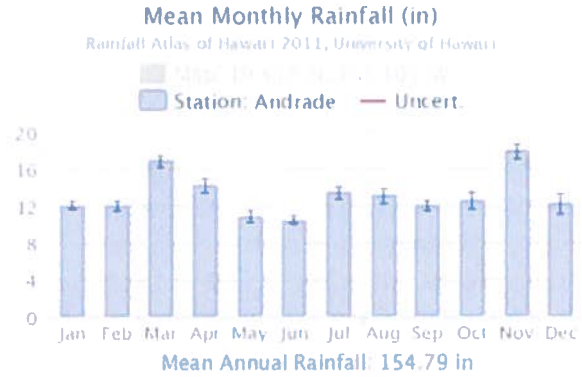


Figure 4.4.1. Mean annual rainfall for the area surrounding the property[1].

4.4.2 Streams

One continuous stream (the Waia'ama Stream) defines the Southern boundary of the property, while an intermittent stream (the Ālia Stream) is located at the Northern boundary (**Map 2**). In the 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 leucomelanos*) 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 (*Asio flammeus*) and Io (*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 'alalā (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 in the 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 'ōhi'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.

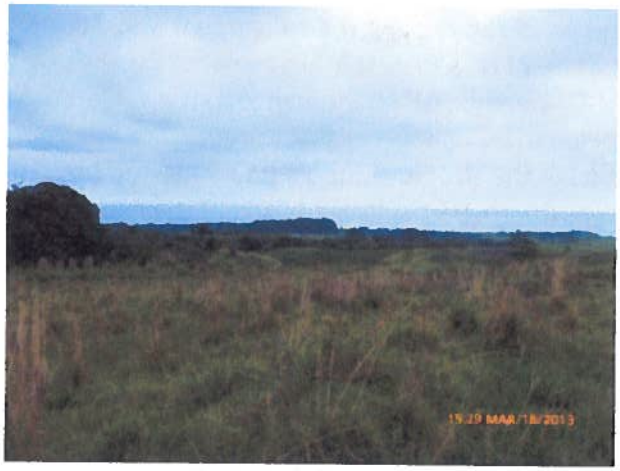


Figure 4.8.1. This exceptional ocean view would be preserved during implementation of the FMP.

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

4.9.1 Access

Significant access infrastructure exists on the property. A road constructed by Hāmākua 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.

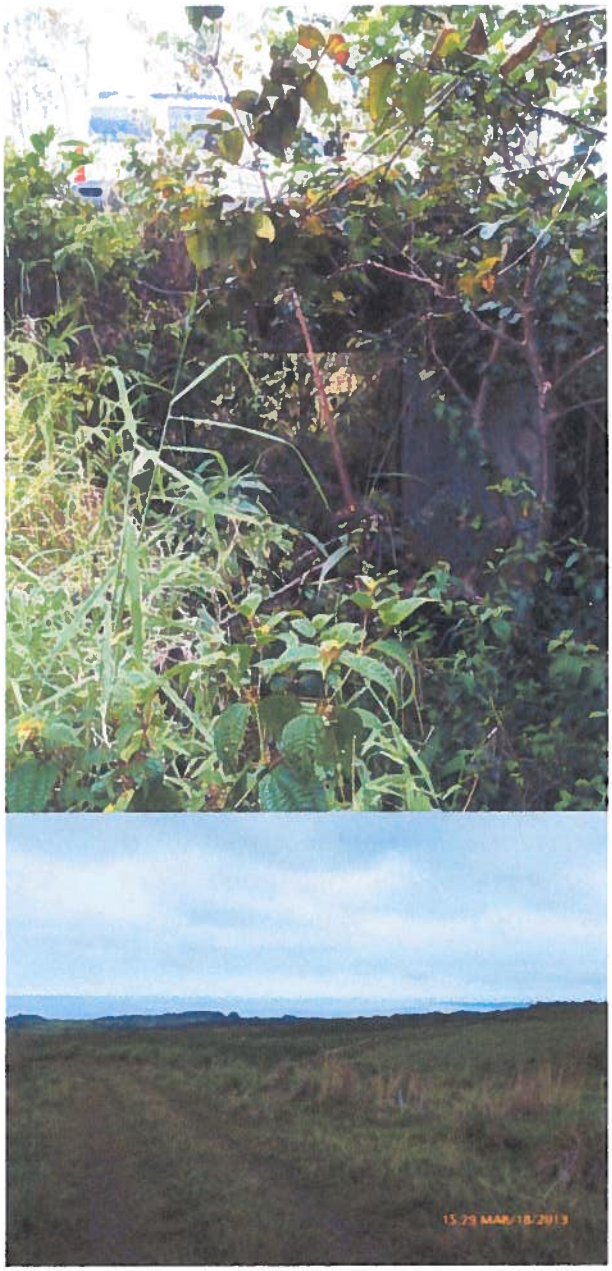


Figure 4.9.1. A concrete culvert (top) allows the old sugar company road (bottom) to safely cross the drainage in the Northern parcel.

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 ungulates 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

5.1 Compartments and Working Circles

5.1.1 Compartmentalization

To accomplish the major objectives outlined in this plan (§3.3), several specific management prescriptions (R_x) 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 R_x. 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 R_x 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 R_x; 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 R_x 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); R_x 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 R_x will both expand native wildlife habitat and improve overall forest 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
H01	Hardwood	101	3.89	0.08
H02	Hardwood	102	4.15	0.09
H03	Hardwood	103	3.62	0.27
H04	Hardwood	104	5.36	0.07
H05	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=7765&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 R_x 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 Hāmākua eucalyptus plantations. In wet areas like Pepeekeo, bedding elevates the seedling root zone and allows trees to establish in soil with improved drainage. The most fertile surface soils, typically the top five inches, are collected by the bedding plow and concentrated in the center of the bed, improving soil fertility in the area immediately surrounding the 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 deglupta* 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 *Cedrella odorata* enjoys a relatively small market share in Hawaii, the available product is quickly sold and always in demand. The native Hawaiian species 'ōhi'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 operational use would be planted in the first year across the majority of compartments H01 and H02 (**Map 2, Table 5.5.2**). One acre in H01 would 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 H01 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 1 are, although selected in the FSP proposal, are not recommended due to known failure.

Genus	Species	Common	Use	Appr. Cost	Rank*	Weed Risk†	Share
Cedrella	*odorata*	tropical cedar	Experimental	$1.50	4	2	2%
Cupressus	*lusitanica*	Mexican cypress	Windbreak	$1.50	4	6	2%
Elaeocarpus	*angustifolius*	blue marble	Operational	$3.00	4	4	40%
Eucalyptus	*deglupta*	rainbow eucalyptus	Operational	$2.20	4	2	40%
Metrosideros	*polymorpha*	ohi'a	Restoration	$7.00	4	NA	---
Dalbergia	*latifolia*	East Indian rosewood	Experimental	$3.29	3	5	2%
Eucalyptus	*microcorys*	tallowwood	Experimental	$1.00	3	1	2%
Pterocarpus	*indicus*	narra	Experimental	$2.89	3	4	2%
Samanea	*saman*	monkeypod	Experimental	$2.75	3	4	2%
Senna	*siamea*	pheasantwood	Experimental	$2.75	3	5	2%
Acacia	*koa*	koa	Experimental	$2.00	2	NA	---
Sweitenia	*macrophylla*	Honduran mahogany	Experimental	$5.50	2	-2	2%
Tabebuia	*rosea*	trumpet tree	Experimental	$2.50	2	3	2%
Tectona	*grandis*	teak	Experimental	$4.75	1	-5	2%

* Ranking: 4: Known to succeed | 3: Expected to succeed | 2: Possible or Unknown | 1: Drawbacks

†http://www.botany.hawaii.edu/faculty/daehler/wra/full_table.asp.html

Many of the high value hardwood species proposed for this project rank between 1 and 6 on the University of Hawai'i weed 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 H01 and H02 in the first year. Experimental 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	
			Operational	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*
H05	Hardwood	2		*Pending experimental results*
S01	SMZ	3-10	Metpol	---
S02	SMZ	3-10	Metpol	---

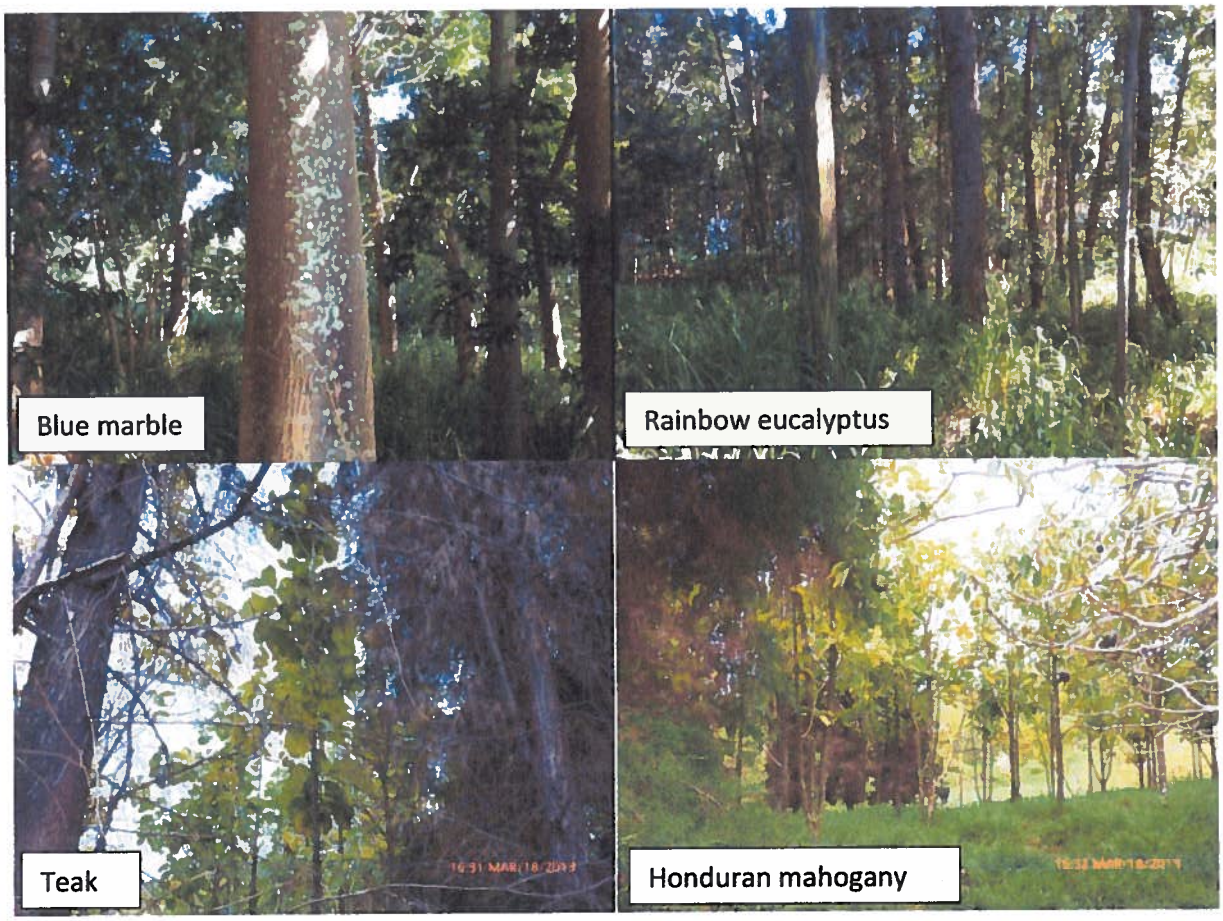


Figure 5.5.1. Performance of operational species (top) is exceptional in the area. Disfavored species originally listed in the FSP proposal should be excluded from plantings because of known performance failures (bottom left) or planted on an experimental basis (bottom right).

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 5' 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 Hāmākua 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 Hāmākua District. Grasses will be the main target 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 *S. saman* and *S. 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 or 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 ʻōhiʻa may be susceptible to the fungal pathogen *Puccinia psidii*, but ʻōhiʻa 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 (IPM) framework.

The IPM 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 IPM, 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 H01 – H05, 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 1/50th 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 long term, hardwood harvesting would 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 50 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 according to 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^{-1}), 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	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
				Year 1						
Management plan	---	$193	-12	$ 752	$ 803	$ 700	$ 1,037	$ 348	$ 681	$ 180
Trail Construction	383	$1.58†	-6	$ 667	$ 751	$ 2,252	$ 584	$ -	$ -	$ -
Access Control	472	$7.00†	-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					

† Cost per foot

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
				Year 1						
Management plan	---	$193	-12	$ 752	$ 803	$ 700	$ 1,037	$ 348	$ 681	$ 180
Trail Construction	383	$1.58†	-6	$ 667	$ 751	$ 2,252	$ 584	$ -	$ -	$ -
Access Control	472	$7.00†	-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 Applicant total:	$ 22,402.29			Year 1 FSP Total:	$ 22,402.29					

† 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	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	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	$ 1,810	$ 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:	$ 19,648.35			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	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	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%	50%	50%	50%	50%	50%
Applicant share:	---	---	---	$ 387	$ 413	$ 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:	$ 19,820.57					

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

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	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 Applicant 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	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	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	$ 1,584	$ 977
FSP share:	---	---	---	$ -	$ -	$ 107	$ 158	$ 53	$ 1,584	$ 977
Year 5 Applicant 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						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	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						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
				Year 7						
Stream 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						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	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^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	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^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	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 6.1.11a. 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	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	0.9 ac
Project Budget Summary: Years 1 - 10										
Compartment subtotal	---	---	---	$ 24,588	$ 23,550	$ 18,035	$ 33,095	$ 14,934	$ 42,032	$ 4,156
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:	---	---	---	$ 12,294	$ 11,775	$ 9,017	$ 16,547	$ 7,467	$ 21,016	$ 2,078
FSP share:	---	---	---	$ 12,294	$ 11,775	$ 9,017	$ 16,547	$ 7,467	$ 21,016	$ 2,078
Applicant total:				$	80,195					
FSP total:				$	80,195					
Project total:				$	160,389					

Table 6.1.11b. Total anticipated costs for the first decade of the hardwood project and SMZ restoration activities, where fencing in the first year occurs on the South, East, and West project boundaries but not along the North boundary.

Activity	NRCS code	Cost unit^{-1}	Start month	Compartment						
				H01	H02	H03	H04	H05	S01	S02
				3.9 ac	4.2 ac	3.6 ac	5.4 ac	1.8 ac	3.5 ac	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					
Project 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 S02 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	H05	S01	S02
Year 1										
Management plan	---	1	-12							
Trail Construction	383	1	-6							
Fence	472	1	-6							
Year 2										
Tree Site Preparation	490	2	-2							
Deep Tillage	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 Preparation	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 management	590	3	20							
Stream Habitat Improvement	395	3	10							
Weed Control	315	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 Planting	342	4	28							
Year 5										
Form correction 2	666	5	36							
Stream Habitat Improvement	395	5	10							
Critical Area Planting	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 Planting	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 Planting	342	9	88							
Year 10										
Stream Habitat Improvement	395	10	10							
Critical Area Planting	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 6.3.1a**). This stumpage value is potentially quite high, with $1.00 a more conservative estimate.

Table 6.3.1a. Economic analysis for increasing stumpage prices at a fixed seedling cost of $3.00 and discount rate of 8%, where fencing is considered.

	Stumpage (Seedling cost fixed at $3.00/tree)				
Costs	$1.00	$1.25	$1.50	$1.80	$2.30
IRR	5.80%	6.43%	6.92%	7.41%	8.06%
NPV	($51,394)	($41,114)	($30,835)	($18,500)	$2,059
NPV/ac	($2,731)	($2,185)	($1,638)	($983)	$109

Table 6.3.1b. Economic analysis for increasing seedling costs at a fixed stumpage price of $2.30.

	Seedling cost (Stumpage fixed at $2.30/bf)				
Costs	$1.00	$2.00	$3.00	$4.00	$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 6.3.1b**), 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**).

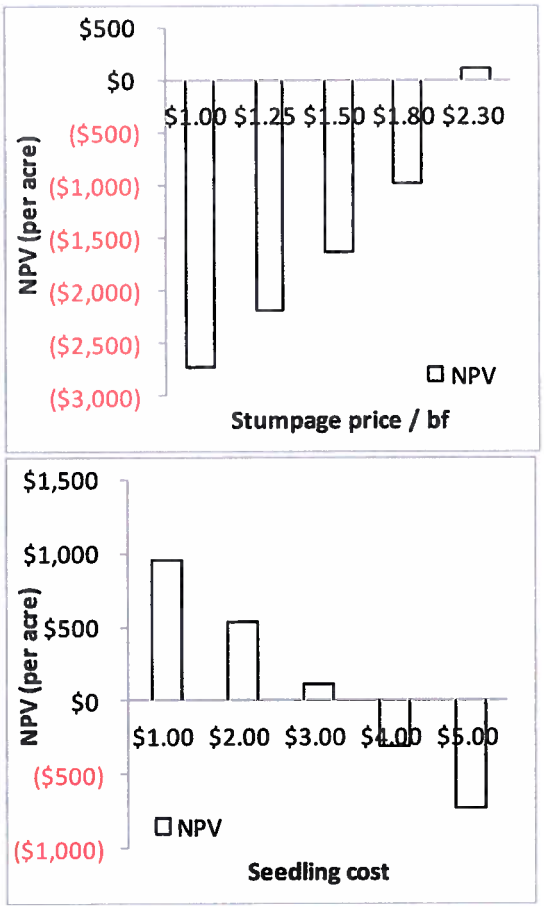


Figure 6.3.1. Financial performance of the *E. angustifolius* investment evaluated for a 45 year rotation across a range of stumpage prices (top) and seedling costs (bottom).

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	6.98%	7.61%	8.12%	8.61%	9.27%
NPV	($18,014)	($7,735)	$2,545	$14,880	$35,438
NPV/ac	($957)	($411)	$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	$10,456	$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. *E. deglupta*), and positive NPV can be achieved at this level for a stumpage price of $1.50 (**Table 6.3.2a**). In fact, 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**).

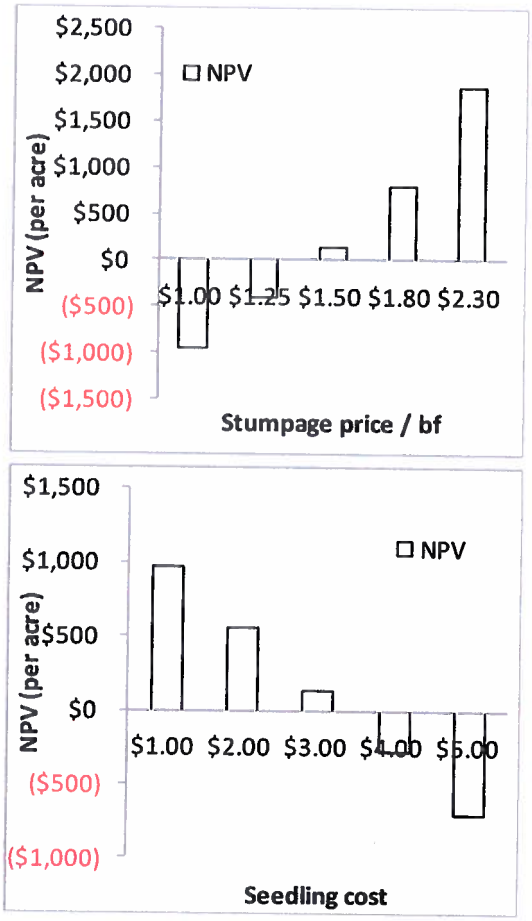
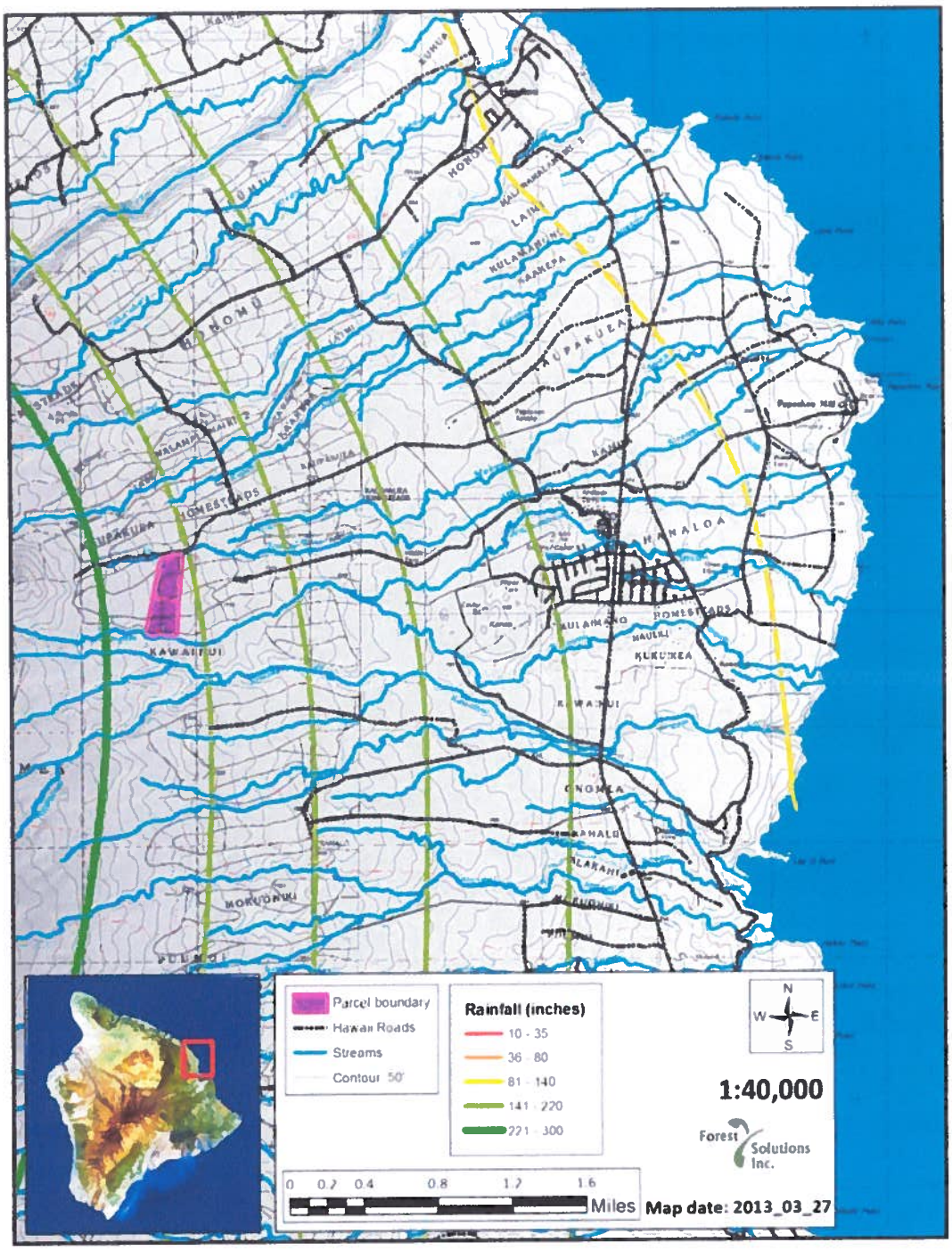


Figure 6.3.2. Financial performance of the *E. angustifolius* investment evaluated for a 45 year rotation across a range of stumpage prices (top) and seedling costs (bottom).

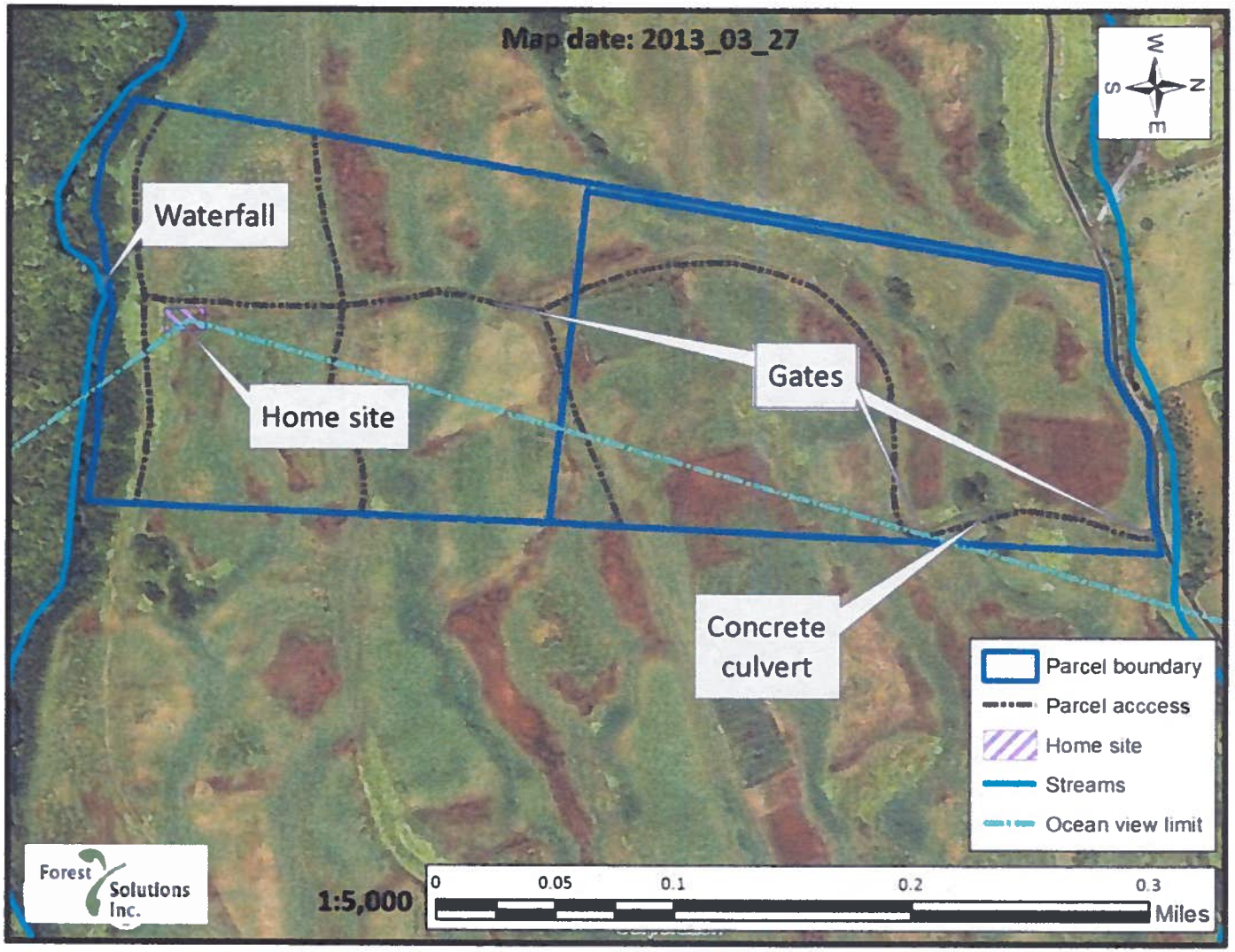
As a concluding remark about general profitability, these economic analyses impose several bounds on the initial conditions of the project in order for a return to be realized. In particular, when fencing costs are excluded, seedling costs must remain below $4.00 in order for the 45 year rotation to 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

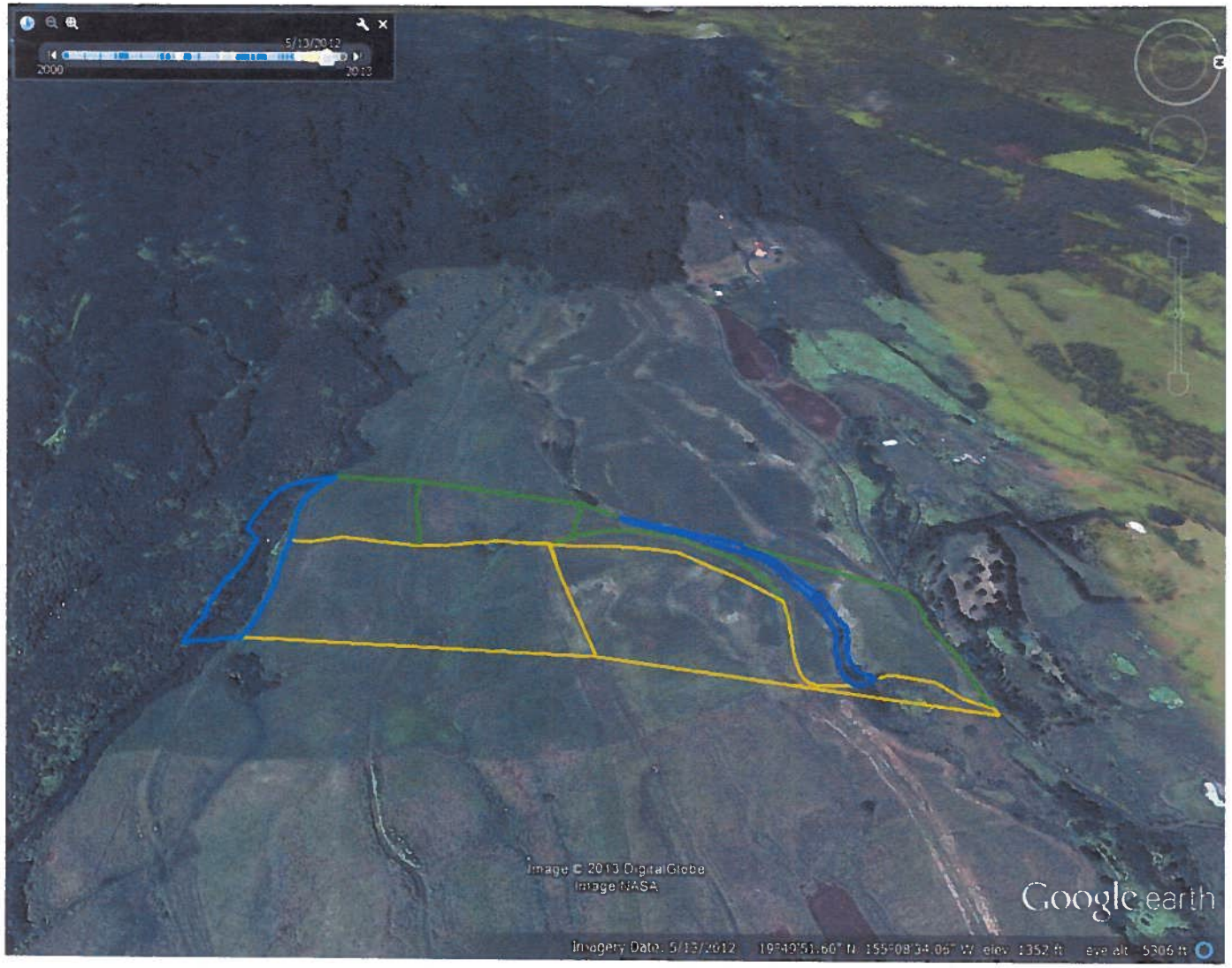


Map 1. Location of the Kaupakuea Orchards LLC property in relation to the Hāmākua Coast; Hilo is located approximately 8 miles to the South. Rainfall exceeds 141 inches annually.

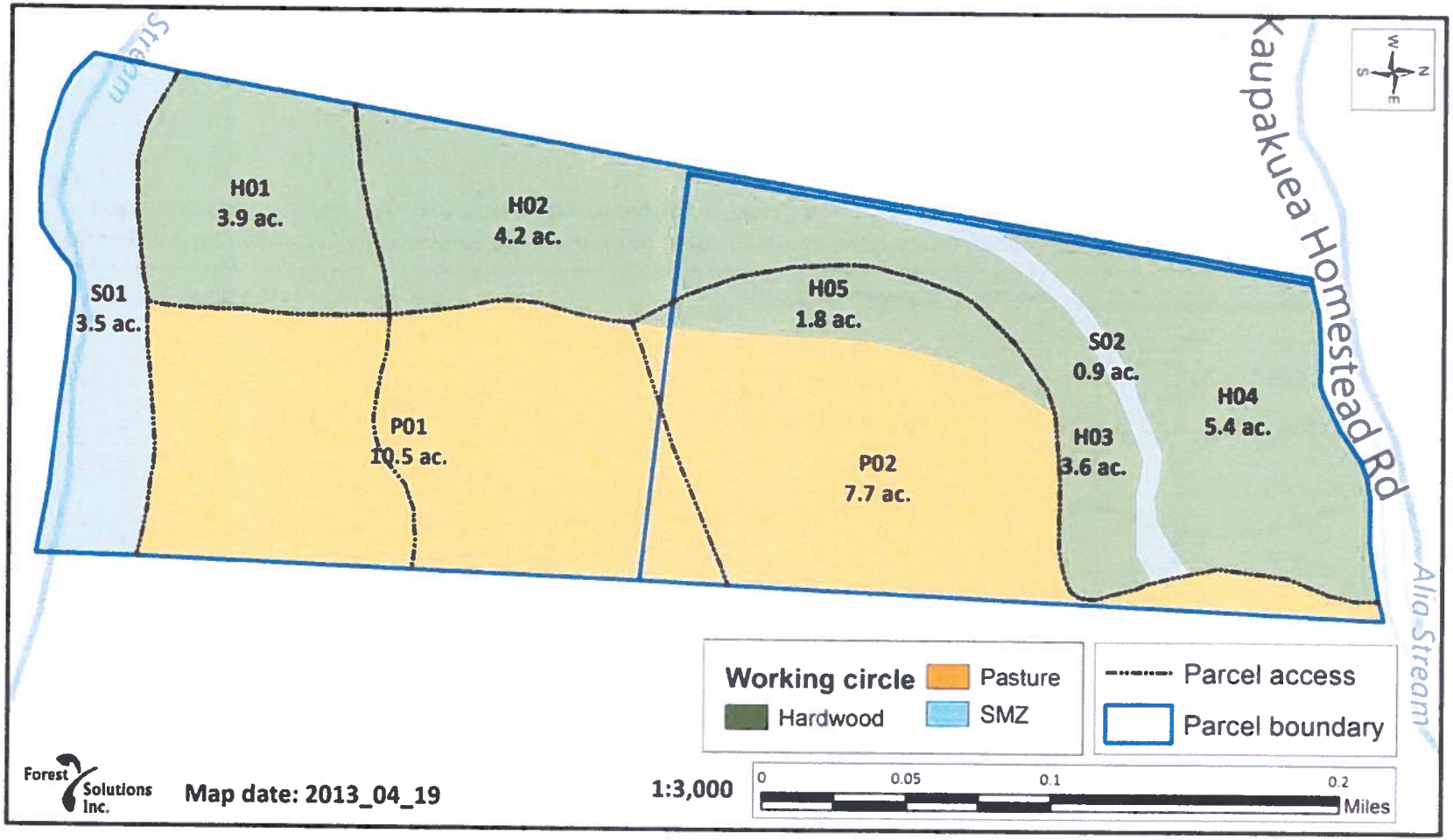
Map 2.



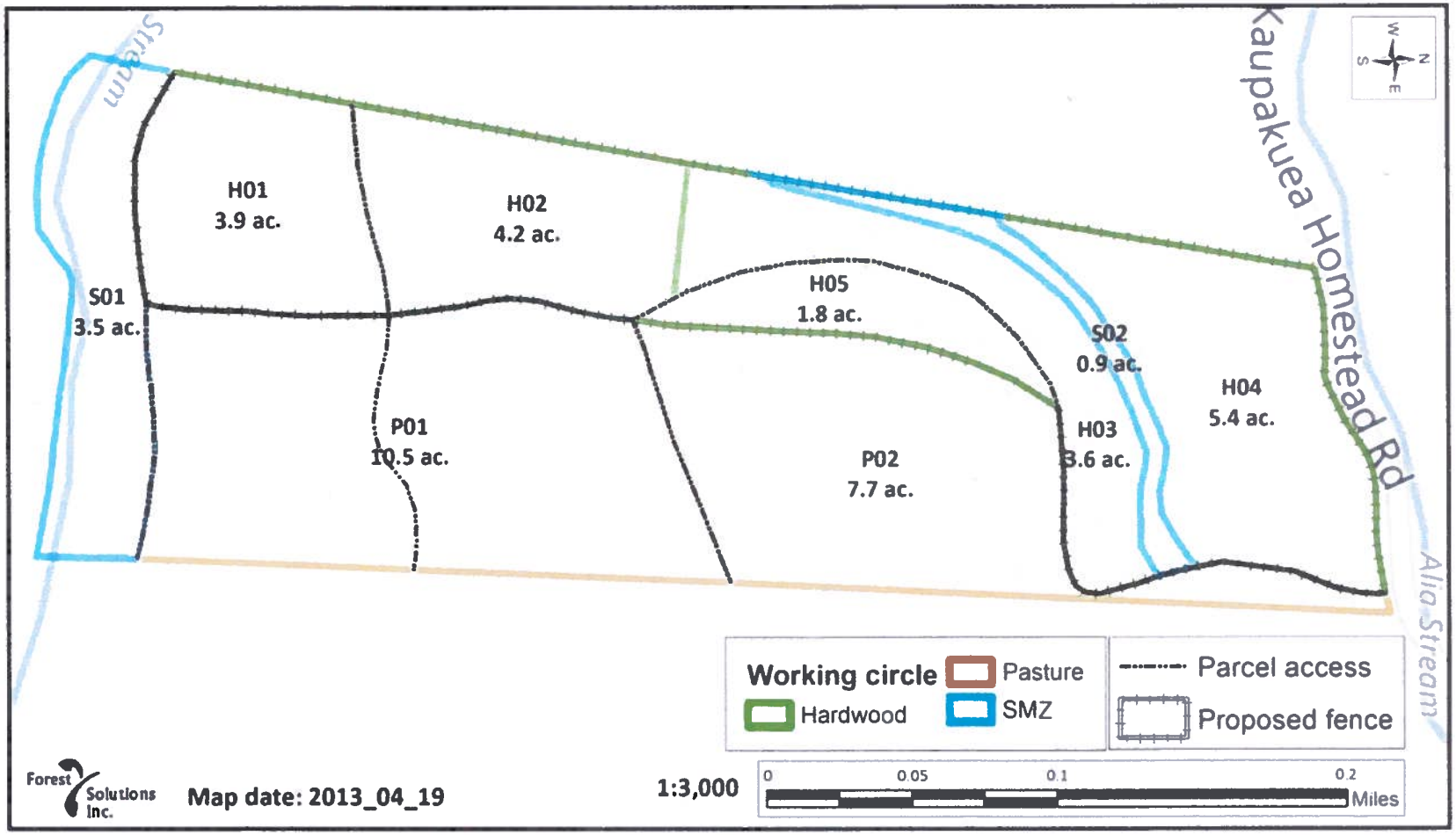
Map 2a. Parcel boundaries define a 19.59-acre parcel to the North and a second 21.90-acre flag lot to the South. The land is bordered by streams on the North and South sides. Forestry is planned for mauka sections, with open land uses planned makai of the access route. A home site is located to the South;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



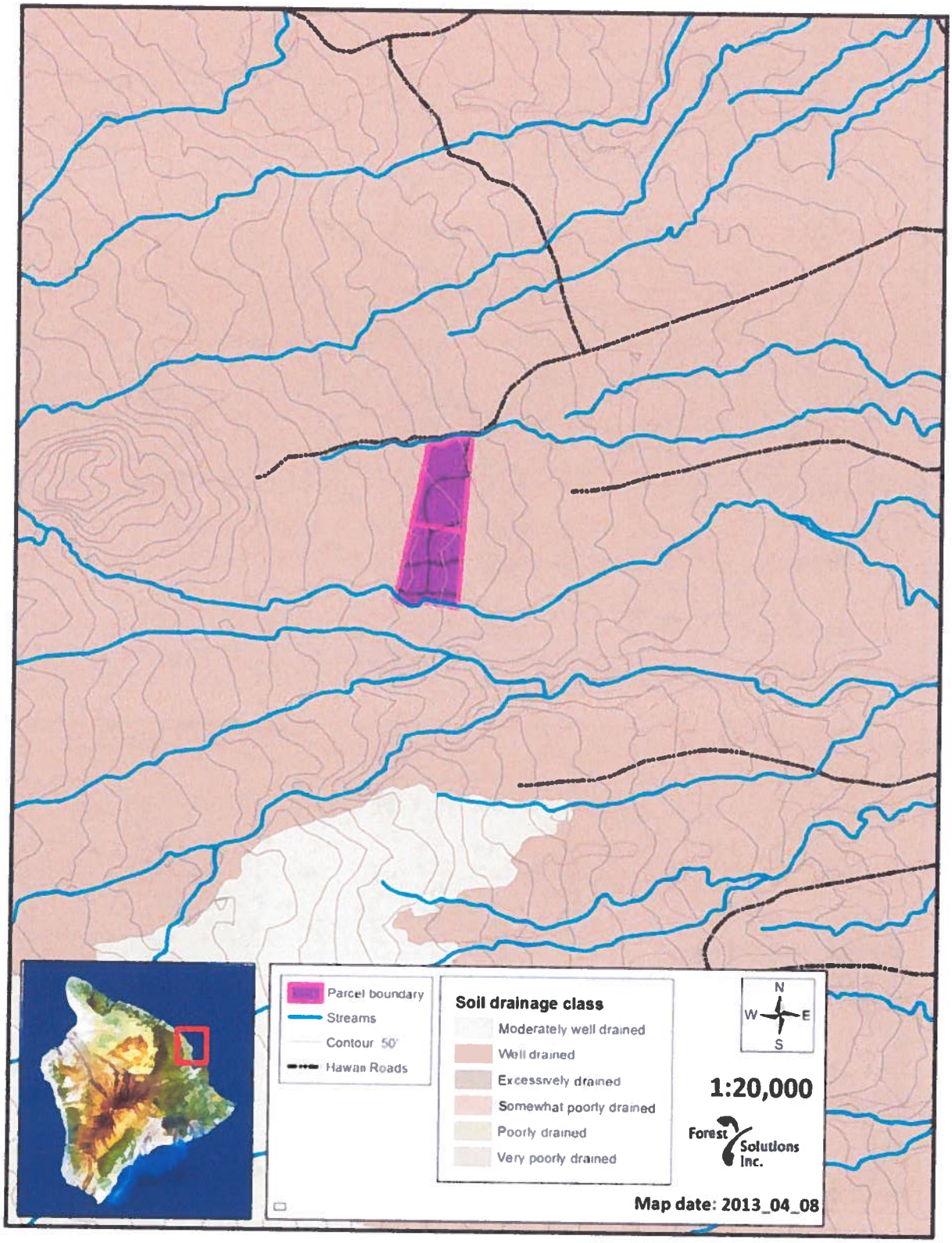
Map 2b. Compartment boundaries are defined in part by pre-existing roads, parcel boundaries, drainages, and other features that are visible in three dimensional relief. This 2012 image (Google Earth) clearly shows the Southern border SMZ and State forested parcel, with additional nearby forest up slope.



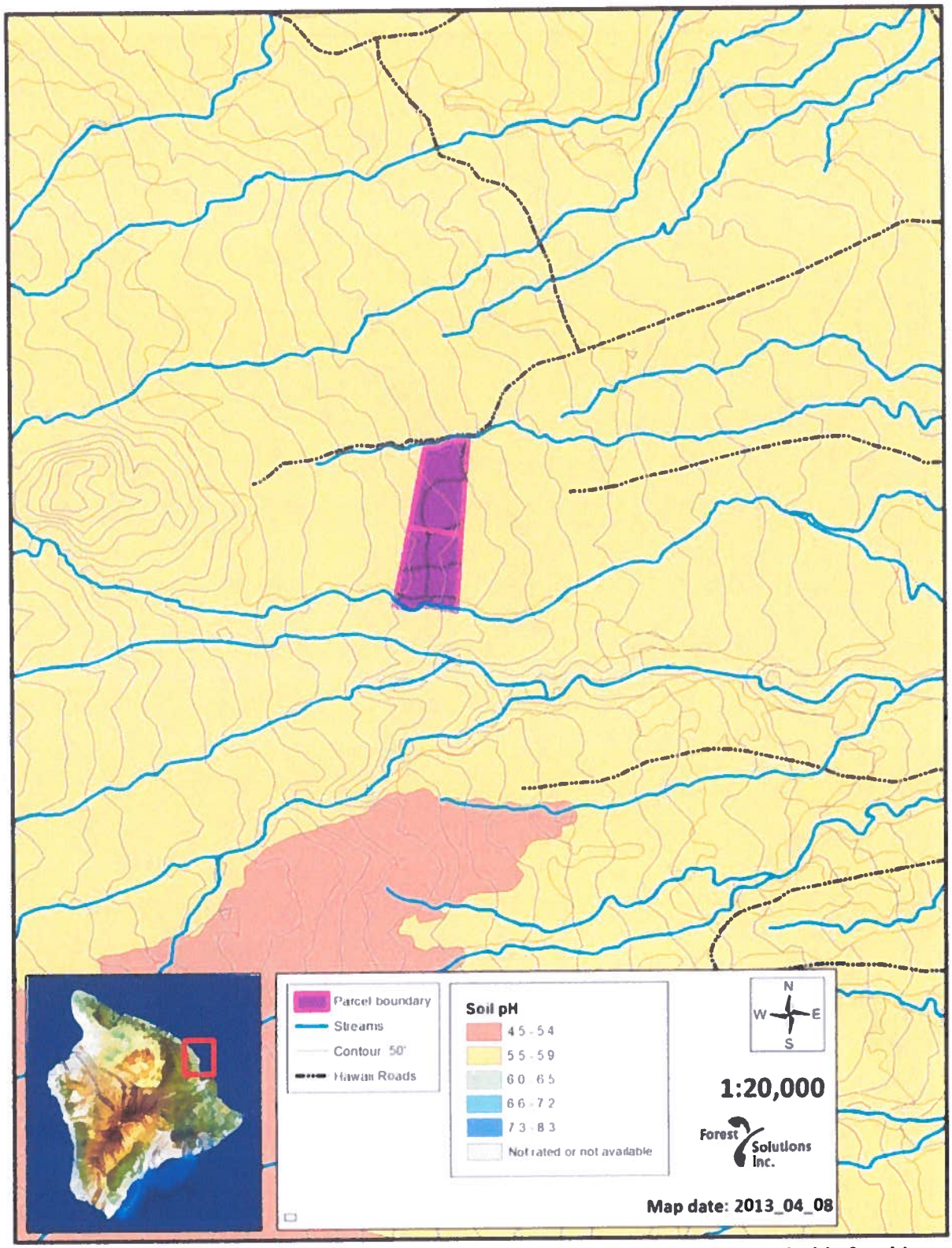
Map 3. Compartment divisions were assigned according the existence of access routes. Areas mauka of the central access route are designated for hardwood planting, while areas adjacent to the riparian sections are reserved for SMZ management.



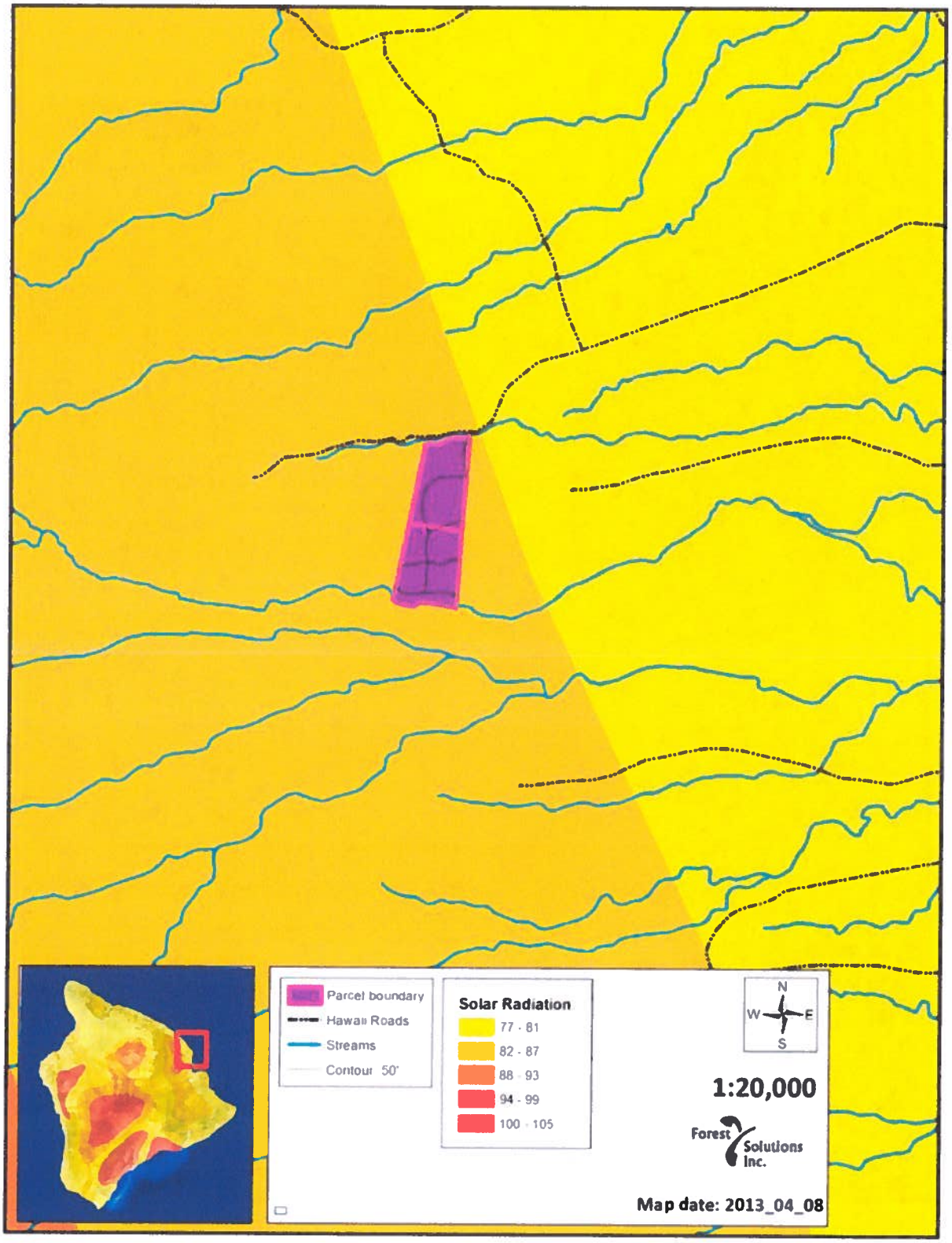
Map 4. Fencing will be necessary surrounding the hardwood planting areas, with a maximum of 5,780 feet of fencing required. Should it be decided that the existing barbed wire fence along the North boundary is adequate, total length of new fencing wo uld be 5,150 feet.



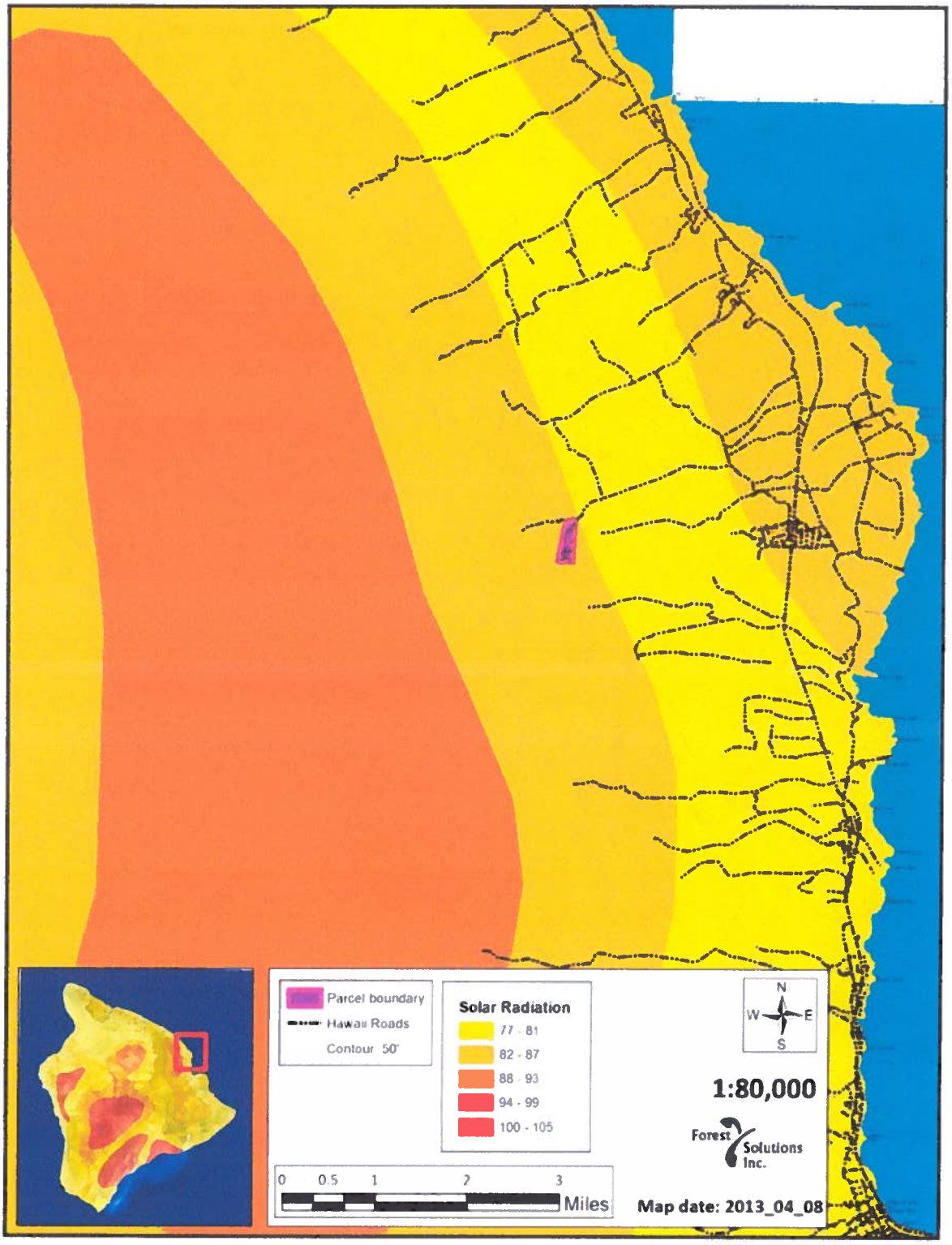
Map 5. Soils across the entire parcel are well drained.



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



Map 7. Cloud cover in the 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.nrcs.usda.gov/references/public/HI/F159AY500HI_Tall_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: **F159AY500HI**	MLRA: **159A**
Colloquial Site Name: **Tall Stature Wet Koa – Ohia/Hapu`u Forest**		
Official Site Name: ***Acacia koa-Metrosideros 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)	Minimum	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	Maximum
Frost Free Period (days):	**365**	**365**
Freeze Free Period (days):	**365**	**365**
Mean Annual Precipitation (inches):	**50**	**140**

Monthly Precipitation (inches) and Temperature (^{0}F)												
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. Avg.	**14.0**	**19.0**	**21.2**	**22.8**	**17.4**	**9.7**	**15.1**	**18.3**	**10.5**	**15.5**	**21.2**	**21.1**
Temp. Max.	**73.1**	**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 alexandrae*), 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 volume of water available to plants 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 $CaCl_2$) 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: (1) **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):0-10 Rock Fragments >3" (%Volume): 0-10
Drainage Class: moderately well to well	Permeability Class: moderately rapid to rapid

	Minimum	Maximum
Depth (inches):	**50**	**>60**
Electrical Conductivity (mmhos/cm):	**0**	**2**
Sodium Adsorption Ratio:	**0**	**0**
Calcium Carbonate Equivalent (percent):	**0**	**0**
Soil Reaction (1:1 Water):		
Soil Reaction (.0-1M CaC12):		
Available Water Capacity (inches):		

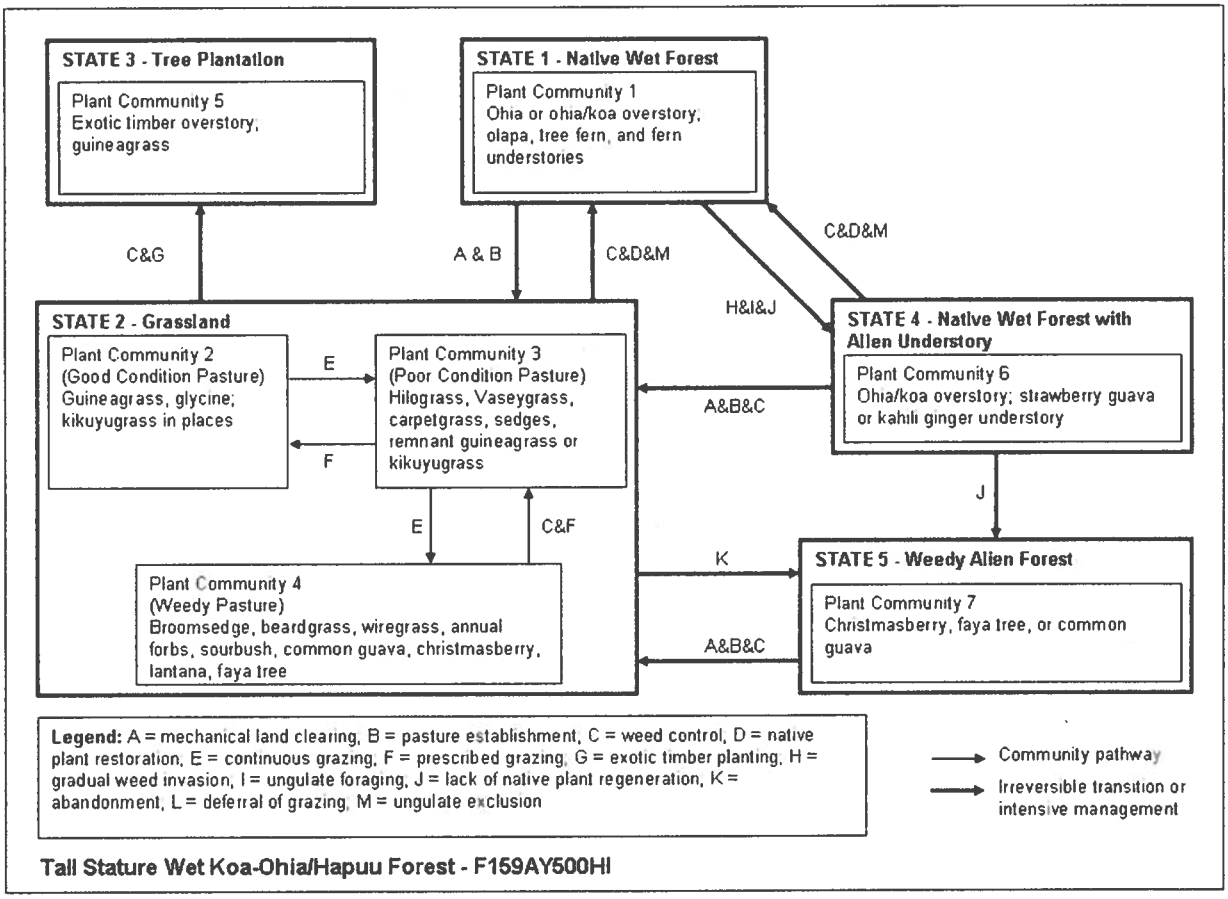
PLANT COMMUNITIES

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 original forest area remains as native forest. However, the native plant community has disturbed 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, christmasberry, 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 with an open or closed upper canopy of ohia or ohia and koa trees up to 100 feet tall, a secondary canopy of diverse trees species 30 to 60 feet tall, a dense tree fern canopy 10 to 30 feet tall, and a diverse understory of shrubs and ferns. Vines are common both on the ground and on trees. All three Big Island tree fern 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 lau

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

The dominant tree canopy can be ohia trees or a combination of ohia and koa trees. We were unable to discern any consistent correlation 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 occurrence. Koa is a fast growing, 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 the forest 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 and/or 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&I&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 shrubs, 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 observed in the course of field work or are derived from reliable 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).

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

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Metrosideros polymorpha	tr	tr	tr	tr	20	1	20	'ohi'a lehua	'ohi'a lehua	n	t	MEPO5
Acacia koa	tr	tr	tr	tr	20	1	20	koa	koa	n	t	ACKO
Cheirodendron trigynum	1	1	1	5	1		10	olapa	olapalapa	n	t	CHTR2
Perrottetia sandwicensis	tr	tr	1	1			1	olomea	olomea	n	t	PESA3
Ilex anomala	tr	tr	1	1	tr		1	kawa`u	Hawai`i holly	n	t	ILAN
Myrsine lessertiana	tr	tr	1	5			5	kolea lau nui	kolea lau nui	n	t	MYLE2
Psychotria sp.	tr	1	1	1			1	kopiko	wild coffee	n	t	PSYCH
Charpentiera sp.	tr	1	1				1	papala	papala	n	t	CHARP
Coprosma rhynchocarpa	tr	1	1	5			5	pilo	woodland mirrorplant	n	t	CORH
Antidesma platyphyllum	tr	1	1	tr			1	hame,ha`a	ha`a	n	t	ANPL2
Antidesma pulvinatum	tr	1	1	tr			1	hame	hame	n	t	ANPU2
Gardenia remyi	?	?	?	?			?	nanu	Remy's gardenia	n	t	GARE
Hedyotis terminalis	tr	tr	1				1	manono	variable starviolet	n	t	HETE21
Pritchardia lanigera	?	?	?	?			?	loulu	lou`ulu	n	t	PRLA4
Urera glabra	tr	tr	1	1			1	opuhe	hopue	n	t	URGL
Myrsine sandwicensis	tr	tr	tr				tr	kolea lau li`i	kolea lau li`i	n	t	MYSA2
Platydesma remyi	?	?	?				?	pilo kea	Hawai`i pilo kea	n	t	PLRE4
Cibotium glaucum	1	1	20	40			50	hapu`u	hapu`u	n	tf	CIGL
Cibotium menziesii	1	1	5	10			20	hapu`u `i`i	hapu`u li	n	tf	CIME8
Cibotium chamissoi	tr	tr	tr	1			1	hapu`u	Chamisso's manfern	n	tf	CICH
Clermontia lindseyana	?	?	?				?	`oha wai	hillside clermontia	n	s	CLLI3

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

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Clermontia peleana	?	?	?				?		pele clermontia	n	s	CLPE2
Clermontia sp.	1	1	1				1	`oha wai	clermontia	n	s	CLERM
Cyrtandra tintinnabula	?	?					?	ha`iwale	Laupahoehoe cyrtandra	n	s	CYTI
Pipturus albidus	tr	tr	1				1	mamaki	Waimea pipturus	n	s	PIAL2
Broussaisia arguta	tr	1	5				5	kanawao	kanawao	n	s	BRAR6
Eurya sandwicensis	?	?					?	anini	anini	n	s	EUSA6
Vaccinium calycinum	1	1	1				1	ohelo	ohelo kau la`u	n	s	VACA8
Styphelia tameiameiae	tr	tr					tr	pukiawe	pukiawe	n	s	STTA
Trematolobelia grandifolia	?	?	?				?		largeflower false lobelia	n	s	TRGR8
Cyanea platyphylla	?	?	?				?	haha	Puna cyanea	n	s	CYPA7
Cyanea tritomantha	?	?	?				?	`aku	`aku`aku	n	t	CYTR6
Cyrtandra giffardii	?	?					?		forest cyrtandra	n	s	CYGI3
Cyrtandra platyphylla	1	1					1	`ilihia	`ilihia	n	s	CYPL5
Cyrtandra sp.	tr	1					1	ha `iwale	Cyrtandra	n	s	CYRTA
Peperomia sp.	1						1	`ala`ala wai nui	peperomia	n	h	PEPER
Astelia menziesiana	1						1	kaluaha	pua'akuhinia	n	h	ASME4
Phytolacca sandwicensis	tr	tr					tr	popolo ku mai	Hawai`i pokeweed	n	h	PHSA2
Joinvillea ascendens	?	?					?	`ohe	`ohe	n	h	JOAS
Korthalsella sp.	1						1	hulumoa	korthal mistletoe	n	h	KORTH
Stenogyne calaminthoides	1						1		bog stenogyne	n	v	STCA9
Stenogyne macrantha	?						?		Hawai`i stenogyne	n	v	STMA3
Stenogyne scrophularioides	?						?		mohihi	n	v	STSC4
Phyllostegia floribunda	?						?		Hawai`i phyllostegia	n	v	PHFL6
Phyllostegia racemosa	?						?		kiponapona	n	v	PHRA6
Phyllostegia vestita	?						?		streambed phyllostegia	n	h	PHVE4
Phyllostegia warshaucri	?						?		Laupahochoe phyllostegia	n	v	PHWA3
Rubus hawaiiensis	1	1					1	`akala	Hawai`i blackberry	n	v	RUHA
Smilax melastomifolia	1						1	hoi kuahiwi	Hawai`i greenbrier	n	v	SMME
Freycenetia arborea	1						1	`ie`ie	`ie`ie	n	v	FRAR
Alyxia oliviformis	1	1					1	maile	maile	n	v	ALOL2
Embelia pacifica	1						1	kilioe	kilioe	n	v	EMPA
Athyrium microphyllum	1						1	`akolea	akolea	n	f	ATMI
Sadleria sp.	1	1	1				1	`ama`u	Sadleria	n	f	SADLE
Adenophorus pinnatifidus	1						1		graceful kihifern	n	f	ADPI
Adenophorus tamariscinus	1						1	wahini noho mauna	wahini noho mauna	n	f	ADTA
Asplenium schizophyllum	1						1		fringed spleenwort	n	f	ASSC8
Coniogramme pilosa	1						1	lo`ulu	loulu	n	f	COPI3
Dicranopteris linearis	1						1	uluhe	Old World forkedfern	n	f	DILI
Diplazium sandwichianum	1	1					1	ho`i`o	Hawai`i twinsorus fern	n	f	DISA3
Dryopteris hawaiiensis	1						1		Hawai`i woodfern	n	f	DRHA
Dryopteris sandwicensis	1	1					1		Pacific woodfern	n	f	DRSA
Dryopteris wallichiana	1	5					5	`i`o nui	alpine woodfern	n	f	DRWA
Grammitis tenella	1						1	kolokolo	kolokolo	n	f	GRTE
Lepisorus thunbergianus	1						1	pakahakaha	weeping fern	n	f	LETH6
Lycopodiella cernua	tr						tr	pakahakaha	weeping fern	n	f	LETH6

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

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Mecodium recurvum	1						1	`ohi`a ku	ohiaku	n	f	HYRE
Nephrolepis exaltata	1						1	Boston swordfern	Boston swordfern	n	f	NEEX
Nothoperanema rubiginosum	1						1		island lacefern	n	f	NORU
Ophioderma pendulum	1						1	puapuamoa	Old World adder's tongue	n	f	OPPEP
Pneumatopteris sandwicensis	1	1					1	ho`i`o kula	Hawai`i airfern	n	f	PNSA
Psilotum complanatum	1						1	moa nahele	flatfork fern	n	f	PSCO3
Psilotum nudum	1						1	moa	whisk fern	n	f	PSNU
Pteridium aquilinum	tr						tr	brackenfern	western brackenfern	n	f	PTAQ
Pteris cretica	1						1	`oali	Cretan brake	n	f	PTCR2
Pteris excelsa	1						1	waimakanui	waimakanui	n	f	PTEX
Sticherus owhyensis	1						1	uluhe	Hawai`i umbrella fern	n	f	STOW
Diplopterigium pinnatum	tr						tr	uluhe lau nui	scrambling fern	n	f	DIPI3
Elaphoglossum crassifolium	1						1	stag's tongue, `ekaha	royal tonguefern	n	f	ELCR2
Elaphoglossum palaeaceum	1						1	maku`e	ekaha	n	f	ELHI3
Sphenomeris chinensis	tr						tr	pala`a	Chinese creepingfern	n	f	ODCH
Microlepia strigosa	1	1					1	palapalai	palapalai	n	f	MIST4
Asplenium sp.	1	1					1		spleenwort	n	f	ASPLE
Asplenium normale	1						1		rainforest spleenwort	n	f	ASNO4
Vandenboschia sp.	1						1	vandenboschia	vandenboschia	n	f	VANDE
Uncinia uncinata	1						1		Hawai`i birdcatching sedge	n	g	UNUN
Carex wahuensis	1						1		Oahu sedge	n	g	CAWA
Carex alligata	1						1		Hawai`i sedge	n	g	CAAL12
Grasslike	1						1					
Native Forbs	1						1					
Exotic Forbs												
Native Vines/Epiphytes	5	1					5					
Exotic Vines												
Small ferns	20	10	1				30					
Native Shrubs	1	5	10				10					
Exotic Shrubs												
Native Trees	1	1	10	20	40	1	60					
Tree ferns (native)	1	1	20	50			70					
Exotic Trees & tree ferns												
Lichen												
Moss (on ground & logs)	10						10					
Moss (on trees)	20						20					
Logs on ground (>4" dia.)	5						5					
Litter (not logs)	70						70					
Surface rocks (>3" dia.)	1						1					
Surface rocks (≤3" dia.)	1						1					
Bare Soil	tr						tr					

Understory species canopy cover under a range of overstory canopy covers in Native Wet Forest. Overstory includes upper tree, secondary tree, and tree fern canopies combined.

Common Name	Scientific Name	Understory Species Canopy Cover as a function of Overstory Canopy Cover		
		Overstory Canopy Cover Percent		
		50	*70*	*90*
'ohi'a lehua	*Metrosideros polymorpha (seedlings and saplings)*	5	1	tr
koa	*Acacia koa (seedlings and saplings)*	5	1	tr
mamaki	*Pipturus albidus*	5	1	tr
olapa	*Cheirodendron trigynum*	10	5	5

State 1, Plant Community 1, Native Wet Forest.

State 2 – Grassland

This state is comprised 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 pastures can be found in Ecological Site Description F160XY502HI – Mauna Kea Koa-Mamane.

Plant Community 2 (Good Condition Pasture) consists of guineagrass with an admixture 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 perpetual 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 eliminated 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 perimeter. 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 guineagrass or kikuyugrass) to C4 or C3 (cool-season) shade-tolerant grasses (typically meadow ricegrass, Hilograss, or carpetgrass). This shade tolerant grass layer can be very dense and detrimental to establishment of native plants. It may be possible to suppress these grasses by planting native shrubs and tree ferns 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 of alien tree species that take over from the initial growth of grasses and weedy shrubs. Common weed tree species are strawberry guava, christmasberry, faya tree, and common guava.

Plant Community 2 – Good Condition Pasture

The dominant grass species in this pasture type is guineagrass that has volunteered in old sugarcane 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 Pasture 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, narrowleaf 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 Tallgrasses			**1**	**11,900-14,000**	**85-100**
guineagrass	Urochloa maxima	URMA3	1	11,900-14,000	85-100
Napier elephantgrass	Pennisetum purpureum	PEPU2	1	T-140	T-1
Naturalized Warm Season Mid-Grasses			**2**	**T-140**	**T-1**
kikuyugrass	Pennisetum clandestinum	PECL2	2	T-300	T-5
Hilograss	Paspalum conjugatum	PACO14	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
Natal redtop	Melinis repens	MERE9	2	T-140	T-1
smutgrass	Sporobolus indicus	SPIN4	2	T-140	T-1
East Indian crabgrass	Digitaria setigera	DISE6	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	Schizachyrium condensatum	SCCO10	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 nictitans	CHNI2	3	T-140	T-1
sensitive plant	Mimosa pudica	MIPU8	3	T-140	T-1
smooth rattlepod	Crotalaria pallida var. obovata	CRPAO	3	T-140	T-1
lilac tasselflower	Emilia sonchifolia	EMSO	3	T-140	T-1
common sow thistle	Sonchus oleraceus	SOOL	3	T-140	T-1
lion's ear mint	Leonotis nepetifolia	LENE	3	T-140	T-1
spiny amaranth	Amaranthus spinosus	AMSP	3	T-140	T-1
SHRUBS					
Naturalized Shrubs, Half-Shrubs, and Trees			**4**	**140-700**	**1-5**
bush indigo	Indigofera suffruticosa	INSU	4	140-420	T-1
sourbush	Pluchea carolinensis	PLCA10	4	T-140	T-1
guava	Psidium guajava	PSGU	4	T-140	T-1
false mallow	Malvastrum coromandelianum	MACO6	4	T-140	T-1
christmasberry	Schinus terebinthifolius	SCTE	4	T-140	T-1
balloon plant	Asclepias physocarpa	ASPH2	4	T-140	T-1
castor bean	Ricinum communis	RICO3	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 Normal	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 of low 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 ensures 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)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Psidium guajava	1	1	1				1	common guava	guava	a	t	PSGU
Schefflera actinophylla	tr						tr	octopus tree	octopus tree	a	t	SCAC2
Falcataria moluccana	tr	tr					tr	albizia	peacocksplume	a	t	FAMO
Schinus terebinthifolius	tr	1	1				1	christmasberry	Brazilian peppertree	a	t	SCTE
Spathodea campanulata	tr	tr					tr	African tuliptree	African tuliptree	a	t	SPCA2
Morella faya	tr	tr					tr	faya tree	firetree	a	t	MOFA
Pluchea carolinensis	tr	1	1				1	sourbush	cure for all	a	s	PLCA10
Indigofera suffruticosa	1	1					1	bush indigo	anil de pasto	a	s	INSU
Ricinus communis	tr	1	1				1	castor bean	castor bean	a	s	RICO3
Rubus argutus	tr	1					1	Florida blackberry	sawtooth blackberry	a	v	RUAR2
Rubus rosifolius	tr	1					1	thimbleberry	West Indian raspberry	a	v	RURO
Nephrolepis multiflora	1						1	scaly swordfern	scaly swordfern	a	f	NEH1
Pteridium aquilinum	tr						tr	brackenfern	western brackenfern	n	f	PTAQ
Dicranopteris linearis	tr						tr	uluhe	Old World forkedfern	n	f	DILI
Ageratina riparia	tr						tr	Hamakua pamakani	spreading snakeroot	a	h	AGRI2
Asclepias physocarpa	tr	1					1	balloonplant	balloonplant	a	h	ASPH2
Chamaecrista nictitans	1						1	partridge pea	partridge pea	a	h	CHNI2
Mimosa pudica	1						1	sensitiveplant	shameplant	a	h	MIPU8
Commelina diffusa	1						1	honohono	climbing dayflower	a	h	CODI5
Crotalaria pallida var. obovata	1						1	smooth rattlepod	smooth rattlebox	a	h	CRPAO
Desmodium triflorum	tr						tr		threeflower ticktrefoil	a	h	DETR4
Emilia sonchifolia	1						1	Flora's paintbrush	lilac tasselflower	a	h	EMSO
Sonchus oleraceus	1						1	pualele	common sowthistle	a	h	SOOL
Malvastrum coromandelianum	1						1	false mallow	threelobe false mallow	a	h	MACO6
Leonotis nepetifolia	1						1	lion's ear	Christmas candlestick	a	h	LENE
Amaranthus spinosus	1						1	spiny amaranth	spiny amaranth	a	h	AMSP
Kyllinga brevifolia	5						5		shortleaf spikesedge	a	g	KYBR
Saccharum spontaneum			tr				tr	wild sugarcane	wild sugarcane	a	g	SASP
Axonopus fissifolius	20						20	narrowleaf carpetgrass	common carpetgrass	a	g	AXFI
Sporobolus indicus	1						1	smut grass	smut grass	a	g	SPIN4
Urochloa maxima		20					20	guineagrass	guineagrass	a	g	URMA3
Pennisetum clandestinum	1						1	kikuyugrass	kikuyugrass	a	g	PECL2
Chloris gayana	1						1	Rhodes grass	Rhodes grass	a	g	CHGA2
Digitaria sanguinalis	1						1		hairy crabgrass	a	g	DISA
Digitaria setigera	1						1		East Indian crabgrass	a	g	DISE6
Eleusine indica	1						1	wiregrass	Indian goosegrass	a	g	ELIN3
Melinis repens	1						1	Natal redtop	rose Natal grass	a	g	MERE9
Andropogon virginicus	5						5	broomsedge	broomsedge bluestem	a	g	ANVI2
Schizachyrium condensatum	5						5	beardgrass	Colombian bluestem	a	g	SCCO10
Setaria parviflora	5						5	yellow foxtail	marsh bristlegrass	a	g	SEPA10
Paspalum urvillei	1	1					1	Vasey grass	Vasey's grass	a	g	PAUR2
Paspalum conjugatum	20						20	hilograss	hilograss	a	g	PACO14

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
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Grasslike	80	20					100					
Native Forbs												
Exotic Forbs	5						5					
Native Vines/Epiphytes												
Exotic Vines	1	1					1					
Small ferns	1						1					
Native Shrubs												
Exotic Shrubs	tr	1	1				1					
Native Trees												
Tree ferns (native)												
Exotic Trees & tree ferns	1	1	1				1					
Lichen												
Moss (on ground & logs)												
Moss (on trees)												
Logs on ground (>4" dia.)												
Litter (not logs)	50						50					
Surface rocks (>3" dia.)												
Surface rocks (≤3" dia.)												
Bare Soil	5						5					

State 2, Plant Community 3, Poor Condition Pasture.

Plant Community 4 – Weedy Pasture

Weedy Pasture is dominated by low-value forage species such as Hilograss, narrowleaf carpetgrass, broomsedge, and beardgrass. Alien blackberries, shrubs such as sourbush, and forbs such as spiny amaranth occupy much of the site. Small tree species and saplings of large 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 of livestock 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 class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Psidium guajava	1	1	10				10	common guava	guava	a	t	PSGU
Schefflera actinophylla	tr	1					1	octopus tree	octopus tree	a	t	SCAC2
Falcataria moluccana	tr	tr	1				1	albizia	peacocksplume	a	t	FAMO
Schinus terebinthifolius	tr	1	5				5	christmasberry	Brazilian peppertree	a	t	SCTE
Spathodea campanulata	tr	tr	1				1	African tuliptree	African tuliptree	a	t	SPCA2
Acacia confusa	tr	tr	1				1		Formosan koa	a	t	ACCO
Lantana camara	1	5	1				5	lantana	lantana	a	s	LACA2
Pluchea carolinensis	tr	5	1				5	sourbush	cure for all	a	s	PLCA10
Ricinus communis	tr	1	1				1	castor bean	castor bean	a	s	RICO3
Rubus argutus	tr	1	1				1	Florida blackberry	sawtooth blackberry	a	v	RUAR2
Rubus rosifolius	tr	1	1				1	thimbleberry	West Indian raspberry	a	v	RURO
Nephrolepis multiflora	1						1	scaly swordfern	scaly swordfern	a	f	NEH1
Ageratina riparia	1						1	Hamakua pamakani	spreading snakeroot	a	h	AGRI2
Asclepias physocarpa	tr	1	1				1	balloonplant	balloonplant	a	h	ASPH2
Chamaecrista nictitans	1						1	partridge pea	partridge pea	a	h	CHNI2
Mimosa pudica	1						1	sensitiveplant	shameplant	a	h	MIPU8
Commelina diffusa	1						1	honohono	climbing dayflower	a	h	CODI5
Crotalaria pallida var. obovata	1	1					1	smooth rattlepod	smooth rattlebox	a	h	CRPAO
Emilia sonchifolia	1						1	Flora's paintbrush	lilac tasselflower	a	h	EMSO
Sonchus oleraceus	1						1	pualele	common sowthistle	a	h	SOOL
Malvastrum coromandelianum	1	1					1	false mallow	threelobe false mallow	a	h	MACO6
Leonotis nepetifolia	1						1	lion's ear	Christmas candlestick	a	h	LENE
Amaranthus spinosus	1	5					5	spiny amaranth	spiny amaranth	a	h	AMSP
Kyllinga brevifolia	5						5		shortleaf spikesedge	a	g	KYBR
Axonopus fissifolius	20						20	narrowleaf carpetgrass	common carpetgrass	a	g	AXFI
Sporobolus indicus	1						1	smut grass	smut grass	a	g	SPIN4
Urochloa maxima		5					5	guineagrass	guineagrass	a	g	URMA3
Chloris gayana	1						1	Rhodes grass	Rhodes grass	a	g	CHGA2
Digitaria sanguinalis	1						1		hairy crabgrass	a	g	DISA
Digitaria setigera	1						1		East Indian crabgrass	a	g	DISE6
Eleusine indica	1						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	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Melinis repens	1						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	SCCO10
Setaria parviflora	5						5	yellow foxtail	marsh bristlegrass	a	g	SEPA10
Paspalum urvillei	1	1					1	Vasey grass	Vasey's grass	a	g	PAUR2
Paspalum conjugatum	20						20	hilograss	hilograss	a	g	PACO14
Grasslike	60	30					80					
Native Forbs												
Exotic Forbs	5	5	1				10					
Native Vines/Epiphytes												
Exotic Vines	tr	1	1				1					
Small ferns	1						1					
Native Shrubs												
Exotic Shrubs	1	10	1				10					
Native Trees												
Tree ferns (native)												
Exotic Trees & tree ferns	1	1	10				10					
Lichen												
Moss (on ground & logs)												
Moss (on trees)												
Logs on ground (>4" dia.)												
Litter (not logs)	40						40					
Surface rocks (>3" dia.)												
Surface rocks (≤3" dia.)												
Bare Soil	10						10					

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 understory weed.

Composite representation of State 3, Plant Community 5, Tree Plantation.

Scientific name	%Canopy cover by height class (ft)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Eucalyptus sp.	tr	1	1	1	90	5	90	eucalyptus	gum	a	t	EUCAL
Psidium cattleianum	tr	tr	tr				tr	waiawi	strawberry guava	a	t	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						tr	thimbleberry	West Indian raspberry	a	v	RURO
Nephrolepis multiflora	1						1	scaly swordfern	scaly swordfern	a	f	NEHI
Urochloa maxima	10	10					10	guineagrass	guineagrass	a	g	URMA3
Microlaena stipoides	1						1	meadow ricegrass	weeping grass	a	g	MIST
Paspalum conjugatum	1						1	hilograss	hilograss	a	g	PACO14
Grasslike	10	10					20					
Native Forbs												
Exotic Forbs	tr	tr					tr					
Native Vines/Epiphytes												
Exotic Vines	tr						tr					
Small ferns	1						1					
Native Shrubs												
Exotic Shrubs	tr						tr					
Native Trees												
Tree ferns (native)												
Exotic Trees & tree ferns	tr	1	1	1	90	5	90					
Lichen												
Moss (on ground & logs)												
Moss (on trees)	1						1					
Logs on ground (>4" dia.)	1						1					
Litter (not logs)	80						80					
Surface rocks (>3" dia.)	1						1					
Surface rocks (≤3" dia.)	1						1					
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, ferns, 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 recreate a 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 be necessary 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	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Metrosideros polymorpha					10		10	'ohi'a lehua	'ohi'a lehua	n	t	MEPO5
Acacia koa					10		10	koa	koa	n	t	ACKO
Psychotria sp.	tr	tr	tr	tr			1	kopiko	wild coffee	n	t	PSYCH
Psidium cattleianum	1	5	10	20			30	waiawi	strawberry guava	a	t	PSCA
Ficus sp.	tr	tr	tr	tr	tr		tr	strangler fig	fig	a	t	FICUS
Cibotium glaucum			1	1			1	hapu`u	hapu`u	n	tf	CIGL
Cibotium menziesii			tr	1			1	hapu`u `i`i	hapu`u li	n	tf	CIME8
Cyathea cooperi	tr	tr	tr				tr	Australian tree fern	Cooper's cyathea	a	tr	CYCO18
Clidemia hirta	1	1					1	Koster's curse	soapbush	a	s	CLHI3
Peperomia sp.	tr						tr	`ala`ala wai nui	peperomia	n	h	PEPER
Hedychium gardnerianum	1	1					1	kahili ginger	Kahila garland-lily	a	h	HEGA
Polygonum punctatum	1						1	water smartweed	dotted smartweed	a	h	POPU5
Freycenetia arborea	tr						tr	`ie`ie	`ie`ie	n	v	FRAR
Passiflora mollissima	1						1	banana poka	banana passionflower	a	v	PAMO5
Dicranopteris linearis	tr						tr	uluhe	Old World forkedfern	n	f	DILI
Lepisorus thunbergianus	tr						tr	pakahakaha	weeping fern	n	f	LETH6
Psilotum nudum	tr						tr	moa	whisk fern	n	f	PSNU
Setaria palmifolia	tr						tr	palmgrass	palmgrass	a	g	SEPA6
Axonopus fissifolius	1						1	narrowleaved carpetgrass	common carpetgrass	a	g	AXFI
Microlaena stipoides	1						1	meadow ricegrass	weeping grass	a	g	MIST
Grasslike	1						1					
Native Forbs	tr						tr					
Exotic Forbs	1	1					1					
Native Vines/Epiphytes	tr						tr					
Exotic Vines	1						1					
Small ferns	1						1					
Native Shrubs												
Exotic Shrubs	1	1					1					
Native Trees	tr	tr	tr	tr	20		20					
Tree ferns (native)			1	1			1					
Exotic Trees & tree ferns	1	5	10	20	tr		30					
Lichen												
Moss (on ground & logs)	10						10					
Moss (on trees)	20						20					
Logs on ground (>4" dia.)	5						5					
Litter (not logs)	70						70					
Surface rocks (>3" dia.)	1						1					
Surface rocks (≤3" dia.)	1						1					
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***
strawberry guava	*Psidium cattleianum*	90	90	90
common guava	*Psidium guajava*	50	40	5
christmasberry	*Schinus terebinthifolius*	90	60	5
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. Strawberry guava, christmasberry, or common guava may dominate a given site, but strawberry 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 clearing of overstory and 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)						Total Cover	Local common name	NRCS common name	Origin	Type	NRCS Code
	0.1 - 2	2.1 - 4.5	4.6 - 13	13.1 - 40	40.1 - 80	80.1 - 120						
Metrosideros polymorpha					tr		tr	'ohi'a lehua	'ohi'a lehua	n	t	MEPO5
Acacia koa					tr		tr	koa	koa	n	t	ACKO
Psychotria sp.	tr	tr	tr	tr			tr	kopiko	wild coffee	n	t	PSYCH
Psidium cattleianum	1	10	30	30			70	waiawi	strawberry guava	a	t	PSCA
Psidium guajava		tr	1	1			1	common guava	guava	a	t	PSGU
Schinus terebinthifolius			1	1			1	christmasberry	Brazilian peppertree	a	t	SCTE
Morella faya			1	1			1	faya tree	firetree	a	t	MOFA
Cibotium glaucum			tr				tr	hapu`u	hapu`u	n	tf	CIGL
Clidemia hirta	1	1					1	Koster's curse	soapbush	a	s	CLHI3
Hedychium gardnerianum	1	1					1	kahili ginger	Kahila garland-lily	a	h	HEGA
Polygonum punctatum	1						1	water smartweed	dotted smartweed	a	h	POPU5
Passiflora mollissima	1						1	banana poka	banana passionflower	a	v	PAMO5
Dicranopteris linearis	tr						tr	uluhe	Old World forkedfern	n	f	DILI
Setaria palmifolia	tr						tr	palmgrass	palmgrass	a	g	SEPA6
Axonopus fissifolius	1						1	narrowleaved carpetgrass	common carpetgrass	a	g	AXFI
Microlaena stipoides	1						1	meadow ricegrass	weeping grass	a	g	MIST
Grasslike	1						1					
Native Forbs												
Exotic Forbs	1	1					1					
Native Vines/Epiphytes												
Exotic Vines	1						1					
Small ferns	tr						tr					
Native Shrubs												
Exotic Shrubs	1	1					1					
Native Trees	tr	tr	tr	tr	tr		tr					
Tree ferns (native)			tr				tr					
Exotic Trees & tree ferns	1	5	20	20			50					
Lichen												
Moss (on ground & logs)	5						5					
Moss (on trees)	10						10					
Logs on ground (>4" dia.)	tr						tr					
Litter (not logs)	70						70					
Surface rocks (>3" dia.)	1						1					
Surface rocks (≤3" dia.)	1						1					
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 polymorpha*					**800**	**2000**	**cu. ft./ac**
koa	*Acacia koa*					**1500**	**3700**	**cu.ft./ac**

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 important 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 amakihi, 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 very 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 Community 2, Good Condition Pasture, with guineagrass. For kikuyugrass pastures on this ecological site, refer to grazing interpretations in Ecological Site Description F160XY502HI – 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 document plant composition and production. More precise carrying capacity estimates should eventually be calculated using the following stocking rate information along with animal preference data, particularly when grazers other than cattle are involved. Under more intensive grazing management, improved harvest efficiencies may result in an increased stocking rate.

Forage Value Rating [1/]	Acre/AUM [3/]	AUM/Acre [3/]
Very High [2/]	0.20 – 0.22	5.13 – 4.49
High	0.22 – 0.26	4.49 – 3.85
Moderate	0.26 –0.39	3.85 –2.56
Low	0.39 - +	2.56 - +

1/ 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.
2/ 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.
3/ Stocking rates vary in accordance with such factors as kind and class of livestock 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 inventories 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 of livestock, at any season, particularly cattle. However, this site is best utilized for grazing during the major plant growth period 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	Forage Preferences											
			J	F	M	A	M	J	J	A	S	O	N	D
Guineagrass	*Urochloa maxima*	entire	P	P	P	P	P	P	P	P	P	P	P	P
Napier elephantgrass	*Pennisetum purpureum*	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	*Digitaria 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 conjugatum*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Narrowleaf carpetgrass	*Axonopus fissifolius*	entire	U	U	U	U	U	U	U	U	U	U	U	U
East Indian crabgrass	*Digitaria setigera*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Hairy crabgrass	*Digitaria sanguinalis*	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	*Chloris gayana*	entire	D	D	D	D	D	D	D	D	D	D	D	D
Broomsedge bluestem	*Andropogon virginicus*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Bushybeard bluestem	*Schizachyrium condensatum*	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 firmula*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Green kyllinga	*Cyperus brevifolius*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Vaseygrass	*Paspalum urvillei*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Glycine	*Neonotonia wightii*	entire	P	P	P	P	P	P	P	P	P	P	P	P
Three-flowered tickletrefoil	*Desmodium triflorum*	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 pallida 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 nepetifolia*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Spiny amaranth	*Amaranthus spinosus*	entire	N	N	N	N	N	N	N	N	N	N	N	N
Bush indigo	*Indigofera suffruticosa*	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
Christmasberry	*Schinus terebinthifolius*	entire	U	U	U	U	U	U	U	U	U	U	U	U
Thimbleberry	*Rubus rosifolius*	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	*Ricinum communis*	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=Used, but degree of utilization unknown.

Hydrology Functions

Recreation Uses

Hunting is the most common recreational use.

Wood Products

There is good potential for production of timber in this 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 Narrative

Similar Sites

Colloquial Site Name	Site ID	Site Narrative
Ohia-Koa/Hapu`u-Kanawao Forest	F159BY500HI	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

	Sample ID			
Data Source	**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-1	7	2001-2003	HI	Hawaii

Type Locality

	Site #1 (NAD83 datum)	Site #2	Site #3
Latitude:	N19d55m59.4s		
Longitude:	W155d17m25.6s		
State:	HI		
County:	Hawaii		
General Description:	Hawaii County, Island of Hawaii, USGS Quad: Keanakolu. From main (highest) Laupahoehoe 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 Resources Studies Unit, 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. of Interior-U.S. Geological Survey. 2006. A GAP Analysis of Hawai`i. Final Report and Data.

Other References

1.	Armstrong, R.W. 1973. Atlas of Hawai`i. University of Hawai`i Press, Honolulu.
2.	Maly, K. and O. Maly. 2004. A Cultural Study of the Pu`u O `Umi Natural Area Reserve and Kohala-Hamakua Mountain Lands, Districts of Kohala and Hamakua, Island of Hawaii. Kumu Pono Associates LLC, Hilo, HI.
3.	Mueller-Dombois, D. and F.R. Fosberg. 1998. Vegetation of the Tropical Pacific Islands. Springer-Verlag New York, Inc.
4.	Palmer, D.D. 2003. Hawai`i's Ferns and Fern Allies. University of Hawai`i Press, Honolulu.
5.	Pratt, H.D. 1998. A Pocket Guide to Hawai`i's Trees and Shrubs. Mutual Publishing, Honolulu.
6.	Rock, J.F. The Indigenous Trees of the Hawaiian Islands. 1st 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. University of Hawai`i Press, Honolulu.
8.	Wagner, WL, DR Herbst, and SH Sohmer. 1990. Manual of the Flowering Plants of Hawai`i. Bishop Museum Special Publication 83, University of Hawaii Press, Honolulu.

Site Description Approval

Author	Date	Approval	Date
David Clausnitzer	**07/07/2008**	**David Clausnitzer**	**07/07/2008**
Joseph May	**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
Department of Land and Natural Resources
Division of Forestry and Wildlife
February 1996

FOREWORD

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 developed 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 controlling potential nonpoint source pollution. Care must also be taken to select BMPs that are practical and economical while maintaining 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 timber 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 practices on water 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 exposed mineral soil areas through natural or artificial revegetation means.

The intent of this guide is to promote better stewardship of the forest resources. This guide delineates environmentally responsible land management methods which, when applied properly, minimizes adverse impacts on the forest ecosystem and maximizes landowner objectives. Unusual situations may arise or pollution control measures 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 education and awareness program. Changing of water quality standards or the required use of protection practices should not be attempted without careful study of 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 million acres are zoned for agricultural or conservation uses. The Conservation district, which is under the jurisdiction of the Department 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 unique 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 of BMPs to protect water quality within Hawaii depends on mutual cooperation and trust among landowners, industry, environmentalists, wood producers, 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 RELATIONSHIP

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 reproduction. 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 effective and high quality groundwater recharge.

Hawaii's streams and aquifers all benefit from the presence of forests. In addition to these water quality benefits, forests provide needed wood and fiber products, wildlife habitat, aquatic resources and habitat, recreation values and aesthetic benefits. It is in managing forests for these benefits that damage to 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 long 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 removing 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.

Road Construction and Drainage Techniques

All facets and phases of a sound forest management program rely heavily on accessibility to the forest. Consequently, temporary and permanent 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 harvesting operations, site preparation and planting and often abandoned after the new stand is established. When abandoned, these temporary roads are normally allowed to revegetate naturally or are planted with trees.

Pollutants from Silvicultural Activities

The major types of water pollutants 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 felling into water drainages, and washout during storms. Organic materials may place an oxygen demand on the receiving water body during the decomposition process. In 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 MANAGEMENT PRACTICES

1.0 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 forestry activity.** Most of this erosion can be prevented by locating, constructing, and maintaining roads to minimize 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, Design, and Location

A well planned 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 will influence the choice of road construction standards and maintenance activities. 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 fill 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 diverting 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 short, 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 of Road	Distance Between Water bars
2%	250 ft.
5%	135 ft.
10%	80 ft.
15%	60 ft.
20%	45 ft.
25%	40 ft.
30%	35 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 allow 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.

2.0 Pre-Harvest Planning

Pre-harvest planning is the collection of information about the area to be harvested and the synthesis of that information into an effective environmental plan. This plan will consider the silvicultural prescription for the species and site, the best estimate of the time 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 government 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-point 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 administrative 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 trained forester or one who is knowledgeable about the specific area is highly recommended.

(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

Timber 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 minimized and the re-establishment of vegetative cover is realized. Guidelines to help reduce the potential for nonpoint source pollution from harvesting trees are as follows:

Felling and Bucking

(1) Careful felling can minimize 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 Considerations

Planning is an essential first step in 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 will leach to ground water.

2) Absorption

Absorption is the inherent ability of a pesticide to bind 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 movement 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 minimize potential impacts on water quality, use of the following practices is encouraged.

A) Transportation

(1) Inspect all containers 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 transportation 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 federal, 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 the 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 be handled and disposed of in accordance with hazardous waste regulations. For more information about proper management of waste pesticides, contact the Department 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 are recommended:

(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.

4.0 Streamside Management 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 reducing or eliminating 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 benefit the aquatic ecosystem in general. In addition, the SMZ is designed to maintain certain forest attributes that will provide specific wildlife habitat values. Snags, den and cavity trees as well as mast producing trees, left in the SMZ, are necessary to meet habitat requirements for certain 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 Streamside 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 precaution is used in carrying out forest management practices. The SMZ also provides shade and functions as a buffer when fertilizers, pesticides, etc. are applied to adjacent lands. For practical purposes, an SMZ must 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. Determining the necessary width involves in part a judgement factor based on reliable local experience.

SMZs should be used where: 1) 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 5) silviculture practices are to be implemented, and 6) the lower edge of cropland, grassland, or forest land is adjacent to permanent or intermittent streams, or border streams, rivers, ponds or intermittent or permanently flooded, open-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. In 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) Food - Leaves and insects drop into streams from overhanging trees and shrubs. In fact, 90% of the food in the forested streams comes from bordering vegetation.

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

(4) Flooding - Healthy SMZs stabilize floodplains. During times of high water, SMZs reduce the velocity of floodwaters. Their dense vegetation and deep humus slow down racing waters. Forest floodplains suffer less damage when SMZs are protected during harvesting activities.

(5) Recreation - 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 Production - For those who grow and harvest trees, the fact is that trees often grow best in SMZs. Trees respond to those deep, fertile, and moist soils. Logging activities should not be eliminated within SMZs but modified to insure that stream channels and banks are protected from disturbance. SMZs are 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 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 reservoirs serving as domestic water supplies. The following best management practices are recommended:

(1) The width of SMZs should be determined depending on the following conditions: slope of land adjacent to stream, soil erodibility, precipitation, knowledge of particular area, sensitivity of stream, etc. These factors can be obtained from soil maps, on-the-ground evaluation 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 Width (each side)
Slightly erodible	0-5	35'
Slightly erodible	5-20	35-50'
Slightly erodible	20+	50-160'
Erodible	0-5	35-50'
Erodible	5-20	80' minimum
Erodible	20+	160' minimum

Table 1. Recommended Widths for Streamside Management Zone

[NOTE: Please contact your local Natural Resources Conservation Service office to determine the erodibility factor of the soil before determining 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 with slopes ranging between 5 and 20 percent, the SMZ width should range between 35 to 50 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 width 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 50 square feet of basal area per acre, evenly distributed, should be retained in the SMZ. This may be adjusted to meet on-site 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 all 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 landowner 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 are prevented or damaged by these animals.

(2) Pastures should be fenced separately from woodlands. 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 all wildfires on grass, brush, and watershed lands and the implementation of a prescribed fire program is a desirable goal. Where wildfires do occur, the first and foremost concern is to control the fire and 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 wildfire control and reclamation:

(1) The first and foremost concern in wildfire control is to prevent harm or damage to people and property. Fireline best management practices should incorporate minimum impact strategies, which meet land and resource 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 rehabilitative 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, and wildfire defense and control. A number of control practices can be implemented during fireline construction to prevent unnecessary 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 perimeter of the burn area and along the boundary of the Streamside Management Zone. The purpose of protecting the Streamside Management Zone from fire 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.

6.2 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 conducted when they are 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 burns 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.

7.0 Reforestation

Reforestation refers to those operations undertaken 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 site 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 receive the minimum 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, shearing, 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.

APPENDICES

1. Definition of Terms
2. Road Construction Applications
3. Streamside Management Zone
4. Available Assistance
5. Suggested Readings

definition of terms

DEFINITION of TERMS:

Best Management 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 activities. 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.

Clearcutting -- 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.

Diversion 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.

Firebreaks -- naturally occurring or man-made barriers preventing the spread of fire.

Fireline 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.

Pre-commercial thinning - 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 reestablishment of tree species following harvest.

Silvicultural 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

Definition:

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

Purpose:

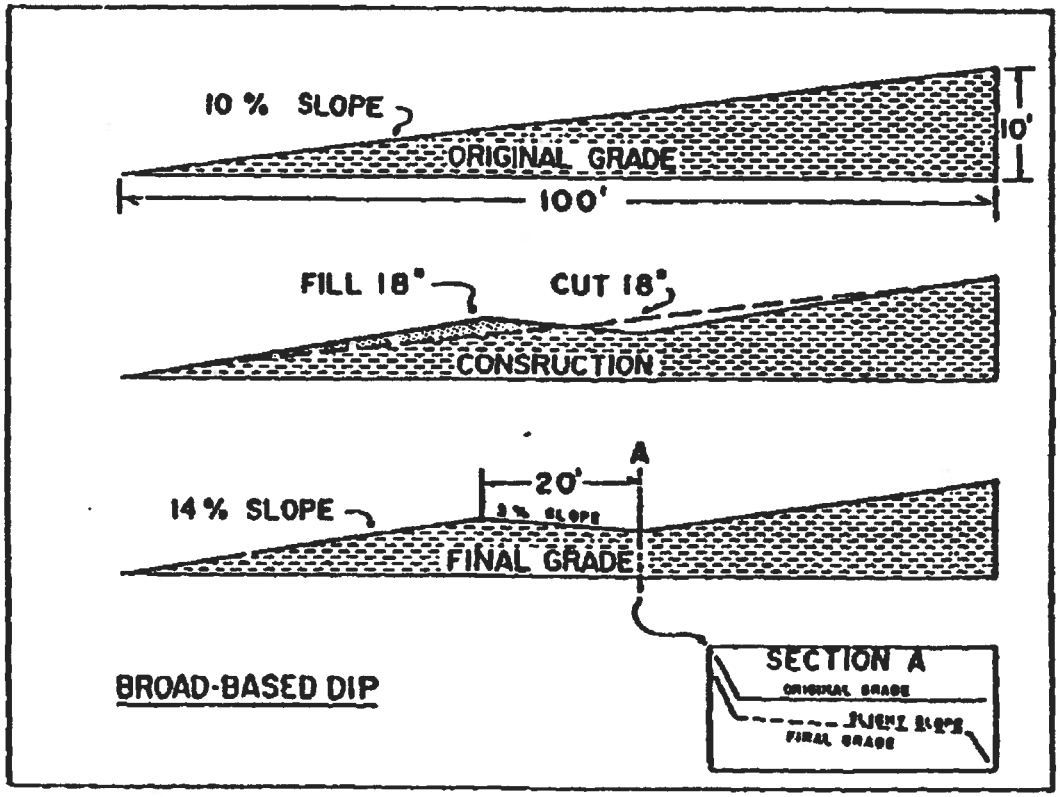
To provide cross drainage on insloped truck roads to prevent build-up of excessive surface runoff and subsequent erosion.

Conditions Where Practice Applies:

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

Guidelines:

* Proper construction requires an experienced bulldozer operator.
* Installed after the basic roadbed has been constructed and before major hauling use.



- 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.

SPACING 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

Definition:

An earthen or reinforced berm constructed across a truck road or skid trail.

Purpose:

To intercept and divert water from side ditches and truck road or skid trail surfaces, therefore minimizing 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.

Guidelines:

* 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 skidder 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 left along the lower side of the water bar.

* Should be constructed at a 30° - 35° angle downslope from a line perpendicular to the direction of the truck road or skid trail.

* Should drain at a 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.

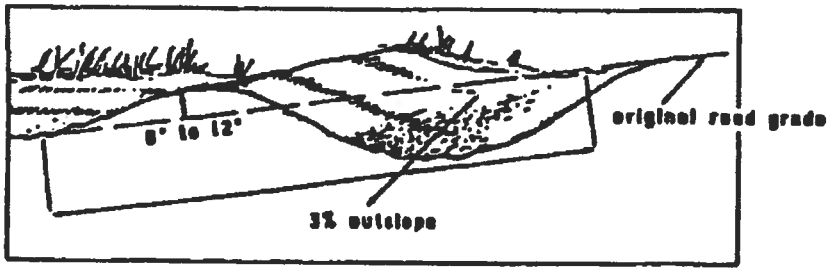
* The downhill end of the water bar should be fully open and extended far enough beyond the edge of the road or trail to disperse runoff water onto undisturbed forest floor.

* Place rocks, slash, or logs to disperse water coming from a water bar.

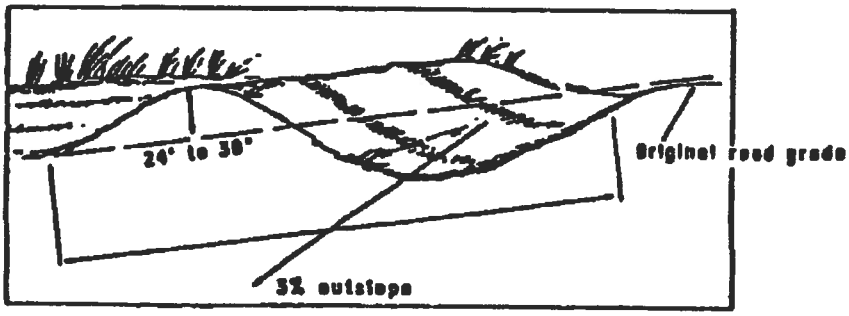
* If the road or trail is to be kept open after the harvesting operation, the following guidelines should be used in order to preserve effective water bars.

  - 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 BARS

Road/Trail Grade (percent)	Spacing Between Water Bars (feet)
2	250
5	135
10	80
15	60
20	45
30	35

CROSS DRAINAGE CULVERTS

Definition:

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:

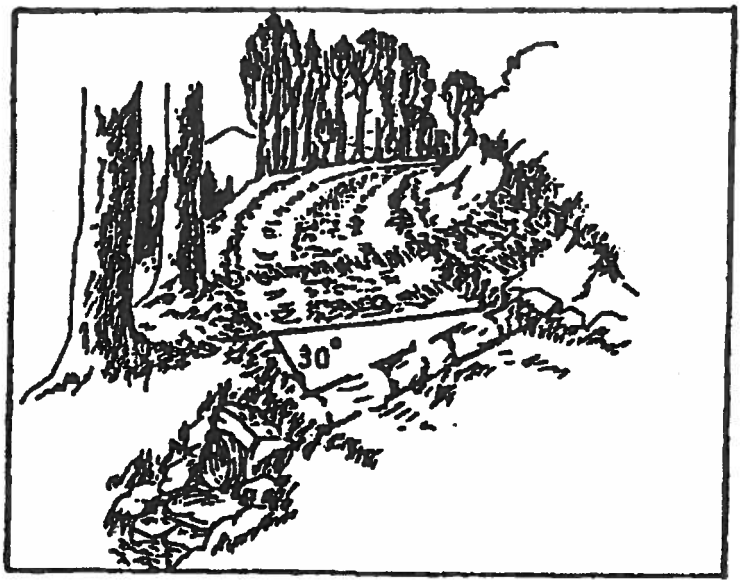
To collect and transmit water flows from side ditches and seeps, under truck haul roads and major skid trails safely without eroding a drainage system or road surface.

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 harvesting 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 inch diameter and 20 feet in length.

- When constructing roads on sidehill locations, ditch uphill side of the roadway to intercept surface runoff.

- Allow inlet end of culvert to extend into side ditch so that it intercepts water flowing in the ditch. Construct a berm across the side ditch to assist in diverting water into the culvert.

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

- Space culverts according to road grade:

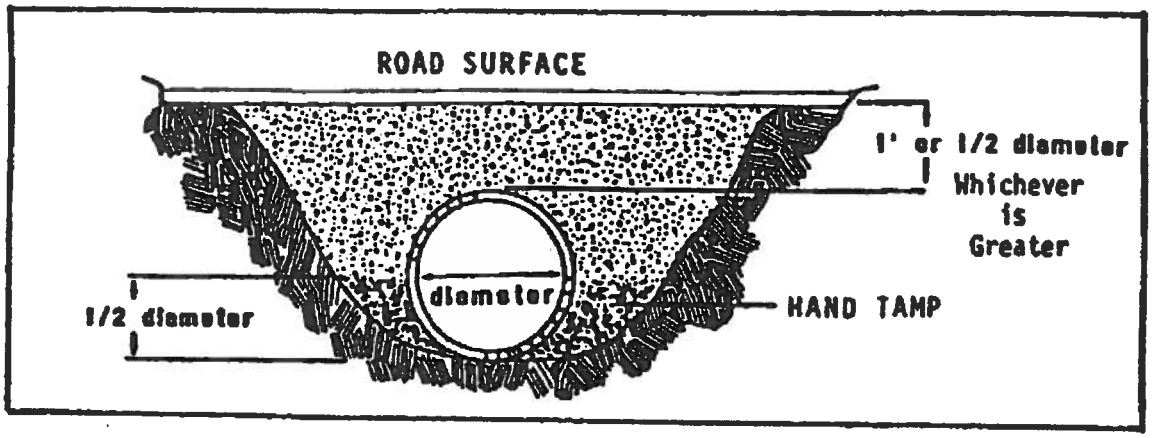
On gentle slopes (1-2%)	300 feet
On moderate slopes (3-10%)	150 feet
On steep slopes (10%+)	100 feet or less

- 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 stabilized by installing water bars and removing all 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 into brooks, streams, ponds or wetlands. It is important to clean culverts regularly. Check after every storm.



- Culvert size selection should be based on the size of the drainage area of a 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

Definition:

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

Purpose:

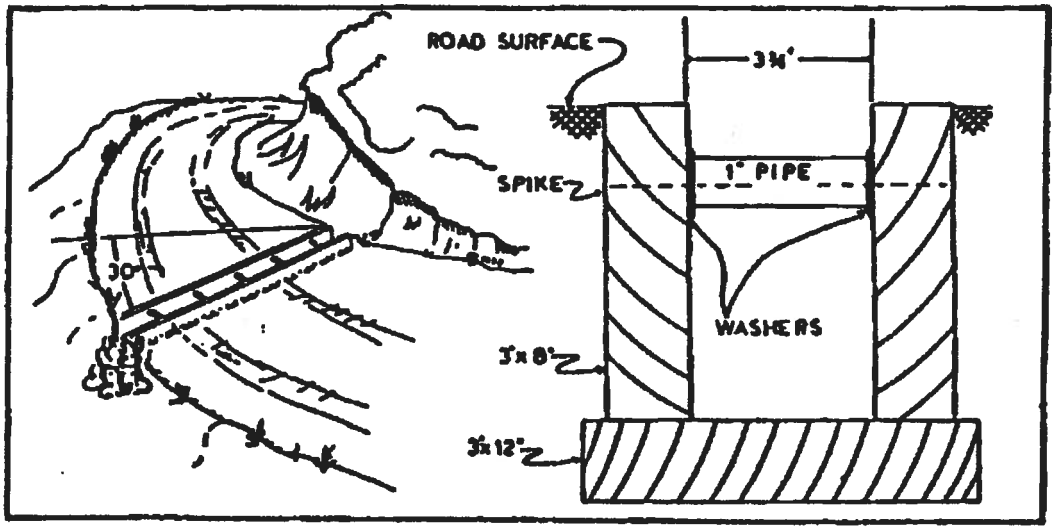
To collect and direct road surface storm runoff and upslope side ditch flows across road without eroding drainage system or road surfaces.

Conditions Where Practice Applies:

This is a temporary drainage structure for on-going 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 sediments, 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	150
10	140
12	130

road construction applications

OUTSLOPING

Definition:

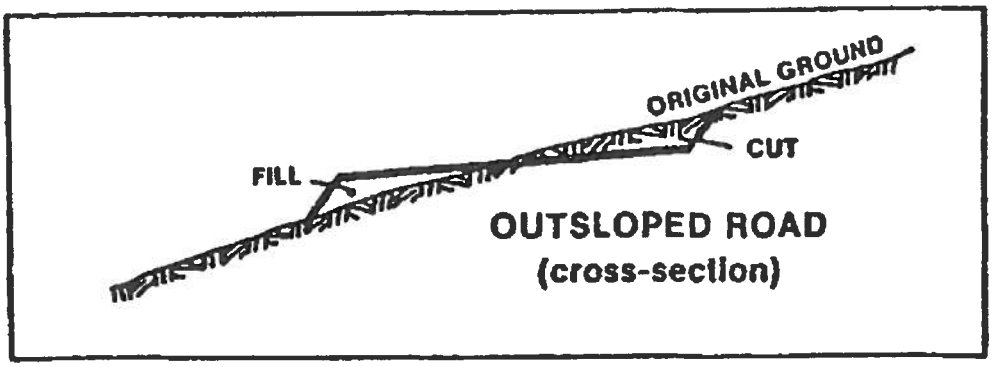
A section of road is sloped slightly (1-3%) from the cut bank to the outside edge of the road bed.

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.



INSLOPING

Definition:

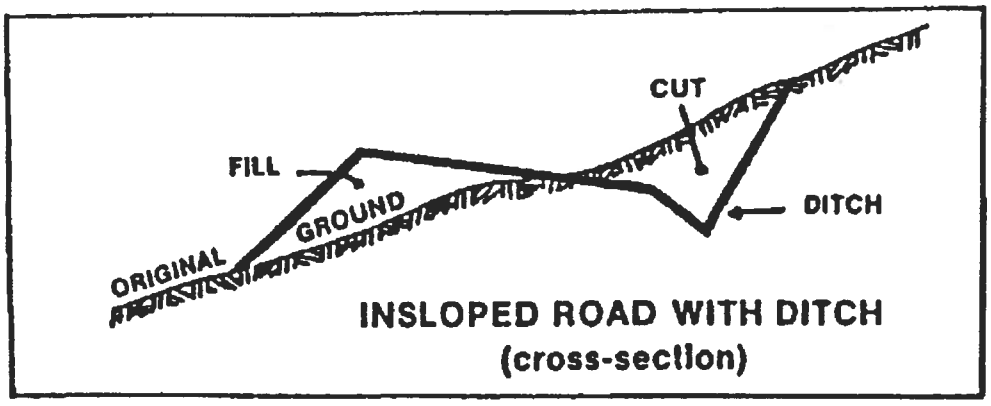
A section of road is sloped slightly (1-3%) toward the cut bank.

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.



INSLOPED ROAD WITH DITCH
(cross-section)

CROWNING

Definition:

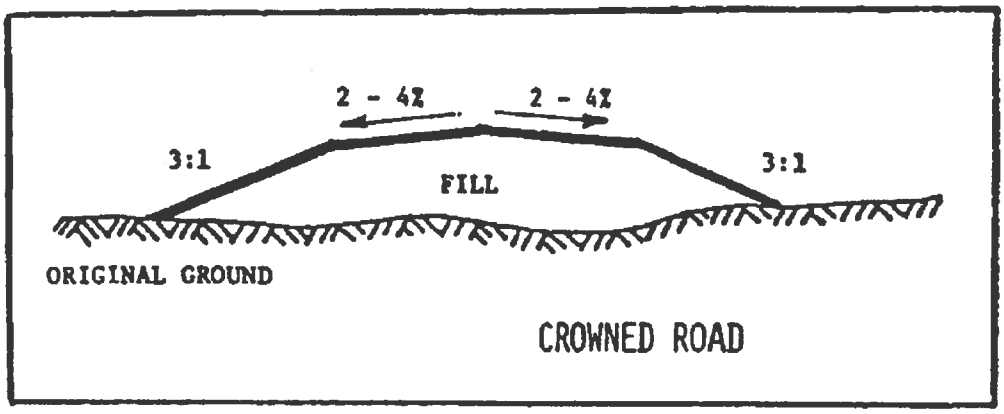
A section of road is sloped slightly (2-4%) from the center line of the road to the outside edges of the roadbed.

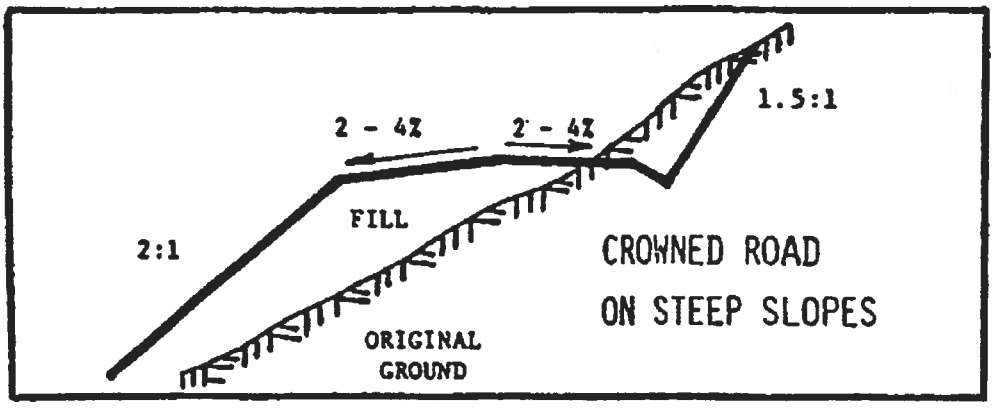
Purpose:

Effective way of limiting 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 erodible when adjacent areas are relatively level with roadbed or on steep side hills.





streamside management zone

STREAMSIDE MANAGEMENT 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 reservoirs 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 particular 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 to protect water quality.

The following is offered as a guideline:

Soil Type	Percent Slope	SMZ Width (each side)
Slightly erodible	0-5	35'
Slightly erodible	5-20	35-50'
Slightly erodible	20+	50-160'
Erodible	0-5	35-50'
Erodible	5-20	80' minimum
Erodible	20+	160' minimum

[NOTE: Please contact your local Natural Resources Conservation Service office to determine the erodibility factor of the soil before determining the proper width of the SMZ.]

available assistance

Available Assistance

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

Hawaii Branch

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

Maui Branch

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

Oahu Branch

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

Kauai Branch

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

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

Hawaii District Offices

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

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

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

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

Natural Resources Conservation Service, cont'd.

Maui District Offices

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

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

Kauai District Office

Lihue Office
4334 Rice Street, Rm. 104
Lihue, HI 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. Dellberg, 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. "Erosion and Sediment Control Guide for Hawaii," Soil Conservation Service, 1981, 178 pp.

Exhibit C

Final Environmental Assessment

for

State of Hawaii

Forest Stewardship Program

Cost Sharing Grant

for a

Riparian Restoration

and

Timber Production Project

Pepeekeo, Hawai'i

TMK (3) 2-8-003:009

TMK (3) 2-8-003:010

Released for public review:

July 22,2013

Prepared by:
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P.O. Box 2037
Kamuela, HI 96743

On behalf of:

Kaupakuea Orchards, LLC

Christopher Trimarco

Table of Contents

1. PROJECT SUMMARY

Project Name:	Riparian Restoration and Timber Production Project
Applicant:	Kaupakuea Orchards, LLC (KOL)
Approving agency:	Department of Land and Natural Resources (DLNR) Division of Forestry and Wildlife (DOFAW)
Requirement for EA:	Seeking cost sharing funds from the State of Hawaii in the form of a Forest Stewardship Grant for restoring native trees in riparian areas and for planting high-value hardwood timber trees to be harvested no earlier than 30 years after planting.
Anticipated determination:	Anticipated Finding of No Significant Impact (AFONSI)
Project Location:	Pepeekeo, Hawaii. The project is located on Kaupakuea Homestead Road, approximately 10 miles north of Hilo, and 1.9 miles mauka from the turnoff from Hawaii Belt Road.
Acreage:	Project proposed for 23.3 acres of a total parcel area of 41.5 acres.
Tax Map Keys:	(3) 2-8-003: 009 and 010
Land Use District:	Agriculture (State, County)
Pre-Consultation:	Nicholas Koch (project consultant, FSI) Thomas Baribault (project consultant, FSI) Office of Hawaiian Affairs DLNR Historic Preservation Division DLNR Division of Forestry and Wildlife County of Hawaii Planning Department Adjacent neighbors

2. PROJECT DESCRIPTION

2.1. Overview

The proposed Forest Management Plan (FMP) would be funded by a cost sharing grant (CSG) with the State of Hawaii (SoH) Forest Stewardship Program (FSP), to be provided by the SoH Department of Land and Natural Resources (DLNR), Division of Forestry and Wildlife (DOFAW). The management plan, which is available for public review at the Hilo Public Library, and by request at (808) 776-9900 x 238, conforms to requirements of the Forest Stewardship Program as outlined in the Forest Stewardship Handbook (see **Appendix A**). The main features of this FMP are (1) restoration of riparian areas along the Waia'ama Stream by removal of invasive species and planting of native species and (2) planting of high-value hardwood trees in abandoned pasture land. The CSG covered by this environmental assessment (EA) covers strictly the first decade of this project, which will involve planting native tree species in the riparian zone and establishing high-value hardwoods in the pasture area. Harvesting of the hardwood trees would not occur within the timeframe of the CSG, and is therefore not the subject of this EA or this FMP. For all restoration, planting, and silvicultural operations, KOL is committed to using best management practices (BMP, see **Appendix B**) endorsed by SoH.

2.2. Project size

The total area encompassed by the two TMK is 41.5 acres, of which 4.4 acres would be dedicated to riparian restoration, and 18.8 acres to hardwood plantings. The remaining acreage encompassed by the two TMKs will be dedicated to a single family home(s), farm buildings, and various agricultural activities. Small scale, non-commercial, fruit orchards, vegetable growing, and ornamental horticulture are anticipated. This area, and the described activities, are not involved with the FMP, are not an element of the CSG request, and do not fall under the scope of this EA.

2.3. Project duration

Although the high value timber element is at least a 30-year project, a CSG is sought only for the first ten years of the project. During this time, timber plantings would be completed within the first three years, with cost sharing for maintenance through the fifth year of the project. Native forest restoration in the riparian areas along Waia'ama Stream would continue for the duration of the project, through the tenth year.

2.4. Environmental Assessment

According to the Forest Stewardship Handbook and rules of the FSP, an EA is required for projects in which SoH CSG funding is sought. In particular, "Plans that include the establishment of timber with the intent of eventual harvest [regardless whether harvest occurs during the cost sharing phase of the plan] and projects involving fencing an area over 10 acres must be accompanied by an Environmental Assessment (EA), HRS §343." This FMP involves both eventual harvest as well as more than 10 acres of area to be fenced, thus triggering the EA requirement under FSP rules. Elements of the Forest Management Plan that concern riparian restoration are not described in detail in this document. The riparian buffer restoration activities are covered under the DLNR Department of Forestry and Wildlife's allowed exemption classes dated June 12,2008. Particularly, Exemption Class 1 number 8 and 9, and

Exemption Class 4 number 6 and 7. Only the 18.8 acres that are to be planted with hardwood trees fall under the scope of this EA.

2.5. Cost Sharing Grant

The duration of the project for which SoH funding is sought is ten (10) years. During this period, KOL seeks a 50% cost sharing for all restoration, establishment, and maintenance operations. Cost sharing for native forest restoration in the riparian areas does not require treatment in this EA; only cost sharing requests for the hardwood plantings are under review in this document.

2.6. Forest management plan

Chief elements of this FMP include restoration and hardwood timber plantings:

- Restore forest cover to the upper elevations of each TMK by establishing plantations of several high value hardwood species (see map, **Appendix C**).
- Protect and expand the existing native forest cover in streamside management zones (SMZ) by controlling invasive weed species (see map, **Appendix C**).
- Restore portions of the SMZ where invasive species have dominated the ecosystem (see map, **Appendix C**).

The long term goals for this FMP are twofold. First, the project will convert more than 18 acres of marginal pasture land to high value hardwood plantations that can be selection harvested on a 45-year rotation. Hardwood tree species are selected on a combination of criteria. These include, viability of establishment and likelihood of thriving (considering local conditions, like soils, rainfall, elevation, amount of sunshine, etc.). Another criteria is economic viability (seedling availability and costs, market demand for timber, etc.) Trees that meet these criteria must also have acceptable ratings from the State of Hawaii Weed Risk Assessment. There will be positive environmental benefits from the outset of the project that will continue well beyond the harvest period. Due to weed mitigation during the establishment period, ongoing maintenance, and the shade cover created by well established hardwood trees, invasive species will be kept at bay. Also, the chosen selective harvesting method plans for forest cover to remain on the landscape beyond the 45 year rotation period. Per the approved FMP, harvesting will follow the best management practices in place at that time. 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 (*Metrosideros polymorpha*) in the canopy and native ferns such as uluhe (*Dicranopteris linearis*) and hapu'u (*Cibotium glaucum*) in the understory. **The project owner, KOL, intends to support this important work in part with a SoH FSP CSG.**

3. Description of site environment

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. Project location is also provided in map form (see **Appendix C**).

3.1. Historical land use

The property was owned by various sugar producing companies from 1900 through 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. 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. Existing vegetation and land use

3.3.1. Vegetation cover

The vast majority (37.2 acres, 93%) of the area on the property is currently active pasture land. In the future, intensive pasture will be discontinued on at least 17 acres and likely across the entirety of both parcels. 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 moluccana*), and ginger (*Hedychium spp*).

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. A few specimens of 'ōhi'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. 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.

The understory of the SMZ property is invaded with smaller 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.

3.3.2. Adjacent land use

3.3.2.1. Agriculture

Areas directly down slope (makai) from the two TMKs under consideration in this EA are used for agricultural production, including ginger cultivation and pasture. Land use in these adjacent areas can be positively affected by management actions proposed for this project. All site preparation, which will involve machinery, will be conducted according to SoH BMP, and under correct and proper permitting. As such, erosion and runoff will not be encountered. The hardwood forest can serve as a windbreak to the adjacent makai properties as well as reducing the amount of invasive species in the immediate vicinity. The riparian restoration will provide benefits to the adjacent makai properties by improving their upstream water quality.

3.3.2.2. Abandoned land

Areas directly up slope (mauka) from the two project parcels are currently unoccupied and unused for any purpose, whether agricultural, residential, or environmental. Proposed project actions will not affect adjacent mauka parcels.

3.3.2.3. Neighboring land owners

Parcels actively occupied by neighbors, defined as parcels with houses in which persons currently reside, are located only on the Northern side of Kaupakuea Homestead Road, and separated from the property by Ālia Stream and by a belt of tall trees. Planting operations, restoration activities, and the eventual stand of trees on the parcels will not affect neighboring land owners.

3.3.2.4. Fire risk

The property is moist year round, with rainfall in excess of 150 inches evenly distributed throughout the year. 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 provide sources of fire fighting water, while the road at the Eastern edge of the timber compartments 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. Easy access to stream water should allow for any fire to be extinguished quickly.

3.3.3. Soils

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 clay loam component makes up 90 percent of the map unit. Slopes are 5 to 15 percent. This component is on ash fields on lava 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. Water movement 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 not flooded. 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 F159AY500HI Acacia koa-Metrosideros polymorpha-cibotium Menziesii/freycinetia Arborea ecological site. Non irrigated land capability classification is 4e. Irrigated land capability classification is 43. This soil does not meet hydric criteria.

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.

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.

3.3.4. Streams and wetlands

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

3.4. 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. However, if during the project, any items are uncovered that are suspected to be of archeological or historical significance, work will be halted and DLNR's State Historic Preservation Department will be contacted as soon as possible.

3.5. Fauna

3.5.1. Non-native fauna

Ground birds, including kalij pheasant (*Lophura leucomelanos*) 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 (*Asio flammeus*) and Io (*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 'alalā (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. 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 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, particularly in the SMZ where the animals disturb soils as they walk to the water to drink.

3.5.2. 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.

4. Anticipated environmental impacts and mitigation measures

4.1. Soil conservation

The proposed project is expected to impact soils solely in a positive way. A century of sugar cultivation by various companies, and two decades of cattle grazing thereafter, has left the parcel with highly compacted soils, a nearly totally alien plant species assemblage, and significant erosion issues due to cattle actively grazing within SMZ. Proposed management actions will improve soils in several ways. First, site preparation in the abandoned pasture areas for hardwood plantings will reverse compaction that occurred during the two decades of grazing. Second, established trees will improve soil retention because their root systems are more extensive than alien grasses, and because cattle will no longer be present in the planted areas. Third, establishment procedures will maintain grass cover in areas between tree rows to stabilize soils while trees are in the juvenile phase; trees will also be mulched, potentially with material derived from invasive species removal in the SMZ, to further protect soils from erosion. Moreover, both native restoration plantings and hardwood trees will be fertilized with formulas appropriate for their respective areas. Native plantings will be fertilized with controlled-release compounds to eliminate risk of eutrophication in the adjacent streams, while nitrogen, phosphorus, and potassium addition to soils for timber plantings will improve overall nutrient balance in this degraded

landscape. College of Tropical Agriculture and Human Resources (CTAHR) fertilization guidelines will be consulted. Please refer to the full Forest Management Plan for further details.

4.2. Water quality

4.2.1. Erosion mitigation

Water quality in the Waia'ama Stream is currently being negatively impacted by cattle grazing immediately adjacent to the stream. Cattle walk from the pasture to the stream, causing severe erosion along stream banks and continuous input of silt and fecal matter to the aquatic ecosystem. The proposed project will eliminate cattle from the landscape, both stopping SMZ erosion as well as improving water quality and purity. The cattle will be fenced from stream access. In the timber plantings, tree cover will further retain soils such that makai reaches of both Waia'ama Stream and Ālia stream will experience reduced sedimentation. To reduce erosion, so as to maintain or improve water quality during the site preparation related to the restoration activity, the roots of the cut trees will be left in place. This will stabilize the soil on the steam bank while the root systems of the newly planted native species take hold and replace the non-natives.

4.2.2. Restoration activities

The current density of *P. cattleianum* cover in many sections of the riparian zone is extreme. 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. 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. 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. 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.

4.3. Impacts on biological resources

Proposed management activities, including restoration and reforestation of degraded SMZ (4.4 acres) and replacement of alien grasses on degraded pasture land by high value hardwood trees (18.8 acres) will yield positive benefits for the land in terms of biodiversity, erosion control, animal habitat, and aesthetics. In SMZ, the vast majority of extant plants are non-natives, principally strawberry guava and ginger. These pernicious invasive species will be replaced by native trees ('ōhi'a, pilo, lama) and ferns (hapu'u, uluhe). Pasture areas of both TMK are currently occupied by alien grasses, which serve no positive purpose for native bird or bat habitat. In contrast, the proposed high-value timber plantings will drastically improve habitat for both groups. Although timber harvesting is not covered in the scope of

this EA or FMP (since no CSG is sought for that activity), harvesting would occur on a selection basis (uneven aged management), which conforms to SoH BMP and would maintain tree cover on the land.

Many of the high value hardwood species proposed for this project rank between 1 and 6 on the University of Hawai'i weed risk assessment scale. These risk values suggest limited potential for invasiveness, and three factors further 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.

4.4. Access

Significant access infrastructure exists on the property. A road constructed by Hāmākua Sugar Company bisects the property, and a concrete box culvert constructed in 1925 allows easy crossing of the drainage in the Northern parcel. 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 SoH BMP. 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. The main access 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.

4.5. Feral ungulate management

The Northern boundary of the property is effectively fenced with barbed wire, 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 ungulates if necessary.** 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 4' 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.

4.6. Impacts on cultural resources

4.6.1. Cultural and historical resources

Just as the century of sugar cultivation and two decades of intensive pasture use have obliterated native ecosystems and resulted in an impoverished flora and fauna across the project area, cultural, archaeological, and historical resources have similarly been erased. Consequently, no negative impacts to historical or archaeological resources are anticipated. The only nominally historical element present on the property is the box culvert from ca. 1925; this feature would be improved and maintained in conjunction with the project, although not using FSP or SoH funding and therefore irrelevant to this EA.

4.6.2. Social issues

The chief social issues involved with forestry projects tend to be (1) aesthetic impacts (trees blocking views) and (2) noise associated with establishment and / or harvesting. First, this project holds zero potential for aesthetic impacts because there are no neighbors at higher elevations and therefore no views to be blocked. Second, establishment activities for this project will involve machinery comparable to that which was in use for decades during sugar cultivation, and similar to machinery currently used in agricultural production on adjacent parcels, translating to minimal impact on neighboring landowners. Finally, harvesting activities are approximately 45 years distant, and since these are not an element of the FMP, should not be considered during review of this EA.

5. Alternatives to proposed management

5.1. No alternative management

The primary alternative to the proposed management is an absence of management. Both parcels are owned outright by KOL, which does not entertain plan for management scenarios other than the FMP under consideration in this EA. Therefore, if the actions proposed here were not undertaken, no management would occur on the property. In an absence of active land management, both pasture areas and SMZ would be rapidly colonized by aggressive invasive plant species, increasing the presence of these unwanted plants as well as the feral ungulates that live in such plant communities. Habitat for native birds and for the Hawaiian bat cannot be regenerated adequately in stands of strawberry guava, which is the primary species that would colonize this land. Overall, the option of no alternative management would yield a landscape in even worse condition than the current pasture cover. In contrast, the proposed action will improve native species biodiversity in SMZ, and improve native fauna habitat in the high-value timber planting areas.

5.2. Alternative agricultural management

Although KOL has no plans to implement alternative agricultural management options, it should be emphasized that these alternatives are also less desirable—from a conservation perspective—than the proposed actions. The two real alternative agriculture options are (1) cultivation of annual row crops and (2) grazing. Regarding (1), repeated tilling of the soil, especially in areas such as Pepeekeo mauka with its high rainfall, leads to significant soil erosion, runoff, siltation, and loss of soil fertility. The proposed management would avoid all of these negative consequences. Regarding (2), grazing is

responsible for soil compaction in pasture areas and severe erosion in SMZ. Forestry projects avoid both of these outcomes, with superior results for ecosystem health, conservation, biodiversity, habitat, etc.

6. Determination

Natural and cultural resource enhancement

The proposed action would replace invasive species with (1) native species in SMZ and (2) high-value hardwood species in degraded pasture areas. This improves natural resources in terms of biodiversity, habitat, and forest cover. This project improves cultural resources by expanding the area on Hawaii Island dedicated to native forest preservation.

Beneficial environmental use

All proposed forestry activities will be consistent with State of Hawaii Best Management Practices. In contrast, current land use (pasture, annual agricultural) is antithetical to forestry BMP; the proposed project therefore replaces a detrimental environmental use with a positive one.

Enhancement of environmental quality

The proposed project is consistent with HRS §344, regarding the policy that projects seeking funding from the SoH, in this case as a CSG, will not conflict with long-term goals of the State environmental policies or guidelines. Moreover, the FMP for which this EA is relevant has been approved by DLNR DOFAW FSP, and is therefore in accord with the FSP guidelines (**Appendix A**).

Cumulative adverse effects

This project will result in no cumulative adverse effects.

Rare, threatened, or endangered species

The parcels involved with this FMP and this EA currently contain virtually no native Hawaiian plants of any type, and support no native fauna. The SMZ restoration elements of this project will restore native Hawaiian plant species along important riparian habitat corridors, thus improving representation of important common Hawaiian tree species as well as providing potential habitat for native fauna.

Economic outcomes

The proposed management actions will involve contracting with local forestry management entities, including foresters, nursery owners, machine operators, forest technicians, and forest laborers. Completing this project will thus yield a net positive economic result for the local community during the establishment and maintenance phases of both the timber planting and the native forest restoration.

Public health outcomes

There are no public health concerns associated with the proposed project.

Secondary outcomes

Not applicable.

Energy consumption

This project consumes no municipal energy, as it features no powered infrastructure.

Aesthetic consequences

Because this project is located mauka from all residential neighbors, the growth of trees can have no negative aesthetic impact.

Overall determination

Anticipated Finding of No Significant Impact.

7. Appendix

Responses to pre-consultation communications:

County of Hawaii Planning Department letter dated August 2, 2013

William P. Kenoi
Mayor

Exhibit C
Duane Kanuha
Director

Bobby Command
Deputy Director

West Hawai'i Office
74-5044 Ane Keohokalole Hwy
Kailua-Kona, Hawai'i 96740
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County of Hawai'i
PLANNING DEPARTMENT

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August 2, 2013

Mr. Christopher Trimarco
4110 NE 27'h Avenue
Lighthouse Point, FL 33064

Dear Mr. Trimarco:

Subject: Pre-Consultation on Environmental Assessment
Applicant: Kaupakuea Orchards, LLC
Project: Riparian Restoration and Hardwood Timber Project
Tax Map Key: 2-8-3:9 and 10.South Hilo.Hawai'i

This is in response to your June 29, 2013 letter regarding the riparian restoration and hardwood timber project that was approved by the Sate of Hawai'i Forest Stewardship Advisory Committee on May IO, 2013. 4.4 acres will be dedicated to riparian restoration and I8.8 acres to hardwood planting.

The proposed Forest Management Plan would be funded by a cost sharing grant with the State of Hawai'i Forest Stewardship Program to be provided by the Department of Land and Natural Resources, Division of Forestry and Wildlife. The main features of this plan are (I) restoration of riparian areas along Waia'ama Stream by removing invasive species and planting of native species and, (2) planting of high-value hardwood trees in abandoned pasture land. The grant covered by the Environmental Assessment is only for the first 10 years of the 30-year project. Harvesting of the hardwood trees would not occur within the timeframe of this grant.

We have the following to offer:

I. Parcel 9, consisting of20 acres, and Parcel 10, consisting of20.44I acres are both zoned Agricultural (A-20a) by the County. Forestry is a permitted use on both parcels.

2. Both parcels are designated Agricultural by the State Land Use Commission.

3. The General Plan designation for both parcels is Important Agricultural Land.

4. Based on the information provided at this time, no Planning Department permits are required.

5. The subject parcels are not located within the County's Special Management Area.

Should you have questions, please contact Esther Imamura at (808) 961-8139.

Sincerely,

DUANE KANUHA
Planning Director

ETI:cs
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cc: Planning Department - Kona